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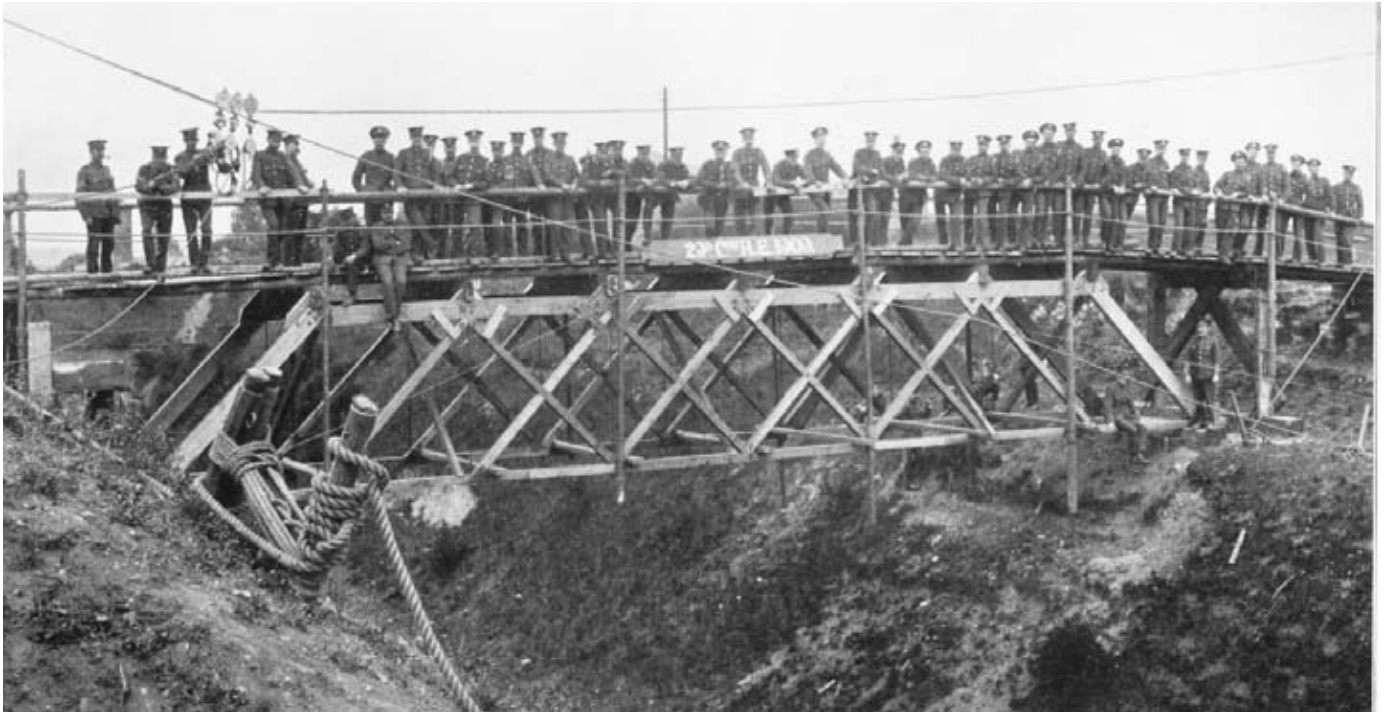
Stone, in Escarp Wall at Athlone, showing Incised Plan of Castle.

THE FYERS FAMILY



LIGHT GIRDER BRIDGE

A LIGHT GIRDER BRIDGE.

By Capt. G. R. Pridham, R.E.

The following short description of a bridge made by the 29th (Line of Communications) Company on its annual course in 1909, may prove of interest, and though the conditions under which it was made are perhaps not applicable to most companies in war, cases may arise in which similar conditions will prevail.

A line of communications company establishes a strong "workshops section" at railhead, and its equipment includes plant for erecting a fairly complete workshop. This workshops section can complete a job for which machinery is required, and the finished material is then sent out for erection either by its other sections or by other companies. Although under ordinary circumstances a field company would not have the advantage of such a section, it might possibly take over an existing shop, and thus be able to construct a bridge similar to the one described below.

In the present instance, as there are no detailed standard designs laid down for light girders—and only light girders could be erected away from a railway—the dimensions, etc., were worked out from first principles, so as to be as light as possible. It will be seen that no heavy parts are required, and every piece could easily be carried in a wagon or cart. The erection too only requires light spars, which could be transported in the same way. For this reason such a bridge might be well worth making up and sending out for erection in a wild and treeless country.

The bridge is designed to carry infantry in fours, crowded at a check, and will also take a concentrated rolling load of $2\frac{1}{2}$ tons distributed on two pairs of wheels.

The drawings (see *Plate*) were put into the hands of the carpenters and smiths. Materials were all drawn in bulk, *i.e.*, the timber had to be sawn, and all bolts, ties, etc., made out of round iron. The remainder of the company worked on the site, where footings had to be prepared and arrangements made for launching the girders. A small sheers 15′ high was put up on each bank, and a 3″ steel wire rope stretched across the gap. Behind these sheers

a derrick was erected on each side to hold the head and tail of the girder.

Each girder weighed about a ton, and had to be very carefully handled to avoid distortion. The launching presented little difficulty. Three travellers were rigged to the steel rope, and to each traveller a block and tackle was fixed. The girder was slung to the travellers in three places and, when it had been hauled out, was lowered on to its footings.

Each girder was fitted carefully in the workshops, and the pieces which came together were lettered, so that they could be put together quickly on the site. By the end of the fourth day both girders had been made, transported to the site, and launched into positions. Distance pieces were then put on at every joint in the bottom boom, and the sleepers which were used as road transoms, were laid and fixed to the joints of the upper boom. Diagonal struts were nailed between the girders to stiffen the bridge.

The roadway was finished as for an ordinary field bridge. A camber of 2″ had been put onto the girders when the tie rods were screwed up. The bridge was loaded to its full working load of 5 cwts. per foot run, and this took about 1″ off the camber. No sign of weakness was seen in any part under the load.

Some of the work may appear to be too elaborate for a field bridge, and no doubt various expedients may suggest themselves for the joints. These latter must however be perfectly rigid.

The excuse for putting forward this bridge is that the subject of really light girders has not been much studied, and this experiment may therefore prove useful.

The following are the detailed calculations for the bridge :—

Span.—52′.

To carry infantry in fours, crowded at a check, and carriages, up to a weight of $2\frac{1}{2}$ tons, distributed on two axles.

The depth between bottom edge of top boom and top edge of bottom boom is fixed at 6′ 6″, and this is also the width of panels from centre to centre of tie rods.

From simple stress diagrams we arrive at the stresses in each member as follows. It is also found that the four centre panels need cross-bracing.

Maximum compression top boom ...	...	...	8	tons.
,, tension bottom boom ...	...	...	8	,,
,, ,, in tie rods ...	...	...	$2\frac{1}{2}$	,,
,, compression in struts ...	...	...	4	,,

Top Boom.—Considered as a column.

Reference, *Principles of Structural Design*, Part I., p. 160.

$$P = \tfrac{1}{3} r_c \times A, \text{ from Formula (4)};$$

$$l \text{ is } 6' + l = 4''.$$

$$P = 8 \text{ tons}, \; r_c = 5{,}400 \text{ lbs.},$$

or $\tfrac{1}{2}$ ton, with a F. of S. of 4 to 5.

Assume the breadth of the strut to be $4''$.

Then $$8 = \tfrac{1}{2} \times \tfrac{1}{3} \times 4d.$$

$\therefore$ $$d = 8''.$$

For Struts.—Taking the cross-bracing as struts fixed at the centre where they cross. From Formula (3), reference as above,

$$4 = \tfrac{5}{6} \times \tfrac{1}{2} \times 4d.$$

Taking the breadth to be $4''$,

$$d = 2\tfrac{1}{2}'' \text{ approximately.}$$

For the end strut, which is not braced, from Formula (4), reference as above,

$$4 = \tfrac{1}{2} \times \tfrac{1}{2} \times 4d.$$

$\therefore$ $$d = 4''.$$

Bottom Boom.—Tensile strength for red pine = 12,000 lbs. Sectional area with a F. of S. of 5 is

$$\frac{8 \times 2240 \times 5}{12000}$$

$$= 8 \text{ sq. ins.}$$

Tie Rods.—Tensile strength for W.I. = 22 tons. Sectional area with a F. of S. of 5 is

$$\frac{2\tfrac{1}{2} \times 5}{22}$$

$$= \cdot 57 \text{ sq. ins.}$$

For convenience of jointing, some of the members are made of larger dimensions than is necessary for strength.

The calculations for each important joint were also carefully worked out, and for these a table in Hurst's "Architectural Surveyors' Hand Book," p. 44, was used, which gives the compression required to compress wood $\frac{1}{20}''$. Anything beyond this would lead to distortion of the girders.

The holding power of nails given in "Notes on Building Construction" (Rimington) is also a useful fact in a rough job of this kind.

GENERAL PRINCIPLES OF ORGANIZATION AND EQUIPMENT, ROYAL ENGINEERS.

INTRODUCTION.

IN the May, June, and July numbers of the *R.E. Journal* of 1896, Colonel (then Major) G. H. Sim contributed a most valuable article on the "General Principles of Organization and Equipment, Royal Engineers." So many changes have taken place of late years not only in the organization of the Corps itself but also in the composition and equipment of the various units, that the details given by Colonel Sim are now of little practical use; but as the paper for many years proved of such value, its complete revision has been suggested.

This has now been done, the C.E., Aldershot, kindly undertaking the revision of the Field Units, and the D.G.O.S. having corrected those of the Survey Companies. The portion referring to recruiting, mobilization, etc., has also been carefully revised, but as regards the latter, constant changes are made in the regulations and reference should therefore be invariably made to mobilization regulations, field army tables, etc.

It has not been possible, unfortunately, to follow strictly on the lines of the original article, which dealt with the subject in the following order :—(1). General scope of duties. (2). Establishments. (3). Organization and duties in connection with Engineer services in peace. (4). Regimental organization and equipment for peace and war. (5). Conditions of service and enlistment. Both Nos. (1) and (3) of these are dealt with in the "Regulations for Engineer Services," which is at present under revision, and it is proposed therefore to deal with them later on.

I. ESTABLISHMENTS.

In the "Army Estimates" of 1909–10 the Corps of Royal Engineers is given as consisting of 1,051 officers and 8,739 warrant officers, N.C. officers and men.

The *Regimental Establishments* of the Corps comprise the following units (see "Regimental Establishments, 1909–10") :—

(*a*). Field Troops		5
(*b*). Field Companies		15
(*c*). Bridging Trains		3
(*d*). Telegraph Companies :—		
(1). Air-Line Companies...		2
(2). Cable Companies		2
(3). Divisional Companies (including 3 Cadres)		7
(4). Wireless Companies...		1
(5). K Company (Postal Telegraphs)		1

(*e*). Balloon School... 1
(*f*). Searchlight Company... 1
(*g*). Railway Companies 3
(*h*). 29th Fortress (Line-of-Communication) Company... 1
(*i*). Fortress Companies—Home 13
" Coast Battalion 2
" Abroad 15
(*j*). Survey Companies 3
(*k*). Depôt Companies (1) at Chatham 9
(2) at Simla 1
(*l*). Training Depôt for Field Units 1
(*m*). Colonial Survey Section 1
(*n*). Instructional and Supernumerary Staff and Permanent Staff for Special Reserve and Territorial.

The following table gives the numbers in the *Army Estimates*, 1909–10, pp. 12, 18, and 24 :—

Unit.	W.O.'s, N.C.O.'s, and Men.	Horses & Mules.
1. Field Troops 5	344	260
2. Field Companies 15	2132	330
3. Bridging Trains 3	24	—
4. Telegraph Companies 11	800	336
5. Balloon School 1	137	36
6. Searchlight Company 1	88	45
7. Railway Companies 3	229	—
8. Fortress (Line-of-Communication) Company 1	60	—
9. Fortress Companies 28	2506	—
10. Coast Battalion Companies ... 2	90	—
11. Survey Companies... 3	342	—
12. Depôt Companies, Fortress ... 9	880	—
13. Field Depôt 1	262	76
14. Colonial Survey Section 1	4	—
15. Regular establishment for Royal Reserve Engineers...	46	—
15. Staff for Colonial Garrisons, Works Services, etc.	718	—
15. S.M.E., etc.	55	—
15. War Office and General Requirements...	22	—
15. India	3	—
Total	8742	1083
Fortress Companies—Hong Kong	50 } Natives.	
Sierra Leone ...	45 }	

Unit.	Officers.	W.O.'s, N.C.O.'s and Men.
Home :—		
Including Regular Establishment of Special Reserve, Permanent Staff of Militia and Territorial Force ...	492	6650
Colonies and Egypt :—		
Including Permanent Staff of Militia	183	2247
India	376	3
Total	1051	8900

Indian Establishment.—There are, besides the above, the following units on the Indian Establishment, composed and officered by natives, but under the command of R.E. officers, and with a few warrant and N.C.O.'s from the British Establishment :—

1st (Prince of Wales') Sappers and Miners :—6 Companies, Pontoon, Mounted, and Telegraph Detachment, 1 Depôt and Experimental Balloon Section.

2nd (Queen's Own) Sappers and Miners :—7 Companies and 2 Depôt Companies.

3rd Sappers and Miners :—7 Companies and 2 Depôt Companies.

Railway Companies :—2.

II. Regimental Organization and Equipment for Peace and War.

The Regimental Establishment units have been already mentioned on p. 317.

They are for the most part organized for supplying the details necessary for active service, but are also arranged that their services may be utilized to the utmost in technical employment during peace.

FIELD TROOPS.

There are at present five field troops, one each at Aldershot, Canterbury, the Curragh, and Chatham, and one in South Africa. The four troops at home are allotted on mobilization to the cavalry division of the Expeditionary Force as Divisional Engineers, with the officer commanding R.E. troops and companies as Commanding Royal Engineer of the division. During peace, each troop is attached to one of the brigades of the division, for its own training and for the instruction of the cavalry pioneers of the brigade.

Establishment.

	Officers.	N.C.O.'s & Men.	Horses.	Vehicles (Peace and War).	No.
Peace ...	3	69	52	Double tool carts	2
				Spring wagons	2
				G.S. wagon	1
War ...	3	78	81	Boat wagon	1
				Water cart	1

A field troop is organized into half-troops. About half the sappers are mounted, the remainder being carried in the spring wagons.

The duties of field troops in war with the cavalry division are mainly :—

Demolition and hasty repair of bridges, railways, and telegraphs; hasty field defences; passage of rivers and obstacles; water supply and camping arrangements.

Assistance in carrying out these duties may be obtained from the cavalry pioneers, of whom there are at least 12 in each squadron.

Principal Tools and Stores.

	No.		No.
Anchors, boat, 46 lbs. ...	1	Detonators, electric, No. 8	250
Axes, felling	26	Exploders, dynamo ...	2
„ pick	40	Forge, field	1
Bags, sand, common ...	264	Fuze, safety, fathoms ...	96
Bars, boring	6	Guncotton, dry primers, 1 oz.	480
„ crow	6	„ wet, slabs, 15 ozs. slabs	280
Blocks, tackle, 1¾" cordage	10	Hooks, bill	19
Boats, collapsible, bow, sections	2	Lashings, tarred	55
Boats, collapsible, stern, sections	4	Pumps, lift and force ...	2
Boats, collapsible, oars	12	Saws, cross cut	2
Boats, collapsible, skids, raft ...	2	„ hand	16
Boats, collapsible, „ ramp ...	2	Shovels, R.E.	39
Cable, electric, D.14, yds....	1000	Telephone, sets	3
„ D.15, „ ...	660	Troughs, waterproof, 600 gallons	2
Cordage, hemp, fathoms ...	359		
Cutters, wire	18		
Detonators, electric, No. 13	100		

The tools and demolition equipment are carried in the two double tool carts and on five pack animals. The canvas boats each consist of three folding sections, and with the superstructure are capable of making up one raft to carry any gun or vehicle with the cavalry division.

A new equipment, with a steel punt and air-bags with raft superstructure, is now under trial.

FIELD COMPANIES.

Field companies now form part of the divisional troops, two being allotted to each of the six divisions of the Expeditionary Force, and these, together with the divisional telegraph company, are under the command of the Divisional C.R.E.

Of the 15 field companies 12 are thus accounted for; the remainder are abroad—two in South Africa and one in Egypt. The stations of home companies are as under :—

2 companies with	1st	Division,	Aldershot and Bordon.
2 ,,	2nd	,,	Aldershot.
2 ,,	3rd	,,	Bulford.
2 ,,	4th	,,	Shorncliffe and Colchester.
2 ,,	5th	,,	Curragh.
2 ,,	6th	,,	Kilworth and Cork.

The establishment is as follows :—

	Officers.	N.C.O.'s and Men. Mounted.	Dismounted.	Horses.	Vehicles.
Peace	3	26	116	25*	13
War	6	49	157	73*†	13

and in addition, when mobilized, 1 A.S.C. driver for the water cart and 2 rank and file, R.A.M.C., for water duties are attached.

The vehicles consist of :—

4 double tool carts.
4 forage carts.
1 G.S. wagon.
2 pontoon wagons.
1 trestle wagon.
1 water cart.

All the above, except the water cart, are 1st line transport.

At war strength, the company consists of headquarters and four sections. The former comprises the major, captain, staff-sergeants, trumpeter, bugler, shoeing and carriage smith, and five sappers. The vehicles attached are the G.S., pontoon, and trestle wagons, and water cart.

Each section is commanded by a subaltern (one horse), and consists of 1 sergeant and 36 dismounted rank and file, 6 mounted men

* Includes officers' horses.
† Includes 2 horses for water cart.

(one riding horse), 9 horses (of which one carries pack equipment), 1 double tool cart (four draught horses), and 1 forage cart (two draught horses), so that each section may be regarded as self-contained as regards its transport, and can be readily detached for special duty.

In the tool carts are packed entrenching and carpenters' tools, explosives, regimental reserve S.A.A., water supply stores, blocks and tackle, cordage and small stores. The forage carts contain also some explosives and heavier tools, but chiefly serve to carry rations, forage, blankets, camp equipment, etc., sufficient for the wants of the sections. The pack gear consists of explosives and tools necessary for demolitions. Similarly, the G.S. wagon provides for the requirements of the headquarters, carrying in addition artificers' tools and materials for repairs, a forge, signalling and sketching equipment, quartermaster's stores, etc., etc.

The bridging equipment comprises two pontoons and two Weldon's trestles, and is sufficient to provide 60′ of medium bridge, or two trestle piers and a raft of two pontoons.

All the equipment, except the explosives, is in company charge, though the special requirements for mobilization are stored apart. The explosives are in charge of the A.O.D., and stored ready for immediate issue; thus when orders for mobilization are received the stores are on hand, and practically nothing has to be indented for from the ordnance stores.

The equipment of a field company is sufficient for it to undertake any small engineering operation which may be required, such as construction of field defences, blockhouses, small repairs to roads, bridges, and railways, demolitions, crossing small streams, and so on; but the tools are necessarily limited, and for large works and extensive repairs resource would have to be made to the A.O.D. for additional tools and materials. The two field companies carry sufficient water supply gear for a division.

Since the abolition of the Bridging Battalion and introduction of bridging trains an important duty has fallen upon the field companies; they will now be responsible for the construction and maintenance of pontoon bridges, the bridging trains only supplying the material.

The composition of a field company, as regards its *personnel* and transport and stores, is set out in detail in the *Manual for Field Service*:—*Engineers. Field Company.* 1908.

In peace time field companies are kept pretty busy most of the drill season with musketry, fieldworks, and pontooning, and with manœuvres, which they carry out with their respective divisions. The officers, in addition, have generally district work under the Divisional C.R.E., and the men, when not being trained as above, are employed in the sub-district workshops and on the works.

The chief stores and tools with a field company are shown below:—

Sandbags	852	Pontoons, bipartite, complete	2
Fuze, safety, No. 9 ... fthms.	224	Weldon's trestles	2
Guncotton, 1 oz. primers ...	720	Baulks	21
„ wet slabs, 15 oz.	560	Chesses	70
Detonators, No. 8	400	Cable, electric, unarmoured yards	1760
„ electric, No. 13	200	Heliographs, 5″	2
Exploders, dynamo... ...	4	Signalling lamps, "B" ...	2
Holdalls, tool, R.E., with carpenters' and smiths' tools	8	„ glass	8
Holdalls, saddlers'	1	Grindstones	5
Axes, felling	48	Field levels...	4
„ hand	28	Cordage, white, 2″ ... fthms.	224
Pickaxes, 8 lbs.	19	„ „ 1½″... „	280
„ 4½ lbs.	89	Pumps, lift and force, to lift 60′, complete with hose	4
Shovels, R.E.	113	Hose, delivery, spare ...	8
Spades, Mark III.	19	Troughs, 600 gallons, waterproof, with stand or pickets	4
Bars, boring, 1½″ × 4′ long ...	8	Saws, cross-cut, 5′... ...	4
„ 1½″ × 2½′ „ ...	12	„ hand	27
„ crow, 4½′	8		
Billhooks	40		

and a large number of other tools and materials and small stores.

BRIDGING TRAINS.

Two bridging trains are included in the army troops of the Expeditionary Force. The war establishment of a bridging train provides for the necessary mounted men and horses for transport of the bridging material, and includes a small proportion of dismounted artificers for carrying out repairs to the equipment.

War Establishment of a Bridging Train.

Officers.	N.C.O.'s and Men.		Horses.	Vehicles.	No.
	Dismounted.	Mounted.			
7*	22	202	331	Pontoon wagons ...	32
				Trestle wagons ...	8
				G.S., R.E., wagons ...	4
				Maltese cart	1
				Water cart	1

* Includes 1 medical officer and 1 veterinary officer.

The full equipment for the two trains is maintained in peace, and is available for the training of field companies in pontooning.

The peace establishment of *personnel* consists of three cadres, each of 1 company quartermaster-sergeant (mounted branch) and 7 artificers.

The 1st and 3rd cadres, with equipment for the 1st Bridging Train, are at present stationed at Aldershot and Christchurch, and the 2nd cadre and equipment for the 2nd Bridging Train are temporarily at Chatham and Limerick, but are intended for the Irish Command.

Mounted cadres for the two trains, each consisting of 2 sergeants, 1 corporal, and 1 second corporal, are also maintained in peace, and are attached to the Training Depôt at Aldershot.

The equipment of a bridging train consists of 32 pontoons and 32 bays of superstructure, carried in 32 pontoon wagons; also 16 trestles and 8 bays of superstructure, carried on 8 trestle wagons. This provides sufficient bridging material for 200 yards of medium bridge. Artificers' tools and material for repair to the equipment are carried in the G.S. wagons.

AIR-LINE TELEGRAPH COMPANIES.

The two air-line companies are allotted to the army troops of the Expeditionary Force. One company is stationed at Aldershot, and the other at Limerick.

Establishment of an Air-Line Telegraph Company.

In	Officers.	N.C.O.'s and Men.	Horses.	Vehicles.	No.
Peace ...	4	129	52	Air-line wagons ...	12
				Cable wagons ...	3
				Light spring wagons	3
War ...	6	217	158	G.S., R.E., wagons ...	4
				Water cart	1

The company is organized in headquarters and three sections, with a subaltern in charge of each section. A section is subdivided into two detachments, with a senior N.C.O. in charge of each detachment.

The peace establishment provides for a headquarters and three sections—(four detachments; Nos. 1 and 2 Sections have only one detachment)—and, in addition, for the clerks and linemen required for the maintenance of 8 telegraph offices and 80 miles of line. The war establishment provides for a headquarters and three sections—(six detachments)—and, in addition, for sufficient *personnel* to maintain 12 offices and 120 miles of line.

A detachment has two air-line wagons, each equipped with 5 miles of air line, 1 second-class Morse office, and tools for 1 lineman. One of the two wagons also carries a complete set of construction tools for the working party. Each section has a cable wagon, carrying 8 miles of cable and 2 vibrator offices, but no *personnel* additional to the air-line detachments is provided for its laying and maintenance.

The total equipment of the air-line company comprises 60 miles of air line and 24 miles of cable, with 12 second-class Morse and 6 third-class vibrator offices.

General Employment.—During active operations air-line companies provide telegraph communication between the advanced depôt and C.-in-C., and between the C.-in-C. and any force acting independently along a line of communication of its own. It is their duty, in conjunction with the cable companies, to arrange that at the close of a day's operations the headquarters of the C.-in-C. are in communication with the most advanced Line-of-Communication Telegraph Company's Office.

They are also required to replace cable communications during sieges or prolonged operations.

Rate of Progress.—The rate of progress of air line varies from ½ mile an hour in close country to 2 miles an hour in open country. Assuming that the rate of advance of an army is 15 miles a day, four air-line detachments would be required for the erection o the line.

CABLE TELEGRAPH COMPANIES.

There are two cable telegraph companies provided for in the establishment of the Expeditionary Force, both of which are allotted to the army troops, their function being to keep the C.-in-C. in the field in telegraphic communication with the general officers commanding divisions.

In peace, the 1st Cable Company is stationed at Aldershot, and the 2nd Cable Telegraph Company at Limerick.

Establishment of a Cable Telegraph Company.

In	Officers.	N.C.O.'s and Men.	Horses.	Vehicles (Peace and War).	No.
Peace ...	3	72	46	Cable wagons ...	9
				Light spring wagons	9
War ...	6	166	123	Water cart	1

The company is divided into headquarters and four sections, each section being further subdivided into two working detachments. Each detachment consists of about 15 N.C.O.'s and men, and has 1 cable wagon and 1 light spring wagon and material for laying down and working a line of cable 10 miles long. Each line is equipped with 1 stationary office for the starting point, 1 movable office in the cable wagon, and a third office in the light spring wagon. The peace establishment of *personnel* and horses provides for four detachments only, which is sufficient for laying down and working a length of 40 miles of cable.

The unit at war strength consists of the headquarters, to which one detachment is allotted, and four sections. This provides for laying and working a line 90 miles long.

The cable wagons are of the limber type, each carrying 8 miles of D. 14 cable. The limber boxes are fitted to carry the office sets and stationery, and 24 light poles for forming "crossings" are carried on the rear carriage. The light spring wagons carry kits, rations, and spare stores, including 2 miles of cable and a spare office set.

DIVISIONAL TELEGRAPH COMPANY.

There are for war seven of these companies. They are responsible for the internal telegraph communications of an infantry division. Each company is divided into three detachments. The working detachment consists of 1 cable wagon and 1 light wagon, 7 mounted and 6 dismounted N.C.O.'s and men, 4 riding horses, and 6 draught horses. A cable wagon carries 8 miles of cable and 2 third-class telegraph offices (vibrator sets), and the light wagon carries another 2 miles of cable and a third telegraph office, in addition to miscellaneous stores, food, and forage for the detachment.

In daylight, under ordinary circumstances, the rate of laying cable is from 3 to 5 miles an hour, but for short distances, on fairly straight roads on open country, the pace can be increased to the rate of 10 or 12 miles per hour. By night 2 miles an hour is a good average pace.

The cable is laid by pulling it off the drum by hand, but is picked up automatically by the drum being made to revolve by the wheels of the wagon.

Establishment of a Divisional Telegraph Company.

In	Officers.	N.C.O.'s and Men.	Horses		Vehicles (Peace and War).	No.
			Riding.*	Draught		
Peace ...	1	34	9	13	Cable wagons ...	3
War ...	2	57	21	20	Wagons, light, spring	3

* Includes officers' horses.

In peace only four of these units exist, one each with 1st (Aldershot), 3rd (Bulford), and 5th (Limerick) Infantry Divisions, and one in South Africa; the other three consist of a cadre only, viz., one sergeant, and have all their equipment in mobilization stores.

The composition of a divisional telegraph company is set out in detail in the *Manual for Field Service:—Engineers. Divisional Telegraph Company.* 1908.

(*To be continued*).

TRAINING OF TERRITORIAL FIELD COMPANIES, R.E.

By MAJOR G. WALKER, R.E.

CAPT. BRUNNER'S article, in the July number of the *R.E. Journal*, has dealt with this subject on broad lines, and his remarks are generally just and true; but he appears to have overlooked a great deal of the preliminary work which is necessary to make an efficient field unit. His remarks will no doubt commend themselves entirely to most of the people concerned, as they deal alone with the interesting part of a Sapper's training, and leave out all the drudgery.

It is conceivable and pardonable in a man who gives practically the whole of his spare time to the King's Service, to desire that the work he does in that time should be such as to catch the public eye; but we Regular soldiers shall be failing very much in our fraternal duty towards the Territorial Force if we in any way deceive them, not only as to the end they should aim at, but also as to the means, no matter how minute, which our experience has taught us should be employed to gain that end.

The first thing that an officer of a Territorial Field Company, R.E., has to learn is military administration and internal economy. The care, feeding, and clothing of his men, the care and feeding of his animals, care of saddlery and equipment generally, are matters which possibly do not, at present, receive due attention. The next points are musketry and drill; and then we come to the combination of all the "home" teaching in march exercises—how in other words to get the unit from "here" to "over there."

The Territorial unit has in the past been accustomed to standing camps, with everything not only provided, but in fact most comfortably provided—large Officers' and Sergeants' Messes, with acetylene light, etc., and so forth. What they have to learn is to fend for themselves, unit by unit, without anybody's help. If these units are not mobile and thoroughly self-contained, they will never have an opportunity of thinking out or working out tactical problems with the other arms.

Having trained the officer, the N.C.O.'s and men come next. Their first lesson should be to realize the necessity for unquestioning loyalty and obedience to their superiors; they must then be taught to look after themselves, their animals, and equipment. Their civil trades will require little consideration, except that in organizing

the company each section should have a due proportion of the useful trades.

Having now welded an aggregation of intelligent artizans into a self-contained and self-supporting military unit, and having taught it the rudiments of its military work, an advance may be made, and the object for which all this troublesome work has been undertaken—namely, the work of a Royal Engineer company in war—may be dealt with more particularly, although it should never have been lost sight of during the early teaching.

People seem to differ in their methods of expressing what the duties of the Corps are; but they may be summed up in the term "general usefulness." Engineers are an auxiliary arm; their duty is to help, and their knowledge and training should be such as to enable them to apply their technical knowledge to the solution of such military problems as may arise, both for other people and for themselves.

The skilful direction of the men's efforts must depend upon the knowledge of the officers of tactical methods, combined with engineering skill, as described in Capt. Brunner's article. In the latter also it is suggested that R.E. duties in connection with camps and communications are of minor importance "relatively." The reservation is a just one, but it seems a dangerous policy to label any work as minor: communications have been before now of dire importance.

As stated above, nothing should be slurred over. If these units are to be properly taught, they must be taught to work without considering the relative attractiveness or otherwise of the various subjects.

A word may be added regarding the formation of clubs. These institutions are most desirable in order to allow officers of different branches to interchange ideas and to learn to look at war from different points of view, and it is to be hoped therefore that funds may eventually be found for their provision in all the larger Territorial centres.

TERRITORIALS OF EARLY ROMAN AND MEDIÆVAL TIMES.

By Colonel O. E. Ruck, late R.E.

In the August issue of the *R.E. Journal*, Colonel S. A. E. Hickson, D.S.O., R.E., contributes a valuable analogy with reference to the similarity of the Roman Republican constitutional methods instituted by Servius Tullius, Circa 440—400 B.C., by which the people, divided into centuries of their classes, gave their votes, to a somewhat similar system in vogue during Anglo-Saxon and up to mediæval times in this country.

It is claimed that effective and victorious national armies were raised under these systems, the chief influence in the national assemblies resting with those who, having an appreciable stake in the country, were patriotic, gave personal service, and, whilst being responsible, were invested with authority above their fellow citizens proportionately to the valuation of their estates.

Taking the quotations from Mommsen as authoritative, it may be helpful, by way of amplification, to refer to those of the early writers, from whose works some of Dr. Mommsen's erudite information may have been derived.

Turning to Varro, it would appear that conjointly with the *jus militiæ*, or the right of the early Roman citizen to take up arms in attack or defence of his country, there existed also the *jus tributorum*, or the right to pay for his own services, together with those of others; this contribution, or personal allowance, was exacted from every individual throughout the tribes called up for service, in due proportion to the Government valuation of his estate (*pro portione census*).[1]

There were three kinds of tribute :—

(A). One imposed equally on each person (*in capita*), which was the system under the first kings.[2]

(B). Another (*pro ratâ*) on the valuation of their estates, this being called (*ex censu*).[3]

(C). A third kind (extraordinary), demanded only in case of dire necessity (*temerarium*), therefore dependent on no fixed rules.[4]

[1] Varro de Ling., Lat., IV., 36. [2] Dionys., IV., 43. [3] Livy, I., 43, IV., 60; Dio., IV., 8, 19. [4] Festus.

This latter kind (C) is reported in Livy, XXVI., 36, as being in many cases voluntary; but when bestowed, a note was made for future consideration that when the Treasury was again enriched, as indeed happened after the second Punic War, the loan might be repaid in full.

After the expulsion of the kings however, the poorer citizens were for some time freed from the burden of taxes until the year A.U.C. 349—B.C. 404, when the Senate decreed that pay should actually be given out by the Treasury to those of the poorer citizens who had hitherto served at their own expense, whereupon all ranks, rich and poor, high and low, were forced to contribute, according to their fortunes, for the pay, while serving, of themselves and their brother soldiery.[1]

This continuity of financial policy did not however endure much longer than a space of 230 years, for in Cicero, Offic. II., 22, we read that in A.U.C. 586—B.C. 167 annual tributes were generously remitted by reason of the immense sums reaped in by the Treasury, owing partly to the aggressive possessive strategy of L. Paullus Æmilius, after the defeat of Perseus, this immunity from taxation fortunately continuing, according to Plutarch, down to the consulship of Hirtius and Pansa.

Again, taking the second quotation from Mommsen as to the obligation of every freeholder for military service, it would appear from the fact of the early Romans being a nation of warriors, as a matter of course both by upbringing, precept, and example, every youth was bound to enter the military profession, the father of the aspirant being termed by Seneca "a domestic judge," by Suetonius "a censor of his son."[2]

Thus amongst the rights possessed by the early Roman citizen was also included the *jus patrum*, this privilege extending down even to the great-grandchildren; none of these descendants were their own masters until the death of their grandfathers.[3]

These being the prevailing conditions, it is not surprising for us to find that every citizen readily enlisted for service when his country required it. The age was fixed at this time at from 17 to 46 for the period of service, nor at first could anyone enjoy any official position in the city who had not served through 10 campaigns;[4] every foot soldier was obliged to serve 20 campaigns, every horse soldier 10.

At first, *i.e.*, in the days of the kings, none of the lowest class were enlisted, neither were freedmen, except in dangerous crises; but this was altered by Marius.[5]

[1] Livy, IV., 59, 60. [2] Sall., Cat., 39; Claud., 16. [3] Cic., de Legg., III., 8; Terence, Heaut, IV., 1; Tacit., Hist., IV., 5; Senec., de Ben., III. [4] Polybius, VI., 17. [5] Livy, X., 21, XXII., 11, 57; Sallust, Jug., 86; Gellius, XVI., 10.

Mommsen, referring to the early Republican constitutional methods of Servius Tullius, points out the changed conditions when every freedman, and even the emancipated slaves, had to serve; but it must be remembered that at this time the Romans were almost always engaged in wars, first with the different states of Italy during 500 years, and then about 200 more years in subduing and holding the various countries which composed their vast Imperial domain.

The number of recruits raised annually was an increasing quantity; in the early Republic times four legions, say 24,000 men, but often a greater number had to be found—ten, eighteen, twenty, twenty-one, twenty-three, under Tiberius twenty-five, even in time of peace, besides the Italians and the forces of the Allies, under Adrian thirty legions, a grand total of 180,000 men a year.[1]

In stating that every freeholder, from his 17th to his 60th year, was liable for service, it would appear that under the constitution of Servius Tullius, which Mommsen is alluding to, the first class, or the *classici*, who held the preponderating voting power in the assemblies, consisted of 80 centuries—40 centuries of young men (17 to 46 years old),[2] 40 centuries of elderly men (age not mentioned), called *seniorum*. The elders were guarders of the city, the youngsters were obliged to take the field (*ut foris bella gererent*). To these were added 18 centuries of *equites* or *celeres*,[3] a more mobile class, who fought on horseback, and were specially selected by Servius Tullius from the Chief Officers of State. Horse allowance of 10,000 pounds of brass (£322 18s. 4d.) was given for purchase of horses, whilst a tax was laid on windows for maintenance and upkeep of the said horses.[4]

Hence the origin of the great Equestrian order, which was of the greatest utility to the State as an intermediate bond between the patricians and plebeians.[5]

In the days of the emperors—time of Augustus, A.U.C. 763—A.D. 10—there appear to have been several causes for exemption from military service (*vacationes militiæ*). Of these the chief were :—

A. *Anno domine* or *ætas* (age), if over 50 years of age.[6]
B. Infirmity or disease (*morbus vel vitium*).[7]
C. Office (*honor*), being a magistrate or priest.[8]
D. Favour or indulgence (*beneficium*) granted by the Senate or people.[9]
E. Those who had served out their time, or *emeriti*.[10]

[1] Livy, II., 30, VII., 35, XXIV., 11, XX., 1, XXVIII., 38; Tacit., Annal., IV., 5; Spartian, 15; Pliny, III., 20, 24. [2] A. Gell., X., 28; Cic., de Sen., 17. [3] Varro et Festus, Livy, I., 30, 43. [4] Livy, I., 43, II., 1. [5] Livy, I., 43, II., 1. [6] Livy, XLII., 33, 34. [7] Suet., Aug., 24. [8] Plutarch in Camill. [9] Cic., Phil., V., 19; de Nat. D., II., 2; Livy, XXXIX., 19. [10] Livy, XXXVII., 4.

Veteran soldiers who had served out their time were sometimes induced to re-enlist as bodyguards to exalted personages as *Evocati*.[1]

With regard to the obligation of emancipated slaves to serve, alluded to by Mommsen, it would appear that the same men who—*quâ* slaves—obtruded themselves into a levy raised upon a sudden alarm (*in tumultu*), and were liable thereby to capital punishment,[2] were, on coming into property, under obligation to serve.

This however appears to have been customary, not only in the Army, but also in the Navy,[3] where their services were utilized as mariners and rowers, a particular class of handy men whose professional attainments were not considered on a par, nor equally honourable, with those of the legionary soldier.[3]

To follow Colonel Hickson and Mommsen into the details of the most important feature of the article by the former in the August *Journal*, viz., the *Comitia Centuriata*, or constitution of Servius Tullius, and how it reacted most favourably on the power of the Roman arms in the future as time went on, necessitates a careful research into the early writers of these details.

Calculations as to the current values of the voting powers when reduced to their modern equivalent in British coin, at the then Government valuation rate, necessitates reducing asses and drachmæ to £ s. d.

Unfortunately the records do not give the total strength of the population at that time—Circa 400 B.C.—but only the number of those vested with the franchise on the register; but it is proposed to give, in a future article, a detailed description of this highly successful political constitution.

[1] Cic., Livy, XXXIV., 56, XLII., 22; Cæsar de Bell. G., VII., 1. [2] Pliny, Ep. X., 38, 39. [3] Tacit., Annal., XV., 51; Suet., Livy, XXXII., 23, Aug., 16.

THE FORM OF HELICOPTERS.

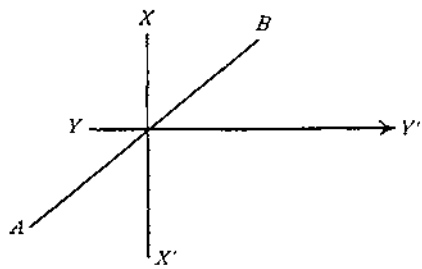
By LIEUT. E. ST. G. KIRKE, R.E.

ALTHOUGH the use of helicopters has not up to the present time come within the range of practical aeronautics, it is still of interest to consider the form of blade which may ultimately be expected to give the greatest lifting power, as soon as driving machinery has improved, power for weight. For the moment, heavier-than-air machines are limited in the sphere of their usefulness by the necessity of having a fairly level stretch of ground from which to rise, or upon which to alight, and in the latter case any miscalculation of speed or distance on the part of the aeronaut will result in damage to the aeroplane, as recently happened to that of M. Bleriot on arrival at Dover. Under active service conditions it may not always be possible to find ground suitable for manœuvring aeroplanes, and it is doubtful if they will vie with dirigibles as engines of war until vertical motion is possible.

Propellers, working in a fluid, depend for their function on the reaction caused by their projecting a mass of the fluid in the opposite direction to that in which the object they are propelling is intended to travel, and their power is proportionate to the mass and velocity of the fluid which they project. The efficiency of the ordinary screw propeller varies considerably according to the amount of its *linear* velocity, as well as to the velocity of rotation, and the propeller which will give very satisfactory results in a ship travelling at 20 knots an hour may be most inefficient in another travelling at ten, although driven by the same engines and at exactly the same number of revolutions. The reason for this is that the resultant of the linear and rotary velocities completely alters the obliquity of the blades relative to the water in which they are working. Again, two similarly engined ships may form entirely different wakes, even when travelling at the same speed, and this factor has considerable bearing on screw efficiency.

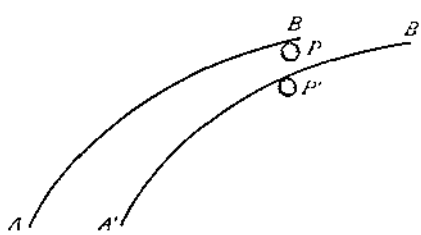
The propeller which projects its stream of water astern with as little shock as possible is obviously the best, and the form of blade most calculated to fulfil this condition will be the most efficient.

A plane AB moving through a liquid with a given velocity in the direction YY′ will force the liquid in the direction XX′ if friction is



not taken into account, but there must be considerable shock as the plane strikes each particle of water prior to imparting velocity. To eliminate this shock the leading edge of the plane must be parallel to the direction of motion, that is to YY′, and the blade as a whole must be curved in such a way that the fluid has velocity impressed upon it with a constant acceleration in the direction XX′.

The curve of the blade necessary to ensure this result can be arrived at as follows:—A propeller AB travels in one second to the



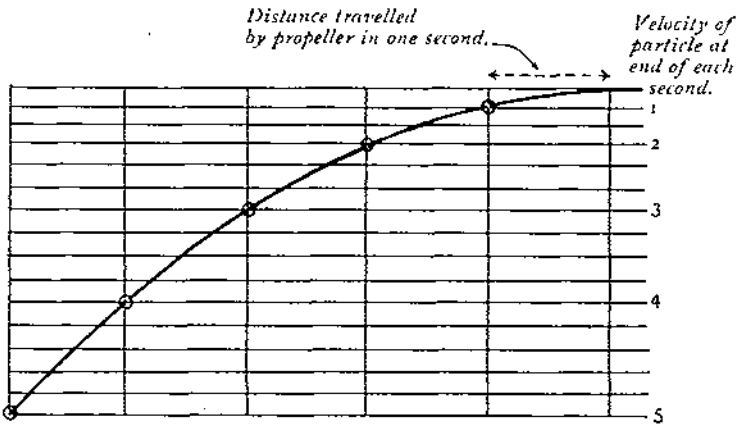
position A′B′, thereby moving the particle P to P′, supposing friction to be non-existent. At the end of this second the particle will have had impressed upon it a velocity V. Taking the acceleration, which has caused this velocity, to be unity, the velocity will itself be unity, and the shape of the blade must be such that during each successive second of motion a unit of velocity will be added to the particle.

The form of blade is therefore easily evolved from the formula

$$v = u + fl.$$

An experimental propeller of the above form, working under ideal

conditions (*i.e.*, without any *linear* velocity), has exerted against a spring recorder a pull five times as great as that of an ordinary Admiralty pattern propeller, turning at the same number of revolutions.



Moreover the direction of the flow of water is altogether different. The ordinary propeller takes water along a line parallel to the axis of its shaft (*Fig.* 1).

A propeller of the form shown in the diagram takes water in a direction normal to the axis of its shaft, as indicated by the arrows (*Fig.* 2).

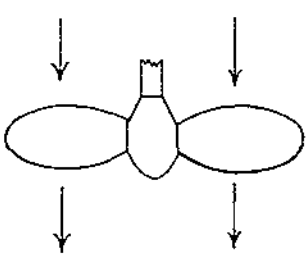


FIG. 1.

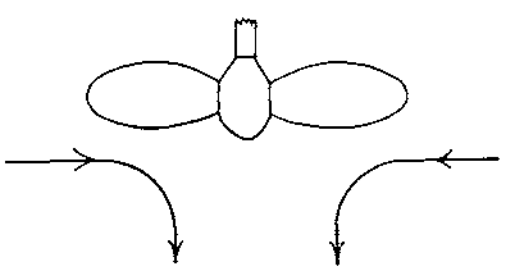


FIG. 2.

It is difficult to say whether any advantage will accrue from this phenomenon as regards aeroplanes, but it would certainly seem possible to use helicopters of the above form under the gas-holder of a dirigible, enabling its elevation to be controlled, even when stationary, otherwise than by adjustments of ballast or gas. For

instance, helicopters could be arranged to hold down a dirigible without any extraneous assistance while its gas-holder was being inflated, and heights, which are now impossible, could be attained without the sacrifice of a certain amount of fuel entailing reduced radius of action. It is to be seriously considered whether the size of gas-holders could not be very much reduced by applying the motive power of a dirigible to assist vertical movement when it is not required for purposes of propulsion, in combination with elevating planes to maintain the dirigible at heights reached with the aid of helicopters, when horizontal travelling is contemplated.

THE FYERS FAMILY.

(Continued).

By Col. Robt. H. Vetch, c.b., late R.E.

Lieut.-General William Fyers, Colonel Commandant, R.E.

(Continued).

During his long stay at Gibraltar, Fyers, on the whole, had found his life a pleasant one. Improvements and alterations both in fortifications and barracks gave him plenty of work to supervise, and his house was a social centre. His young family had grown up about him. Three of his charming daughters, who assisted Mrs. Fyers to dispense the hospitality of the Commanding Royal Engineer's house, had been happily married. His eldest son, Thomas, already in the Corps, had come out to Gibraltar to serve under him, and his younger son, Edward, was at Woolwich hoping to get Sappers. He had been able during his sojourn at the Rock to revive old friendships with comrades who had served with him in the American War of Independence, and to form new ones with the younger generation of the Services who came to do duty for a time at the fortress, or stayed there on their way to and from Corsica, Malta, or Egypt. He had taken the greatest interest in the welfare of the garrison. The magnificent Garrison Library which he founded, and spared no pains to develop and improve, is a lasting memorial of one phase of this interest. His long labours in connection with it were heartily recognized by his brother officers, who in 1790 caused his portrait to be painted and hung in the Library, where it still remains. A reproduction of this portrait appears in Porter's *History of the Corps of Royal Engineers*. Colonel Fyers had enjoyed exceptionally good health at Gibraltar in spite of several epidemics of disease in the garrison during the years he had been there, but at length, in the beginning of 1807, his health broke down, and he was seriously ill for several months. The doctors ordered him home as soon as he was able to travel, and he arrived in England in May of that year.

After only two months' leave of absence, Colonel Fyers was again ready for work. In July he was made a member of the Committee at the Tower. This Committee was originally instituted in 1782. Four officers of Royal Engineers were then appointed to assist the Chief Engineer of Great Britain as a board of reference, whose duty

it was to report upon all plans and estimates submitted to it. The members of the Committee had no other duties to perform. In 1802 the Royal Warrant of 21st April, which changed the title of Chief Engineer of Great Britain into that of Inspector-General of Fortifications, also abolished the permanent Committee at the Tower. The duties were transferred to the new Inspector-General of Fortifications, Lieut.-General Robert Morse, who was permitted, when expedient, to nominate an unpaid Committee to examine and report to him upon projects, plans, and estimates submitted to it. Such a committee was formed shortly after (in 1803), composed of officers holding other appointments, for which they drew their pay. The nomination of Colonel William Fyers to this Committee was no doubt in anticipation of his undertaking the duties of Deputy Inspector-General of Fortifications, a new office which was to come into being on the 31st August, 1807.

Major-General Whitworth Porter, in his *History of the Corps of Royal Engineers*, seems to think that the Committee at the Tower, as it was called, was abolished at this time, but this is an error. Colonel W. Fyers continued to serve on the Committee while he was Deputy Inspector-General of Fortifications, and his son-in-law, Major-General Cornelius Mann, was a member of it from 1814 to 1830, during the time he was holding staff appointments at the Board of Ordnance. I have traced records of meetings of the Committee down to 1835.

In his post at the Board of Ordnance Fyers found himself very fully occupied, and in close touch with his old chief at Gibraltar, General Robert Morse, who knew his value, and with whom he worked most cordially. Fyers was also in frequent communication with the Master-General of the Ordnance, John, Earl of Chatham, who had entered on office the same year that Fyers was appointed Deputy Inspector-General of Fortifications. Fyers had known him in America, and also at Gibraltar. When therefore a chance of again going on active service occurred, his previous war services were not forgotten, and with both the Master-General of the Ordnance and his own chief to recommend him, he was fortunate enough to be again employed in war service. Whether he had forgotten the advice of his old friend, General O'Hara, at Gibraltar, when he was anxious to volunteer for Toulon, or whether he considered that with his youngest child already 10 years old the advice did not hold good, or that he was ordered to go without being consulted, in any case he was appointed the Commanding Royal Engineer of a very formidable expedition.

In 1809 Napoleon Buonaparte had succeeded in establishing extensive dockyards and arsenals at Antwerp, Terneuse, and Flushing. From these he had already launched and fitted out a powerful fleet, which lay in the Scheldt fully manned and ready for immediate

service. Other ships were on the stocks, and a vast quantity of timber and stores of all sorts had been collected. These establishments, together with the fleet, were always protected by a large land force, and were the subject of serious apprehension to England. But when Napoleon invaded Austria in 1809, after the retreat of the British in the north of Spain, under Sir John Moore, he ventured to withdraw his troops from the Low Countries to swell his invading army. The British Government deemed the opportunity a favourable one to destroy the establishments that had been built by the labour of many years and the expenditure of many millions, and as soon as Napoleon was occupied in operations across the Rhine, an expedition was organized with the object: of capturing or destroying the enemy's ships either building at Antwerp or Flushing, or afloat on the Scheldt; of destroying the arsenals and dockyards at Antwerp, Terneuse, and Flushing; of reducing the island of Walcheren; and, if possible, of rendering the Scheldt unnavigable for ships of war.

A joint naval and military expedition was organized on a very large scale. The fleet, commanded by Rear-Admiral Sir Richard Strachan, comprised no less than 37 sail of the line, two 50-gun ships, three 44-gun ships, 23 frigates, and 180 sloops, gunboats, bomb vessels, etc., altogether 245 war vessels, accompanied by 400 transports.

It is perhaps easier to realize what an imposing fleet this was if we recall the review by the King of the fleet at Spithead on 31st July last, when the 1st-class battleships and cruisers numbered 38, the 2nd-class battleships and cruisers 34, other cruisers 29, and gunboats, scouts, destroyers, etc., 143, altogether 244 war vessels.

The land force, 40,000 strong, was commanded by the Earl of Chatham. To this force Colonel Fyers was appointed Commanding Royal Engineer. He had under his orders with the several divisions of the Army the following officers of the Corps:—Lieut.-Colonels D'Arcy and Pilkington, Capts. Rudyard, Birch, Squire, Pasley, Fanshawe, Macleod, Boteler, and J. T. Jones (who acted as Brigade-Major), Lieuts. Calder, Lascelles, Cardew, Hutchinson, Ross, Brown, Harry Jones, Rawlinson, Bonnycastle, Trench, Colby, Longley, Power, McDonald, Dickenson (Adjutant), and Wells (Adjutant), with Meinecke, of the King's German Legion.

The enormous fleet of ships of war and transports sailed from the Downs on the 28th July. Landings were effected on the 30th to reduce the island of Walcheren, Middelburg was occupied, and Veere surrendered on the 1st August, its garrison becoming prisoners of war. The same day the British troops were put in movement for the investment of Flushing, Lord Chatham fixing his headquarters at Middelburg.

Much of the ground around Flushing was liable to inundation, and regular siege approaches were impracticable. It was decided by Colonel Fyers's advice to try the effect of bombardment in order to

induce a capitulation. Colonel Fyers recommended that batteries should be constructed on detached points which happened to be above the ordinary level, and also on the dykes themselves, and that these batteries should be connected by a trench, which should follow the highest levels available. First however it was necessary to reduce Fort Rammekins, already blockaded by Lieut.-General Frazer's division, because it commanded the Sloe Channel separating Walcheren from South Beveland, by which alone the transports then at anchor off Veere could enter the Western Scheldt. Colonel Fyers judged that the Commandant of Fort Rammekins would surrender on bombardment, and selected a spot for a gun and mortar battery to be begun at dusk on the 2nd August. The next day the garrison directed a good deal of fire on the battery in progress, till the 95th Rifle Corps was pushed forward close to the ramparts wherever cover could be found, and fired at such of the garrison as showed themselves above the parapet, or at the embrasures, till they had silenced the fire of the fort. On the afternoon of the 3rd, when the battery was nearly ready, the garrison of Fort Rammekins, numbering 127 men, surrendered themselves prisoners of war. Thus the Sloe Channel was open, and in the meantime Sir John Hope had obtained possession of every part of South Beveland, the Dutch General, Bruce, having retired with his troops, some 500 men, to Bergen-op-Zoom.

The besieging force before Flushing mustered altogether 17,000 men, consisting of the divisions of Lord Paget, Lieut.-General Graham, Lieut.-General Grosvenor, Lieut.-General Frazer, and a reserve under Brigadier-General Houston. On the night of the 3rd August the construction of siege batteries began. Bad weather hindered the work and also, in conjunction with the intricacies of the navigation, delayed the sea blockade, which was not effectually established until the 6th August, so that in the interval the French were able to ferry over 2,000 men and augment the garrison to 5,000 effectives. A strong sortie, under General Monnet, the Governor, was made with great spirit on Lieut.-General Graham's division on the afternoon of the 7th; but it was repulsed, our loss being 13 men killed, and 8 officers and 126 men wounded. The connection of the siege batteries by a trench, or parallel, was a difficult matter, the trench having to follow the higher levels and yet be free of enfilade fire, and it therefore assumed a very meandering line. In consequence of the increased numbers of the Flushing garrison, Colonel Fyers proposed to augment very considerably the works of the attack. He enlarged the battery on the Knolle Dyke (No. 5) to contain 12 24-prs., 6 mortars, and 2 howitzers, and Battery No. 2 to contain 4 heavy mortars. On the morning of the 9th the Naval flotilla effected the investment of Flushing, on the sea side. The following day the garrison partially opened the sluices, so far as greatly to incommode the besiegers without laying the whole country under water.

On the morning of the 13th August the batteries opened fire. The same night an advanced *flèche* on the right, in advance of the demi-bastion, was stormed, and carried by a detachment under Lieut.-Colonel Nicholson. He captured a gun and brought off 30 prisoners, with the loss of 8 killed and wounded. Colonel Fyers, who was present and making observations through his glass, was struck on the chest by a musket ball fired by a picquet posted in Old Flushing, not 100 yards away. Fortunately the bullet grazed the parapet before striking him, or he would have been killed.

The following day Sir Richard Strahan, with seven line-of-battle ships, stood up the Scheldt and joined in the bombardment. The general bombardment continued till 4 p.m., when the artillery of the place was silenced, and the town was blazing furiously. At night it was ascertained that the garrison in desperation was cutting the eastern dyke to let in the sea. To stop this menacing work was imperative at any cost, or the whole of the British trenches and batteries, except those on the dyke, would have been inundated to 4′ or 5′ of depth. A large storming party, under Lieut.-Colonel Pack, was detailed to assault the advanced works on the eastern side. This was successfully accomplished. Many of the defenders were killed and 40 prisoners taken, but 5 officers and 30 men were the British casualties. Capt. Pasley, R.E. (afterwards General Sir C. W. Pasley, K.C.B.), greatly distinguished himself on the occasion when leading the storming party which carried one of the works. Having received a musket ball through his body and a bayonet stab in his thigh, he nevertheless stuck one Frenchman, disarmed a second, stabbed a third, and was attacking a fourth when he fell. On the following day General Monnet capitulated, and on the 18th the garrison marched out over 5,000 strong, and laid down their arms as prisoners of war.

Colonel Fyers in spite of his wound insisted on all Engineer reports being rendered to him, and the next senior officer of Engineers was very nearly tried by court-martial for raising an objection. It is only necessary to refer very briefly to the remainder of the campaign. A week later Lord Chatham's force, concentrated at Bathz and protected by the fleet, was ready to disembark on the Continent and lay siege to Antwerp. But a change had come over the scene. The French had recovered from their surprise, had collected an army of 25,000 men round Antwerp, and had flooded the country. The great chance had gone, and a campaign which began with so much promise ended in fiasco. The reduction of Flushing virtually ended the campaign. A council of war was held on the 27th August, at which it was decided to abandon any attempt on Antwerp. The force fell back on Walcheren.

On the 17th August Lord Chatham had asked Colonel Fyers to prepare plans and submit to him his proposals for assuring the

security of the island of Walcheren. Fyers considered that the basis of defence for Flushing laid down by Napoleon in his decree of 26th March, 1808, held good for the English. This was that the defence of Flushing rests on inundations, and that when an enemy appears the dykes must be cut and the island laid under water; but as an enemy can approach the dykes, a point on each dyke must be occupied, so that no enemy can get within range of the fortress. Fyers desired so far to modify the drastic treatment approved by Napoleon as to limit the inundation to what was absolutely necessary to secure Flushing from attack without overwhelming the island. He therefore proposed to finish the works on the dykes already begun, and by means of an interior counter-dyke passing across the peninsula in front of Flushing, with its extremities resting on the new forts, to confine the inundation to a radius of 2,200 yards from the ramparts. He proposed to feed this inundation by large sluices under the protection of the Flushing defences, so that should an enemy cut the interior counter-dyke, such a flow of water might be maintained over the ground between the town and dyke as would prevent him carrying his approaches over it. On account of its great cost, the proposal could not be authorized until it was decided whether the Government would permanently retain possession of Walcheren Island, and in the meantime Fyers employed the peasantry in strengthening the existing defences of Flushing, Rammekins, and Veere. Lord Chatham arranged to leave nearly 17,000 men to garrison Walcheren, and on the 14th September embarked the remainder of the army for England, Fyers accompanying him.

Colonel Fyers resumed his duties as Deputy Inspector-General of Fortifications on his return from the campaign, and when the terrible sickness decimated the British troops at Walcheren, until their effective strength was reduced to 4,000 men, and it was decided to evacuate the island, Lieut.-Colonel Pilkington carried out the destruction of the defences, and of the basin and breakwater at Flushing, which had been ordered.

Fyers was promoted to be Major-General on the 4th June, 1811, but he continued to hold his appointment at the Board of Ordnance until Colonel Rowley relieved him six months later. He was then given the Engineer Command in Ireland. It is a curious coincidence that Fyers's service in Ireland, which lasted until his death, was as nearly as possible the same length as his service at Gibraltar, viz., 18 years. He seems to have been as popular a chief in Dublin as he was at the Rock. There are however no details of his service in Ireland available. His son, Capt. Edward Fyers, R.E., was his Aide-de-Camp in Ireland in 1812 and 1813, and again for a short time in 1816.

When the order was issued at the end of 1814, removing from the strength of the Corps all general officers who were not Colonels

Commandant, a great compliment was paid to Major-General Fyers. He was offered the choice either of retaining the Engineer Command in Ireland without receiving the pay of a general officer, or of accepting the new rule. Fyers had no hesitation as to his choice. He did not feel at the age of 61 years at all inclined to go on the shelf. So long as he could continue the life he was leading he was quite indifferent to the loss of pay. So he replied in the following terms :—

"It is my choice and the wish of my heart to serve His Majesty in the Corps to which my genius and inclination led me in early youth, and in which I have used my best exertions for 42 years with unremitting anxiety of mind, frequently before His Majesty's enemies, and I trust never with discredit."

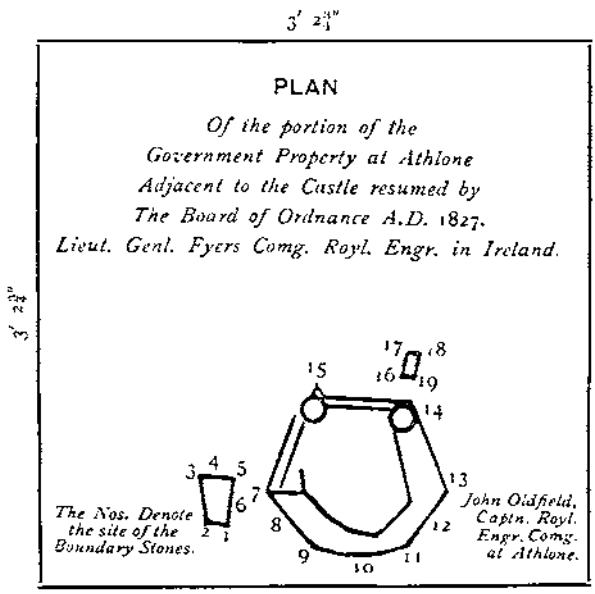
Fyers became a Colonel Commandant of the Corps on the 11th November, 1816, and on the 12th August, 1819, was promoted to be Lieut.-General. He seems to have preserved his energy and capacity for work until the end, for he died in harness, after an illness of only two days, on the 27th October, 1829, in the 77th year of his age.

He was very much respected in Dublin, and his own officers were particularly attached to him. He was buried in Christ Church Cathedral. His brother officers who served under him erected in the Cathedral a tablet of white marble edged with black, on which was inscribed the following epitaph :—

To the Memory
of
LIEUT.-GENERAL WILLIAM FYERS,
Colonel Commandant,
And Commanding Royal Engineer in Ireland,
Who died October 27th, 1829, aged 77 years,
And was here buried.
This tablet is erected by the officers
Who served under the Lieutenant-General,
In testimony of their sincere respect and esteem.

By the kindness of the Commanding Royal Engineer at Belfast, I am able to refer to a curious memorial of the General's command in Ireland which exists at Athlone. It is an incised plan of the castle on a stone let into the escarp. Colonel St. John has sent me a copy of the inscription and plan (given below), and a photograph showing its position, which is also reproduced.

I have already mentioned that the daughters of Thomas Fyers, Overseer of the King's Works in Scotland, were all married, but special reference was only made to Alexandrina, the third daughter, who married the Rev. James Reid, and became the mother of Lieut.-General Sir William Reid. Another daughter, and she the eldest, should



have had some notice. Elizabeth Fyers was born at Inverness on the 13th October, 1751. She married George Peter, Esq., of Chappel, Selkirkshire, and died young, leaving three children, a boy and two girls, who were brought up by their grandmother, old Mrs. Fyers, in Edinburgh. None of these children married. The eldest, George Peter, got a commission in the 59th Foot. He was for some time Captain and Adjutant of his regiment, and it is stated that he rose to the rank of Colonel, but this I have not been able to trace.

The children of Thomas Fyers that have received some sort of notice in this paper are in order of seniority:—Elizabeth (Mrs. Peter); William Fyers, Lieut.-General and Colonel Commandant, R.E.; Alexandrina (Mrs. Reid); Thomas Fyers, Treasurer of Malta; and Peter Fyers, Major-General and Colonel Commandant, R.A.

The other daughters were:—Anne, married to James Thomson, of Leith; Mary, married to the Rev. D. Mackenzie, of Fodarty, Ross; and Margaret, married to W. Kerr, of Leith, but of their families I have no information.

My main design in writing this paper was to give a memoir of Lieut.-General William Fyers, Colonel Commandant, R.E., and incidentally to show how large a number of officers of the Services have descended from his father, Thomas Fyers, Overseer of the King's Works in Scotland.

The first purpose has now been achieved, however imperfectly. I propose next to deal with the other object in view.

(*To be continued*).

THE USE OF LARGE GAS ENGINES FOR GENERATING ELECTRIC POWER.

Abstracted from the Proceedings of the Institution of Electrical Engineers by CAPT. A. E. DAVIDSON, R.E., *with the kind permission of the Council of the Institution.*

THE following article on the use of large gas engines for generating electric power is practically an abstract of a lecture given on the above subject by Messrs. L. Andrews and R. Porter, and also of the points brought out at the subsequent discussion. The question is at the present moment one of vital importance to engineers, as was evidenced by the record audiences which crowded the Lecture Theatre of the Institute of Civil Engineers to its utmost capacity, both when the paper was read and also at the subsequent discussion.

Hitherto the use of large gas engines has been chiefly confined to iron and steel works, where they are run, on blast furnace and other waste gases, for driving blowing engines and generating electric power.

In Germany, however, the manufacture of large gas engines is an established industry on a large scale, and whilst for some years there have been a few blast furnace gas-engine installations working in this country, the engines used have been mainly limited to capacities of from 300 to 500 B.H.P. Credit must undoubtedly be given therefore to the German iron and steel industry for having created the demand which has brought the large gas engine to its present state of perfection.

The use also of large gas engines for driving electric generators is a subject which is receiving considerable attention in the United States, where a special committee has reported upon it.

Whilst the authors believe that there is an important field for the use of large gas engines for driving electric generators, they do not consider that there is justification at present for the suggestion that has been made, that the internal combustion engine will in the early future be used to the exclusion of the external combustion engine.

The position, as far as present knowledge goes, may be briefly summarized as follows :—

I. The internal combustion engine is very much more economical than any external combustion engine yet known.

II. The capital cost of a gas-engine and producer installation is greater than that of a steam-turbine and boiler installation of equivalent overload capacity.

III. There is no material difference in the reliability or in the cost of labour, stores, and repairs of the respective systems.

In cases therefore, where the cost of fuel is low and the load factor is low, it will generally be a mistake to use gas engines. On the other hand, where the load factor is high or the cost of fuel is high, there can be no doubt that gas engines will prove to be by far the cheapest prime mover to employ for driving electric generators. The majority of cases to be dealt with will doubtless fall between these two extremes.

As it is difficult for engineers to utilize the available knowledge upon the subject to the best advantage, the authors have endeavoured to collect the facts from a large number of different sources, and to apply the information obtained to a hypothetical scheme, as nearly comparable as possible with existing power supply schemes now being carried out.

In the first scheme to be considered, the estimated maximum load to be dealt with is estimated at 8,000 k.w., and it is assumed :—

(1). That the overload and stand-by capacity of the plant shall be such as to carry the maximum load of 8,000 k.w. for at least two hours, should any portion of the plant break down at the time when one unit is already laid off for overhaul.

(2). That the power generated is utilized for public and private lighting, and for a tramway and general industrial motor load; that the load factor—*i.e.*, $\frac{\text{units sold} \times 100}{\text{maximum demand} \times 8760}$, equals 24 per cent. and that the efficiency of distribution—*i.e.*, $\frac{\text{units sold} \times 100}{\text{units generated}}$, equals 80 per cent., and that the mean daily load curve is approximately of the shape shown in B, *Fig.* 1.

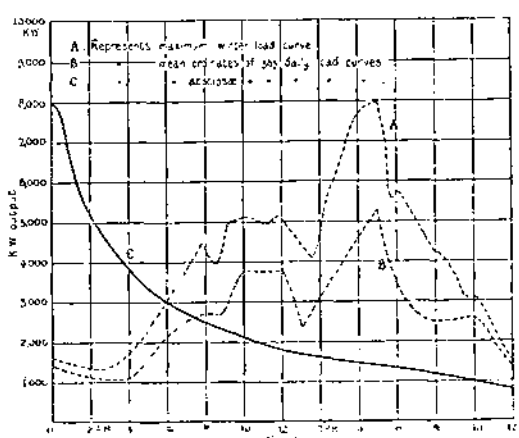


FIG. 1.

NOTE.—Curves A and B are the usual daily load curves. Curve C shows the number of hours in a day during which a given load is maintained.

(3). That the cost of good bituminous slack, having a calorific value of 13,000 B.Th.U.'s per lb., is 12s. per ton, delivered at the generating station.

Choice of Site.—The points to be considered in selecting a site for a gas-driven station are practically the same as for a steam-driven station, viz. :—

A.—A plentiful supply of water for cooling purposes.
B.—Transport of fuel.
C.—Suitability of site relatively to position of centre of distributing area, as affecting the cost of feeders.
D.—Liability of nuisance to adjoining property.
E.—Cheapness of land.
F.—Cost of constructing foundations for plant, buildings, and chimneys.

In choosing a site for a steam-turbine station, it is often good policy to sacrifice other advantages in order to get a site with a plentiful supply of cold water for condensing purposes. This advantage has usually, however, to be heavily paid for. It is consequently often very much cheaper, on the whole, to put down cooling towers for condensing purposes.

A convenient lay-out for the steam plant is shown in *Figs.* 2 and 3. *Figs.* 4 and 5 show a convenient lay-out for the gas plant.

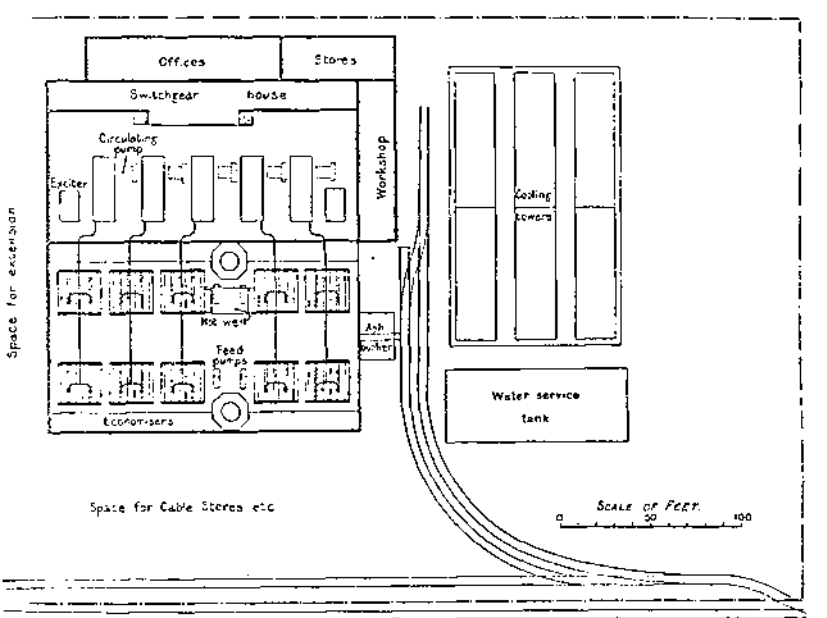


FIG. 2.—10,000-*k.w. Steam Plant* (*Plan*).

cost and running cost than small units, and so units giving an overload capacity of 8,000 k.w. might be installed.

To comply however with the suggested specification as to overload capacity, it appears that the most economical arrangement of units would be five plants, each having a normal capacity of 2,000 k.w., with an overload capacity for two hours of $33\frac{1}{3}$ per cent.

The output of gas-engine units is at present limited to about 1,500-B.H.P. per cylinder. Four such cylinders arranged in twin tandem would give a combined output of, say, 4,000 k.w. But as the overload capacity of gas engines is only some 10 or 12 per cent., seven generators, normal capacity 1,450 k.w., overload capacity 1,600 k.w., would appear to be an economical installation.

Single Tandem versus Twin Tandem Combinations.—The next point to be determined is whether the engines shall be of the single tandem or twin tandem type. The only advantage of the twin tandem over the single tandem combination appears to be that, with a 4-cycle engine, the crank shaft will receive four impulses instead of two. It is obvious therefore that, with a given flywheel effect, the cyclic irregularity will be considerably greater with the latter than with the former.

Fig. 6 shows the cyclic variation for four types of engines, and *Fig.* 7 the comparative flywheel effect necessary to ensure a cyclic irregularity not exceeding 1/250, this being the maximum variation under which generator makers usually guarantee satisfactory parallel running. *Fig.* 8 shows the relative costs of the two types.

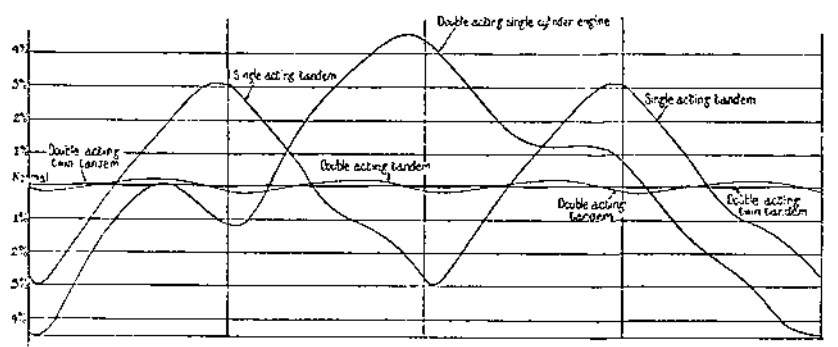


FIG. 6.—*750-B.H.P. Speed Curves showing per Cent. Variation above and below Normal when fitted with a Flywheel constructed for a Tandem Double-Acting Engine having a speed variation of 1/250.*

Double-acting twin tandem	0·02 per cent.
Double-acting single tandem	0·2 ,,
Single-acting tandem	3·1 ,,
Double-acting single cylinder...	4·3 ,,

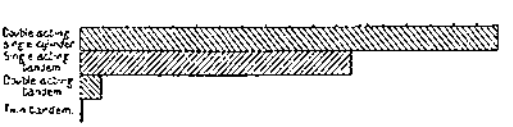


FIG. 7.—*The Flywheel Effect necessary to ensure Cyclic Irregularity not exceeding 1/250.*

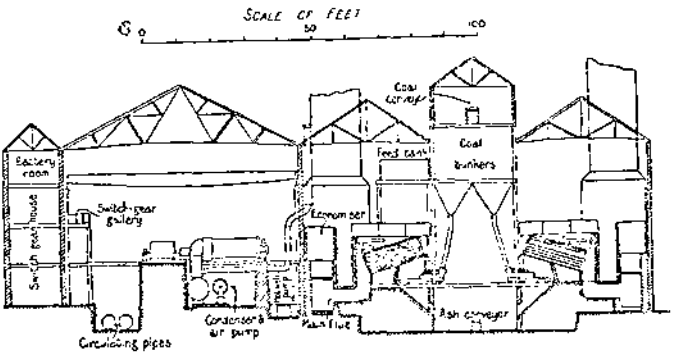


FIG. 3.—10,000-*k.w. Steam Plant* (*Elevation*).

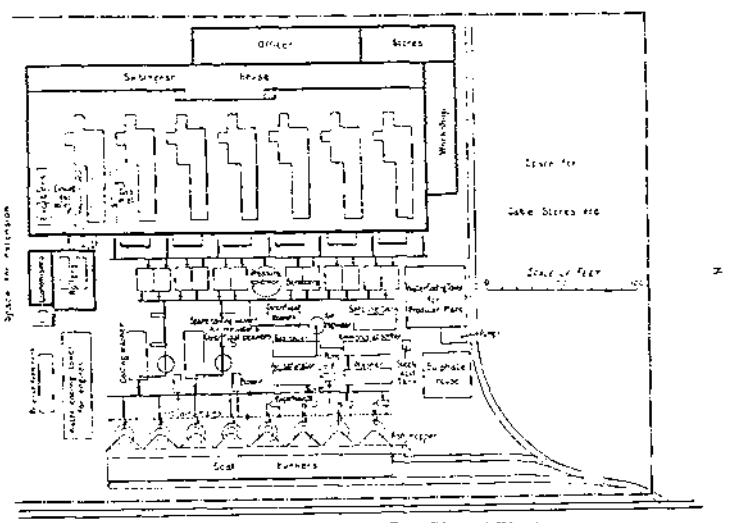


FIG. 4.—10,000-*k.w. Gas Plant* (*Plan*).

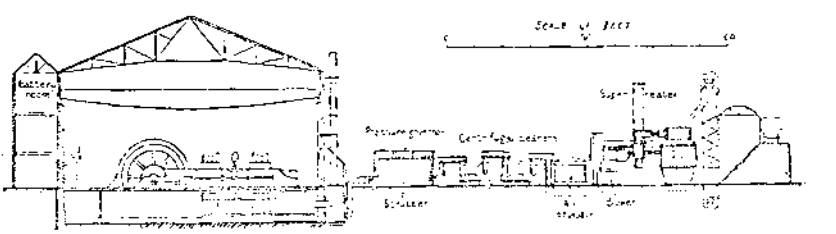


FIG. 5.—10,000-*k.w. Gas Plant* (*Elevation*).

Type of Generating Plant.—For the *steam plant* the authors assume turbines of horizontal type, each exhausting into a separate surface condenser placed directly below. Natural draught cooling towers, circulating water obtained from town supply. For the *gas plant* engines of slow speed, 4-cycle, double-acting tandem type, directly coupled to overhanging flywheel 3-phase generators. Cooling water for engines treated in the same manner as in the case of the steam plant.

Capacity of Generator Units.—Experience has shown that large units in steam plant are considerably more economical both in first

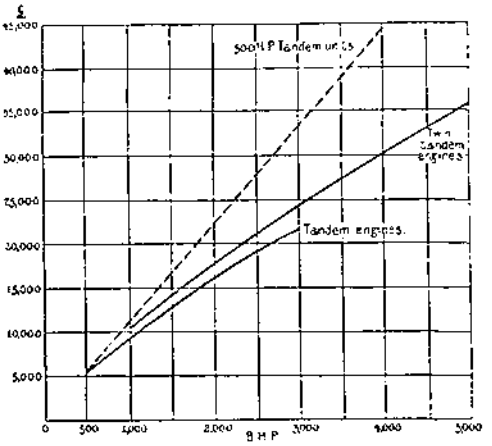


FIG. 8.—*Capital Costs of Slow-Speed Horizontal Gas Engines.*

It appears that for the conditions under discussion the single tandem engine is the best type of plant for the purpose.

Boilers.—Water-tube boilers with self-contained superheaters and automatic stokers have been selected. On the basis of 20 lbs. steam per unit generated, four 10,000-lb. boilers have been put down for each 2,000-k.w. turbine.

An economizer has been provided for each boiler.

Producers are to be found working in this country in an entirely satisfactory manner with bituminous coal in conjunction with large gas engines. With properly designed engines there appear to be no greater difficulties to contend with than when working on blast furnace gas. The comparatively high percentage of hydrogen requires a lower compression in the engine. Difficulties were experienced in the earlier days in the removal of tar, dust, and other impurities, but they appear to have been overcome by efficient cleaning appliances.

Difficulties arising from variations in the quality of the gas—caused by charging or clinkering the producers—practically disappear when a number of producers are connected together to feed into a common main or common receiver, where the gases from the various producers are mixed together, and the effect of any variation in the quality of the gas from individual producers is thereby neutralized. To derive the full benefit of this feature the producer plant should not be divided into units corresponding to the generator units, as has been recommended for steam boilers.

Sulphate of Ammonia Recovery Plants.—A very important point to be considered in designing a gas-engine station is that of providing for the recovery of sulphate of ammonia.

There are numbers of recovery plants that have been working for some years, where the sale of the by-product has almost equalled the cost of the fuel used. Results obtained have been so entirely satisfactory that one is at first sight tempted to think it must pay to provide

for sulphate of ammonia recovery in every instance. There are however many expenses incidental to the recovery of sulphate of ammonia in addition to the fuel.

The following points must be taken into consideration as affecting the use of ammonia recovery plants :—

1. The first cost of the recovery plant, particularly for small sizes, is very much greater than the first cost of non-recovery plant.
2. Considerable extra labour is involved in operating the plant.
3. The purchase of sulphuric acid, of which approximately 1 ton is required for every ton of sulphate of ammonia turned out, is quite a heavy item.
4. The yield of heat units per ton of coal is slightly less if sulphate of ammonia is recovered than the yield from non-recovery plants.
5. The extra cost of repairs and the cost of handling and packing the by-product absorb some of the profits effected by the recovery process.

Experience, up to the present, appears to indicate that it is not worth while to attempt to recover sulphate of ammonia unless the total output of the plant is greater than 2,000-H.P., and then only on an exceedingly good load factor.

For a maximum output of 8,000 k.w. it would probably pay to put down ammonia recovery plant, even for so poor a load factor as 24 per cent. An even more profitable arrangement however would be to provide for ammonia recovery on one portion of the plant, which could be kept working at a very high load factor almost continuously, and to use non-recovery plant for dealing with the peak load and remaining portion of the total output.

Buildings and Foundations.—The cost of the engine room and engine foundations for the gas-driven plant is of course considerably greater than that of the steam plant, but practically no buildings are required for the producers. The total cost of buildings amounts to considerably less therefore for the gas station than for the steam station.

Exciting Plant, Switchgear, etc.—It has been assumed that for both the steam plant and the gas plant the field circuits of the generators would be excited from busbars fed by two steam-driven exciters, each capable of generating the whole of the exciting current required on full load. The exciters would be supplemented by a battery capable of maintaining the full field current required for a period of 24 hours.

The switchgear would be of the remote control type; as there are two more panels, its capital cost is greater in the case of the gas plant.

Capital Outlay.—The total capital cost of the respective steam and gas plants is then estimated as under :—

Steam Plant.

	£	s.	d.
Five 2,000-k.w. turbo-generators, erected complete	39,500	0	0
Five surface condensers with air and circulating pumps	9,875	0	0
Circulating pipes	1,200	0	0
Cooling towers erected complete	6,900	0	0
Twenty water-tube boilers erected complete with mechanical stokers, economizers, superheaters, feed pumps, water-service tank and feed tank, water-softening plant, and all pipe work ...	31,300	0	0
Buildings with engine and boiler foundations, two chimneys and flues	33,600	0	0
Overhead travelling crane	1,000	0	0
Steel structural work, coal bunkers, coal and ash conveying plant	8,900	0	0
Exciters, battery, switchgear, and connections to generator	7,250	0	0
	£139,525	0	0

Or £13·952 per kilowatt installed.

Gas Plant.

	£	s.	d.
Seven 1,450-k.w. gas engines, generators, air compressors, gas, water, air, and exhaust pipes, and all auxiliaries erected complete...	98,000	0	0
Four ammonia-recovery producers, erected complete with superheaters, blowers, cooling and washing towers, centrifugal cleaners, scrubbers, ammonia absorber, and all pipe work	18,490	0	0
Duplicate blower, washer, and centrifugal cleaners...	3,780	0	0
Four non-recovery producers with necessary scrubbers, etc.	10,340	0	0
Steam-raising plant, economizers, feed pumps, etc....	4,850	0	0
Water-cooling towers, pumps, and water softener ...	1,990	0	0
Buildings and foundations, etc.	24,275	0	0
Overhead travelling crane	1,250	0	0
Steel structural work, coal bunkers, coal and ash conveying plant	6,150	0	0
Exciters, battery, switchgear, and connections to generators	7,750	0	0
	£176,875	0	0

Or £17·68 per kilowatt installed.

Operation of Gas Plant.—As there are probably many engineers interested in the design of power stations who are not familiar with the method of operating a combined producer and gas-engine station, a few words on this subject may not be out of place before considering the comparative running cost of the respective systems.

The coal is fed by means of the endless chain elevator into bunkers above the producers, from which it gravitates through a valve to the hoppers. From the hopper it is fed into the producer from time to time as the fuel therein gradually burns away. The ashes are regularly withdrawn through the water lute every four hours, the quantity being determined by the rapidity of combustion in the producer.

The hot gases escaping from the outlet at the top of the producer pass into the superheater, which consists of a series of vertical pipes surrounded by the steam and air passing on their way to the producer. A considerable portion of the sensible heat is herein extracted and utilized.

The gas is then passed to the mechanical washer, where it is treated with a spray of warm water thrown up by revolving paddle-wheels. The dust and soot in the gas are by this means removed and the temperature of the gas considerably reduced. The warm water is also at the same time heated up and passed to the air saturator, in which, by heating and saturating the air on its way to the producer, it is cooled for further use in washer.

Passing from the washer, the gas next enters the mechanical ammonia absorber, where it meets a fine spray of a solution of sulphate of ammonia, which contains a small amount of free sulphuric acid. In this apparatus the acid in the solution combines with the ammonia in the gas, producing sulphate of ammonia. The acidity of the liquor is kept up by a small trickle of sulphuric acid into the absorber; the sulphate liquor, which is continually being augmented in volume by the new sulphate of ammonia formed, slowly and continuously trickles out of the absorber to the stock liquor tanks.

Following the passage of the gas, it is next treated in a mechanical gas cooler, where it meets a spray of cold water, and where it gives up the bulk of its tar. The gas leaving this cooler passes to the air regulator, which is merely a small gas-holder, the height of which regulates the quantity of air supplied by the blowers. Thence the gas passes through two centrifugal cleaners in series, which, revolving at high speeds and in conjunction with a small amount of injected water, effectually remove all but very small traces of the tar contained. These latter are removed by passing through the sawdust scrubbers, whence it emerges in a thoroughly cool and purified condition and enters another gas-holder, which serves to keep a constant pressure in the supply main to the gas engines.

The non-recovery process (the apparatus for which is shown on the left of the general lay-out drawing, *Fig.* 4) is very much simpler. The gas, in this case, passes direct into the cooling washer, and from this, through the gas regulator and centrifugal cleaners, to the scrubbers and engines.

Running Cost.—The fuel consumption of a gas plant, as of a steam plant, is dependent upon at least four important factors :—

1. The actual output, which in an electric generating plant will be expressed in kilowatt-hours generated.
2. The no-load losses, which include friction, windage, and electrical losses incurred in running the generator on open circuit, together with all power required for exciters, pumps, and other auxiliaries.
3. Stand-by losses of banking boilers or producers.
4. The ratio of the actual ascertained fuel consumption under day-by-day working conditions to the theoretical consumption based upon test results applied to Items 1, 2, and 3, which will be termed the discrepancy factor.

Stand-by Losses.—The losses through radiation of heat and through leakage of all sorts is a heavy item in all steam-driven electric generating stations, as the conditions of load are generally such that the majority of the boilers are banked for many hours every day.

The fuel required for banking producers is only a small fraction of that required for banking boilers. The actual estimated quantities are 448 lbs. coal per hour per set of boilers for a 2,000-k.w. unit, and 50 lbs. per 1,450-k.w. producer.

Discrepancy Factor.—It is difficult for those who have not had actual experience in running a generating station to appreciate how impossible it is to keep this factor within reasonable limits. For both the steam and gas plants 25 per cent. has been added to the ascertained fuel consumption under test conditions to cover the above contingencies.

Coal Consumption.—For a maximum demand of 8,000 k.w., a load factor of 24 per cent., and a distribution efficiency of 80 per cent. the units generated per annum will be 21,000,000. The authors then give a very interesting method for obtaining the fuel consumption.

This works out to 3·55 lbs. per unit generated in the case of the steam plant, and 2·18 lbs. in the gas plant. These it should be noted are exactly double the figures obtained on test at full load. The annual coal consumption then works out to 33,300 tons and 20,465 tons respectively.

Oil, Waste, and Stores.—The cost of oil as given by various authorities for the steam-turbine plant is estimated at 0·003d. per unit generated, and that for the gas plant about 0·009d., in addition to what is required for the auxiliary plant.

The cost of waste and stores in both cases is taken at 0·002d. per unit. This works out to a total of 0·005d. and 0·015d., per unit respectively, or to totals of £438 and £1,345.

Water.—The water in both cases, it is assumed, will cost 6d. per 1,000 gallons.

The cost for the steam plant is £2,760 per annum, and for the gas plant £555.

It is assumed that 12 gallons of water are required per k.w. hour for cooling the gas engines. Of this 3 per cent. is assumed to be evaporated. Also 35,000 gallons are required per diem in the producers.

Labour.—The labour charges are calculated upon the assumption that the following staff would be required for the respective schemes :—

Steam Plant.

	£	s.	d.
Three charge engineers at £3 per week ...	9	0	0
Three switchboard attendants at 30s. per week	4	10	0
Four drivers at 35s. per week...	7	0	0
Four assistant drivers or cleaners at 28s. per week	5	12	0
Three firemen at 35s. per week	5	5	0
*Nine boiler house and auxiliary plant hands at 30s. per week...	13	10	0
Three men for unloading coal and removing ashes at 28s. per week	4	4	0
	£49	1	0

Total labour charges per annum, £2,550.

Gas Plant.

	£	s.	d.
Three charge engineers at £3 per week ...	£9	0	0
Three switchboard attendants at 30s. per week	4	10	0
Six drivers at 35s. per week	10	10	0
Five drivers at 30s. per week...	7	10	0
Two cleaners at 28s. per week	2	16	0
Three producer hands at 35s. per week ...	5	5	0
Six producer hands at 28s. per week	8	8	0
Seven ammonia recovery hands at 30s. per week	10	10	0
Two men for unloading coal and removing ashes at 28s. per week	2	16	0
	£61	5	0

Total labour charges per annum, £3,180.

*Includes men for cleaning boilers.

Maintenance and Repairs.—This is the most difficult item to estimate with any degree of accuracy for either the steam or the gas

plant. It is practically useless citing the experiences of existing stations.

The authors consider that there is no reason why the cost of repairs should be high with a properly designed gas plant. The gas generators should be cheaper to maintain than the steam generators. And so in each case the cost has been put down at a lump sum of £4,000.

Antiquation, Depreciation, and Interest.—The authors do not anticipate that the gas plant will change very much in type for some years to come, and consider that the depreciation would be small. So in both types of plant the figure of 10 per cent. of capital cost is taken under this head. A lower figure, say 6 per cent., comes out much more favourable to the gas plant.

The total running costs of generating 21,000,000 units under the above conditions will, we estimate, be respectively as follows :—

	Gas. £	s.	d.	Steam. £	s.	d.
Total cost of coal at 12s. per ton ...	12,280	0	0	19,968	0	0
Less sale of sulphate of ammonia ...	5,524	0	0			
Net cost of coal	6,756	0	0	19,968	0	0
Oil, waste, and stores...	1,345	0	0	438	0	0
Water	555	0	0	2,550	0	0
Labour	3,180	0	0	2,590	0	0
Repairs...	4,000	0	0	4,000	0	0
Interest and depreciation at 10 per cent. on capital	17,687	0	0	13,952	0	0
Total cost	33,523	0	0	43,668	0	0
Total cost per unit	0·383d.			0·498d.		
Total cost, allowing 6¼ per cent. for interest and depreciation	£26,900	0	0	£38,428	0	0
Total cost per unit	0·306d.			0·438d.		

Effect of Price of Coal and Load Factor.—In the particular case considered the conditions are favourable for the use of a gas plant, as the load factor is higher than is usual in municipal electric supply schemes, and also it is usually possible to obtain coal for less than 12s. a ton.

Going to the other extreme, and considering the case of a generating station having the poor load factor of 10 per cent., with coal at 8s. per ton, a maximum output of 4,000 k.w., and a load which would not justify the use of an ammonia recovery plant, it is found that the saving in fuel effected by the gas engine is barely sufficient to pay the 10 per cent. interest, etc., charges on the higher capital outlay.

It has been suggested that for such conditions a combined gas and steam plant might be used, the gas plant being utilized for the long

hour portion of the load curve, and the steam plant with its lower capital charges for the peak load.

A detailed comparison is then made of the three systems—gas, steam, and combined gas and steam—for a 4,000-k.w. station working under the above conditions. The costs per unit are also worked out for different load factors and costs for fuel, and are plotted in *Fig.* 9. The authors show that for *entirely* new stations the combined plant never pays.

From the figure it will be seen that the steam plant comes out the cheapest when the conditions as to cost of fuel and load factor are to the left of the line AB, and the gas plant is cheaper when they are to the right of that line.

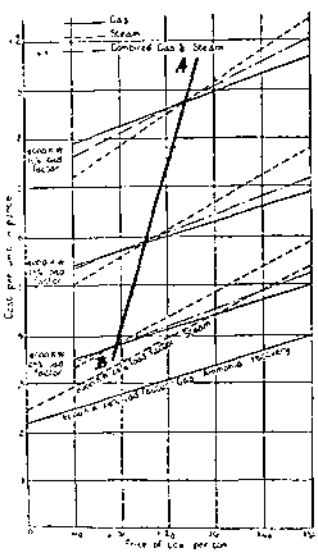


FIG. 9.

There are however many existing installations equipped with comparatively inefficient plant, where a large economy would be effected by installing gas engines which would be used for the flat portion of the curve, the inefficient plant being retained for the peak load and stand-by.

In the discussion which followed there was of course considerable divergence of opinion among speakers.

As the whole question ultimately boils down to the financial and not to the engineering point of view, the criticisms on the finances of the proposed stations will be dealt with first.

Turning to the tabulated costs of the plants, speakers seemed to agree generally that the cost of the steam plant could be cut down to £120,000, partly by putting in larger units and fewer economizers, and

partly by placing the station near an adequate supply of water. The cost of the gas plant was not criticized, except that it seems assured that the cost will come down considerably in the near future as larger numbers are turned out.

As regards running costs, it was held that 12s. was a high price for coal, and also that a cheaper quality of coal could be utilized in the boilers than in the producers.

As regards water, it was held that the difficulties *re* supply of condenser water for the steam plant were overestimated. Nowadays, with high-tension distribution, the central station could be some way from the electrical "centre of load" without unduly increasing the cost for cables, and so could nearly always be near an abundant or cheap supply of water.

As regards the item of £4,000 for repairs to gas plant, opinions varied largely. Several speakers gave their experiences, some of which were satisfactory, and some the reverse. It seemed to be difficult to eliminate the expenses brought about by lack of experience, installing experimental engines, etc., but on the whole the figure taken was allowed to be as near an approximation as could reasonably be taken.

The result of these criticisms would be to considerably reduce the running costs of the steam plant to a figure which would be very little in excess of those for the gas plant.

Referring to *Fig.* 1, Curve C, which shows the number of hours in a day during which any particular load is maintained, it was held that the proper way to make use of gas-engine plants with their low-running costs is to instal them to generate for the level part of the load curve, and to work them with ammonia recovery, so as to reduce the running costs to a minimum. In this way the interest, etc., on high capital outlay would be borne by a large number of units generated, and would not come to a high cost per unit.

Acting on this principle, it was suggested by Mr. Highfield that the way to introduce gas engines was not to put up huge stations, but to add gas plant to existing steam plant, and use it for as much of the continuous load as possible, and gradually to alter the design of the steam plant, so as to reduce the stand-by losses to a minimum.

This opinion seems to be endorsed by the technical press, which on the whole seems to consider that the wholesale introduction of large gas-engine stations has not yet arrived.

The paper and discussion disposed of the objection to gas engines on the score of the difficulty of running alternators in parallel, and seemed to show that the item for repairs would not be a heavy one. The chief difficulty which it was thought would crop up was that the number of men who are used to working gas plants is very limited, and that through inexperience at first there might be unsatisfactory and uneconomical running.

TRANSCRIPT.

THE FINAL STRUGGLE FOR 203-METRE HILL AT PORT ARTHUR.

Translation of an article by Staff-Capt. Kostiushko in the March, April, and May numbers of the *Ezenhenernee Zhoornal.*

(*Continued*).

(1). *Fighting on Visokaya and Flat Hills.*

On the 28th November, from 10 a.m. till evening, the Japanese shelled Visokaya, and fired in that interval 25 11″ shells, 80 6″, 60 mines, and 300 other shells of small calibre from field guns, mountain guns, etc.; the bombardment caused a great amount of damage.

General Tretyakov during the day watched the fighting on the right flank and centre, and from what he saw concluded that the Japanese were transferring the attack to the left flank, and towards evening he passed the following order along the position:—"I am expecting an attack on our positions. Let everything be in readiness to offer due resistance.—Colonel Tretyakov." The companies of the reserve were ordered to stand by in readiness near the 5th Regiment headquarters, and the trenches of the 2nd line, *i.e.*, those lying between Forts Nos. 4 and 5 (Red Hill, Fougasse, Two-Angled, and New Lunettes), were occupied by the companies of non-combatants allotted to this section, *i.e.*, those of the 5th, 13th, and 28th Regiments.

The reason that the non-combatants were ordered to occupy positions was because even during the earliest fighting at Port Arthur it was felt that the garrison was too weak in numbers. To make up the deficiency the corps of Port Arthur Foot Town Guards was formed, but as even then numbers were insufficient, after the sanguinary fighting in August and September, General Stessel ordered all non-combatant establishments to be reduced to a minimum and all men thus saved to be sent to the positions. In consequence of this, not only the staffs of clerks, bakers, and other specialists were reduced by about one-half, but even in each of the Officers' Messes only three men were left, and those preferably men who had recently come out of hospital after having been seriously wounded.

Officers' private servants were also reduced and replaced by wounded men, and the men of the bearer companies, required for carrying the wounded, were replaced by the remainder of the clerks and musicians. In a word, General Stessel arranged that during the fighting not a man should be wasted. But in spite of this an insufficiency of fighting men

was experienced. Then he went further and ordered that all non-combatants, except the drivers in charge of the travelling kitchens and the ammunition carts, must go to the positions. This measure supplied about 1,000 fighting men, but as on their departure all regimental routine was at a standstill, he further ordered that when no attack was either going on or immediately expected, these non-combatants were to carry on their usual work.

In case of need they had to come up at the first call, and as General Tretyakov summoned his non-combatants into position, it is evident that he had no doubt that his section was about to be attacked. And so it was.

The Japanese kept up a steady rifle and artillery fire on Soloviev's position all day and all night, in the hopes of drawing off attention and reserves from Visokaya Hill.

On the *28th November*, from 9 a.m. till evening, they kept up a heavy fire on Visokaya, and expended about 800 11" shells, 300 6" shells, 20 mines, and more than 1,000 smaller shells.

On this day the Japanese artillery directed all their fire on the redoubts excavated in the rock on the two summits of the hill. The redoubts were much damaged; in places the 11" shells cut off great masses of granite half the size of a cottage, which fell down and in places completely blocked the trenches; but as the infantry were in the ring trench, and the redoubts during the bombardment were occupied only by sentries, the losses were very small in comparison with the number of shells fired.

Towards evening General Tretyakov, expecting an attack, sent the 7th Company, 14th Regiment, to reinforce Visokaya Hill, and the 12th Company, 5th Regiment, to Flat Hill; but both companies eventually went to Flat Hill, as by the time they came up it was evident that they were more needed there.

At 5 p.m. the Japanese infantry attacked Visokaya, but were repulsed. At the same time they attacked Flat Hill, and here they were at first successful, driving out the remnants of the 5th Company, 27th Regiment; pressing on to the Stony Redoubt, they had even burst into it, when the reinforcing companies came up in time and beat them out.

In this struggle the 4th Section, 7th Company, 14th Regiment, under Sergt. Loshkarev, especially distinguished itself. Arriving with the rest of the company at Flat Hill, this N.C.O. got leave to lead forward his section against the Japanese, who had got into the Stony Redoubt and were collected there in bunches, uncertain what to do next and probably waiting to be reorganized.

This gallant section, without waiting for the Japanese to recover themselves, charged into them with the bayonet. They lost their heads and rushed back, practically offering no opposition. The remainder of the company then came up, followed by the 12th Company, 5th Regiment; under Lieut. Ivanov, and drove the Japanese from the lower trenches also.

About 6 p.m., just as the Japanese had broken into the redoubt, one of the columns driven back from Visokaya attempted to seize the saddle between Visokaya and Flat Hills; information was sent forthwith by telephone to the batteries, which immediately opened a heavy fire on the column. At the same time rifle fire was brought to bear upon it from

Visokaya. Entrenchment No. 4 was the first to open an especially successful fire on this column. Under this combined fire the column fell back, but in the darkness it was difficult to estimate its losses.

In the centre of Flat Hill the Japanese also had some success, but were driven back by half of the 9th Company, 5th Regiment.

By 8.45 p.m. the Russians were everywhere re-established in their original positions, and while some engaged in a hand-grenade fight with the Japanese, others repaired their damaged works.

The riflemen who took part in this fighting, when they considered the undecided action of the Japanese in the captured redoubt, so different from their usual ready way of adapting themselves to circumstances and their previous stout resistance to counter-attacks, decided that they must have been recruits. It was also noticed that the few wounded Japanese who were captured were young-looking men. These appearances led to a rumour that the Japanese were nearing the end of their resources, and in order to replace their enormous losses had to draw upon untrained recruits and youths of 18 and 19.

In the evening the non-combatant company, 5th Regiment (81 men), was sent to Flat Hill; the 12th Company, 5th Regiment, took over on Flat Hill part of the trenches of the 5th Company, 27th Regiment.

At about 6 p.m., in the thick of the fighting on Flat Hill, several alarming telegrams came in. From Division Hill it was reported that fully a company of the enemy were lying under the slope near the 3rd Company trenches, and that opposite the left flank of Division Hill the Japanese were coming forward in groups from Dead Knoll. From Flat Hill reports arrived that the Japanese had broken in and the hill was in great danger, and that reinforcements were urgently necessary; and from Visokaya that the enemy's columns were moving between Visokaya and Flat Hills.

Among the others, the following message was received:—"To-morrow, by order of General Fok, General Nedein and I are coming to inspect the biscuit store of the 5th Regiment.—Staff-Capt. Shelkovnikov." In spite of the want of consideration on the part of the commander of the 4th E. Siberian Division, which this message, sent at such a time, displayed, General Tretyakov found time to make suitable arrangements, and on the following day the supply officer, Staff-Capt. Felitsin, commanding the non-combatant company, with the quartermaster, Lieut. Frost, and a few drivers—the rest of the non-combatants being then on Flat Hill—were taken away from their work for several hours.

On the 29th General Irman ordered, by telephone, Capt. Romanovski, commanding the 2nd Division of the West Front of the Land Defence, to send the section of quick-firing artillery, commanded by Lieut. Siromyatnikov (2nd Battery, 4th E. Siberian Rifled Artillery Brigade), from Lyaoteshan, to a position at the village Liudzyatun, near Pigeon Bay, with the object of sweeping with fire the southern and western slopes of Visokaya, and thus striking the Japanese attacking columns in flank and rear.

The General sent a special message to this officer that he must assist the defenders of Visokaya Hill by every means in his power, and that their chief hope lay in him.

30th November.—In two hours, *i.e.*, between 3 and 5 a.m., Lieut.

Siromyatnikov brought his two guns into position behind a low hill, which successfully concealed them from the enemy's view, without impeding their fire by its sloping sides. A gently sloping rise in rear of the guns blended imperceptibly with the foreground, and thus masked them from Japanese detection. Firing began at dawn, but was penalized by the bad quality of the fuzes, which frequently failed to burst the shells.

The observation post was skilfully selected on the crest of the hill in front and to the left of the guns, and, masked by Chinese tombs, the observers got a good view of Visokaya Hill and the approaches to it from the enemy's side. They remained continually on the alert, and when the Japanese advanced they promptly opened fire on them.

A few well-aimed shells compelled the Japanese to disperse and take cover in their approaches, where these guns, which were equipped with nothing but shrapnel, were unable to touch them. In the evening they were reinforced by another section, under Staff-Capt. Nezhentsov, but unfortunately the limited supply of shells prevented their fire from being developed as much as the occasion demanded.

These guns kept up their fire by night, using as a stationary directing object the Lyaoteshan Lighthouse, which was situated about 5 versts in rear of the position. The Japanese did not direct any serious fire in their direction, but from the occasional common shell which fell in their vicinity it appeared that they were searching for their position.

With a view to diverting attention from Visokaya Hill and depriving the Russians of a position which commanded their approaches to that point, the Japanese before dawn advanced once more against Soloviev's position; but after three attacks had failed, at about 5 a.m. they desisted, and contented themselves with shelling the Pigeon Bay defences.

30th November.—The Japanese continued the whole night shelling Visokaya and Flat Hills, and although their fire was weaker than it had been during the day, yet the damage done exceeded in extent the repairs which the defenders managed to carry out. At dawn the fire increased, and at that moment they again advanced to the assault. The 4th Company, 7th Reserve Battalion, was sent up to Visokaya at 8 a.m., and a composite company of the 3rd Division (71 men) at 8.20. So impetuously did the Japanese press the attack that a few men gained the left peak of the hill and there posted a flag, but owing to the timely arrival of reinforcements the attack was repulsed, the gallant men who had reached the crest were slain, and the flag thrown down. After this the Japanese began collecting under the hill for a fresh attack.

At 10.30 a.m. the non-combatant company, 15th Regiment, was sent to Visokaya Hill, and as no more reserves remained with the staff of 5th Regiment, General Tretyakov ordered the 1st Company, 7th Reserve Battalion (Staff-Capt. Diukin, 89 men), which had just been sent as a reinforcement to Flat Hill, to go over to Visokaya. This shows clearly how urgent was the need of reinforcements.

Meanwhile the Japanese maintained a strong artillery fire, which caused enormous losses. About 11.0 they carried out a fresh attack, but owing to the timely arrival of reinforcements it also was repulsed. About 11.40 the artillery fire ceased, their infantry went away, and quiet lasted for about an hour. They were probably having their dinners. The

Russians sent down urgent messages for food to be sent up to the positions, but owing to want of haste and also to the stocktaking in the biscuit store, no food arrived before 12.30, just as the Japanese reopened their fire, and with such energy that even 11" shells fell three or four at once. The men grew fewer and fewer, and all the local reserves were expended in replacing the dead. At 2 p.m. the 6th Company of the Kwantung Naval Detachment (109 men), under Lieut. Pashkov, was sent to Visokaya, and a little later the non-combatant company, 14th Regiment (100 men), under Lieut. Lokoshchenko, and also the non-combatant company, 16th Regiment (121 men), under Lieut. Yenkovich.

On Flat Hill nothing of importance was happening, but the trenches of the two companies on the left flank (the 5th and 8th Companies, 27th Regiment) were wrecked and many of the men put out of action. The commandant, Lieut.-Colonel Budyanski, expecting a night attack, called urgently for reinforcements, but there were none to send; in fact, both General Tretyakov and General Irman received refusals from headquarters to their own pressing and reiterated requests for more men to be sent to them. The 7th Company, 27th Regiment, which came up at about 2.0 p.m., was at once sent to Flat Hill, and the only reserve which remained with the 5th Regiment Staff was a half-company of sailors, landed from the *Amur* (71 men), who were kept back in case of the enemy breaking in between Flat Hill and Visokaya.

Meanwhile at 3.10 p.m. Capt. Stempnevski I., commanding on Visokaya, reported that in the centre of that hill all the blindages were wrecked, on the right flank almost all were choked with earth, that many of the men were crowded together and buried in the blindages, and there were no spare hands to assist in digging them out, and in any case this was impossible owing to the fire; the communication trench leading to the centre was blocked in two places, and all communication had become very difficult. It was also reported that the losses were enormous and reinforcements very necessary.

At 3.20 p.m. Lieut. Erofeev, who was observing the front of Visokaya from Pigeon Bay, reported about a company of Japanese lying to the east of some groups of stones under the left peak, and that east of their communication trench dense lines of Japanese were climbing out of their saps, and more still were following them. Evidently they were preparing another attack on the hill. Generals Tretyakov and Irman again urgently begged for reinforcements, but the only answer they got was that there were no reserves left, and that Visokaya Hill was expending such a large number of reinforcements that they must really be more economical.

As soon as, by continuous pounding, the Japanese had thoroughly prepared the way for success, at 4.30 p.m. they advanced up Visokaya Hill in dense masses. The attenuated Russian line had no power to resist them, and they occupied the front, or western, part of the ring trench.

Stempnevski now reported by telephone that the Japanese were crowding into his position in large numbers, that he had not got sufficient men to hold it any longer, and begged for permission to give it up.

General Tretyakov wanted to go up to the hill in order himself to take over the superintendence of its defence, but his staff restrained him; whereupon he sent an order to Stempnevski to hold the top at all costs. At the same time the condition of affairs on the hill was reported to the Staff of the Land Defence.

Tretyakov now ordered the 5th Company, 5th Regiment, on Division Hill, to come at once to the 5th Regiment headquarters, and the 7th Company, who were alongside them, to spread out into the 5th Company trenches. General Irman, who had been following the fight on Visokaya with field glasses from Fougasse Hill, now returned to 5th Regiment headquarters and confirmed Tretyakov's dispositions. He thanked him, and when at 5 p.m. he got into conversation through the telephone with General Kondratenko, he told him that the hill had only been held hitherto by the energy and resourcefulness of General Tretyakov. At the same time he sent the following report to the Fortress Staff:—"The Japanese have occupied nearly the whole of Visokaya. . The whole of the trench on Flat Hill is in their hands. I am expecting them to break in, and have in reserve only a half-company of sailors.—From General Irman; 5 p.m., 30th November."

Both the Land Defence Staff and also General Stessel sent orders to hold Visokaya at all costs.

After this alarm as to the fate of Visokaya had been realized, reinforcements began to arrive in some proportion to the urgency of the case. General Kondratenko, anxious about the hill, came himself at 6 p.m. to the 5th Regiment headquarters, in order that he might become more closely acquainted with the conditions and give his sage advice.

All met this heroic man with joy, and felt more confident in his presence. By his gracious tone, his kindness, and tranquillity—rare qualities, which did not desert him even for a moment—he was universally welcome.

Meanwhile conditions on Visokaya had become worse and worse. Having established themselves in the ring trench, the Japanese climbed up to the redoubts and on to the saddle. They captured part of the left redoubt, but in the remaining parts, thanks to the vigorous action of Stempnevski, a desperate struggle was maintained.

General Tretyakov, fearful for the fate of the hill, eventually rode up to take immediate charge of the fighting. On the way his horse was wounded in the foot by a rifle bullet fired from the hill, which gives some idea to what extent it was then occupied by the Japanese.

At 9.30 p.m. the following telephone message was received at the 5th Regiment Staff, and immediately transmitted to Tretyakov on Visokaya:—"From General Stessel. To Colonel Tretyakov. I order you to defend Visokaya Hill like Bayazid. It is a most important point."

When Tretyakov on arrival had taken up the direction of the defence and had personally ascertained the state of affairs, he reported:—"The trenches on Visokaya are destroyed, the blindages broken, and its maintenance is very difficult. I will do what I can." Then collecting the newly-arrived reinforcements and distributing the men among the various areas, he led them forward to drive the Japanese from the trenches which they had occupied and from the left redoubt.

The following reinforcements reached Visokaya Hill before midnight, but their times of arrival are not accurately known:—5th Company, 5th Regiment, 89 men, Capt. Fofanov; two companies of seamen from the *Amur*, 20 men; 7th Company, 7th Reserve Battalion, Lieut. Antonov, 44 men; composite company, 28th Regiment, Sergt.-Major Kurnosov, 71 men; half of the 8th Company, 26th Regiment, 60 men; and at 2 a.m. on the 1st December, the 3rd Company, Naval Battalion (from the ironclad *Pobieda*), Midshipmen Bershadski and Fleisher, 171 men.

The first counter-attack was unsuccessful; the companies took the wrong direction and then fell back at 10 p.m.

Just then, another company coming up, General Tretyakov added it to his forces, and again distributed the companies to areas, encouraged them, and personally led them to the attack.

The night was dark; all around were heard the crackling of rifles, the sharp cries now of the Russians and now of the Japanese, the bursts of hand grenades, and the deafening crashes of large and small shells. In the darkness, from time to time, now here, now there, the Russian riflemen lighted up Roman candles, improvised for them by their mining officers.

In this night fighting success sometimes favoured one side, sometimes the other. To avoid going into too great detail, it will be sufficient to record here only one important and interesting occurrence.

The reinforcing companies, encouraged by General Tretyakov, moved forward rapidly, but as they approached the Japanese they stopped; cries were heard, disorder spread among them, and the next moment they had broken backwards, carrying away with them the line which had hitherto stood firm. The whole hill was cleared in a moment. The ruin appeared to be irretrievable, and no power could turn the flying men. Near General Tretyakov, among a small group of riflemen and one or two officers, stood Ensign Ermakov, and to him Tretyakov gave orders to run down the hill and turn back the runaways, while he himself, brandishing his sword, began exhorting those who were left, imploring them to remember their oaths, their Faith, and their Tzar. In the end, seeing little prospect of success, he exclaimed in despair "Well, then, retire; I alone am going to retake the hill."

Among the garrison were many men of the 5th Regiment who loved their commanding officer and were touched with shame, so that voices began to be heard, "Brothers, the Commandant of the Regiment is left on the hill; we must go and rescue him." Whereupon this living wave, with Ermakov at their head, broke back up the hill. Tretyakov, taking advantage of this enthusiasm, lost no time in leading the men against the Japanese, and with him in front of the attack went Lieut. Fetter, of the Mining Company, Ensign Ermakov, and others. In this attack the men of the various corps were so intermingled that there was no question of rearranging them in their companies.

The Japanese were already occupying the summits of Visokaya when this attack burst upon them, and so impetuously was it pushed home that not only the redoubts, but even the trenches below them, were recovered. Only a very small section of the trench on the left flank remained in the hands of the Japanese, and all attempts to drive them

out of that failed. But this short length of a few paces had little importance; the hill had been recaptured, and the full credit belonged to General Tretyakov, and to his faculty of not losing his head in a moment of difficulty.

General Irman reported the occurrence in the following words:—"To the Fortress Staff. From the 5th Regiment Staff. The Japanese have been beaten from all the trenches, and the whole of Visokaya is in our hands, thanks to the energy and initiative of Colonel Tretyakov. The repairing of trenches has begun.—Colonel Irman, 12.50 a.m., 30th November—1st December."

The Japanese were driven from the hill at about midnight. The joyful news flew through the city, which was anxiously awaiting the result of the fighting. Some idea of the general relief may be gathered from the following message received from General Stessel at 1.30 a.m.:—"Hoorah. You heroes will receive worthy rewards. Thanks to Irman, to Tretyakov. I embrace you all heartily.—Stessel."

After having repulsed the Japanese, Tretyakov set to work to reorganize his command and to repair damages, which latter work included the clearing of trenches and communications, excavating collapsed blindages, and repairing the wire entanglements.

Against Flat Hill the enemy from daybreak had opened a powerful artillery fire, and after dinner they threw several mines, endeavouring thereby to destroy two machine guns which were posted in the trenches of the left flank. The machine-gun detachment, which consisted of sailors, frequently changed the position of these guns, and at last withdrew them altogether from the parapet and hid them in the trench, "to escape the attention of the Japanese gunners." With one of the guns was 1st Class Seaman V. D. Perevozchikov, of the cruiser *Pallada*.

For some time the Japanese infantry had been collecting in the parallels on the slope of Visokaya, and in that nearest to Flat Hill two companies, each numbering from 250 to 300 men, were crowded. It was evident that they were preparing for an attack on Visokaya, and while awaiting the appointed hour, not anticipating any danger, some were sitting and others lying in the sap, making themselves as comfortable as circumstances permitted. Their rifles were leaning against the parapet, and in two or three places the smoke of fires was peacefully rising. On noticing this, the sailors of the machine-gun detachment quickly planted their guns in a spot from which it was possible to enfilade this parallel, and about a score of the most skilful riflemen joined them. All took careful aim, and when everything was ready they fired together.

The Japanese trench at once awoke to a scene of the most frightful confusion. The men threw themselves from side to side like madmen, in fruitless search for cover; some leapt out of this unexpected tomb and as if on wings dashed down the hill, but here the bullets caught them before they had succeeded in reaching a place of safety. In a minute or two the turmoil had ceased. The parallel was filled with dead bodies, and looked more like a combined grave than a trench, and it is needless to say that the Japanese did not again collect in it.

At 3 p.m. an attack by the Japanese infantry was made against a small portion of trench in the section of the 12th Company, 5th Regiment, on the left flank of Flat Hill, near the dead ground. This section had suffered very heavily from artillery fire, and at the moment of attack was defended by only nine riflemen, the rest having been killed or wounded. The Japanese rose unexpectedly from the dead ground; the defenders opened fire on them, but some found their rifles choked with dust and had to have recourse to their bayonets. Several perished in the hand-to-hand struggle that ensued, and the rest fell back to right and left along the trench. After this the Japanese were pelted with hand grenades and fired on with rifles, and they replied in the same manner; and in this way about an hour passed.

By this success on the part of the enemy the 12th Company was cut in two, and volunteers were promptly called for from the two half-companies to advance simultaneously from both sides and restore connection. From the 2nd Half-Company there came forward Zakharov, senior sergeant of the 3rd Section, Sergt. Tvorogov, Corpl. Yakimov, and Town-Guard Vavilov, and from the 1st Half-Company Rifleman Polyakov, and the rest followed them. After throwing hand grenades into the trench and firing at those of the enemy who were in the act of climbing over the parapet, the volunteers of the 2nd Half-Company dashed forward until they had joined hands with the 1st Half-Company.

Many dead and severely wounded Japanese lay in the trench, and among them, concealed by a traverse, were three only slightly wounded. Unaware of their presence, Tvorogov and Yakimov advanced along the trench and were promptly bayoneted. The men who rushed to their assistance took vengeance on all the Japanese who were found alive in the trench for the destruction of their brave comrades; but Tvorogov and Yakimov, who had always taken the lead in their company's charges, expired after about half-an-hour's agony.

Meanwhile the damaged parapet was built up with Japanese corpses, and preparations were made for meeting a fresh assault, which came off almost simultaneously with that on Visokaya Hill at about 5.15 p.m. As before, the Japanese were at first successful in a few places, but were eventually driven back at all points, losing a few prisoners.

On this day, the 30th, the Russians lost about 1,000 men, and the Japanese probably about 3,000.

At 11 p.m. Staff-Capt. Belozerov took over command of the hill from Capt. Stempnevski I.

At that time the receipt of an order to go to Visokaya Hill amounted practically to a sentence of death. Thither daily many went, but rarely did one return. Generally, in not more than an hour after moving off, the more fortunate (wounded) were carried back on stretchers to the hospitals; the less fortunate (killed) no one troubled about, but left them on the hill.

But, after all, the conditions in November for the wounded were so horrible that it would be difficult to say who were more fortunate, they or the killed. The dead at any rate were out of pain, and for them every place was suitable, everywhere there was room. But for the wounded it

was necessary to look for room; and where could they look, when all the hospitals were full, not only the beds, but even the very floors of the corridors?

In the hospitals it was customary to place the beds two together, so that each pair could take three wounded. On the news arriving that a fresh assault had begun, in order to make room for a fresh influx of wounded, all those whose wounds had begun to heal, or who could use their legs, were sent out to join the detachments of invalids, or to the ranks. For two or three days afterwards they were allowed to visit hospital for dressing or medicine; and many used this privilege, so that towards the end of the siege as many as 3,000 daily were attending the hospitals in Arthur. But it is difficult to say how many in the ranks were really fit.

But these measures were insufficient, and during a serious attack the influx of wounded men was so great that all available space was filled in the course of the first day.

The fighting on Visokaya followed immediately upon the assaults of the 28th November on Forts Nos. 2 and 3, so that the hospitals were full to overflowing before this fighting had even begun. During the fighting the bearers carried their wounded to the nearest hospital, and if they found a spare place they left him there. Failing this they laid down their stretcher in the corridor without asking whether the hospital could take him in or not. But when the corridors were full and no room could be found, they had to carry him to a second hospital, and then to a third, and so on. Sometimes these journeys took many hours, if not a whole day, all the hospitals being visited in turn. In this way it not infrequently happened that the wounded man could not endure such treatment, and died before he could be crowded in anywhere. Nor was this surprising; the men were extremely exhausted with hard work, poor food, and want of rest, and their wounds, with loss of blood and physical suffering, added to their weakness. They wanted warm rooms and rest, but instead of this they were borne in the cold all round the filthy streets of Arthur, and their painful condition was exposed in all its nakedness and horror.

The stretcher-bearers also were placed in a position of great difficulty. The hospitals could not receive the wounded, and there was nowhere else to take them. But what could they do? They could not leave them in the middle of the road, and yet where was there to take them?

Within the hospitals work went on unceasingly, attendants striving to clear the corridors, Sisters of Mercy attending the wounded on their arrival and trying to ease their sufferings, and surgeons with pale, tired faces performing endless operations. They worked all day and all night. Sometimes they stopped for two or three hours in the night, to begin their terrible work afresh at 6 a.m. next morning; but even then they got no rest, for they felt that those minutes of leisure were gained only at the cost of human lives.

They worked on indefatigably to the sound of shells crashing overhead and occasionally even striking the hospitals. Thus, for instance, over the Composite Hospital shells were continually shrieking; some fell in the

yard and close to it, and one actually struck the room next to the operating theatre. But all the same those heroic surgeons, Giubbenet and Ivanov, took no notice of the danger, and with cheery good humour went on with their work.

The 9th Hospital was the first to receive damage, as a shell struck it in the first bombardment of the town during August, and in subsequent bombardments shells fell in the yard and out-buildings, and occasionally in the building itself. After the fall of Visokaya Hill the upper storey was rendered uninhabitable. In this hospital that skilful surgeon, Krzhivets, without relief or rest day or night, performed operations unceasingly. Pale, silent, and stern of countenance, he carried out the most difficult work. For instance, under the eyes of the writer he put 14 stitches in the intestines of a non-commissioned officer who was wounded in the stomach, doing the operation with marvellous confidence and rapidity. The impression produced upon the writer was such that if he were ever wounded and required an operation, he would pray to be given into the hands of this man. Under his knife he would die happily.

He would also trust himself in the hands of Giubbenet and Ivanov, and also in those of the surgeon of the Red Cross Hospital, Mirotvorets, and yet in their case a certain amount of pity was felt for the patients, while no one pitied those of Dr. Krzhivets.

Both the 6th Mobile and the 6th Reserve Hospitals were seriously damaged by shells. The Dalninski Hospital, since the first bombardment, had to move four times. But every hospital was exposed to danger, and in each unnoticed but heroic men worked unceasingly without relief or rest. In fact, the surgeons in Port Arthur earned the character of heroes without fear and without reproach, gallant in heart and in their work.

The same respect is due to the Sisters of Mercy; in an unostentatious manner they also carried out most heroic work.

On the evening of the 30th November the gallant naval lieutenant, Deichman, fell on Visokaya Hill. It was due to his enterprise that some time previously a Japanese war vessel was blown up in Kerr Bay. This is how it happened:—

The Japanese wanted to make Kerr Bay, which had been mined by the Russians, navigable to their ships, and had consequently dragged away the mines, and in this way formed a channel, which they marked by buoys, consisting of anchored barrels.

Deichman begged permission to be allowed to make a trap for the Japanese, and taking a few trusty naval volunteers on a dark night about the 15th May, he went in one or two small boats and removed the casks to the area into which the mines had been dragged. In the greatest danger this gallant party worked the whole night without being discovered.

At dawn on the 17th May a Japanese cruiser, probably the *Asama*, approached Kerr Bay, and guided by the casks she struck on a mine. The scene of the disaster was marked on that day by her masts, which alone rose above the surface of the water. On the 19th May, in the

presence of the 5th Regiment at Kinchow, General Stessel publicly thanked and decorated Deichman, who also received many congratulations from the officers of the 5th Regiment, but replied, modestly, that he had only done his duty.

After Kinchow the writer lost sight of him, but he became famous in Port Arthur for having broken through the Japanese blockade with despatches for Kuropatkin, and returned shortly before the fighting on Visokaya Hill. After this he volunteered for service on land, and having asked for an appointment in the 5th Regiment, was given the command of the 6th Company, which happened to be vacant.

At 6.30 on the dark evening of the 30th November, when the storm on Visokaya Hill was at its height, and anxious watchers were awaiting news with sinking hearts, the 6th Company stood at the headquarters, 5th Regiment, awaiting the order to proceed to the hill; Deichman, after receiving a few final orders from General Kondratenko, came up to them and greeted them cordially as their new commander. He met with a cordial reception, and telling the men that they were ordered to the hill, and that there they would have many opportunities of becoming better acquainted with him, he marched them up and reported to Stempnevski, who was arranging an attack to drive the Japanese from the redoubt on the right. This attack was carried out from three sides by three separate parties; on the left Stempnevski himself made a demonstration with a few men using rifle fire and grenades; in the centre Deichman charged in with 10 volunteers, but was immediately killed with a bullet through the forehead; and after that 15 men, with naval Lieut. Morozov and Ensign Ermakov at their head, advanced towards the redoubt, and after hurling a few grenades, went in with the bayonet; but most of the Japanese succeeded in getting away, except a small party who were caught sitting in a blindage. This party having been disposed of by grenades, the redoubt was finally cleared of the enemy. Both of these last-named officers distinguished themselves by many deeds of valour on Visokaya Hill.

On that same evening another gallant officer, Staff-Capt. Vanikovski, commanding the 7th Company, 14th Regiment, also fell. He was killed by a stone thrown up by a bursting shell, and his men, who went out into most dangerous ground to recover his body, bitterly lamented his loss. The commander of the 4th Company, 15th Regiment, Staff-Capt. Borzinski, and Staff-Capt. Rozhanski, of the same regiment, were also wounded on this day by a bullet which ricocheted from Ensign Ermakov's rifle.

1st December.—Visokaya Hill was bombarded all night with every sort of shell, and although the firing was less intense than it had been during the day, yet the damage done exceeded the repairs which it was possible to carry out during the night, while the continual firing kept the garrisons of both hills in a state of extreme anxiety. Another demonstration was made in the direction of Pigeon Bay, but Capt. Romanovski, with his detachment, did not allow it to advance far.

At 6.30 a.m. some Japanese infantry moved forward against the right flank of Visokaya, but were easily driven back, owing to the failure of

their main attack against the left redoubt, which was dispersed by the quick-firing guns in the neighbourhood of Pigeon Bay.

During this day these guns, under Staff-Capt. Nezhentsov and Lieut. Siromyatnikov, were especially successful. This was due to the fact that one of the sections had with it about 80 Chinese common shell, which, though intended for use with ordinary powder, were nevertheless suited to the Russian guns, and proved an unpleasant surprise to the Japanese, who had hitherto gained complete cover from shrapnel in their trenches and blindages.

Selecting the moment (6.30 a.m.) when the Japanese were massing for the attack, these officers opened a rapid and well-directed fire on the trenches. The Japanese, finding that their trenches no longer protected them, retired downhill and round to the north, and 40 shell were sufficient to disperse the column intended for the attack on the south-west slope of the hill.

At 7.30 a.m. an order was sent by telephone to Staff-Capt. Marchenko, commanding the 8th Company, 5th Regiment, on False Hill, to detach a section to occupy a small unnamed knoll in rear of Visokaya, in order to prevent the enemy from gaining access to the Tea Ravine, between Flat and False Hills, in the event of the fall of Visokaya Hill.

At the same time the 6th Company, 15th Regiment, under Lieut. Silvin (120 men), and a company of about 91 sailors were sent to reinforce Visokaya. At 8 a.m. Staff-Capt. Belozerov reported their arrival, and also that large reinforcements were arriving for the Japanese from beyond Angle Hill.

At 7 a.m. the Japanese increased their fire on Visokaya Hill with 11″ and 6″ shells and with mines, and maintained it until evening.

At 3 p.m. Belozerov reported that only two of the blindages on the left flank remained uninjured, and that these were occupied by sailors. All the rest were wrecked, and it was hard to say how many men were buried in the débris, as communication along the trenches had been interrupted.

While the artillery fire was thus destroying the works and causing great losses among the men, the Japanese infantry were able to approach without molestation and mass secretly in their saps and approaches, and at 4 p.m. these masses moved forward to the assault.

With their trenches interrupted and their numbers terribly thinned, the Russian riflemen, reduced to a few disconnected handfuls, were unable to resist the shock of the advancing masses, and all perished, while the Japanese penetrated to the very summit of the hill and there planted their flag. General Tretyakov had only 100 men in reserve when he was informed of the sudden appearance of the Japanese on the crest. On the left summit the enemy's flag was floating, and thither dashed Belozerov with a section hastily taken from this reserve.

This example of action encouraged all, and simplified matters for General Tretyakov, who forthwith sent another section in support, and himself led the rest against the saddle and the right redoubt. Lieut. Seifulin, 5th Regiment, who was also on the hill, took an active part in driving back this assault.

The following reinforcements were then sent to Visokaya Hill:—

A composite company from the boat reserve (155 men, under Lieut. Normand).

The company landed from the *Poltava* (109 men, under Lieut. Baranov and Midshipman Yunkovski).

The company landed from the *Sevastopol* (87 men, under Midshipmen Petrov and Shnakenburg).

And to Flat Hill the following hospital detachments:—

1st. 150 men, under Lieut. Suvorov, 25th Regiment.

2nd. 150 men, under Staff-Capt. Maslenkov, 26th Regiment.

3rd. 90 men, under Lieut. Vasilevski, 28th Regiment, and 45 convalescents without an officer.

The 4th Hospital Detachment arrived later.

Capt. Geiking, commanding the Hospital Battalion, was also sent to Flat Hill.

During the skilful counter-attack on the left redoubt, Staff-Capt. Belozerov was struck in the head by the splinter of an 11" shell and part of his brain was laid bare. He was borne from the hill in a state of unconsciousness, while his men, who had been encouraged by his example, completed their work. In spite of the numerical superiority of the enemy they drove them at the point of the bayonet from the left redoubt, and captured their flag and sent it to the 5th Regiment headquarters.

At 5 p.m., when the reinforcements came up, the rest of the hill was cleared of the enemy, a result due in part to the energetic action of General Tretyakov, in part to the gallant conduct of the men and officers, and in part to the skilful artillery practice from Forts Nos. 4 and 5, Entrenchments Nos. 4 and 5, Battery Letter D, Red Hill, and above all to that of the quick-firing guns in Liudzyatun village on the left flank.

The artillery commander on Red Hill, Staff-Capt. Kornilovich, 4th E. Siberian Rifled Artillery Brigade, did all he could to assist the infantry, carrying his enthusiasm for his quick-firing guns to the point of laying them himself. That the fire from Red Hill was specially annoying to the Japanese was evident from the fact that on it was directed the fire from several of their batteries. Kornilovich, deeply engrossed in his firing, paid no attention to the shells which were falling within a few paces of him, and continued his accurate fire in spite of the entreaties of his men to go under cover. In the end the gun which he was working was struck by a Japanese shell, and splinters from a broken wheel covered him with wounds, from which he died before reaching hospital. He was at once replaced by Capt. Benua, already distinguished on the 18th May, who successfully carried on the firing and was fortunate enough to escape uninjured.

About 4 p.m. Capt. Nezhentsev and Lieut. Siromyatnikov, observing to the front of Visokaya, noticed dense columns of Japanese reinforcements going up the hill, and opened on them a rapid mixed fire of shrapnel and common shell from their four guns. Again the Japanese could not endure this, and broke in disorder, leaving killed and wounded on the slope.

In this way the assault was repulsed by the mutually supported action of infantry and artillery.

At the same time the Japanese assaulted Flat Hill, and again they chiefly directed their efforts against the unfortunate section near the dead ground. On this occasion the section was occupied by part of the 9th Company, 5th Regiment, the remainder of the company holding the trenches further to the right.

The Japanese infantry were within 50 paces, carrying on a hand-grenade and rifle fight with the Russians, while their artillery battered the trenches of the whole hill, and especially of this section, with 6″ and 11″ shells and mines. The losses were very great, and in the "unfortunate" section the men had to be taken out and only sentries left. Towards evening the attack took place, and before the sentries could report its approach the section was in the hands of the enemy. The company on the left also evacuated a part of their trench. Seeing this success, the Japanese, in number about a battalion, moved up to the Stony Redoubt and lay down on the glacis, leaving in the captured portion of the trench only a small party with the wounded. The 9th Company, under Lieut. Sirotko, without loss of time charged to the left along the trench and drove out the Japanese, re-occupying the whole of the captured portion of their trench.

At this time there came up two companies of Japanese reinforcements. The 9th Company received them with grenades and rifle fire, and these companies, not expecting such a surprise, broke back to their trenches and opened fire. Part of the 9th Company engaged them with rifle fire and grenades, and the rest of the men faced back up the hill and opened fire on the Japanese, who were lying on the glacis of the Stony Redoubt, at about 200 paces distance from their trench. This fire proved so effective that the Japanese were put into disorder, and small parties and single men began to fall back, but were shot down by the men of the 9th Company. The rest were also harassed with rifle fire and grenades from the redoubt, and at last they could stand it no longer and all broke back to the place where they had crossed the trench. Many volunteers from the 12th Company, 5th Regiment, ran to the assistance of the 9th Company, and all opened a heavy fire, from which many of the Japanese fell on the slope; but a few succeeded in reaching the trench and joined in a bayonet fight, from which about 20 of them eventually succeeded in rejoining their comrades. The losses of the 9th Company amounted to more than 40 men, and the company was replaced by the 10th Company, 5th Regiment.

About 7 p.m. Capt. Stempnevski I. arrived and resumed his duties as commandant.

After several more unsuccessful attacks on Visokaya and Flat Hills the Japanese infantry drew off about midnight, but the artillery as before kept up their fire all night. The Russian losses on the 1st December amounted to from 600 to 700 men.

The continual bombarding of Visokaya caused many casualties. If there had not been constant expectation of infantry attacks, it would have been possible to remove the men during the bombardment; but this could

not be risked, and consequently great losses were incurred from artillery fire, the men being replaced from time to time from the reserves. In this way the reserves gradually melted away, and requests were constantly coming in for more men and also for grenades. At first whole companies, each of 100 men, were sent up, but even by the 1st December there began to come up small parties of stretcher-bearers, odd men, and convalescents, without rifles and ammunition; these men were very keen to join the fighting, but it was often a matter of question whether they were fit for it, and in fact whether they were of any use whatever.

In the parties from the hospitals were to be found men of various regiments, including sailors and gunners. Each of them had some physical defect; one was so lame that it took him half the day to march some 1½ to 2 versts, another could not use his hand, and a third had lost an eye. Others could hardly move from weakness, due to wounds, exhaustion, or incipient scurvy. The very sight of such fighting men made one shudder!

As the writer was then Regimental Adjutant, all these parties reported to him, and his feelings may be imagined when he had to place arms in the hands of such cripples, and form them into detachments, and send them up to the front. As a matter of fact, the greater part of them he sent to Entrenchment No. 4 and Fort No. 5, as in those works, if the Japanese should advance, three cripples might take the place of one uninjured man, if the latter were urgently required elsewhere. This gave a certain amount of excuse for taking the 1st Volunteer Party, 5th Regiment, from Entrenchment No. 4 on the 2nd December.

General Stessel, at his wits' end for reserves, gave orders to replace the active service rank and file of the bearer companies by town guards, and to form from them the Hospital Infantry Battalion, under the command of Capt. Baron Geikin, 11th Regiment. These men he sent to the Staff of the Western Front as a reserve, and was thus able to improvise 600 men at the expense of all the hands skilled in care of the wounded.

The Japanese continued to pound Visokaya Hill all night with 6″ high-explosive shell, shrapnel, and mines, supplemented with 11″ shell, which the soldiers called "steam engines," and which fell at the rate of one every five or six minutes. The fire was less intense than it had been during the day, but it caused a great amount of damage and casualties. General Tretyakov strove to carry on work at repairing damage and restoring communication in trenches and approaches, personally superintending the work, and by exposing himself in the most dangerous places set an example of courage that urged the men to increased efforts. The name of Ensign Ermakov deserves mention as his chief assistant in this strenuous work.

But however hard they worked the night's bombardment destroyed more than they could repair. Some idea of the intensity of the fire may be gained from the fact that during the 1st December, of 11″ shell alone there were counted more than 1,000, while of 6″ shell and projectiles of smaller calibres all count was lost.

END OF PART I.

F. E. G. SKEY.

REVIEWS.

APPLIED PRINCIPLES OF FIELD FORTIFICATION FOR LINE OFFICERS.

By Capt. J. A. Woodruff, Corps of Engineers, U.S.A.

This work has been written for the use of the members of the Army School of the Line and Staff College in America, and it is intended to be used with the official textbook on Field Fortification, the *Engineer Field Manual*, Part V., which is constantly referred to for details.

The book would seem to be well suited for the purpose for which it is intended. It is short, logically arranged, and contains (together with the *Engineer Field Manual* referred to) sufficient information to work out ordinary defence problems.

The first chapter deals with general principles, and it is evident that the author belongs to the school which considers that field fortification is all-sufficient, and that the class of works commonly known as "permanent" is unnecessary. He remarks that "positions surrounding important nuclei are usually occupied by permanent fortifications, often supplemented by fieldworks, as at Port Arthur. But examples in field fortification may be found in Plevna, Vicksburg, Petersburg, and Sebastopol." It is undoubtedly true that these are good examples of defences made behind fieldworks, but it must be remembered that there was no choice in the matter, they possessed no permanent works and had to be defended.

Again, discussing the form which points of support should take, the author says that "anything in the nature of a fort or redoubt must always form a more or less conspicuous target, and be certain of receiving a heavy and concentrated fire from the besieger's batteries." Also, "it seems probable therefore that each of the detached points that go to make up a great defensive position would consist merely of a locality or tract of ground rendered defensible by a skilful treatment of its natural features, that is to say, by the provision of simple trenches and parapets."

It is undeniable that a splendid defence has often been made behind pure fieldworks for long periods, but when the superior cover, obstacle, and comfort afforded by the usual type of permanent work is considered, one cannot help thinking that the same troops who made this good defence behind fieldworks would have done better had their points of

support been permanent ones, or, what is equally important, the number of men might have been reduced. The author very properly points out that siege and field warfare only differ in degree, but this applies also to works of defence. Earth, concrete, and steel are all materials which may be used for giving cover, and only differ in degree. Also it is not necessary that a permanent point of support should take the form of high upstanding works exposed to the enemy's artillery fire and helpless to make reply. The forts at Port Arthur were neither models in design nor choice of site.

An important point, which is always made much of on the Continent, is the value of flanking fire from the points of support over the intervals between them. This is referred to in this book, but receives but little prominence.

The author agrees with the French idea of preparing advanced positions and second lines. There is a great deal to be said on both sides, but the arguments against this course are strong. Money and labour are expended on these positions which otherwise might have been expended on the main position. Garrisons must be told off to them separately, or they will never be held properly, and this generally means weakness all over. Also the moral effect of losing a position on which a great deal of labour has been expended and to which great importance is attached must be great, or else the troops are apt to consider that it does not matter losing a position since there is another behind it. It is a very different thing preparing a retrenched position when it is seen that a portion of the main line is likely to fall.

In a chapter on the design of infantry works the remarks about siting trenches are very clearly expressed. Stress is laid on the necessity for very flat exterior slopes to induce ricochet and to assist concealment. The latter point receives much attention, and the author points out that it is the distant view of a trench which matters; within 400 yards its appearance is immaterial.

As regards the position of obstacles, it is stated that they should be placed from 90 to 100 yards from the parapet. This is considerably further than we advocate. The whole of this chapter is of value.

Some details are given of the men and time required to execute works. It is interesting to compare these with our figures. Rates of excavating are the same. The use of "traction ditchers" is mentioned, and it is stated that some of these can dig a ditch 30" wide and 3' deep at the rate of 1 yard a minute. The task for men cutting brushwood is only 60 per cent. of what we give; for small trees it is 50 per cent., while for large trees it is nearly double. For loopholing and notching walls the task is respectively twice and thrice ours, while in the manufacture of hurdles and fascines the time taken is twice and five times what we lay down—and do.

The book concludes by giving three examples of problems, illustrated by maps. These problems are worked out in considerable detail. The maps are rather difficult to read.

J. C. MATHESON.

NOTES ON R.E. WORKS ON ACTIVE SERVICE.

In these notes, which are full of interest to R.E. officers, the author places before us the results of his wide experience in cantonment building, and to those who were associated with this work in Africa the book will bring back many memories. His African experience predominates the book, but very little ingenuity is required to adapt the general principles and advice to almost any country, and the individual who owns of a copy of these notes, and who is landed in a country and under conditions which no regulations can touch, will be grateful.

In reading the book we must bear in mind the title, and remember that if the designs of roofs and floors are not in accordance with the principles laid down in the usual textbooks, yet for rapid construction and temporary use the buildings have been actually put up and used, and have fulfilled the purpose for which they were built.

Chapter I. Organization and Preparation.—The importance of getting in touch with the civil authorities, the principles of organization, backed up by Bacon, and the necessities for proper accommodation in the works camps are most clearly stated. Hints on bluffing the impetuous heads of departments concerned may be found in para. 12.

Chapter II. Execution of Works.—Method, the personal equation, and protection of the private and public purse is dealt with. The notes on the personal equation are well worth the study of all R.E. officers, who will have to deal sympathetically with other departments at some time during their service. Even under peace conditions the precautions mentioned against the pastime of stealing Government stores and loitering on the works are worth remembering.

Chapter III. Design.—As mentioned above, in this section there are many points on which R.E. builders would join issue with the author. The timbers used in the roofs are light enough to cause apprehension of an early collapse; but we know that they successfully stood the test and performed what was required of them. The gauge of corrugated iron 24—25 can only be used for very temporary buildings. Those of us who saw the huts constructed by the author can understand his note in para. 48, under "appearance." We remember how he could convert a sausage-shaped hut into a dainty bungalow with no extra charge—or nearly so.

Chapter IV. Water Supply, Drainage, and Sanitation.—This is full of useful information, and gives useful hints as to how corrugated iron may be made to eke out a scanty supply of drainpipes, traps, etc.

Chapter V. Miscellaneous.—In many respects regarding the details of construction of hospital huts these notes are not in accordance with the latest decisions, but the general principles are correct. Perhaps, by the next war, the hospital synopsis will be available to correct these notes by.

Portable Huts.—There is, I think, no doubt that the suggestion that these should be made at the base and sent up country is sound. The portable huts on the market that are good, are costly, and the cheap ones are worthless for export.

Appendix I. Piecework.—This is well worth reading, and gives some very useful information for checking costs, etc.

The book closes with a series of appendices devoted to regulations for sanitation in camps and barracks. A book of plates is provided to illustrate the notes.

N.B.—R.E. officers can obtain copies free from the Chief Instructor, Construction, S.M.E., on remitting 4d. to cover postage.

RETAINING WALLS IN THEORY AND PRACTICE: A TEXT-BOOK FOR STUDENTS.

By T. E. COLEMAN.—(E. and F. N. Spon, 1909. xii.—160 pp. 5s. net).

This little book on retaining walls contains as much of the theory of the subject as most Engineer officers are likely to require to know. Little or nothing being known for certain as to the thrust to which retaining walls are subject, all the theories about it start with a number of assumptions, and the assumptions of even the greatest authorities are not always above criticism. The Author points out (p. 84) that one of Professor Rankine's assumptions sometimes leads to results which are manifestly incorrect, and wisely omits all reference to a theory of another professor, which also in certain cases leads to unsound conclusions. In an example he shows the difference in the results obtained by basing the design of a wall on different theories. He is also careful to point out another point often overlooked, viz., that when a wall is such that tensile stress may be set up in it, it is not the tensile strength of the bricks or of the mortar that must be considered, but the adhesion of the mortar to the bricks. This is always far lower than the tensile strength of the materials, and if the workmanship is inferior, may be very small indeed.

The practical points, being scattered about the book, are not easily referred to. It would be an improvement to collect together into one chapter a few notes on the design of the foundations and the exclusion of water from them, the filling in of the earth behind the wall, the misuse of projecting copings on a battered wall, the advantages of a rough back, bonding, etc., and on the actual construction of brick, stone, and concrete walls.

The book is well illustrated by diagrams, but drawings of two or three typical walls recently constructed, such as the walls built by railway companies in the course of widenings, would have added considerably to its value. As far as it goes however, the book is a good little book and can be recommended.

'A.M.H.'

NOTICES OF MAGAZINES.

ELECTRICIAN.

July 30th.

NEW TELEFUNKEN METHOD OF WIRELESS TELEGRAPHY (*p.* 617) is dealt with at some length. Two previous articles described the system, and the present one criticizes certain portions of it, and investigates the advantages which are claimed for it. The conclusions are that two genuine improvements in the practical application of wireless telegraphy are brought about, namely, extreme stranding into insulated strands of conductors carrying oscillatory currents to reduce ohmic loss (this theoretical consideration has been advocated for a long time), and the employment of more frequent sparks than are usually used with the singing arc.

SUBMARINE TELEGRAPHY (*p.* 622).—By S. A. Brown.—Part I. deals with (*a*) cables and their capacity; (*b*), use of condensers and inductances to improve signals both in strength and clearness; (*c*), methods of duplexing.

ELECTRIC POWER SUPPLY OF CHICAGO. III. (*p.* 624).—Distribution Methods and System.—In the central office is a large plan on the wall of the whole high-tension system, and from it one or more operators, called "Load despatchers," control, by telephonic communication, the operation of all the high-tension switch gear. All connections when made are shown in the plan. This approximates to the operations of a "train despatcher" in a railway system.

ILLUMINATION (*p.* 634).—The necessity for good lighting is dealt with in a leading article. It is not a question of mere candle-power, but of presenting the light in a suitable form, so as not to damage the eye. It must be particularly borne in mind when metallic filament lamps are substituted for carbon filament.

ENERGY CONSUMPTION OF TRAINS (*p.* 636).—Results of trials on the Midland Railway at Heysham are given, and are, for a level line, 1 mile between stops:—Schedule speed (*i.e.*, average speed *including* stops), 26 m.p.h.; maximum acceleration, 1·91′ per sec. per sec.; consumption, 99·3 watt-hours per ton-mile for all purposes.

It should be noted that to get higher schedule speeds, such as the 30 m.p.h. of the L. & Y. Liverpool to Southport service, the consumption required must be very largely increased.

August 6th.

ELECTRIC POWER SUPPLY OF CHICAGO. IV. (*p.* 662).—A description is given of the newest station, which has 14,000-kw. turbo-generators, and contains several novel features, which it is alleged put it ahead of any station in existence.

MODERN SUBMARINE TELEGRAPHY. II. (*p.* 669).—The most important item is a description of Brown's drum cable relay, which is the first practical attempt to turn the siphon recorder into a relay.

August 13th.

DETERIORATION OF LEAD CABLE SHEATHS (*p.* 719).—This article gives the following as the general causes for their deterioration:—(1), Mechanical injury; (2), chemical decomposition; (3), electrolysis; (4), vibration; (5), lightning; (6), impurities in lead. Mechanical injuries are most frequent, and there is no way to preserve cables other than to avoid where possible these dangerous conditions. As regards (2) and (3), the remedy is to (*a*) keep damp out of conduits, and (*b*) earth and bond cables wherever necessary.

August 20th.

TYPES OF ALTERNATING CURRENT COMMUTATOR MOTORS BY EICHBERG (*p.* 739).—Motors for railway work are especially considered. Generally speaking, for such work a frequency of 15 ~ per second is advocated owing to commutation trouble in the motors, but the Eichberg motor (as used in L.B. & S.C. Railway electrification) is shown to run satisfactorily at 25 ~ with considerable attendant advantages.

In the Supplement there are some useful advertisements, notably the Simplex Conduits Co.'s new heating apparatus, and various fans.

A. E. DAVIDSON.

ELECTRICAL REVIEW.

3rd September.

TRANSFORMERS FOR METALLIC FILAMENT LAMPS (*p.* 364).—The general considerations as to design are considered. The principal requirements are that there should be no load losses, and the sizes usually used for house wiring should be efficient. This efficiency varies from about 94 per cent. to 98 per cent., according to size and make, etc. Where transformation ratio is 2:1, the use of balanced transformers is advocated. In these the winding is divided into two parts, each of which gives half the voltage of the primary circuit. The low-tension side then resembles a 3-wire system. The advantages obtained are (1) a smaller transformer can be used, reducing the initial outlay, and (2) there is a saving of some of the transformer losses.

RECTIFIER FOR SMALL POWERS UP TO 240 WATTS (*p.* 371).—The method of operation of this rectifier is based on the fact that, if two secondaries of a transformer are alternately put into circuit, at each half period the induced current in the secondary circuit will be unindirectional. Its chief use is for charging accumulators off an alternating current house supply. On test the loss in the rectifier was 6 per cent., which makes it more efficient than others on the market. Nothing is said as to the time it will run without regulation.

10th September.

ELECTRICITY IN ARMSTRONG'S WORKS (*p.* 404).—Power for the shops was first obtained from plant in the firm's own works, but with increasing demand it was found better to go to the Corporation. The cables are mostly run in the tie rods of the roof. They are held by wood cleats. As spans are short, the weight is evenly distributed. This method (1) keeps the cable out of the way of cranes, etc.; (2), is cheap; (3), allows of rapid installation.

ELECTRIC WATER HEATER (*p.* 415).—This apparatus is designed to store up heat. A small amount of energy is used for a number of hours at a constant rate, thus enabling consumers to obtain energy at a low price per unit. Hot water to the capacity of the heater can be drawn when required.

PRESERVATION OF POLES (*p.* 433).—Poles decay through the action of germs, which attack them from the outside. An American method of preservation is to dig down say 14" below ground level; clean the lower end of pole; put a layer of Portland cement and sand on the ground; place a jacket of "hydrobestos" round the pole, leaving an annular space of 2"; fill in this space with germicides (hydrated lime and chloride of sodium mixed with coarse sand, and ¼ to 1 lb. of sulphate of copper per pole); and finally put a special cap on the top of the jacket to exclude moisture. The chemicals are dissolved by the natural moisture in the pole, and pass into it by capillary attraction.

MACHINERY BREAKDOWNS IN 1908 (*p.* 438).—According to Mr. Longridge's annual report, the bulk of electrical breakdowns are due to oil, dust, and damp—especially the first mentioned, as when the oil escapes from bearings it is liable to creep over the other parts of a machine. The ratio of breakdowns to machines insured is about 1 in 10. Over 30 per cent. of breakdowns are due to dirt and neglect.

17th September.

ELECTRICITY IN ARMSTRONG'S WORKS (*p.* 443).—Part II. gives conditions under which group drive and individual drive were considered advisable for various machine tools.

HYDRO-ELECTRIC POWER IN CANADA (*p.* 454).—The short descriptions of various existing plants show the enormous amount of power not only available, but utilized.

RESULTS OF WIRELESS TELEGRAPHY ON THE POULSEN SYSTEM AT CULLERCOATS (*p.* 463).—Denmark was communicated with, 4 kws. being required at the sending station to transmit a message 600 miles. The various parts of the apparatus are mentioned, and the speed of working is given at from 50 to 100 words a minute.

24th September.

It is advocated that coal (*p.* 482) should be bought on the basis of the number of British thermal units it contains, with restrictions as to the amount of ash, sulphur, moisture, etc., allowable.

MURRAY PHOTO PRINTING SYSTEM (*p.* 483).—A description is given of printing in Roman type direct from line, using Wheatstone transmitting apparatus and the Morse alphabet. The advantage lies in the fact that the letters are printed on sensitized paper, and a greater speed of recording can be obtained.

HYDRO-ELECTRIC POWER STATIONS IN CANADA. Part II. (*p.* 518).—The wide use of aluminium conductors for overhead lines is worth noting.

A. E. DAVIDSON.

JOURNAL DES SCIENCES MILITAIRES.

July 15th and August 1st, 1909.

The Russian staff officer—whose impressions of the French manœuvres appeared in the two previous numbers of the *Journal*—has written an account of his experiences at the German manœuvres, which took place in the Metz-Sarrebruck district from September 7th—10th, 1908.

The manœuvre scheme was drawn up by the German attaché to the Japanese Army in Manchuria. The manœuvre area is crossed by a great number of streams, and communications are easy owing to the many roads and railways. The soil, on the other hand, is clay and very sticky in wet weather. The Emperor in person directed the manœuvres, and although the decisions of umpires based solely on the tactical situation were obeyed as orders given by him, important decisions were always communicated to him.

The general idea was that a "French" army had succeeded in invading the country before carrying out its strategical deployment, in order to strike the defender's left flank while the corps composing it were still scattered. This corresponds to the national characteristics, French dash and German method. Neither side knew more than was impossible to keep secret, and cavalry reconnaissance for this reason began the very first day.

The principal event on the 8th was an extraordinary cavalry attack by the six Bavarian cavalry regiments on unbroken "French" infantry, in a

vain endeavour to neutralize the superior "French" numbers. As this took place in full view of the Emperor, it is possible that it was not entirely on the "German" commander's order.

As the "French" were too successful, the director so altered the manœuvre theme that on the last day a "parade combat" took place, in which the 80,000 combatants were collected in a small area and frontal attacks were made in close order under a heavy fire.

The physical condition of the German officers is good, and they are under very severe discipline. The staff use their knowledge well, and do not interfere with the dispositions of subordinates. The regimental officers do not hesitate to act, but a weak point is the tendency of corps commanders to follow the combat by eye and in the open. There is no jealousy between the various arms, and a strong line of demarcation exists between the captains and the subalterns. The N.C.O.'s are good, especially in the cavalry. They all have maps and know how to use them.

The contemporary German writers all exalt the offensive as the secret of success, and the general reserve is considered the key to the situation. The scheme almost always carried out at the Imperial manœuvres is a frontal attack coupled with the envelopment of a flank.

In defence a corps puts all its divisions (two or three) in line; if an extra division comes up unexpectedly, it is used as a turning force.

There were no night attacks, but most of the preliminary marches to battle were made at night. The troops also bivouacked after dark. March discipline is severe, and marches are carried out in silence; opening out does not occur.

Fire is never opened at more than 1,000 or 1,500 yards. The author only saw magazine fire used against a cavalry attack at 600 yards, and on the last fire position at 200 yards.

Other points noted are that the retreat after a lost action is very well done; the spade is used both on defensive and offensive; the artillery horses are good. Some artillery always accompanies the advanced guard, and when a position has been occupied it is only abandoned on the complete exhaustion of ammunition or men; the cavalry horses are as good as those of the French, and better than the Russian horses. The officers use the ground well and reconnoitre intelligently. Although charges were made against infantry, they were never carried out against cavalry. Dismounted action is not in favour; machine guns have been rapidly increased in number; communications are very good indeed; no sign of automobile transport was to be seen, nor yet of the rumoured grey-green uniform. The German officer is a conscientious workman, but the soldier lacks dash.

Finally, the writer thinks that the nation which can put a general of talent in supreme command, as well as a numerous and well-taught army in the field composed of soldiers of equal individual character to the German soldier, can look forward with confidence to a contest with the German nation.

H. L. Woodhouse.

MITTEILUNGEN ÜBER GEGENSTÄNDE DES ARTILLERIE-UND GENIEWESENS.

June, 1909.

FRANCE.—*Aerial Cruiser.*—The French War Office has offered a reward of 5,000 francs for an "aerial cruiser" which satisfies the following conditions:—(1). Has a velocity of 50 kilometres an hour. (2). Can stay 15 hours on end in the air. (3). Can carry a crew of at least six persons, the minimum weight of each person being 75 kilogrammes. (4). Can rise to a height of 2,000 metres. (5). Volume of airship not to be greater than 6,500 cubic metres. (6). Dimensions:—Length, 90 metres; height, 20 metres; diameter, 13 metres.

The tests it will have to undergo are:—(1). To make a circular voyage of 500 kilometres in 15 hours, against a wind of 7 metres a second. (2). To do two-thirds of this journey at a minimum height of 1,300 metres.

The Radio-Steering of Torpedoes.—The "torpille radio automatique" of Monsieur Gabet has recently been finished and tried at Le Creusot. It looks like a submarine, and carries a propeller behind it. It can carry 900 kilogrammes of explosive—instead of 90 as heretofore—is 9 metres long, weighs 4,000 kilogrammes, and is directed by means of Hertzian waves. It moves like a small submarine.

AUSTRIA.—*Through Brakes for Goods Trains.*—There are four types commonly used in Austro-Hungary:—

(1). The automatic Vacuum brakes, used on the Austrian State railways.
(2). The Zweikämmer-Carpenter compressed air brake, used on the Palatinate railways.
(3). The Westinghouse brake, used on the Hungarian State railways.
(4). The Knorr brake of the Prussian railways.

Of these, experiments made in 1908 show the first—the Vacuum brake—to be the best. It was tried with trains of 100, 150, and 200 axles—passenger carriages being added to the 100-axle trains, as would be the case on active service. The Vacuum brake underwent the test perfectly

The Zweikämmer-Carpenter system proved unsatisfactory, the same braking—and thus the same retardation—not being applied to each car. Moreover, a constant speed could not be kept down hills.

The Westinghouse brake was very satisfactory, although it does not stop the train in as short a distance as the Vacuum. The addition of an extra valve and pipe renders this scheme expensive.

The Knorr brake (Prussian) was most unsatisfactory, and quite useless on steep inclines.

July, 1909.

BULGARIA.—The engineers have just been reorganized as follows:—

(*a*). Three Sapper Battalions, each of six companies, garrisoned at Sofia, Jamboli, and Choumen.
(*b*). One Telegraph Battalion (three companies) at Sofia.

(*c*). One Pontooning Battalion (five companies)—of which two for heavy bridges are at Beila, and three for light bridges at Beila, Nikopolis, and Jamboli.

(*d*). One Railway Battalion (four companies) for both railway construction and traffic managing. To this are attached an airship section and an engineer park.

Russia.—Sandbags now form part of the equipment of the infantry and field artillery. Owing to lack of money they are obtained and made by the battalions themselves.

A new manual on fortress warfare has just appeared. In it the phrase authorizing the commander to "ask a council of war, chosen by himself, whether the besieged fortress has reached its limit of resistance or not" is completely left out. To this phrase was largely due the fall of Port Arthur. The expression "fall of the fortress" is replaced by "capture of the fortress." The new regulations lay down that the fortress commander must prolong the defence to the utmost, and remember that every extra day he holds out affects the general situation and final result of the campaign.

Observation from Balloons.—It is almost universally believed that it is as easy to observe from a captive balloon, several hundred feet above the level of the ground, as it is to do so from a mountain of equal height, which has no dead ground on any side. This belief is however erroneous; it is easier to observe from *terra firma* than it is to do so from a balloon. The following are the reasons for this:—

(*a*). Not only does the movement of the car, which the slightest breeze suffices to produce, make observations with field glasses extremely difficult, as the object is continually going out of the field, but also inexperienced aeronauts suffer from "aerial sickness," or "air sickness," on account of it.

(*b*). In a strong wind (over 15 metres a second) captive balloons cannot be used; firstly, because they require too many men to hold them down, and, secondly, because the strain on the envelope is too great.

(*c*). The appearance of objects when seen from a height is extremely deceptive. Thus wet meadows look like lakes, and hedges, orchards, bushes, and folds in the grounds are very likely to be mistaken for lines of trenches or for troops. It is indeed only by repeated observations at different heights and under different atmospheric conditions that the nature of such doubtful objects can be ascertained.

It will thus be seen that it is only by continual practice that perfection and rapidity of observation can be attained.

The difficulties are by no means lessened by the large area which has to be observed. Thus assuming the limit of vision as 10 kilometres, the

visible area = 314 square kilometres, and even if only one quadrant of the circle and objects in it over 3 kilometres from the balloon have to be sighted, the area to be searched is still 71 square kilometres. Moreover, as the boundaries of the quadrant are marked by no hard-and-fast artificial lines on the ground, even an experienced officer will waste a certain amount of time in looking at ground outside his own area.

At manœuvres the use of captive balloons does not show up as favourably as under active service conditions. Firstly, because other reconnoitring bodies are working under more favourable conditions than would be the case in war time, and, secondly, because the balloons are working under disadvantageous conditions to themselves. In peace exercises all scouting parties are endowed with an invulnerability which enables them to go far nearer the enemy than they would do if bullets were singing about their ears. A large number of civilian vehicles, which in war time would not travel about, move on the ground manœuvred over, and it is extremely difficult from the balloons to fix their identity, whereas the horseman can easily approach them and do so. The use of false fronts and sham battery positions to deceive the enemy is now fully recognized. These are however not built in peace practices. In war they could at once be put down as shams when seen from a balloon, as the absence of life or paucity of numbers holding them would at once be noticed. Again, whereas on active service the positions of guns are given away by their flashes and the direction of the burst, in peace the guns are quite invisible.

An interesting example of the value of captive balloons was given at Paardeberg in the South African War, when, after shelling Cronje's imaginary position for five days, the English sent up a captive balloon and discovered both their error and Cronje's camp, with the result that the Boer force was captured, an episode which marked the end of regular and the beginning of the guerilla and blockhouse periods of the war.

Finally, in manœuvres it is common for the observer to be constantly worried by telephone messages, which necessitate his laying his glasses aside to reply to them. This involves a loss of time which in war would not be possible, especially if the enemy took it into their heads to shell the balloon.

Observation from balloons must be carried out by a staff of officers who are trained at it all the year round—a mere course for artillery officers and three to four weeks' practice in several years is by no means sufficient. The results which it is desired to obtain are:—

(1). To discover officers who can rapidly "spot" objects and can keep their glasses on them in spite of the oscillations of the car.

(2). To so train them that the different appearance of the ground does not deceive them

(3). To enable them by training to easily recognize sham positions from real ones.

(4). To teach them never to send in any information about the veracity of which there is any doubt; such information formed from imperfect observation may spoil a whole operation.

To obtain these results the following programme for the training of balloon officers is suggested:—

Each instructional ascent should last at least half an hour, to enable the observer to get accustomed to the shaking of the car and to find his position on the map.

Exercises to be carried out aloft:—

(1). Judging distances and verifying them from the map.
(2). Rapid orientation of the map, and map reading.
(3). A detailed examination of stationary and moving objects—*e.g.*, to find out the colour, material, number of windows and chimneys of houses, and the composition, number, and direction of march of bodies of troops.
(4). The description of all objects in a given area, about 4 kilometres away.
(5). A description, from memory, of an observation made aloft, and observations from the balloons of any changes made in the area.
(6). Making estimates of the numbers of bodies of troops of all arms moving in a certain area, and the discovery of entrenchments, field depôts, hospitals, etc.
(7). The exact description of a village, the materials of which it is made, the roads leading to it, the most favourable edge for defence, and subsequent verification of the description by a visit to the place observed.
(8). Photographing of the areas near the balloon.
(9). Sketches and panoramas.
(10). Night observations with the aid of searchlights.
(11). Observation of fire by day and by night.
(12). Observation in winter.
(13). The readjusting of maps for the purposes of balloon observations.
(14). The recording on maps and plans any changes made on a piece of ground examined the year before. The changes are to be discovered by comparison of two sets of photographs taken at intervals of one year.

Practical exercises include:—

(1). Manœuvres.
(2). Manœuvres with fortress troops in fortress war exercises.
(3). The observation and correction of artillery fire under service conditions.
(4). Frequent exercises with forces consisting of the three arms.
(5). Last, but not least, free balloon trips as often as possible. These voyages develop to the utmost the powers of observation, feeling of security, and spirit of initiative of the aeronauts.

A. H. Scott.

NATURE.

FLYING ANIMALS AND FLYING MACHINES (*p.* 247).—Human flight has till quite lately been considered impracticable. No creature the weight of which approaches even one-quarter that of a man has been able to fly. In order that the wings may support the body, their movement must generate a downward current of air, of which the momentum per unit of wind is equivalent to the downward momentum, which the body and wings would acquire in the same time under the influence of gravity. This does not necessitate a large expenditure of work. For instance, when a weight is attached to a parachute and is dropped from a height, the speed of descent soon becomes constant. The resistance of the parachute is proportional to its area, and the speed of descent can be made as small as we please if the area is made large enough.

If we suspend an animal from the parachute by a long rope ladder, when the speed of descent is slow enough, it will have no difficulty in climbing the ladder at such a rate that the centre of gravity of the "system" may remain stationary in the air, and this by an expenditure of work which can be diminished indefinitely by increasing the area of the parachute. This is analogous to the hovering of a bird in the air without horizontal velocity during the downward stroke of the wings.

The animal is the only source of power in supporting the total weight of itself and the parachute. The total weight of similar systems varies as the cube of the linear dimensions, while the supporting area varies as the square, and the living power available varies, not as the total weight, but as the total weight less the weight of the supporting wing. If the animal can only produce a certain amount of power per unit weight of body, these conditions lead to an absolute limit to the weight of an animal which can sustain itself stationary in the air. Thus, if no more favourable way of supporting a weight were available than the down stroke of a wing in still air, flight would be impossible for all except the very smallest animals.

As is well known however, the vertical reaction on a slightly inclined plane, moving rapidly in a horizontal direction, enormously exceeds that which it would experience in dropping through still air, and although the proportionalities between the weights and the supporting area still remain, the actual weight supported by a given area increases indefinitely as the horizontal speed increases.

Air friction however fixes a limit beyond which the inclination of the plane to the direction of motion cannot be advantageously reduced. Experiments have shown that this inclination is about 5°, and that then the ratio of the supporting force to the resistance lies between 5 and 7. A knowledge of the best angle of inclination and the ratio of the resistance of the force on the plane at right angles to its path, afford means of determining the possible efficiency. Experiments in this direction have been made on model screws by Mr. R. E. Froude.

Among birds, those which fly continuously seldom have the ratio of weight to wing area much more than 1 lb. per square foot, and in many

cases, such as hawks and swallows, the ratio is something like $\frac{1}{2}$ lb. per square foot; but whatever the ratio may be, so long as the animal can only give out a limited amount of power proportional to its weight, a definite limit can be given to the size and weight of the body which can sustain itself in flight by muscular action.

The weight of a flock of birds is limited simply by the numbers in the flock, and we have only to suppose the individuals to be connected by a light framework to convert the flock into a flying machine, the wing weight of which is proportional to the wing area. To a certain extent, the biplane flying machine carries out the same idea, but in most of the existing types the weight of the connecting framework must to a great extent neutralize the reduction of weight which should accompany the reduced linear dimension.

It is due to the advent of the internal combustion engine that it is now possible to carry air-borne loads of more than 1,000 lbs. To carry heavy loads with a moderate wing area requires large horizontal velocities, and in such machines as have succeeded the load per square foot generally exceeds 2 lbs. The high velocity requisite is advantageous when the machine is launched and pursuing a straight course, but it adds to the difficulty of starting and stopping, and is a restriction on manœuvring power; that is, it increases the radius of the circle in which the machine can turn. In flying in a horizontal curve, therefore, the normal force must be increased by quickening the engine revolutions, and the fore and aft trim of the wings altered. It requires more power to fly in a curve than in a straight course at the same speed. Exact experiments have yet to be made on the manœuvring capacity of flying machines, and the subject will have to be carefully investigated, also as to intrinsic stability, with ease of starting and stopping.

The Cadastral Survey of Egypt.—By Capt. H. G. Lyons, late R.E. (*p.* 194).—In Egypt, when the present Survey Department was established in 1898, it was found that though vast sums (at least half a million) had been expended upon spasmodic efforts at map making, no work of a permanent nature had been done, and for all practical purposes most of the money so spent might as profitably have been thrown into the Nile, as no system of triangulation or other accurate fixation of points had been carried out. In 1898 this waste came to an end, and the whole work was started upon sound and permanent lines. The result of this is that Egypt now possesses a map of the cultivated area, upon a uniform scale of 1/2500, a possession of enormous value to the agricultural development of this country. An account of a cadastral survey is usually a dry subject to the general reader, but many portions of the present volume, especially the description of old land measures and the method of arriving at the areas of holdings, are extremely interesting.

Surveyors will owe a debt of gratitude to Capt. Lyons and his Staff for the trouble they have taken to place on record the fruits of their experience.

W. E. Warrand.

NEUE MILITÄRISCHE BLÄTTER.

The possibility, which seemed imminent at the beginning of the present year of an armed conflict between the Hapsburg Monarchy and Russia, lead to an interesting article in the *Neue Militärische Blätter* on the frontier territories of Austria and Russia, and the probable theatre of operations. The area of concentration and base of operations for Austria would be Galicia, and in no case is it to be supposed that with her strong and well-organized army she would act otherwise than on the offensive. She possesses the more concentrated strength and the better prepared forces. Study of military history besides teaches the advantage of taking the offensive, that is to say, the freedom of movement which it gives, and superiority of moral. Austria-Hungary has formed in Galicia two strong fortified places—Cracow and Przemsyl—and the network of railways is constructed to the best advantage under all strategical considerations. Two great lines traverse Galicia—one from Cracow *viâ* Tarnow-Przemsyl-Lemburg to Tarnopol, in the north, and, in the south, a line somewhat parallel with it along the northern base of the Carpathians. Both these main lines are connected with Hungary by not less than six mountain lines over the Carpathians, and these again are connected by a whole network of lines, while not less than nine lines lead right up to the Russian frontier. In view of all this, it must be admitted that Austria-Hungary has procured an excellent foundation on which to construct strategical offensive operations.

Russia has, as everybody knows, for nearly three decades collected large bodies of troops in Poland against Austria-Hungary. These are distributed more or less in two groups:—(1), In the so-called Polish fortified triangle—Warsaw-Ivangorod-Brest-Litowsky; (2), at Kiev, Shitomir, and Berdischew. Between both these areas a huge swampy wooded district extends, almost devoid of towns and roads, and always well-nigh impassable in the spring. The Russian network of railways has been considerably improved in the last 10 years or so, and the extensions have been made with particular regard to strategical considerations. There are however still some large gaps in it, and it is not to be compared to the Austrian frontier.

With regard to her preparedness for war, Russia suffers from the extraordinarily long distances, which cannot be completely bridged even by extensive railway construction. From the strategical line, Kiev-Warsaw, there are certainly some branch lines stretching southward, but hardly to such an extent as to provide sufficient communication to the Galician frontier. Owing to this want of efficient communication, and to the well-known inclination of Russian generalship to adopt a waiting attitude, the writer is led to believe that the Russians will hardly act on an offensive plan. He thinks that if ever a rupture occurred it is not improbable that Russia would act on the defensive in the fortified triangle, and there await the enemy's attack. The time which she would hope to gain in this way would presumably be used in collecting a second great army at Kiev from the interior of Russia.

This army would then stand on the right flank of the Austrian Army, operating against the fortified triangle.

Even allowing for the advantage gained by taking the offensive, and the assumed tactical superiority of her troops, Austria's task would be no light one. The theatre of war would be very extended, and offers two objectives eccentrically situated, namely, Warsaw and Kiev. Russia's best ally would be her vast size.

If then, the writer concludes, the strategical and tactical conditions offer good prospects for Austria at the commencement of a campaign, it must not be overlooked that Russia, if she wished to carry on the war with tenacity to the bitter end, would have natural allies, which would exhaust her opponents and would ultimately place victory within her reach.

E. G. Wace.

Revue du Génie Militaire.

April, 1909.

Tramways for Animal Traction in Manchuria.—The Russians constructed over 3,000 kilometres of light tramway during the war with Japan. The gauge used was 70 centimetres. The rails were made up in sections of 75 centimetres, 1·5 and 2·5 metres, attached to steel sleepers. Each rail had a hook at one end and a stud at the other. The hooks of one section gripped the studs of the next. Rails and sleepers together weighed 33 kilogrammes per metre. The trucks were mounted on two bogies. Each truck had a floor space of 1·4 × 4·2 metres, and could carry 1,640 kilogrammes. When time allowed the formation level was prepared by digging two trenches 5·25 metres apart, and about 1 metre in depth, and ·7 metres in breadth. The soil from these trenches was thrown towards the centre, and on it the sleepers were laid. In marshy ground fascines were laid down first and the soil thrown on the top. Nine trains a day were run in each direction. The passenger trains consisted of three covered trucks, and seven trucks for baggage; they travelled from 8 to 12 kilometres per hour. The goods trains averaged 4 to 6 kilometres per hour.

Aerial Sustaining Propellers.—An investigation of the theory of aerial propellers. A propeller with a very low pitch is theoretically the most effective, but the lower the pitch the larger must be the propeller, and the higher the speed of revolution to develop a given thrust. A large propeller constructed on the Louvre system appears to offer the best results.

May, 1909.

The Engineers at Casablanca.—An account of the organization of the engineer services in Morocco during 1907 and 1908.

TRAMWAYS FOR ANIMAL TRACTION IN MANCHURIA.—A continuation of a previous article. An account is given of the lines of tramway that were laid down to serve the Russian positions at Liao-yang, Mukden, and Sypingai. These lines enabled the Russians to mount their heavy guns at a distance of 15 kilometres from the railway, and finally to remove them during the retreat.

June, 1909.

THE ENGINEERS AT CASABLANCA.—A continuation of a previous article. The French constructed stone forts and blockhouses for their advanced posts; their larger posts and the standing camps were surrounded by an ordinary earthen parapet, traversed at intervals, and with a shallow ditch in front.

A pile bridge, 620′ long, was constructed over the Neffi-fick. Trestles could not be used, as the bottom of the river was shifting sand. A flying bridge was used for crossing the Oum-er-Rebea. The passage of this river was first made by means of a boat constructed out of the bodies of two Moroccan carts, over which a tarpaulin was lashed. This boat was put together in 15 minutes.

A tramway of the Decauville pattern was laid between Casablanca and Bu Reched, a distance of 40 kilometres. The gauge was half a metre. Each truck carried a ton, and was drawn by one mule. The rails were laid on a stone-ballasted track, 2 metres in breadth. The ballast was well consolidated to form a roadway for the mules. At one side of the track a footway was left for the driver. The normal traffic amounted to a convoy of 40 trucks each way per day.

TRAMWAYS FOR ANIMAL TRACTION.—A continuation of previous articles. These articles are founded on an account of the Russian tramways in Manchuria, which appeared in the *Eenzhenernee Zhoornal*. A transcript of this article has been published already in the *R.E. Journal*.

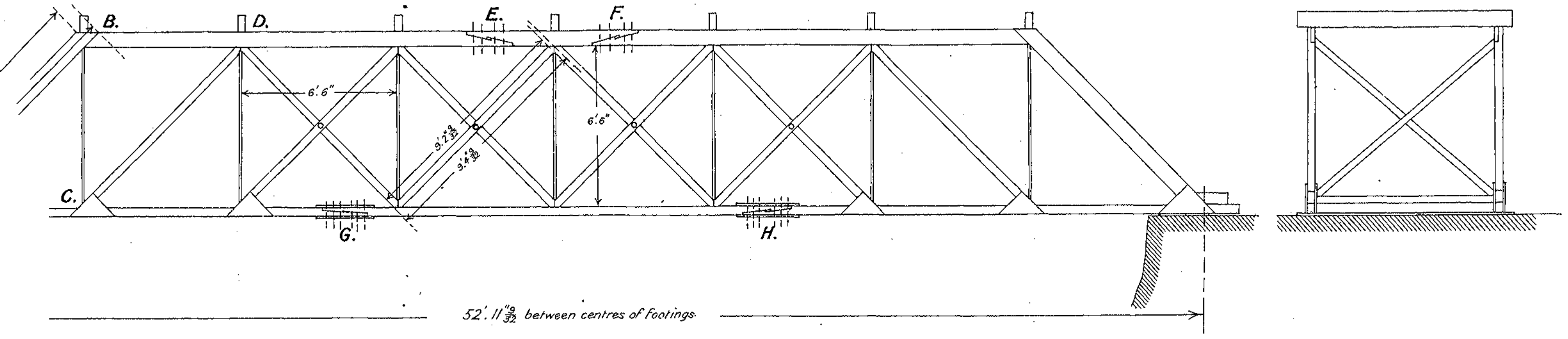
July, 1909.

THE ENGINEERS AT CASABLANCA.—A continuation of previous articles. Semi-permanent barracks were constructed for the French troops. These consisted of wooden huts, roofed with corrugated iron. The walls were lined on the inside with ruberoid or tarred paper, and ceilings were made of the same materials. The huts for the European troops had wooden floors, raised 3′ from the ground, and were surrounded by a 6′ verandah. The Foreign Legion and the artillery constructed their own barracks, under the direction of the engineers. The engineers constructed barracks for the remainder of the troops. At Ber Rechid the huts were built with mud walls and corrugated iron roofs.

WATER STERILIZATION.—The mercury vapour lamp gives out a light that is very rich in ultra-violet rays. It has been found that microbes exposed to these rays are quickly destroyed. In this way water may be sterilized in the course of a few minutes. It is probable that the process will be adopted for water purification.

J. E. E. CRASTER.

A LIGHT GIRDER BRIDGE.



Details = 1/8.