THE ROYAL ENGINEERS JOURNAL.

Vol. XI. No. 5. MAY, 1910.

CONTENTS.

CONTENTS.

Authors alone are responsible for the statements made and the opinions expressed in their papers.

Bird's-eye View of Mooi River Hospital, No. 4 General, 1900.

TEMPORARY HOSPITAL CONSTRUCTION

TEMPORARY HOSPITAL CONSTRUCTION.

By Capt. G. S. C. Cooke, R.E.

Introduction.—The construction of a field general—or other temporary—hospital, must to a great extent be governed by the nature and resources of the country in which it has to be provided.

If the hospital is required in, or near a modern town, it will probably be possible to appropriate existing buildings for the purpose. Thus, the Maritzburg College and Garrison Church in Maritzburg, Natal, were used as hospitals during part of the South African Campaign.

Such an extemporized hospital has undoubted advantages, as it is more likely to be ready at once for the reception of patients than would be a hospital erected *de novo* with tents or huts and temporary buildings, and in addition to this it would be less susceptible to changes of temperature. On the other hand, the latter can be more easily adapted to its site. Existing permanent buildings, too, are often amongst undesirable surroundings, or are insanitary, inconvenient, and generally unsuited to hospital purposes, and they almost always require to be supplemented and improved.

In the present article it is proposed to consider only a hospital erected *de novo*, from such materials as are likely to be generally available, or are easily imported as war stores.

The examples quoted are taken from the general hospitals and from standing camps, etc., in S. Natal during the South African War, as being those of which the writer had personal knowledge. Howick and Mooi River are especially referred to, as they were very highly spoken of on p. 67 of the "Report of Royal Commission on Care . . . of Sick . . . in South Africa."*

As in the case of permanent hospitals, so in building a temporary hospital the two principal objects to be borne in mind are *convenience* and *sanitation*.

* Mooi River Hospital had been in existence nine months and Howick was just completed when the writer first saw them in September, 1900, and he continued in Natal until after the hospitals and camps referred to had disappeared.

It is proposed to consider the construction under the following headings :—

(A). Siting.
(B). Buildings to be provided.
(C). Arrangement and order of erection.
(D). Construction of buildings.
(E). Water supply.
(F). Drainage.
(G). Disposal of sewage, refuse, etc.
(H). Other accessories.

(A). *Siting.*—In choosing the site for a field general hospital, military considerations will generally predominate. It must, for instance, be on, or close to the railway or other line of communication, accessibility being an obvious essential. On a line of communications, hospitals should generally be placed at intervals of one or two days' journey, for convenience of convoys. The local availability of supplies is also a consideration.

The salubrity of the place chosen is of very great importance. While the site itself should be open, dry, and gently sloping with no marshy or contaminated ground in the neighbourhood, it should lend itself to drainage, and water must also be available. The soil ought to be light and fairly fertile, and the subsoil permeable. A cheerful outlook is desirable. The absolute and relative elevations of the site should be considered, as also shelter from any prevailing and undesirable winds, etc. Concerning the latter, local knowledge should be sought.

The ultimate decision as to the site will doubtless be given by the staff, but it is desirable that the first selection should be made by the R.E. and R.A.M.C. *jointly*. This last remark applies also to the laying out of the hospital on the site. To secure a good general design in the first instance will greatly facilitate the working of the hospital, and is essential to its efficiency.

(B). *Buildings to be Supplied.*—The number and sizes of the accessory buildings to be supplied will vary somewhat with the number of beds the hospital is built for; and the adoption of tents or buildings for certain purposes will depend on the probable life of the hospital.

In any case, such accessories as latrines, ablution rooms, kitchens, the more important stores, the operating theatre, and special ward should be buildings, not tents (see List (I.) below). Other accessories might be "tented" to begin with, and replaced by buildings if the hospital continued for any length of time.

It would act as a check on excessive demands, if the normal scale on which such buildings should be provided were agreed upon by the C.E. and the P.M.O. of either the army or of the Line of Communications.

The following is suggested as a normal scale for a field general hospital (520 beds with power of expansion), and is based upon the accommodation provided at Mooi River and Howick :—

(I.). BUILDINGS ALWAYS REQUIRED.

Main Hospital.

(i.). Operating theatre, preparation room for operations, and X-ray room with dark room (in one building, about 60′ × 22′).

(ii.). Dispensary and utensil store (60′ × 22′).

(iii.). Special ward (for hospitals with "tented" wards only) (60′ × 22′).

(iv.). Provision store (60′ × 22′).

(v.). Clean linen store (60′ × 22′).

(vi.). Foul linen store (30′ × 22′).

(vii.). Pack store (with a portion at one end partitioned off to take kits in bulk on arrival of convoy) (60′ × 22′).

(viii.). Hospital kitchens (two, 30′ × 22′).

(ix.). Lamp room and oil store (20′ × 16′—not required if the wards and other buildings are lighted electrically).

(x.). Filter shed. (This may be placed under the main storage tanks).

(xi.). Patients' latrines (seats, 10 per cent. of accommodation).

(xii.). Patients' ablution rooms (two, 46′ × 15′, unless these are included in the hut wards).

(xiii.). Officers', sisters', sergeants', and orderlies' latrines.

(xiv.). Orderlies' ablution rooms (30′ × 12′).

(xv.). Enteric excreta enclosure (no roof) (12′ × 10′).

(xvi.). Disinfecting enclosures (two, 10′ × 8′, for surgical and medical divisions) (no roof).

(xvii.). Shed for disinfector (Thresh's or other).

(xviii.). Shed for portable destructor (if provided).

(xix.). Latrines and ablution rooms for sanitary staff.

Isolation Division.

Complete with its own latrines; ablution rooms; kitchen; linen, foul linen, and pack stores; and also dispensary and disinfecting enclosure. The necessity for making the isolation division a complete hospital in itself cannot be over-emphasized.

(II.). BUILDINGS OR TENTS ACCORDING TO THE PROBABLE DURATION OF HOSPITAL, AND THE CLIMATE.

Main Hospital.

(xx.). Officers', sisters', sergeants', and orderlies' kitchens; also one for sanitary staff.

(xxi.). Recreation room and chapel (60′ × 22′). (The same building can be used for both, but the provision of a separate chapel would be an improvement).

(xxii.). Sisters' night duty room (not very necessary if the wards are huts).

(xxiii.). Orderlies' dining and recreation room. (Even if only a rough building, this adds greatly to the comfort of the orderlies and tends towards efficiency).

(xxiv.). Hospital wards. In South Africa the tents—especially the Indian "E.P." tents—proved nearly, though not quite, as cool as huts in summer, but were colder in winter. Tents however wear out quickly, and it will probably be economical to build huts if the hospital is likely to last for a year or more. The possible utility of the buildings after the war is over should not be overlooked; thus Howick Hospital was used as temporary barracks for two years or so after the war, being occupied in turn by two brigades of R.F.A. and one or more infantry battalions.

(xxv.). Huts for officers and sisters.

(xxvi.). Huts for N.C.O.'s and men.

(xxvii.). P.M.O.'s offices, etc.

(xxviii.). Sergeants' Mess.

(xxix.). Officers' and Sisters' Messes. (Tent messes of two marquees forming a T are very comfortable).

(C). *Arrangement and Order of Erection.*—Administrative buildings should be centrally placed, and sanitary accessories should be located where they will be the least nuisance, while not too far from the wards.

The arrangement adopted at Howick and Mooi River is convenient and meets the case, the administrative buildings being in the centre, with the medical and surgical divisions on either side, and the isolation division being separate. It would however have been better to have had two kitchens, so placed that each could conveniently serve half the hospital, and not too close to the operating theatre or special ward on the account of the smell of cooking.

The facing of the camp as a whole will depend on the prevailing wind, the sun, and the slope of the site.

Drainage will be simplified if buildings are erected at an angle to the contours (a *slight* angle if the slope of the ground be considerable), instead of along them; the best aspect for hut wards is with their long axes N. and S.

If the latrines, etc., be placed at a reasonable distance from the wards and be well kept, no nuisance will arise from them.

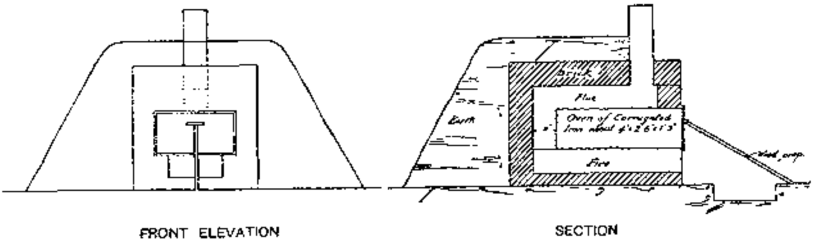
As already stated, a separate isolation division, complete in itself, with accessory buildings, stores, and kitchen, is very desirable, and would be an advance on South African practice.

As essentials *must* come first, and a part of all absolute essentials to meet initial requirements should be proceeded with simultaneously, the order of erection is simply decided, viz.:—

Latrines (with their surrounding drains).
Drainage.
Water (this can be carted as a temporary measure, but the sterilizing apparatus should be installed very early).
Ablution rooms.
Destructors (if portable ones are available, time will be saved).
Hospital kitchens. At Howick patients arrived before kitchens were complete. Field kitchens and a corrugated iron oven (see sketch) were used meanwhile.
Operating theatre.
Other buildings.

Sketch of Improvised Ovens used temporarily at Howick Hospital.
(Designed by S.S. Gordon, R.E.).

Scale—$\frac{3}{8}'' = 1'$.

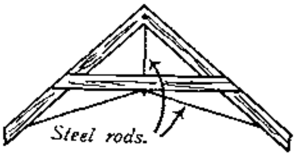


It must be remembered that while many things can be temporarily accommodated in tents, *sanitary accessories cannot be so accommodated.*

(D). *Construction of Buildings.*—The general construction of temporary buildings need not be treated fully; a summary of general principles is enough.

Very light scantlings will suffice, timbering being merely a support for corrugated iron, which braces itself. For this reason, as well as for others, with all its faults corrugated iron—24 gauge—would seem to be the best material for temporary work. The buildings should be designed so as to save cutting the corrugated iron, and to allow of utilizing sizes ordinarily imported. Elaborate timber joints should be avoided, and ready-made flooring, doors, and windows used as far as possible (American doors and Baltic windows are best). If white ants exist, the piles should be of a wood which they do not like; creosoted railway sleepers are good, but there will probably be some local wood which termites dislike, *e.g.*, "Sneezewood," in Natal. The building is then erected as follows :—Piles, bottom plates, floor joists (if any), side timbers, gable ends (put together on ground), roof timbers and covering, windows and side covering, then flooring, and finally complete inside.

As walls will take no thrust, roof trusses *must* have ties (or collar ties placed rather low); a useful and simple pattern is as sketched.



The whole floor level of wooden floored buildings should be kept above ground; and the ground should not be cut into to level the site, but the building should be raised on piles. With earth or concrete floors, as little cutting as possible should be done, low ground being made up instead. There is no harm in floors of temporary buildings having a slight slope if they drain clear.

It is desirable that the ground under the floors of inhabited buildings should have a layer of concrete (2"), graded to drain dry. If this cannot be done, the floors should be raised well off the ground and the latter should be left open to the air, the space below such buildings being enclosed with netting, to keep out vermin.

Surface channels are needed round buildings (with or without eaves gutters) to carry off storm water.

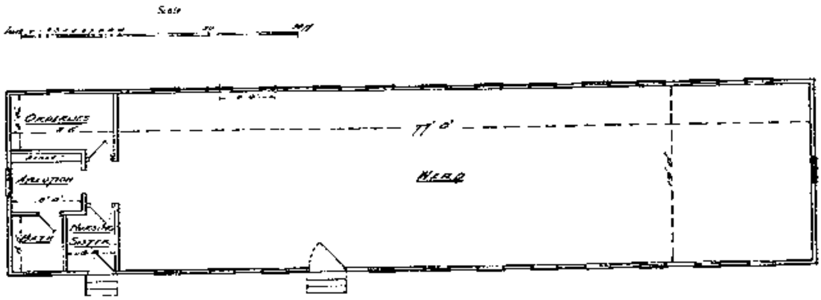
To cool buildings, limewhite can be made to adhere to galvanized iron by adding salt or tallow. If the climate is a very hot or a very cold one, some roof-cooling compound might be tried; and even with moderate heat it is well to ventilate the space between roof and ceilings of wards and other lined buildings, by raising the ridging and leaving the space under eaves and behind fascia boards open.

Timber flooring is recommended for wards and recreation rooms. All other buildings need a concrete or other hard floor, and enteric excreta enclosures (in which excreta are collected and mixed with disinfectant), disinfecting enclosures, and destructor and disinfector sheds require the floors tarred.

Wards.—Neither matchboard nor calico form a sanitary lining. Willesden paper (4-ply) is suggested. The makers say it will take paint or distemper; it is washable, portable, and cheap, and joints can be made dust tight. The paper might perhaps be painted with Silicate paint.

Plenty of windows should be allowed, and a proportion of small wards should be partitioned off for acute cases. Howick Wards, otherwise good (see plan), were deficient in this respect. Doors should be wide, to admit stretchers. Medical officers like curved ventilators at ends, made to open and close. In hot climates wide verandahs, on the sunny side at least, are needed.

Howick Hospital—24-Hut Ward.

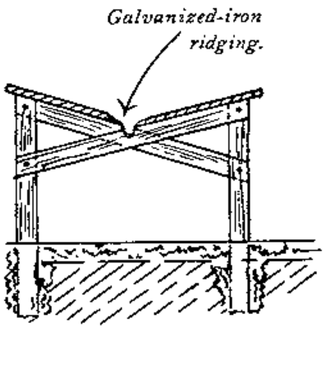


Operating Theatre and *X-Ray Room* (in one building). *The former* needs a preparation room attached; must be lined; should be painted white; have overhead light with blinds; and all its corners and angles should be rounded. The use of a smooth, impermeable, and washable lining material is especially important here. The floor also should be impermeable (not wood), raised in the centre and graded to a gutter all round. Water must be laid on; hot water should be arranged for; and a suitable sink provided. *The latter* need not be lined, but is better so; should be painted dark, with heavy curtains to windows. A dark room with sink, rack, and ruby window should be annexed.

The various *Store Buildings* require no lining, only rough racks and shelves for fitments.

The *Main Kitchens* need eight 72″ cooking ranges (for 1,000 beds), besides shelving, etc. (Soyer's stoves from A.O.D.). A hot table made like a hot tray is useful.

Latrines (*dry earth*) and *Ablution Rooms.*—Floors (concrete) must drain dry (to the rear in latrines). They should be surrounded by drains (see under "Drainage"). Walls should not reach to floor below or roof above. All salient angles should be chamfered in concrete.



Space should be provided in latrines to stand urine tubs (night urinals are not needed in a hospital), and plenty of dry earth boxes should be supplied to latrines. For ablution rooms a simple pattern of bench is as sketched.

With Tent Wards stands must be provided behind each, of wood or concrete tarred, to take bed pans, chambers, and slop pails. Though not essential, it would be well to concrete the ground under tent bottoms. (P.M.O.'s will probably have tarpaulins laid over the latter).

The Hospital Enclosure should be fenced—the isolation division separately.

(E). *Water Supply.*—On active service water will very often have to be taken from a "doubtful" or even "dangerous" source. Hence water supply resolves itself into:—

(I.). Actual supply of water.

(II.). Sterilization of impure water.

(I.). Unless local conditions render it impossible (which is unlikely), water would be laid on by pipes, and separate systems of washing and drinking water may be desirable. The use of screwed pipes, even up to 3″ and 4″, is recommended for temporary work, as they are easily laid, taken up, and relaid.

Carting water is never satisfactory for any length of time, but if it has to be resorted to, a suitable hard place for carts to stand on when being filled should be provided, and drainage from this place should not be able to reach the intake.

The medical authorities can be trusted to see that the carts are kept in sanitary condition. If however carts are used to carry drinking water, they should be kept quite distinct (differently painted) from all others, and provision should be made for sterilizing them periodically by injecting steam from a high pressure boiler.

The possible sources of water, being a subject in itself, cannot be discussed here; but if the supply be from a stream, the intake should be above every source of pollution that can reasonably be avoided.

For raising water, steam pumps are most generally used, and of these, the Steam Worthington is usually the most convenient pattern. They were largely used in South Africa during and after the war. At Mooi River Hospital however a small portable Merryweather Steam Valiant was installed, which, against a lift of 100′, supplied the hospital for over two years. It was a very compact machine, pump and boiler being complete in one.

As a number of steam pumps will almost certainly be required in a campaign for hospitals, standing camps, remount depôts, etc., it might prove well worth while to take out at the beginning of operations, as war stores, a number of semi-portable pumps and boilers of varying capacity, and on wheels complete.

Although steam pumps are general, other means of raising water may be useful. At Howick, for instance, advantage was taken of a small waterfall in the river Umvoti to drive a 6″ Little Giant turbine, working two vertical double throw pumps, which supplied the hospital and convalescent depôt for many months.

These pumps were later replaced by a single larger pump, and when the three large Boer refugee camps (for about 5,000 persons) were built, a 12″ turbine was also installed, working a single cylinder geared pump, supplying all the water required for refugees, hospital, and convalescent depôt, the smaller turbine being kept in reserve (see photo).

A duplicate plant, or at least some scheme for supplying water in case of temporary breakdown, is most necessary, and storage tanks holding one day's supply are also desirable.

When purchasing pumps, boilers, etc., the usual and best method is to state the exact conditions of lift, distance, etc., and required delivery, calling upon firms consulted to quote for a machine capable of performing the duty named. The Construction School, S.M.E., issues a paper (No. 152) on this subject.

In estimating requirements allowance for possible increase should be made, as, *e.g.*, a convalescent depôt might be added later.

(II.). Sterilization of Impure Water.

Sand filters not being practicable, the efficient feasible methods are few, namely :—

(i.). *Boiling.*—This is effective if properly carried out. To attain this end it is advisable that it should be done in bulk by R.E. (Colonel Sim's system), otherwise it is difficult, even with the most careful supervision, to ensure all water being boiled ; medical officers, too, are busy enough without having "water boiling" by their staff, to supervise.

The system mentioned is worked as follows (see Appendix VII., p. 114, Report of Enteric Fever Commission) :—

Three sets of tanks are installed, each holding one day's drinking supply (estimated liberally).

One set is boiled each day by the injection of steam from a boiler, until the temperature reaches 200° to 210° Fahr. They are kept at this for about half an hour, and then allowed to cool, being used on the third day.

This system was introduced in Ladysmith (after the siege) by Colonel Sim. It was also adopted for the Mooi River standing camp after the war, where 4,000 gallons were boiled daily by two vertical cross-tube boilers (6 and 4-H.P. nominal, I think). These boilers and the pumping plant were worked by one engine driver. Samples (*a*) from intake and (*b*) from a drinking tap, where taken without warning by the S.M.O., after the system had been in use some months (a year or 18 months, I think), and tested in the Government Bacteriological Laboratory. (*a*) was described as being "from a dangerously polluted source" and (*b*) as "quite sterile."

The principal drawbacks to boiling are, first, the cost of fuel, and second, the flat and insipid taste produced.

(ii.). *Sterilizers* (such as the "Maiche").—The principle on which these work is that of bringing water to a temperature of about 212° Fahr. *under pressure*, and then allowing it to cool. This prevents the dispersion of dissolved gases.

The "Maiche" has an "exchange heater," wherein the outgoing sterilized water is cooled by giving up its heat to the incoming unsterilized water, thus economizing fuel. It has also an ingenious automatic control valve for maintaining a uniform temperature. One was brought to South Africa by Colonel H. E. Rawson, and used at Maritzburg for several years. Its chief defect was inaccessibility of the parts, with the result that, when finally overhauled, a leak was discovered which nullified the sterilization. This was repaired, and the parts were made more accessible to inspection.

(iii.). *Pasteur-Chamberland Filter*.—The efficiency of this filter in removing bacteria from water may, I think, be taken as sufficiently proven, though a few remarks may not be amiss. In a thesis published in August, 1894, Surgeon-Major (now Lieut.-Colonel) H. H. Johnston, A.M.S., describes experiments made with this filter, the "Berkefeld," and some others*; the results proved the Pasteur-Chamberland to be the only reliable one. Since then the makers of the Berkefeld claim to have improved their filter, and regard the thesis as out of date. In an article however written for the Journal of the R.A.M.C., April, 1902, Lieut.-Colonel Johnston, C.B., R.A.M.C., shows that in five months, while Berkefeld filters were in use at Mooi River Hospital, 31 cases of enteric were contracted by orderlies, while in the succeeding 26 months, with a "P.C." filter (an automatic syphon action one of 336 candles), only six cases occurred. This filter is therefore probably the best method to adopt.

If the water be muddy it should, prior to boiling or filtering, be either passed through broken brick and sand (or something similar), or else treated with alum.

Unless the whole of the water supply can be sterilized, which is most unlikely, the provision of two separate systems of supply pipes is strongly advocated. Although this was not done in the Natal hospitals, it would have been a distinct improvement to them, and was adopted with great success in the Mooi River Camp, where one system led direct from the main storage tanks to the ablution rooms

* The new Brownlow filter was not, I believe, then invented, and I am ignorant as to its merits compared with the Pasteur-Chamberland.

and horse troughs only, while the other was taken to the cook-houses and to standpipes between the lines of tents, all taps bearing boards marked "Drinking" or "Unfit for Drinking."

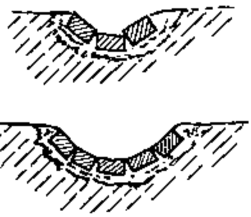
(F). *Drainage.*—Storm water must be led away from buildings and roads, etc. Surface drains will suffice for the purpose, and, if the soil be hard or the rainfall small, the earth channels need not even be lined.

Should a water-carriage system be decided on for the latrines, the foul drains should be laid as in permanent work to a radius of 100 yards from the nearest building or thoroughfare, beyond which hastily made joints would suffice.

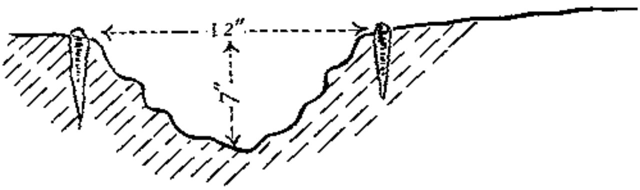
With dry earth latrines the surrounding drains should lead to sunken tanks (or other lined pits), which would be emptied daily, the contents being pumped into sanitary carts and removed therein.

Drainage from ablution rooms, cook-houses, and operating theatre (especially the latter) may be treated similarly, or may be led away in lined surface channels to a distance of at least 100 yards from the nearest building, discharging into a stream direct, or into an unlined pit filled with breeze (or some such material), the storm water either going with it or being disposed of separately. A breeze pit, $60' \times 20' \times 5'$ deep, was successfully used at Howick.

Surface drains, taking foul water, must be lined. A brick lining is advocated in preference to concrete, being quickly laid and easy to repair. A good section is as shown, the centre brick being slightly dropped.



Drains lined with corrugated iron were laid in some Natal camps, *e.g.*, Convalescent Depôt and Refugee Camps, and proved quite satisfactory. Their section was as below.



Where ever traffic crosses surface channels the latter should be bridged. Railway sleepers make a good bridge for wheeled traffic, and tarred planks for foot passengers.

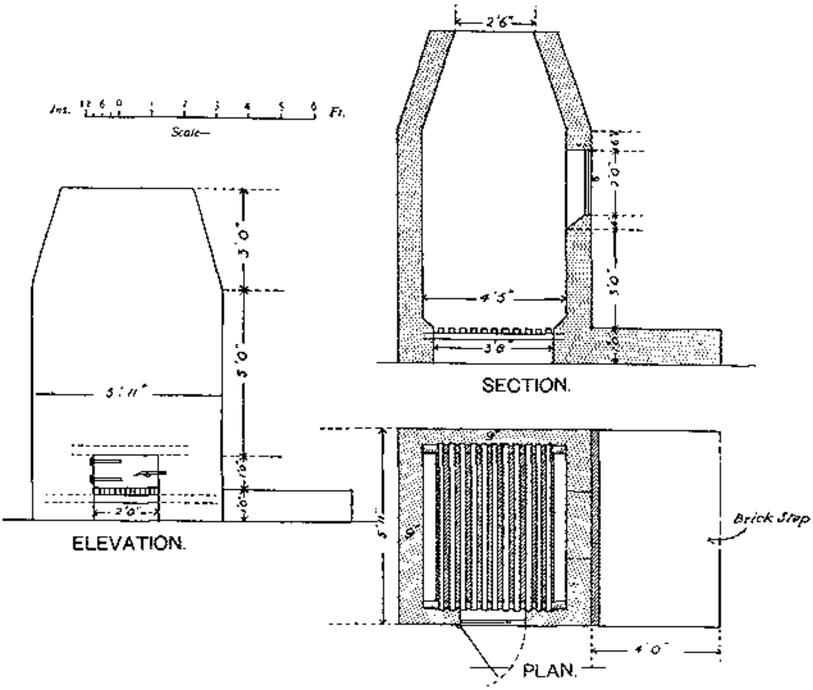
(G). *Disposal of Refuse, Sewage, etc.*—The method of sewage disposal depends on the adoption of "dry earth" or "water carriage" for latrines; other sewage can be dealt with as above. If a permanent foul drainage system is handy, it may be well to adopt water carriage and connect to it; otherwise, although sewage might be taken to a river or a septic tank, or land treatment be improvised, the dry earth system would most probably be favoured by medical opinion. The disposal of night soil is not a R.E. service, and it will suffice that sewage, whether liquid or solid, should be buried in trenches 3′ wide, 1′ apart, and not more than 9′ deep, these trenches being at least a mile from any habitation.

An earth ramp with a corrugated iron shoot should be provided for emptying slops from hand-carts into croly carts.

All enteric (and other infectious) excreta *must* be burnt.

This leads to the disposal of refuse generally, including the various forms of highly infectious and offensive matter inseparable from a hospital.

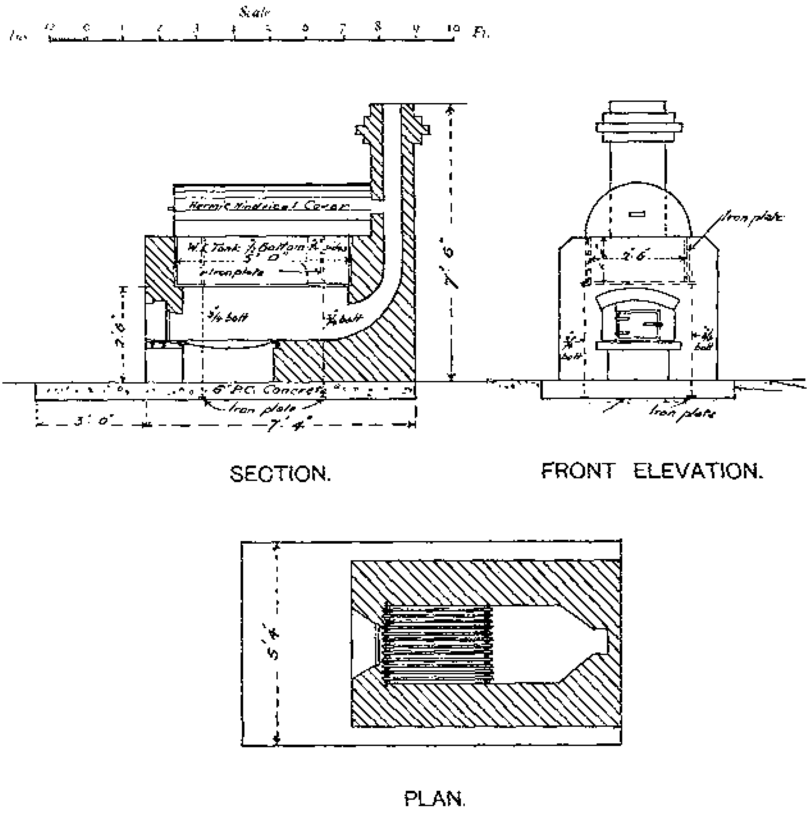
Natal.—Mooi River, 29. 6. 01.—*No. 4 General Hospital, L. of C.*
Detail of "Rubbish Destructor."



In a book entitled *Small Destructors for Institutional and Trade Waste*, Mr. Goodrich, Assoc. Inst. Public Health, lays stress on the necessity of destroying all such matters by fire. On p. 63 he quotes from Dr. Poore's *Colonial and Camp Sanitation* with reference to faulty scavenging on Salisbury Plain; and on pp. 64 and 65 he refers to the evidence of Sir C. Warren, Surgeon-General Jameson, and Dr. Fripp before the S.A. War Commission, advocating the destruction by fire of all such refuse. From Dr. Fripp's evidence the author draws the conclusion that no destructors or incinerators were used in South Africa. This was not however the case, and sketches are given of the patterns improvised in Natal (other patterns were used elsewhere).

The incinerators at Mooi River, to take an example, were worked thus :—Two incinerators (for 400 enteric patients) were built side by side, with another shallow tray over a third fire between them. The excreta mixed with izal and sawdust were placed in the two outer trays, reduced nearly to dryness, then dried on the central tray, and finally burnt on the fires below.

Natal.—Mooi River.—No. 4 General Hospital, L. of C.
Sketch of Incinerator.



PLAN.

The smell was the main fault, which the hemi-cylindrical covers, added as an improvement, did not entirely cure. To obviate this, Mr. Goodrich emphasizes the necessity of forced draught and high temperature. In his book (Chapter IV.) he describes some portable patterns :—One by Horsfall destroys 4 tons daily (its own weight not given); another by Meldrum Bros. consumes 5 and weighs 7 tons (cost something over £500). The latter firm however inform me that they have now introduced a smaller portable pattern destroying 3½ cwts. an hour, and weighing 3 tons only (cost £300). This is more hopeful, though if several firms were asked to compete, something still better might result.

(H). *Other Accessories.*—The need of a *disinfector*, such as Thresh's Steam Portable, need not be emphasized. A shed should be provided, partitioned in the centre round the body of the disinfector, and having a door at each end. Infected clothes enter by one door, and disinfected clothes pass out by the other. The floor should be of concrete tarred.

A cemetery is another necessity. It should not be too close to, and if possible be out of view of, the hospital. There should be no possibility of its contaminating water supply, and endeavours should be made to select a site on public land (Crown or municipal).

If the hospital be near a railway line, a *railway siding* is most desirable (on a short branch line if need be), where patients can be entrained and detrained quietly and without hurry, and where hospital trains arriving late at night may remain undisturbed till morning (*e.g.*, Howick Hospital).

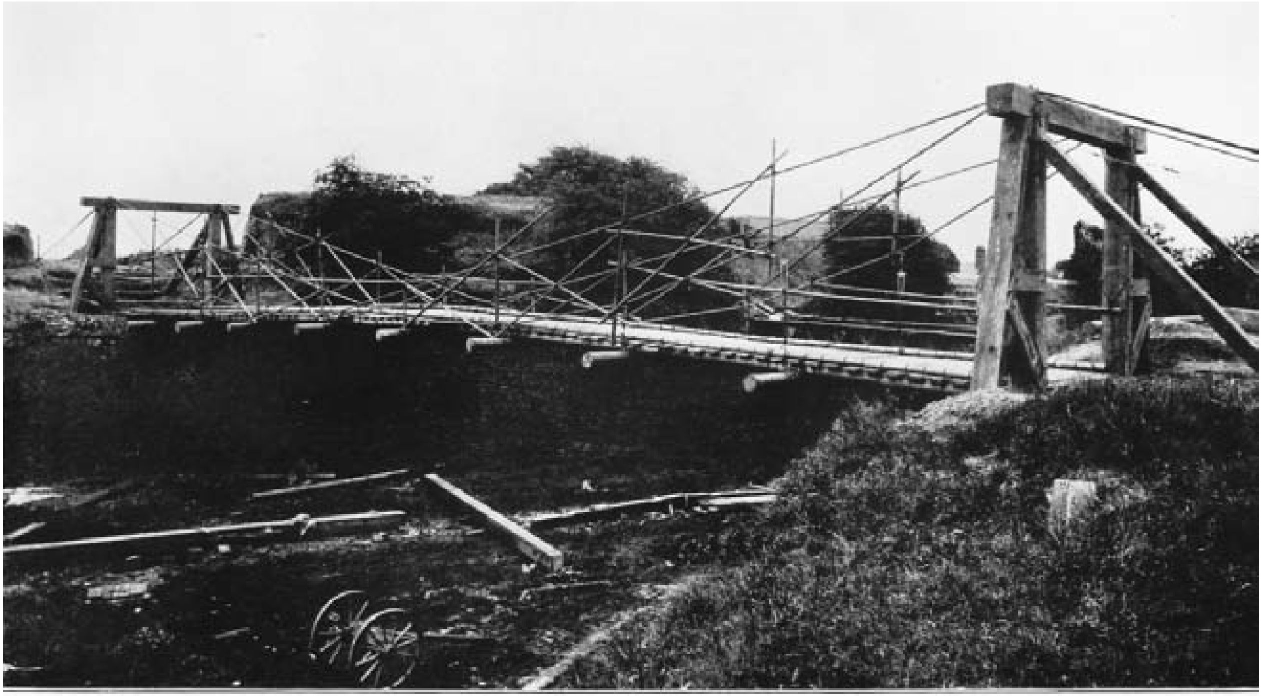
A telephone between hospital and station is another useful adjunct.

Roads need not, I think, be dwelt upon; their necessity is, or should be, obvious.

Lighting.—It may prove economical to light the hospital by electricity, especially as current is required for charging X-ray batteries. Current may be supplied (as in Natal) from accumulators brought by rail in special trucks, and kept on a siding; or an engine and dynamo may be installed.

Thus at Mooi River the Natal Government Railway ultimately erected an engine and dynamo on a locomotive under-frame, lighting the station yard, hospital, and village. At Howick a dynamo captured from the Boers was driven by a small horizontal engine.

Finally a *flagstaff*—for the Red Cross flag by day and the "two white lights" by night—must not be forgotten.



RIGID SUSPENSION BRIDGE

RIGID SUSPENSION BRIDGES.

By Capt. C. E. P. Sankey, R.E.

A suspension bridge of a somewhat uncommon type was erected by the 5th (Field) Company, R.E., at Aldershot, in their annual course of instruction in military engineering for 1909, and a similar one was subsequently built at Chatham in the same year, by a party of young officers. As the type possesses several distinct advantages, it is thought that a description of it might be useful. It will be seen that it could be made by unskilled labour, and that the materials required, over and above the cables, are likely to be available in most places in the field.

It consists essentially of two parabolic semi-ribs, hinged together at the centre. Each semi-rib consists of a straight upper member, and a parabolic lower member, the two being united by diagonal bracing.

It has been said that this type of suspension bridge is uncommon, but it cannot be called novel. It seems to have been proposed as long ago as 1861, and was afterwards elaborated by Mr. Claxton Fidler in 1875. It is considered fully in his book on the Construction of Bridges, and concisely in Major (now Brig.-General) Scott-Moncrieff's *Principles of Structural Design.* It has been applied to the shore spans of the Tower Bridge in London. Its possibilities as a field suspension bridge were realized by Lieut. (now Capt.) R. Ommanney, R.E., who erected a bridge of this type about the year 1898.

The cables of an ordinary suspension bridge will hang in a parabolic curve symmetrically about a vertical axis through the centre of the span, assuming that the tops of the piers are at the same level on either side, and that the whole bridge is uniformly loaded horizontally, either with the dead weight of the structure alone, or with a load of traffic in addition. This will no longer be the case if the traffic is not uniformly distributed, as for instance when the head of a body of troops crossing the bridge is still somewhere on the span. The more heavily loaded portion of the cables will be depressed, and therefore the more lightly loaded portion elevated, the roadway being distorted in accordance. If the only load on the cables were that of the traffic, the loaded portion would hang in a parabolic curve, the unloaded portion being straight, and tangential to the loaded portion. As however the dead weight of the structure still remains uniformly distributed, the curve assumed by the cables will be intermediate between this and the symmetrical parabolic curve. The greater the weight of traffic in proportion to the dead weight of the structure, the greater will be the distortion, therefore in field suspension bridges, where the spans as a rule are short, and where the dead weight is kept as small as possible, this distortion, with the consequent oscillations, becomes a very important point.

The greater the dip of the cables, the greater will be the distortion produced by the moving load, and therefore the dip has to be kept small, generally not more than 1/10 and often less, although this leads to a great sacrifice of constructional economy.

To prevent distortion and oscillation as far as possible, various devices are employed, such as inclined ties, struts at the shore bays, inverted cables below the roadway, and so forth; but all such measures only partially remove the want of stiffness that is inherent in the original design.

It is however possible to design the structure so that no distortion is produced by the moving load, except that due to the elasticity of the materials employed.

One such method of construction is to employ rigid roadway girders, supported by the flexible cables. This has several disadvantages. If the girders are continuous across the span, an increase in the length of the cables, due to a rise in temperature, will place a large extra stress on the girders; in order to meet this, they must be made of a far greater strength than that required to give rigidity. If the girders are hinged in the centre, they can accommodate themselves to this elongation of the cables, but, in order to give rigidity to the structure, must be made strong enough to carry the load over half the span, while the cables must still be strong enough to carry the load over the whole span, as well as the weight of the girders.

Another way, and a far more satisfactory one, is to make the curved members themselves rigid, as in the design under present consideration.

The principle of this method will be best understood by a reference to the diagrammatic construction shown in *Fig.* 1. Let AB represent

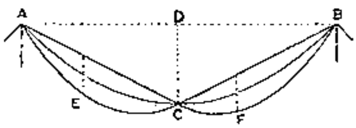


FIG. 1.

the tops of the piers, and let ACB be a parabola, having any required dip, CD, at the centre. Join AC and BC. These will represent the upper members of each semi-rib. The lower members, AEC, BFC, are found by determining a series of points, E, F, such that their vertical distances to the original parabola are equal to the distances between the upper members and the original parabola, in the same vertical planes. The original parabola will thus become the neutral axis of the rib, that is, the line which everywhere bisects its vertical depth.

These ribs are then divided into panels by verticals at intervals, preferably at the points of attachment of the slings, and cross-bracing added to each panel, as shown in *Fig.* 2. The slings can be attached either to the lower or to the upper member. The latter involves the transmission of the stress through the cross-bracing, and the former thus seems to be better.

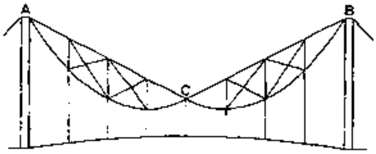


FIG. 2.

It is obvious that if these semi-ribs are strong enough to withstand the bending moment produced by a non-uniformly distributed load, no distortion can take place. It will be shown that the united sectional areas of the upper and lower members need be no greater, or very little greater, than that of a single flexible cable, designed to carry the same total load; and having this sectional area, that they will resist the bending action of the unequal load, without suffering any greater stress.

As rigidity is secured by this design, the dip of the neutral parabola is only limited by the permissible height of the piers; and by increasing the dip, considerable economy can be introduced.

Referring to *Fig.* 3, if the span AB be taken as a, and the dip CD as d, the equation to the neutral parabola, referred to the

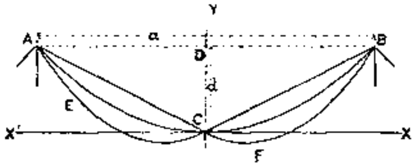


FIG. 3.

tangent at the vertex, and a vertical line through the vertex, as axes, will be

$$y = \frac{4d}{a^2} x^2$$

and the equations to the straight lines AC, BC, will be

$$y = \mp \frac{2d}{a} x.$$

Therefore, by the method of construction, the equations to the lower members will be

$$y = 2\frac{4d}{a^2} x^2 \pm \frac{2d}{a} x,$$

which may be written

$$\left(y + \frac{d}{8}\right) = \frac{8d}{a^2} \left(x \pm \frac{a}{8}\right)^2.$$

That is, they are parabolas, whose axes are vertical, whose vertices are at the points

$$\mp\frac{a}{8}, \ -\frac{d}{8}$$

and whose *latera recta* are half that of the original parabola.

Moreover the straight lines AC, BC,

$$y=\mp\frac{2d}{a}x$$

meet the tangent at the vertices of the parabolas of the lower members, whose equation is

$$y=-\frac{d}{8}$$

in the points

$$\pm\frac{a}{16}, \ -\frac{d}{8}$$

respectively, and thus by a well-known property of the parabola, the upper members AC, BC, are tangential to the curved members BFC, and AEC, respectively.

It will be seen therefore that the lower member of each semi-rib, if uniformly loaded horizontally, will hang in equilibrium, together with the upper member of the other semi-rib, and that there will be no stress in the web of each semi-rib, that is to say, in the verticals and the cross-bracing.

It has been assumed above, and will be assumed in the subsequent calculations, that the points of suspension are sufficiently numerous to consider the cables as hanging in parabolic curves, and not in polygons. This assumption simplifies the calculations and will not diminish the practical accuracy of the general results.

For a uniform load of w per unit of length, it is therefore possible to work out the tensions in the cables, assuming that each half of the bridge, the left for example, passes over two piers, A and C, of unequal height. It will be found that their values are as follows :—

Horizontal tension at lowest point

$$=\frac{wa^2}{16d}.$$

Tension at higher pier A

$$=\frac{wa^2}{16d}\sqrt{1+\left(\frac{6d}{a}\right)^2}.$$

Tension at lower pier C

$$=\frac{wa^2}{16d}\sqrt{1+\left(\frac{2d}{a}\right)^2}.$$

This last tension will be the uniform tension in the upper member, BC, of the other semi-rib.

Were the ribs to be replaced by a single flexible cable, hanging in the neutral parabola, the tensions in that would be as follows :—

Horizontal tension at lowest point

$$\frac{wa^2}{8d}.$$

Tension at piers

$$\frac{wa^2}{8d}\sqrt{1+\left(\frac{4d}{a}\right)^2}.$$

That is, the horizontal tension throughout the single cable is exactly twice the horizontal tension throughout each cable of the rigid system, while the direct tension in the single cable at the piers is rather less than twice that of the lower members at the piers, and rather more than twice that of the upper members, of the rigid system.

To illustrate this by a numerical example, suppose the dip to be 1/10 of the span, then

Rigid System.

Horizontal tension in each cable	·625 *wa*.
Tension in lower member at pier	·729 *wa*.
Tension in upper member	·637 *wa*.

Flexible Cable.

Horizontal tension	1·250 *wa*.
Tension at piers	1·346 *wa*.

This shows that practically speaking, the total sectional area of the two cables of the rigid system need be no more than that of the single flexible cable for the same uniform load.

So far nothing but a uniform load has been considered, but as this design is principally intended to meet the case of a moving load, it must now be dealt with. For this purpose, the method of calculation employed by Mr. Claxton Fidler is more suitable, and as the question is gone into very thoroughly in his book on Bridge Construction, it will here be sufficient to touch upon it briefly.

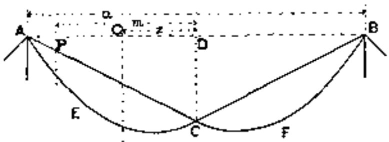


FIG. 4.

He proves that the horizontal component throughout the system, shown in *Fig.* 4, when uniformly loaded, is a tension

$$\frac{wa^2}{8d}$$

equally divided at all sections between the upper and the lower member, that is a horizontal component tension

$$\frac{wa^2}{16d}$$

in each, an expression that agrees, of course, with that found above.

The load w per unit of length is made up of two portions, p per unit of length due to the dead weight of the structure, that can be considered as always uniformly distributed, and q per unit of length due to the traffic load, that may be on the whole, or on any portion of the bridge.

It may be noted here, that throughout the investigation, the expressions given by Mr. Claxton Fidler refer only to the horizontal component of the stress at any point. To obtain the direct stress, this value must be multiplied by sec θ, where θ is the inclination of the member at that point to the horizontal.

He then shows, that for a dead load of intensity p, uniformly distributed over the whole span a, the horizontal tension at any point of the upper or lower member is

$$\frac{pa^2}{16d}$$

and that this loading produces no stress in the diagonal bracing.

If the live load covers the span, its intensity being q, the horizontal tension due to this is

$$\frac{qa^2}{16d}$$

and as before, there is no stress in the diagonal bracing.

The sum of these two is of course the same as the expression found previously, for

$$w=p+q.$$

When the traffic load exactly covers the half-span AC, the horizontal tension due to this load at any point of the lower member of AC, or of the upper member of BC, is

$$\frac{qa^2}{16d}$$

and as far as this load is concerned, no stress is produced in the upper member of AC, nor in the lower member of BC, nor in the diagonal bracing. This is accounted for by the fact, shown previously, that the members AEC and CB together form a cable in equilibrium under such a load.

The maximum and minimum horizontal stress in any portion of the lower member AEC, due to any position of the moving load upon the bridge, will be, as a maximum, a tension

$$\frac{(p+q)\,a^2}{16d}=\frac{wa^2}{16d}$$

and as a minimum, a tension

$$\frac{pa^2}{16d},$$

that is, the member will always be in tension.

Still referring to *Fig.* 4, the greatest stress producible by the moving load alone, at any point P of the upper member AC, occurs when that load extends from G to B, the distance GD, or z, being equal to

$$m\frac{a}{a+2m}$$

where m is the horizontal distance PD.

The value of its horizontal component is then a tension

$$\frac{qa^2}{16d}\left(1+\frac{2m}{a+2m}\right).$$

If however the moving load extends from A to G, with no traffic load on the remainder of the span, the resulting horizontal stress at the point P, due to the moving load, is a compression

$$\frac{qa^2}{16d}\left(\frac{2m}{a+2m}\right).$$

The maximum and minimum values of the total horizontal tensions at P will therefore be, maximum,

$$\frac{a^2}{16d}\left\{p+q\left(1+\frac{2m}{a+2m}\right)\right\}$$

and minimum

$$\frac{a^2}{16d}\left\{p-q\left(\frac{2m}{a+2m}\right)\right\}.$$

It will be seen at once that a difficulty arises here, for in order that the minimum stress at the point P may be a tension, and not a compression, it is necessary that p be not less than

$$q\left(\frac{2m}{a+2m}\right).$$

In permanent bridges of any considerable size, it is probable that this supposition holds good and that the upper member is always therefore in tension; but in field bridges, where the traffic load is, generally speaking, large compared to the dead weight of the structure, this may be by no means the case for certain positions of P, and thus the cable composing the upper member may have a stress produced in it at those points, that it is not capable of resisting.

In order to make this investigation as simple as possible, it may be noted that it is not worth while, nor indeed practicable, in field structures, to alter the section of the suspension member in proportion to the varying stresses at different points. That is, the same sized cable will be employed throughout the system and it will be sufficient therefore to consider the worst case.

It will be seen that the expression

$$\frac{2m}{a+2m}$$

increases with m, and assuming as before that the number of panel points is large enough to treat the cables as continuous curves, m may be given a maximum value of $\frac{a}{2}$, and then the expression becomes equal to $\frac{1}{2}$.

Thus the traffic load q must not be more than twice the dead weight p, to ensure that the upper member has no portion in compression.

It may be noted that when $m=\frac{a}{2}$, z will $=\frac{a}{4}$, and thus the extreme cases occur when the traffic load is over three-quarters, and one-quarter, of the span, respectively.

Take the case of a bridge with a span of 100′ and 10′ bays, to carry infantry in fours. The dead weight of the structure may be estimated as follows:—

Cables and slings	15	lbs.	per foot-run.
Road-bearers	50	„	„
Transom	20	„	„
Planking	65	„	„
Verticals and bracing	10	„	„
Ribands...	15	„	„
Handrail, etc.	5	„	„
Total...	180	„	„

Thus p may be taken as 180.

On the other hand, the weight of infantry in fours is generally taken as

560 lbs. + 50 per cent.
840 lbs. per foot-run,

and thus the necessary proportion of dead weight to traffic load is very far from being obtained.

There is however another way of looking at this question. The weight given above for infantry in fours, is their weight when crowded at a check to the utmost extent possible without losing their formation. Normally the weight of infantry in fours is not more than 150—200 lbs. per foot-run. Even adding 50 per cent. to this, it will be seen that the proportion of dead weight to traffic load now obtained is such that the upper member will remain in tension. In calculations where the actual strength of the structure is involved, that is to say in determining the maximum stresses in the cables, it is of course necessary to take into account the greatest load that can be imposed on the bridge, but in the present instance the result of such a maximum loading would be only a temporary loss of rigidity, and it is therefore permissible, for the purpose of stiffness alone, to take the weight of the traffic at a lower value. As a matter of fact, the traffic load would have to be about 240 lbs. per foot-run, before the tension in the upper member was changed to a compression, and then only near the piers.

If thought necessary, it would be possible to lash light spars to the upper members over the first two bays on either side, to take any compression that might occur. They would butt against the caps of the piers, and would be also secured to the bracing.

With longer spans, the dead weight of the structure per foot-run increases, and the possibility of this reversal of stress becomes less.

It may be pointed out that such a reversal would only occur when about one-quarter of the bridge was covered with traffic, the remainder being unoccupied; it is clear that such a condition would rarely be coincident with an extreme crowding of troops at a check.

It has been mentioned before that the constructional methods of field bridges do not allow of a reduction of area of member to meet varying stresses. That is to say for the present purpose it will be sufficient to consider the maximum possible stress in both the upper and lower members, and design the cables to meet the larger of these two, as it will be seen that the lower member of one semi-rib becomes the upper member of the other.

The maximum values of the horizontal components have already been considered, and thus it will be seen that the maximum direct tensions are as follows:—

Lower member—

$$(p+q)\,\frac{a^2}{16d}\sqrt{1+\left(\frac{6d}{a}\right)^2};$$

upper member—

$$\frac{a^2}{16d}\left\{p+q\,\left(1+\tfrac{1}{2}\right)\right\}\sqrt{1+\left(\frac{2d}{a}\right)^2},$$

giving m its maximum value of $\frac{a}{2}$.

Which of these two is the greater, depends on the proportion of p to q, and on the proportion of dip to span, though for usual values it will be found that the maximum tension in the upper member will be the greater, and will thus determine the size of the cables. As pointed out above, the value given to q in this calculation must be the maximum possible, as the strength of the structure is involved, and not merely its rigidity.

Turning to a consideration of the strength necessary in the diagonal bracing, it will be seen at once that some of the members are redundant, and that the stress in any panel will be divided between the two braces, one in tension, and one in compression, in an unknown proportion. The possibility of initial stresses must be also considered, and in consequence great care should be taken in the construction of the rib to avoid this.

It would not be safe to assume in calculating the dimensions of the diagonals, that the stress is equally divided between them, while on the other hand it would be extravagant to calculate the one in compression as taking all the stress. A satisfactory compromise would be to calculate them so that each should be able to bear the entire stress in tension.

It is shown by Mr. Claxton Fidler that the horizontal component of the maximum stress in any diagonal due to any distribution of the moving load is

$$\frac{1}{2}\left(\frac{qa^2}{16d}\right)\left(\frac{2b}{a+2b}\right)$$

where b is the breadth of the panel. The division by 2 is necessary, as the bridge is suspended from two cable girders, one on each side of the roadway.

To find the direct stress, this expression must be multiplied by the secant of the inclination of the diagonal to the horizontal. This inclination varies with each diagonal in every panel, but sufficient accuracy would be obtained by taking an average inclination ϕ, where ϕ is

$$\tan^{-1}\frac{d}{2b}.$$

The stresses can however be found graphically, more accurately and almost as quickly. If the scale for the stresses be so chosen that b, the panel breadth, represents the horizontal component, then the lengths of the various diagonals, to the same scale, will represent the direct stresses in them.

With a single system of bracing, the stress in each vertical would be the vertical component of the direct stress in the corresponding diagonal, but with the system of cross-bracing, they may be relieved of a large portion of this.

In determining their cross-sections, however, it is better to take into account the full stress, which can be found graphically with sufficient accuracy, from the length of the verticals, using the same scale for these stresses, as was used before. The verticals should be strong enough to bear this stress in compression.

The case of a concentrated weight, or a series of concentrated weights, crossing the bridge, will not be considered at any length. It is sufficient to say that the calculated safe strength of the cables will not be exceeded if the concentrated weight on any one bay does not exceed qb, q being the maximum value of the distributed traffic load, and rigidity will not be lost if the concentrated weight of each bay does not exceed $2pb$, where p is the dead weight of the structure per unit of length, and then only if coincident with the worst case of loading, that is to say, one-quarter of the span being covered, the remainder clear of traffic.

The thrust on the piers, the inclination of the cables from the piers to the anchorages, and the strength necessary in the anchorages, can all be calculated as though the rigid system were replaced by a single cable, hanging in the neutral parabola. It should be noted that the piers will require careful strutting and staying, to withstand the varying stresses due to a moving load.

The length of each cable of the rigid system can be taken with sufficient accuracy as that of a cable in the neutral parabola, the usual allowances being made for length required at the anchorages, and so forth.

The length of the slings can be found graphically or by calculation, in either case making the necessary allowances for the camber of the roadway, and the length of the shortest sling, noting however that in this type of bridge, the central sling will not be the shortest, but that there will be two shortest slings, real or imaginary, one from the vertex of each parabolic lower member, at a distance from the abutment on each side equal to $\frac{3}{8}$ of the span.

As a diagram will probably have to be drawn in any case to determine the stresses in the bracing, the graphical method will perhaps be the quicker way, and sufficiently accurate.

The other method is to make use of the equation derived from the mode of construction, which gives the length of each sling, measured from the horizontal tangent at the vertex of the neutral parabola, as

$$\frac{8d}{a^2}x^2 - \frac{2d}{a}x,$$

x being measured either way from the vertex of the neutral parabola.

The other calculations necessary, such as strength of slings, transoms, road-bearers, and anchorages, differ in no way from those required in the normal type, and will not be considered here.

No mention has been made of wind-bracing. It is obvious that the stiffness given by this construction is only in the vertical plane, and that lateral stiffness must be given by any of the usual methods, such as horizontal wind-ties, or horizontal girders. Sufficient lateral stiffness might perhaps be obtained by giving the bridge a "waist" in plan.

As an example, the necessary calculations, where they differ from those of the ordinary type, will be given for a bridge of 100′ span, 10′ bays, dip 1/8, to carry infantry in fours. This example is chosen as it is comparable with the bridge actually erected at Chatham, and for which certain data as to the labour required for its construction will be given subsequently. It has been already mentioned that a larger dip than usual can be used in this type of bridge without loss of rigidity.

The estimate already given for dead weight of structure will hold good, and p can thus be taken as 180. In calculating the strength of the cables, q must be taken as 840.

Then maximum tension in lower members is

$$\frac{(180+840)\ 100^2}{16\times 12\cdot 5}\sqrt{1+\left(\frac{75}{100}\right)^2}$$

$$=63,699 \text{ lbs.}$$

$$=29 \text{ tons nearly.}$$

And maximum tension in upper member is

$$\frac{100^2}{16\times 12\cdot 5}\{180+840\times 1\cdot 5\}\sqrt{1+\left(\frac{25}{100}\right)^2}$$

$$=74,088 \text{ lbs.}$$

$$=33 \text{ tons practically.}$$

This latter figure will therefore decide the size of the cables.

Each upper member will have to stand half of this or 16·5 tons, and taking the safe stress in steel wire rope as 9 C^2 cwt., the necessary size of rope is found to be 6″.

The maximum horizontal component of the stress in the diagonal bracing is

$$\tfrac{1}{2}\times\frac{840\times 100^2}{16\times 12\cdot 5}\left(\frac{20}{100+20}\right)$$

$$=3,500 \text{ lbs.}$$

The direct stresses in the various diagonals and verticals can be best determined graphically. Referring to *Fig.* 5, and choosing a scale for the stresses, such that the length representing 10′, the breadth of the panel, shall also represent 3,500 lbs., it will be found that the direct stresses are as follows :—

Diagonals.

JN	3,714 lbs.
KM	4,183 ,,
MT	3,717 ,,
NS	4,599 ,,
SY	3,553 ,,
TX	4,592 ,,

Verticals.

JK	1,400 lbs.	Length	4′
MN	2,100 ,,	,,	6′
ST	2,100 ,,	,,	6′
XY	1,400 ,,	,,	4′

Using round spars of Baltic fir, and allowing 2,000 lbs. per square inch safe stress in tension, and 1,500 lbs. per square inch compression,

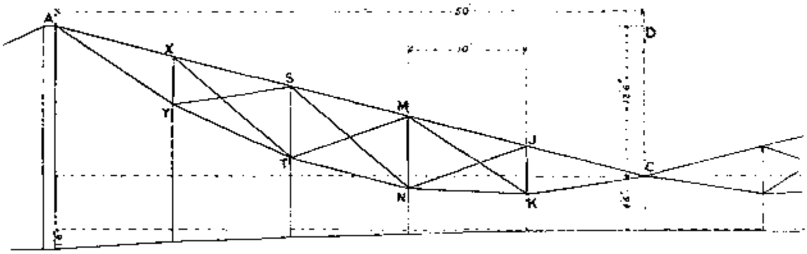


FIG. 5.

it will be seen that spars of 2" diameter will be suitable for all the diagonals, and that spars of 3" diameter will do for the verticals JK and XY, and of 4" diameter for MN and ST.

To calculate the length of the slings, their length from the horizontal line through C is given by the formula

$$y=\frac{8\times 12\cdot 5}{100^2}x^2-\frac{2\times 12\cdot 5}{100}x,$$

and giving x the successive values of 40, 30, 20, and 10, these lengths are found to be

1st sling	+6'
2nd ,, ...	+1' 6"
3rd ,, ...	−1'
4th ,, ...	−1' 6"

To make the length of the shortest slings about 3', an allowance of 4' 6" will have to be added to each of these values, and there is also the camber of the roadway to be allowed for. If the roadway has a parabolic camber, with a rise of 1/60 of the span at the centre, the allowances to be made are found from the formula

$$y=\frac{4\times\frac{100}{60}}{100^2}x^2,$$

x being measured as before. Substituting the values of x, these allowances are found to be

1st sling...	+1' $0\frac{3}{4}$"
2nd ,, ...	+ $7\frac{1}{4}$"
3rd ,, ...	+ $3\frac{1}{4}$"
4th ,, ...	+ $\frac{3}{4}$"

and the length of the slings is as set forth in the following table :—

Distance from Abutment.	Number of Sling.	Length to Horizontal through C.	Length of Central Sling.	Camber Allowance.	Total.
10'	1st	+6'	+4' 6"	+1' $0\frac{3}{4}$"	= 11' $6\frac{3}{4}$"
20'	2nd	+1' 6"	+4' 6"	+ $7\frac{1}{4}$"	= 6' $7\frac{1}{4}$"
30'	3rd	−1'	+4' 6"	+ $3\frac{1}{4}$"	= 3' $9\frac{1}{4}$"
40'	4th	−1' 6"	+4' 6"	+ $\frac{3}{4}$"	= 3' $0\frac{3}{4}$"
50'	5th		+4' 6"		= 4' 6"

The height of the piers is

$$12'\ 6'' + 4'\ 6'' + 1'\ 8'' = 18'\ 8''.$$

As a useful check on the accuracy of the calculations to determine the length of the slings, and the height of the piers, it may be noted that their extremities lie on curves of the second degree, and therefore, as they are at constant distance apart, their second differences must be equal, as follows :—

		1st Difference.	2nd Difference.
Piers	18′ 8″		
		+7′ $1\frac{1}{4}$″	
1st sling ...	11′ $6\frac{3}{4}$″		+2′ $1\frac{3}{4}$″
		+4′ $11\frac{1}{2}$″	
2nd „ ...	6′ $7\frac{1}{4}$″		+2′ $1\frac{1}{2}$″
		+2′ 10″	
3rd „ ...	3′ $9\frac{1}{4}$″		+2′ $1\frac{1}{2}$″
		+ $8\frac{1}{2}$″	
4th „ ...	3′ $0\frac{3}{4}$″		+2′ $1\frac{3}{4}$″
		−1′ $5\frac{1}{4}$″	
5th „ ...	4′ 6″		

All the other calculations necessary can be worked out in the usual manner, and will not be gone into here.

As regards erection, this type of bridge does not differ materially from the ordinary kind, but a few points may be noted.

The parabolic semi-ribs, or cable girders, should be constructed on shore. For this purpose, a series of park pickets, or other stout pickets, should be driven into the ground to represent the various panel points, as shown in *Fig.* 6. Their positions are best found

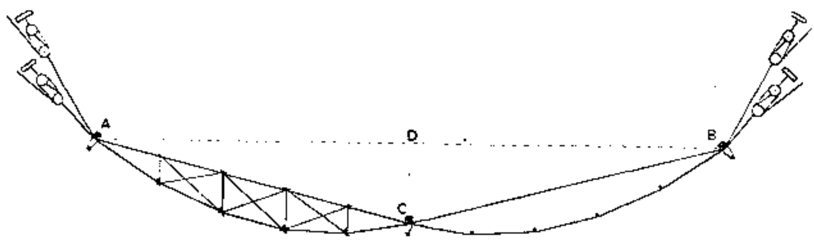


FIG. 6.

from a base line and ordinates, and the greatest care must be taken to lay out the girders as accurately as possible, to avoid initial stress in the diagonals, when they are placed in position in the bridge. It is especially necessary to ensure that the girders are made the same horizontal length as the distance between the piers. It is advisable to place a group of three pickets at each of the points representing A, B, and C, and also to stay them back to another picket, as a considerable amount of stress will come upon them in the process of taking the stretch out of the cables. This is done by securing a tackle to each end of each cable, as shown in the figure, differential tackle, if available, being very convenient. When the cables have been thus stretched in position, the diagonals and verticals are lashed to them very securely, endeavouring to make the various members meet as far as possible in the calculated panel points. It is more convenient, in the subsequent erection, if these spars project no more than is necessary beyond the cables.

The cables must be thoroughly fastened together where they cross, at the point C, as the rigidity of the structure, when the load is not uniformly distributed, depends on the cables not slipping here. Some form of bolted clip would appear to be desirable. It is best to make this joint and to secure it to the group of pickets at C, before applying the tackles to the free ends of the cables.

The points of attachment of the various slings should be marked with paint, in case the cross-bracing should get displaced, and the portions of the cables that are to rest on the piers should be similarly marked. For convenience in subsequent handling, the cables may be secured together at the points A and B.

When one cable girder has been completed, it is lifted off the framework, and the other one then made.

These girders are best put into position by being launched along a ropeway, stretched from a derrick on each bank, by securing slings to the upper panel points and attaching these slings to snatch-blocks travelling on the ropeway, care being taken to keep the girders in their proper shape, to avoid undue stresses in the bracing.

Each cable is taken separately round the anchorage, and secured in any of the usual ways, after being adjusted so that the portions marked are over the piers.

The following method of securing the cables was used in the Chatham bridge, and was found very convenient for making the final adjustments. Each cable was taken round the anchorage without a round turn, and secured by two bolted clips. The cables were pulled up a little above their final position, and when the bridge was completed, were adjusted with great accuracy, by loosening the clip further from the anchorage, passing an inch or so of the cable through it, and tightening it up again; the other clip was then loosened a little, thus allowing the slack in the cable to run through slowly, and then tightened again. This operation was repeated until the girders were adjusted.

The operation of placing the slings and transoms may perhaps be not quite so easy as in the ordinary type of suspension bridge, but no serious difficulty is experienced, especially as the majority of the slings are short; by building out the bridge bay by bay, they can be put on the cables and allowed to slip out to their positions, being automatically stopped by the bracing at the right place.

Turning to a brief consideration of the labour required for the erection of this type of bridge, it must be at once admitted that more is required than in a similar bridge of the ordinary type. It may however be remarked, that time is usually the dominating factor, and not the number of men available, and all the extra operations, such as rigging the ropeway, making the cable girders, and so forth, can proceed independently of the other operations; thus the length of time required to erect a bridge of this description will be no more than that necessary for the ordinary kind, provided that the extra men are forthcoming.

In this connection the following labour data for the bridge erected at Chatham may be interesting.

The span of the bridge was 90′, the bays were 10′, and the dip was 1/10. It was designed to carry infantry in fours. The necessary timber was available in suitable scantlings, and hence no carpenter's labour was required, with the exception of framing the piers out of 12″ × 12″ baulks.

The total amount of labour required was 616 man-hours, approximately 7 man-hours per foot-run of bridge, a figure that compares favourably with the examples given in Part III. of *Military Engineering*.

The labour required was made up as follows:—

	Man-hours.
Making cable girders	58
Erecting ropeway	33
Anchorages	51
Framing and erecting piers	125
Launching cables and general work till completion ...	349
Total	616

It was found that an average party of about 25 men could be profitably employed, and therefore the bridge ought to be completed in about 24 hours. The total time actually taken was about 29 hours.

GENERAL PRINCIPLES OF ORGANIZATION AND EQUIPMENT, ROYAL ENGINEERS.

(*Continued*).

Conditions of Service and Enlistment.

All recruits are sent to Chatham (except sappers for the Field Troops and drivers) to be approved and tested at the trades, and undergo the prescribed course of instruction in drill and military engineering. Sappers for the Field Troops and drivers are sent to Aldershot on enlistment for training.

Every sapper recruit for the Royal Engineers, with a few exceptions, must be a tradesman or artizan, of a trade authorized as useful for the Corps, and the *personnel* of the different units is made up of men of different kinds of trades proportioned according to the special requirements or duties of the unit.

Conditions of Enlistment.

The conditions of enlistment and terms of service are laid down in the Regulations for Recruiting.

Every man eligible for the R.A., R.E., or the Foot Guards, is, before enlistment, to be encouraged to join any of these which is open for recruiting in the district; and steps are taken to ascertain that this order has been complied with in each case before the recruit is finally approved.

The requirements as to age, height, chest measurement, and weight are as follows:—

Limits of age (with the exceptions specified below)	18 to 25 years.
Engine Drivers	18 to 30 years.
Military Mechanists	25 to 35 years.
Telegraph Reserve	19 to 30 years.

The regulated height, weight, and chest measurement are at present as follows:—

Height.

Sappers (except as specified below) ...	5′ 6″ and upwards.
Military Mechanists	5′ 7″ ,,
Bricklayers	5′ 5″ ,,
Shoemakers	,, ,,
Tailors	,, ,,
Telegraph Reserve	,, ,,
Drivers	5′ 5″ to 5′ 7″.
Sappers for Field Troops	,, ,,

Weight and Chest Measurement.

SAPPERS AND DRIVERS.

Age.	Height.	Weight.	Chest Girth when fully expanded.	Range of Expansion not less than
	Inches.	Lbs.	Inches.	Inches.
18	62 and under 65	115	34½	2
	65 ,, 68	115	35	2
	68 ,, 72	118	35½	2
	72 and upwards.	122	36	2½
19	62 and under 65	115	35	2
	65 ,, 68	117	35	2
	68 ,, 70	120	35½	2
	70 ,, 72	124	36	2
	72 and upwards.	128	36½	2½
20	62 and under 65	115	35	2
	65 ,, 68	120	35	2
	68 ,, 70	123	35½	2
	70 ,, 72	126	36	2½
	72 and upwards.	130	36½	2½
21	62 and under 65	118	35	2
	65 ,, 68	121	35½	2
	68 ,, 70	124	36	2
	70 ,, 72	127	36½	2½
	72 and upwards.	132	37	2½
22 and over.	62 and under 65	120	35	2
	65 ,, 68	123	35½	2
	68 ,, 70	126	36	2
	70 ,, 72	130	36½	2½
	72 and upwards.	133	37	2½

The terms of service are as follows:—

	With the Colours.	In the Reserve.
Sappers	3 years.	9 years.
Sappers of certain trades as laid down in para. 9A, Appendix II., Recruiting Regulations	3 or 7 years.	9 or 5 years.
Drivers	2 years.	10 years.
Men enlisted for appointment as Military Mechanists	12 ,,	*Nil.*
*Telegraph Reserve	3 ,,	3 years.

* Recruits for the Telegraph Reserve will be transferred to the Reserve immediately on enlistment. During peace they will not be retained with the colours more than six months after the cessation of hostilities, and they will be liable to be discharged when they cease to be employed in the Post Office.

SPECIAL QUALIFICATIONS.

(a). Sappers and Drivers.

(i.). Every recruit for the Royal Engineers must be able to read and write, and obtain a certificate of character (on Army Form B. 64) from his late employer.

Sappers must also obtain a certificate of trade proficiency (on Army Form B. 195) and sign a certificate as to engineer pay (on Army Form B. 151).

(ii.). A man of any of the following trades may be enlisted as a sapper (European) for the companies of the Corps :—

Balloonist.	Moulder.
Blacksmith.*	Painter.*
Boilermaker.	Paper-hanger.
Bricklayer.*	Pattern-maker.
Cabinet-maker.	Plasterer.
Carpenter.*	Plumber.*
Coppersmith.	Rigger.
Cooper.	Rivetter.
Electrician.	Sawyer.
Engine Driver.	Slater.
Engine Erector.	Telegraphist { line. / office (see para. (*b*)).
Fitter.*	
Gasfitter.	
Harness-maker.*	Telephonist.
Instrument Repairer.	Tinsmith.
Joiner.*	Wheelwright.*
Mason.*	Whitesmith.
Metal Turner.	Wood Turner.

(iii.). A man of the following minor trades may be enlisted as a sapper (European) for the companies of the Corps :—

Cable Jointer.§	Motor Fitter.§
Driller.§	Pavior.§
Dynamo Attendant.§	Plumber's Mate.§
Electric Bell Fitter.§	Scaffolder.§
Fettler.§	Striker or Hammerman.§
Fireman or Stoker.§	Switch-board Attendant.§
Joiner's Helper.§	Tool Grinder.§
Machinist.§	Wireman.§

(iv.). A man of any of the following trades may only be enlisted

* See para. (v.). § See para. (vi.).

as a sapper (European) for the companies of the Corps after reference to the officer i/c R.E. Records :—

Architect.§
Brennan-worker.
Clerk.*
Draughtsman.
Lithographer.
Photographer.
Platelayer.
Printer.
Sailmaker (for training as Kitemaker).
Shoemaker.§*
Surveyor.
Tailor.§*
Any other trade likely to be useful in the Corps.§

(v.). Only men of the trades marked with an asterisk may be enlisted as "mounted" sappers for the Field Troops, after reference to the officer i/c R.E. Records.

(vi.). A man of any of the trades marked § is not eligible for rates of engineer pay higher than the 6th (6d. a day), unless he qualifies by test after joining the Corps in one of the other trades enumerated in paragraphs (ii.) and (iv.).

(vii.). Men of the following trades, viz., blacksmiths, electricians, engine drivers, engine erectors, fitters, gasfitters, instrument repairers, metal turners, and any other men possessing educational qualifications approximating to those required for a second class certificate of education, may elect whether they will enlist for 3 or 7 years' colour service. Recruits should be informed that 7 years' men have preferential consideration in selection of men for coast defence training.

(viii.). A farrier or shoeing-smith may be enlisted either as a sapper for the Field Troops, or as a driver, and should be sent to Aldershot for training in mounted duties in view to subsequent employment as a shoeing and carriage smith in the field units of the Corps.

(ix.). Special care should be taken as regards the trade qualifications of a recruit, and only those should be enlisted who are reported to be at least "fair" tradesmen, if examined in a military workshop, or "good" if examined by a civilian tradesman. A sapper enlisted for the companies of the Corps is rated for engineer pay according to trade test after joining the Corps. Men of the trades enumerated in paragraph (ii.), whose trade qualifications are found after enlistment to be less than fair will, whenever possible, be classified as belonging to one of the minor trades enumerated in paragraph (iii.).

(x.). No man should, as a rule, be enlisted as a driver unless he is accustomed to the care and management of horses. A driver is classified as such for engineer pay.

(b). Telegraphists.

The name and address of any man desiring to enlist as an office telegraphist is to be sent by the recruiting officer to the O.C. 'K' Telegraph Company, R.E., Aldborough House, Dublin, who will cause him to be tested, and will furnish a certificate of his qualification, stating if he recommends the enlistment. If the certificate (which should be attached to the attestation) is satisfactory and the enlistment recommended, the recruit may be enlisted, provided he is up to the prescribed standard, but authority must first be obtained from the War Office. If recommended, although not up to the standard, an application for his special enlistment should be submitted.

(c). *Telephonists.*

A man who is able to read fluently and write correctly and rapidly from dictation, and who has been employed in the construction or maintenance of telegraph or telephone systems, may be enlisted as a telephonist with a view to going through a course of instruction to qualify in the special military requirements.

A man so enlisted must have a fair technical knowledge of the work on which he has been employed. Any man who has been merely employed as a labourer on construction work should not be accepted.

(d). *Military Mechanists.*

A limited number of men are enlisted, by special authority from the War Office, for appointment as military mechanists. The trades of men required will be notified when candidates are called for. Such men will not be required to sign the certificate as to engineer pay.

On enlistment as mechanists, men will at once be promoted mechanist staff-sergeants on probation, and generally be sent, in the first instance, to the School of Military Engineering, Chatham.

The period of probation will not exceed 12 months, and for the first three months—or such longer period as may be necessary—they will be placed under instruction in drill, etc.

Their appointment to the permanent establishment on completion of probation will be subject to their being considered duly qualified, and in possession of at least a 2nd class certificate of education.

A list of candidates for enlistment as mechanists is kept by the officer i/c R.E. Records.

Applications for names to be registered should be made to the Recruiting Officer or Commanding Royal Engineer of the District in which candidates reside.

All recommendations for registration, or enlistment, should be made on Army Form B 203, and accompanied by certificates of character, of past trade experience, and of present trade qualifications, as well as by certified specimens of writing from dictation and arithmetic; they will also be supplemented by any information which the officers nominating the men may be able to obtain concerning their general suitability.

(e). Telegraph Reserve.

In addition to the telegraphists enlisted under ordinary conditions for the Royal Engineers, a limited number of post office telegraphists will also be enlisted by special authority, and at once passed to the Army Reserve.

They will be selected from the 8th Battalion City of London Regiment, and the consent of the Postmaster-General will be obtained before enlistment, on the form prescribed in the Recruiting Regulations.

(f). Enlistment of Boys.

Boys of good character, and between 14 and 16 years of age, may be enlisted for training as musicians, trumpeters, or buglers, according to proportions laid down in Recruiting Regulations. Boys from the Gordon Boys' Home who have been specially trained as musicians or in some trade may be enlisted up to 17 years of age.

The Royal Engineers are, in addition, allowed 30 boys between 15 and 15½ years of age for training as telegraphists, and 40 boys between 14 and 15½ years of age for training as tailors and shoemakers.

The boys, except those for training as trumpeters, must come up to the following standards:—

Age.	Height.	Chest Girth. When fully expanded.
14 to 14½ years	4′ 10″	28½″
14½ to 15 "	4′ 11½″	29½″
15 to 15½ "	5′ 1″	30½″

No special standard is fixed for trumpeters, each case being considered on its merits; but boys of smaller physique are usually accepted for this class.

Sons of deceased non-commissioned officers and men of the Corps may be specially considered as to physique.

For the R.E. the selection of boys rests with the officer i/c R.E. Records, to whom application should be made in each case.

Applications for names to be registered should be made through the recruiting officer, or Commanding Royal Engineer of the sub-district in which the candidate resides.

Applications for names to be registered for training as buglers, tailors, shoemakers, and telegraphists will be forwarded to the officer i/c R.E. Records, and for trumpeters to the O.C. Troops and Companies, R.E., Aldershot, for consideration, and will be accompanied by the following documents:—

Descriptive return on Army Form B. 203 (showing chest girth when fully expanded, and range of expansion in inches).

Certified specimens of handwriting from dictation, and arithmetic, and a certificate of the Army or Council School Standard that he has passed.

Certificates of birth and good character.

The written consent of parents or guardians to the enlistment, stating the class for which the consent is given for the lad to enlist.

It should also be stated whether the candidate's father ever served in the Army, and, if so, his regimental number, rank, and regiment (or corps) should be given. Any subsequent advance in standard of education should be at once communicated, with a certificate, to the officer i/c R.E. Records. Any change of address should also be notified.

The earliest date at which boys' names are noted is 13 years, but no boy can be enlisted until he is 14 years of age.

Mobilization.

The *Regulations for Mobilization* contain the detail and orders laid down for the whole Army under the following headings :—

PART I.

EXPLANATION OF TERMS USED.

PART II.

MOBILIZATION ARRANGEMENTS FOR ALL UNITS.

Section I.—General principles.

Section II.—Preparatory measures—

General instructions.
Personnel.
Animals.
War outfit.

Section III.—Procedure on Mobilization.

PART III.

REGULAR ARMY AND REGULAR RESERVISTS.

Section IV.—Preparatory measures—

General instructions.
Personnel.
Animals.
War outfit.
Documents.

Section V.—Procedure on Mobilization—

General instructions.
Special instructions regarding units formed on mobilization.
Reservists joining the colours.
Duties of an officer i/c records.
Duties of an O.C. a regimental depôt (or company R.A.M.C.).
Duties of an O.C. a unit.
Duties of an O.C. the details of a unit or units.

SECTION VI.—SPECIAL INSTRUCTIONS AFFECTING THE PAY, ALLOWANCES, ETC., OF REGULAR RESERVISTS AND PENSIONERS ON MOBILIZATION—

Regular Reservists.

Pensioners.

PART IV.

SPECIAL RESERVE.

SECTION VII.—PREPARATORY MEASURES—

Personnel.

Animals.

War outfit.

Documents.

SECTION VIII.—PROCEDURE ON MOBILIZATION.

PART V.

TERRITORIAL FORCE.

SECTION IX.—PREPARATORY MEASURES—

Personnel.

Animals.

War outfit.

Documents.

SECTION X.—PROCEDURE ON MOBILIZATION.

NOTES.

Parts I. and II. of these regulations are generally applicable to all units which would mobilize at home, either for service abroad or for home defence.

Parts III., IV., and V. deal with procedure, not already provided for in Parts I. and II., which is specially applicable to the Regular Army and Regular Reserve, Special Reserve, and Territorial Force respectively.

Printed lists of the various equipments, showing the articles to be drawn by each unit, are issued to officers commanding, and are termed "Mobilization Store Tables."

These Tables serve as :—

(*a*). Record of war equipment of the unit.

(*b*). Storehouse label for mobilization equipment.

(*c*). Form on which to render return of mobilization equipment, as may be ordered.

(*d*). Voucher for issue of mobilization equipment.

THE MONOCRETE MACHINE.

By Lieut. D. McA. Hogg, R.E.

This machine is, I am aware, well known to a number of R.E. officers, but I think that a brief account might prove of interest. It is the invention of Mr. R. Bowen, to whom I am indebted for his kindness and courtesy in supplying me with information on the subject.

The machine builds, in a few minutes and in a single operation, a section of wall in concrete which is equivalent, in ordinary masonry, to from 72 to 450 bricks, according to the thickness of wall, etc.

The foundations of the building are first laid in ordinary masonry of any kind, and it is on this that the "Monocrete" machine is set to work. The machine itself is made of magnalium, an alloy of magnesium and aluminium—tougher than the latter and equally rust proof, though subject continually to the dampness of the concrete which it moulds into wall work.

Method of using the Monocrete Machine.

The machine is laid and aligned on the masonry foundation. Thus set up, it forms a box or mould without top or bottom, one end being permanently closed when in use, and the other being closed by a clip-tie and board (*Fig.* 1) while the sides are hinged vertically at

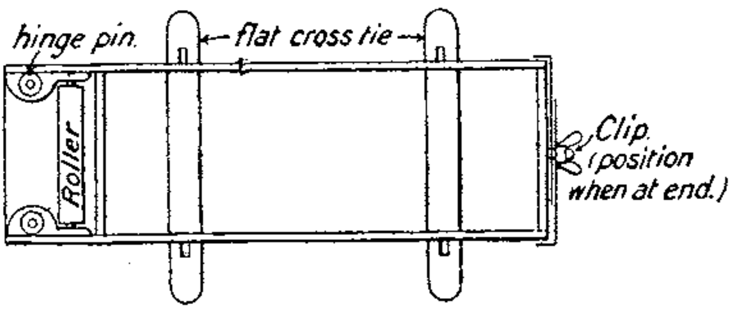


Fig. 1.—*Top View of the Machine.*

one end. It will be seen that this "board" is only required for the construction of the first section of a course, being removed for succeeding sections. *Fig. 2* shows the end elevation of the Monocrete

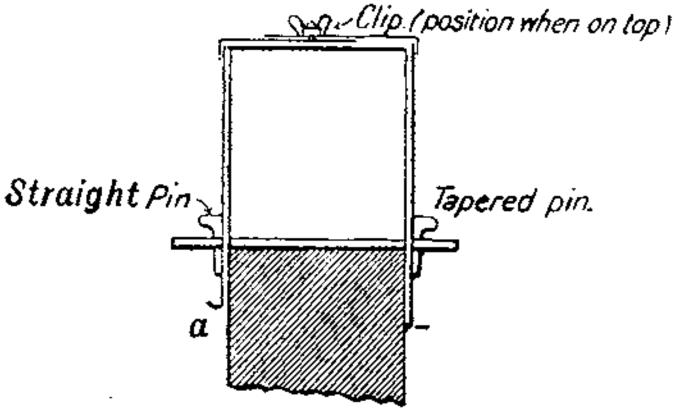


FIG. 2.—*End View of the Machine.*

machine with the lower portions of the sides gripping the course below, and thereby keeping the wall vertical. Seen from the top, the machine presents the appearance of an oblong trough, the sides being hung on hinges beyond the box portion.

Into this box, concrete in a semi-wet condition is shovelled. It is well rammed and made true on top, the clip and side wedges are removed, the sides are swung out on their hinges, and the machine is immediately rolled along to the next section, leaving a completed section of concrete wall behind it. The "board" referred to above is now removed and is not required for the rest of this course. Again the machine is filled with concrete, rammed down, and the operation repeated.

An essential feature of the operation of the machine is the consistency of the concrete with which it is filled. It has only from 10 to 12 per cent. of water, a proportion amply sufficient to ensure perfect crystallization of the cement, so that the mould can be removed directly the concrete has been well rammed, leaving it to set naturally. There is no work of mortaring the interstices between one block and the next, as there are none; for the blocks being constructed in contact while green, and layer upon layer, the whole wall forms a monolith. On the top of the layer which it built up on its last journey, the machine starts another journey, raising up a further course of concrete in perfect cohesion with the one below.

The machine works so evenly and exactly that the use of a plumb line is unnecessary up to at least 20′ in height, though of course one can and should be applied occasionally for verification.

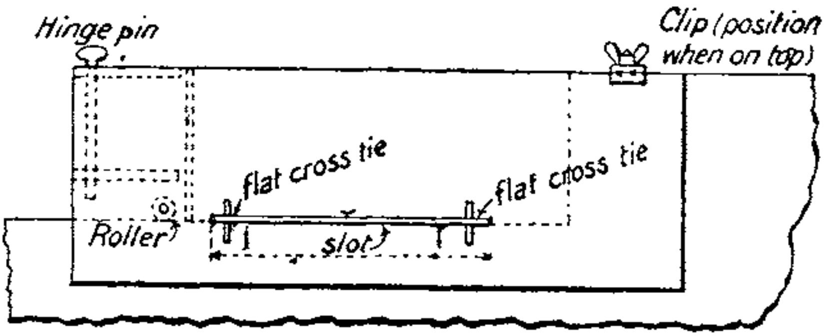


FIG. 3.

By a simple contrivance a corner can be turned, so that the machine can be worked round a structure, or can be made to construct chimney breasts, front door return walls, and even bay windows.

By the use of moulds, mouldings for cornices, cores, centering, etc.—any one of which is merely placed in the machine where wanted—window and door spaces and reveals, recesses, circular flues, sockets for beams and joists, arches, etc., can be made without any extra expense.

The placing of metal core boxes in the mould forms whatever cavities or places for resting joists are required. The metal surfaces of the machine give a sufficiently smooth surface to the concrete which thus requires no finishing by hand; though as the concrete is still fairly soft when the machine passes on, it is easy to mark imitation joints upon each layer, or to scrabble its face, or to dash pebbles upon it to make it rough cast.

Internally, the walls are smooth enough to leave without plastering in cheaper houses.

With material ready mixed and a staff of two unskilled labourers under the supervision of a man with a general knowledge of the building trade, a Monocrete machine erects wall work equal to at least 2,500 to 3,500 bricks, at a cost in labour of five shillings per 1,000 bricks. In practice the working of the machine can be left to ordinary unskilled labour after a very few hours' instruction and supervision. The machine is adjustable and can build walls from $4\frac{1}{2}''$ to $18''$ in thickness. The length of the section or the depth of a course can also be varied.

Various adaptations of this machine have been designed for special purposes, but this appears to be the one of most interest to R.E. officers.

The saving in the cost of buildings, etc., is enormous. The advantages of this system over the old system of concrete work, involving the use and setting up of shuttering, finishing of surface, etc., require no emphasis.

Note.—Practice, of course, varies immensely but the following proportion and sizes of aggregate have been found to work very well :—

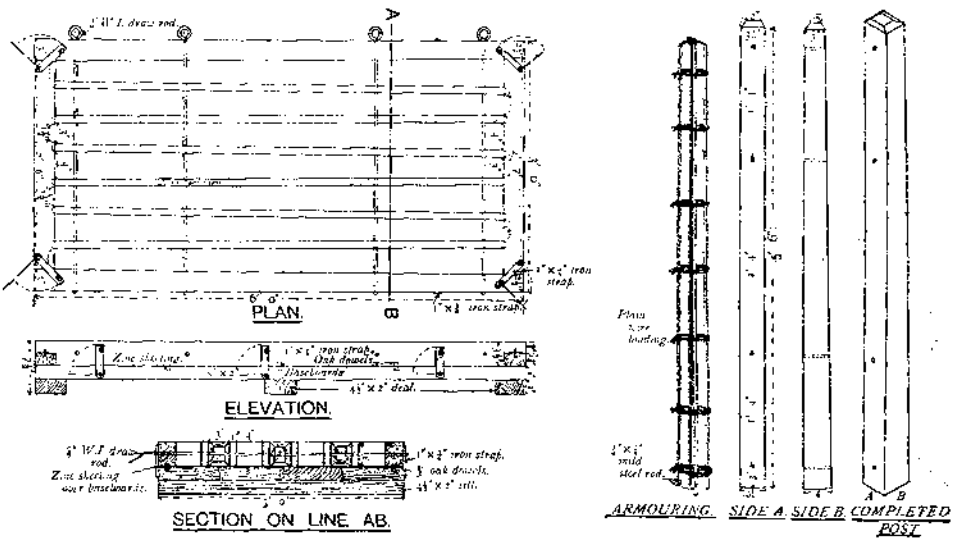
3 parts by measure of crushed material or gravel ⅝″ to dust.
3 parts of clean sharp sand.
1 part of best Portland cement.

REINFORCED CONCRETE versus WOOD OR IRON.

By MAJOR H. E. G. CLAYTON, R.E.

REFERRING to Major Riach's article in *R.E. Journal* for February, 1909, the following notes in connection with the construction and fixing of reinforced concrete posts for wire entanglement may be useful.

The accompanying plan illustrates the posts of which 660 were made, and the moulds in which they were cast. One mason and 1 labourer could make 28 posts in 1 day.



The constituents of the concrete were :—

½″ granite siftings	2 parts.
Granite dust	1 part.
Cement	1 ,,

The reinforcing consisted of about 5 lbs. of ¼″×¼″ mild steel rod, and binding wire, constructed as shown on plan, and fixed at least ½″ from surfaces of posts.

A few posts were tested for cross breaking by placing them on supports 4′ apart, and piling iron on the centre (1′ bearing). A weight of 600 lbs. would not bend a post $\frac{1}{16}$th of an inch, nor produce any sign of cracking. 736 lbs. caused a post to sag $\frac{3}{16}$ths of an inch, and produced minute cracks on under side. Two men bearing heavily on the weights fractured the concrete, and slightly drew the iron rods on one side.

The posts were allowed 3 days to set in the mould, and 21 days to harden when stacked. The weight of a post, when completed, averages 69 lbs., and the cost of material for each post may be taken as follows:—

Mild steel (A.O.D. supply)		4¼d.
Cement ($\frac{1}{8}$th bushel at 2s. 8d. delivered) ...		4d.
Granite siftings, Granite dust } ($\frac{1}{48}$th Y.C. at 1s.)		¼d.
Binding wire, 10′ run (A.O.D. supply)		½d.
		9d.
Labour per post		7·8d.
*Fixing in position	1s.	1d.
Concrete surrounding foot of post (2′ cube) ...		8d.
(Say 3s. 2d.).	3s.	1·8d.

Posts were fixed 1′ 6″ in the ground, and projected 4′.

				£	s.	d.
The amount expended, 2s. 9d. per post (including A.O.D. material)...	£90	15	0			
Constructing moulds, erecting sheds, surplus material, casual labour in removing material from boat to store, etc.	20	18	9			
				111	13	9
Value of materials obtained from A.O.D.				10	4	8
Transport (land)				8	9	3
				£130	7	8

It should be noted that mild steel as issued by A.O.D. will not grip the concrete unless the metal has been heated sufficiently to remove the preservative with which it is covered. This increases the cost considerably.

The station at which these posts were made is one at which granite siftings are obtainable at a very cheap rate.

* This item was very heavy in consequence of the labour entailed in cutting away rock.

REVIEW.

SPON'S ARCHITECTS' AND BUILDERS' POCKET PRICE BOOK, 1910.—(Size $6\frac{1}{2}'' \times 3\frac{3}{4}'' \times \frac{9}{16}''$).

This work contains in a convenient and readily accessible form, prices for measured work arranged by trades. Its cost is 3s. net, which compares favourably with the general price of such pocket books. The book is divided into two parts: Part I. is a summary of useful memoranda and tables in connection with the various materials used by engineers and builders and of questions arising in those professions; it includes such items as the size of a croquet lawn, the requirements for an air gas installation, and the law concerning casements. Under Part II. for each trade there are tables for constants of labour and material, prices for measured work, and day work prices, so that with the help of a good index at the end of Part II. an approximate estimate can be quickly arrived at by allowing a proportion between the tabulated prices and the current prices in the district in question. The book has the further advantage of being printed on superior paper with clear legible letterpress.

NOTICES OF MAGAZINES.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

January, February.

Under the title "Artillery for Airship Attack," are described the three general classes of ordnance—manufactured by Krupp—for firing at great heights against aerial craft. They include—(I.). Field type. (II.). Automobile type. (III.). Fixed type.

The maximum elevation of fire is 70° for the first, and 75° for the others.

Type I.—Field gun type, fitted with hydraulic recoil.—Bore, 2·6″; weight of projectile, 9 lbs.; weight of gun (alone), 775 lbs.; weight of trail, etc., 1,150 lbs.; total weight of gun and carriage, 1,925 lbs.; maximum vertical angle of fire, 70°; muzzle velocity, 2,050′ per second; maximum range (horizontal), 9,500 yards; maximum range (vertical), 18,800′. The wheels are pivoted so that they can be turned crosswise.

Types II. and III. differ from Type I., in that they are mounted on a central pivot allowing of rapid traversing round the complete circle.

Type II.—Automobile type with hydraulic recoil and central pivot.—Bore, 3″; weight of projectile, 12 lbs.; weight of gun, 990 lbs.; weight of support, 1,550 lbs.; total weight of gun and mounting, 2,540 lbs.; maximum vertical angle of fire, 75°; muzzle velocity, 2,060′ per second; maximum range (horizontal), 10,000 yards; maximum range (vertical), 20,000′; weight of automobile, 3½ tons (exclusive of gun and mounting); average speed, 30 m.p.h.; motor, 50-H.P.

Both axles of the car are driving axles, and it can therefore be manœuvred over rough and steep ground. To ensure steadiness, the platform is rigidly fastened to the axles, and in the general design ample space is allowed for ammunition and all spares, while vulnerable parts can be armoured. Gears for traversing the gun are quick-acting as well as slow motion.

Type III.—The fixed type, pivot mounted, resembling Type II. in general details but heavier and more powerful, is intended for use on coast defences, torpedo boats and swift cruisers and can of course be used as an ordinary gun.—Bore, 4·2″; weight of gun, 3,080 lbs.; weight of support, 3,520 lbs.; total weight of gun and mounting, 6,600 lbs.; muzzle velocity, 2,300′ per second; maximum range (horizontal), 14,800 yards; maximum range (vertical), 37,620′; maximum vertical angle of fire, 75°.

Rapidity of fire is, in all cases, obtained by the automatic opening and closing of the breech.

The sighting is telescopic, aided by a general finder with a large field of view. The range is first obtained by a range-finder, subsequent ranges and elevations for different positions of the airship being obtained directly, without the necessity for using range tables.

Various experiments have been carried out for determining the best form of projectile. It has been found that the rents made by shrapnel bullets in the envelope, are usually closed again by the internal pressure of the gas, and in most cases the airship can reach a place of safety.

The most effective form of projectile is a species of grenade, fitted with a very sensitive percussion fuze, exploding in the interior of the envelope and causing the ignition of the gas. The path of the projectile is marked by a trail of smoke that facilitates ranging, the smoke-producing device being ignited on the firing of the gun. At night the track of the grenade is visible by the light emitted by the smoke-producer.

W. H. Bunbury.

Nature.

January, 1910.

Mosquito or Man.—By Sir Robert Boyce (*p.* 158).—The author endeavours to show that the diseases of the tropics stand, so to speak, by themselves and thus require special teaching in the medical schools of this country. Take Uganda for instance, all the harm that the climate does for you there is to give you a sunstroke if you go out in the heat of the day with inadequate headgear, and to make it very difficult to keep awake after lunch; most of our familiar plagues such as tuberculosis, rheumatic fever and influenza appear to be absent. The diseases that are really to be feared are all such as spring from bites of arthropads. If you protect yourself from the mosquito you will not get malaria; avoid the tsetse fly, which is very easily done, and you are safe from sleeping sickness; do not sleep on mud floors nor pitch your tent on old encampments, and relapsing fever will not trouble you; keep rats and flies at a distance, and you are safe from the plague. With a little care and attention to surroundings, the European will find his life in the tropics, if anything, more free from disease than in our temperate, but influenza-ridden palæarctic climate. The historical survey of yellow fever contained in Chapter XI. gives an idea of what the West Indian islands were like in the old days, when the Secretary for War in England in 1783 wanted to know from the Governor of British Guiana why in a few months 69 per cent. of the white troops had perished and it is said of the slopes of the Morne in St. Lucia that there is not a square yard without the remains of a soldier under it. Chapter XIV. contains an account of the anti-yellow fever campaign in Havana in 1900. Havana had been a notoriously unhealthy place, 35,932 persons perishing of yellow fever between the years 1853—1900, this being equivalent to 754 a year, or to two deaths a day, and now after a thoroughly efficient sanitary administration and a special raid upon the breeding places of the slegomyia, the death rate of Cuba has come down to between 11—17 per thousand, only one case of yellow fever having been reported at Havana last year. Equally remarkable are the results that follow the extermination of anophelines for malaria. Ross began his anti-malarial campaign at Ismailia in 1901 when every inhabitant was infected, by 1904 the cases were diminishing fast and by 1908 there were no new cases at all, indicating that the disease had been entirely stamped out. The book is clearly and ably written, is most interesting to read, is illustrated by beautiful photographs and does credit in every way to its author.

DIRIGIBLE AIRSHIP COMPANIES (*p.* 344) are moving fast in Germany. A Parseval airship was ordered this month by the Munich Aeronautical Company, the share capital of which is 400,000 marks. It is to be delivered on 1st May when regular aerial tours are to be commenced. An airship station is to be made in Upper Bavaria, to which flights will be made from Munich. The municipality of Grägrath has placed 68 acres of ground at the disposal of another company which has been founded for exploiting motor-driven airships according to the system of Herr Zarn and for establishing air lines. Major Von Parseval has been appointed to lecture on dirigible airships at the Charlottenburgh High School.

THE LIFE OF SIR CHARLES WILSON, R.E., K.C.M.G. (*p.* 311), by Colonel Sir Charles Watson, belongs to that class of biography, which as Carlyle held, ought to be written; of such materials as this "life" will future history be made. His career was one of those devoted to the public service, and of the highest usefulness, unrecognized by, and hardly known to the ordinary world of newspaper readers. In Wilson's case, were it not for the accusations, long since withdrawn as totally unfounded, of a failure on his part to do all that was humanly possible to relieve Khartum before its capture by the Mahdi, his name would possibly be little known.

The first important post that Wilson filled (after his entry into the Royal Engineers) was that of Secretary to the British Commission for delimiting the boundary between the United States and Canada from the Lake of the Woods to the Pacific along the 49th parallel of latitude. The line as then marked out was not a true parallel of latitude but quite as near as could be traced within any reasonable limit of time. The urgent point was to get some acceptable boundary marked out on the ground so that nobody could have any doubt as to which side of the line they were on at any given moment. The country traversed by the line was almost unknown and of an extremely wild and mountainous character. The winters were very severe, and though little more than a boy, Wilson was trusted with the duties of the commissariat—acting as store and transport officer.

Soon after the termination of this Commission, he was employed on the survey of Palestine and the surrounding region, a work which occupied his energies for a large part of his life.

In 1867 he again went to the East to carry out a special task for the Palestine Exploration Fund, the survey of the Sinai Peninsula, in order to identify Mount Sinai and to elucidate the events of the Bible history.

Wilson's share in the Nile Expedition of 1884, and in the attempt to relieve Khartum and rescue Gordon is dealt with at length. The author, as a lifelong friend of Wilson, welcomed this opportunity of putting on record his version of the history in view of the opinion strongly held by him that Lord Cromer in his *Modern Egypt* was less than fair to Gordon.

In 1878 Wilson was appointed to delimit the Turco-Servian frontier and he afterwards served as Consul-General in Servia. He was for seven years, 1886–94, Director-General of the Ordnance Survey and then for three years he held the office of Director of Military Education.

The present biography is written in a simple style and gives a clear account of the events of which it treats.

W. E. WARRAND.

REVUE MILITAIRE DES ARMÉES ÉTRANGÈRES.

December, 1909.

(1). THE MILITARY FORCES OF PERU.—Every Peruvian is liable to serve between the ages of 19 and 50. From 19 to 23 in the regular army, from 24 to 30 in the 1st class reserve, from 31 to 35 in the 2nd class reserve, and the remainder of the time in the national guard. In mounted branches the time of service in the active army is four years, and in the dismounted branches three years. Young men between the ages of 19 and 23 who are not serving in the ranks of the regular army, are known as supernumeraries, and may at any moment be called to take their place in the ranks, to bring their corps up to strength. The 1st class reserve is called out for two months in the year, the 2nd class answer a roll call at headquarters once a year, and the national guards are not supposed to absent themselves from their town of origin.

The strength of the regular army is 4,000 men, and it is composed as follows:—

Artillery.—A regiment of mountain artillery of 2 brigades, each consisting of 2 four-gun batteries; a brigade of field artillery, *i.e.*, 2 four-gun batteries; a company of fortress artillery; a company of sappers. The field artillery is armed with the 75-m.m. Q.F. Schneider-Canet gun, and the fortress artillery with a battery of 152-m.m. and 2 batteries of 24-c.m. Q.F. Schneider-Canet guns.

Infantry.—6 battalions of 4 companies each.

Cavalry.—6 squadrons, including the escort of the president. The infantry are armed with the 1891 pattern Mauser, and the cavalry and artillery with the Mauser carbine.

The staff was organized in 1901, and reorganized in 1906 by officers lent by the French Government. It is divided as follows:—No. 1 Section—Military operations, recruiting and education. No. 2 Section—Mobilization. No. 3 Section—Historical documents, information on foreign armies, and the library. The staff is assisted by:—The cavalry, artillery and infantry inspections; the engineer department; the topographical department. These are also controlled by French officers.

The military college of Peru is at Chorrillos, and comprises 2 divisions: the senior, 100 strong, is for those who intend to become officers; the course for these pupils lasts four years. The junior division, 700 strong, prepares N.C.O.'s for the army. The school of musketry is in the same buildings as the military college, and trains officers in a six months' course in the use of the machine gun as well as of the rifle. Only specially selected officers are sent there, and as the ammunition grant is most liberal, the course includes a large amount of experimental work. The veterinary school trains a few officers, but its main object is the provision of smiths for the army. The supply and medical departments are under the direct command of the War Minister.

(2). THE ENGLISH GRAND MANŒUVRES OF 1909.—The operations of the 20th, 21st, and 22nd September are described, and the article concludes with a large number of observations on the British Army generally, of which the following is a brief *résumé*:—(1). The advanced guards used were too weak; they were used too much, merely as protective troops, and not as bodies to be manœuvred. In consequence, the main body not only often extended too soon, but the reserves were also thrown in too soon. (2). The infantry distinguished itself by the length of some of its marches. Although the British soldier has less to carry on his back than the men in most Continental armies, manœuvres are harder for him than for the others, as he has to fight all day, and bivouac all night. Good use was invariably made of natural cover. (3). The cavalry was very energetic. It showed perhaps a tendency to seek out the opposing cavalry, rather than combine with the other arms. It proved itself to be especially good at dismounted action. The condition of the horses was very good. (4). The artillery supported its infantry very well on all occasions. Good communication was kept up between battery and brigade commanders. (5). The desire to adopt the offensive was prevalent throughout.

(3). THE MANŒUVRES OF THE AMERICAN MILITIA.—The following is a *précis* of the observations on these operations:—(1). Both officers and men proved themselves to be really useful, and stood the test well in spite of the inclement weather. (2). The transport, which was supposed to include more than the regulation number of vehicles was swelled by the addition of numerous carts of all descriptions, with various unauthorized loads. (3). Two 37-m.m. naval guns were mounted on heavy motor cars, of 24 to 30-H.P. with solid india-rubber tyres. The car also carried the detachments (three men and a N.C.O.) and the ammunition. These cars were, however, used more as means of transporting troops rapidly to a given place to carry out some operation, than as guns. In the opinion of the directing staff, the guns might with advantage be replaced by machine guns, and the number of cars increased. (4). Eleven other motor cars of the same type were employed, two as hospital cars, and the remainder for transport purposes.

(4). FOREIGN NEWS OF DIFFERENT COUNTRIES.—*Austria.*—The mountain troops are to be supplied with large company mess tins which work on the "Thermos flask" principle. They will be carried on mules. *Belgium.*—Conscription is to be shortly replaced by universal military service. *Germany.*—The number of admissions to the Staff College was greater by 27 in 1909 than in 1908. This number will slowly be increased from 400 to 480 officers per annum. No officer having over 10 years' service will in future be admitted to the Staff College. In consequence of the creation of 1 company of machine guns per infantry regiment, steps are being taken to form a reserve of officers to fill the ranks of these companies on mobilization. A new helmet is being issued to the infantry. It has a green cover, the badges on it are in dull bronze, and the spike can be removed when carrying out field operations. The front and back can be lifted up, so that the wearer shall be comfortable when firing in the lying position. The cavalry have been ordered in future to carry their swords fixed to the saddle, except when on ceremonial parades. Eleven German officers of all three arms have been lent by the government to the Sultan to train the Turkish Army. *Holland.* — Two cyclist companies and 2 mounted machine gun detachments have recently been formed. *Italy.*—Important modifications have been lately made in the conditions of admission to, and the programme of studies at the Staff College. In future 100 officers of all arms will be admitted to the college. There are only three written papers: military law, military history, and topographical drawing. The oral subjects are:—Questions on the written subjects, and also on administration, military geography, French, and either English, German or Russian. Under the title of "Specialists' Brigade" have been grouped together 2 specialist companies, a wireless telegraph section, a photographic company, and a company of "train." The Italian military dirigible No. 1 Bis. travelled, on the occasion of the visit of the French Mediterranean squadron, from Bracciano (near Rome) to Naples, and back again (a distance of 500 kilometres) in 14 hours 25 minutes. The capacity of the balloon is 3,500 cubic metres. The envelope is divided into eight entirely separate compartments; of which seven are filled with hydrogen, and one with air. The stiffness of the envelope is provided for by means of a metallic framework. The airship, normally, only carries four passengers, but can carry as many as eight. The War Ministry has decided on the adoption of the following new articles of medical equipment:—(1). A stretcher for the use of Alpine troops. (2). A stretcher which can be rolled up and taken into two pieces, and can be easily carried by pack animals or in a carriage as required. (3). Trestle legs to support stretchers in the field, whilst preliminary dressings are being carried out. (4). Acetylene lamps to assist in looking out for wounded men on the field of battle at night. (5). Acetylene lamps to indicate hospital tents. (6). Iron bedsteads for use in surgical operations. *Russia.*—Changes at the Staff College.—The conditions of admission have been altered, formerly no officers above the rank of 2nd captains were admitted; now, admission is possible to officers up to the rank of 1st captain. No officers who have served for less than three years with their regiment and taken part in two periods of summer training are allowed to compete, except in the case of officers who are desirous of joining the geodetic section. On leaving the academy, these officers cannot of course occupy any staff billets except in the geodetic section. The entrance examination is in two parts; the written, and the oral. The former consists of:—(1). An essay on some tactical subject. (2). The solution of a tactical scheme. (3). An essay on political history or geography, at the choice of the candidate. The oral part includes:—(1). Military law. (2). Administration. (3). Artillery. (4). Fortification. (5). Elementary mathematics. (6). Political history. (7). The Russian language. (8). German, French, or English. (9). Geography. (10). Topography. The study of one foreign language only is required, instead of two as formerly, but the knowledge possessed by the candidate of that one language must be very thorough. Officers obtaining an average of 83 per cent. on the course, are, on leaving the school, attached to divisional staffs, and on completion of the training season go back to their units, till there is a vacancy for them on the staff. They also receive a year's pay, four months' leave on full pay, the right to change their corps or arm, and are recommended for a decoration. For the officers who obtain less than the above-mentioned percentage, the advantages are the same, but they are not recommended for a decoration; they go straight back to their units.

A. H. SCOTT.

RIVISTA DI ARTIGLIERIA E GENIO.

December, 1909.

REVIEWS OF BOOKS.—*Pro Calabria e Sicilia.*—By Engineers V. Gianfranceschi and G. Revere.—This work, which relates to the construction of buildings in those regions of Italy that are subject to seismic movements, is published by the Lombard Co-operative Society of Public Works, under the auspices of the College of Engineers and Architects of Milan. It has been very favourably judged by the committee of that assembly, a second prize for merit being awarded to the authors.

After a careful examination of the various points to be considered in constructions of this kind, the authors propose, for the foundations, a system of ample areas, not morticed to the ground, but, as it were, resting on it and rigidly joined to the superstructure.

For ordinary walls a special type of construction is proposed consisting of hollow blocks of cemented masonry. These however do not include walls for structures of wood or iron.

AUSTRIA-HUNGARY.—*Formation of Balloon Detachments.*—From the *Militär Wochenblatt* we learn that in January next a detachment of balloonists will be formed in Austria. Up to the present time the balloon service was entrusted to the section formed for studying military aeronautics and attached to the 1st Regiment of Fortress Artillery of the garrison of Vienna, its *personnel* being composed of 12 officers and 20 men under whose instruction 20 officers and 150 men of the troops of the various arms were attached.

The Austrian military aerostatic park which, up to the present time, consisted only of spherical balloons and of *drachen*, will next year be augmented by three dirigible balloons, viz.:—A Parseval with a capacity of 1,800 cubic metres with a Daimler motor; a Lebaudy of about 3,000 cubic metres with a Daimler motor supplied from the Austrian Society for the construction of aerostats; and a third dirigible with a capacity of 2,000 cubic metres. These dirigibles are required to travel with a velocity of 45 k.m. per hour, to carry a crew of five men; the height of flight being not less than 1,500 m., and its duration not less than eight consecutive hours.

The balloon detachment will be stationed at Fischamend where there is a hangar for balloons 180 metres long and 20 metres in height. The troops will wear the same uniform as the regiment of railway telegraphists, with a distinctive design of a spherical balloon on the collar.

Troops for Communications.—By a decree of the 7th October a brigade of troops, for the line of communications, has been formed in Austria under the command of Major-General Schleger. This brigade will be composed of the regiment of railway telegraphists, the detachment of automobilists, the detachment of balloonists and the service for homing pigeons.

PROPORTION OF ARTILLERY TO INFANTRY DURING THE LAST CAMPAIGN IN MOROCCO.—An article from the *Memorial de Artilleria* of last November entitled *Hablan los hechos* gives details of the amount of artillery that was brought into action during the recent campaigns conducted by the French and the Spaniards.

Although, says the author, the campaigns were against an enemy unprovided with artillery and wanting both in discipline and in the good arrangements of regular armies, they possessed qualities which would render them dangerous unless adequate measures were taken against them.

At the commencement of the campaigns the insuperable difficulties of attacking a position without the aid of a strong artillery was evident. It was only by this means that the heavy daily fire of the enemy was overcome, and his skilful marksmanship and knowledge of the ground itself and how to make the best use of it was neutralized.

From the first the Spaniards and French, recognizing all the advantages to be gained from artillery fire against the assaults of an intrepid enemy, had learnt the necessity of distributing strong artillery to the several corps, and the final proportion of guns was eight for 1,000 infantry, and four for 1,000 cavalry.

BRAZIL.—*New Places for Wireless Telegraphy Stations.*—*La Revue Scientifique* of the 13th November announces that the Brazilian Government has set up two stations for wireless telegraphy, one at Pernambuco, and the other at the island Fernando di Naronha.

The station at Fernando will be able to communicate with the transatlantic stations and to correspond directly with Dakar. The station at Pernambuco has a length of wave of transmission of 600 m.; that at Fernando, in addition to an installation similar to the preceding, has another with 60-H.P., and a length ot wave of transmission of 1,800 m.

EDWARD T. THACKERAY.

THE AËRONAUTICAL JOURNAL.

January.

This number contains some interesting details by Mr. H. B. Molesworth, M.I.C.E., for determining the pressure of air on flat planes. The details consist of two tables giving alternative values for the force of wind, and a diagram of pressure curves to which to apply them.

There is also a brief description of the Sem-Jacobsen system of man-lifting kites which have been purchased by the Danish Government for the use of the Amundsen Polar Expedition during the coming year. This system consists of seven kites, of a modified Hargrave type, with either a linen gondola or a basket suspended beneath.

The team of kites comprises one kite of 5·3 square metres, four of 13 square metres and two of 21 square metres surface, all being built of bamboo (or magnalium tubing if preferred) covered with Egyptian cotton cloth or silk. The cable is of extra flexible steel wire, 8 m.m. thick, and the windlass is of the ordinary type with exchange and hand-brake.

The team can be used in a wind velocity of anything between 25 and 50′ per second, though a velocity of 27′ per second is sufficient to raise one man with six kites only, or two men with seven kites.

Ascents have been made to a height of 2,600′.

The whole apparatus, which costs approximately £170, can be stowed away on an ordinary wagon, and can be fitted up ready for an ascent in half an hour by eight men.

W. H. BUNBURY.

Plan of
No 4 General Hospital
Mooi River Natal
1902

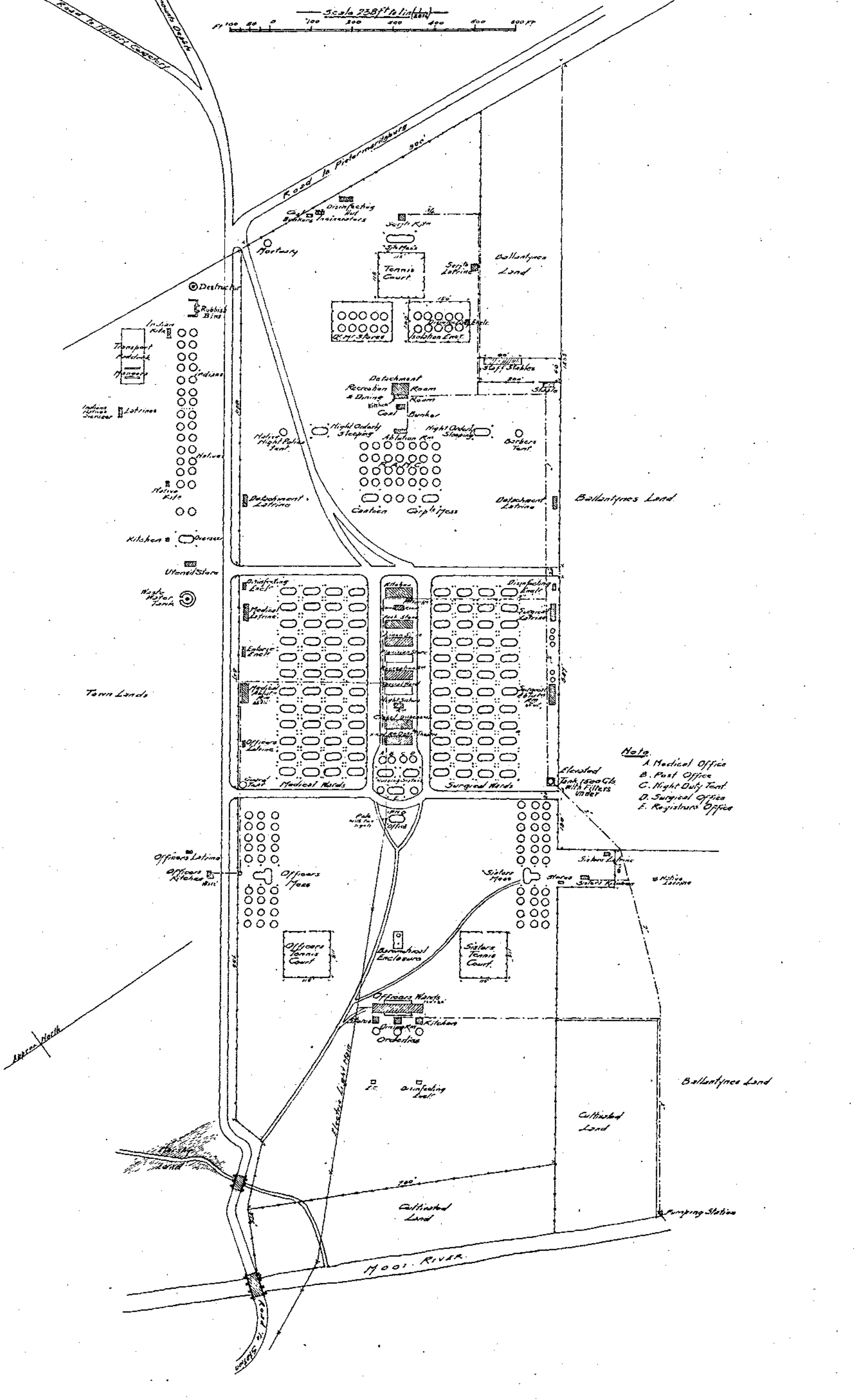
Reference

Fences marked thus

Water supply

Electric Light wires

Scale 238 ft to 1 in



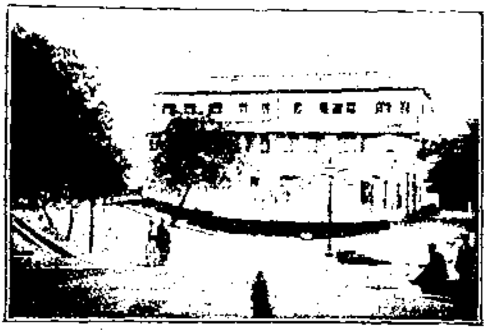
RUBEROID! ROOFING!

A High Grade Permanent Roofing Material in general use for all classes of Buildings. Its light weight as compared with other roof coverings makes it particularly useful where long transport of building materials is necessary.

THOROUGHLY TESTED FOR ALL CLIMATES.

Supplied to H.M. WAR OFFICE for

GIBRALTAR, SIERRA LEONE, CHATHAM, MAIDSTONE, PORTSMOUTH, BANTRY BAY, Etc.



Government House, Cape Coast, West Africa.
The Roof of which is entirely covered with RUBEROID.

Unaffected by Concussion of Gun Fire.

—:o:—

CAN BE LAID on all kinds of ROOFS, FLAT OR PITCH, CONCRETE OR WOOD.

Full particulars of cost and shipping weights gladly supplied. Our Illustrated Catalogue, No. 39, and samples sent post free on application.

THE RUBEROID COMPANY, Limited, 81 & 83, Knightrider St., LONDON, E.C.

Military Men who play Golf

will appreciate the advantages of the Dunlop Ball. In driving, approaching and putting the Dunlop has no equal. Follow the example of champion golfers and play the

DUNLOP

"ORANGE SPOT" or "JUNIOR."

Notwithstanding the high price of rubber, the prices of these two balls remains the same.

Price 2/- each.

5d. allowed on each Dunlop returned at time of purchase of new ones.

DUNLOP RUBBER CO., LTD., MANOR MILLS, ASTON, BIRMINGHAM.