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NOTES ON BRIDGE REPAIRS.

By CAPT. W. N. BORTON, R.E.

HOW many of us when faced with the problem of repairing "on paper" a demolished bridge, whether on manœuvres or at war games or winter schemes, have not proposed to obtain materials from neighbouring buildings—often without seeing the buildings in question or examining what materials could actually be obtained from them? The object of these notes is to consider this subject.

In the *R.E. Journal* of June, 1911, Major Matheson, writing on bridge demolitions, proposed two formulæ for calculating the charges for girder bridges, both railway and road, which will be found very useful on manœuvres or on service. The basis of these formulæ was the fact that the Civil Engineer who designed the bridge made it to carry a definite load, and in order to do so was obliged to use a more or less definite amount of "stuff," which would require a more or less definite amount of explosive to destroy it. The only variables were span, depth of girder, and number of girders, all of them easily measured. The formulæ, though very general, were sufficiently accurate for use "in the presence of the enemy," in which circumstances we are ordered to add 50 per cent. to the amount of our calculated charges. Some such simple formulæ would be very useful also to save calculations in hasty repairs to a broken bridge.

Suppose then that we are confronted with a demolished bridge; it may be that the gap produced is of a simple nature and easily crossed by a normal trestle bridge; then all we have to do is to rip up the floors of some neighbouring buildings and having obtained a supply of nails wire or rope to put together plank trestles made from floor joists, and to use other joists as road-bearers, and floor boarding for the bridge floor, and over we go.

But we must remember that the enemy's pioneers will be experienced in bridge repairs as well as in demolitions, and we must therefore expect him to select, for demolition, a bridge which will be relatively difficult to repair; subject of course to strategic and tactical conditions. Furthermore he will be anxious to husband his explosive, and will therefore make for bridges with long spans, in which an effective gap can be produced with much smaller charges than are required for a bridge consisting, for example, of a number of short-span brick arches. In fact we shall frequently be confronted with a demolished bridge whose spans are greater than the length of timbers which one can obtain from an ordinary house floor, and in which special conditions prohibit the use of intermediate supports, even in war time. Example.—A main road bridge crossing a double line of rails in a deep cutting; the demolished bridge consisting of two 24-ft. span brick arches, the central support of which has been blown down at a depth of 30 ft. below the roadway. It is desired to use both the railway and the road for army communications.

If, as in the above case, we cannot get across with simple floor joists and we are not permitted to block the roadway underneath with intermediate trestles, we must construct some form of girder.

If we turn now to the roofs of our buildings, we find in the roof trusses ready-made girders of sorts, which can be removed and used intact as bridge girders. It is proposed in the following examples to consider how best they can be arranged for this purpose. The objection may be raised that, in order to get at the roof trusses, the whole roof has got to be stripped. This is so, but it will perhaps not take so long as one would at first suppose, and most of the material so obtained, viz. purlins, rafters and boarding, will be required for our bridge.

It may here be remarked that practice in "house breaking" would form very valuable training for R.E. Companies on the somewhat rare occasions on which War Department buildings or barracks are condemned and pulled down.

In the following examples the figures for weights of roof materials and the distribution of loads on the trusses have been taken from Major E. N. Stockley's "Notes on Roofs," recently published as a R.E. Professional Paper.

Considering the loads on roofs of small span we see, from Table III. of the above-mentioned "Notes on Roofs," that roofs may be divided into several classes, *e.g.* temporary roofs, light roofs, ordinary roofs, heavy roofs. For purposes of rapid calculation in the field we want a standard roof, and we might therefore take the "ordinary" figures. But on the other hand we must remember that we may come "up against" the "jerry builder," and it will therefore be better to adopt the figures for light roofs, *i.e.* asbestos slates on 1-in. boarding, as our standard. Here we have a total working load of 30 lbs. per square foot of roof *surface*, made up as follows. Roof covering and boarding 6 lbs., rafters, purlins and trusses 4 lbs., workmen *or* wind 20 lbs., total 30 lbs.

Omitting the 4 lbs. for purlins, etc. (we will show why later), we get 26 lbs. per square foot of roof surface measured on the slope. Measured in plan, the load would be greater per square foot, say 30 lbs., and if we deduct the weight of boarding as well as purlins we might take 26 lbs. per square foot of covered area as the load due to slates and workmen, to be borne by the trusses.

The spacing of the trusses will vary from about 8 ft. to 12 ft. centre to centre. Let us adopt 8 ft. as our standard, anything over that will mean stronger trusses, and therefore greater safety. (A common spacing in British barracks is 11 ft.). Then the load borne by each truss will be $26 \times 8 = 208$ lbs. per foot-run of span. It should be noticed that this figure holds good whatever the span, and with slight modifications could be adopted even for the largest span steel roofs—always provided that the loads are applied at the correct points on the truss.

Let us now consider what load the roof trusses have to bear when used as bridge girders.

Taking infantry in fours to weigh 5 cwt. per foot-run $= 560$ lbs. per foot-run *live* load $= 560 + 50$ per cent. $= 840$ lbs. per foot-run dead load, we see that four trusses would carry

$$208 \times 4 = 832 \text{ lbs. per foot-run.}$$

Therefore provided the loads are applied at the ordinary position of the purlins, and provided the original spacing of the trusses in the roof is 8 ft. or more, four roof trusses will carry infantry in fours crowded, over the whole span of the truss whatever that span may be.

It will be remarked that no allowance has been made for the (1). weight of superstructure on the trusses of the bridge, but it will be remembered also that the weight of purlins, rafters and boarding was omitted in considering the loads on the trusses in the roof. Taking this at 4 + say 2 or 6 lbs. per foot for the four bays of roof it will give a weight of $4 \times 6 \times 8$ ft. $= 192$ lbs. per foot-run of four trusses and 180 lbs. is an ample allowance for the superstructure of a bridge for infantry in fours.

Sometimes it will be convenient to load the trusses at the purlin points, and sometimes it will be more convenient to carry the bridge floor along the tie-beam.

As an example of the first case, a brick arch over a canal has been demolished by charges at each haunch. The original clear span was 18 ft. and it is proposed to repair it with four kingpost trusses of 24-ft. span. The nature of the gap produced is shown in *Fig.* 1.

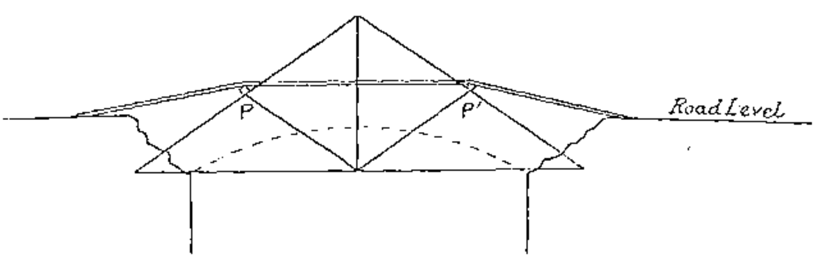


FIG. 1.

The proposed position of the trusses is shown in outline, two trusses being placed side by side on each side of the roadway. If now a pair of road transoms are fixed at PP′, we can get across very conveniently, with a centre span of about 12 ft., and two other spans of about 8 ft.

Sometimes however it will be more convenient, as in the case of a girder bridge in which the girders have been cut and dropped into the gap without damaging the piers, to support the roadway directly on to the tie-beams of the trusses.

We will now consider this case; the point to be looked to, especially in timber trusses, is that members which were designed to take compression are not subjected to tension, or failure will probably occur at the joints.

Fig. 2 shows the loading of the truss in the roof and the diagram of stresses in the various members.

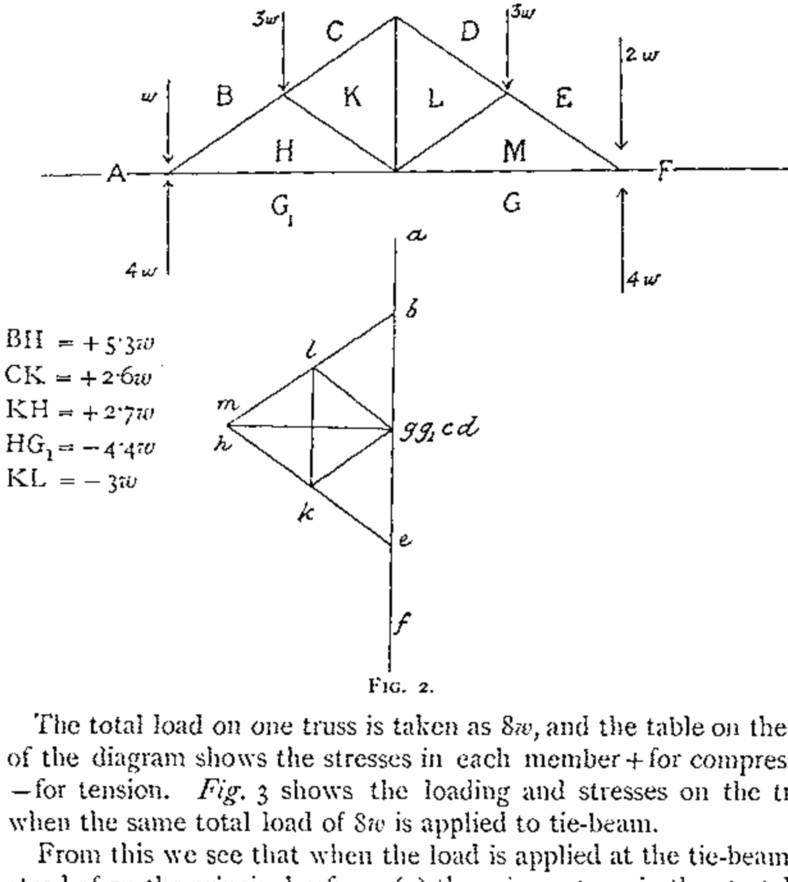
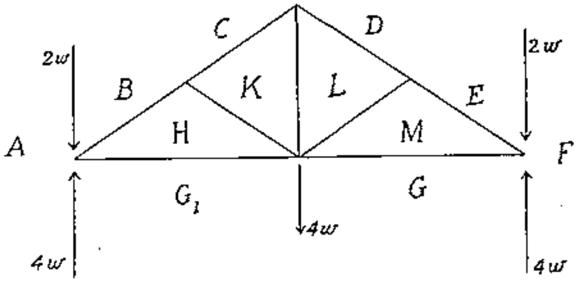


FIG. 2.

The total load on one truss is taken as $8w$, and the table on the left of the diagram shows the stresses in each member + for compression − for tension. *Fig.* 3 shows the loading and stresses on the truss, when the same total load of $8w$ is applied to tie-beam.

From this we see that when the load is applied at the tie-beam, instead of on the principal rafters, (1) there is no stress in the strut KH. (2) the only members in which the stress is increased are CK and KL. CK will be of the same section as BH and it is not now greater than the original BH, so KL may be taken as the weak point in the truss, and $\frac{KL_1}{KL_2} = \frac{3}{4}$, and, as we have shown that to carry infantry in fours four trusses were formerly required, we now want $\frac{4 \times 4}{3} = 5·3$ say six trusses.

Therefore six timber kingpost trusses will carry infantry in fours, (2). whatever the span may be, when the load comes directly on the tie-beam.



BH = + 3·6w
CK = + 3·6w
KH = 0w
HG = − 3w
KL = − 4w

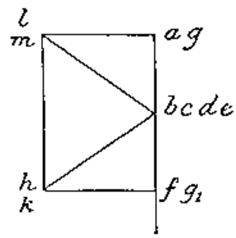


FIG. 3.

It will be remarked that since there is now no stress in the member HK, the principal rafter can no longer be considered as supported in the middle and the unsupported length will be double, and this member will be liable to buckle either upwards or sideways. This can be got over by passing a few turns of wire round the truss above the purlin cleat and under the tie-beam, and windlassing the returns up tight so as to put a strain on the member HK. Also, as there are now no purlins, the three trusses on each side of the bridge should be braced together at intervals up the principal rafter, so as to prevent the danger of side-buckling.

The roadway can be supported on to the tie-beams in two ways (1) by placing a pair of transoms at the centre of the span (these transoms can be made of the roof purlins), and bridging across this gap with common rafters or, better, with floor joists. (2). By placing the floor joists at close intervals along the tie-beam and across the line of the bridge, and covering these with two layers of boarding, the lower layer lengthways along the bridge, and the upper layer across the bridge. This latter method puts a transverse stress on the tie-beams which would therefore have to be calculated; but as the tie-beam is for convenience of joints, usually made of unnecessarily large scantling, it will probably be strong enough. Take the case of a 24-ft. truss which might have a tie-beam of 6″ × 4″, if there is no ceiling.

Then using the short formula $bd^2 = \frac{WL}{133}$ for the six trusses

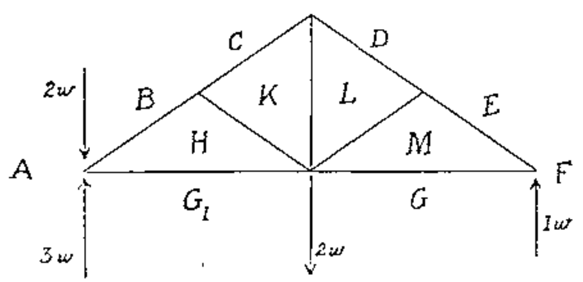
$$6 \times 4 \times 6 \times 6 = \frac{W \times 12'}{133}$$
$$W = 9{,}576 \text{ lbs.}$$

Infantry in fours was, we said, 840 lbs. dead load per foot-run, say 900 lbs. with roadway. Load for 12-ft. run will be 10,800 lbs. so the tie-beams are not quite strong enough, but practically, being continuous over the whole span, they could be regarded as "half fixed" and therefore amply strong. If there is a ceiling, the scantling would probably be about $9'' \times 4''$.

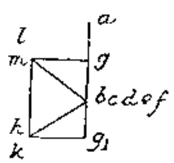
The maximum concentrated load that can be taken by the bridge will vary with the span.

(3). In the above case it would be $12' \times 560 = 6{,}720$ lbs. $= 3$ tons live load.

It may be well to see what happens when only part of the bridge is loaded. *Fig.* 4 shows the case of a load of infantry in fours over half the span, the load being directly on the tie-beam. The same lettering and units of load are used as in *Figs.* 2 and 3.



BH = + 3·6w
CK = + 3·6w
KH = 0w
HG = − 3w
KL = − 4w

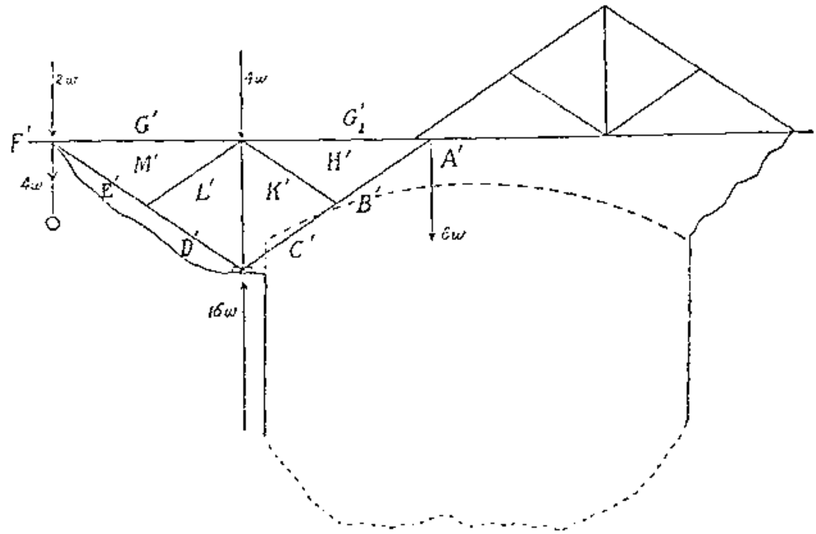


BH = + 1·8w
CK = + 1·8w
KH = 0
HG = − 1·5w
KL = − 2w

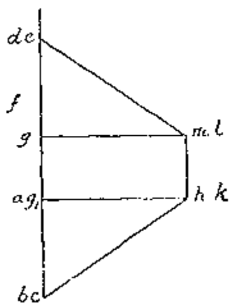
FIG. 4.

On the left of the diagram are the values from *Fig.* 3, while on the right are the new values showing that all the stresses are of the same sign but half the value, so the bridge is uneffected by partial loading.

(4). It will often happen that we shall be unable to find trusses of sufficient span to get across the gap in one step, or we may find a number of trusses of small span on the site of a building in course of construction, and may want to use them to save the time which would be required to dismantle a roof of larger span. We could in these circumstances use some of our trusses as cantilevers on one or both shore-ends, with a central span of other trusses used as simple supported beams (*Fig.* 5).



BH = + 5·3*w*
CK = + 2·6*w*
KH = + 2·7*w*
HG_1 = − 4·4*w*
KL = − 3*w*



B′H′ = + 11*w*
C′K′ = + 11*w*
K′H′ = 0
$H'G'_1$ = − 9·2*w*
K′L′ = + 4*w*

FIG. 5.

Fig. 5 shows trusses used as cantilevers for the left half of the span and as supported beams on the right half. The stress diagram gives the stresses in the cantilevers, and comparing them with the stress in the similar members in *Fig.* 2 we see that

$$\frac{BH'}{BH} = \frac{11w}{5{\cdot}3w} = 2{\cdot}07$$

or

$$\frac{HG'}{HG} = \frac{9{\cdot}2w}{4{\cdot}4w} = 2{\cdot}09.$$

In *Fig.* 2 we saw that we required four trusses, and as the unit "*w*" (5). is the same we now require for the cantilever span

$$2{\cdot}09 \times 4 = 8{\cdot}36 \text{ say } 9 \text{ trusses.}$$

Total for the bridge 9 + 6 = 15 trusses as against six if we could have got them of sufficient span for the whole gap.

As before, the principal rafter must be secured against buckling.

The nine trusses can be spaced equally across the width of the roadway, and we shall therefore require no transoms or joists, but can nail our boarding direct on to the tie-beams.

The anchorage for the cantilever span will be easily arranged. The pull is $4w = \frac{1}{2}$ the weight of infantry on over the whole span, or, when the load is coming on from right to left in *Fig.* 5, it will be a maximum of $6w$ (always provided that the two sets of trusses are of the same span).

It should be specially noticed that the stress in KL, the kingpost, is compression and not tension as before. With timber trusses this will not matter as far as the joints are concerned, but it may be as well to consider the kingpost for buckling. The length of the post is about the same as the strut KH and we saw in *Fig.* 2 that KH takes $2{\cdot}7w$ with four trusses, therefore nine kingposts will be easily able to take $4w$ which is less than twice $2{\cdot}7w$ as the scantling of the kingpost will be slightly larger than that of the strut.

If, however, the kingpost is an iron rod, as sometimes happens, it will not do at all and a special strut each side of the rod will have to be introduced to take the weight GG_1. The large amount of pressure DC should be noted and provided for in the footings.

Before going on to discuss steel roofs it may be as well to summarize the conclusions to which we have so far come. These are :—

(1). If loads are applied to the principal rafters in the normal position of the single purlin, then

Four timber roof trusses will carry infantry in fours crowded, over the whole of their length. N.B.—Original spacing of the trusses in the roof must not be less than 8 ft.

(2). If loads are applied to the tie-beams, six trusses will be required to do the same work.

(3). Kingpost trusses if loaded as in (2) above will take a concentrated load equal to half the weight of infantry in fours over their whole span.

(4). Partial loading does not matter.

(5). Trusses can be used as cantilever shore ends with a central girder. If all the trusses are of the same span, then with nine trusses at each end and six in the middle, total 24, we can bridge a *clear* span of twice the length of the trusses, or three times that length, counting in the slope of the abutments (*Fig.* 5).

We may now pass on to consider roofs having wrought iron on steel trusses. Steel trusses are becoming more commonly used every year even for moderate spans, and for the larger spans are almost universal. For our purpose steel trusses will offer several advantages over wood.

(1). They will be more likely to be of sufficient span to be really valuable.

(2). They will often be found in single storey buildings, and often used without a ceiling, which will greatly assist in selection of suitable trusses and in dismantling from the roof.

(3). They are generally riveted, but divided up into portions of 20-ft. length for convenience of transport, these portions being secured by bolts so that they can be broken up into convenient lengths for carrying from the building to the site of the bridge.

On the other hand they offer certain disadvantages, viz. :—

(1). Difficulty of securing the roadway and the cross bracing of wood to the steel work.
(2). Great variety in design and spacing.
(3). The unit truss is of considerable weight.
(4). Not generally economical unless the load is applied on the principal rafters.
(5). Liable to buckle sideways in launching.

We saw that with timber trusses the thing to avoid is reversal of stress in the members, especially those normally in compression. With steel trusses however the compression joints and members will usually take tension equally well, but the tension members are quite unsuited to take compression. Consequently it will generally be advisable only to load the trusses at the points which were designed to take a load on the roof. In fact it will require careful consideration before we carry the roadway directly on the tie-beams, although we have seen that for many classes of gap this is the most convenient (though uneconomical) method with timber trusses.

Iron trusses of large span are designed to carry either permanent load (roof material and purlins, etc.) + workmen, or permanent load + wind pressure, the higher value being taken in the design of each individual member.

For our purpose, however, the strength to resist wind pressure may be neglected, and we can take, as before, the load due to workmen which is to be equated to the reduced live load (whether infantry or concentrated) to be borne by the bridge trusses, in order to find the requisite number of trusses. But as we are now dealing with trusses of considerable span (which means weight) we shall be well advised to seek economy, and we will therefore try for a more accurate formula.

If we adhere to our unit roof load of 26 lbs. per foot-super of covered area, then suppose the spacing of trusses was 10 ft. we get $26 \times 10 = 260$ lbs. per foot-run.

The equivalent dead load of infantry in fours was, we said, 840 lbs. per foot-run, therefore for 10 ft. we require $\frac{840}{260} = 3{\cdot}23$ trusses.

Substituting "S" for 10 ft. we get

$$N = \frac{32}{S}$$

where N = the number of trusses required to carry infantry in fours (on the principals) and S = the original spacing of trusses in the roof before dismantling.

If owing to the nature of the gap we wish to carry the load on the tie-beam, we must draw two stress diagrams, one for the original loading and the second for the proposed loading; and so, finding the stress in the most hardly used member, establish a new value for the strength of the truss, and equate this to the bridge-load in order to find N.

Lastly a few remarks on selecting suitable roofs.

Go first for the roofs of large buildings which will have a large number of trusses of equal span and pitch. The most likely type of buildings will be warehouses, workshops, breweries, railway goods sheds, motor garages, skating rinks, drill halls. If possible select a building of only one storey and with no ceiling. Here we can see what we shall get before we start work, and we shall cause less despondency among the inhabitants, remembering that an Englishman's home is his castle, as is also that of any other nation.

In attacking the roof a hole must first be broken through near the ridge, and through this a line of Sappers would be extended along the ridge at about 2 yards interval, armed with pickaxes. They would work down the roof, stripping off slates and boarding and throwing all over the eaves. Rafters would then be removed and the ridge board and purlins of the first truss, and the top of the truss would be secured with guys. If convenient the truss would then be lowered inside the building and carried away through the doorway by a party of infantry, or if the door is too small, the truss must be pulled out over one of the outside walls. This will be more easily done if a hole is made in the arch over a window, so that one end can be lowered to the level of the window sill before the other end leaves the opposite wall plate.

Riveted steel trusses are usually put together in lengths of about 20 ft., which lengths are afterwards bolted together to form the truss; they can therefore easily be broken up into these lengths for more easy transport from the building to the bridge site.

The following example of handling steel roofs will perhaps be of interest. A firm contracted to supply and erect the steel work of a gymnasium consisting of eight 40-ft. steel roof trusses carried on 14-ft. stanchions. The whole work of erection was done by three men, one of whom was a professional "erector," the second was a carpenter and the third a casual labourer picked up on the spot. The stores used were a 40-ft. derrick spar with 2-in. wire rope tackle and a small winch, a ladder, spanners, and crowbars. The work took about a fortnight (say 300 men-hours).

MECHANICAL TRANSPORT FOR MILITARY PURPOSES.

By CAPT. R. K. BAGNALL-WILD, LATE R.E.

MECHANICAL TRANSPORT is now recognized as a necessity for a modern army operating under normal war conditions, and the type of vehicle best suited for military purposes is generally considered to be an internal combustion engined lorry, capable of carrying useful loads of from 30 cwt. to 5 tons.

Many experiments have been carried out with other types of vehicles, including tractors and heavy traction engines. An immense amount of time and energy has been expended on this type question, and many European military authorities have drawn up detailed technical specifications for lorries to meet their requirements.

The most important point, however, is that of supply, and this question has until recently received but little attention. England, her colonies, and other countries have each their own problem to solve, and, before submitting suggestions as to a solution, the conditions must first of all be reviewed.

The number of lorries that would be required in England for the Regular Army for war purposes, exists in the commercial world, but the military ideal lorry is not to be found in general use. The present subsidy scheme has been put forward to encourage the general public to purchase and use lorries specially built to W.D. specification, but so far the results have not been satisfactory. Manufacturers have not responded as a body, and for these reasons, (1) they are at present fully occupied in turning out standard vehicles to the full capacity of their works, (2) a new type of lorry involves heavy initial expense, (3) the military type costs more to produce, (4) many details required by the W.D. are not wanted in commercial work, and consequently this lorry is difficult to sell even taking into consideration the amount of the subsidy which goes to the user.

If this comparatively cheap method of producing suitable vehicles fails, at least two alternatives remain, one to purchase lorries entirely built for war purposes (the subsidy specification is only a compromise as regards design), or to use what exists. If this latter alternative is adopted the expense in times of peace is reduced to a minimum, but the spare part difficulty has to be faced. This difficulty of supplying spares for a fleet of lorries in the field is enormous, and when that fleet consists of a variety of types or rather of a number of types, where vehicles of the same general design differ largely in detail, the task of supply of spares is almost impossible.

Manufacturers hold large stocks of spares, which would be available, but the trouble lies in identity. It is a comparatively simple matter for the owner of a small fleet to get his spares, he knows the date and identity of each of his vehicles, the manufacturer also has similar records; but imagine the task of an officer in charge of a fleet which has been thrust into his hands and which he hardly knows by sight. His demands for spares have to be transmitted through a tortuous channel to the manufacturer, and the spares have to travel back by a similar route. If anything he wanted ever reached him, he would be fortunate.

What would happen under these circumstances? The transport authorities would have to provide an additional number of vehicles to replace casualties, and with the exception of roadside repairs no overhauling or replacement of worn parts could be attempted. There are enough lorries in England to fulfil this programme within reasonable limits. It has the advantage of being cheap in peace time but extravagant in war.

In actual working a great deal could be done to reduce undue waste in war, and the number of casualties at any rate during the first few months reduced to a minimum.

In peace time lorries can be selected for purchase on the outbreak of war. The age should not exceed eighteen months to two years. Sections of each transport company can be formed of lorries of one type and make. The location of spares in times of peace can be ascertained. For a small annual subsidy fee owners can be induced to keep their vehicles in a good state of repair. Further, a reserve of lorries should be noted for replacement of casualties as the war progresses.

There is an important point which must not be lost sight of in selecting vehicles, and that is their peace duties. In war time the civil population must be fed and a number of lorries are required for the transport of food. It is of course possible to utilize the better and newer vehicles for the Army and to substitute older ones for civil purposes, but these arrangements must be made in peace time.

It is thought that by these means a very serviceable and cheap supply of lorries would be available on the outbreak of war, but the scheme has, as already pointed out, the disadvantage of involving difficulties as to the supply of spare parts, and most certainly does not produce vehicles that would be most suited for military purposes

Another state of things has to be faced by a country or colony where civilian vehicles do not exist in sufficient numbers to meet military needs.

In Germany, for example, a heavy subsidy is being paid to induce civil firms to adopt more largely mechanical transport. In this case the military authorities are in a position to dictate as regards type. They have only to deal with home products, as the heavy duty imposed practically excludes vehicles of foreign manufacture. Also the subsidy is so substantial that competition is practically *nil;* the market is therefore confined to vehicles suitable for military purposes.

This is a very costly method of producing the required number of lorries, but it has two advantages: the one that a military type is manufactured, the other that the Government is aiding the general commercial welfare of the State by encouraging a cheap and rapid means of road transport at the expense, of course, of the amount of the subsidy.

There is yet another condition of affairs that requires consideration. Take India for example. No lorries are manufactured and but few exist in the country. This example is worthy of consideration, though possibly lorries are not so essential for general military purposes in India. Local transport by bullock cart, etc., is extraordinarily cheap, and many doubts have been expressed as to the possibility of competing with mechanical transport with financial success. There are, however, figures availiable which prove that in many cases the lorry can be run at a profit. For example, take the Federated Malay States where an extensive goods and passenger service has been in existence for some years and has proved a success.

As far as India is concerned capital outlay is needed. Private enterprises may be encouraged by state subsidy and here, of course, the State would have the control of the type of vehicle used.

The number of vehicles required for a colonial army is not very great, and at first sight it might seem that a suitable type should be purchased and used to best advantage in times of peace. This leads up to a solution the whole problem, not only for India but for all countries.

All subsidy schemes so far in operation and methods of enrolling existing commercial type vehicles are but half-hearted; they do not produce the required article, they are more or less costly, and in some cases very far from achieving even the hoped-for result.

This would seem to show that the matter should be treated on entirely different lines, and that the vehicles should be purchased by the State. Such a scheme involves capital, and may on first sight appear to be rather a difficult proposition. It would be obviously impracticable to store up a large fleet of lorries using only the small proportion, which would be required for military purposes in times of peace. At the end of every seven or eight years the whole of the vehicles would have to be sold as obsolete and practically useless—they would fetch little more than scrap value.

It is clear therefore that these war lorries have to be used in times of peace, and the following scheme is suggested as being a practical way of not only utilizing them, but also of doing so with a fair probability of financial success. There are many examples of State-owned enterprises :—State railways; the Post Office; telegraphs, telephones, etc. Why not State-owned transport companies?

Such a policy would result in a highly trained transport service. Every officer and every man would be fully exercised all the year round in duties which would be practically the same as under war conditions. Every vehicle would be constructed exactly to military specifications. Spare parts would have to exist in peace, and would be available for war with practically no change in *régime*. To a transport officer such a condition of things would be ideal. Granted that from the executive point of view the idea is as near perfection as possible, it is then necessary to consider how the treasury would be affected, and also what would be the result from the commercial standpoint.

Existing transport companies would have to be considered, and in due fairness to them, a scale of minimum rates would have to be agreed upon.

These companies would argue that there is no room for anybody else, but this is not so at the present time. In England we have several old-established firms of carriers, formerly employing horses, now almost universally adopting lorries. These firms are increasing their fleets daily. New firms are springing into existence with increasing rapidity. Manufacturers cannot produce lorries fast enough to meet the present demand. These facts surely prove that there is room for more; they further prove that mechanical transport is being run at a profit. At the present time the Army transport costs the British public a large sum of money per annum, though Mechanical Transport has proved more economical than horses. A State transport company would save this amount, could be made to produce money, and would result in the most perfect military transport system imaginable—suitable vehicles, and fully trained officers and men.

It may be argued that State methods of control are costly as compared with those adopted by civil firms—even admitting this possibility, it would still be feasible to run the State transport at a small profit or at the worst at no loss.

The amount of capital is not excessive, and for the present purpose may be assumed to be about £1,400,000, probably less when purchasing in large numbers, and this amount would be spread over a number of years.

To ask English manufacturers to produce the number of vehicles which would probably be required in one year would unduly disturb the output required for commercial purposes, and, unless a heavy import duty were imposed, would give an undue advantage to foreign manufacturers. It would be more advantageous to spread the production over say three or four years, and this would facilitate the organization of the carrying service.

The administration of such a company would at first be no light matter. Services would have to be arranged, and a close relation established with the firms who have goods for transport. Once organized, the working becomes almost automatic.

The total number of vehicles available for general commercial transport purposes would depend on the number that would be used for Government transport. It is natural in organizing such a company that the Government should be the first to benefit. Many departments require transport, and it is obvious that it would be economical from the State point of view to effect the same at cost price by the State transport company. Here again the gross profit that could be derived would be reduced in accordance with the extent to which the vehicles were used for Government purposes, though on the other hand a saving to the State should result as compared with cost involved under existing methods.

Some idea of the annual cost of the scheme may be derived from the following figures :—

Annual cost of one lorry of 3-ton carrying capacity :—

	£
Depreciation at 15 per cent. on chassis, viz., on £600 ...	90
Depreciation at 20 per cent. on the body, viz., on £40...	8
Interest on capital outlay at 5 per cent. on £640 ...	32
Tyres	112
Petrol	90
Driver	100
Lubricants and lighting	25
Repairs and maintenance	25
Garage, etc....	20
	£502

Annual mileage	18,000
Rates obtained, 1/- per mile	£900

Allowing for lost mileage a considerable margin remains for overhead and administration charges.

The necessary organization to a certain extent already exists. Troops are quartered in many industrial centres :—London, Manchester, Leeds, Birmingham, etc. In such centres road transport is on the increase, and could readily be further developed. Co-operation with the Post Office as regards road mail services would assist to a large extent and haulage could be organized between depôts at the important towns.

Much has been said about the possibility of utilizing motor omnibuses; they are, however, the most unsuitable type it is possible to select. Formerly the London bus was a genuine 3-ton chassis; to-day, the bus is constructed to take a body which has a platform area equal to that of a 3-ton chassis, but it cannot and is not required to carry this load. A bus body weighs at the outside 20 cwt., the load is 34 passengers or a little over 2 tons; it is required to travel on first-class roads and to fulfil conditions which in no way coincide with those necessary for goods haulage. In other words the commercial chassis can carry 3 tons of useful load in addition to the body, whereas the bus chassis cannot, although the available platform area of the two types is the same. The State transport company could not therefore entertain a town passenger-carrying proposition with any reasonable prospect of success. The lorries would be as unsuitable for bus work, as the bus chassis is for general haulage.

In the colonies conditions as a rule are not so favourable as in England. Roads are not so numerous and often are not equal to English roads as regards their capacity for mechanical transport.

The main consideration in this case is that of cost, and here there are many parallel examples. Take the Sudan Railway. This can hardly be said, up to date, to be a financial success judged as a railway company, but the Sudan Government is apparently prepared to run their railway at cost, or even below actual cost in order to open up the country. In other words the great increase in trade and general improvement in the financial condition of the country is brought about by the greater facilities for transport afforded by the railway—a small loss in one department results in a general financial gain on the whole, which would be otherwise unattainable.

This reasoning applies to mechanical transport, especially in India. If the Government of that country operated a system of State-owned lorries, many ends would be served. The military needs would be met, increased facilities for rapid transport by road must mean an advance in commercial prosperity. Granting that mechanical transport can only be run at a loss as compared with bullock haulage, though this statement is strongly disputed, surely the gains outweigh the loss.

As has been previously stated it is an accepted fact that lorry transport is a necessity for a modern army and it has to be paid for. A State transport company stands a fair chance of financial success, and under the worst possible conditions would cost less than any subsidy scheme of practical value.

This proposal is not the outcome of casual observation of existing circumstances, but is made with an intimate knowledge of mechanical transport, both under commercial conditions, and under military control, not only in England, but also on the Continent; and it is contended that a State transport company would not only spell economy, efficiency and an aid to commercial prosperity, but would in fact be the solution to the problem of military transport.

ECONOMY IN CONSTRUCTION: SOME SUGGESTIONS.

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

ECONOMY nowadays is of such increasing importance that a few suggestions for effecting it may perhaps be of interest. In Delhi in particular, these notes may be of some use, since they are founded upon Punjab experience.

1. ROLLED STEEL BEAMS.

These form a large item of expense in building construction, particularly in those parts of India where the flat type of roof is retained, and it is seldom that the large saving which can be effected by the substitution of some form of truss is fully appreciated. The reasons for this may be any of the following :—(*a*). The requisite rolled steel beams are already in stock, or, owing to the necessity of spending money at the end of the financial year, time for calculating an alternative is too short. (*b*). Calculations for finding the requisite size of R.S. beam from the tables are so easy, and the beams themselves are so easily procured and handled that the designer does not feel called upon to enter into further investigation. (*c*). The building under consideration may be one in which a truss would be thought unsightly, *e.g.*, a residential bungalow.

The kind of truss suggested is on the same lines as that almost universally adopted for the sole-bars of bogie rolling stock for railways, with the substitution of I beams for channel beams. In roofs where a heavier section of R.S. beam than the 9 in. × 4 in. at 21 lbs. is required, the saving effected by the substitution of a truss may be in the region of 50 per cent. of the total R.S. beam bill. An example may be given. The standard type of Indian infantry barrack has a span of 20 ft., and for this the girder usually employed is a 10 in. × 5 in. at 30 lbs. The cost of these is something like Rs.45 each, but in some of the Pioneer Lines in Lahore a truss was introduced, formed of a 7 in. × 4 in. at 16 lbs. with a single central strut and tie-bar, which cost under Rs.30, and, had it not been for the fact that the 16-lb. beams were already at site, a further reduction could have been effected by the use of 12-lb. beams (6 in. × 3 in.). In the lines in question, which were not up to full establishment pending a decision as to the proportion of married quarters, there were 15 girders in each of 16 blocks of barracks, or 240 in all. That is, a saving of at least £240 (Rs.3,600) could have been effected by putting in even the heavier type of truss. The objection may be raised that so light a girder would be insufficient, regarded as a strut, to sustain the compressive thrust along it. In practice however this excess over the theoretical safe working load is of no consequence whatever, inasmuch as the requisite lateral support can always be given by stout nails in the superincumbent rafters when tiled roofs are employed, and in the case of jack-arched roofs the arches themselves give continuous lateral support. In this connection it is interesting to record the fact that in Lahore Cantonment there is a flat tiled roof of 24-ft. span with 4 in. of mud superimposed, supported on 6 in. × 3 in. girders about 5 ft. apart, bent to an ellipse with a 1-ft. rise, the "bowstring" being a 1-in. rod. No lateral support had been given to them and they have consequently got a bit of a twist now, but they show conclusively what R.S. beams can be made to do without failure. For this span and type of roof theory would demand a 12 in. × 5 in. at 32 lbs., if only on grounds of deflection. The form of girder employed therefore represents a saving of something like 100 per cent. This brings us to the second heading under which great economy can be effected, namely :—

2. FACTORS OF SAFETY.

It is curious that the soundness of insisting upon a factor of safety of 4 has not been more frequently questioned, at any rate where static loads are concerned, especially in view of the excellence of modern rolled steel, and it is certain that a large measure of the favour accorded to rolled steel beams of continental manufacture in India is directly attributable to the greater loads which they are advertised to support, owing of course to a factor of safety of only three being employed in calculating their strengths. It is doubtful if such a beam fully loaded has ever failed in practice. Where the loads to be dealt with are partly permanent and partly occasional, the policy of allowing a factor of safety of 4 for the whole is obviously wasteful extravagance. A short time ago I met the engineer in charge of the Amir's roads in Afghanistan and asked him what factor of safety had been employed in calculating the strengths of road bridge girders. His answer was somewhat surprising : " $1\frac{1}{2}$, when they worried about one at all." Even so it appeared that no bridge had failed and they were only being strengthened to take motor lorry traffic, which the Amir is anxious to start between Kabul and Jellalabad. It is not suggested that a factor of safety of $1\frac{1}{2}$ is sufficient or anywhere near it, but the story again shows what rolled steel beams will stand in defiance of theory. And we now come to the third heading :—

3. Moving Loads.

The railway engineer is confronted with a problem the solution of which, after more than 50 years' experience, still remains almost entirely empirical, and there are bridge designers in the first flight who hold that any allowance for impact on spans exceeding 40 ft. is entirely unnecessary. In support of this opinion it may be noted that deflection diagrams taken during tests of all manner of bridges over 40-ft. span fail to show any increase in deflection due to speed. Indeed it has frequently been noticed that the deflection at 60 miles per hour is less than at 30 miles per hour, and that both are less than when the test train is stationary on the middle of the bridge. This seems to be corroborated by all engineers of repute who have made a practical, as opposed to a theoretical, study of the question. The absence of increased deflection however is not proof that *individual* members of the bridge are not put to greater stress under a moving load such as is represented by a train, and Mr. Sales, Bridge Engineer to the N.W. Railway of India, has, after a long series of experiments, come to the conclusion that the weight on the driving axle of a locomotive may momentarily be almost doubled at high speeds. This is attributable to a variety of causes, such as the obliquity of the connecting rods, the balance weights of the driving wheels, wide rail joints, oscillation, or lurching due to uneven track, etc. Mr. Farr, in a paper entitled "Moving Loads on Railway Underbridges," read before the Institute of Mechanical Engineers in 1900, gave an impact curve varying from 30 per cent. increased stress for 5-ft. spans to 10 per cent. for 100-ft. spans for main girders, and for cross girders allowances varying from 50 per cent. for 3 ft., to 25 per cent. for 10-ft. spans. The reduction of this problem to a universally accepted rule, however, seems to remain as far off as ever, and it has been pointed out that the Britannia Bridge was stressed to something like 7 tons per square inch, without any allowance for impact whatever, 50 years after its erection. The Government of India rules allow a stress of 8 tons per square inch in mild steel, but their allowance for impact is something like three times as high as Mr. Farr's given above. While admittedly much too liberal for present requirements, this policy is held to be advisable in view of future developments in rolling stock, and the Government has already had ample experience of the inconvenience and financial loss arising from the necessity of strengthening or renewing girders on lines open to traffic.

The question of railway bridges has been touched upon as presenting the most difficult aspect of the problem of moving loads. The case before the military engineer who has to design a road bridge is an entirely different one. In his case the most disturbing factors in calculation (the moving and badly balanced parts of locomotives, wide rail joints, etc.) are entirely absent, and in no form of road engine does the driving mechanism act direct on the road wheels. The question arises whether any allowance for impact whatever is necessary in designing bridges to take traction engines and other forms of military transport, unless indeed the intention is to run a light railway across it at some future date, as, for instance, the Gambila Bridge between Bannu and Dera Ismail Khan.

It is suggested therefore that a road bridge with a factor of safety of 4 and without any allowance for impact is amply strong enough, and that experiments with a factor of safety of 3 would not be wasted in the interests of economy.

4. WELL CURBS.

In alluvial soils, like that of the Punjab plains where sub-surface rock is entirely absent, the use of heavy and costly steel, or steel and iron well curbs seems to be quite unnecessary for ordinary water works purposes; possibly also for bridge work, though in this the writer has so far made no experiments. The substitute successfully employed in one of two additional 16-ft. diameter wells for the Lahore Cantonment water supply a year and a-half ago was $\frac{3}{4}$ per cent. reinforced concrete. The other well was sunk on a steel and wood curb identical with those of the four original wells. The subjoined comparison clearly shows the saving effected by the use of reinforced concrete, both in cost and time. The labour employed on the wooden curb could probably have got the reinforcement of the other ready in a couple of days. The concrete itself was mixed just on the edge of the well, in the proportion 1 : 1½ : 4, run down an iron shoot to site 18 ft. or 20 ft. below, placed and rammed in four hours. The other curb took 10 days to fix at site after a month's work above ground. Six oiled 1-in. wooden plugs were left in the concrete temporarily to make holes for the steining rods, as being easier to handle than the heavy rods themselves. The time taken to sink the two wells 28 ft. is also noteworthy. The one on the concrete curb, which had been made to project 2 in. outside the steining, was sunk in 36 days, the other in 52. I am indebted to Mr. Sullivan, M.W.S., for the following figures, and it will be noted that a large part of the cost of the reinforced concrete curb, namely Rs.147, is accounted for by the centreing, which is of course removable. The cost per well therefore in a large installation would be inversely proportional to the number of wells. Any old planks can be cut up and used for this purpose, and the bottom planks, which are responsible for most of the labour expended upon centreing, being sawn radially, might possibly be wholely replaced by the oiled paper which was used to prevent the cement running out through the chinks. The vertical planks are placed in position by striking radii from a central peg, and packing with bricks or earth behind.

Cost of Curbs including all Steel Work.

1. Wood and steel Rs.630

2. $\frac{3}{4}$ per cent. reinforced concrete 1 : $1\frac{1}{2}$: 4.

(*a*). Materials—

$4\frac{1}{2}$ barrels Portland cement at Rs.10/12	Rs.48/6/0
3 cart loads sand at Rs.1	3
70 c.f. $\frac{1}{2}$-in. stone ballast at Rs.25	17/8
4 cwt. mild steel $\frac{1}{4}$ in. and $\frac{3}{8}$ in. round at Rs.12	48
Planks, paper, oil for mould	113/2
Total material	Rs.230

(*b*). Labour—

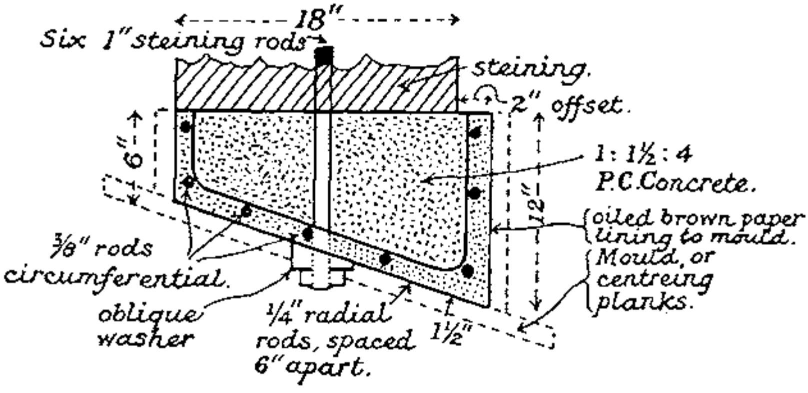
(i.). Centreing—	
4 carpenters for 7 days at Rs.1	Rs.28/0/0
2 coolies for 7 days at -/6/-	5/4
(ii.). Reinforcement—	
2 blacksmiths for 5 days at Rs.1	10
(iii.). Mixing and placing concrete—	
11 coolies for 1 day at -/6/-	4/2
1 bhisti for 1 day at -/7/-	7
1 mason for 1 day at Rs.1	1
1 mistri for 1 day at Rs.1/8	1/8
Total labour	Rs.50/5/0

Total Rs.280/3

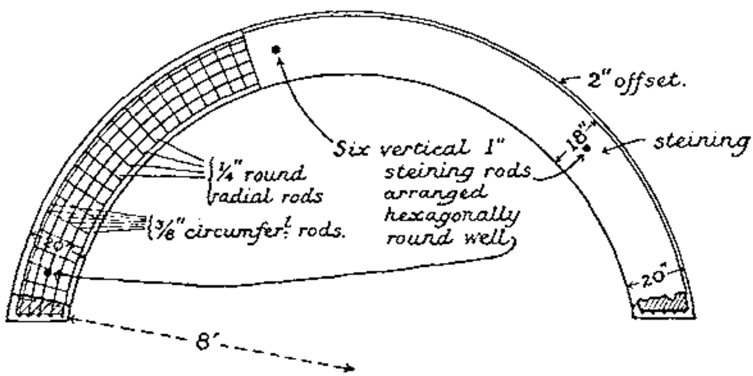
Mr. F. R. Bagley, late Engineer-in-Chief, N.W. Railway of India, has successfully sunk 16-ft. diameter wells on no more elaborate curbs than 2 ft. of corbelled cement masonry resting on a circumferential bottom ring of angle steel through which the steining rods passed, and there seems to be no reason why, for wells of moderate depth, this practice should not be more generally adopted, as it has all the necessary elements of strength.

As a result of the successful sinking of the Lahore Cantonment well on a reinforced concrete curb, it may be mentioned that the Lahore Municipality used the same material to sink all of 18 new wells which were put down to meet an increasing demand for piped water a year ago.

Writing of reinforced P.C. concrete, the American plan of pouring it in of the same consistency as porridge, with no more ramming than is required to level the surface, will be found quite sufficient for all practical purposes, and saves a lot of unnecessary labour. A good way of avoiding leaks caused by cracked flanges in well suction pipes may here be mentioned, namely the introduction of a short length of flexible tubing between the steining and the suction pipe. Where wells are liable to settle after pipe connections have been made, this will be found to save a lot of subsequent trouble.



Section of Curb for 16-ft. Well.
Scale, 1 in. = 1 ft.



Part Plan of Curb.
Scale, 5 ft. = 1 in.

5. Roof Battens.

The span between girders at which it becomes economical to replace single battens by rafters and light subsidiary battens for flat tiled roofs, is another question that seldom engages attention, and the Table below has been made out, from the formula in the *M.W.S. Handbook*, on the assumptions that (for India) the depth of a rafter or batten should not exceed double its width, and that its width should not be less than 2 in. to efficiently support the tiles. It will be seen that it is cheaper to put rafters and small battens in spans of 7 ft. and over. An instance of the application of this Table may be cited. A saving of Rs.600 would have been effected in the roof of the upper story of a certain British infantry barracks for two companies, by the substitution of rafters and small battens for single heavy battens over 9 and 10-ft. spans. It will always be found cheapest to space the rafters 3 ft. apart, whatever their length, but this may not be always convenient.

Table of Battens and Rafters (Deodar) to Support Flat Double Tile Roofs with 4" Mud and Plaster.

Spans between Girders.	Rafters.	Battens.
3′	—	2″ × 1¾″
4′	—	2″ × 2½″
5′	—	2″ × 3″
6′	—	2″ × 3½″
7′	3″ × 5¾″ 3′ apart. 3¼″ × 6″ 3½′ ,,	2″ × 1¾″ 2″ × 2″
8′	3¼″ × 6½″ 3′ ,, 3½″ × 7″ 4′ ,,	Battens as per 3′—5′ above. ,, ,, ,,
9′	3½″ × 7″ 3′ ,, 4″ × 7½″ 4′ ,, 4¼″ × 8″ 5′ ,,	,, ,, ,, ,, ,, ,, ,, ,, ,,
10′	3¾″ × 7½″ 3′ ,, 4¼″ × 8″ 4′ ,, 4½″ × 8¾″ 5′ ,,	,, ,, ,, ,, ,, ,, ,, ,, ,,

6. FOUNDATIONS.

In hard homogeneous soil, like the Punjab "pat," which is not subject to more than 10 degrees of frost, it will generally be sufficient for single-storied buildings to take the foundations only so deep as will bring them flush with ground level, especially when the ground round the building is banked up about a foot above its original level, for drainage purposes. The only danger to guard against is the possibility of the ground in which the foundations rest becoming sodden in the rains, and in all ordinary cases the 1-ft. bank referred to above is sufficient. Where, as in the Punjab, surface soil is to all intents and purposes as hard as that deeper down, the practice of digging down 3 and 4 ft. for foundations is extremely wasteful, as the cavities thus excavated have to be filled in with masonry, and no good purpose is served. In the Ferozepore Fort the pressure on the foundations is over 2 tons per square foot in the case of the double-storied barracks, and this is shown to be quite a safe pressure for normal "pat" soil (though I believe only 1½ tons is usually allowed). In the case of servants' quarters, provided a 1-ft. bank is put all round subsequently, there seems to be no reason for putting down any foundations at all, and just levelling up the ground under the walls will be sufficient. This statement may be objected to, but seeing that the mud walls and the ground are of exactly the same material it stands to reason that the undisturbed ground must be capable of standing a greater pressure than the built-up walls, and is therefore amply strong enough, provided it is in no danger from floods.

NOTES ON WIND PRESSURE ON ROOFS.

By LIEUT. C. R. SATTERTHWAITE, R.E.

THE question of the effect of wind on roofs is one which has never been very satisfactorily dealt with. Most of the text books at present in use tell us that wind on reaching a sloping roof surface may be considered as split up into two components, one normal and one parallel to the roof surface; the former only is considered in the design, as a downward pressure on the windward surface of the roof. If this were the true state of affairs we should expect to find the roofs of a cantonment after a typhoon blown in and downward into the buildings they covered: whereas it is a matter of experience that they are always blown upwards or outwards, and frequently found some distance from their buildings.

Many experiments to ascertain the true behaviour of wind on reaching a roof have been made in recent years, and all give similar results, namely, that downward pressure is caused on the windward, and upward suction on the leeward slope. Those carried out at the National Physical Laboratory at Teddington in 1908 by Dr. T. E. Stanton, who has very kindly given me permission to quote some of his results, are the most modern, satisfactory and comprehensive. They were carried out on large size roof models in the open air. R.E. officers frequently have to design large span roofs for exposed situations, and it is proposed in this paper to suggest some practical methods of calculation, based on the results of Dr. Stanton's experiments.

Attention will be confined to the design of roof principals, and those of steel only will be considered. Timber roofs for large spans are now unusual, and for small spans it is quite rightly the custom to disregard wind pressure as far as principals are concerned.

It has been customary to take 50 lbs. per foot super as the maximum wind pressure on a vertical surface in England. Dr. Stanton's experiments tend to show that this figure is excessive. His aim was to find values of the constant k in the formula $P=kV^2$, P being the pressure in lbs. per foot super due to wind of velocity V miles per hour. To do this readings of a pressure gauge were taken at the middle point of the principal rafter on both sides of roof models of varying slopes, as well as on vertical surfaces. The means of supporting the roofs were varied, between the limits of an entirely closed building and an open shed without walls (such as a railway station platform). The results as far as they concern us may be stated as under.

TABLE I.—*Giving values of k in formula $P = kV^2$.*

For a vertical surface $k = \cdot 0032$.

For a Roof on Stanchions without Walls.

	30°	45°	60°
Slope of roof	30°	45°	60°
Values of k Windward side ...	+ ·0015	+ ·0028	+ ·0034
Values of k Leeward side ...	Negligible.	Negligible.	—

For a Roof of an Ordinary Building.

Slope of Roof	30°	45°	60°
Values of k Windward side ...	+ ·0015	+ ·0028	+ ·0034
Values of k Leeward side ...	− ·0022	− ·0027	− ·0032

(Downward pressures are considered positive, upward suctions negative).

It remains to evolve a practical method of design based upon these data. It is suggested that 100 m.p.h. is the outside maximum wind velocity that need be legislated for in England; indeed there are few stations abroad where it would be exceeded. As a round figure simplifies calculation 100 m.h.p. has been adopted as the maximum in the investigations following. The values of k in Table I. then become pressures in lbs. per foot super simply by removing the decimal point.

It must be noted however that they give the *intensity* of pressure at the middle point of the principal rafter. Now previous experiments* have tended to show that, on the windward slope, the intensity of pressure is greatest near the middle point, and decreases considerably towards the eaves and ridge; indeed may become a suction at either of those points, depending on the angle of slope of the roof. As far as the design of the members of the principal goes, it will be found that little error is introduced by considering the pressure as distributed uniformly over the rafter, at an intensity equal to the average intensity over all; that is, approximately half the maximum. This point will be further considered later. The suction on the leeward slope has been shown by the same experiments to be approximately of constant intensity.

* See *Min. Proc. Inst. C.E.*, Vol. CLVI., pp. 78, 105.

To illustrate the method suggested a simple roof of 40-ft. span is considered. The slope is 30°, the spacing of principals 10 ft. and the covering any one of the light modern materials such as ruberoid, asbestos slates, etc., on 1-in. deal boarding. The truss is of the common "king post" type and purlins are placed only over the joints on the principal rafter (*Fig.* 1).

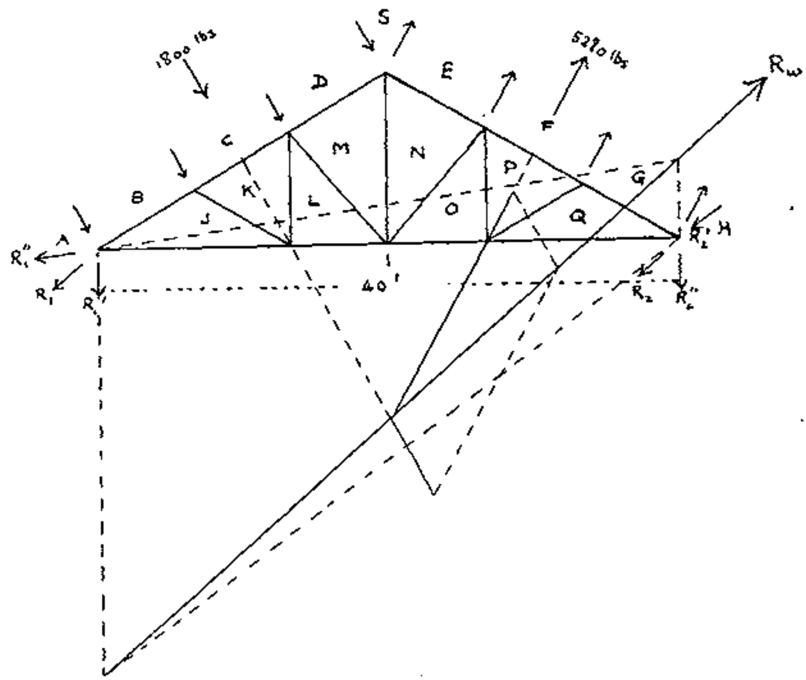


Fig 1.

The dead weight of such a roof, including the weight of the principals, will be about 10 lbs. per foot super, and by considering all this weight evenly divided up and applied at the purlins and pole-plates (the usual assumption) a fair estimate of the stresses in each member of the truss, due to permanent dead load, may be obtained by drawing a stress diagram in the usual way. These values are given in Column 2 of Table II. It is necessary further to allow for the weight of workmen on a roof, fixing or repairing the covering: taking this as equivalent to 20 lbs. per foot super dead load, and multiplying all the stresses in Column 2 by $\frac{20}{10}$ we get the values in Column 3 for the stresses due to occasional loads only.

It now remains to consider wind effect. From Table I. the intensity of normal pressure and suction at the centres of the principal rafters is 15 lbs. and 22 lbs. respectively: this gives a total pressure evenly distributed of $\frac{1}{2} \times 15 \times 24 \times 10$ or 1,800 lbs. per principal on the windward side, and a suction of $22 \times 24 \times 10$ or 5,280 lbs. per principal on the leeward side. To estimate the wind effect only, we may consider the truss as weightless and in that case it is acted on by two sets of parallel external forces only, the resultants of which act at the middle points of the principal rafters. By combining these two (*Fig.* 1) the total wind resultant, R*w*, is obtained; and this is resisted by the reactions at the walls, which will normally be parallel to it. If the expansion end of the truss is slipping or about to slip, the reaction there must be vertical; and by considering each end of the truss "free" in turn and applying the triangle of forces we can assess all the external forces on the truss, for the three usual different cases. Stress diagrams can now be drawn for all three cases; they can be combined on one diagram, the reactions only varying. The wind loads—pressure and suction—may be considered as divided up among the joints on the principal rafter, and the diagram (*Fig.* 2) is comparatively simple.

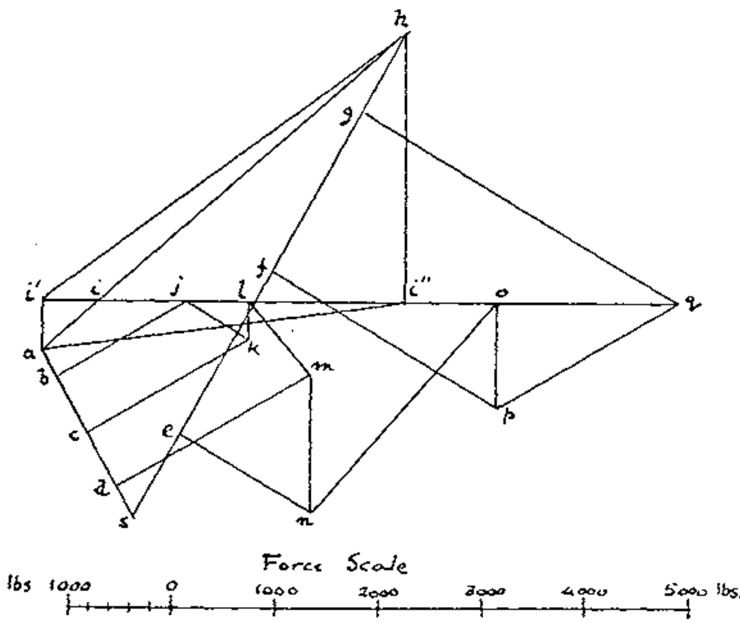


FIG. 2.

The stresses in the various members, given in Columns 4, 5, and 6 of Table II. are thus obtained. It will be seen that only the small stresses in the members on the windward side of the truss (JK, KL, LM, etc.) are effected by our assumption that the wind pressure is evenly distributed over that side. These stresses will not affect the ultimate design of the members, as they are less than those which would be brought on them by the workmen-load, or by wind in the opposite direction; so the assumption referred to seems justified, though it is true that the deviation from the centre of the windward rafter of the "centre of effort" of the wind pressure on that side may cause slight inaccuracies in the determination of the "wind resultant," which cannot be satisfactorily legislated for. Columns 7 and 8 of Table II. now give the maximum stresses, + and −, to which each member may be subjected, under permanent load + either wind or workmen (but not both, as workmen may be trusted not to venture on the roof in a gale).

TABLE II.—*Stresses in lbs. on each Member of Truss.*

Member.	Dead Load.	Workmen.	Wind Pressure.			Maximum + Stress.	Maximum − Stress.
			Reactions Parallel.	Windward End Free.	Leeward End Free.		
BJ	+4000	+8000	−1440	—	−3600		
CK	+3200	+6400	−1800	—	−2520		
DM	+2400	+4800	−2160	—	−1440	+12000 (BJ to GQ)	
EN	+2400	+4800	−1440	—	−2160		
FP	+3200	+6400	−2520	—	−1800		
GQ	+4000	+8000	−3600	—	−1440		
IJ	−3460	−6920	+ 840	+1380	+2640	—	
IL	−2770	−5540	+1440	+1980	+ 900	—	−10380 (IJ to IQ)
IO	−2770	−5540	+3840	+4380	−1500	+1610	
IQ	−3460	−6920	+5580	+6120	−2160	+2600	
JK	+ 800	+1600	+ 720	—	−2040	+2400	−1240
LM	+1080	+2160	+ 960	—	−2700	+3240	−1620
NO	+1080	+2160	−2700	—	+ 960	+3240	−1620
PQ	+ 800	+1600	−2040	—	+ 720	+2400	−1240
KL	− 400	− 800	− 360	—	+1020	+ 620	−1200
MN	−1600	−3200	+1320	—	+1320	—	−4800
OP	− 400	− 800	+1020	—	− 360	+ 620	−1200

It seems that every member of the principal except the king-post is subject to compression under some conditions and many of them to reversal of stress. This would be the case with all members if the permanent roof load were lighter—corrugated sheets for example. All except the king-post then should be designed to take what compression they are liable to, and made of L or T-sections. The tie-bar is the only member largely affected; the use of a T-section for this is not inconvenient for the joints as a rule, nor does it involve a very large increase in the weight of metal in the truss.

Table III. gives the sections which might be adopted for the roof in question for the tie-bar and the short ties KL, OP, together with the sections which would be used if the roof were designed according to the old ideas; and the increase in weight involved. The other members of the roof will not be affected by wind pressure.

TABLE III.

	Section.	Weight per Foot-Run.
Tie-Bar—		
Designed as above ...	$3\frac{1}{2}'' \times 3\frac{1}{2}'' \times \frac{3}{8}''$ T	8·49 lbs.
Designed by old method ...	$3'' \times \frac{3}{8}''$ flat	3·8 lbs.
Short Ties KL, OP—		
Designed as above ...	$2'' \times 2'' \times \frac{3}{8}''$ L	4·62 lbs.
Designed by old method ...	$2'' \times \frac{3}{8}''$ flat	2·5 lbs.

The introduction of camber in the tie-bar would complicate the stress diagrams, but the general method remains the same and no great difficulties crop up.

Various practical points are impressed on the designer by these new ideas. The importance of securely fastening down the roof covering, to resist the leeward suction, is apparent. It also seems clear that the ends of the trusses themselves should be fastened down. If the wind resultant were to pass *below* the abutment (see *Fig.* 1) the reaction at the other abutment would be upward in tendency: this may occur in some cases.

It is recognized that the subject is by no means exhausted by the cases considered. The effect of wind on "saw-tooth" roofs, and the stiffening effect of hipped ends, are difficult questions, and further experiments are needed to throw light on them. It is hoped however that these notes may suggest methods suitable for simple cases, such as R.E. officers may encounter at any time.

MOTOR FIRE BRIGADE APPARATUS.

By Capt. E. H. Harvey, late R.E.

On former occasions when contributing articles on fire appliances to the *R.E. Journal* I have made reference to the continued progress in the adoption of the motor for fire work; during the last three years, however, the extension of the use of this class of apparatus has been so notable, that I hope a more complete summary of the subject up to the present date may be of some interest to Engineers who are concerned at times in matters of fire protection.

While from about ten years ago modern motor engines began to come into use by British fire brigades, it is only quite recently that some, at least, of our largest cities have definitely adopted the principle of a change from horse to motor traction. Now this change is in continued progress not only in London and our own great towns, but in Continental capitals such as Paris and Berlin, and in smaller cities abroad; so that before long it is reasonable to expect that in city work at least the horse-drawn engine will become a thing of the past.

Early Designs.

From quite an early period in the history of steam locomotion occasional efforts—most of them mechanically successful—were made towards the construction of motor fire engines. In 1840 Mr. Hodge at New York built a powerful machine having a locomotive boiler with circular fire-box of the "Bury" type—generally similar, in fact, to the 4-wheel railway locomotives of the time; the cylinders were horizontal and outside, and the piston rods prolonged through the front covers to work the two pump cylinders placed in front of the smoke-box with two air vessels between them. On arrival at a fire the hind wheels (the "drivers") were slightly raised from the ground by jacking up the after end of the machine, to allow them to revolve freely and act as fly-wheels while the engine was pumping. Four jets could be worked at once, and water thrown to a height of about 140 ft. This machine, efficient as it was, seems to have been in advance of its time, and no similar ones appear to have been built after it. In 1851 a steam self-propeller was built at Cincinnati, and in 1862 one in England, running on three wheels and with a vertical boiler, which attended fires in the east of London for a considerable time.

In 1877 Messrs. Shand & Mason fitted one of their "Equilibrium" engines also as a self-propeller, but do not appear to have considered the time yet ripe for repeating the experiment.

The restrictions placed on locomotives on the highway until recent years, naturally tended to discourage the construction of motor fire appliances as well as of all other motor cars; and so long as coal was the fuel in use for steam fire engines the difficulty arose that, it being impracticable to keep a coal fire always alight in a small boiler without choking the tubes, etc., the turn out would always be delayed by the interval necessary for starting a good solid fire in the boiler, sufficient to keep steam steadily on the road. Even then, these small boilers with their strong blast would cause a heavy smoke and emission of sparks dangerous and annoying to other traffic in our often narrow English roads. With the introduction of a paraffin spray burner, capable of being lighted up immediately at full power and causing little smoke, the motor steamer speedily became an accomplished fact; Messrs. Merryweather's motor "Fire King," brought out about the year 1900, being now so well known that it is unnecessary to give a long account of it. In this type of engine the same steam cylinders and shaft that work the pumps also propel the machine on the road; in a later type of motor steamer built by Messrs. Shand & Mason, there are separate steam engines for each purpose on the vehicle.

CLASSES OF MACHINES.

Motor and horse fire brigade appliances alike may be grouped in two principal divisions—(*a*). Those which are simply carriages for hose, life-saving ladders (from the large-wheeled telescopic escape to the "Pompier" ladder or the ordinary scaling-ladder), men, and tools, with the addition of a chemical engine for first aid in many cases, but which do not carry a full-powered pumping engine. (*b*). Engines in the strict sense of the word, *i.e.* large power-driven pumps capable of lifting their water by suction without necessarily requiring water-mains to supply them, and of working one or more powerful jets continuously through the full-sized hose. Class (*a*), where there is a good pressure on the street mains and a complete hydrant system, in large towns fulfil the purpose of an engine in many cases of everyday work.

MODERN ORGANIZATION.

In modern fire brigade systems the tendency is to organize the machines in what may be called "tactical units" for purposes of turn-out. That is to say such an unit will consist usually of a first-turn-out machine carrying a large fire escape, chemical engine, and hose, and of at least one engine, *i.e.* a steamer or motor pump.

The latter will often have a light telescopic ladder 30 to 35 ft. long carried on it, as an appliance for reaching windows over enclosed gardens and courts. Such an unit will therefore, with its two crews of firemen, provide for all ordinary contingencies. A long ladder will be added to the organization of the unit, with a third crew, in cases where the buildings of the district are generally large and high.

Motive Powers.

The foregoing division of the classes of machine has a certain bearing on the nature of the motive power which may be applied. Class (*a*) require no supply of power beyond that which takes them to their work; petrol is the most common in England, but electricity is also used in appliances for city work, particularly on the Continent, and will probably be much more so utilized as time goes on. Electric escape-vans have been put into service in London and Liverpool.

In class (*b*) the petrol motor is now being generally introduced, the engine being obviously so well adapted both for the propulsion and for the pumping. Four and six-cylinder engines of 40 to 70 H.P. are commonly employed. The "motor pump," if properly looked after by a qualified fireman-mechanic, is one of the simplest and most suitable forms of fire engine that can be devised. The self-propelled steam fire engine is also a most valuable and reliable appliance, but it involves (unless a few minutes delay be admissible, as may be the usual case where a country volunteer brigade has to muster) the cost due to its being always kept under a low head of steam.

Steam and Petrol Compared.

The question of "Steam *versus* Petrol" for pumping is one which does not yet appear to be finally settled. Some authorities yet prefer the steam engine, and the comparative working life of the two classes of engine is a matter on which long experience has yet to be gained. "Steamers" well looked after will last in service for 20 or 30 years, and even more (with a renewal of the boiler during that period): whether the modern petrol pump will show such a record remains yet to be seen. On the Continent and in New York (where the abolition of horse traction in the Fire Department is now in progress), steam fire engines are in use fitted on a motor chassis independent of the steam power, either petrol-motor or electric. In England some practical opinion inclines to the doubt as to whether a petrol vehicle is, in the interests of safety, peculiarly adapted to the carrying of a lighted boiler fire in such close proximity to the motor, more especially should the engine meet with an accident on the road. On the Continent the electric chassis for carrying the steamer appears to find favour, being both safe, and quiet running. Several points, however, appear worth consideration, which are these, in favour of the self-propelling steamer using its own steam. In large towns, where the firemen are instantly ready for a turn-out, it is necessary in any case to keep the water in the fire engine boiler, by means of gas or hot water connections, at least on the boil to ensure steam being ready for pumping after a very short run; being committed to this expense, and in the case of oil-fired engines (horsed as well as motor) to the need of keeping about 20 lbs. of steam always on the boiler in order to start the oil spray burner without the use of an air pump or lighting a fire of shavings and wood, it seems to be at least as simple a matter to utilize the steam already available—and which can be brought up to a pressure sufficient to propel the engine in a minute or two by turning on the spray burner full—as to incur the complication of having a second motive power fitted to the vehicle, with the need of both a "steam man" and an electrician, or motor-mechanic, to attend to the two parts of the gear. For reserve engines, which need not be kept always under steam, an electric chassis would probably be economical. Other points are that the steam self-propelled engine is independent of working within the limits of an electricity supply, and can therefore make a long country run if wanted. As a minor disadvantage it is less silent on the road than an electric vehicle; but from a good deal of observation of these engines running at high speed, it would be hard to say that they are any more noisy than many a private motor.

Comparing the self-propelled steamer with the petrol motor pump as to running generally, the latter is faster on long open stretches of road, but in a crowded town either kind of engine can travel as fast as traffic conditions usually allow. Much, of course, depends, too, on the skill of the driver.

The steam motor needs two men to actually run it on the road, one steering and one attending to the boiler, as against one for a petrol machine; but, on the other hand, it is practically advisable always to have at least two qualified men in charge of any such vehicle, in case of either meeting with accident while out on duty.

It may also be noted that in case of difficulty about oil supply for a steamer out on a country job, some modern oil spray burners are made easily removable, enabling the boiler to be stoked with coal if necessary.

FIRST TURN-OUT MACHINES.

Returning to the subject of first turn-out machines, the general modern tendency is to the adoption of (*a*) a large, or standard size, for principal fire stations, *i.e.* a vehicle carrying a wheeled escape, a chemical or first-aid appliance, space for about 1,000 ft. of canvas hose, and the small gear and tools necessary for firemen's work, including one or two hand chemical "extincteurs" of 7 or 8 gallons capacity, and probably a smoke helmet equipment, and (*b*) a rather lighter machine than the above, for sub-stations, with a telescopic extension ladder 35 or 40 ft. long, and similar accommodation for hose, tools and chemical appliances. In each size of machines there will be room (standing or sitting) for at least 6 to 8 firemen, including the driver. One or two lengths of hook or "Pompier" ladder will also, probably, be part of the equipment. For signalling purposes on the road the ship's bell, now well known in London, and elsewhere, finds great favour; hung fairly high on the vehicle, and rung in the usual way, it has a remarkable carrying power, probably largely due to its position level with the heads of pedestrians and horses' backs. Very powerful gongs, rung by the driver's foot acting on a "push" in the footboard, are also much used, and do not require a second person to work them, as the bell does.

In regard to the chemical engine the adoption of motor propulsion, petrol or electric, for first-turn-out machines has rendered it possible, where desired, to dispense with the necessity, hitherto existent in horse-drawn vehicles of this class, of the chemical action, or of a compressed air or CO_2 bottle to provide the motive power for a first-aid jet through small hose. What is more important is that the necessity of a closed chemical cylinder or tank to carry a high pressure—with the need of careful inspection, and the possibility (if not kept in good order) of serious explosion—passes away through the substitution for the chemical (or other pressure) arrangement of a small pump driven either by friction gear from the propelling motor, or electrically from the accumulators that drive the vehicle to and from its work, and of an ordinary tank of water. This principle was also previously adopted in some of the steam Merryweather "Fire Kings," which were fitted with an auxiliary pump and a tank for the first-aid water supply, about 30—40 gallons. It would be, moreover, a much easier matter to replenish the supply tank by means of a line of hose (or even bucket supply), and so enable the first-aid jet to complete its work without setting an additional delivery to work from a large engine or a hydrant. On the Continent a fitting has been adopted in some cases with a similar object in view, *i.e.* the continuance, where thought desirable, of the small first-aid jet until the fire is completely extinguished. This is the inclusion in the line of delivery hose from the first-aid (or chemical) engine of a three-way piece with controlling valves. To the second inlet of this, when run out, connection is made by suitable fittings to a hydrant while the chemical engine is discharging itself in the first attack; and should the supply in the latter be not quite sufficient, the hydrant is turned in to continue it, the chemical cylinder, when empty, being shut off.

In regard to the method of carrying first-aid hose, modern English practice favours a hydraulic reel, fore-and-aft on the vehicle (situated below the escape ladder when stowed for travelling). From this the hose can be run out equally well, and walked away with immediately to either side into a burning building; and the water (as in a garden reel) passes through the whole length of the hose coiled and extended, so that no delay arises in starting the jet, which is delivered through a ¼-in. nozzle.

The length of the first-aid hose is about 140 to 180 ft.

MOTOR PUMPS.

Passing on to the subject of petrol engines, *i.e.* motor pumps, two classes are in use, varying in the nature of the pump. This may be either of the reciprocating or the high-pressure turbine type, and two representative makes of engine may be briefly mentioned as in use by the London Fire Brigade, and in many other towns, *i.e.* the Merryweather "Hatfield" with Aster motor, and the Dennis motor carrying the Gwynne turbine pump. Very high pressures of water (over 200 lbs. per square inch), indispensable to firemen in these days of high buildings (*e.g.* in cases such as the Carlton Hotel fire in London), are easily attained by either class of pump. The motors have either four or six cylinders, as previously stated. In these two types of pump, for the turbine are claimed the advantages of simplicity, saving of space by the absence of air vessels, and the capacity of delivering a very large quantity of water at a low pressure when requi ed for such work as cooling down ruins. On the other hand special means have to be fitted to exhaust the suction when first getting to work with a lift from open water, as from the edge of a wharf or sunk cistern. In many towns where the suction hose is connected direct with the hydrant, this additional fitting will only occasionally be brought into use, the water, of course, entering the pump at once with the pressure in the main, and no vacuum having to be artificially obtained to start.

The nominal delivery in gallons per minute is, in petrol fire pumps, similar to that of the standard steamers in use, *i.e.* 350, 400, and 500—discharging through two or more hose outlets, according to size. The pump is fixed across the machine at the rear end, and driven by a shaft along the centre line from the motor. The exhaust passes away by the usual outlet as when travelling. The ordinary fittings for carrying hose and tools, and seats for several men are provided, as in the motor escape-vans, sometimes an extra large size hose box, and often a light ladder overhead. A glass motor wind screen is added to some machines of recent make. The weight loaded and manned will be from 4 to 5½ tons.

POINTS IN WORKING.

In considering various types of petrol motor engines the following points are suggested as being worthy of special observation where comparison is desired :—

(*a*). Horse-power and number of cylinders in relation to delivery of pump per minute.

(*b*). Comparative amount of vibration and number of revolutions when working at full power.

(*c*). Delivery of water through at least 150 or 200 ft. of canvas hose on each delivery outlet, with working-size nozzles on each. A motor pump or steamer will generally stand at some little distance from a burning building when at work, for the sake of safety and convenience—perhaps 100 yards away or more, even in a town; tests through only a very short length of hose are, therefore, hardly a measure of practical working conditions. The pressure maintained to be, of course, noted. A moderate quantity of water at a very high pressure is more useful to firemen in city work than a larger quantity at low pressure, owing to the height of modern buildings, at the top of which, very often, the branches will be at work.

(*d*). The ease and rapidity with which the pump picks up its water from a fair lift: it is suggested that during a test the pump be stopped at short notice and re-started, the time of again delivering the jets being noted. Engines have to stop work in this manner in practice and re-start as soon as possible, owing to the need of shifting hose, or replacing, perhaps, a damaged length at a critical time in the operations.

(*e*). The manner in which the machine travels on the road, with regard to the steadiness and easy riding of any long ladders carried overhead.

Use of Tractors.

A concluding note on the matter of engines may be made on the subject of the employment of motor appliances as tractors for the hauling of reserve machines to the scene of a large fire in lieu of horses. Many fire brigades possess serviceable horse-drawn steamers which it would be a loss to sell or to scrap, even though they may be superseded for ordinary calls by modern motors. A powerful first-turn-out machine might well be adapted in such cases with a draw-bar arrangement for the bringing up of these older engines, as it would, after unloading its complement of men, hose, etc., otherwise at a great fire have no particular duty. Such an arrangement (*i.e.* for the haulage of a large steamer by petrol motor engine) has been successfully brought into use recently in Dublin. It would be of course necessary to provide ample brake-power, and ascertain that the roads are suitable for the handling of a tractor.

Motor Long Ladders.

Of motor appliances which yet remain to be noticed are the varieties of self-propelled long ladder, a 4-wheeled motor van of great stability on which is carried a self-supporting escape of extreme strength and stiffness, revolving, when erect, on the vehicle on a turn-table arrangement, and reaching a height of 70 to 90 ft.

From the top of such a ladder, standing balanced with its own counterweights away from a burning building, a fireman can effectually direct a jet of water at a safe distance; and these appliances are increasingly finding favour for use at warehouse and similar great fires in London and other British cities at home and abroad.

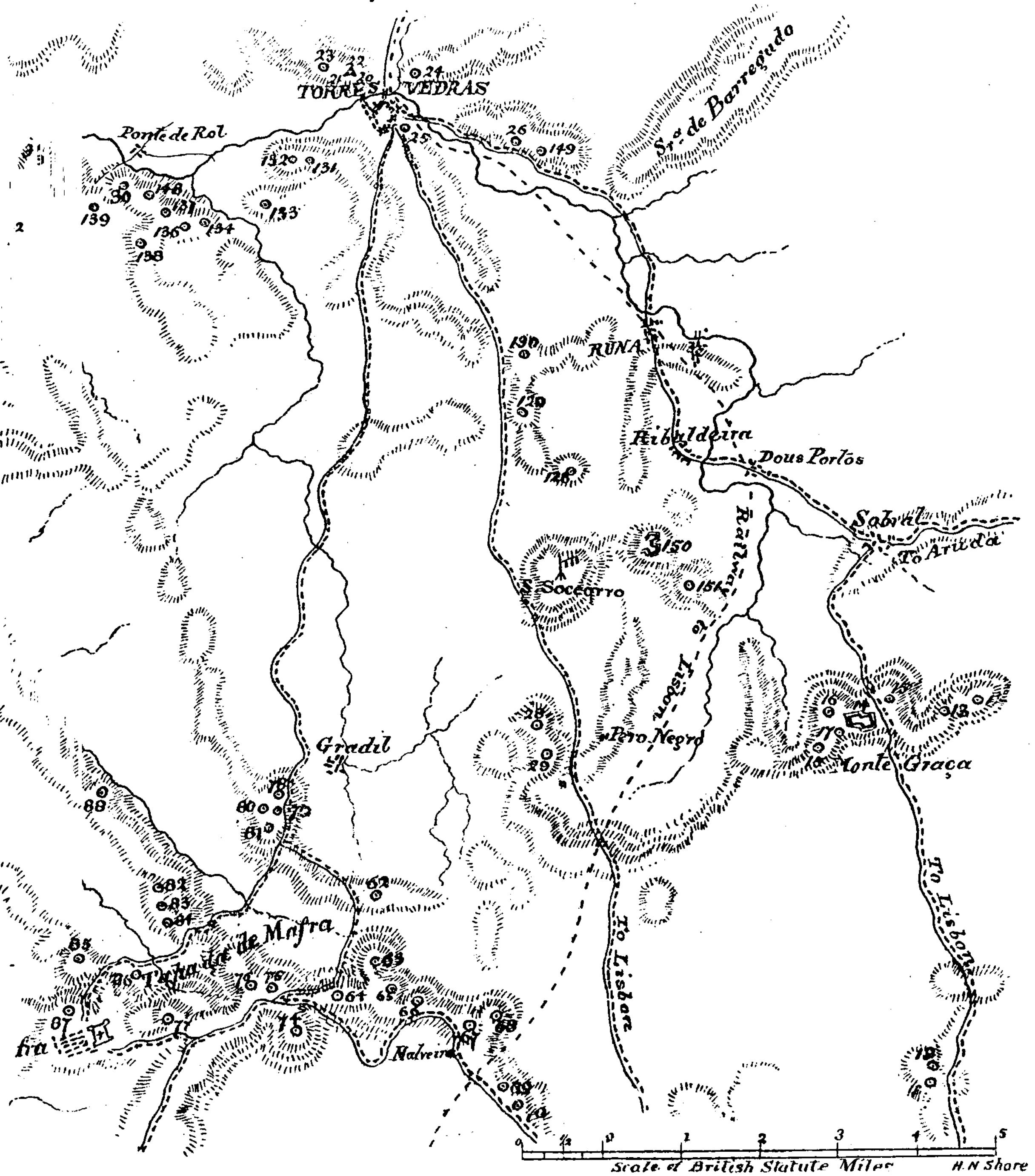
A long ladder, while not so much intended primarily for life-saving, is always valuable for that purpose in difficult situations, as it may be pitched at a low angle, and bridge over enclosed courtyards, etc., to the top of a high building far back from the street to which otherwise a 40 or 50-ft. escape could not always gain access. Moreover, in some such cases where the ground floor is well alight, it may be difficult even to raise a chain of "Pompier" ladders, and the long ladder (covered by jets of water, if necessary, for a short time) would carry the rescuers well above the worst of the heat during their difficult task.

In concluding this article, mention may be made of the reduction in time of turn out which is effected, with proper maintenance in the stations of a professional or a permanent police brigade, even as compared with the standard attained by the best quick-harnessing arrangements for horses. Records of as low as 8 to 10 seconds have been attained with petrol-driven appliances, and generally speaking the start of the machine is facilitated by the use of the motor, especially in stations where the engine room is cramped for space.

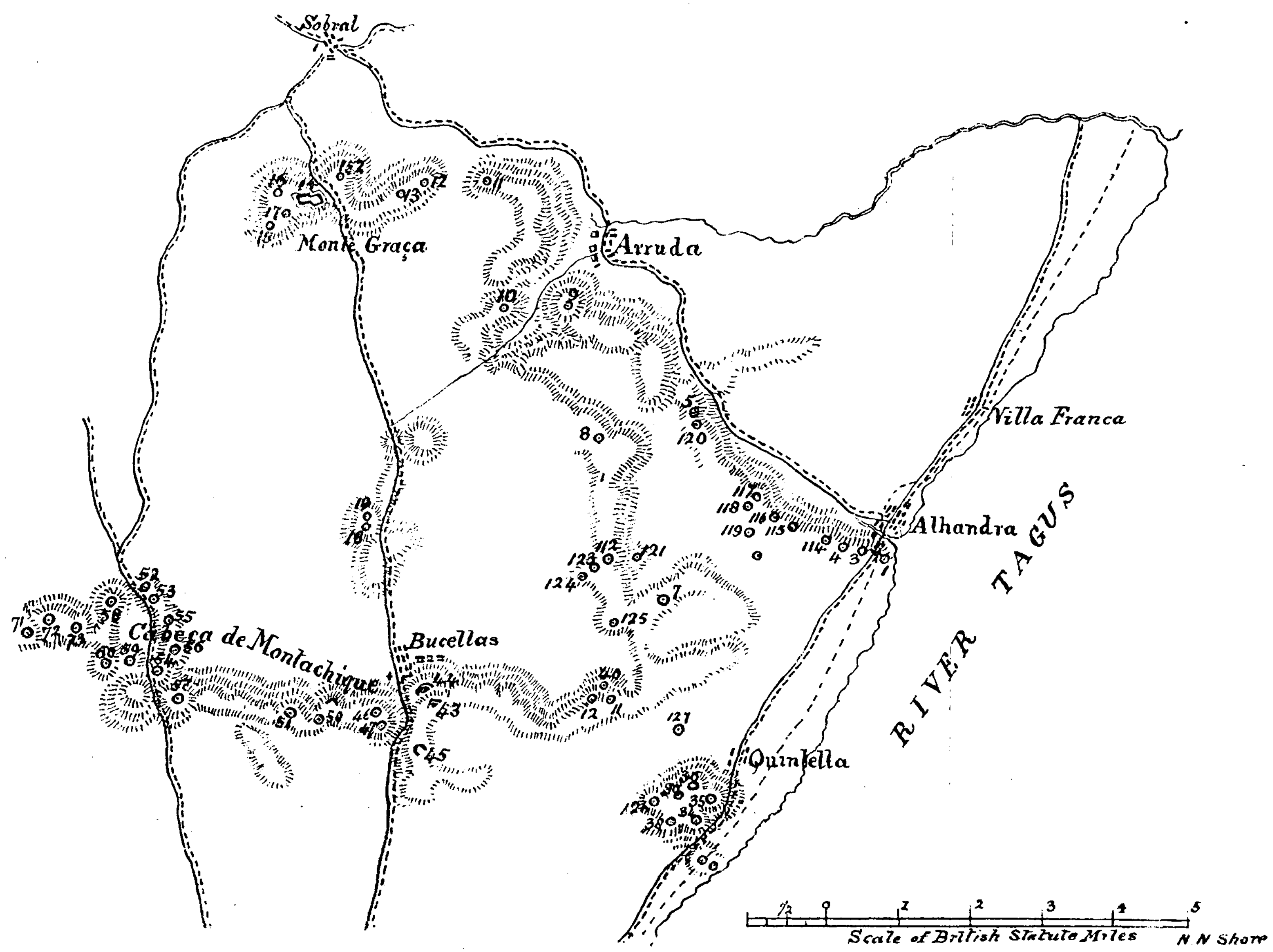
A useful invention for raising steam from cold water in the case of self-propelled steamers which stand (as in some country brigades) with a cold boiler, has also been recently brought out, in the form of a portable oil-flare apparatus worked by a hand blower, similarly to the heating of the vaporizer of a stationary oil engine. The flame of this—played into the firebox door of a "Fire King" engine—enables steam to be very quickly raised to the pressure necessary for the operation of the ordinary spray burner by the boiler itself, and obviates the necessity of lighting a wood fire in the firebox.

of the Lines of Torres Vedras, showing the first and second lines of defence. The redoubts were numbered, in
from east to west : the numbers, as shown on the map, supply a clue to the order, in regard to date, in which
This map has been compiled partly from that in Sir J. Jones' *Journal of the Sieges in Spain*, and from the

Paved roads, as they existed in 1810.
Railway.



Map of the eastern portion of the Lines.



AN ENGINEER OFFICER UNDER WELLINGTON IN THE PENINSULA.

(*Continued*).

(*Edited by* Commander the Hon. Henry N. Shore, R.N., Retired).

To resume the Diary :—

August 12, 1810. The Telegraph at the Castle completed. Ross of the Artillery rode to Linhares, from whence he distinguished the signals made by the Portuguese Telegraph with one arm, fixed upon the Castle here (Celorico). The French are reported to have retired from Penamacor towards Coria ; the peasantry have harassed them considerably during their stay in that neighbourhood.

August 13. The Portuguese General Silveyra has taken a Battln. of the 3rd Swiss Regt. in the French service, in Puebla de Canabria, consisting of 400 men ; they had been shut up in that place from the 29th of July, previous to their surrender.

August 15. The Telegraph at Guarda reports a skirmish to have taken place in front of the city, in which Capt. Cocks, 16th Lt. Dragoons, aided by the peasantry of the country had killed 4 and taken 18 of a party of the enemy. Enemy said to be moving on our left.

August 18. The army begins to get into motion towards the front, and reports of an immediate advance become prevalent. Mulcaster writes me from Guarda ;—" 17 *August*, 1810, 8 p.m. The firing has been very brisk from Almeida during this day. The enemy are certainly constructing a Battery on the Knoll opposite the face of the exposed Bastion. They are also at work near the Mill, and appear to occupy a house between that and the Knoll, nearer the ruins." At this time, Maj.-Genl. Picton's Division occupied the town of Celorico and neighbourhood ;—the Guards, Cortica and vicinity ;—the Light Division at Riturina, 3 or 4 miles in front and to the right.

August 20. The Guards arrive and are quartered here (Celorico). Genl. Picton's Division advance to the village to the left of Marsal de Chao ; the Light Division move to Freixerao ; the Cavalry are encamped in the valley between it and Alverca ; Head Quarters are to move to Alverca ; the Guards were ordered to march there also ; but in the course of the day they were countermanded, and all idea of a forward movement vanishes.

August 21. Head Qrs. returned to this village (Alverca da Beira). After dinner Col. Fletcher and I rode to Freixedas, and from thence with the Marquis of Tweedale to a hill from whence we had a tolerable view of Almeida; the sun set just as we reached the hill and prevented our seeing the enemy's works. Almeida keeps up a constant fire upon the besiegers. Mulcaster writes from Guarda, Aug. 19, that the enemy have completed a parallel from the Mill to the Knoll, and have begun a zig-zag from about the centre of it. The firing continues from the place. The Col. and Chapman looking out for Telegraph situations.

August 25. The Guards move from Celorico to Marsal de Chao. A party of 13th Lt. Dragoons and Portuguese Cavalry take 2 officers and 39 Dragoons near Belmonte, the Comdg. Officer and 2 others only escaping.

This dashing little affair, in which the hitherto-despised Portuguese cavalry gave a specimen of their mettle, is less known than it deserves to be. Capt. Warre, on the staff of Marshal Beresford, wrote to a friend, under date, Aug. 29,—"Capt. White of 13th Light Dragoons speaks very highly of the gallantry and good conduct of Cornet Raymundo Oliveira and the troop of the 4th Cavalry who charged along with his own troop, and tumbled the mounseers over in a minute (near Castello Branco). They attacked 60 French Cavalry, and without loss of man or horse, took 50 men, 7 corporals, 3 sergeants, 2 officers; others were killed by the peasantry; not one went back to tell the tale."

August 26. Very heavy firing at Almeida during last night; increased in the morning and during the day; the enemy said to have begun their 2nd Parallel, and to have opened their Batteries on the place.

August 27. An explosion heard in the direction of Almeida last night. The firing ceased about 10 o'clock this morning. Col. Fletcher and I went to the hill on the left of Freixidas at sunset; found everything perfectly quiet in the neighbourhood of Almeida, and concluded that the Fortress had surrendered. Upon our return to Alverca found that Lord Wellington, having come to the same conclusion, had given orders for the army to retire at daylight. At ½ past 9 o'clock a heavy fire recommenced at Almeida and continued until midnight, in consequence of which the orders for retiring were suspended. A violent thunder storm with rain again at dusk.

August 28. Lord Wellington, Col. Fletcher, etc., rode to the front at daylight; no firing heard from Almeida; the enemy felt about our videttes with a few cavalry and infantry. About 10 or 11 o'clock orders were given for Head Qrs. to move to Celorico. The Lt. Div., and Genl. Picton's, halt in the vicinity of Baracal and Marcial de Chao; the Guards in Celorico; the cavalry at Alverca. The enemy entered Freixidas, murdered 3 old men, destroyed the Telegraph, and soon after retired. A great deal of thunder and lightning all day.

August 29. A French Colonel and 3 men of Massena's *gens d'armes* brought in by the peasants from a village between Fort Conception and Guarda. Went with the Col. to Marsul de Chao and fixed upon the height above the village for the Telegraph to communicate from Alverca to Celorico. I rode on to Alverca and examined the hill to find the most eligible site for a Telegraph. A peasant who escaped from Almeida yesterday afternoon came in and reports that the town did not surrender until Tuesday (Aug. 28) about 10 o'clock; that the garrison laid down their arms on the Glacis, and were marched as prisoners towards Ciudad Rodrigo; and that the Magazine in the Castle had blown up and damaged the town considerably. The Lt. Div. move into Celorico and the villages near the bridges; the Guards and the remainder towards the rear.

The disaster, which had so unexpectedly befallen Almeida, is thus described by Napier:—"This fortress was garrisoned by 4,000 Portuguese regulars and militia under the English Col. Cox. On the morning of Aug. 26th sixty-five pieces of artillery, opening at once, set many houses in flames, which the garrison were unable to extinguish. The counter-fire was however briskly maintained and very little military damage was sustained. Towards evening the cannonade slackened, but just after dark the ground suddenly trembled, the castle bursting into a thousand pieces gave vent to a column of smoke and fire, and with a prodigious noise the whole town sunk into a shapeless ruin! Treason or accident had caused the magazines to explode, and the devastation was incredible. Further resistance was impossible."

The Governor, Colonel Cox, hoped to have held out notwithstanding, till the allies could succour him; but his efforts were foiled by treachery, and the expressed determination of the Lieut.-Govr. to hoist the white flag. Accordingly the place capitulated.

The only Portuguese Regt. of regulars amongst the garrison of Almeida was the 24th; and very conflicting statements have been published as to their conduct after capitulation. Napier says bluntly, "The 24th Portuguese regiment certainly took service with the French in a body. Yet, so easily are men's minds moved by present circumstances, that the greater number deserted again when they saw the allied armies." Lord Londonderry speaks of this in even stronger terms, but how little deserved was his sweeping condemnation will be evident from a consideration of the facts set forth by Southey. He tells us that, "when the Portuguese laid down their arms, they were invited to volunteer into the French service; but not a man was found base enough to come forward. On the following day, they were tried separately; and were told, that unless they accepted the alternative that was offered them, they must immediately be marched into France; and the hardships they would suffer were represented to them in strong terms. Officers and men, with an unanimity which might well have been suspected, agreed then to enlist in the enemy's service. They found means of informing Marshal Beresford that they did this only for the sake of remaining within reach of their own country, and making their escape as soon as possible; and the truth of this was proved by the numbers who soon rejoined the allied army."

Marshal Beresford immediately issued a general order expressing his strong disapprobation of such conduct; for the soldiers, he said, some allowance was to be made; yet he hoped that in future any who fell into the enemy's hands would suffer anything rather than bring a stain upon the national honour. With regard to the officers, however, he declared nothing could excuse conduct so base, so abominable, and so unworthy of the Portuguese name; they had rendered themselves false and infamous; and that he should report their conduct to their Prince, that they might be dismissed with ignominy from the service. He at the same time published the names of five officers who, under a proper sense of duty, had refused to dishonour themselves in this manner.

Southey further states that a night had not elapsed before great part both of officers and men were missing, and in less than a fortnight nearly the whole had escaped;—"the men, instead of deserting, rejoining their countrymen in arms; the officers, unconscious of having done anything unworthy, presenting themselves to the commander of the first detachment they could reach, in a condition which pleaded for them, exhausted with fatigue and hunger." Further enquiry led Marshal Beresford to mitigate the terms of his censure, and to refer the conduct of these officers to a council of inquiry. Further light confirmatory of the above, is thrown on the matter by our Diarist.

August 30. Got the Telegraph erected at Alverca, at daylight this morning; it fell down soon after; but, thro. the assistance of Capt. Bull of the Horse Artly. repaired and replaced it again.

Celorico, August 31. Head Qrs. remain in this town ready to retire upon the advance of the French which is hourly expected. The men belonging to the Militia Regts. at Almeida (the Guarda and Arganil) came in, having billets signed by the Marquis de Alorna (a traitorous Portuguese officer who had taken service with the French on Junot's invasion, and was now on the staff of Marshal Massena) stating that they are to return to their homes and not to take arms again; they report that some, if not the whole of the regular Regt. there, No. 24, (reported as in "very good order" by Capt. Burgoyne in his Diary) have entered the French service. The governor (Col. Cox) and English were marched as prisoners into Spain.

Sept. 1. The enemy's advanced pickets along our whole front appear to be withdrawn towards their own lines.

Sept. 2. A party of the enemy drove in our Cavalry Piquets from Freixidas and Alverca. Head Qrs. remain in readiness to retire at the shortest notice; orders given to march to Cia in the morning.

Sept. 3. The French retire from Alverca and Freixidas again. Head Qrs. removed to Gouveia, beautifully situated on a small river, and on the side of a hill at the foot of the Serra de Estrella.

Head Qrs. remained here from the 3rd till 16th Sept. Napier thus explains the inactivity of the enemy:—"Massena, chilled by age and honours, was wasting time. He found it difficult to feed his troops, was disinclined to invade so late in the year, and undecided as to the mode. It was two months since Ciudad Rodrigo fell, Almeida had only resisted ten days, yet the French Army was still behind the Coa. It was not until the 15th that Massena's intentions declared themselves: and he advanced in entire ignorance of the tremendous impediment that had been thrown across his path to Lisbon—his declared goal, and the prize he already considered within his grasp."

The entries in the Diary, during this period, may be thus epitomized:—*Sept. 5th.* Ross gone to Celorico to establish a Telegraphic communication with this place. *7th.* Two deserters report that the army under Massena began to retire towards Salamanca and Valladodid 6 days ago; rumours prevalent that the French are making a movement on our right. *10th.* The peasants brought in a French Surgeon as prisoner; he is a most shabby figure, and states that Marshal Massena's Head Qrs. are to be at Pinhel to-morrow. *The 24th Regt. of Portuguese infantry who were taken at Almeida, and who entered into the French service have (with the exception of about 20) all deserted and rejoined us.* (The italics are the Editor's). *12th.* Received Newspapers from England to the 25th July; filled with erroneous and ridiculous statements in the shape of private letters from the army. *13th.* Goldfinch went to the top of the Serra last night at 11 o'clock, with W. and B. to see the rising of the sun from thence. *14th.* Papers arrived from England; received a letter from poor Hamilton's mother (Capt. Hamilton, his brother-officer who died at Lisbon).

Sept. 15. Heard this evening that the enemy had advanced in force to Celorico. *16th.* Head Qrs. removed to Cea, about noon. The Divisions of the army begin all to retire. Goldfinch remained at Gouveia with Lt.-Col. Waters* to ascertain what numbers of the enemy pass.

Filiadoza, Sept. 17. Marched from Cea to this place in the afternoon; the army continues retiring. Col. Fletcher and Chapman set off in the morning to reconnoitre about Ponte de Murcella. Had a

* A very active and enterprising "Intelligence Officer."

severe attack of the ague before I quitted Cea; obliged to lie down immediately upon my arrival here. Heard that part of the enemy's force had crossed the Mondego.

Cortica, Sept. 18. Quitted Filiadoza at daybreak, and proceeded along the main road towards Ponte de Murcella, through Lerosa,—like every place in this part of the country, entirely deserted, the poor peasants flying with what they can carry off in every direction.

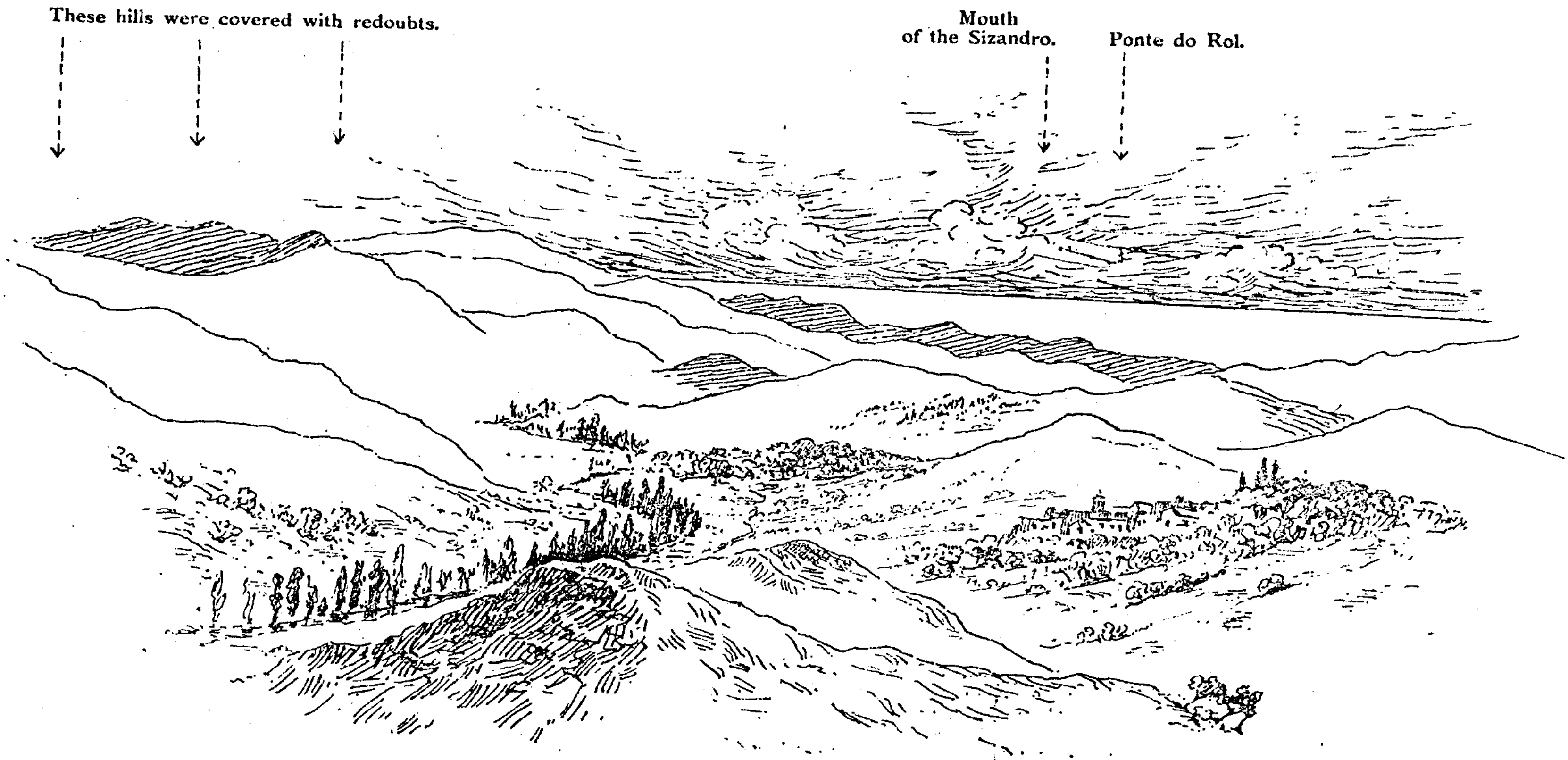
Lord Wellington, unable, from the smallness of his force, to stem the flood of invasion, was now retiring upon that "stupendous and impregnable citadel," in front of Lisbon, which his forethought had caused to be raised; while the more effectually to thwart the enemy's designs, he had induced the Portuguese authorities to order the inhabitants along the line of invasion to destroy their mills, remove their boats, break down their bridges, lay waste their fields, abandon their dwellings, and carry away their property. "It was a design of terrible energy"—as Napier truly observes; that it was not literally carried out, need cause no surprise; for—as Napier does well to remind us,—"Wellington was a foreigner, ill-supported by his own Government, and holding power under that of Portugal by a precarious tenure; and he was vehemently opposed by the local authorities, by the ministers, and by the nobility." Moreover, Massena, on the eve of his invasion, had issued a proclamation to the Portuguese, in which he informed them that the Emperor of the French bore them no enmity;—"on the contrary, it is his highest wish to promote your happiness, and the first step for securing it is to dismiss from the country those locusts who consume your property, blast your harvests, and palsy your efforts"; and he went on to assure them that "in opposing the Emperor, you oppose your true friend; a friend who has it in his power to render you the happiest people in the world." But the conduct of the French troops in the course of two previous invasions proved the worthlessness of the Emperor's professions of friendship, and had excited against them feelings of utter detestation.

Reverting to the Diary:—

Sept. 19. *Cortica.* The army began to move towards and across the Mondego, it being ascertained that the main body of the enemy are in Viseu and its neighbourhood. Capt. Mulcaster ordered to proceed with B.-Genl. Pack's Brigade to destroy the bridge near San Combadao and to prepare that at Criz. Lt. Thomson went to destroy the bridge at Taboa. Capt. Burgoyne ordered to Coimbra to report upon the bridge there and wait for orders respecting it. Capt. Chapman reconnoitred part of the position near Moita. The Col. accompanied Lord Wellington on a reconnaissance the other side of the Mondego.

Sept. 20. Passed thro. Ponte de Murcella to Val de Mayor where I was seized with a fit of the ague and was obliged to lie down in a

Looking west from the Great Redoubt, Torres Vedras, showing the course of the River Sizandro, which was dammed at intervals, so as to flood the valley, and the distant ocean.



cottage 2 or 3 hours before I could proceed. We crossed the Mondego at the ford below Pena Cova; with much difficulty I arrived at Lurvao. Quartered in a tolerable house with civil people and procured good beds.

Sept. 21st, 22nd, 23rd, 25th. Marched from Lurvao to the Convent of Bussaco. Head Qrs. occupied the whole of the Convent*; the Departs. attached to Hd. Qrs. are in the little Chapels which are scattered about the grounds round the Convent. We are in that of Calvary on the hill overlooking the country north of Coimbra. Took my Qrs. in the adjacent little cell of the Hermitage of the Sepulchre, where I remained for the most part within doors during the five days mentioned on the margin; being so ill and weak from the ague that I was unable to go out; our officers were busily employed in forming communications along the position in the Serra, and making a Flèche for musketry on the left. On the afternoon of the 25th, the enemy advanced upon Mortagao and drove our advance into the position, taking up their own ground on the opposite hill. Hoey of the Adjt.-Genl.'s Depart. severely wounded whilst looking out in the front.

NOTE.—In respect of scenic effect, and grandeur of its surroundings, probably no military spectacle was ever more superbly staged than that witnessed by the allied troops, from "grim Busaco's iron ridge" on the afternoon of Sept. 25th, 1810, while the French Army was taking up its position on the ground facing, but rather below, that occupied by the allies. "My regiment had no sooner piled arms," wrote Capt. Sherer, "than I walked to the verge of the mountain on which we lay, in the hope that I might discover something of the enemy. Little, however, was I prepared for the magnificent scene which burst on my astonished sight. Far as the eye could reach, the glittering of steel, and clouds of dust raised by cavalry and artillery, proclaimed the march of a countless army; thousands of them were already halted in their bivouacs, and column after column, arriving in quick succession, reposed upon the ground allotted to them, and swelled the black and enormous masses. Here lay before me the men who had once, for nearly two years, kept the whole coast of England in alarm; who had conquered Italy, overrun Austria, shouted victory on the plains of Austerlitz, and humbled, in one day, the power, the pride, and the martial renown of Prussia, on the field of Jena." To this inspiring description there is appended, in a pencil note, by an unknown reader:—"Scarcely a dust, as the movements were executed either on grass or on heath. I remember it as if I had

* As late as the year 1844, the Prior, leading an English visitor into a long hall, from whence many cells opened, said to him, "Here, before the battle your great Duke established his quarters; in that room he slept; see, I have painted the name of 'Wellington' over the door."

(Now converted into a sumptuous Hotel, and advertised as one of the "Beauty-spots" of Portugal. At the time in question, the vast enclosure was a *terra incognita*).

seen it but yesterday—the vast square bodies of infantry supposed to contain nearly twenty-thousand men each;—when they took their ground it seemed as if they would have kept ranging for ever. . . . Numbers of fires—the fires of the two armies, making the night one of the grandest sights I ever saw,—and was, during the whole time they were opposed to each other." Even Napier admits that, "only veterans tired of war could have slept while that serene sky glittered above, and the dark mountains were crowned with the innumerable bivouac fires of more than a hundred thousand warriors."

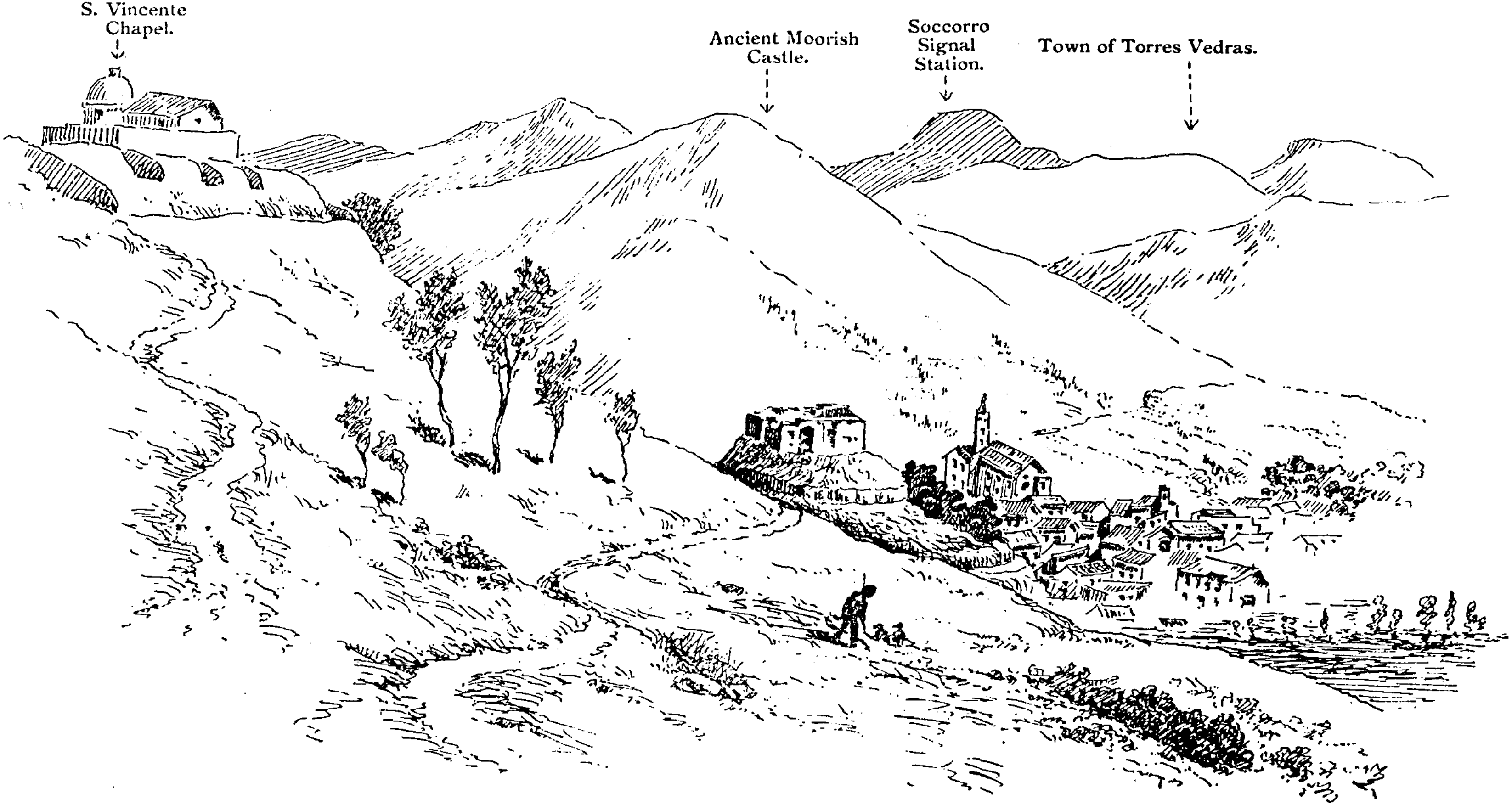
Reverting to the Diary:—

Sept. 26. The whole line under arms before daylight this morning. The fog was for some time very thick; when it cleared we perceived the enemy upon the opposite hills; but they did not attack us during the day; remained on the ground until dark.

Sept. 27. The enemy attacked our position soon after 6 o'clock this Morning, in two strong columns. One attempted to push up the road to the Convent, but were repulsed as they reached the brow of the hill, principally by the Light Division. The other at first succeeded in gaining the summit near where the road from St. Antonio de Cantara to Coimbra crosses the mountain, but were soon driven back. General St. Simon and 300 men taken; about 2,000 left on the ground, and from 5 to 6,000 wounded is the loss of the French. We lost not more than 200 killed and 1,000 wounded. *The Portuguese astonished us by their coolness and bravery, more particularly their Cacadores.* (*Light troops*). (The italics are the Editor's).

The Battle of Bussaco is wont to be regarded as a British victory. It must come as an unpleasant surprise, therefore, to many people to learn that but half of Wellington's army, on that memorable occasion, was composed of British troops. In the first place there was a contingent of Germans—chiefly Hanoverians—known as the "King's German Legion," a body of soldiers who rendered invaluable service throughout the war. But the battle was chiefly notable for the participation therein of Marshal Beresford's newly-organized Portuguese army, of which over 20,000 men were lined up with the British troops, for the first time, to give battle to the French invaders. That is a feature of the battle our writers are too prone to ignore. It is well to bear in mind, moreover that in default of those brave soldiers Wellington would never have offered battle. All hope of effective assistance from the Spaniards had long been abandoned. The number of British troops available was insignificant. The Portuguese were the last hope; everything hinged therefore on their conduct. Would they face the French? The opponents of the war, in England, had scouted the notion of Portuguese levies facing the veterans of Austerlitz; and it must be frankly confessed that, amongst the generality of British officers at the seat of war, there was a feeling of utter scepticism concerning the fighting qualities of the Portuguese—

From the north-west bastion of the Great Redoubt of Torres Vedras, looking south.



a view differing but little, indeed, from that expressed by Massena in a letter to the Emperor, before the battle—that they were "a *canaile* who would bolt at the first shot." The hour had arrived when the mettle of the Portuguese troops was to be put to the test. And, naturally, profound anxiety was felt as to the issue. If they turned their backs on the invader, all hopes of saving Portugal must be abandoned, and the British troops withdrawn from the country. So completely had the English Government given up all hope of success, that, at this very time an officer of Engineers had arrived at Lisbon, whose instructions,—received personally from Lord Liverpool, commenced thus:—"As it is probable the army will embark in September."* The transports were lying in the Tagus.

In the battle, the Portuguese bore themselves nobly; winning ungrudging praise from all who witnessed their behaviour; and proving themselves worthy of fighting alongside the troops of their "ancient ally." Lord Wellington, in his despatch, paid a generous tribute to the gallantry of the Portuguese, concluding with these memorable words:—"They have proved that they are worthy of contending in the same ranks with British troops in this interesting cause, which they afford the best hopes of saving." Perhaps the highest compliment paid to the Portuguese troops on that memorable day was by the French General Simon, who, after being taken prisoner, remarked, that it had been a clever ruse dressing up English soldiers in Portuguese uniforms, in order to deceive the French.

It was certainly a novel experience for Napoleon's veterans—who had been accustomed to "walk through" the best troops of the Continent—to meet with such a drubbing as they had received—administered, too, by less than half their own numbers. And what made the pill all the more nauseous was that, of the allied troops who had administered the drubbing, quite half were the despised Portuguese—the "*canaile* that would bolt at the first shot!"

The Battle of Bussaco, viewed in its true perspective, stands out as the turning-point of the Peninsular War. The opinion had widely prevailed hitherto, that a few weeks would see the wreck of the British Army on board its transports in the Tagus. Bussaco had changed everything. The British troops, according to their wont, had behaved nobly. But Bussaco taught the world something infinitely more important than that oft-repeated lesson—"The day gave the Portuguese confidence in themselves and with the army in general," as a British cavalry officer expressed it. It was the right

* A distinguished German, discussing the spirit of pessimism which at one time prevailed in England, as to the outcome of the struggle, wrote:—"Why are the English so gloomy in their forebodings of the issue of this war?—Because their happy constitution, combined with English spleen, engenders in them a peculiar foolish tendency, and makes them the greatest calumniators of themselves. The Briton disparages himself, ignores his own merits, exaggerates his deficiencies, and is always ringing the alarm-bell."

interpretation of this lesson that enabled Wellington to stem the flood of invasion at the Lines of Torres Vedras, and thence to march, from victory to victory, until, four years later, he was able to dictate terms of peace to the tyrant of Europe on French soil.

It was on that glorious field that the Portuguese began that companionship-in-arms which lasted till the close of the war. Had they shown their backs to the foe on that fateful day—as was foretold, aye, and hoped for by the opposition in England—the Peninsula must have been abandoned forthwith.

What were Lord Wellington's views in respect of the battle? Writing, a few days afterwards to the Rt. Hon. W. Pole, he observes:—"The croakers about useless battles will attack me again on that of Bussaco, *notwithstanding that our loss was really trifling; but I should have been inexcusable if, knowing what I did, I had not endeavoured to stop the enemy then*, and I should have stopped him entirely if it had not been for the blunders of the Portuguese General commanding in the North, who was prevented by a small French patrol from sending Trant up the road by which he was ordered to march. If he had come by that road, the French could not have turned our position, and they must have attacked us again: they could not have carried it and they must have retired. . . . To this add that the battle has had the best effects in inspiring confidence in the Portuguese troops, both among our croaking officers and the people of the country. This likewise removed an inference which began to be very general, that we intended to fight no more, but to retire to our ships: and it has given the Portuguese troops a taste for an amusement to which they were not before accustomed, and which they would not have acquired if I had not put them in a very strong position."

Bussaco, Sept. 28. Remained under arms all day; the enemy appear to be making a number of movements, that end in their turning our left flank, and obliging us to retire, which we did in the night by torch-light, and in great confusion.

A night-retirement, by torch-light, through the Convent woods, over the rough, precipitous tracks—hardly deserving the name of roads—in the rear, would naturally entail some confusion. And this is confirmed by Capt. Burgoyne, of the Engineers, who was attached to Picton's Division. Orders for retirement were only received at 1 a.m., on the 29th:—"It was a rainy night, the road was very bad, and we found much confusion in Genl. Leith's part of the line . . . some regimental pickets not called in, etc. . . . Our pickets which were to have retired in a body at daylight, finding this confusion, did not march off till 8; they destroyed 36 barrels of ammunition found in the rear of Genl. Leith's ground, and recommended a Portuguese Regt. of Militia which was on the heights, *and had received no orders*, to retire."

(*To be continued*).

REVIEWS.

GUNNERY.

By CAPT. J. C. WISE, *U.S.A. Volunteers.*

THIS is of course an elementary book as far as gunnery is concerned. There is an excellent introduction on "The Study and the Value of Theory," which is well worth reading.

Part I. then consists of "An Elementary Course of Mathematics for Field Artillerymen," which occupies 55 pages. It is clear, but, as its title implies, is elementary enough for one who has done little school work, or has forgotten what he did at school.

The rest of the book is on the same lines; it touches practically no mathematics, and is therefore of use to the man who wants to learn about explosives, field artillery training and gunnery without any mathematics to trouble him. There are no gunnery tables, and no explanations as to how these are put together, and how range tables are compiled and made use of. The chapter on "Indirect Fire and Deflection" occupies some 38 pages, the illustrations are numerous and good, and this chapter is excellent and most useful for a field artilleryman. A good index at the end enables a reader to quickly find the part of the book he requires.

C.E.P.

THE PRINCIPLES OF STRUCTURAL MECHANICS.

By PERCY J. WALDRAM, *Lecturer at the Central School of Arts and Crafts, London.*—(B. T. Batsford. 7s. 6d.).

IT is claimed that this book contains a practical explanation of the construction and application of formulæ and rules in ordinary use for determining the strength and stability of structures without the use of higher mathematics. A timely warning is issued with regard to the danger of misapplying formulæ through only partially understanding them. As a matter of fact the reasoning given is so simple, and the expressions deduced for the results follow so clearly, that in reading the book "formulæ" scarcely seem to be encountered. The author analyzes the conditions of the various problems thoroughly from first principles, and holds aside the mathematical curtain with which text-books usually enshroud them. The reader with only very elementary mathematical knowledge and no previous ideas as to the action and result of forces, should have no difficulty in following the book. The elements of statics are clearly explained, and then, after consideration of bending moments and moments of resistance, shear and deflection, the novice is easily and quickly led to the solution of problems connected with such structural designs as plate and girder bridges, retaining walls, roofs, domes and arches. Stress is laid on the importance of shear, and the analysis of its action is commendably clear—a strong point in favour of the book, as this is a subject which is often made so mysterious to the tyro that he is inclined to disregard it, being afraid to tackle it at all. The action of wind pressure is summarized from recent experiments at the National Physical Laboratory, and useful and concise data are tabulated for the solution of problems affected by it. The subject of columns is carefully treated, and the book concludes with a practical chapter on shoring. We can confidently recommend the book to those making a first study of the subject, as also to those who have been rushed through it and tried to cram it up without grasping its elements. It is to be hoped that the author will fulfil his intention of issuing a companion volume with examples of practical calculations and working drawings showing the application of the theories he has so clearly investigated.

A.S.R.

BUILDING CONSTRUCTION.

By CHARLES F. MITCHELL, *Lecturer on Building Construction to the Regent Street Polytechnic, London.*—(Advanced Course, seventh edition, 1912. Published by B. T. Batsford. 6s.).

THIS new edition has been called for by the effects of the L.C.C. Regulations in connection with Skeleton Frame Buildings, and the L.C.C. proposals with regard to Reinforced Concrete—the chapters devoted to these subjects have been re-written.

The bulk of the Second Report with the standard notation of the R.I.B.A. Joint Committee on Reinforced Concrete is included.

This book like its companion volume, the Elementary Course by the same author, has been designed to meet examination needs as well as the requirements of those employed on practical building work.

A.S.R.

BUILDING CONSTRUCTION AND DRAWING.

By CHARLES F. MITCHELL, *Lecturer on Building Construction to the Regent Street Polytechnic, London.*—(Elementary Course, eighth edition, 1911. Published by B. T. Batsford. 3s.).

THIS book gives greater detail of certain structural items than previous editions, and embodies quotations from the L.C.C. General Powers Act, 1909, and the New Rules for the admeasurement of Slating and Tiling.

The chapters and arrangement have not been altered, but the letterpress has been increased by 22 pages. The examination papers for the elementary stage of the Board of Education, South Kensington, have been added down to May, 1911. It is the syllabus for this examination, as well as the needs of the practical builder, that this book has been designed to meet.

A.S.R.

NOTICES OF MAGAZINES.

Revue d'Artillerie.

May, 1912.

Quick-Firing Siege Guns of Large Caliber.—This article is written by Capt. Pelloux, of the Artillery, and is illustrated by five good photographs and a diagram. After enumerating the general requirements of siege guns, he proceeds to describe the 105-m.m. ($4\frac{1}{8}$-in.) gun and gives the following particulars:—

Table.

Weight of projectile	k.g. 16 = $35\frac{1}{4}$ lbs.
Initial velocity	m. 615 = 2,018 f.s.
Muzzle energy	t.m. 308·4 = 455 ft. tons.
Height of line of fire	m.m. 1,830 = 6′.
Amount of elevation	deg. − 5 to + 40.
" " training	" 6.
Diameter of wheels	m.m. 1,500 = 4′ 11″.
Track	" 1,524 = 5′ about.
Weight of gun	k.g. 1,090 = $21\frac{1}{2}$ cwt. nearly.
" " breech piece	" 35 = 77 lbs.
" " carriage complete	" 1,955 = $38\frac{1}{2}$ cwt.
" " one wheel	" 125 = 2·46 "
" " shield (6 m.m.) (= $\frac{1}{4}$″) ...	" 160 = 3 "
" " gun in battery	" 3,045 = 60 "
" " limber	" 3,375 = $66\frac{1}{2}$ "
" " wagon limber (22 rounds)	" 1,080 = $21\frac{1}{4}$ "
" " wagon (42 rounds) ...	" 1,615 = 31·8 "
Maximum range	m. 11,450 = 12,522 yds.
Rounds per minute	10 to 12.

After this follows a description of the 150-m.m. (6-in.) quick-firing siege gun. This gun is fitted with a variable recoil. The full recoil of 2 metres is allowed between the maximum depression, and an elevation of 14°, and a reduced recoil from + 20° to the maximum elevation. Between + 14 and + 20 the recoil varies. A full description of the arrangement, with a diagram, is given. The gun carriage and limber are also described.

Table.

Weight of projectile	k.g. 40 = 88¼ lbs.
Initial velocity	m. 6·45 = 2,116 f.s.
Muzzle energy	t.m. 848 = 2,643 ft. tons.
Height of line of fire	m.m. 1,830 = 6′.
Extent of elevation	deg. − 5 to + 40.
„ „ training	„ 4·3.
Diameter of wheels	m.m. 1,500 = 4′ 11″.
Width of track	„ 1,524 = 5′ about.
Weight of gun complete	k.g. 2,475 = 50 cwt. nearly.
„ „ breech	„ 67 = 147¾ lbs.
„ „ carriage complete	„ 2,960 = 60 cwt. nearly.
„ „ one wheel	„ 148 = 3 „ „
„ „ shield (6 m.m.)	„ 160 = 3 „
„ „ gun in battery ...	„ 5,435 = 107 „
„ „ filled carriage	„ 3,860 = 76 „
„ „ limber	„ 3,290 = 65 „
Maximum range...	m. 12,600 = 13,780′.
Rounds per minute	4 to 5.

ITALY.—*Throwing Projectiles from an Aeroplane on the Enemy in the Field.*—The Turco-Italian War has provided the aeroplane with the opportunity of showing its capabilities, not only as an instrument of reconnaissance but also as an offensive instrument in actual warfare, and the experiences of the Italians in Tripoli are therefore the more interesting.

Several years ago experiments were made with a grenade charged with picrate of potassium. These experiments, which cost their author his life, have since been continued at Spezzia with grenades of the size of an apple. To throw the grenade it is made to slide along a wire the end of which is secured to a catch; when the grenade arrives at the end the catch opens and releases it. The grenade bursts on hitting any resisting body. Other experiments have been tried, such as allowing cylindro-conical grenades to fall from the top of a viaduct. The effects have been extremely destructive within a circle of 20 metres radius.

The bombs actually used in Tripoli are cylindro-spherical in shape, the spherical portion is very heavy and remains below during the fall. They are charged with picric acid and balls, and their weight is about 10 k.g. (22 lbs.). They are fitted with a handle for throwing. These projectiles would be capable of great destructive effects, if the necessity for avoiding the enemy's fire did not involve the aviator flying at a height of about 1,000 metres. The result is that the aim is uncertain, and in many cases the bomb buries itself before bursting, which considerably diminishes the effect. To obviate the latter defect experiments are now being carried out by the Italians at Viareggio and Fontana Liri with fuzed bombs, which burst about 15 seconds after discharge. A premature explosion is very dangerous for the aeroplane and pilot, and the effect on the enemy when they burst too high is very small. Attempts are now being made to ensure a burst at about 20 metres from the ground.

Extracted from Various German Periodicals.—An article in the *Streffleurs Militärische Zeitschrift* gives some interesting details about the Russian artillery in Manchuria. Out of 1,400 quick-firing guns with recoil buffers which took part in the campaign, 129 (about 9 per cent.) were lost in action and 83 (or 6 per cent.) were disabled. It is calculated that an average of 2,000 rounds sufficed to render a gun useless. (On the other hand it is recorded that a Krupp 75-m.m. gun fired 7,000 rounds without its initial velocity being much impaired, and in France it is often stated that 75-m.m. guns will fire 4,000 rounds without detriment to their quality or accuracy).

It is well known, and even the Russian records support the statement, that the Russians expended enormous quantities of ammunition, opening rapid fire when slow would have sufficed, emptying their wagons on the position to hasten their replenishment, and even burying projectiles which they had not time to use, and could not carry back, or firing simply because the noise gave heart to the combatants. Heavy siege guns and mortars equally squandered their ammunition, sometimes going so far as to fire on single infantrymen. In the Battle of San-de-pu 27 batteries fired 76,000 rounds, (360 per gun) almost double the rounds fired by the German guns at the Battle of St. Privat. At the Battle of Ta-shi-chiao one battery fired 522 rounds per gun during one day, and General Bohre calculates that it took 40 rounds to disable one Japanese. On the Japanese side the largest expenditure in one day was 200 rounds per gun.

June, 1912.

Observations on the Manœuvres, 1911.—During the month of June the observations of the General Staff on the 1911 manœuvres were issued as hints for the 1912 manœuvres. The following are of particular interest:—

Communications on the Battlefield.—"Communications from the lower to the higher commands leave much to be desired."

"It is indispensable that each unit should keep its next higher commander constantly informed of its situation, its progress, and physical and moral condition. A commander thus enlightened can utilize his reserves and make his decisions with full knowledge of the necessities."

"Communication from above to below is easy at the beginning of an action. The duty of the commander, as soon as his decision is made, is to inform his subordinates clearly of the situation, the end to be attained and to lay down the part to be followed by each."

"During the engagement, communication sometimes becomes difficult. It is therefore highly important that a thorough system should be acquired during peace by practice on the map and in the field, and that complete initiative should be left to all as to the best method of attaining the end that has been assigned to them. In critical moments the connection from above to below is chiefly moral, and is a matter of education and confidence."

"But it is necessary to re-establish the chain at the earliest possible moment by floods of information from below, in the light of which the commander can renew his control of the operations and form new decisions . . ."

Artillery.—"The commanders have a reprehensible tendency towards distributing the artillery from the very beginning amongst the subordinate commands. By so doing they deprive themselves of the power of exercising effective influence on the combat."

"Besides, this distribution of the artillery conduces to a strict division of the battlefield into compartments. Employed to fire direct to its front, the artillery cannot employ its powerful weapons of flank and reverse fire, and convergent fire is not realizable."

"The action of masses of artillery does not appear to be sufficiently understood."

"The conduct of the command and employment of important groups of artillery (corps and divisional artillery united under one command) should be practised at war games and during manœuvres . . ."

As will be seen, communication between executives of the different arms is not mentioned. The military virtues emphasized are, the utilization of information received from below, the execution of orders issued from above, and co-ordination of teaching and initiative. No new precept is added to the Provisional Field Artillery Regulations of 1910, and no rules are introduced more strict than those already enjoining mutual support between artillery and the other arms.

As to the employment of artillery, it is satisfactory to note that attention is called to the characteristic properties of artillery, *i.e.* long range and wide field of action. The former enables it to assist troops, from a position far from the line of march, by flanking fire which is often more efficacious, and realized with less danger than direct fire. The mobility of its fire enables the rain of projectiles to be instantaneously changed from one point to another many thousand yards distant, but this power is only at the disposition of the commander if he has not previously disarmed himself, by placing it at the disposal of his subordinates. Artillery is a powerful weapon, but has its weak points. It can accomplish much or may be employed unprofitably.

UMPIRING DURING THE 1912 MANŒUVRES.—The publication of the observations on the 1911 manœuvres was followed by the issue of ministerial directions for umpiring during 1912. The chief point in these directions is that it places the functions of Chief Umpire where they ought to be, that is in the person of the Director of Manœuvres.

Umpiring offers many difficulties, above all in that which concerns artillery. But difficulties must not discourage fresh efforts, and it is to be hoped that those made in 1912 will be completely successful.

One criticism has for several years been addressed to the artillery, and that is that several batteries have been found firing at the same time on the same object, while another equally important object close to it was left unmolested. The conclusion arrived at is insufficient dispersion of fire, bad intercommunication, etc.

This mistake, however, is one that belongs to times of peace. Others may be committed in war, but never this one. The fact is that during manœuvres a battery only fires a few blank rounds, and batteries cannot see where their neighbours' shells are bursting. In war this would be clear to all and sufficient to prevent all superposition of fire, except that which is really intentional.

Contribution towards the History of the Artillery.—The second article is a contribution towards the history of the artillery, and gives details of the conflict that raged during the first half of the 19th century over the question of allowing senior officers of artillery and engineers to command bodies of troops of all arms whether in peace or war. It is not of sufficient interest to reproduce here.

Studies of Gun Fire.—This is the second part of an article by Capt. Commandant Eugène Pagezy of the Artillery of the 2nd Cavalry Division. The first part appeared in the *Revue d'Artillerie* for January, 1912, and evidently laid down certain formulæ without which this second part is not very intelligible. It deals with the necessity for cover for the guns and the choice of positions for them, and is illustrated by several diagrams.

Safety in the Aeroplane.—By P. Lucas-Girardville, Major of Artillery.—The first problem to be solved with regard to the safety of aeroplanes is to give them sufficient strength to resist the abnormal strains to which they may under certain conditions be subjected during flight. Accidents have occurred that have moved and surprised us. The emotion is natural, the surprise is due to the widespread idea that, as the laws of the strengths of materials are known, it should be easy to apply them to the case of aeroplanes. But the difficulty is that the strains to which the materials may be subjected are not known. All we can say for certain is, that when an aeroplane weighing 400 k.g. is flying horizontally, the vertical component of the pressure of the air is 400 k.g. We can even calculate approximately the centre of pressure. But we do not know how these strains are distributed in the frame, or to what strains the apparatus is subjected in a disturbed atmosphere, or in a sudden check after a swift flight.

After an accident additional strength has been given where it was found necessary, but it is impossible to say what effect this has had on the general strength of the machine, it may even happen that this addition has weakened another part. Through the centuries all crafts have depended upon experiment to prove the strengths of their materials, but the grave results of an accident in the air do not admit of these tests in the case of aeroplanes, nor are they compatible with the rapid evolution of the industry. Besides strength, stability is a factor that requires more study, and both these qualities must be associated in the design.

Till now static tests of strength have been made by placing sand on the wings to represent the pressure of the air, but the difficultiy is that we cannot thus represent actions of which we are ignorant. The result is that accidents have happened to machines thus tested quite as often as to untested machines.

It follows from this that aeroplanes must be tested by the air in aerodynamic proving grounds fitted with apparatus suitable for giving a machine a velocity greater than that of its normal speed, and allowing the reproduction as far as possible of any event that might occur during flight. Instruments for recording the effects produced are also necessary.

Two kinds of proving grounds of this nature have been suggested; one in which the vehicle to which the aeroplane is attached moves along a cable stretched between two points, and the other in which it moves along a railway. One of the former kind has been installed at the Military Aviation Establishment in Vincennes, the result of which has been so satisfactory that the authorities have asked for an aerodynamic cable, 500 metres long and 25 metres above the ground, on which large machines can be tested at their normal speed.

These cables suit perfectly for studying the action of the air on the planes at normal speeds and the strength of the frames, but they are no use for destructive tests, nor for studying the reaction caused by the recovery of the aeroplane after any manœuvres. For such tests an unyielding device is required, with arrangements for varying the slope of the planes. To meet this want, a proving ground with a railway has been suggested. To be of any use the tractor must be sufficiently powerful to drag at 150 kilometres (94 miles) an hour the largest aeroplanes, and so designed that no pressure or sudden break of the latter can upset it off the rails. One great advantage of this rail tractor will be that the experimenter can accompany the aeroplane in safety during its full flight, and produce at will any effect he wishes to study.

Very interesting experiments of this nature have lately been made on the Railway du Nord, by attaching a monoplane to a truck with the spread of the wings at right angles to the direction of its motion. The experimentalists were in another truck and the whole was given a velocity of 106 to 114 k.m. per hour by a locomotive of 1,500 horse-power. But such tests can only be made on open lines along selected sections, for the spread of the monoplane used was 9 metres. They could not be prolonged or often repeated owing to the interference they caused in the regular train service, but they gave useful hints as to the conditions necessary for experiments of this nature.

Of the results of these experiments two points may be mentioned. The first is that all the stays and shrouds of the aeroplane were distorted, and according to calculation the stresses to which they had been subjected were far less than those which had been successfully borne, without any deformation, under the sand test. The second point is that 1,500 horse-power was used. The conclusion to be drawn is firstly the superiority of aerodynamic over static tests, and secondly that the existing installations, the best of which disposes of 80 horse-power only, are insufficient.

The writer then proceeds to advocate certain improvements in the Vincennes establishment, including a cinematograph installation for recording all experiments, and hopes that the results obtained will permit of the laying down of rules for the construction of aeroplanes. The article is to be continued.

July, 1912.

The first article is by M. P. Charbonnier, Chief Engineer of the naval artillery, and entitled the Ellipse of Shell Bursts. He refers to an article by Capt. L. Grossmann, of the 4th Regiment, Austrian Artillery, in the latest number of the *Mitteilungen über Gegenstände des Artillerie-und Geniewesens* on time and distance fuzes, and treats the subject somewhat differently. The investigation necessitates the use of the calculi, and is of considerable interest. The ellipse of bursts is due to slight errors in the angle of fire, in the initial velocity and in the ballistic coefficient of the projectile. There appears to be some difference of opinion as to whether it is better to design the fuzes to give an ellipse with the major axis parallel to, or at right angles to, the objective. The former would be more effective against troops in line, the latter against troops arranged in depth.

Initial Velocity in Field Artillery.—By Lantereau du Part, Lieut.-Colonel of Artillery.—The writer queries the necessity for high initial velocities, which he considers belong to large calibre guns only, the projectiles of which maintain their velocity at distant ranges. Where the ranges are determined by the configuration of the ground and the visibility of the objective, he maintains that high initial velocities are not required. The formula $\frac{1}{2}mV^2$ for the *vis viva* sounds well, and is responsible for a great deal of the misunderstanding about the necessity for high velocities. He defines the efficiency of a shrapnel burst and then investigates the factors on which this efficiency depends. From the results of experiments he works out a formula for this efficiency, and from it shows that a 75-c.m. (3-in.) shell at both 2,000 and 3,000 metres range is more effective with a muzzle velocity of 460 than 530 metres.

To answer those who argue that engagements will now commence at 5 or 6 kilometres, since observation by aeroplanes has extended the field of observation, he shows that to raise the power of the gun to give at 5,000 metres the efficiency now obtainable at 3,000 metres, the weight of the gun and carriage must be so increased that it is no longer a field gun.

The third article is a contribution to the history of the Artillery dealing with the right of command of troops and other arms, and is of no particular interest in Great Britain.

Then follows the third and last article on Studies of Fire, for understanding which a perusal of the first and second parts is necessary. The writer completes his investigations of the calculations required to be made by a commander, who is directing his battery from a point at a considerable distance away. The article is interesting.

Security in Aeroplanes.—Last article by P. Lucas-Girardville, Major of Artillery.—The writer discusses the question of automatic and mechanical means for securing stability in aeroplanes. If no automatic arrangements are provided, the strain placed on the pilot in manipulating the mechanical devices is too great, and a small error may bring about an accident. Some automatic devices are necessary, but if these are carried too far and some aerial current diverts the course of the machine, it will be difficult to bring the mechanical appliances into action quickly enough. At high altitudes their action will be sufficiently rapid, but this may not be the case if the deviation in the course of the aeroplanes occurs just as a landing is being effected.

From observation of a recording anemometer it is evident that the pressure of the horizontal component of the air varies between large differences in a few seconds. The barometer does not record these changes of pressure and the general atmospheric pressure must therefore remain the same, the change of pressure in the wind being evidently due to a change in its direction, either lateral or vertical. It is these latter currents—either ascending or descending—that are so dangerous to the flying machine.

It is argued that existing designs of flying machines are wrong, the rudders especially being sources of danger when encountering vertical currents. The writer sums up by laying down as an axiom that the pilot must be protected against the air by flexibility, and against himself by automatic stabilizing devices.

INFORMATION ON VARIOUS SUBJECTS.—An extract is published from an article in the *National Zeitung* of the 13th June, 1912, criticizing the French Field Artillery, which is described as the best arm in the French Army. But the weak point in most of the regiments in the mother country is the low strength in horses. A group of three batteries needs for manœuvres 205 saddle and draught horses, and as each battery only has about 40 it takes five batteries to supply horses for that group, and more if loans of horses of any extent have to be made to the infantry. The result is that only about half the field artillery in an army corps can be taken each year for manœuvres.

Side by side with this void in the means of preparing for war, the organization in the command and tactical superintendence leaves much to be desired, both as regards training and in war.

The reviewer however issues a warning that the defects he points out must not be taken as denoting the inferiority of the French Field Artillery. The article should be well worth perusal in the original German.

At the Michelin aero-cible meeting the prizes of 25,000 and 50,000 francs were both won by a lieutenant in the American Artillery. The conditions of the first contest were, in one single flight over a target, to place the greatest number of shots out of a total of 15 in a rectangle of 120 m. by 40 m. The winner succeeded in getting eight in. For the second-named prize he placed 12 shots out of 15 on a target of 20 m. diameter from a height of 200 m.

PROGRESS IN THE GERMAN ARMY IN 1911.—The peace strength surpassed that of 1910 by 180 officers, 1,225 N.C.O.'s, 2,807 men, and 4,084 horses. Lines of communication troops were particularly developed; the total number of automobiles is 57,800; there are 10 dirigibles all fitted with wireless telegraph apparatus; the issue of the new bridging equipment begun in 1909 was continued; also moving kitchens and mules. Study is being given to a haversack which is proof against rifles, also portable tools for infantry and cavalry, motor-ambulances, and Röntgen ray apparatus for line of communication hospitals, etc.

Various additions to, and improvements in the equipment of, the artillery are noted, including guns for the attack of balloons.

A. R. Reynolds.

Rivista di Artiglieria e Genio.

June, 1912.

Military Transport and the Navigation of Rivers in Italy.—The ancient Romans made large use of the natural waterways for increasing the communications between the people of an immense empire, and constructed wonderful artificial works, such as the port constructed by Claudius, extended by Trajan and placed in communication with the Tiber by means of the Fosse Triania (canal of Fiumicino). During the Roman domination in Gaul, Marius opened a canal between Arles and the sea, and established special corporations to regulate the rights of the boats traversing the principal water courses.

With the fall of the Roman Empire the waterways, as well as the land communications, fell into disuse; and it was not until the epoch of the rise of the Communes that the restoration of the canals, and the improvements in the natural waterways took place. In fact the commencement of the XIIth century was marked by the opening of the great navigable canal of Milan and the canals of Bologna and Modena; and works were constructed which rendered the Mincio open to navigation from Mantua to the Po. From 1100 to 1400 the Brenta was made navigable from Padua to Venice, the Arno from Pisa to the sea, the Ticino and the Adda from Verbano and from Lario to Milan.

With the invention of locks began the movement of the construction of canals which became so active two centuries afterwards, especially in France.

The canals now open for navigation are the new canal of Pavia which unites Milan with the Ticino; the minor canal Polesella between the Po and the Bianco canal; the canal Scortico between the canal Bianco and the Addigetto; the canal Loreo between the Bianco canal and the Adige; the Valle canal between the Adige and the Gorzone; the Bretella between Brenta and Bacchiglione; the canal of Ravenna to Porto Corsini; the Fiumicino canal.

The Modern Conditions of River Navigation in Italy.—The navigable lines in Italy are naturally confined to a few plains; these are:—

(1). The plains of eastern Italy watered by the Po with its numerous affluents, and the rivers of Venice. It is in these plains that the greater part of the artificial canals are met with. (2). The plains of Tuscany watered by the Arno which have some artificial canals. (3). The Roman plains, watered by the Tiber which is navigable from Rome to the Fiumicino canal. To the south of these plains there is a network of bridged canals. (4). The plains of Campania.

The total length of the lines of navigation of Italian rivers amounts to 3,000 k.m. of which 1,000 are artificial canals.

The river navigation is generally effected by means of barges drawn by animals, but for some years the system of towing the barges by steam boats has been adopted. Navigation by steamers has been adopted on the great lakes, on the Tiber and sometimes, also, on the Po.

With regard to the commercial movement on the Italian navigable rivers, it may be said that the traffic diminished during part of the XIXth century owing to the number of ordinary roads and railways. Now, however, it being recognized that their navigation is a valuable complement to the railways especially for the transport of a heavy and not very valuable nature, there is a decided improvement in the commerce on the internal navigation.

The following is a short list of the projects by private enterprise for the internal navigation of Italy:—(1) from Milan to Pavia; (2) from Reggio Emilia to the Po; (3) from the Lake Izeo to the Po; (4) from the lake of Garda to the Po.

In 1807 Napoleon approved of a project for a navigable canal from Savona to Alessandria. In 1816 Pasqualini projected a canal to unite the Teneno with the Adriatic. In 1820 Lippi thought to unite the Adriatic and the Mediterranean by a navigable canal supplied with water from Lake Fucino. In 1826 Carlo Afan de Rivera published a project for uniting the Teneno with the Adriatic. In 1824 the engineer Michelotti projected a canal from the Mediterranean to Lake Maggiore, starting from Albenga along the valleys of Tanaco, the Po and the Ticino.

The following projects were also initiated by the Government for river navigation.

In 1905 and 1909 a commission published 18 splendid volumes rich in data and suggestions for internal navigation. Nine of these were by the technical executive committee presided over by the Hon. Romarius Jacur; three by the economic-administrative committee, president General Bigotti; and three others by the commission appointed to study the subject in foreign countries. The recommendations of these commissions were:—(1). To make the greatest possible improvements for navigation in the river Po. (2). To increase the internal navigation of waterways of primary importance as far as Turin and the lakes. (3). To open out a plan of a network of navigable canals from the Alpine lakes, to the eastern confines of the kingdom, touching all the more important centres of commerce and production in Northern Italy, and opening up the navigation not only to the Adriatic, but also to the Mediterranean.

River Navigation and Military Transport.—It is only by a good system of ways of communication, that an army can be assured of the supply of reinforcements and provisions, as well as the transport of the sick and wounded and prisoners whose presence hinders the movement of the columns.

Some Historic Examples.—The genius of Napoleon fully recognized the value of waterways, and of every kind of military transport tending to make strategical movements more rapid. Entering into Italy in 1796 with 30,000 men he at once separated the Piedmontese from the Austrians at Montenotte and at Millesimo; embarrassing the first and imposing upon them the armistice of Cherasco, and following the latter so that they hastened to cross the Po, and throw themselves into Lombardy His first care on touching the right bank of this river near Piacenza was to requisition all the barges and boats. Although the Austrians had taken the precaution of destroying as many as possible, Generals Angereau and Massena arrived in a short time and collected a sufficient number to throw a bridge across the river. On the 9th May, Napoleon's army crossed the Po at Piacenza, then the Adda at Lodi, thus seizing Lombardy. Buonaparte remained here for a short time collecting resources of every kind supplied by this rich region, and collected these in the magazines, arsenals and hospitals along the Po. Continuing his successes he moved on the line of the Adige; all the left bank of the Po up to Mincio remained in his power. For the security of the right bank he concluded treaties with the Duchies of Parma and Modena. Many other instances are given to show the wonderful foresight and organization of Napoleon with regard to the river navigation and that of the lakes during his Italian campaigns.

The experience gained during the Franco-Prussian War of 1870–71 shows that there was much disorder and inconvenience owing to too much reliance being placed on the railways, especially in the conveyance of stores and ammunition, etc., the railway service being almost entirely taken up in carrying the troops. It is of the first necessity to be able to come to the assistance of the railways which are always overworked. The example of all modern wars, and especially that of 1870, shows this very clearly. In order to make proper use during war of the navigable waterways it is necessary to study during peace times the service and traffic of the barges, and all provisions should be made during war for guarding the various waterways, and for their destruction and repair.

The great river of Italy, the Po, enters at once into consideration as most important for transport of every kind during war, and, with this view, projects should be based in time of peace so that it may not have to be used without preparation as happened in 1848 and in 1866.

As has been well said by General Bigotti, the first pioneer of internal navigation, "when a war happens either in the east or in the west, the network of rivers and canals of the valley of the Po should be of valuable assistance to the railways, which latter being relieved of the transport of a part of the material with which they would be encumbered would be more usefully employed in the transport of the combatants."

July—August, 1912.

DESERT WARFARE.—*La Revue Internationale*, in its supplement for July, publishes an article by Capt. Boyer in which the author basing his experience on the campaign carried out by Germany in South-West Africa, explains with much clearness the difficulties which European nations have to encounter in the conquest of African territory. The treachery of the natives, their methods of conducting war, the insanitary soil and climate in which the European troops are engaged, are all matters of real importance.

The author commences his article with a saying of General Leutwein during the German campaign against the Hereros in 1904, viz. "that it is easy to commence an African war but difficult to finish it."

A nation which has the supremacy of the sea finds no difficulty in occupying the coast, and the African maritime towns; the real strife commences when she proceeds to the conquest of the interior.

An army taught on the principles of modern European warfare, finds itself confronted with absolutely new conditions. The maps are inexact, ways of communication do not exist, objective and strategical points on which to direct the troops are entirely wanting. All this causes uncertainty in the operations of war. The enemy also carries on the war in a special way of his own. He does not wish to engage in regular battles, but seeks to tire out his adversary, obliging him to make long marches and détours; then when he thinks him sufficiently weakened, he attacks his rear. And while a colonial war signifies an increase of expense becoming greater day by day for the nation engaged, time has no value to the natives, especially the Arabs. An African war therefore to obtain satisfactory results requires great efforts on the part of the European troops, and is a severe trial of patience.

It is necessary also to keep in mind that the native enemy, even when inferior in number and equipped with less perfect weapons, has great advantages over white troops in his thorough knowledge of the ground, enabling him to make use of small resources which are wanting to his pursuers. Also, being mounted on animals accustomed to the climate and more mobile, he is able to see and observe the movements of his adversary much better than the Europeans can discover him. Being friendly with the population, he can surround the columns with a network of spies who inform him of everything that may be useful to him.

In this kind of warfare it is very important to know how to discover the traces left by men and animals, which the natives can do with wonderful accuracy. All the astuteness of guerilla warfare is known to them; the morning attack from the east, and the attack in the evening from the west, because the enemy is then harassed by the sun in his face; at night before stretching himself on the ground a native listens for and avoids sounds; concealing himself behind a rock or in the sand of the desert, ready to fire on a passing patrol without the latter being able to see where the shots come from. In this kind of warfare the native is superior to the European, and the author states that in their operations in the south-west of Africa, the Germans had to give up patrols altogether so as to reduce their losses.

Even in the matter of signalling the natives do not seem inferior to the Europeans. The African natives are wonderfully well acquainted with special signals : chiefly by fires and smoke. Also in other small particulars which do not seem to be of great importance, for instance heaps of stones on the edge of a road or path, are sometimes used as signals, especially if native traitors are found in the service of the invaders.

Any European nation, which disembarks on an African coast its strong brigades and divisions, finds too soon that these armed masses will not be able to advance into the interior of the country. It is necessary to follow and come into touch with the enemy with a part of the available force, and to work only in small columns owing to the wretched state of the paths, the want of water, and the great difficulties of transport. But above all, the want of water is what hampers the decisions of the commander, and makes so many of his schemes impossible.

The horses, mules, and oxen are naturally useless if deprived of water; and to a certain extent the camels also, besides requiring special nutriment and care.

Lastly, great difficulty is met with in the provision for the commissariat. The country offers no resources, and it is necessary to replenish the troops with ammunition, clothing and equipment. There is also need to transport water, wood, benzine for the automobiles and aeroplanes, hydrogen for the dirigibles, etc. An enormous convoy is thus formed following each column and having to traverse the interior of the African continent: a convoy which burdens the troops and restrains their movements, making them entirely dependent on the lines of communication.

The further the troops are distant from their bases of operations the greater the difficulty becomes; and it may be added that the reprovisioning convoys require escorts for security, and it is necessary to provide supplies for men and animals for the columns and escorts, and these have to be subtracted from the loads carried by the convoys. From time to time as the distance increases from the base of operations, it becomes necessary to establish stations and depôts along the line of march, and these naturally require men to guard them.

The draught animals employed in transport suffer much from the African desert sand, and days of rest are required or they would die from exhaustion, as the supplies of fodder carried with them are not sufficient for their nourishment. The author cites an example during the campaign against the Hottentots. Along one line of march only the Germans lost half a million of marks in draught oxen. These animals died in such great numbers from want of proper fodder, that the smell from their decomposition filled all the *Pad*. Again, the slowness of movement of the convoys presents a great obstacle because, whilst the troops can march about 5 k.m. in the hour, the carts can only do 2 or 3 in the deep sand, frequent rests being necessary for the animals.

A special fact to be considered in warfare in the African forests is that the natives are well acquainted with the paths and tracks. They know perfectly when to find a convoy at a disadvantage.

If a column is required to advance quickly, it has to leave an escort for the convoy which has to be very strong so as to ensure the safety of the latter: thus the column is reduced to a few troops. In fact, as the author says, from 15,000 men that Germany had in the south-east of Africa, the strength of some of the columns did not exceed 800. Nor must the losses due to sickness be forgotten. War in the desert claims many victims owing to the impossibility of obtaining proper medicines and medical appliances, added to which are the illnesses caused by thirst, bad climate, and tropical heat. If there is not a sufficient supply of water for drinking there certainly will not be enough for washing, and, as this frequently happens, it is impossible to provide for personal cleanliness. There is also the moral influence in desert warfare which tells heavily on the spirits of the troops: for days, weeks, and months they traverse wide areas, deprived of all necessaries, seldom seeing the enemy against whom they march, so that gradually they begin to imagine that all their efforts are fruitless.

The heat enervates the soldier, the monotony deprives him of his usual gaiety, and an unconquerable weariness takes the place of his enthusiasm and vigour.

In this warfare great importance must be attached to the modern technical appliances which are at the disposal of armies. The field telegraph and telephone lines render valuable services to the operating columns, by corresponding with the base of operations and the commander-in-chief; but their working is much interrupted by damage caused by wild beasts, by the convoy animals and by the enemy. In the African campaign in the south-east the Hottentots frequently broke the telegraph and telephone wires and ambushed the patrols that were sent for their repairs.

A more secure result, but a slower one was obtained by visual signalling, across the transparent African atmosphere it was possible to read signals at a distance of 50 k.m. by day, and 150 k.m. by night with acetylene lights.

Wireless telegraphy also was of the greatest use: the field radiotelegraph apparatus was well able to accompany the columns and added to other means was able to correspond with the base of operations at the coast. The Germans in their South African campaigns have been able to correspond to a distance of 300 k.m.

With regard to aviation the author thinks that it is difficult to foresee the importance that this may assume in desert warfare; it may become a decisive factor especially with bold aviators. In the African campaigns of the Germans, the use of automobiles has not proved a success owing to the fine sand of the desert penetrating the delicate parts of the mechanism.

E. T. THACKERAY.