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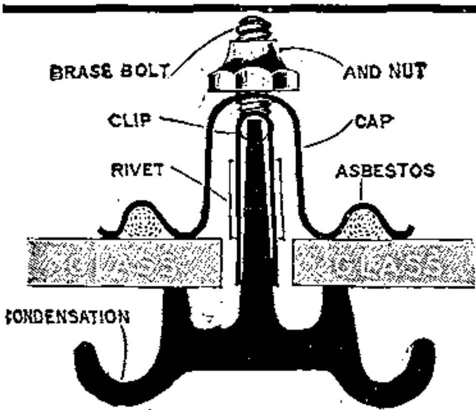

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CONTENTS.

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SOME EXPERIMENTS IN THE DESTRUCTION OF DEFECTIVE POM-POM AMMUNITION.

Photo 1.

Photo 2

DEFECTIVE POMPOM AMMUNITION

REPORT ON SOME EXPERIMENTS IN THE DESTRUCTION OF DEFECTIVE POM-POM AMMUNITION.

By CAPT. P. S. GREIG, R.E.

ORDERS having been received to destroy, in the best way possible, a considerable number of rounds of defective pom-pom ammunition, the following experiments were carried out by the writer and an Ordnance officer, assisted by some N.C.O.'s. As the results were not a little instructive (as well as exciting) and may be of interest to others, a detailed account is given herewith :—

Experiment No. 1.—The ammunition is packed in wooden boxes of 80 rounds each. To avoid the trouble of having to open each box, our first endeavour (which was purely tentative as we had no idea of what the result would be) was to try the effect of a half slab of guncotton placed on the outside of the box, which was placed on its side in a rocky donga.

Details.—Charge = half slab of guncotton with 1 oz. guncotton primer and 5′ of safety fuze, placed on outside of box and tamped with four sandbags on top and four at sides of box.

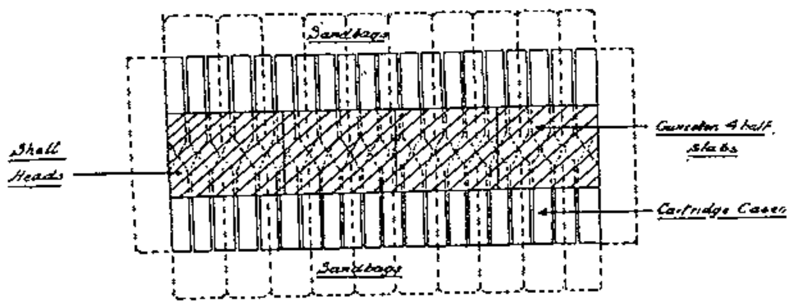
Result.—The result was not a success. The ammunition was found in every stage, some quite intact, some cartridge cases blown to bits, some full or partially full of unexploded cordite, others with unexploded caps and no cordite. As far as could be ascertained none of the shells had been broken, and they were lying about probably in a "live" condition, *i.e.*, the shells were liable to explode if dropped.

The lesson to be learnt was the necessity of destroying the "shell end" of the ammunition, and letting the cartridge cases (with their cordite contents) join in the *mêlée* if they would.

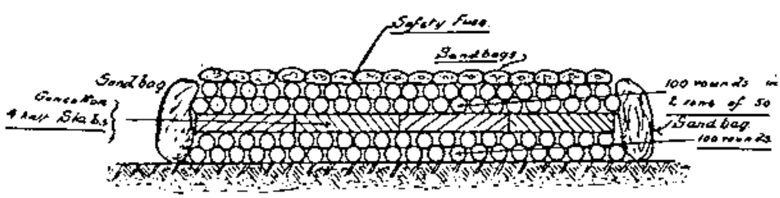
Experiment No. 2.—In this experiment quite a different procedure was adopted. The ammunition was taken out of the cases and laid nose to nose in rows on the rocky bed of a donga, first two rows of 50, then four half slabs of guncotton laid touching each other down the centre, so that the guncotton was in contact with the shells, then two more rows of 50 rounds each, the whole being tamped with six sandbags and stones, and on the top of everything a large bundle of wire netting about 10′ long and 4′ in diameter, used for blasting purposes.

Result.—The result was very successful ; on the rocky bed of the donga where the explosion took place, nothing was to be seen.

Some minute portions of cartridge cases, found in the vicinity, pointed to the complete detonation of the cordite, while the absence of any shells indicated that the object in view had been obtained *i.e.* the breaking up of the "shell ends" of the ammunition.



PLAN. (*at level of Guncotton*).



ELEVATION.

This method, though altogether successful, was very expensive in guncotton, *i.e.* two slabs had only destroyed 200 rounds (necessitating, at the same rate, a very large number of slabs for the total amount awaiting destruction).

Experiment No. 3.—In the next experiment therefore the number of rows of ammunition was increased to six, with about 28 rounds in a row *i.e.* a total of two boxes. In addition two complete *unopened* boxes, were placed one each side of the pile (see *Photo* 1).

The charge of guncotton, two and a-half slabs in this case, was placed on the top of the rows, the whole being tamped with 10 sand-bags and a bundle of wire 10′ × 4′. The guncotton primer was placed in the centre slab with 5′ of safety fuze.

We watched the result from the shelter of a sangar on the top of a neighbouring kopje, about ¼ mile away.

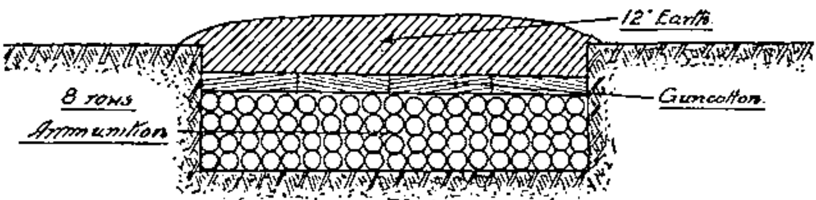
Result.—The result was a tremendous explosion. The coil of wire was carried aloft on the crest of a dense column of smoke to a height of about 200′—a fine spectacle! Shells however whistled in all directions and five distinct explosions took place, the most distant being some 500 yards from the scene of the charge. This was probably due to the two unopened boxes, which it was hoped would be destroyed in the general conflagration.

As in the previous experiment, nothing was to be found in the immediate vicinity of the charge, but several live shell heads, lying about among the rocks, showed plainly that the right solution had not yet been arrived at.

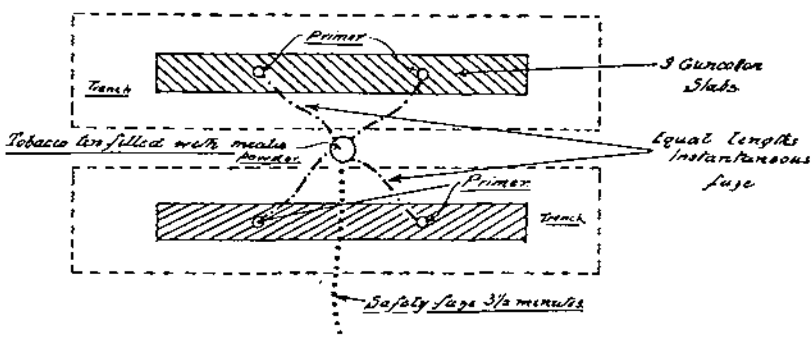
Experiment No. 4.—In this experiment we decided to discard the wire netting (which merely made aerial voyages and did nothing in the way of confining the splinters) and to place the ammunition in trenches, so as to localize the effect of the explosion and create a crater in which subsequent charges might be placed.

Two trenches were accordingly dug about 12″ apart (each being 15″ wide and 9′ long and about 2′ 6″ deep), in which eight rows of ammunition were stacked "nose to nose" as before.

The charge (per trench of 760 rounds) consisted of nine slabs of guncotton, cut in halves, and placed against the shell heads, the whole being tamped with 12″ earth. Nineteen boxes of ammunition, *i.e.*, 1,520 rounds altogether, were placed in the trenches.



Longitudinal Section thro' Trench



The above diagram shows arrangements for firing the charge.

Everything being prepared, we sent the natives to the shelter of a neighbouring farm, while we betook ourselves to our eyrie on the hill, (some 200′ above the donga and ¼ mile from the charge) where we had previously taken the precaution of providing some head cover of two sheets of corrugated iron over the sangar.

The explosion was very fine. I had just looked over the parapet and pressed the bulb of my camera, when a cry of "look out" reached me from my next-door companion. At the same time a shell burst on our right flank and a large splinter struck the roof of our shelter fairly in the middle, fortunately without penetrating the corrugated iron.

The air was alive with things whistling and rotating and obeying various centrifugal, centripetal and other compelling forces, but from our coign of vantage we only saw one other shell actually burst.

The owner of the neighbouring farm (about $\frac{1}{2}$ mile distant) told us afterwards, that he had seen five shells burst; one alighted on the roof of his stable (but did not penetrate) while the native boy inside nearly died of fright, thinking every moment was going to be his last. One unexploded round (cartridge case and shell) was found near the farm, giving some idea of the force of the explosion.

Result.—In the crater ($17' \times 14' \times 5'$ deep, which elicited many "waghs" of astonishment from the natives), a number of unexploded rounds were found, in some of which the shell had been driven $3''$ into the cartridge case without exploding. A certain number of unexploded shells were also to be seen lying about in the vicinity.

At this stage we gave up the problem of any efficient "*demolition*," or detonation of the ammunition. We had spent two long hot mornings, used up 23 slabs of guncotton, 7 primers, some 25′ of safety fuze, 16′ of instantaneous fuze, several sandbags, and we could only point, on the asset side, to some 1,968 rounds expended and certain amount of experience gained, and it was decided therefore to discontinue this method of destruction.

Accompanying *Photo 2* shows explosion No. 4.

DEMOLITION OF GIRDERS.

By MAJOR J. C. MATHESON, R.E.

THE present textbook gives directions how to calculate the charge of guncotton required to demolish a girder, and extensive trials have proved their correctness. They involve, however, the measurement of the section of the girder, and it is not difficult to conceive of cases when this would be a dangerous or even an impossible task, to say nothing of the time it would always take to do. On active service bridges may, and will, have to be destroyed by night and in as short a time as possible. In all probability no calculations would be done in such a case, the officer carrying out the demolition would on arrival at the bridge hastily glance at it, guess at the charge and then add a large percentage of explosive in order to avoid failure.

But it may be necessary to study economy of explosives, and in any case it would certainly ease the mind of the aforesaid officer before the explosion, if there were some simple *expression for* the charge which required the minimum of measurement and arithmetic.

According to the textbook directions, the charge required depends upon the breadth and thickness of the various parts which go to make up the girder. But *the section of the* girder according to type depends upon the span, the depth, and the load it has to carry. Therefore the charge should be some function of these factors. The general form of this expression has been found to be

$$\text{charge} = \frac{LW}{kD} \qquad \text{(1)}$$

where L = span of girder in feet
W = breaking weight in tons
D = depth in feet
k = a coefficient.

In almost every case L and D can easily be measured, or a fairly accurate approximation to them can be made. The coefficient k depends upon the type of girder, and values can be obtained for it by equating to the charge, as worked out by the textbook method, once the breaking weight is known. This latter however cannot be determined by inspection and it is impossible to give a value which will include all cases, but, by making certain assumptions, it is possible to give a value to W which will include a fair range of the ordinary type of girder bridges, and the expression (1) will then give results of sufficient accuracy. It must always be remembered that we are not dealing with an exact science, what is aimed at is to arrive at a charge which will cut the girder with certainty and without undue expenditure of guncotton.

Girder bridges are met with mostly on railways, and one of the most usual types is the plate girder for small spans.

To obtain the required expression for girders of this type the following are the assumed data :—

Spans, from 20′ to 80′ of 4′ 8½″ gauge.
Load, 2·67 tons per foot-run of single line.
Factor of safety, 8.
Charge, expressed in service slabs of guncotton ("guncotton, wet, slabs, field, 15-oz."), including the allowance of 50 per cent. for the presence of the enemy.

On the above assumptions the general expression (1) becomes

$$\frac{L^2}{15D} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

This will give the charge necessary for each of the two girders and it must be placed near an abutment, being divided up and fixed to the girder in the manner described in the textbook.

Where one girder has to bear the whole load of a line of railway, *e.g.* two girders carrying a double line, or a central girder carrying half of two single lines, the amount given by expression (2) should be doubled. This will however give rather more than the necessary charge.

For spans between 80′ and 200′, fairly accurate results are obtained from the expression

$$\frac{L^2}{24D} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Expressions (2) and (3) are primarily intended for plate girders but they may also be used for lattice and box girders with a fair amount of accuracy, the results given being generally more than the textbook charge.

The accuracy of these expressions may be judged from the following table which gives instances of existing bridges or of girders of requisite strength taken from catalogues :—

Girder.	Span in feet.	Textbook Charge in Slabs + 50 per cent.	$\frac{L^2}{15D}$ or $\frac{L^2}{24D}$ according to span, doubled if necessary.	Remarks.
Plate. Single line ...	30	21	20	Example M.E. Part IV.
" " ...	24	18	16	From Dorman Long's Catalogue. Depths of girders vary.
" " ...	28	18	18	
" " ...	30	26	24	
" " ...	32	23	23	
" " ...	40	30	27	
" " ...	40	21	21	S.E.C. Railway.
" Centre of two lines	40	40	42	
" Double line ..	46	45	62	"
" Single line ...	56	42	42	"
" " ...	170	84	81	S.E.C. Railway, Medway bridge.
" Centre of two lines	170	140	160	
" Single line ...	100	55	53	C.P. Railway.
" " ...	55	35	36	Caledonian Ry.
Lattice. Single line ...	50	18	21	From Bridge Manual.
" Double line ...	120	83	80	S.E.C. Railway, Medway bridge.
" " ...	144	91	115	
" " ...	171	102	162	
Box. Single line ...	28	17	21	From Dorman Long's Catalogue.
" " ..	46	31	36	
" " ...	56	49	53	

For railways of other than standard gauge the charge will vary in proportion to the gauge.

The application of an expression of this kind to girder road bridges is a more difficult task on account of the varying loads which these bridges are built to carry. For first-class road bridges, up to 50′ span, carrying such traffic as traction engines, the following expression may not be very far wrong :—

$$\frac{BL^2}{160 \times nD} \dots\dots\dots\dots\dots\dots\dots\dots (4)$$

where B = breadth of bridge in feet
L = span in feet
n = number of girders
D = depth of girders in feet.

It is true that this expression requires some arithmetic in working, but the measurements can all be taken very quickly. The results given by (4) in the case of three bridges were :—

(*a*).	Textbook	charge	19	slabs,	expression	27.
(*b*).	,,	,,	32	,,	,,	30.
(*c*).	,,	,,	11	,,	,,	14.

As it has been somewhat difficult to find examples of this type of bridge which permitted of proper measurement, possibly some officers in other places may find time and opportunity to check the accuracy of the expression.

SOME RECENT DEVELOPMENTS IN THE DESIGN AND CONSTRUCTION OF EARTHEN DAMS.

By CAPT. A. FF. GARRETT, R.E.

CONSIDERABLE attention has been devoted in India during the past 10 or 15 years to the theory and construction of earthen dams for impounding reservoirs, and it seems desirable to put on record the experience gained, especially as no comprehensive account of recent developments appears to have yet been published. Earthen dams have been built in India by the thousand from time immemorial. There are said to be over 40,000 in the Central Provinces alone, and there are countless numbers in the Madras Presidency, and many more in Rajputana and Bombay. Most of these are small village tanks with catchment areas of a few acres only, but on the other hand there are several native dams of quite large dimensions, holding up sometimes as much as 3 or 4 square miles of water. The large majority of these native tanks have been built for purposes of storing the monsoon rainfall for irrigation; many of the smaller ones are used as sources of water supply for drinking purposes by the villages near to which they are situated, whilst a few of the larger ones in Rajputana seem to have been constructed chiefly as pleasure lakes by rajas of a bygone day. There is little or nothing to be gained by a study of these native tanks. There is no evidence of scientific design. The cross sections of the dams of the larger and successful works are usually exceedingly heavy, while numbers of the smaller works are breached every year. It is, however, only comparatively lately that earthen dam construction has been taken up on a considerable scale by Government, and the subject scientifically studied. Two important principles, profoundly affecting the design of earthen dams and reservoirs, have recently been enquired into. The first of these is the investigation of the line of hydraulic saturation in a dam, and the second is the evolution of formulæ to allow, in calculating the waste weir, for the temporary storage of flood water between the full supply level of tank and the high flood level. The first affords for the first time a criterion by which the sufficiency of the cross section of an earthen dam may be judged, while the second has led to a far more correct appreciation of the true principles on which the waste weir should be designed, and has resulted in the saving of large sums of money.

In this paper it is proposed to deal with :—

I. The design of the cross section of an earthen dam, giving examples of successful practice in India, and a brief account of the recent experiments on the line of hydraulic saturation.

II. The design of the waste weir with an account of the recent flood storage formulæ.

III. Other miscellaneous matters in connection with the subject.

I.—THE DESIGN OF AN EARTHEN DAM.

An earthen dam may fail in four ways :—

(1). The earth may be cut away, or scoured by wave action, and the dam breached.

(2). An excessively high flood may cause the water level to rise over the top of the embankment.

(3). Water may percolate through a hole in the bank, and gradually enlarge the passage until the work fails.

(4). The earth work of the dam may slip, or it may subside or settle down.

Failures under (1) are prevented by protecting the inner slope. The cheapest method is usually to provide dry stone pitching from 9" to 12" thick, but, on a well-consolidated bank, concrete is sometimes used. The latter practice is, however, somewhat risky as any slight settlement in the bank will cause bad cracks in the concrete. For low banks, branches of trees well pegged down afford a good though temporary protection. In the case of small works, where the prevailing winds blow away from the dam and the earth is fairly good, no protection at all may be necessary.

In laying pitching certain precautions are necessary. If the dam will be exposed to strong winds blowing over a considerable area of the impounded water, waves will be generated which will tend to wash out the earth between the joints of the pitching, which will then subside and may cause a failure of the work. It is therefore most necessary that the joints of the pitching should be kept as close as possible, especially at the under side where the stones rest on the earthwork. If, as is often the case, the stone be of such a character as not to admit of close joints being easily made by a simple hammer dressing, it is advisable to lay down a 3" or 4" layer of coarse gravel or stone chips between the earthwork and the pitching. If the earth tends to be washed out by wave action, the dam will give constant trouble, and it is well worth while to spend a little more money to begin with to avoid all risk of such difficulties afterwards. The pitching may be left quite rough on the face. This may not look very neat, but it tends to break up waves, and is therefore rather an advantage than otherwise.

Failures under (2) can of course only occur from inadequate waste weir provision, or a bad subsidence of the earthwork.

Failures under (3) are not very uncommon. Holes may be left in the bank owing to faulty supervision during construction. If large clods are allowed in a bank, there will be interstices through which water may percolate and so cause failure. An instance of this came under the writer's notice about three years ago. The bank about 35′ high had been somewhat hurriedly constructed during the hot dry weather. The earth was a clayey loam and had been baked excessively hard by the Indian sun, and the labour of breaking clods was therefore heavy. In fact it was almost impossible to secure thorough consolidation even by repeated rolling. On the bursting of the monsoon the reservoir filled up to about 10′, and the work then failed from percolation. It was stated that the water could be actually heard gurgling through the bank. An examination of the cross section of the dam subsequently showed that although there were very few clods over the specified size of 3″, yet there were numerous interstices between the smaller clods. Holes may also be formed in the bank by the burrowing of rats and other animals, or by the decaying of roots of trees. For this reason trees are not allowed to grow on the banks. If the bank is built of a clayey soil, large cracks may be found in hot dry weather through which water may percolate and cause failure. For this reason some authorities—*e.g.* Fanning—object to puddle altogether in the embankment, and prefer a mixture of clay, sand and fine gravel. Yet another way in which percolation may occur is by creeping along the junctions of earthwork and masonry. At these places it is necessary to take the usual precaution—to leave the back of the masonry as rough as possible, and to ram the earth tightly against it—and to provide staunching or creep walls at intervals.

The consolidation of the earth is a most important matter. In English practice it is usual to rely entirely on the puddle core to prevent percolation, and no special precautions are taken about the consolidation of the rest of the earthwork. Where puddle of as excellent a quality as is obtained in England is available, this method gives very good results, but in other parts of the world it often happens that no such first-class puddle clay can be obtained, and it thus becomes necessary to provide not merely a puddle core, but a substantial hearting of the best clayey material available. Also in tropical countries there is a risk of a puddle core becoming dry and cracking, and it is therefore better to provide a more massive *hearting* of a somewhat less clayey material, and to restrict the use of puddle to portions of work lying below the ground where moisture will be better retained. In parts of India the system has been tried of constructing the whole dam of clay, but recent experience has shown that this is a great mistake as will be mentioned below. Assuming then that a substantial hearting of clay is to be adopted, the object is to secure as thorough a consolidation as possible into one homogeneous mass. It is usually specified that no clods over a certain size, say 3″, are to be allowed in the bank, that the earth is to be laid in 6″ layers sloping slightly inwards, and that each layer is to be thoroughly rolled or rammed until well consolidated. It is a disputed point as to whether it is desirable to water the earthwork or not. On the one hand it is claimed that wetting the earth softens it and secures better union between clod and clod, while some authorities state that, as earth expands when wetted, it is much better to construct the bank dry, so that, when it is eventually wetted by rain or by the filling of the reservoir, the earth will expand and a much more solid bank will be obtained than if it were originally constructed of damp earth. For low dams, not holding up more than 25′ of water, experience shows that watering is usually unnecessary, but the whole matter is merely one of proper consolidation and prevention of percolation. No interstices must be left through which water can percolate. This condition can be secured either by thorough rolling when the earth is in a damp and plastic condition, or by breaking up the earth into small lumps not exceeding 1″ in diameter and rolling dry. It has even been proposed to lay puddle in the form of dry powdered clay well rammed. This would probably be very effective, and would form a very dense and compact mass of clay when wetted, but the expense of so finely dividing the dry clay before laying would generally be heavy. The consolidation must be frequently tested during construction by digging into and examining the newly-erected earth, and that amount of watering and clod breaking carried out, which actual experience of the particular earth being used shows to give the best consolidation. It is dangerous to use a very clayey earth dry, as such material forms hard lumps which it is almost impossible to consolidate even by heavy rolling. On the other hand a more loamy earth, even when dry, is more or less friable, and can often be closely consolidated by rolling. In any case it is not advisable to raise the bank more than about 30′ in one year, so as to allow the rain to penetrate the whole bank, and so help to consolidate the lower portions of the work before raising the dam to the full height. It is stated that better consolidation can be obtained by driving laden carts over the earthwork than by ordinary rolling, and an American writer recommends that diagonal bands be fixed on the rollers. A 6 or 8-ton steam roller is very useful for large banks. Too much care cannot be taken in the proper consolidation of the lower layers of a big earth dam, and numerous are the failures which have occurred from percolation. All earthen banks settle more or less when the reservoir fills with water, however much care may be taken over the consolidation, and it is necessary to allow for this during construction by making up the bank to a higher level ; an allowance of 1" to $1\frac{1}{2}$" per foot of height is usually sufficient.

Failures under (4), due to slips, require more detailed examination, and it is along these lines that recent investigations have been made. Long practical experience has shown that a section under certain dimensions is liable to slip, and most of the textbooks lay down that the front or water slope should be about 3 to 1, and the back or outer slope 2 to 1.

The top width, they state, should be 6′ for a small dam, up to 10′, 12′ or 15′ for larger works. In all earth banks, a danger to be guarded against is a slip of the earthwork, and as the angle of repose of wet earth is less than that of dry earth, it has been the usual practice to make the inner slope, which is necessarily saturated when the reservoir is full, flatter than the outer slope. It has, however, been recognized that for high earth dams, to hold up say over 25′ of water, this section is inadequate, and either horizontal berms have been added on the back slope, or the slope itself has been flattened in an arbitrary manner, see *Fig.* 1, which is taken from Colonel Scott-Moncrieff's *Water Supply of Barracks and Cantonments.* Recently, however, a considerable advance has been made. Mr. Hill, Chief Engineer in the Bombay Presidency, took up the investigation of a number of slips which had occurred on the back slopes of several reservoirs in the Bombay Presidency, and the results of his enquiries are to be found in paper No. 17 of the Irrigation Conference, Simla, 1904, and also in a Bombay technical paper published by him in 1909.

The method of investigation adopted was to sink a series of pipes along a cross section of the dam, and then ascertain the height to which water rose in these pipes. It is evident that below the water level in the pipes, the earthwork in the dam must be completely saturated. Joining the water level in the various pipes by a line, the line of hydraulic saturation in any given dam is obtained. In *Fig.* 2, which is a cross section of the Mukti tank dam, the position of six such pipes is shown, and the line of hydraulic saturation is shown in a thick chain-dotted line. The straight line joining the maximum water level inside the dam with the outer toe of the dam, is the "hydraulic gradient" and can be easily followed. Mr. Hill found that in all cases where slips occurred the hydraulic gradient was steeper than 1 in 4. When it was flatter than 1 in 4 there were no slips.

Mr. Hill gives the following list of reservoirs in which slips have been observed :—

Name of Work.	Depth of Water below Crest.	Hydraulic Gradient.
Waghad	83	2·7 to 1
Nhasvad	67	3 „ 1
Nehr	60	3·00 „ 1
Ekruk	58	3·48 „ 1
Ashti	50	3·09 „ 1
Bhadalvaldi	44	3·50 „ 1
Shirsuphal	43	2·70 „ 1
Pashan	40	3·4 „ 1
—	43	3·1 „ 1
Matoba	39	3·4 „ 1

Of these, the first five slipped badly while the last five slipped at the outer toe. Mr. Hill continues "The slips at these banks seem to show that the limiting height for safety for the cross section adopted had been decidedly exceeded for the banks with 50′ depth or over, and just passed for depth of about 40′. When suitable berms are added at the rear of these 40′ depth banks, the slipping is stopped. The addition of the berms reduces the hydraulic gradient to about 1 in 4. In addition to this Indian experience, valuable information is available in the report of the Board of Engineers in America appointed to consider the proposal that part of the Croton Dam should be of earthwork. The Board took observations of the saturation of the earth of six earthen dams from 50′ to 90′ total height and found as follows :—

That the embankments were always completely saturated as far as the puddle wall; that moisture passed through the puddle wall with a loss of head of about 10′; that the line of saturation to the rear of the puddle wall varied with the material; when watertight the slope was 35 per cent., or about 3 to 1, and, where very porous, 10 per cent. or 10 to 1. They deduce from their observations that, with carefully selected material, a drop of 17 per cent. of the head in the reservoir may be expected at the puddle wall, and a slope saturation of 23 per cent., or 5 to 1 in the rear of the bank."

Mr. Hill's final conclusion is that it is not safe to construct a high earthen dam of clayey materials alone, but the full significance of the results of his investigations seems to be hardly yet appreciated. In the table below, ten of the principal Bombay tanks have been arranged in order of their clayeyness—so to speak. Thus the dams of the first five tanks consist entirely of clay. The hydraulic gradient varies from 5 to 1 to 2·7 to 1. It will be seen that all these banks slipped except No. 3, in which the hydraulic gradient was 5 to 1. The case of No. 5 is interesting, as the water level was gradually

Number.	Name of Dam.	Nature of Bank.	Front Slope.	Rear Slope.	Depth below Weir Crest.	Hydraulic Gradient.	Remarks.
1	Waghad ..	Entirely clay, bank all like good puddle.	—	—	83	2·7 to 1	Slipped badly, extensive repairs with large masses of dry stone drains were executed.
2	Nehr........	Entirely clay	3 to 1	2 to 1	60	3 „ 1	Slipped badly and a berm was added.
3	Wadshivne	Entirely clay mixture, 2 black soil and 1 moorum in centre, 1 moorum and 1½ black soil in casing.	3 „ 1	2 „ 1	39	5 „ 1	Has apparently given no trouble.
4	Matoba......	Uniform clay........................	3 „ 1	1½ „ 1	39	3·4 „ 1	Slipped slightly at the outer toe.
5	Pashan	Mostly clay with puddle wall......	3 „ 1	2 „ 1	40	3·4 „ 1	Depth stored was increased until a slip occurred in downstream toe, which was then strengthened.
6	Mhaswad ...	Selected clayey earth hearting—mixture of earth and casing.	3 „ 1	2 „ 1	67	3 „ 1	Slipped badly.
7	Mayni	Selected earth and moorum on well-drained moorum foundations.	3 „ 1	2 „ 1	42	5 „ 1	— —
8	Unkal	Upper side and hearting of clay downstream side good drainage material.	3 „ 1	2 „ 1	42	3·5 „ 1	Constructed in 1893 and has given no trouble.
9	Mukti	Selected earth hearting slopes 1 to 1 moorum outside.	2½ „ 1	2·13 to 1	55	2·8 „ 1	One of the best banks in the Deccan and has never given trouble.
10	Parsul	Retentive clay hearting slope 1½ to 1 moorum outside. Dry stone drain extending well into bank.	3 „ 1	2 to 1	53	3 „ 1	Has given no trouble—drainage is very complete.

raised until a slip occurred, with a hydraulic gradient of 3·4 to 1. This is, however, not a very high dam, the maximum depth of water being only 40′. It is therefore quite clear, as pointed out by Mr. Hill, that it will not be safe to construct any high dam entirely of clayey material, unless the hydraulic gradient is at least 4 to 1. But an examination of the statistics for tanks Nos. 8, 9 and 10 shows that with porous backing and effective drainage arrangements, high dams may be safely built with hydraulic gradients as steep as, or even steeper than, 3 to 1. The case of No. 9 is particularly striking. The bank consists of a selected clayey earth hearting with 1 to 1 slopes, and moorum outside (moorum is a very porous red gravelly earth). This dam is said to be "one of the best banks in the Deccan and has never given trouble." Yet the hydraulic gradient is only 2·8 to 1. A cross section of this dam is given in *Fig.* 2. An examination of the line of saturation shows at once the reason why this dam has stood so satisfactorily. It will be seen that half-way down the back slope there is over 30′ of dry moorum above the line of saturation. It is evident that this will be more than ample to check any tendency to slip on the part of the selected hearting. The line of saturation starting from the water level dips rapidly down through the inside moorum slope, till it reaches the clay hearting, when it flattens to about 1 in 5, but directly it gets through the hearting, it dips suddenly down at an angle of about 45° to within 10′ of the original ground line, and then runs out at about 1 in 6 to the outer toe of the dam. Compare this with *Fig.* 3 in which the line of saturation in the Matoba dams, a typical all-clay bank, is given. Instead of 30′ of dry moorum, there are 10′ of clay only to prevent slipping. Yet the hydraulic gradient of this dam is flatter than in the case of the Mukti tank. *Fig.* 4 shows the line of saturation of the Parsul dam, No. 10 in above table. This has been a very successful dam holding up 53′ of water with a hydraulic gradient of only 3 to 1. In this case very complete drainage is afforded by the heavy dry stone foundation under the outer toe, thus securing 24′ of dry material to prevent the hearting slipping. Thus instead of a 4 to 1 hydraulic gradient being necessary to secure safety, it is seen that the two most successful works investigated in Bombay have gradients of only 3 to 1 and 2·8 to 1, and that the safety of an earthen dam depends, not so much on the actual slope of the hydraulic gradient, as on the depth of dry material which can be secured in the back slope of the dam above the line of saturation.

The principles on which an earthen dam should be designed are then as follows :—

1. The inner slope should be such that there will be no danger of slipping when it is saturated.

2. The earth between the inner slope and the hearting should be preferably of porous material, so as to admit water freely to the clay hearting and keep the latter wet, and thus reduce the tendency of the hearting to become dry and cracking.
3. In the centre of the dam should be a clay or puddle hearting of sufficient thickness to render the work more or less watertight.
4. As this clay hearting will never be quite watertight, it is necessary to drain the back of the hearting as thoroughly as possible, and to support it with a heavy backing.
5. This backing must be sufficiently massive to prevent all danger of slips.
6. The change in the nature of the various kinds of material used must not be too sudden, as this might tend to cause cracks under variation of temperature and moisture. Thus the clayey hearting should gradually change to porous backing—gravel should not butt straight up against clay.

The recent orders of the Government of India with regard to earth dams are to assume the line of saturation at 1 in 4, and to provide at least 8′ of dry earth over this. This will nearly always ensure a safe section whatever material the bank may be made of, but, as shown above, it is possible to obtain a much steeper line of saturation than 1 in 4 with perfect safety. It is impossible to give a type suitable for every case, but, judging from the results obtained in Bombay, the section given in *Fig.* 5 would appear to be perfectly safe for heads of water up to 50′ and very economical, and it will be seen that the section in *Fig.* 5 satisfies the above-mentioned six principles. *But suitable materials must be available for construction.* The most porous material in the dam should be a layer immediately behind the hearting, so as to take the line of saturation down to ground level as quickly as possible. Behind this layer any kind of non-slipping material may be used. Probably gravel, or some heavy material, is best. A dry stone toe is a great advantage in securing thorough and effective drainage and in preventing slips. But, as has been pointed out by Mr. Hill, there is danger of such stone toes becoming filled with wet earth forced into them by the pressure of the superincumbent bank. This can be prevented by arranging a layer of fine ballast between the earth and the stone toe.

In *Fig.* 5 the hydraulic gradient works out at 1 in 3·4. The line of saturation has been drawn in in a similar manner to that actually observed in the case of the Mukti tank (see *Fig.* 2), and there is no doubt that the actual line of saturation will approximate to this, *provided that suitable porous material is used* in the dam between the hearting and backing. There is a maximum depth of 28′ dry earth, and a minimum of 10′ over this line of saturation.

For heads of water of more than 50′, it would be desirable to flatten out the lower part of the back slope so as to secure 15′ to 20′ of dry earth or gravel as a minimum over the line of saturation.

In the case of porous non-slipping material not being available for the backing, the hydraulic gradient must be made flatter. For anything except a very clayey backing the Government of India rule of 8′ of dry earth over a 4 to 1 gradient should be perfectly safe, but for a pure clay dam even this might slip, and a flatter gradient have to be adopted.

As an example of a high earth dam, a cross section of proposed Tendula dam is given in *Fig.* 6. The maximum height is 109′, and 24′ of loose sand have to be removed from the bed of the river which is to be dammed. A quantity of loose stone will be available and this will be utilized to provide heavy stone toes. For a dam of this magnitude, the Government of India have assumed a line of saturation at 1 in 4, and a minimum of 10′ dry earth over it, with the extra precaution of the stone toe. The inner slope will be $2\frac{1}{4}$ to 1 only, but it will be heavily pitched with 12″ and 18″ stones, and it is not considered that there will be any risk of a slip. The construction of this work is just beginning.

It is interesting to note that in the typical high earthen dam as constructed in Europe, the line of saturation assumed at 1 in 4 passes well within the outer slope, in fact is more or less parallel to it. Thus see *Fig.* 1 in which the line of saturation has been drawn. Thus the result of Mr. Hill's observations is to prove the correctness of the principles on which European engineers have been designing earth dams, though these principles were not worked out by them on any experimental data, but were merely arrived at by empirical rules based on long practical experience.

II.—Design of the Waste Weir.

In every reservoir scheme, whether for waterworks, for irrigation, or for any other purpose, the provision of a waste weir to discharge safely surplus water is a prime necessity. A failure of the waste weir, or an inadequate discharging capacity, means a failure of the whole work, the loss of enormous sums of money and possibly of human life, to say nothing of the extreme inconvenience that is caused by a stoppage of the usual water supply. In temperate climates where the rainfall is moderate, and where accurate statistics are available for a long series of years, the design of the waste weir presents but little difficulty, and empirical rules based on past experience will usually give satisfactory dimensions. Such rules will be found in the standard books on waterworks engineering, where it is generally stated that it is advisable to limit the depth of flood water flowing over the crest of the weir to 2′ or 3′, and to allow a length of so many feet of weir per acre of catchment area. As full information can be obtained from these books, it is not proposed to further examine such cases here, but a little consideration of any particular case will show that the matter must be much more thoroughly gone into when the reservoir is to be built in a country subject to tropical rainfall, which may come in sudden bursts of 4″ per hour or even more, giving rise to sudden floods of very high intensity.

It is evident that the discharging power of the waste weir must depend upon the maximum flood which is likely to come into the reservoir, but it is a great mistake to make it equal to the estimated maximum flood discharge, though this has often been done, and large sums of money squandered in providing excessively long weirs. In the first place a lake or reservoir, formed by damming a river, acts as a regulator, and will have the effect of converting a short flood of high intensity into a prolonged flood of lower intensity. Thus take the case of the Lake of Lucerne. This is fed by a number of mountain streams while it is drained by the river Reuss, which flows out of the lake at the Lucerne end. During heavy rains, the hill torrents come down in floods of great intensity, but owing to the large area of the lake, its level is only raised a few inches, and the discharge of the Reuss only slightly increased. But on the other hand this increased discharge of the Reuss continues for many days after the hill torrents have resumed their normal dimensions. Exactly the same thing occurs in the case of an artificial reservoir, and the larger the water-spread area of the reservoir, the less will be the ratio of the maximum discharge over the waste weir to the maximum flood inflow. In fact in order to arrive at a reliable waste weir formula, it is necessary to take into account :—

(i.). The maximum flood discharge expected to flow into the reservoir.

(ii.). The length of time during which such a flood may be expected to persist.

(iii.). The water-spread area of the reservoir when full.

The maximum flood influx can be estimated by a consideration of the catchment area and rainfall records, by methods fully described in the textbooks, or, what is much more satisfactory, by looking up the gauge records of the river it is proposed to dam, where such records are available for a sufficiently long period. The length of time during which the maximum flood may be expected to persist must be arrived at by consulting the rainfall records and by general knowledge of the district concerned. When these figures have been fixed, the following formula can be applied :—

$$B = \frac{Ti}{2hA}, \quad l = \frac{ni}{ch^{\frac{3}{2}}}.$$

When i=maximum estimated flood influx into the reservoir in cubic feet per second.

T=time in seconds during which such a flood may be expected to persist.

h=rise in the water level of the reservoir due to the flood i persisting for time T, or what is the same thing, the maximum depth of water which it is intended to allow to flow over the waste weir, or the difference between full supply and high flood level.

A=the area of the water spread of the reservoir in square feet, when the water level is midway between full supply and high flood level.

l=length of weir required in feet.

c=coefficient depending on the form of the weir. The value of c can be obtained from any textbook on hydraulics. For a sharp-crested weir with a free overfall c=3·25.

B and n are quantities connected by a somewhat complex relation. Having found B, from the first equation, the corresponding value of n is obtained from the table below for calculating l by the second equation $l = \frac{ni}{ch^{\frac{3}{2}}}$. The proof of these formulæ is rather long, but it is given in the appendix.

As an example of the use of these formulæ, which were worked out by the writer in 1906 and are now used for calculating the lengths of all waste weirs for storage works in the Central Provinces, the maximum flood influx i, is calculated by Dicken's formula $i = cM^{\frac{3}{4}}$, where c is a coefficient, taken as 1,400 for Central Provinces, and M is the catchment area in square miles. It is assumed that this maximum flood will only persist for three hours. But it is also usual to calculate the weir for a prolonged flood of less intensity, viz. :—a flood due to a steady run off of $\frac{1}{2}''$ depth of water per hour from the whole catchment area persisting for 24 hours. These are of course high figures, which would only apply to countries subject to tropical rainfall. But as regards the Central Provinces the results have been very satisfactory. To take a concrete instance, the calculations for the waste weir for the Bardih reservoir may be quoted. The data are :—

TABLE.—VALUES OF B AND n.

FOR FLOOD STORAGE FORMULA.

B.	n.	Difference for ·001.	B.	n.	Difference for ·001.	B.	n.	Difference for ·001.
·50	·0	—	·80	·728	1·1	1·10	·908	·3
·51	·049	4·9	·81	·738	1·0	1·11	·911	·3
·52	·095	4·6	·82	·748	1·0	1·12	·914	·3
·53	·138	4·3	·83	·757	·9	1·13	·917	·3
·54	·178	4·0	·84	·766	·9	1·14	·920	·3
·55	·216	3·8	·85	·775	·9	1·15	·923	·3
·56	·252	3·6	·86	·783	·8	1·16	·925	·2
·57	·286	3·4	·87	·791	·8	1·17	·928	·3
·58	·318	3·2	·88	·799	·8	1·18	·930	·2
·59	·348	3·0	·89	·806	·7	1·19	·932	·2
·60	·377	2·9	·90	·813	·7	1·20	·934	·2
·61	·404	2·7	·91	·820	·7	1·21	·936	·2
·62	·429	2·5	·92	·826	·6	1·22	·938	·2
·63	·454	2·5	·93	·833	·7	1·23	·940	·2
·64	·477	2·3	·94	·839	·6	1·24	·942	·2
·65	·499	2·2	·95	·844	·5	1·25	·944	·2
·66	·520	2·1	·96	·850	·6	1·26	·946	·2
·67	·540	2·0	·97	·855	·5	1·27	·948	·2
·68	·559	1·9	·98	·860	·5	1·28	·950	·2
·69	·577	1·8	·99	·865	·5	1·29	·952	·2
·70	·594	1·7	1·00	·870	·5	1·30	·954	·2
·71	·610	1·6	1·01	·875	·5	1·35	·960	
·72	·626	1·6	1·02	·879	·4	1·40	·965	
·73	·641	1·5	1·03	·883	·4	1·45	·970	
·74	·655	1·4	1·04	·887	·4	1·50	·974	
·75	·669	1·4	1·05	·891	·4	1·55	·978	
·76	·682	1·3	1·06	·894	·3	1·60	·981	
·77	·694	1·2	1·07	·898	·4	1·80	·990	
·78	·706	1·2	1·08	·901	·3	Infinite	1·000	
·79	·717	1·1	1·09	·905	·4	—	—	

$$\left.\begin{array}{lr}\text{Full supply level} \quad \ldots \quad \ldots & 103 \\ \text{High flood level} \quad \ldots \quad \ldots & 106\end{array}\right\} h=3$$

Area of water spread at mean of these levels, or at 104·5, 38,400,000 square feet.

Catchment area M = 8 square miles.

Then i = 1,400, $M^{\frac{3}{4}}$ = 6,664 cubic feet per second, so that

$$B = \frac{Ti}{2hA} = \frac{3 \times 60 \times 60 \times 6664}{2 \times 3 \times 38{,}400{,}000} = \cdot 312.$$

Turning to the Table, it is seen that if B is less than ·5, n is zero or negative. This shows that theoretically no weir at all is required, or, in other words that a flood of 6,664 cubic feet per second persisting for three hours would not fill up the reservoir to 106 level, even if no weir at all were provided.

Now consider a prolonged flood caused by $\frac{1}{2}''$ run off per hour persisting for 24 hours. The intensity of this flood will be in cubic feet per second

$$\frac{\frac{1}{24} \times 5280 \times 5280 \times 8}{60 \times 60} = 2582.$$

Calculating B again, we get

$$B = \frac{Ti}{2hA} = \frac{24 \times 60 \times 60 \times 2582}{2 \times 3 \times 38,400,000} = \cdot 968.$$

Turning to the Table the corresponding value of n is found to be $\cdot 854$, so that

$$l = \frac{ni}{ch^{\frac{3}{2}}} = \frac{\cdot 854 \times 2582}{3\cdot 25 \times 3^{\frac{3}{2}}} = 130\cdot 6'.$$

A weir of this length will be more than sufficient to dispose of the maximum flood of 6,664 cubic feet per second for three hours. If, as has so often been done, the weir had been calculated of sufficient length to dispose of 6,664 cubic feet per second for an indefinite time, we should have

$$L = \frac{i}{ch^{\frac{3}{2}}} = \frac{6664}{3\cdot 25 \times 3^{\frac{3}{2}}} = 394',$$

which is more than three times the length actually required. Waste weirs are often very expensive to construct, and this example shows clearly what an excessive length with consequent waste of money may be given by the old method of calculation.

It will be noticed that if L denote the length of weir of actual discharging power equal to i, the estimated intensity of the maximum flood likely to flow into the reservoir, then nL will represent the length of weir actually required, or, what comes to the same thing, it will only be necessary to design the weir to discharge ni cubic feet per second instead of i cubic feet per second. Thus, if the weir is a drowned weir or if there is a velocity of approach or other complications, the appropriate formula may be used, and the length of the particular kind of weir required will be calculated by that formula taking the maximum discharge over the weir as ni cubic feet per second.

It will be found in practice that, except for small catchment areas, or in cases where the water-spread area of the tank is comparatively small, the prolonged flood requires a longer weir than the maximum 3-hour spate. It is therefore best to calculate the weir first for the 24 hours' flood, and then check for the 3-hour flood. In using these formulæ, the difficulty is to fix the values of T and i. But if T be taken as 24 hours, then i, in the absence of more reliable local information, may be calculated from the equation

$$i = 37mpM^{\frac{3}{4}}.$$

Where m is the maximum rainfall in inches recorded during *two* consecutive days in the neighbourhood of the proposed work

p is the estimated percentage of run-off.
M is the catchment area in square miles.

In this formula p may be taken as $\frac{2}{3}$ for an ordinary catchment with moderate slopes and a certain amount of vegetation. It may be as high as 80 to 95 per cent. in the case of bare rocky catchments with steep slopes, and in sandy catchments it may be below 50 per cent. But as we are considering maximum rainfall, the percentage of run-off will be high—much higher than the average annual run-off—and not so variable for different kinds of catchments.

This formula for i has not yet been tried in practical work, but it gives results consistent with current practice in India, America and England, so that it will probably be useful as a guide in calculating a weir in a country where there is but little previous experience to go upon. Adopting this value of i, the length of weir can be calculated by the above formulæ, taking T as 86,400″, and the length of weir should then be again calculated for the maximum probable 3-hour flood (taking T as 10,800″) and the greater of the two lengths adopted.

In this manner the length of the weir crest may be determined, but the safe discharge of the surplus water down the tail channel into a natural water course often presents a problem of some difficulty. By the construction of the reservoir, the level of the water is raised several feet above its old level in the river, and it is generally necessary to safely lead the surplus back to its old level. This involves a drop of several feet, and, unless the surplus water can be discharged over a rock bar, it is necessary to construct masonry works or falls at convenient points in the tail channel, and to limit the velocity between these falls to about 6′ per second, which is the most that unprotected earthwork can stand. The position and detailed designs of these falls will vary with each particular case, and it is impossible to consider the matter exhaustively here. Generally speaking, however, the most economical arrangement is to make the fall at the weir crest as low as possible and then rapidly contract the channel below the weir, and consequently increase the depth of the water. This will considerably reduce the cost of the second fall. Thus to take the case of the Bardih reservoir alluded to above. At high flood we should have 3′ of water running over the crest of the weir in a stream 130·6′ wide. Suppose we have to drop the water 20′ so as to deliver into a natural water course that no rock bar is available to discharge over, and that having regard to the nature of the soil it is not desirable to increase the velocity in the tail channel beyond 6′ per second. The maximum discharge to be dealt with is mi or $\cdot 854 \times 2582 = 2205$ cubic feet per second. At 6′ per second a waterway of $\frac{2205}{6} = 367$ square feet is required, so that if the depth of water be increased from 3′ to 6′, it will be possible to contract the tail channel from 130·6′ to $\frac{367}{6}$ or 61′. It is nearly always cheaper to make a channel 61′ wide and 6′ deep than a channel 130·6′ wide and 3′ deep. Also by running 6′ deep it will be found that the length of any falls which may be required will be considerably less than 61′, and a very large saving in masonry will be effected. The bed slope of the tail channel must of course be calculated by the usual formulæ so as to give a velocity not exceeding 6′ per second, and the dimensions of the falls must be calculated by the usual text-book formulæ for discharges over weirs, etc.

III.—MISCELLANEOUS.

1. *Core and Face Walls.*—The general principles governing the design and construction of puddle cores are fully described in the textbooks, and a discussion of the method of substituting a selected earth hearting has been given above. But in many cases masonry core walls or face walls have been very successfully used. On the whole it would seem that a carefully constructed masonry wall is about as efficient as a puddle core as regards percolation, whereas in a hot dry climate it is safer and more permanent. It is, however, usually more costly. Masonry core walls have been largely employed in Rajputana, where the earth is generally sandy and good clay difficult to obtain. These masonry cores are placed in the centre of the dam, and carried down as far below ground level as may be considered necessary to secure watertight foundations. Being supported by earth on each side, they can be made quite thin. Thus for a wall 50′ high, a base thickness of about 4′ would be sufficient, and this might diminish by offsets to 2′ at the top. The same care should be taken in building these walls, as in the case of a masonry dam, to secure every joint being thoroughly and completely filled with mortar. The faces of the wall should be left as rough as possible and selected earth rammed tight against each face.

Face walls with an earth backing make very neat dams, but are rather costly. In such cases the section of the face walls must be worked out as a retaining wall to hold up the earth backing when the reservoir is empty. Many of the larger native dams in Rajputana have been built on this system.

2. *Watertightness of Reservoir.*—It is only possible to be quite certain that a proposed reservoir will be watertight, if a thorough geological examination of the basin is made and the existence of an impermeable stratum underlying the whole basin proved, and the foundations of the dam carried down well into this stratum. These conditions are usually obtained in the case of the more important European reservoirs, but are by no means always necessary to render a work a success. Large tracts of country frequently possess a more or less clayey subsoil. Dams constructed in such tracts with quite shallow foundations will frequently prove nearly watertight, or quite sufficiently so for all practical purposes. In the Central Provinces,

for instance, the puddle trench at any point is usually taken down to a depth of about half the height of the water which will eventually stand over that point when the reservoir is full. This procedure has given very satisfactory results. In more porous strata, however, the matter is more difficult to decide. Colonel S. L. Jacob, C.I.E., who has constructed about 150 earth dams in the very varying soils of Rajputana, states that, in the absence of geological assurance as to the existence of an impermeable stratum underlying the whole basin, it is impossible to make quite sure of any proposed reservoir being watertight, and that the risk of failure to hold water satisfactorily appears to be greater in hilly tracts than in the plains. In the hills there is often less soil, and fissured rock may be nearer the surface than in the plains. But, provided there is a good depth of soil which is not of an obviously porous nature, it is generally possible to construct a satisfactory reservoir in flat or gently undulating country without any very serious risk of undue leakage. On the other hand, in the neighbourhood of hills, even very deep core walls will sometimes be nearly useless. At the back of the Alwar city in Rajputana is an old native dam constructed of earth with a thick masonry face wall, but the reservoir has never held water satisfactorily. The reservoir frequently fills, but after a week the water is all absorbed, and the reservoir becomes quite empty. The site of the dam is in a gorge between two hills, and the subsoil in the gorge consists of boulders and clay. A trial pit was sunk just in front of the face wall to explore the foundation of the latter, and it was eventually discovered that the face wall was founded quite 70′ below the surface of the ground in the same boulders and clay. One would naturally have thought that 70′ of boulders and clay compacted by several feet of water standing over it for prolonged periods would eventually become watertight. Yet, as mentioned above, this tank failed to hold water even for a week.

3. *Sand Dams.*—Colonel S. L. Jacob has constructed two very remarkable sand dams in the Jaipur State of Rajputana. One of these is described in Colonel Scott-Moncrieff's *Water Supply of Barracks and Cantonments*, p. 77, but encouraged by the success of this work, Colonel Jacob built a far more ambitious dam on the same principle at Ramgarh, some 25 miles from Jaipur. The site is peculiar. The *nala* which is dammed flows through a narrow gorge with steep rock sides, and the place appears to be an ideal one for a masonry dam. Examination showed, however, that there would be great difficulty with the foundations, as the bed of the river was composed of loose sand to a great depth. About a quarter of a mile above the gorge the river flows past a sand hill, and Colonel Jacob conceived the bold idea of constructing a sand dam on sand foundations at this point. The work has proved most successful, and has been built for only about half of what the masonry dam in the gorge would have cost. The dam is constructed of pure sand resting on

sand. So loose is the sand that it has been found necessary to cover the whole of the back slope with stone pitching to prevent its being blown away by the hot weather winds. The dam is 80′ high and the greatest depth of water impounded up to date is 56′. There is a core wall of rammed "dhaminy" earth, that is sand mixed with clay or earth, carried up to the high-water line. This core is 8′ thick at the top and 22′ thick at the bottom. The inner slope of the dam is 4 to 1 and the outer slope 2 to 1. The hydraulic gradient at high-water level is about 1 in 5·5, but had the dam been turned round the other way, and the 4 to 1 slope placed downstream, the hydraulic gradient would be reduced to 1 in 9·5. There is of course a certain amount of leakage, but this is not a source of danger, as by an inverted filter bed arrangement at the outer toe all the leakage water comes through perfectly clear, and is unable to carry away in suspension particles of sand from the dam. All over the outer toe, and for some 10′ above it, is laid a layer of fine ballast, then another layer of coarser ballast, and finally a thick layer of stone pitching. This arrangement is quite effective. Two miles lower down a low stone weir has been built across the river, and this catches all the leakage, and diverts it down the canal which takes off just above the weir. This dam is probably quite unique. It has been in existence now for nine years, and has shown no sign of weakness.

There is a good deal to be said in favour of sand as a material for dams in cases where a certain amount of leakage is not of much consequence. Sand is easily consolidated so that no interstices are left, and, if an animal burrows a hole in the bank, this hole soon fills up again by loose sand falling in. Again sand is extremely cheap to dig and handle, and provided precautions are taken to prevent its being washed out at the outer toe by leakage, and the slopes are protected against scour and wind, the Jaipur experience shows that quite large dams can be successfully built of this material. One other precaution is necessary, and that is to introduce frequent creep walls at the junction of the sand with any masonry work. Water has a very pronounced tendency to flow along such junctions, and it appears almost as if the masonry had the effect of concentrating the flow in some way. The masonry must be thoroughly tied to the sand by frequent projections and offsets, so that the course of any water creeping along the face of the masonry may be as tortuous as possible. Similarly in the case of core or face walls in sandy soil, it is necessary to be very careful to project the ends well into the banks on either side. Many bunds have failed in Rajputana by percolation round the ends of the core walls. Of course no one would think of building a dam entirely of sand when suitable clay or earth is available. But there are many sites where little except sand can be obtained, and it is worth remembering that even with this apparently unfavourable material, successful reservoirs may be constructed.

APPENDIX.

PROOF OF FLOOD STORAGE FORMULÆ.

It is assumed that the reservoir is just full of water up to the crest of the weir when the maximum flood of i cubic feet per second begins to pour into the reservoir, and it is required to find what time must elapse before the water level will rise h feet up to high flood level.

Let y be the height in feet of the water surface above the crest of the weir at t seconds after the commencement of the flood.

A_y be the area of the surface of the water when the water level is y feet above the weir crest.

C_y be the quantity of water in cubic feet in the reservoir above the level of the weir crest, when the water level is y.

l = length of weir in feet.

Δ = discharge over the weir in cubic feet per second.

Then by the usual formulæ for weir discharges

$$\Delta = lcy^{\frac{3}{2}}$$

where c is a coefficient depending on the form of weir.

For a sharp-crested weir with a free overfall $c = 3{\cdot}25$ approximately. Hence we have the flood i pouring into the reservoir and an outflow over the weir of $lcy^{\frac{3}{2}}$. Hence the nett increase in the quantity of water in the reservoir is $i - lcy^{\frac{3}{2}}$ and evidently

$$\frac{dC_y}{dt} = i - lcy^{\frac{3}{2}}$$

But

$$\frac{dC_y}{dy} = A_y,$$

so that

$$\frac{dt}{dy} = \frac{A_y}{i - lcy^{\frac{3}{2}}}$$

and

$$t = \int \frac{A_y\,dy}{i - lcy^{\frac{3}{2}}}.$$

Now this integral will have to be taken between the limits $y = 0$ and $y = h$, where h is the maximum depth of water to be allowed on the weir crest. But h will be small compared with the the total depth of water in the reservoir, and hence without sensible error, we may replace A_y by its mean value A, A being taken as the mean of the areas of the surface of the water at full supply and high flood level respectively.

We then get

$$t = \int_0^h \frac{A\,dy}{i - lcy^{\frac{3}{2}}}$$

where A is constant.

The integration is rather troublesome, but may be performed by putting $\sqrt{y}=x$, $i/cl=a^3$, $x/a=z$, when it reduces to

$$t=\frac{2A}{acl}\int\frac{zdz}{1-z^3}$$

$$=\frac{2A}{acl}\left\{\frac{1}{6}\log\frac{1+z+z^2}{(1-z)^2}-\frac{1}{\sqrt{3}}\tan^{-1}\frac{2z+1}{\sqrt{3}}\right\}+\text{constant.}$$

To find the constant, we have $t=0$, when $y=0$, $x=0$ and $z=0$, so that

$$\text{constant}=\frac{1}{\sqrt{3}}\tan^{-1}\frac{2z+1}{\sqrt{3}}=\frac{\pi}{6\sqrt{3}}=\cdot 3023.$$

The integral has to be taken between the limits $y=h$ and $y=0$. When $y=h$, we have $z=x/a=\sqrt{h}/a$, so that $a=\sqrt{h}/z$, and $cl=i/a^3=iz^3/h^{\frac{3}{2}}$.

Therefore $$\frac{2A}{acl}=\frac{2Ah}{iz^2}.$$

Hence between the limits h and 0,

$$T=\frac{2Ah}{iz^2}\left\{\frac{1}{6}\log\frac{1+z+z^2}{(1-z)^2}-\frac{1}{\sqrt{3}}\tan^{-1}\frac{2z+1}{\sqrt{3}}+\cdot 3023\right\}.$$

For $$\frac{1}{z^2}\left\{\frac{1}{6}\log\frac{1+z+z^2}{(1-z)^2}-\frac{1}{\sqrt{3}}\tan^{-1}\frac{2z+1}{\sqrt{3}}+\cdot 3023\right\}$$
write B.

Then $$T=\frac{2ABh}{i}, \text{ and } B=\frac{Ti}{2Ah}.$$

Writing n for z^3, we have also

$$cl=ni/h^{\frac{3}{2}}, \text{ or } l=ni/h^{\frac{3}{2}}.$$

Hence we have the formulæ

$$B=\frac{Ti}{2Ah} \text{ and } l=\frac{ni}{Ch^{\frac{3}{2}}}$$

where B and n are connected by the relation indicated above. It will be seen that B is entirely a function of z, and therefore of n, so that it has been possible to construct a table giving the values of n for any value of B, and thus make these formulæ, though depending on a troublesome integration, extremely simple to use practically.

Ski-ing is now the national sport of Norway and has worked wonders in developing the physique and spirited self-reliance of the nation. The best Norwegian runners are at present unsurpassed.

In 1890 came Nansen's *First Crossing of Greenland*. This book, which contains a long and admirable account of the sport written in the language of an enthusiast, created a stir in mountaineering circles.

Mountaineering, originally introduced by our countrymen, had for some time been popular in Central Europe both amongst the Swiss, Germans and Austrians, but in winter the Alps were practically a sealed book; in the ski, however, climbers thought they had discovered something more serviceable, and experiment soon verified their expectations. Many Ski Clubs have since been formed all over the world, amongst them being the Ski Club of Great Britain founded in 1903 and the Scottish Ski Club in 1907. The former may be regarded as the M.C.C. of sport as far as Englishmen are concerned.

There now seems a likelihood that all the different associations of Europe will soon be united into one large body with one set of competition rules and regulations.

Uses of the Ski.

Civilian.—In the mountainous regions of temperate climates snow often makes communication from one valley to another difficult, if not impossible, unless the roads are kept open at great expense. Every house outside the villages is isolated, and much privation and suffering caused to those stricken with poverty or illness. Every village remains cut off from the rest of the world for weeks and months at a time owing to the deep snow covering the ground. Necessity has in some countries developed various patterns of snow shoes. These are unfortunately only of little help when the snow is soft and deep; their employment is laborious, especially on steep slopes. The ski, however, does not present the same inconvenience, consequently the rapidity with which it has been introduced into the mountains of Central Europe is not to be wondered at. The snow is now no longer an obstacle, nor are expeditions confined to the summer season.

Children go to school on ski in Switzerland and the skill they attain to is marvellous, while the mountain postmen are also provided with them and are becoming very expert.

Another application, entirely sporting, consists in being towed over the level by a horse, and is called skijoring, the skier holding the reins in one hand and the traces in the other, or the latter are fastened to his body—a more dangerous arrangement.

Military.—Most countries have adopted ski for troops stationed in the mountainous regions, especially the Alpine regiments of France and Italy, and the Swiss detachments on the St. Gothard. The Norwegians, Swedish, Russians, Germans and Austrians employ them for winter manœuvres, more especially for scouting. The only difficulty experienced is that of keeping the men together and under control, above all during the descents.

Owing to the initiative of the Swiss Officers' Society, courses of ski-ing were organised in 1904 for officers and N.C.O.'s of all arms in different parts of Switzerland, in particular at Zweisimmen, Gryon, St. Croix, Mont-Soleil, Simplon, Andermatt and St. Moritz. Since 1907 the Swiss Government has interested itself in these courses and have provided the necessary funds. The programme of these courses includes technical exercises, *i.e.*, in the use of ski and tactical exercises. These latter consist mainly of patrolling and scouting practices.

There is no finer exercise than ski-ing to develop the muscles or presence of mind. It is wonderfully bracing when combined with the glorious sunshine and clear fresh air of the mountains. Compared to skating, the apprenticeship served is shorter; while the skater is often confined to the same surface, sometimes very restricted, the skier has for his ground the plains, forests, hills, mountains and valleys, in fact almost any surface with snow.

Some Ski-ing Countries.

British Isles.—The opportunities for ski-ing in this country are far more frequent than most people imagine. The Welsh and Scottish mountains are often covered with snow for many weeks and even months at a time, and of lower lying ground, the Peak District in Derbyshire and the country around Sedbergh in Yorkshire may be mentioned. The Highlands of Scotland are very suitable for ski-ing and no one could desire a better country than that near towns like Kingussie, Newtonmore or Dalwhinnie, which are within a comfortable night's journey of London. The best month is probably February. Gamekeepers, shepherds, postmen, doctors, etc., who have to make journeys across the hills in all sorts of weather, are now beginning to appreciate and use ski on the Grampians also, and doubtless the custom will soon spread to other parts of the country.

The Ski Club of Great Britain, and the Scottish Ski Club, have admirable arrangements whereby members are supplied with information by telegram concerning the snow in almost any part of the country, and their year books contain very useful information about ski-ing at home. The address of the former club is 1, Great George Street, Westminster.

Norway.—The sport centres in the country round about Christiania, which is within a short two days' journey of England. The district is covered with pine forests and is undulating rather than mountainous in character. The big jumping competition takes place at Holmenkollen which is a hill within half-an-hour's journey of Christiania. The date fixed is usually the end of February or the beginning of March.

Christiania however suffers sometimes from a deficiency of snow, and even after a snowfall the snow is very soon beaten down by the large number of ski-runners crossing it. A visit up country to such places as Telemarken, Gudbrandsdalen and Oesterdalen should therefore be made. There are also vast plateaux lying above the tree level from which spring the higher mountains. All this upper ground is called fjaeld and should not be omitted. Fefer is a comfortable little place, and at Norsaater, near Lillehammer, and Mysusaeter, near Otta, rougher but cosy quarters are obtainable. Other places are the Hardanger Vidden and Bessheim in the Jotunheim Mountains. The best time of the year to go to the fjaelds is about the middle of March, as the days are then longer and good ski-ing is often to be had, close to the big glaciers, even in June!

Maps may be obtained at Christiania, but they are not very good; a compass is also essential.

The cost of living is small, running about 5s. 6d. to 8s. 6d. per day.

Sweden.—The country round Stockholm is, in general, too flat and not very suitable. There are, however, two admirable jumping hills. Skijoring is a favourite pastime with the Swedes, and other sports abound—such as skating, ice-sailing, etc.

The province of Jemtland, easily reached by train, is perhaps the best ski-ing resort in the country, and a good centre is Are on the line between Stockholm and Trondhjem. Storlien, further up the line, is also good, and expeditions may be made across the frontier into Norway and also to the Syl Mountains. The general character of the country is like the Norwegian fjaelds and the same remarks apply.

Germany.—The Feldberg, in the Black Forest, is perhaps the nearest certain ski-ing ground within easy reach of London. The ground is admirable, being mostly undulating, as in Norway, with plenty of long open hills and plenty of wood. There is a first-class jumping hill near the hotel. February is usually the best month.

The only drawback to the district is the fogs to which it is somewhat liable. The ordinary outfit, not forgetting maps and a good compass, is all that is necessary.

Switzerland.—The chief centres are Adelboden (4,450′) Chateau-d'Oex (3,500′), Arosa (4,720′), Davos (3,115′), Engelberg (3,355′), Grindelwald (3,500′), Wengen (4,200′), Montana (5,000′), St. Moritz (6,090′) and Villars (4,250′), to give an adequate description of which would fill a large volume. Prices run from about 10 francs a day upwards. The Swiss ground is in general steeper than that previously mentioned, and ordinary tours take the form of climbing some mountain or pass and running back to the hotel. January is the best month.

The Austrian Tyrol.—The general character of the ground is not quite so steep as Switzerland, but steeper than Norway or the Black Forest. St. Anton, St. Christoph, Innsbruck, Kitzbühel and Zell-am-See are perhaps the best-known places, and all contain jumping hills. A large number of well-found inns and club-huts are scattered about all over the country at heights of 7,000 or 8,000′ above sea level; using these as centres, an endless series of tours can be undertaken until about the middle of March, often considerably later.

The above by no means exhausts the places where good ski-ing may be had. The French and Italian Alps and the Vosges, for instance, are delightful, as also are the Erzebirge, Riesengebirge and Böhmerwald Mountains. Even Australia is not without its ski-runner.

The Ski.

This is of course the most important part of one's outfit. The wood from which ski are made should be cheap, hard, springy, tough, and light. It should also be of an even consistency throughout, *i.e.*, without soft layers. Hickory would be perfect if it were cheaper, less heavy and tougher. Ash, too, would be perfect if it were less expensive and heavy, and if it did not contain soft layers. Birch is light, but apt to be brittle. Pine, though serviceable, is soft and also brittle.

Ash and hickory are the most widely used, especially the former, but all ash is not equally good. Genuine Norwegian ash is excellent, but it is getting scarce. Danish ash and the best German and Swiss ashes are good. The weight of an ash ski is a very good guide to the merit of the wood, as good ash is heavy.

Another test is the "grain." The less grain there is about an ash ski the better, as the grain portion is softer, more porous and brittle than the remainder. It soon wears away into grooves which tend to clog and slow the running. The best wood for making ski is that which is cut from the outside of the lower part of the trunk. It is preferable that the grain and good wood should be in horizontal rather than vertical layers. Such layers should, in any case, "run out" as little as possible, and that little should not be at the bend or under the foot, and should be in a direction running from toe to heel and not *vice versâ*.

The Telemark type of ski is recommended for all-round service and is made in different sizes. The ordinary rule is that the ski, when stood vertically against the body, should reach to the middle of the fingers with the hand held above the head.

NOTES ON SKI.

By CAPT. A. D. ST. G. BREMNER, R.E.

As there are probably many who have never tasted of the joys of ski-ing, the following notes by one who has served his apprenticeship in Switzerland during the past three years, may perhaps serve as an introduction to one of the finest sports in the world, and one which at the same time also has its military uses.

HISTORICAL.

The earliest mention of ski-ing of which we have at present any record occurs in Procopius (526—559 A.D.), who mentions a race of Skridfinnar, *i.e.*, gliding Finns.

The word ski however has nothing to do with "gliding" or "sliding," but belongs to a group of words, Gothic-Skaidan, German-Scheiden, Latin-Scindere (Scidi), Greek Οχνζειν which imply "splitting," and refers to the original method of making the ski. It is properly pronounced "she," but in Switzerland there is a tendency to pronounce it as "skee," as the former pronunciation has another meaning in the French language. Ski have been used in warfare from a very early date in Sweden. It is recorded that King Swerre, at the Battle of Oslo in 1206, sent out a captain and company of ski-runners to reconnoitre.

An interesting description of ski-ing is to be found in Sir Arthur De Capel Brooke's *A Winter in Lapland and Sweden*, 1827. The military use of ski is insisted upon and 50 miles is put down as a fair day's work for a Lapp.

In those early days the use of the ski was certainly utilitarian in the main, and ski were employed very generally all over Scandinavia for military purposes and for locomotion in winter. Old State papers have been discovered in Norway showing that competitions for soldiers were held as far back as 1767, but as a sport its history may be said to date from the introduction of peasants from Telemark (a province in Norway) to Christiania about 1870.

Before this time, however, it is interesting to note that ski appear to have been used in Great Britain, being used about the sixties in the last century by the Weardale miners in Cumberland to go to and from their work. In 1883 the Norwegian Ski Association was founded and held their first meeting on the Huseby Hill, but, as this hill faced south and was often in bad condition, the venue was changed to the world-famous Holmenkollen Hill in 1892.

A ski has two bends in it, one running throughout its entire length and forming a gentle arch so that when unweighted the ends alone stand on the ground, and the other the upward turn in front called the bend. The total height of the arch should not exceed three-quarters of an inch, but too little is better than too much. The section is either rectangular or rounded on the upper surface, and most patterns have a groove, generally semicircular, about one-twelfth of an inch deep on the lower or running surface to facilitate straight running. The ski is parallel in plan, except at the bend where it is rather wider and then runs off to a point, and at the rear end which is also a little broader than the centre portion. It is most important that a ski should be absolutely true, otherwise it will not run straight.

A skilfully fashioned bend is the hall-mark of a first-class ski. It should begin very gently and subtly and should on no account be abrupt and exaggerated. A total rise of 5″ or 6″ is amply sufficient.

The thickness of wood at the bend is also important ; it should be comparatively thin to make it as springy as possible, since the bend is the place where the ski will most likely break.

The upper surface and sides are best varnished, though some are painted ; the lower surface should be coated with linseed oil mingled with a little paraffin. A sling for carrying a ski is required when rocks have to be climbed ; it is not necessary for ordinary tours.

Binding.—A really good binding should be (1) strong, (2) light, (3) compact, (4) easily repaired, (5) easily put on and taken of, (6) cheap, (7) comfortable, (8) such that the foot is secured so that under *all ordinary strains* it is rigid as regards lateral movement. The heel of the foot should be *partially* free to move up and down vertically. This vertical movement should be such that the heel can easily rise for 3″ or so from the ski, after which the heel should be checked mechanically by the binding, so that it rises with increasing difficulty till the runner can just kneel comfortably on the ski. Care should be taken that the toe strap never reaches further down the foot than the joint where the big toe joins the foot. No existing binding fulfils all the above conditions, but the Huitfeldt pattern, combined with Ellefsen's Clamp for the heel strap, is one to be recommended. It consists of an iron leather-covered side plate, passing through a slot in the ski to which the toe strap is fastened. A strap is carried from the iron plate round the heel of the boot. The Ellefsen binding is also good, but the writer does not recommend the use of other types.

It is usual to have some sort of footplate and perhaps the simplest as well as the most durable is a very thin piece of metal, such as brass or zinc, secured at the corners by small screws and elsewhere by a few plain nails.

Sticks.—Use double bamboo or hazel sticks reaching to the shoulders, and provided with biggish wicker rings suitably fixed. The lower ends of the sticks are generally iron pointed. Their uses would take too long to describe here, but the beginner had better at first leave them behind until a certain proficiency has been attained.

Sealskin.—There are numberless dodges to prevent ski slipping back when climbing, such as sealskin (fixed or detachable), wedges, etc. Perhaps the simplest and cheapest is a kind of net made of rope, which is slipped over the front half of the ski and made fast to the boot.

On the other hand, in warm weather snow is apt to stick to the ski. The cure for this is wax, rubbed on while hot to the running surface. There are several kinds of wax on the market made up in various degrees of solidity. It is best to dry the ski before applying any of these preparations.

Repairing Outfit.—It is well to be provided with such as the following :—(1) A "tin toe," sold in all the shops ; (2) a strong gimlet ; (3) a handy tool comprising, a hammer, a small axe, a pair of pliers and a screw-driver all in one ; (4) some small pieces of sheet brass with holes round the edges ; (5) some small screws and other nails ; (6) a long leather thong, spare straps and string.

The Rucksack.—Should be capacious but made of light material. Leather is too heavy. A couple of outside pockets are a great convenience for articles which are constantly in use. The shoulder straps should be broad.

Boots and Socks.—The ski runner cannot be too particular about his boots. They should be strong, waterproof, pliable and large enough to contain the foot covered by an ordinary pair of thick socks, as well as a special pair of ski socks made of goats' hair. The Lotus ski-boot (English made, costing 35s.) is excellent and superior to those made on the Continent. With a cork sole, two pairs of Army socks, a pair of long woollen stockings and putties outside all, it is possible to keep the feet absolutely dry and warm. It is important too that the fit round the instep and ankle should be quite perfect or sore heels may result.

A few small nails in the soles and heels are an advantage for crossing ice when carrying ski. Dubbin should be used sparingly to keep the leather soft and pliable.

Gloves.—The inner covering should be woollen without separate divisions for the fingers and reach a little above the wrists. The outer covering may well be made on the same plan out of the rubbered canvas sold for patching motor tyres, and should reach well above the end of the coat sleeve with some sort of tightening arrangement to prevent the entrance of snow.

Headgear.—A light cap with a flap round the edge, which may be drawn down over the tops of the ears, is useful, but by far the best thing is the ordinary woollen Balaclava cap, generally worn folded up.

Other Clothing.—The underclothing should be of wool or flannel, and the coat and knickerbockers of some closely woven material to prevent wind penetrating, but it must be smooth stuff. Pockets should be capacious and have flaps which can be buttoned down. Some of them may with advantage be lined with waterproof. A light warm sweater is also serviceable.

Goggles are often worn, especially in Norway and Sweden, as a protection against snow-blindness.

As regards the actual practice of ski-running, it is impossible to go into the subject here. It is best to study some good book before commencing practical instruction, and the following are recommended :—

Ski-ing for Beginners and Mountaineers, by W. R. Richmers.

How to Ski, by V. Caulfield.

The Ski-Runner, by E. C. Richardson, to which I am largely indebted for the above notes.

THE SPACING OF STIRRUPS IN REINFORCED CONCRETE BEAMS.

By Capt. T. E. Kelsall, R.E.

When designing reinforced concrete beams, it is generally necessary to introduce stirrups or other means of providing against failure by horizontal shear. In the case of uniformly loaded beams the shear is a maximum at the ends, diminishing to zero at the centre, the shear stress diagram for each half of the beam being a triangle. Consequently if equally spaced stirrups are used their sectional area has to be varied to correspond with the varying stresses.

An alternative method, which has practical advantages, is to assume a distance from the end of the beam for the first stirrup, the sectional area of which can then be calculated, and to make all the others of the same dimensions, their spacing being increased towards the centre of the beam. Some simple means of ascertaining this spacing is therefore necessary.

Vertical stirrups, so spaced that perpendiculars through them cut off equal areas of the shear stress diagram, would appear to be correctly spaced. This is presumably true also of diagonal stirrups, if the perpendiculars are drawn from similar points in all of them.

Knowing the length of the beam and the distance of the first stirrup from the end, the distances of the others can be calculated.

The following two sets of general expressions give the distance in feet of the various stirrups from the end of a beam whose length is L feet, when the first stirrup is 6″ and 1′ respectively from the end of the beam :—

Distance in feet of stirrups from end of beam.

1st stirrup	$\frac{1}{2}'$	$1'$
2nd „	$\frac{1}{2}(L - \sqrt{L^2 - 4L + 2})$	$\frac{1}{2}(L - \sqrt{L^2 - 8L + 8})$
3rd „	$\frac{1}{2}(L - \sqrt{L^2 - 6L + 3})$	$\frac{1}{2}(L - \sqrt{L^2 - 12L + 12})$
4th „	$\frac{1}{2}(L - \sqrt{L^2 - 8L + 4})$	$\frac{1}{2}(L - \sqrt{L^2 - 16L + 16})$
5th „	$\frac{1}{2}(L - \sqrt{L^2 - 10L + 5})$	$\frac{1}{2}(L - \sqrt{L^2 - 20L + 20})$
6th „	$\frac{1}{2}(L - \sqrt{L^2 - 12L + 6})$	$\frac{1}{2}(L - \sqrt{L^2 - 24L + 24})$
7th „	$\frac{1}{2}(L - \sqrt{L^2 - 14L + 7})$	$\frac{1}{2}(L - \sqrt{L^2 - 28L + 28})$
8th „	$\frac{1}{2}(L - \sqrt{L^2 - 16L + 8})$	$\frac{1}{2}(L - \sqrt{L^2 - 32L + 32})$
9th „	$\frac{1}{2}(L - \sqrt{L^2 - 18L + 9})$	$\frac{1}{2}(L - \sqrt{L^2 - 36L + 36})$
10th „	$\frac{1}{2}(L - \sqrt{L^2 - 20L + 10})$	$\frac{1}{2}(L - \sqrt{L^2 - 40L + 40})$

Working out these expressions for various values of L, we get the following tabular statements :—

Length of Beam in Feet ...		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Number of stirrups in each half length of beam.		3	3	4	4	5	5	6	6	7	7	8	8	9	9	10
		′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
Approximate distance from end of beam of each stirrup in feet and inches.	1st	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
	2nd	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
	3rd	2.2	1.11	1.10	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7
	4th			3.0	2.8	2.7	2.6	2.5	2.4	2.4	2.4	2.3	2.3	2.2	2.2	2.2
	5th					3.11	3.6	3.4	3.2	3.1	3.1	3.0	2.11	2.11	2.10	2.10
	6th							4.10	4.4	4.1	4.0	3.10	3.9	3.8	3.7	3.7
	7th									5.8	5.2	4.11	4.8	4.7	4.5	4.5
	8th											6.7	6.0	5.8	5.5	5.4
	9th													7.6	6.10	6.6
	10th															8.5

Length of beam in feet.		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of stirrups in each half length of beam.		1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6
		′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
Approximate distance from end of beam of each stirrup in feet and inches	1st	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2nd		3.0	2.7	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.1
	3rd						5.0	4.3	4.0	3.10	3.9	3.8	3.7	3.7	3.6	3.5	3.5	3.5	3.4	3.4	3.4
	4th										7.0	6.0	5.8	5.5	5.3	5.1	5.0	4.11	4.10	4.10	4.9
	5th														9.0	7.9	7.4	7.0	6.10	6.7	6.6
	6th																		11.0	9.7	9.0

For intermediate lengths of beams the spacing can be obtained with sufficient accuracy by interpolation. For longer beams the spacing can be worked out from the general expressions. The general expressions for the 11th and subsequent stirrups will be evident from an inspection of those given above for the first 10.

The general expressions and tables are only given for two alternative distances of the first stirrup from the end of the beam, as this will usually give sufficient latitude in designing.

General Sir James Frankfort Manners Browne, K.C.B.,
Colonel Commandant, Royal Engineers.

Gen Sir James Frankfort Manners Browne KCB

MEMOIR.

GENERAL SIR JAMES FRANKFORT MANNERS BROWNE, K.C.B., COLONEL COMMANDANT, ROYAL ENGINEERS.

By COL. R. H. VETCH, C.B., LATE R.E.

SIR JAMES F. M. BROWNE was born in Dublin on the 24th April, 1823. He was the only son of the Very Rev., the Hon. Henry Montague Browne (1799—1884), Dean of Lismore, who was the 2nd son of James Caulfeild Browne, 2nd Lord Kilmaine. His mother was the Hon. Catherine Penelope, daughter of Lodge Evans Morres, 1st Viscount Frankfort de Montmorency She died in 1858.

Educated at Epsom and at Mr. Miller's at Woolwich he entered the Royal Military Academy in May, 1838, and received his first commission in the Royal Engineers on 1st January, 1842. From the R.E. Establishment at Chatham, of which Colonel (afterwards General Sir) C. Pasley was at that time Director, he went to Woolwich, and thence to Ireland. In March, 1845, his turn for foreign service came round and he was sent to Halifax, Nova Scotia. In April he was promoted 1st lieutenant and in November, 1846, he was moved to Quebec.

In June, 1847, Lieut. Browne was sent on special service to Fort Garry in the Red River Settlement, Hudson's Bay Territory (now Manitoba). A detachment of Royal Artillery and another of Royal Sappers and Miners with three companies of the 6th Foot had been quartered at Fort Garry since the summer of 1846. They were sent there on account of a good deal of restlessness and some ill-feeling along the line of frontier between Canada and the United States of America, in connection with the demarcation of the boundary between the two countries. The officers of Royal Engineers and the Sappers and Miners were employed in surveying, improving the portages, and other engineering work, and in superintending the clearance of forest in the neighbourhood by the troops and other pioneering work, as well as strengthening the defences of the Upper and Lower Forts Garry. So difficult and arduous was the journey that it took two months for Lieut. Browne in the height of summer to reach what was then a rather inaccessible spot, and is now the prosperous city of Winnipeg. A diary of his journey to Fort Garry, written at the time, has been found among the General's papers. The route taken, the primitive conditions of the country, and the mode of travel into the western regions was so different at that time when the west was indeed the "wild west," and the sport he met with on the way was so interesting that I have appended to this memoir a *résumé* of the journal kept by Lieut. Browne.

In August of the following year the troops were withdrawn from Fort Garry and Lieut. Browne returned to Quebec, but whether he went back by the same route there is nothing to show. The time occupied in the return journey was only half that taken to reach Fort Garry a year before, and it must be assumed that knowing the ropes there were fewer delays and stoppages.

In the autumn of 1851 Lieut. Browne returned home and was sent to do duty in Ireland for the next two years, first at Clonmel and then at Kilkenny. He was promoted to be 2nd captain on the 7th February, 1854, and in the following July was sent to Chatham to command the 1st Company of Royal Sappers and Miners. He put it through a course of fieldwork instruction and on the 5th January, 1855, embarked with it for the Crimea.

On reaching Balaklava on the 5th February the company was at first employed for a short time in putting up hutting for the troops and for stores, but Engineers were too much wanted at the front for this employment to continue and Capt. Browne and his Company were soon moved to the trenches of the British right attack on Sebastopol. Here Capt. Browne began that arduous and prolonged duty in the trenches which lasted until near the end of August.

On the 22nd March, 1855, and again on the 5th April, Capt. Browne took part in the repulse of sorties made in force by the Russians. He was promoted to be 1st captain on the 1st June, 1855, and was the Senior Executive Officer of Engineers on the 7th June, when he rendered conspicuous service in the successful attack on the Quarry outworks covering the Redan. The execution of the arrangements as well as the general superintendence of the work was in his hands. Capt. (now Field Marshal Viscount) Wolseley of the 90th Foot was his assistant engineer, and Capt. Browne reported in high terms of his conduct on this occasion. Capt. Browne was mentioned in the despatches both of Sir Harry Jones (8th June), and of Lord Raglan (9th June), for his gallantry and zeal. On the 17th July a brevet majority was conferred upon him for his services.

When Lieut.-Colonel Richard Tylden, R.E., director of the right attack, was fatally wounded in the unsuccessful attempt to assault the Redan on the 18th June, 1855, his duties devolved on Major Browne who, for rather more than two months, carried on the work of this responsible position. On the 24th August Major Browne was severely wounded by a rifle bullet, which broke his left arm, passed through the shoulder, and injured his jaw. He was in hospital until the 18th November when he was invalided home. He was mentioned in Sir Harry Jones's despatch of 9th September, 1855. For his services in the Crimea he was created a Companion of the Order of the Bath, Military Division, and a Knight of the Legion of Honour, he received the war medal with clasp for Sebastopol, the Sardinian and Turkish medals, the Order of the Medjidie (5th class) and a second brevet, that of lieutenant-colonel, was gazetted on the 26th December, 1856. A pension of £200 a year was awarded him for his wounds for three years, but this was afterwards made permanent.

Recovering from his wounds at the end of 1856 Colonel Browne was quartered in Dublin until July, 1859, when he went out to India to command the Engineers in the Bombay Presidency with headquarters at Poona; in March, 1860, he went on to Mauritius as Commanding Royal Engineer and in August, 1861, he returned home to take up the appointment of Superintendent of Military Discipline (now called Assistant Commandant) at Chatham, where he was second in command, and had special charge of the drill and training of the battalions of Royal Engineers quartered there. He was promoted to be brevet colonel on the 26th December, 1864, and regimental lieutenant-colonel on the 2nd May, 1865.

On the 1st January, 1866, Colonel Browne was moved from Chatham to headquarters at the War Office, as Assistant Adjutant-General for Royal Engineers, and five years later, he succeeded Colonel the Hon. H. F. Keane as Deputy Adjutant-General. In July, 1870, he was a member of the committee on the pay of officers of Royal Artillery and Royal Engineers and in January, 1873, on the admission of gentlemen educated at the universities to the scientific corps. He was selected for a distinguished Service pension in October, 1871.

On the 1st January, 1876, Colonel Browne was appointed Colonel on the Staff and Commanding Royal Engineer of the South Eastern District with his headquarters at Dover, but his promotion to be major-general on the 2nd October, 1877, (afterwards antedated to 22nd February, 1870) placed him on the half-pay list. On the 2nd June, 1880, he was appointed Governor of the Royal Military Academy at Woolwich. He remained in this post for 7 years, was promoted to be lieutenant-general on the 13th August, 1881, was placed on the unemployed list in 1887, and was promoted to be general on the 12th February, 1888. General Browne retired on a pension on the 5th May, 1888. On the 6th April, 1890, he was made a Colonel Commandant of Royal Engineers, and on the 26th May, 1894, he was created a Knight Commander of the Order of the Bath.

He died at his residence, 19, Roland Gardens, London, on the 6th December, 1910. His remains were buried in Brompton Cemetery, after a funeral service at St Peter's, Cranley Gardens, on 10th

December. The King was represented at the funeral service and at the grave by Colonel R. U. H. Buckland, R.E., Aide-de-Camp to His Majesty.

On his twenty-seventh birthday, April 24th, 1850, Sir James Browne was married at Quebec, Canada, by the Lord Bishop of the diocese to Mary, daughter of James Hunt, of Quebec. She died at 19, Roland Gardens, London, on the 30th May, 1888, and was buried at Brompton Cemetery on 2nd June. By her he left two unmarried daughters; Annie Kathleen de Montmorency, born in Dublin 1858, and Agnes Montague, born in London in 1867.

A portrait in oils of the general painted by Mr. Charles Lutyens, is in possession of his daughters.

His sword hangs with those of other Governors of the Royal Military Academy in the dining hall of the cadets and his daughters are making an altar frontal for the Chapel in memory of him.

A "Résumé" of a Journal of Travel from Quebec to Fort Garry, Red River Settlement, Hudson's Bay Territory, made by Lieut. J. F. M. Browne, R.E., between 28th June and 26th August, 1847.

Leaving Quebec on the 28th June, 1847, with instructions to proceed immediately to the Red River Lieut. Browne and an officer of the Commissariat named Darling made their way by a succession of steamers up the St. Lawrence and through Lake Ontario, calling at Montreal, La Chine, Kingston, and Toronto to Queenstown where they arrived on the evening of the 3rd July and went by a horse tram to Niagara putting up at the Clifton House. On the 4th they remained all day at the Falls and visited the battlefields of Queenstown heights, Lundy Lane. On the 5th they left the Falls for Chippewa by wagon and there embarked in a steamer for Buffalo. They left Buffalo in the evening in the "Niagara" steamer for Chicago, a voyage of 1,080 miles, through Lakes Erie, Huron and Michigan. They stopped on the way at Cleveland, Detroit, Mackinaw Straits and Manitou Islands, arriving at Chicago on the evening of the 9th July, not bad going for the distance.

At Chicago they arranged for the conveyance of their baggage by wagon to Galina and, to allow time for it to get there before they did, remained at the Lake Hotel at Chicago until the 14th. The weather being oppressively hot the stage by which they travelled left at 2 o'clock in the morning, and driving through prairie land all night and the following day, they covered 180 miles, reached Galina at 7 p.m. on the 15th, and put up at the American hotel. Galina, known for its lead mines, Browne describes as the hottest and most uncomfortable place he was ever in; it was built on the banks of a muddy river called Fever River, 6 miles from the Mississippi. Here they waited for a steamer from St. Louis to take them to St. Peters in Iowa Territory. They met two men at the hotel who belonged to the Red River and were waiting for the same steamer as themselves; they agreed to join company as these men undertook to convey their baggage across the plains from St. Peters to the Red River Settlement. They brought horses, harness, a wagon, etc., and provisions (consisting principally of ham and biscuits) for crossing the plains.

The "Cara" steamer arrived in the evening of the 17th and they were glad to embark all their baggage and horses and to get away from Galina. For the next four days they steamed up the Mississippi, passing on the third day the lodges of Winnipeg and Sieux Indians. In the evening of the 21st July they reached the village, of St. Pauls, in Wisconsin territory, where they disembarked and had all their baggage put in a store. They put up at the house of a Mr. Jackson, but apparently there was not room for both of them to sleep there, because Browne says "Darling slept inside and I slept in the store." St. Pauls was 8 miles below St. Peters and was the village where most of the Red River traders kept their carts, horses, etc.; situated on the east bank of the Mississippi it was more convenient for them than St. Peters. "It is," says Browne, "a wretched place and the inhabitants about the greatest known blackguards. There were a good many Sieux Indians about, generally drunk." The next day Browne and Darling rode over to St. Peters to see Capt. Eastman, the officer commanding the American garrison at Fort Snelling. They crossed the Mississippi in a flat-bottomed barge, the fort being on the west bank, near where the St. Peter's River runs with the Mississippi. The captain gave them letters for the Red River garrison. They then visited the American Fur Company Establishment, leaving their horses at the fort and crossing the St. Peter's River. Mr. Libley who was in charge was very civil and gave them a good dinner which was most acceptable as there was nothing but salt pork to be got at St. Pauls. After posting letters at the fort, where the post office was kept, they returned to St. Pauls, and Browne pitched his tent at the back of the houses to avoid mosquitoes and vermin.

On the 23rd July about 1 p.m. they started on their march for Fort Garry, a party of 11 men and a boy, including themselves, 15 carts drawn by horses and oxen and Browne's wagon. They camped at the Falls of St. Anthony on the Mississippi, about 9 miles from St. Pauls and the same distance from St. Peters. Here Browne was able to shoot some prairie fowl for supper. They had to remain at the falls until the 27th July as some of their men expected freight to come by the next steamer for conveyance to Red River. The steamer arrived on the evening of the 26th, but not the expected freight; so, on the morning of the 27th, they began to travel up the east bank of the Mississippi, Browne and Darling riding. They did about 14 or 15 miles a day the carts being heavily laden and the oxen slow. On the 27th they breakfasted at Drunken River and camped at Corn River; on the 28th the places named are Rum River and Elk River. On the 29th they camped at Bear Island in the Mississippi, where it was very pretty and Browne shot duck. On the 30th they breakfasted at Chain of Lakes and camped at the Sac Rapids on the Mississippi. Next day they forded the river without accident, about 50 miles above St. Peters.

The Mississippi at that place was about $\frac{1}{4}$ mile wide and at that time about 3′ 6″ deep and very rapid, with a rough, strong bottom. There was an island in the middle which made the crossing easier. Five or 6 miles after crossing the river they met a large party of half-breeds belonging to St. Pauls who had been buffalo hunting near Lac Travers. They had killed a good many and their carts were loaded with dried meat. The half-breeds told Browne's party that they would fall in with buffalo and elk and that a large party of traders from St. Pauls for Red River were three days ahead, also that two parties one of 180 and the other of 72 of Sieux Indians had crossed the track going eastwards on the warpath against the Chippeways. Browne scoured the country vainly in search of game. Their horses were much annoyed by a horsefly called "Bulldog" which bit severely.

On the 1st August they were compelled to halt all day to repair the carts which had suffered from the bad tracks. Darling was greatly alarmed by rattlesnakes and the horses could not feed on account of the "Bulldogs." On the 2nd August they reached the Sac River. The next day was very wet and as Darling was unwell they remained in camp. On the 4th they moved across the Sac River, and Browne saw a wolf, but the beast got into cover before he could get a shot in. He also saw deer for the first time, and had a long chase after a fine buck, but the buck got into a swamp and crossed the river. Darling was too ill to ride and travelled on a cart. At night he was delirious. They got to the edge of the great prairies on this day. Next morning Darling was better and Browne took the seat off his wagon, on which they made a bed for him, which he used for the rest of the journey. They were now in the Sieux country and established a watch at night for the first time, and pushed on by day as fast as possible.

On the 7th August they reached a part of the country called the "Height of Land," because it was the highest country between Red River and St. Peters. They saw swans, pelicans, geese, and ducks on some small lakes they passed. They crossed the trail of a party of about 25 Sieux going westward, evidently part of the war party of 72 that they had heard of and were glad that the Indians had not crossed behind them as they might have followed to steal some of their horses. Water and wood were scarce. They camped at a small lake where Browne managed to shoot a few ducks. On the 8th Darling was very ill with fever and ague. They saw the tracks of three small parties of Sieux going westward who had crossed about two days before. On the 9th they camped by a very pretty lake, where there were swans and pelicans and a great number of ducks. There was an Indian encampment which had been left about a week before, supposed to belong to Chippeways on a warpath against the Sieux. At sundown there was a terrific thunderstorm and the rain lasted till daylight. As Browne had given up pitching his tent and generally lay under a cart he had a bad time of it.

10th and 11th August. Getting off at 6 a.m. they halted for breakfast at 11 a.m. on the Mimence prairie, where they dried their blankets, etc., and got away again in the afternoon; two of their men went on ahead towards the Otter-Tail Lake River to look for buffalo, but were unsuccessful. An object was seen ½ mile away on the right which, at first, they took to be Indians and Browne with a man who could talk Sieux language rode towards it. It turned out to be three elks, or more properly Wapiti deer. Giving the man his shooting coat and nearly everything but his gun and ammunition Browne prepared for a chase. The deer allowed him to ride quietly up to within about 200 yards before they made off, with Browne after them. But he had not ridden more than ¼ mile when his horse got his forelegs into a narrow swamp sinking up to his chest and, throwing Browne over his head, fell on his side. They both scrambled out unhurt and Browne continued the chase until the deer crossed swamps where he was unable to follow. He was returning to the track of his party, when he met Darling's servant, Miller, riding his master's horse, and a few minutes later getting a view of the deer again gave chase and ran them for 5 or 6 miles, when the largest of them showed signs of being done up and running into a swamp with high grass threw himself down. Miller jumped off his horse and ran into the swamp with a large horse pistol, which missed fire but caused the deer to jump up and make off again. Browne followed him and shot him dead. He proved to be a very large specimen with fine horns. Browne sent Miller off to get a cart for the meat and was to wait by the deer until his return.

Near sundown Browne got uneasy and rode off to look for the track, which unfortunately for him had taken a long round to the left to avoid some lakes, of which he did not know. He hunted about for the track until quite dark; then he unsaddled and having tied his horse by a line round his own waist, he sat in his saddle being unable to sleep as he had only his shirt and trousers on and the mosquitoes were dreadful. Towards morning it became very cold and he was quite wet through from the heavy dew. When day broke he could not find his way back and wandered about the prairie in search of the track without success, there being a heavy mist which did not clear away until about 9 o'clock. After another hour he got very hungry. He felt totally lost and began to consider which was the most tender part of his horse in case of necessity. However, an hour later, Miller and two other men, who had been out looking for him since daylight, appeared. One of the men went back to the cart to tell Darling that his friend was found, while Browne and the other two men went in search of the deer. They found it and sent for a cart. By the time they overtook their party it was crossing the Otter-Tail Lake River, which is the head water of the Red River. Darling had been very anxious about Browne's absence, and some of the party, wishing to push on on account of the Indians about on the warpath, had objected to waiting to search for him. Browne always said that Darling by the firm stand he made, in spite of his own illness, had saved his life.

Starting early on the 12th August they had to travel till 2 p.m. before they could find water and then it was bad. Browne saw seven wolves run out of the swamp just as they came up to it, but his horse was too tired to hunt them. He also saw a herd of the small jumping deer which the half-breeds call antelopes, pretty animals a little smaller than the common American deer and much faster. A violent thunderstorm came on in the evening which wet them through and put out the fires so they had to go to sleep supperless.

Darling was so ill next morning that they remained in camp. One of the men fancied he saw buffalo and Browne and five of the men got their guns and rode off. When they got to the Red River, some 2 miles from the camp, they found instead of buffalo a party of traders under the command of Mr. Kitson of the American Fur Company, who had left St. Peters a few days before them, and taken a round to the west to trade with the Indians in the Sieux country. Browne and his men crossed the river and dined with the Kitson party and agreed to join parties for the rest of the journey, and, as Kitson's route was more westerly than their own, Browne hoped to get buffalo. When they returned to their own camp near evening, Darling was better and they brought up all their carts, etc., ready to cross the river in the morning. Then another party belonging to a man named Hayden, of Red River, appeared, and it was agreed that the three parties should travel together on the west bank of the Red River. It was an extraordinary circumstance three parties meeting on the prairie on the same day.

On the 14th August the whole cavalcade consisting of 25 men and 50 carts assembled on the west side of the Red River. Where Browne crossed at this time of the year the river was about 80 yards wide and $3\frac{1}{2}'$ to $4'$ deep. When the party halted in the evening at Rice River it was found that the bridge had been carried away. So they set to work to make a new one, by cutting down trees and throwing them lengthways into the river and laying willows across them. When it was completed next day the crossing was effected, but with some trouble. Browne and Kitson rode on ahead towards the Shyenne River and Kitson spied a buffalo bull. Riding on quietly they hoped to drive him towards their carts. They got within 150 yards of him before he saw them, and then started off. Browne rode alongside of him and fired, missing the first barrel, but hitting him in the shoulder with the second. He fell on his knees and nose, but got up again and went off very slowly. Browne reloaded and rode up in front of him, on which he faced Browne shaking his head and tail furiously but did not attempt to charge. At this time Browne was not more than 12 yards from the bull, but could not get his horse (who had never seen buffalo) to stand quiet. He fired again and hit the bull in the chest, but he walked off and not till another shot hit him between the shoulders did he fall dead. They skinned part of the beast and carried away some of the meat, which they found very tough, but better than the salt junk they had lived on so long. He was a very old bull, which accounted for his not running as well as they generally do. Cows run much faster and further than bulls. That night the party encamped on Shyenne River and had another thunderstorm.

On the 16th they camped on Maple River and next day crossing that river Browne and Kitson were ahead when they saw a buffalo bull and riding up to within 100 yards Browne fired from horseback and missed him. He went off and they followed. Browne got another shot which hit him behind and Kitson hit him in the back, then Browne stopped him with a hit in the shoulder and riding up close killed him. He was an old bull blind in one eye which may have accounted for their being able to get close before he started. That night they camped on the Rush River. On the 18th they saw no game and camped near a swamp with very bad water. Next day they hunted two bulls Browne killing one and Kitson the other. Halting at a swamp for dinner Browne managed to kill another bull. They came across the track of the Red River buffalo hunters and followed it till they reached a bend of the Goose River where they camped. Large herds of buffalo were in the hills all round them. They were all tired of bull meat and arranged to start early on the 20th to kill some cows.

Browne, Kitson, and some of the men after riding for some time discovered a herd which they had some difficulty in approaching on account of the number of bulls, who were very shy. At last by riding along the edge of a low lake they got a good start and Browne singled out a cow which he killed after a run of a couple of miles over a bad, hilly and stony country. The cow was not very fat but much better eating than bull meat. Kitson also killed a cow and having cut them both up they sent a cart for them. Towards evening Browne killed his sixth bull. There were plenty of calves which run even better than the cows. The whole country was covered with buffalo and Browne greatly regretted he hadn't two or three horses as he might have killed many more. "A wounded bull," he says, "will often charge if a man goes too close and his horse is not well trained, but the principal danger is from your horse putting his foot into a badger hole and falling."

On the 21st they camped on Turtle River near the place where Mr. Simpson, the Arctic voyager, was found shot. The next day the weather continuing very hot they camped on Salt River and Darling, being a little better and very anxious to get to the end of his journey, they determined to go ahead of the main party, hoping to reach the settlement in four days. On the 23rd Browne, Darling, his servant Miller, the Sieux interpreter Campbell, and two brothers named Spence pushed on ahead. They had two carts with them as light as possible. Darling's horse was in the wagon, while his servant drove their cart. They halted for dinner at Little Hillock Creek and went on again until evening, when they were obliged to stop on account of the loss of a linchpin of the wagon, and there was no water for the poor horses. Having repaired their wheels as well as they could their baggage carts being very old and shaky, they crossed the Tongue River on the 24th, watered their horses and just as they were close to Pembina River their cart broke down altogether. They were obliged to transfer their traps to Spence's cart and put in their horse as leader and so reached the river. On the 25th they reached the Grand Point on the Red River and pushing on got to Scratching River in the evening where they camped. As they were little more than 40 miles from the settlement Browne determined to push on by himself in the morning and try to reach Fort Garry early enough to send fresh horses for Darling next evening. Leaving at 5 a.m. on the 26th he rode as fast as he could and got to the fort by 11 a.m. Darling was got in the next day and the baggage four days after them.

Itinerary.

Quebec to Montreal	180	miles.
Montreal to Kingston	186	,,
Kingston to Toronto	188	,,
Toronto to Niagara	40	,,
Niagara to Buffalo	23	,,
Buffalo to Chicago	1,075	,,
Chicago to Galina	180	,,
Galina to St. Peters	328	,,
St. Peters to Red River Settlement	600	,,
Total	2,800	miles.

TRANSCRIPT.

RAILWAY CONSTRUCTION IN THE FAR EAST.

From an article by V. Rikachev in the November, 1910, number of the *Injenerni Jurnal.*

The condition of China at the close of the last century presented a pitiable spectacle of utter helplessness. Her government, after a historical life of 3,000 years, possessing an enormous territory and a population of over four hundred millions, with all the resources necessary for a flourishing commerce and trade, yet found itself obliged to submit with humiliation to the territorial and concessional requisitions of foreigners.

Her war with Japan in 1894–95 exposed her utter weakness without and within. The attempt at civil war in 1900 ended equally unsuccessfully. The loss of Formosa and the Pescador Islands, the declaration of independence in Korea and it passing under Japanese protection, the occupation by Europeans of Kwantung, Wei-hai-Wei and Kiau-chow, awoke China from her long sleep, and forced her to recognize that all fear of her elementary strength had irrevocably gone. To guard the integrity of her empire, not visionary powers, but actual armies and actual fleets were necessary wherewith to support her foreign policy, and she needed also considerable pecuniary resources.

As to these last, she took various measures for regulating and augmenting her supplies, and one of the most important of these measures was a plan of extensive railroad construction, calculated to cover the vast territory of the middle empire with a network of railways. This plan was calculated upon the enormous impulse which the new communications would give to the development of trade and industry, and to the transference of labour from the thickly populated to the almost unpopulated districts, and this impulse, it was hoped, would in time relieve the government from chronic poverty and onerous dependence on foreign governments.

Pekin and the Secondary Railway Centres.—In the scheme of development Pekin, as the centre of administration, acquires great importance as a railway centre. It is proposed that from here main lines shall run in four directions:—(1) South, to Hankau and Canton; (2) North, to Kalgan, Urga and Kiakhta; (3) East, to Tien-tsin, Shang-hai-kwan, Hsin-minting, Taonanfu, Tsitsikar and Aigun; and (4) West, to Tai-yuen, Langchau, Uruntsi and Kuldja. The scheme further proposes that Si-ngan, Hankau and Canton shall become secondary railway centres, and that from these cities lines shall run in all directions.

The Southern Main Line.—The main line from Pekin to Hankau was constructed in 1905 and has a total length of 748½ miles. Its extension to Canton is important in view of the proposal to extend the eastern main line to the Amur. By April, 1910, some 130 miles had been constructed northwards from Canton and work was also being commenced southwards from Hankau.

Two branch lines have already started from the southern main line :—(1) From Ching-ting station to Tai-yuen (capital of the Shansi province); and (2) from Kai-fong-foo to Honan, in the province of the same name. The first is 165 miles in length and the second 145 miles. The second of these branch lines follows the southern bank of the river Hwang-ho, and will be extended to Si-ngan, the capital of the Shensi province.

The Northern Main Line.—Of the northern main line, the portion Pekin to Kalgan (145 miles) had recently been finished. The line was made entirely by Chinese engineers and with Chinese materials, and its opening to traffic was an occasion of great rejoicing. A branch, 12 miles in length, from Pekin to Mantougou, in a colliery district, belongs to this system.

Kalgan is the trade centre of Mongolia and has a population of more than 100,000. Its trade with Southern China will be greatly benefited by the extension to Canton. The northern extension to Urga and Maimachen, called the Transmongolian railway, will encourage the trade and the settlement of Mongolia. At present in this direction there is only a *kutcha* road through the Gobi Steppe which shows great vitality, in spite of the difficulties of the way. The soil is rich and suitable for cattle rearing.

The Chinese Administration attaches great strategic and commercial value to this line, but at present the means for its construction are not forthcoming. Parallel to this the Russians have started a proposal to run a line from Missovaya to Kiakhta. The ruling considerations of this project are briefly these :—Now that the line has been opened to Kalgan, the extension of a Chinese railway into Mongolia and so on to the Russian frontier is only a matter of time. If the Russian branch line to Kiakhta is not then completed the strategic equilibrium will be upset unfavourably to Russia. If this branch were made, then the Russians could rely upon the argument of the 48 pairs of trains a day on the Siberian line, and upon the Irkutsk military district, to confine the Chinese to the peaceful development of their line for goods and passenger traffic.

It is estimated that with the double line of the Siberian railway, and with the proposed rate for expresses of 1,000 kilometres in 24 hours, the journey from Paris to Pekin, *viâ* Berlin, Petersburg, Perm, Omsk, Irkutsk and Kiakhta will take 9 days and 5 hours, from Moskow to Kiakhta 4 days, and to Pekin 5 days. In this case it is certain that all the European mails to China, and an enormous number of passengers will go by this route. As regards commerce exchange, the line will carry Hankau tea to Russia, and Siberian corn, timber, coal, etc., into China.

The Eastern Main Line.—The eastern main line, Pekin–Tientsin–Kinchow–Kou-pangtzu–Hsin-ming-ting–Mukden, with a branch Kou-pang-tzu–Ying-kou (Newchuang), is run entirely by Chinese, except that the chief agents are Englishmen. The portion Hsin-ming-ting–Mukden was made during the Russo-Japanese War by the Japanese, who used their own materials and labour, but it has since been handed over to the Chinese.

In this way the Chinese eastern main line is connected up with the

Japanese Southern Manchurian system, and, through the latter, with the Russian East China railway. But the Chinese Road Administration, in order to be independent of foreign lines, has formed a project to carry forward their line from Hsin-ming-ting, through Fa-kuo-men and Tsitsikar to the Amur. As part of this project a line 20 miles in length has been opened from the Tsitsikar station on the East China railway to the town of the same name. The original project has since been modified, and the line, as at present projected, will run from Lanshanwan, through Kinchow and Taonanfu to Tsitsikar and Aigun.

The Japanese press considers that the project of constructing a line from Kinchow to Taonanfu has every prospect of realization. The line will pass through Chao-yang, on the river Taling-ho, and Fusin, and probably Chentsiatun. The length of this portion is estimated at 516 miles, and the extension to Tsitsikar would be 480 miles more. Undoubtedly, say the Japanese, the cost of such an undertaking would be beyond the powers of the Chinese, and the fact that they are considering it seriously points to a powerful backing of American capital.

The English papers announce that the line will run as follows:—

Kinchow—Shao-kulin	197 miles.
Shao-kulin—Chentsiatun	218 ,,
Chentsiatun—Taonanfu	148 ,,
Taonanfu—Tsitsikar	150 ,,
Tsitsikar—Aigun	250 ,,
Total	963 miles.

The author has checked these distances and makes the total 1,099 miles, and, including the extension to the sea at Lanshanwan, 1,119 miles. Serious difficulties will be met with in the mountainous country between Kinchow and Chentsiatun, and between Mergen and Aigun, where it will be necessary to tunnel the Khingan Mountains.

As regards fuel, this line will pass in the neighbourhood of four coal-fields:—(1) Lian-shan, which is about 6 miles from Nan-yuan-chow, the third station to the west of Kinchow; (2) Lin-heisk, 11 miles to north-west of Kinchow; (3) about 46 miles to west of Taonanfu, in the spurs of the great Khingan, the Chinese report large seams of beautiful coal; and (4) Gan-heisk, 33 miles west of Mergen, on the right bank of the Gan-ho.

If the line Pekin-Kiakhta, in a strategic sense, threatens to cut off Transbaikal from Russia, the Kinchow-Aigun line is still more menacing, as it crosses the East China railway at Tsitsikar, and threatens the line of the Amur with an inroad at Blagovyeshchensk. To this must be added another menace, the request of the Japanese for rights to construct a line from Tieh-ling to Taonanfu. In fact if this project is completed before the completion of the Amur railway, the Russian position in the Far East might become very critical. Economically, the development of the Taonanfu district is very promising.

To the eastern system there also belongs the line from Pekin to Tunchow (on the Pei-ho), 13 miles in length, which was made by the English in 1901 to connect the capital with the wharfs, and is very important.

The Line from Kwang-cheng to Kirin.—Another branch of the eastern main line is the line from Kwang-cheng to Kirin, which was to be begun in 1910. *Kwang-cheng* at the present time gains importance by being the borderland of Russian and Japanese influence in Manchuria. It is a centre from which a very large quantity of farm products is exported to Europe, China and Manchuria, supplying a large traffic on both the Russian East China and the Japanese Southern Manchurian lines. *Kirin* is of considerable strategic importance, and economically it will supply Southern Manchuria with timber and the products of the hills.

For the construction of this line an agreement was made between Japan and China, of which most of the advantages rest with the Japanese. By the agreement the two nations took equal shares, but the control will long remain with the Japanese, as to meet their share of the cost the Chinese were obliged to borrow from the S. Manchurian Railway Company on a 25-year agreement without the right of redemption of the loan before the end of that period. The line is 80 miles in length, and should be finished in the autumn of 1911.

Lines to the West.—Up to the present the only lines running westwards in China are the two branches already mentioned, to Tai-yuen and Ho-nan. The latter will eventually extend, beyond Si-ngan, to Lang-chow, the capital of Kansu province.

From Lang-chow at the present time a *kutcha* road runs to the frontier of the Russian Semiryetchensk province, and to Kashgar. There is another *kutcha* road running westwards from Kalgan, through Uliassutai and Kobdo, to the Tomsk frontier. Another important trade route runs south-west from Kalgan, along the Hwang-ho, and beyond, to Tibet.

Secondary Railway Centres.—Si-ngan.—Turning now to the schemes of development of the secondary railway centres, we will take first Si-ngan, the chief town of the Shensi province. From here it is intended that lines shall run in five directions:—To Tai-yuen, Lang-chow, Ching-tu (province Cze-chuen), Hankau (province Hu-peh), and Hai-fong-foo (province Honan).

Hankau.—From Hankau, already a very important trade centre, lines are to run:—Northwards to Pekin, north-westwards to Si-ngan, eastwards to Nanking and Ngan-king-foo, southwards to Nanchang and Canton and westwards to Ching-tu.

The Chinese government are fully alive to the strategic importance and the urgency of connecting Hankau and Ching-tu. By the latest accounts they had authorized the deputies of the Hupeh and Czechuen provinces to raise Chinese capital for the construction of this Hankau-Czechuen railway, hoping to be able to prevent foreign capitalists from intervening. But the agents of three foreign governments were trying to obtain influence in the line, the English, probably on account of Tibet, wanted the portion nearest to Ching-tu, the French wanted the same portion, while the American financiers had not quite decided upon what they wanted.

Canton.—The railway now under construction from Hankau to Canton passes through two large manufacturing towns Changsha and Heng-choo-foo, and will eventually be connected with the railway system designed for the province of Yunnan. Canton has at present no railway except that to Hong Kong, but it will in time, in addition to these northern and western connections, be linked up with Macao, Amoy and Fuchow, on the coast.

Chinese Turkestan, Tibet and Yunnan.—In the west and south of China the following lines are proposed:—In Chinese Turkestan a line from Lang-chau to Kuldja connecting the provinces Kansu and Sin-kiang; in Tibet a line from Ching-tu to Lhasa; in Yunnan there is already a line from Li-ngan to Laokai, on the Tonking frontier, connected through Hanoi and Namdinh with the coast, in the Gulf of Tonking. A concession has also been given to the French for the construction of the Yunnan-Annam railway, and the English are proposing a line from Yunnan to Burmah. Besides this the French have already completed a line from Chen-nankuan, on the Tonking frontier, to Lung-chau, in the province of Kwang-si, which the Chinese will extend to Nan-ning, and from there to Wuchau, on the West River.

Shanghai.—On the east coast, from Shanghai, there are two lines, one, completed, to Nanking, and the other, which is approaching completion, runs to Hang-chau, Ning-pu and Fenching on the borders of the Chekiang province. This last is, up to date, the biggest work of the Chinese engineers, and it is surprisingly good. The stations are built in handsome style in brick and stone, the bridges are of solid construction and the line is made double throughout. The rolling stock is American.

Nanking.—Nanking, the ornament and pride of the Yangtsi valley, whose silk industry was destroyed by the Tai-ping rebellion, is now reviving under the influence of its railway connection with Shanghai. Opposite to it, on the north bank of the river, is Pukou, the terminus of a line from Tientsin which is now under construction. This line will connect the east coast and northern railway systems. It should be completed early in 1912, and passes through a country rich in coal, hides and other products.

The line from Shanghai to Nanking is of English construction. Surveys have already been made for an extension to Wuhu, about 50 miles. In the course of 5 or 10 years there is little doubt that Nanking will be connected up with Hankau.

Shan-tung.—In the province of Shan-tung the Germans have made a line, 250 miles in length, from Kiau-chau to Tsinan, and a branch, 36 miles in length, to Bo-shang.

Such is the scheme of railway development which, when it is realized, will make China one of the richest countries in the world. That her warlike strength will also revive rapidly is very doubtful. Her conditions of government are difficult and complicated, and her present backwardness leaves her a great deal of leeway to make up.

Railways in Korea.—*Seoul-Wiju Main Line.*—The railway centre in Korea is the capital Seoul. The main lines run to Fusan and Wiju, with branches completed to Chemulpo, Chenampo and Masanpo, and under construction to Kunsan. The extension to Antung and Mukden is being reconstructed to broad gauge. Lines are also projected from Seoul to Gensan, from Ping-yang to Gensan and from Song-chin, through Horiong, to Kirin.

Needless to say Korea owes its network of railways to the enterprise of the Japanese. Their method of construction is so interesting that it deserves to be explained in full detail.

At the time of its construction the Fusan-Seoul main line had extreme importance, for in it the Japanese saw the key to the economic and political occupation of the country. The extension to the Yalu is completed with the exception of a few of the stations.

The line, along its whole length, is broad gauge (5'), well made and fully suited to the heaviest traffic. The bridges and tunnels however are designed for a single line, and complicate the question of the proposed duplication of the line.

During the construction, the Japanese paid chief attention to the line and the rolling stock. They have large Pullman cars for passengers of all three classes, wagons of dimensions and carrying power approximately double those of the Russians, and engines suited to these conditions. The stations were at first temporary, rough, structures, and are being gradually remodelled in keeping with the prosperity of the line. In this way Japan carries forward, in an economical manner, her strategic policy, pushing forward her lines, and afterwards, as they begin to pay, equipping them for commercial requirements.

The line from Fusan to Seoul is 274 miles in length, from Seoul to Wiju 312 miles, and from Wiju to Mukden 190 miles.

At the time of writing, when the reconstruction of the Antung-Mukden line had actually commenced and materials were collected for building a bridge over the Yalu, the strategic importance of the Korean main line was greatly increasing.

It will be possible for the Japanese troop trains to make the uninterrupted journey from Fusan to Mukden in two days, and taking into consideration the size of their wagons it can be seen at once not only how quickly Japanese troops can appear at Mukden, but also how quickly they can concentrate there.

Regarding the proposed lines, that from Gensan to Ping-yang will connect up the eastern and southern coasts of the peninsula and two existing fortresses. The line Songchin-Horiong-Kirin will approach the flank of Vladivostock and might serve as a base for cutting it off from Russia.

Fusan.—The Japanese are making great efforts towards developing the town and port of Fusan, they are constructing a large mole in the harbour, building a wharf and extending warehouses.

Even in its existing state the accommodation allows of six ships being unloaded, simultaneously, directly into railway trucks. When the new work is finished this will be considerably increased.

In connection with the details already given of the lines to Mukden it may be added that the passages from Nagasaki, Sasebo, Moji and Simonoseki to Fusan are each about 12 to 14 hours. The most careful arrangements are made towards facilitating and hastening the transference of troops from the islands to the mainland. In case of war, no time will be wasted in mobilization, but the men will be sent on board unequipped, without transport, provisions, etc., and will find everything necessary for them already in Korea, where equipment, weapons, provisions, stores, etc., are collected in arsenals and stores, distributed all over the country in accordance with the war scheme and the points selected for disembarkation.

Wiju.—The new town of Wiju, which forms the northern terminus of the Korean main line, still presents the unfinished, temporary, appearance which it owes to its hasty construction during the war, with enormous godowns, constructed of various materials, and large levelled spaces. But it has a great future, and is already beginning to show the effects due to the development of the Antung-Mukden railway.

Antung-Mukden Railway.—The Antung-Mukden railway was hastily built by the Japanese during the war, and afterwards secured to them by treaty with China. It is of narrow, 30″, gauge, and looks like a toy railway, with toy trains, no separate classes and no attempt at comfort. None the less the line works, and, at small cost, it was of enormous use to the Japanese during the war. Each truck will carry more than 2 tons of goods, and the small Baldwyn engines will drag as many as 12 trucks on level ground. The line was begun in the summer of 1904, and by October it was completed as far as Finhuangchen; three months later trains were running to Lanshanguan, and went far towards making possible the defeat of the Russians at Mukden.

The country is mountainous and the line has very steep gradients and very sharp curves. The bridges, 20 in number, are made of wood. In certain sections, at the stations Man-tsia-pu, Hziao-gou, Tsiunu-chuan and Tsi-guan-shan, the trains are divided and run in halves. At some of the sharper curves there have been many accidents, and in consequence of the danger, trains are only run by day, and the journey from Antung to Mukden at present takes two days, Tsao-ho-kow station being the halfway house.

In its present state the line is a brilliant example of military engineering but has little commercial value, but in their treaty with the Chinese, the Japanese secured the right of not only keeping up the line in its original state but of adapting it to commercial uses, in other words of reconstructing it into a wide gauge railway of permanent type.

In the reconstruction it has been decided to follow the original direction. The work consists in constructing bridges, excavating tunnels, reducing gradients and widening the track. The length of the reconstructed line will be 170 miles. By the latest information the work was being pressed forward rapidly, 60,000 Chinese coolies being employed, and it was hoped that the sections Mukden–Pensiu and Antung–Kikwanshan would be opened to traffic in the autumn of 1910. The present year should see the whole line completed and also the bridge over the Yalu, and then the journey from Mukden to Wiju could be accomplished in eight to nine hours, and Fusan would be connected with Europe by an uninterrupted line of rail.

In this way Japan, having annexed Korea, will, in the very near future, be able to concentrate her troops at Mukden by means of the two lines from Fusan and Port Arthur. In other words she now stands face to face with Russia, while, as opposed to China, she has already cut her way into the very heart of Manchuria.

Sakhalin.—It remains to say a few words about Sakhalin. The Japanese while colonizing the coasts of their part of the island, have decided to make four railway lines, starting from the old Korsakovsk post, where their civil and military administrations of the island are concentrated. These lines are (1) from Ostamar (Korsakovsk) to Sakaiham; about 24 miles of this line are already completed, and the whole line, about 70 miles, will probably be open in 1913, (2) a line along the west coast covered from the side of the United States of America and (3 and 4) two lines on the east coast covered from the Russians.

As elsewhere, the character of the work shows moderate cost, and no undue haste to obtain luxuries. Compared with Japanese methods, the Americans build rapidly and expensively, the Russians, in the opinion of the author, build still more expensively and astonishingly slowly.

F. E. G. SKEY.

REVIEW.

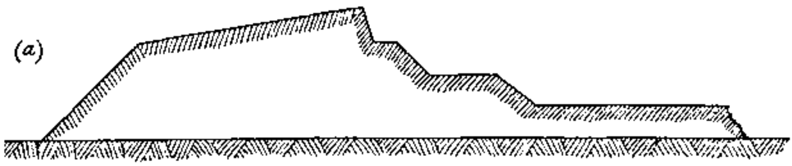
VON BRUNNER'S PERMANENT FORTIFICATION.

(Translated by Capt. R. Walker, R.E.).

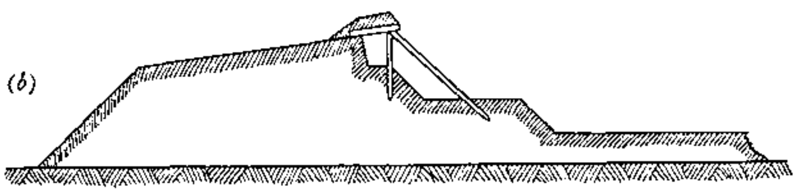
This book, having been recently translated, is now accessible to all R.E. officers, and while all will concur in the general excellence of the work, they will discover during its perusal small problems, the solution of which will be rendered easier by discussion.

The sections of the works given in the plates present one of them. It will be noticed that none of the sections given are suitable for the establishment of overhead cover for the infantry firing line. The general type of parapet shown is that below:—

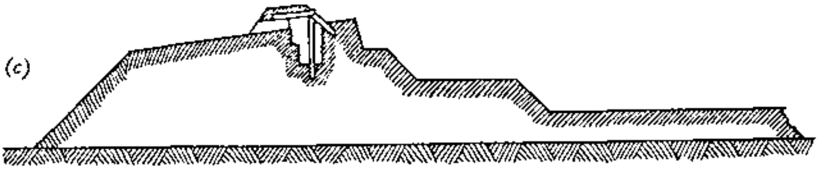
(*a*)



(*b*)



(*c*)



(*a*), shows the parapet without overhead cover.

(*b*), shows the difficulty of establishing overhead cover, the abnormal length necessary for the raking strut rendering it practically impossible to do so.

(*c*), shows an alternative method of establishing overhead cover in an old-fashioned parapet.

The author disposes of the matter in the following words*:—"The whole infantry position might be made of concrete, and shields might be provided as a protection againt artillery fire, but the expense would be prohibitive. Overhead cover against shrapnel bullets and shell splinters for the infantry manning the parapet might be provided, but any such light protection will be completely destroyed during the bombardment which often lasts for many weeks." Now this statement, particularly the latter portion of it, "any such light protection would be completely destroyed during the bombardment which often lasts for many weeks," may be true of the Continent, but is it true of the land fronts of British and Colonial fortresses? Certainly not, that is, if the fortresses on the frontier of India be omitted from consideration. If the land front of a British or Colonial fortress had to undergo a bombardment of many weeks, it would have lost its *raison d'être*, for such a prolonged siege implies a loss of sea command which would in itself render any resistance on the part of the fortress useless. In all probability Great Britain would have been forced to submit to a humiliating peace even before the heavy guns of the besieger could have been placed in position.

From the foregoing considerations we arrive at a conclusion which clearly shows why in small details British should differ from Continental practice. Another case in which this occurs may be mentioned here. As our fortresses are unlikely to be exposed to a prolonged bombardment, armoured casemates and cupolas are unnecessary for the heavier types of howitzers and flat trajectory guns. Armoured cupolas and emplacements however should be provided for the lighter Q.F. and machine guns which are employed for flanking obstacles or for sweeping the intervals between the forts, otherwise a concentrated shrapnel fire from field guns and such siege guns as may be landed, aimed at those sited at critical points, might render it impossible to serve them when the moment for such action arrived.

In conclusion one small criticism of an otherwise excellent translation may perhaps be made. On page 40 of the translation, page 58 of the original the words "Traditor Casemate" occur. What are these "Traditor Casemates"? They are nothing but orillons brought up to date, and why not call them therefore orillons, or perhaps, better still, retired flanks, and avoid adding another expression to those already forming the jargon of a somewhat technical art, a jargon that it is as well to avoid if we wish to be read by the layman or even by the infantry soldier, whose business, amongst others, it may be to defend any land fronts that we may erect.

H. E. G. CLAYTON.

* Page 35 of translation, page 49 of original.

NOTICES OF MAGAZINES.

MEMORIAL DE INGENIEROS.

April, 1911.

The Administration of the *Memorial de Ingenieros* is to be congratulated on the excellent number (containing 280 pages), which it has published in commemoration of the 200th anniversary of the foundation of the Corps of Engineers in Spain.

The number opens with a dedicatory note from the pen of General Don José Marvá in which he briefly sketches the history of the corps from its initiation on the 21st April, 1711, to the present day, and mentions a few of the distinguished names that have adorned its history. Its motto is Onward! ever Onward! and if a halt is made to cast a glance back over the past, it is only with the object of gaining a fresh stimulus to push on towards the future.

Biographies are given of ten notable engineer officers. Of these the most interesting to an Englishman is that of General Verboom, the founder of the corps. This distinguished officer was born at Antwerp in the year 1665, son of Cornelius Verboom, Chief Engineer of the Spanish forces in the Low Countries. His military career commenced in 1674, when at the age of 9 he took part with his father in the defence of Besançon and Dôle. On the 5th February, 1677, he was appointed an Infantry Cadet and in 1684 Volunteer Engineer. In 1691 he was present at the Siege of Mons, fighting under King William III. against the French.

In 1693 on the death of his father Verboom was appointed to succeed him as Chief Engineer, though his army rank was only that of captain of infantry, and two years later he assisted the celebrated Dutch general, Coehoorn, at the Siege of Namur.

After the Peace of Ryswych, signed on the 28th September, 1697, Dutch garrisons were placed in the so-called barrier fortresses of the Low Countries, and consequently the duties of the Spanish Chief Engineer were much lightened, and Verboom, though still retaining that title, was promoted colonel of the Lorraine Regiment of cavalry in 1698.

The death of Charles II. of Spain in 1700 completely changed the European situation, and from that date onwards Verboom, who had previously fought three campaigns on the side of the English, found himself during the remainder of his long life constantly fighting against them.

As the King left no direct heirs, the succession to the throne of Spain was disputed by the Houses of France and Austria. Louis XIV. supported the candidature of his grandson, the Duc d'Anjou, and Maximilian, Elector of Bavaria, who was at that time Regent of the Spanish Netherlands, proclaimed him in Brussels under the name of Phillip V. The Austrian candidate was the Archduke Charles, son of the Emperor Leopold I., and amongst his supporters were England and Holland, the bitter enemies of the French King.

Verboom's first duty was to reorganize the defences of Antwerp, and to this end he built the forts of Dam and Austruweel, with numerous batteries, threw a bridge across the Scheldt, and projected a bridgehead on the left bank of that river. On the 8th February, 1702, he was promoted brigadier-general and two months later he was serving under Vauban at the Siege of Hulst. Shortly afterwards he was in Antwerp when that place capitulated to Lord Cadogan.

During the campaign of 1706 Verboom gained high praise for his relief of Termonde which was being besieged by the Duke of Marlborough, but for some unknown reason, he was arrested shortly afterwards and confined in the Citadel of Valenciennes. He did not, however, long remain a prisoner.

All Phillip's hopes of retaining the Low Countries were dashed to the ground by the defeat of the French Army at Ramillies, and those of his Belgián officers who did not transfer their allegiance to the Archduke, retired to Spain. Amongst them was Verboom, who arrived in Madrid early in 1709. He was at once entrusted with the organization of a Corps of Engineers in the Spanish Army, but as he was ordered to join the troops that were operating on the Portuguese frontier his work was much delayed. On the 18th December of this year he was promoted lieutenant-general, and on the 13th of the following January appointed Engineer General and Quartermaster-General of the Royal armies.

The first Spanish engineer of whom there is any record is D. Pedro Navarro who served in the armies of Ferdinand and Isabella at the end of the 15th and beginning of the 16th centuries. Charles V. employed many Italian engineers, and Phillip II. devoted special attention to engineering matters. The latter monarch acted as his own Chief Engineer, conducted direct correspondence with the engineers charged with carrying out various important works in fortresses, examined their projects and gave them instructions thereon. During the reigns of Phillip III. and Phillip IV. the number of engineers diminished, and during the period of penury which prevailed during the reign of Charles II. the engineer service practically disappeared. Verboom had consequently great difficulties to contend with in organizing a Corps of Engineers, as there were no trained officers in Spain to form the nucleus of the corps. He had therefore to endeavour to obtain from Flanders some of the engineers who had there served under his orders.

On his return from Portugal, he was given but a short rest, and in May, 1710, accompanied the King to Lérida where the army of the Marques de Villadarias was engaged with the Archduke's forces under Count Staremberg. The result of this campaign was disastrous, for on the 27th July Phillip's army was routed at the Battle of Almenara, and Verboom himself was taken prisoner, and confined in Barcelona where he remained until exchanged in March, 1712.

The time spent in prison was not, however, wasted, as he appears to have enjoyed a great deal of liberty and was able not merely to complete his scheme for the organization of the corps but also to reconnoitre the Austrian defences, thus obtaining information which proved invaluable when in 1714 he found himself Chief Engineer of the army which was laying siege to Barcelona. That city was captured on the 13th September of that year by the Duke of Berwick exactly three months after the opening of the trenches, his success being largely due to Verboom's engineering talents.

Verboom's scheme for the organization of a Corps of Engineers was approved by a Royal decree of the 21st April, 1711. It provided for an Engineer General, one Engineer Director for each province, and an establishment of second and third engineers to whom was to be assigned the equivalent army rank of lieutenant-colonel, captain and lieutenant respectively. In making the latter recommendation Verboom remarked that "there was no reason why this class of officer who worked more and was more exposed to the dangers of war than any other should be" deprived of army rank. In war time brigades of from 8 to 10 engineer officers were to be formed under a Chief Engineer assisted by a sub-chief and an adjutant.

In May, 1718, Verboom was appointed Governor of the Citadel of Barcelona, a post which he held for the remaining 26 years of his long life. He was not, however, permitted to remain there in idleness, for in the same year he took part in the expedition to Sicily and was Engineer-in-Chief of the Spanish Army at the capture of the fortress of Palermo and Messina.

In the autumn of 1719 he returned to Spain, to find a fresh change in the kaleidoscope of European politics. Louis XIV. had died four years earlier, and the jealousy which had been smouldering for some time between the Regent Orleans and Phillip V. soon broke into flame. France entered into an alliance with England and Austria and invaded the Peninsula along the roads at both ends of the Pyrenees. The eastern army occupied Seo de Urgel, and Verboom's first task on returning from Sicily, was to assist in laying siege to that fortress. Trenches were opened on the 22nd January, 1720, and on the 29th of the same month the place surrendered. Verboom was appointed Governor of the fortress and lost no time in commencing the reconstruction of its defences. Peace was signed at The Hague on the 17th February, 1720, and Verboom then found time to propose various improvements in the organization of the engineer corps.

His plans were approved, and the establishment was fixed at 1 Engineer General, 9 Engineer Directors, 9 Chief Engineers, 27 Second Engineers, 42 Ordinary Engineers, and 40 Extraordinary Engineers. Engineers Commands were established in the provinces of Andalusia, Extremadura, Castille and Asturias, Galicia, Navarre, Guipuzcoa and Vizcaya; Aragon, Valencia and Murcia; Granada and the possessions in the north of Africa; and Catalonia. A Military Mathematical Academy was also founded in Barcelona under the inspectorship of the Engineer-General.

From 1721 to 1727 Verboom was constantly engaged on tours of inspection, Pamplona, Alicante, Murcia, Malaga, Ceuta, Cadiz and Seville being visited in turn and important works undertaken at each of them. In 1726 Verboom was called to Madrid to advise on the proposed siege of Gibraltar. In January, 1727, he was created Vizconde de Nieuvorde and Marqués de Verboom, and in the same month he joined the army of the Count de Torres before Gibraltar. This army consisted of 30 battalions of infantry, 6 companies of carabineros, 900 cavalry and a siege train of 100 guns with many mortars and 4,000 quintals of powder. The siege commenced by an assault on the Devil's Tower, but the attackers suffered such heavy losses that they were compelled to withdraw, and renewed their attack on the other side of the isthmus. Verboom, at a council of war, held at the end of January, expressed the opinion that any attack on the Rock was doomed to failure unless made in co-operation with a strong naval force, which was not at that time available for the Spaniards. The differences between himself and the Commander-in-Chief became so acute that he was shortly afterwards recalled to Madrid where he remained till the beginning of 1731, occupied amongst other things in preparing plans for the defence of Cuba, Montevideo and Buenos Aires.

In 1737 Verboom was promoted Captain-General, and died in his quarters at the Citadel of Barcelona on the 19th January, 1744, after 70 years of service during which he had taken part in no fewer than 28 campaigns. He was buried in the Church of Saint Catherine, now demolished.

His two sons were both engineer officers, the elder predeceased him by 11 years, and the younger only survived him by a few months.

The most interesting of the remaining biographies is that of General Zarco del Valle who fought throughout the Peninsular War and played a most distinguished part in the reign of Isabella II.

The number closes with a complete list of all other officers of the Corps from its foundation in 1711 to the present time, and also with list of the names, as far as they are known, of the engineers who served in the Spanish Army during the 15th, 16th and 17th centuries.

'M.'

RIVISTA TECNICA DI AERONAUTICA.

July to December, 1910.

There is an interesting account of a voyage of the Italian military airship No. 2 from Bracciano to Campalto from 29th September to 2nd October. This airship has a cubic capacity of about 150,000 cub. ft., a 100-H.P. motor and carries fuel for 20 hours. The car is a real boat suitable for navigation on water.

The envelope is different from former types, being somewhat rounded at the stern, and is divided into eight compartments. The material is different being an experimental rubbered fabric, not covered with aluminium powder.

The speed is about 50 k.m. per hour. The voyage was full of incident.

Near Chiusi a stoppage was caused by the motor heating, the defect being soon put right. At Arerro after five hours' journey a forced landing was made, with the motor stopped owing to a propeller catching in the suspension and being broken. Fortunately the motor was at once stopped or the envelope might have been torn, and a disaster have occurred.

The landing place was inconvenient being heavily wooded, but fortunately a number of peasants were available who saved the ship bumping and took her off to a sheltered spot, where repairs were carried out.

At 9.30 on the 30th the ship started again for Venice and crossed the Apennines without difficulty, though all the ballast and some of the fuel had to be jettisoned, and a descent made for fresh supplies of hydrogen and fuel near Sant' Arcangelo.

A fresh start was made at 12.15 on October 1st, but near Porto Caleri towards evening the slackness of the envelope, due to cold and loss of hydrogen, suggested a further stop.

The last stage (40 k.m.) to Venice was effected on the morning of October 2nd, and she was safely housed in her shed at Campalto.

There is a useful mathematical investigation of the pressure on the supporting surfaces of an aeroplane.

There is a short account of the progress of "aerostation" in Italy in 1910. It has not progressed much in 1909, in which it differs from "aviation," which has made very rapid progress. Important work has, however, been carried out, the military airships have made many useful journeys, a great impetus has been given to the sport of spherical ballooning, and Engineer Forlanini and Count Almerigo da Schio have improved their airships.

At the International Congress held at Verona in May, the following general propositions met with approval, and show in what form we may expect the international character of the air to be treated :—

1. That the atmosphere over the land and territorial waters of every state should be considered as territorial atmosphere subject to the sovereignty of each particular state. Atmosphere over unoccupied lands or free waters should be considered as free.
2. That within territorial atmosphere, the journeys of aerial vessels should be free, subject to such control as is necessary to safeguard public and private interests, and subject to the laws of the nation to which the vessel belongs.
3. That journeys of aerial vessels in free atmosphere, ought, in all important respects, to be regulated by international rules.

Many interesting papers were read at this conference.

The Italian Touring Club has instituted a National Commission of Aerial Touring which has taken up the question of maps for aerial pilots, and that of pilots and control of licenses.

The latter is recognized to be now of great importance. The F.A.I. deals satisfactorily with all members of aero clubs, but has no control over those who are not members, who may be quite unskilled, whose machines may be badly designed and constructed, and yet are able to take up passengers and generally endanger the public.

Laws are necessary on the subject.

A new airship under construction by the Airship Co. "Veeh" at Monaco, is expected shortly to make its *début*. It is a large ship on a new system.

The envelope is about 100 m. long and 16 m. in diameter with a capacity of 13,030 c.m. (about 455,000 cub. ft.). It is constructed of a new material metalled on either side, which renders it waterproof and also prevents the sun's rays affecting the interior gas. The total height of the ship is 25 m. and it has an overall breadth of 18 m.

All the framework is of steel tubing. The car has two towers which extend into the envelope and carries two horizontal screws for raising or lowering the ship vertically.

In all there are eight screws operated by four motors viz.: two 200-H.P. "Wodan" and two 150-H.P. of the same make. They are said to weigh 2 k.g. per H.P. and to be entirely reliable. The anticipated speed is not given, but with this large H.P. is expected to be high.

The ship is to carry 40 passengers, but the length of journey with this load is not stated.

This Review would appear to be badly supported as the months from July to December, 1910, inclusive make only one part of the usual monthly size.

J. E. CAPPER

CORRESPONDENCE.

THE "DRIFT" OF A BULLET.

Dear Sir,

Colonel de Villamil's paper on "Drift" in the March number of *R.E. Journal*, p. 318, line 13 from bottom, says "the point turns out of the plane of the paper and towards the spectator." I am afraid the opposite is the case, as can be verified from any book dealing with rotational dynamics. All photographs of rotating bullets in air show that "the point of the bullet is above the line of the trajectory."

Professor J. B. Henderson, D.SC., in his "Flight of a Rifle Projectile in Air," *Proceedings of the Royal Society A.*, Vol. 82, 1909, shows the gyroscopic action which takes place, and so explains drift and other phenomena of a projectile in air.

Professor Magnus, Berlin, carried out, some 50 years ago, a series of experiments on spherical and elongated projectiles, and he proved that an ogival-headed projectile drifts to the right (with right-handed twist of rotation) provided the point of the projectile be a trifle above the line of the trajectory. Photographs show that this is the case.

CGD being the direction of motion of G, the centre of gravity of the projectile, GAB its axis, the resultant resistance of the air tends to turn the projectile about an axis through G, perpendicular to the plane BGD, in the direction shown by the arrows. If the shot had no rotation, it would fly end over end. But when the shot seen from C has a right-handed rotation about its axis, this motion combined with that which the resistance of the air imparts to the shot deflects the point A as seen from C to the right. In consequence of this deflection of the point A to the right, the resistance of the air acting on the left-hand-side surface of the ogival-headed projectile creates a couple about G whose axis is vertical and right-handed, when looking downwards from C: this couple then, when combined with the rotation of the projectile turns the axis GA of the shot downwards, that is towards the tangent to the trajectory.

C. E. Phipps,
Major, R.A.

The Editor, *R.E. Journal.*

Sir,

I have to thank Capt. Edgeworth for pointing out a foolish mistake I have fallen into. Always repeating an experiment in the same manner, coupled with the impression, apparently shared with Capt. Carey, that it had been found that the bullet drifted "in the wrong direction to suit this theory," is the probable reason for this: though that is no real excuse and I can only apologize for making the statement I did. My line of argument is not materially altered by the change—except that everything must be reversed, "right" for "left," "up" for "down," and so on—the essential being that the gyroscopic action turns the point of the bullet to the left of the trajectory, and that the horizontal component of the resulting resistance, in "hurrying up the precession," forces the point of the bullet vertically towards the line of the trajectory. There is no necessity, of course, to make any assumption that the point of the bullet is *below* the trajectory.

Possibly this is what the writer of the Textbook meant. If so I also am an "uncompromising supporter" of this theory, though I think that the wording of the description leaves much to be desired. Personally I am more interested in the resistance than in the "drift."

I am afraid I cannot agree that Capt. Carey's explanation of a bullet rolling on the air is very simple. The coefficient of viscosity μ is "independent of the density," (Stokes) so the bullet could get no more "grip" on the air if the latter were much compressed.

With regard to C. S. Jackson's letter—no excuse necessary for being a mere student: before Nature we are all students, and poor things at that—there are doubtless many formulæ of the type proposed by me. Newton, Coulomb, Dr. Young and Girard (to name only a few of the most eminent men) employed similar formulæ.

The formula offered by me is intended to include all possible motions of the air. A is the coefficient for all direct motion, B for sinuous motion (eddies, vortices, etc.) and C for all motion due to compression of the air. "Air carried with the bullet" would come under A, which varies as the length of the bullet and as its diameter.

"Potential energy" is a convenient expression which I employed in the sense used by Lord Rayleigh in the formula

$$P_o = p + \tfrac{1}{2}\rho v^2$$

where p = potential energy, or pressure and $\frac{1}{2}\rho v^2$ the kinetic energy, per unit of volume, in all parts of a stream line (*Hydrodynamics*, 1876). When $p = o$, I expressed it as being "exhausted." The bullet "still generates waves," of course, but the kinetic energy generated, per unit of time *remains constant*.

Yours faithfully,

May 8th, 1911. R. DE VILLAMIL.

P.S.—Since writing the above I have been allowed to see a copy of Major Phipps' letter and I thoroughly agree that the explanation given at the end of it appears a correct statement of what takes place, ordinarily. It is, of course, only a good *first approximation*; for the point of the projectile must be describing some sort of a curve (? spiral) and this would tend to cause other minor movements.

May 9th, 1911.

The Editor, *R.E. Journal*.

RECENT PUBLICATIONS OF MILITARY INTEREST.

APRIL, 1911.

(*Published Quarterly*).

THE following extracts from the list compiled by the General Staff, War Office, are published in the *R.E. Journal* by permission of the Army Council.

*PART II.**

SECTION I.

AERIAL NAVIGATION.

THE CONSTRUCTION OF AIRSHIP SHEDS (Luftschiffhallenbau). By Haenig. 170 pp., with numerous diagrams. 8vo. Rostock, 1910. Volckmann. 6s. 6d.

This book, which is written by an engineer, discusses in detail the various systems of construction of airship sheds.

MEANS OF COMMUNICATION IN WAR (Die Verkehrsmittel im Kriege). By Schmiedecke. 363 pp., with numerous maps and diagrams. 8vo. Berlin, 1911. Mittler. 7s. 6d.

This is the second edition of a book originally published in 1905. It has been brought up to date, and a special chapter has been devoted to airships.

BOOKS OF REFERENCE.

THE ARMY ANNUAL AND YEAR BOOK, 1910. By Major B. F. S. Baden-Powell and Lieut.-Colonel H. M. E. Brunker. 384 pp. 8vo. London, 1910. W. Clowes. 7s. 6d.

This volume forms a fairly complete book of reference on matters connected with the Forces of the Crown for 1909 and the first six months of 1910.

Amongst others, the book contains the following articles:—

- Military defence of the Empire and the Imperial General Staff.
- Discipline in the army.
- The military forces of the Crown which includes Lord Kitchener's recommendations for the organization of the forces of Australia and New Zealand.
- The boy scouts.
- The army manœuvres in England, 1909.
- The training of the Cavalry Division in England in 1909.
- Military inventions of the year.

In their preface the authors very briefly summarize the chief events and changes of the year. They conclude by hoping that "readers will offer any suggestions which they think will tend to make the *Army Annual* a thoroughly useful and reliable work of reference on military matters."

* The titles of all books are given in English; this does not indicate that the books have been translated. The original title in the language in which a work is written, if not in English, is given in brackets.

CAVALRY.

Part I. Cavalry Tactics as illustrated by the War of the Rebellion. By Capt. Alonzo Gray, 14th U.S. Cavalry. 187 pp. 8vo. Fort Leavenworth, Kansas, 1910. U.S. Cavalry Association. 5s. 9d.

At first sight this book may appear dry reading—comprising as it does a number of tabulated extracts from official reports and despatches with marginal notes. When gone into, however, it is most interesting. The author has collected a large number of examples from the American Civil War to illustrate various points connected with the armament, leading tactics, equipment, etc., of cavalry in the field. Each point is dealt with separately, and at the end of the extracts he has collected the author gives his own comments.

The book is worth study by officers of mounted corps.

FORTIFICATION AND MILITARY ENGINEERING.

Instructions for the Attack and Defence of Fortresses (Anleitung für den Kamp um Festungen). Official. 95 pp., with 2 sketches. 12mo. Berlin, 1910. Mittler. 10d.

These instructions have been issued to enable officers to study the principles of fortress warfare, and to ensure that the troops are thoroughly trained in peace in the duties required of them in war in the attack and defence of fortresses.

In the short introduction to the book, it is stated that commanders must always bear in mind that a spirit of bold offensive is the best guarantee for success, not only in the attack, but also in the defence.

The first portion of the *Instructions* deals with the attack of the fortress. Here the absolute necessity for the most intimate co-operation of all arms is mentioned again and again. It is pointed out that the infantry is incapable of making any progress or of reaching the final stages of the attack without the closest support of the artillery, and that, in the final stages, the assistance of the engineers alone will render it possible for the infantry to gain a footing in the enemy's final position.

As regards the artillery, care is to be taken that the guns of the attack do not engage in battle unless they are superior in number and calibre to those of the enemy and have sufficient ammunition to carry on the contest.

In the second portion of the book, which deals with the defence of fortresses, the *Instructions* show how advanced positions are likely to play a more important *rôle* than hitherto. The increased range of modern guns will enable the defender to offer a more protracted resistance in his advanced positions, provided the latter are situated within effective range of his main position.

The final decision, according to the *Instructions*, is to be sought for in the defender's main position, in contra-distinction to the French *Instructions* which state that, in the final stages, the troops should retire from their main position, and should await the assault in a position still further back called "la position de soutien."

Both in the attack and in the defence the German *Instructions* deal fully with the latest developments of technique likely to be of special importance in fortress warfare, such as wireless telegraphy, airships, aeroplanes, motors, etc.

Siege Warfare (La Guerra d'Assedio). By Lieut.-Colonel Sachero. 162 pp. 8vo. Turin, 1909. Olivero. 4s.

This study of siege warfare is an epitome of the lectures delivered by Colonel Sachero on this subject at the Italian Staff College. The book is divided into three parts. Part I. is historical, and traces the development of all classes of fortification from the beginning of the century to the Siege of Port Arthur. In Part II. the offensive and defensive weapons used in siege warfare are discussed from a technical point of view. In Part III. the sytematic progress of a siege is discussed clearly and in considerable detail. An appendix contains a useful list of the latest works on the subject in French, German and Italian.

HISTORICAL.

OFFICIAL HISTORY (NAVAL AND MILITARY) OF THE RUSSO-JAPANESE WAR. Vol. I. To the 24th August, 1904. Prepared by the Historical Section of the Committee of Imperial Defence. 566 pp., with 20 plates in the text and case of 18 charts and strategical maps. 8vo. London, 1910. His Majesty's Stationery Office. 15s.

This volume contains an account of the Russo-Japanese War from the opening of hostilities until the end of the first general attack upon Port Arthur on the 24th August, 1904. It deals with both the sea and the land operations. The account is to be completed in two further volumes.

The narrative of the land operations has already appeared in Parts 1, 2 and 3 of the *Official History of the Russo-Japanese War* issued by the Committee of Imperial Defence. The chapters of this work are now reprinted interspersed with naval chapters. Some new material has been added to them, notably the instructions given by General Kuropatkin to General Stoessel with regard to the general line of conduct to be followed by the garrison of the Kuan-tung Peninsula in case of a Japanese landing, and the latter commander's instructions to his subordinates based on them. Panoramas of the Ya-lu, Nan Shan and the Mo-tien Ling have also been added. There has been a slight rearrangement of the original chapters. Nan Shan has now a chapter to itself, instead of being included in the chapter on the landing of the Second Japanese Army; whilst "The Defences of Port Arthur" and "The Capture of Ta-ku Shan and Hsiao-ku Shan," which were separate chapters, now form one.

The chief interest in the volume is therefore naval. Whereas, however, the original military work was purely a narrative of events, the present combined account contains one chapter of 14 pages of "Naval Comments," followed by one of 23 pages of "Military Comments." In these the connection between the sea operations and the land operations is brought out.

The naval narrative is clearly and simply written, and is well illustrated by charts and black and white pictures of the actions. The only expression used which is not likely to be at once understood by landsmen is "blockship" or "block ship" (both versions appear in the book), to mean a vessel used for blocking a harbour entrance.

It is well in these days to be reminded again of the hazardous and uncertain nature of naval war as compared with war on land. In less than an hour's fighting on the 10th August, the after turrets of both the *Mikasa* and the *Asahi* became "silent and the *Shikishima* had one of her foremost 12" guns out of action, reducing the primary armament of the (Japanese) battleships from 16 to 11 guns." At the end of an hour's hard fighting when neither fleet had gained any real advantage, "a lucky shot," as the account truly calls it, killed the Russian Admiral, nearly brought down the foremast of the flagship and in some way interfered with its helm, causing uncertainty and confusion in the fleet, of which the Japanese took advantage. This "lucky shot" was the direct cause of the dispersal of the Russians. Nothing in any way similar could occur in land warfare, except, perhaps, during a night attack, or to a cavalry brigade, were the general commanding and staff suddenly wiped out when the squadrons had been brought within a decisive radius of the enemy's horsemen. In reading the naval narrative one is in fact constantly reminded of the similarities between the action of a fleet and that of a cavalry division manœuvring on a perfectly level plain without chance of concealment or hope of mystifying the enemy.

The most serious misfortune, however, happened to the Japanese fleet when it was, to use military language, within its own lines. On the 15th May two of the six first-class battleships, the *Hatsuse* and the *Yashima*, whilst on blockading duty off Port Arthur, struck mechanical mines and sank. Admiral Nashiba, who was on the former ship, transferred his flag to the despatch vessel the *Tatsuda*, but this vessel went ashore the same evening on one of the Elliot Islands and remained there for a month. "In the early hours of the same day, the Japanese fleet had sustained yet another loss, not on this occasion due to any act of the enemy." The second-class cruiser *Yoshino* was rammed in a thick fog by the *Kasuga* and sank in deep water, only 90 of her crew being saved. "Even this was not the last of the Japanese misfortunes," for on the night of the 17th May the destroyer *Akatsuki* struck a mine and sank immediately. "Thus, in the course of little more than three days, the Japanese Navy had been deprived of two battleships, a second-class cruiser, a destroyer and a gunboat," without having even a Russian dinghey to show on the profit side. As a great critic has pointed out, the lesson for England "is the frightful risk and overmastering anxiety which arise from the maintenance of an inadequate margin of naval strength." Henceforward aggressive tactics on the part of Admiral Togo became impossible.

The chapter of "Naval Comments" is practically wholly devoted to strategy. The only other topic treated in it is the influence of recent inventions. A page and a-half are given to illustrating the extraordinary value of submarine mines. They are stated, in addition to the material damage they actually occasioned, to "have proved most useful in delaying the movements of the (Japanese) enemy and in preventing co-operation between his army and navy," and later to have been "a source of great anxiety to the Japanese." The five 10" guns in the Electric Cliff Battery were "sufficiently formidable to keep the Japanese fleet at a distance of over seven miles." "The value of a few modern guns of high power mounted on shore was thus very clearly proved." It is further stated that "the risks are so great that a fleet will seldom be justified in engaging permanent works." Compared with the submarine mine and the gun, the torpedo "proved a somewhat ineffective weapon." "On the nights of the 23rd June and the 10th August, although a large number of attacks were made under conditions which might be considered favourable to the assailants, and many torpedoes were fired, not a single Russian ship was struck."

In dealing with naval strategy, it is pointed out that "the maintenance of Russian supremacy in Manchuria was only indirectly dependent upon the fleet, since there was a complete line of land communication from St. Petersburg to Port Arthur." On the other hand the island power "Japan was so placed that defeat at sea would have been disastrous, while victory, however complete, was no more than a supremely important step towards the defeat of the Russian Army." It is clear that, as has been said of defensive warfare, naval victories may prolong the agony but they cannot win a war.

It is admitted that Togo's "true *rôle* was in its essence defensive." "From first to last the Japanese naval commanders never forgot that their first duty was to guard the oversea communications of the army." He is praised for his self-restraint and perseverance in sticking to his plan of confining his enemy to Port Arthur and declining, after the heavy losses from accident that the Japanese fleet had sustained in May, to risk his "precious battleships." It is, however, laid down that "It is a cardinal rule of warfare that once battle is accepted no effort should be spared to make the result decisive." "It is conceivable that had Admiral Togo (on the 10th August in the Battle of the Yellow Sea) closed to effective range at the outset, the victory would have been as complete as that of the Sea of Japan a year later."

The chapter of "Military Comments," like that of "Naval Comments," is mainly strategical. Less than four pages are devoted to tactics and of these more than half relate to cavalry. The failure of the Russian cavalry is said to be "not difficult to account for . . . the country was most unsuitable for mounted action; large bodies could always be checked by well-posted infantry, and, at the same time, the Cossacks were practically untrained to act on foot, or in small bodies." The ineffectiveness of the Japanese cavalry is attributed to "faulty organization . . . more than three-quarters of the available mounted troops were tied to the infantry" (as divisional cavalry). As regards the other arms only two points are noticed at this point of the history:—the gradual conversion of the Russian artillery to indirect fire and the bold handling of the Japanese reserves.

It is stated that the "idea which underlay their (the Japanese) land strategy from the outset of the war" was the conviction "that Liao-yang was the point at which the first great battle against the Russian main army would be fought . . . and, true to their German teaching, they resolved that from the first their troops must be deployed in such a way as to enable them to envelop their enemy at Liao-yang."

It is, however, pointed out several pages later that the interest attaching to Port Arthur had a special effect on the strategy. "Be the result of the war what it might in other ways, on one point the mind of the Japanese people was made up, namely, that Port Arthur should become Japanese territory; and it was realized that when the time should come to make peace, it would greatly strengthen the hands of statesmen if the coveted fortress was already in the hands of soldiers and sailors." The problem which arose "as soon as the decision to pursue the double objective had been formed" is carefully examined. The dispersion it imposed is held to have been "to some extent obviated by the landing of the 10th Division at Ta-ku-shan, but still more by the skill with which numbers and intentions were concealed from the enemy."

In strong contrast to the Japanese, whose "diplomacy and strategy kept pace," the Russians are said to have been "completely unprepared. The inevitable result followed. The initiative in the conduct of operations was resigned to the enemy." Their strategy in holding on to Port Arthur is accounted to be correct, because the ships it contained were a constant menace to Japanese communications."

There are 100 pages of appendices. In addition to the military ones which have already appeared, there are naval appendices giving lists of Japanese and Russian war vessels and auxiliary vessels, and of the 67 "merchant vessels seized or sunk up to the 19th August, 1904"; the losses at the Battles of the Yellow Sea and Ulsan (as the fight in which the *Rurik* was lost is now called); and the damages sustained by Russian ships in these battles.

THE CAMPAIGN OF CHANCELLORSVILLE. A strategic and tactical study by John Bigelow, Jr., Major, U.S. Army (Retired). 528 pp., with 44 maps and plans. 4to. New Haven, 1909. Yale University Press. London, Henry Frowde. Oxford University Press. £2 10s.

This exhaustive work on the most dramatic campaign of the American Civil War is the result of a course of study undertaken by the author for the purpose of delivering a series of lectures at the Massachusetts Institute of Technology. He selected this campaign because it "presented a greater variety of military problems and experiences than any other in which an army of the United States has taken part. In no other was there so rapid a succession of critical situations. Moreover no other, approaching it in importance, has been so imperfectly apprehended and misunderstood." As a result of his studies he has produced a work, which, if not the last word on the subject, is far in advance of any earlier book.

DUPLEIX. By Colonel John Biddulph. 178 pp., with an appendix. 8vo. London, 1910. White. 5s.

A concise account of the life of an interesting and striking figure. The author has written without bias, and has presented a faithful and unexaggerated history of the career of the man who first brought India within the scope of European politics.

THE RUSSO-JAPANESE WAR, PART IV. (Der Japanisch-Russische Krieg, IV Teil). By General von Lignitz. 287 pp. (numbered 501–788). Table of contents; list of maps; list of authorities; 19 illustrations in text; 10 sketch maps; 2 sheets of plans; 23 appendices. 8vo. Berlin, 1911. Vossische Buchhandlung. 7s. 6d.

This volume deals with the Siege of Port Arthur from the middle of November, 1904, onward, and with the Battles of Heikoutai, Mukden and Tsushima, and the fighting in Saghalien. The sketch maps and plans show the front of attack at Port Arthur, the 203-metre height (from N.W. and S.E.), and Fort Sung-shu; the fighting at Mukden (several plans); the march of the Japanese 3rd Army (from Japanese sources) between the 26th February and the 10th March; the Malakov; Vladivostock; Harbin; Saghalien.

BUSSACO. By Lieut.-Colonel G. L. Chambers. 260 pp., with maps and illustrations. 8vo. London, 1910. Swan, Sonnenschein & Co. 7s. 6d.

The author briefly reviews the events leading to the battle, and deals in detail with the course of the battle itself. The special feature of the book is the careful study of the ground which it affords by means of a number of excellent photographs.

The description of the battle is put in an interesting way and is easy to follow.

ORGANIZATION AND ADMINISTRATION.

THE MOTOR CAR AND THE ARMY (L'Automobile et l'Armée). By Capt. Vannier, 111th Infantry Regiment. 414 pp., with 60 illustrations and 3 maps. Paris, 1911. Chapelot. 8s.

This is a comprehensive and useful treatise on the military use of motor cars. After giving an account of the history and present position of the question in various foreign countries, of which Germany, England, Austria and Italy have made the greatest progress, the author describes in great detail the machine which the French War Office has purchased and the various trials and competitions for which Government prizes have been offered. He then discusses from the point of view of the French Army the future employment of motor lorries and considers that their use will permit of the suppression of the divisional cattle-park, three-quarters of the supply columns and parks, and one-half of the ammunition columns and parks. But since his calculations require for the French Army the use of 75 "Renard" trains, 4,000 motor lorries, 3,300 light motors and 600 motor-bicycles, it is evident that some years must still elapse before his plan can be brought into practice.

Chapter VI. contains a carefully worked out scheme for the supply of food, ammunition, stores, etc., to an army corps by motor transport, and since the general idea is the same as that in *Un Voyage d'Etat Major de Corps d'Armée*, published in 1908 by Chapelot, we have an interesting comparison between motor and horse transport.

The book will be useful to any officer desirous of studying the problem of motor transport and the administrative services of the French Army.

TRAINING AND EDUCATION.

STAFF RIDES. By Capt. Marindin, The Black Watch. 104 pp. 12 mo. London, 1910. Hugh Rees. 2s.

This is the fifth edition of a useful little book, which is now well known in the Service. The new edition was necessary in order to bring it into line with field service regulations. It is fairly complete and should prove a great help to officers responsible for the direction of staff rides—or staff tours as they are now called in Training and Manœuvre Regulations. The latter manual was not in existence when Capt. Marindin first brought out his book.

THE DEFENCE OF UNITED SOUTH AFRICA AS A PART OF THE BRITISH EMPIRE. Lectures by Brigadier-General G. G. Aston, C.B., with a Preface by General Lord Methuen. 63 pp. 16mo. London, 1910. Hugh Rees. 1s.

Under the above title are printed three lectures and an address by Brigadier-General G. G. Aston, together with a preface by General Lord Methuen, General Officer Commanding-in-Chief, South Africa.

MISCELLANEOUS.

THE PATHAN BORDERLAND. By C. M. Enriquez, 21st Panjabis. 141 pp., with a map and appendix. 8vo. Calcutta, 1910. Thacker. 6s.

An interesting little book, in which the author gives a good deal of useful general information concerning the frontier tribes who inhabit the districts adjacent to our Indian border-land, from Chitral to Dera Ismail Khan.

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