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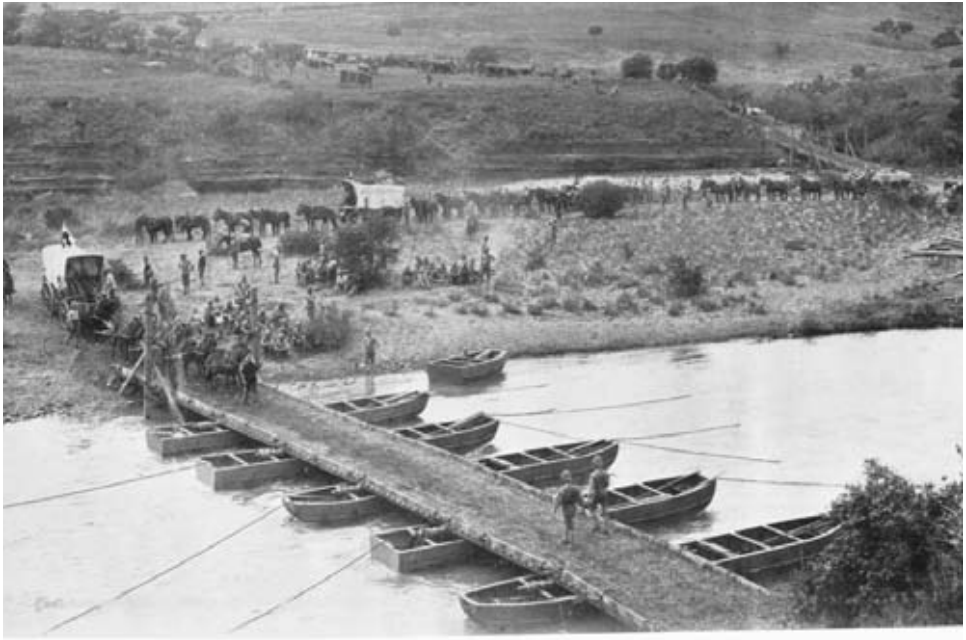

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THE ORGANISATION OF THE CORPS OF ROYAL ENGINEERS.

By 'NEMO.'

THE Army is passing through a period of re-organisation. The future of the Corps of Royal Engineers is now under consideration with the rest.

The subject is probably uppermost in the minds of most officers of the Corps, and it therefore seems appropriate to deal with it in our *Journal*.

The organisation of the Corps in Peace must be governed by the work it is required to perform in War and the organisation that will then be required for the execution of this work.

The work of the Corps in War may be broadly divided into :—

(1) General Engineering in the Field and in Fortresses.
(2) Telegraphs.
(3) Railways.
(4) Survey.

Each of these branches of work involves considerable organisation and special knowledge.

To carry out these duties four principal Officers are appointed to a Force in the Field :—

(1) A Chief Field Engineer, responsible to the Chief of the General Staff.
(2) A Director of Telegraphs, responsible to the Chief of the General Staff.
(3) A Director of Railways, responsible to the Quartermaster-General.
(4) A Director of Survey, responsible to the Chief of the General Staff.

The work for the execution of which these four Officers are responsible may be generally defined as follows :—

CHIEF FIELD ENGINEER.—Piers and landing places; roads; bridges; huts; cantonments; buildings of all kinds; water supply; engineering works in siege operations (attack or defence); construction and demolition of field defences; search lights; advance telephones; tramways; workshops for production of special engineer stores; ballooning.

DIRECTOR OF TELEGRAPHS.—Construction, extension, repair, maintenance, and working of all telegraph wires and offices, and of

trunk telephone wires and exchanges; dealings with civil telegraph administrations and cable companies.

DIRECTOR OF RAILWAYS.—Construction, extension, repair, maintenance, and working of all railway lines; dealings with administrations of Civil Railways worked by Civil Staff and utilised by Army; control of movements of the Army on the railways; railway extension to siege or field works, whether in attack or defence.

DIRECTOR OF SURVEY.—Production of maps of the country as required by the Army; mapping of the greatest possible area for subsequent use.

To carry out the above work the three first-named heads of Branches require :—

(A). Regular Engineer Units formed of enlisted skilled artisans under Royal Engineer Officers;—to move about with the various forces, executing rapid construction and repairs and the work within the danger zone where disciplined troops are required, moving without delay from one place to another according to the emergency, marching and working under military conditions.

(B). An Engineering Staff and Personnel at the Base, on the Lines of Communication in the districts occupied by the Army, and at the front;—to maintain the work rapidly constructed by the Units of their branch; to administer and carry out all the Engineering Work in the districts; to raise and direct skilled and unskilled labour for the execution of the larger works which cannot be undertaken by constantly moving Units with limited numbers; to procure and organise the resources of Material and Stores which will provide both the Units and all the other Engineering personnel with the means of carrying on their work; to arrange Contracts, run Workshops, and account for Funds.

Thus, besides the regular Engineer Units, it is also necessary to have the administering Staff and subordinate personnel for "Engineer Districts" which remain more or less stationary;—to work and maintain the engineer works within them, while the Units pass from the control of one district to another according to the emergency, executing the rapid construction and repairs, carving out the work ahead.

An Engineer District may be at the Front, on the L. of C., or at the Base. In the case of the Field Engineers it would be in charge of a District Field Engineer, in the case of the Telegraphs in charge of an Assistant Director of Telegraphs, these controlling all the Units and Engineer personnel of their respective branches within it and being responsible to the General in Command of the Troops in that District

or section of the Front or L. of C. The number of Field or Telegraph Units, or Engineering Staff and Personnel, allotted to any force would depend upon the amount of engineering work within the district in which that force was operating. The C.G.S., on the advice of the C.F.E. or D. of T. would distribute the Units and the administering Engineer Staff with its subordinate personnel among the various districts and forces; and he would alter the distribution from time to time, just as he alters the proportions of the various arms (Cavalry, Artillery, and Infantry) according to the nature of the military operations on which they may be engaged.

Thus, although a Field Company and a C.R.E. (or D.F.E.) might be allotted to a Division on mobilization, they would not remain with it unless there was sufficient engineering work to employ them in the portion of the country in which it was operating. The C.R.E. would be allotted to a District either at the front or elsewhere, and would remain in charge of that District whether one, two, three, or even no Divisions of the Army were operating therein. The Engineering Districts would, however, correspond, as a rule, with the commands of the Army, just as they do in peace.

On the Railways the district is also the unit; and a district staff, divided into the departments usual upon Railways and responsible to the Heads of those departments, would be provided for every Railway district constructed or captured. The Heads of the Railway Departments, with their supervising staff, workshops, and stores, would form the Central Railway Establishment under the General Manager; while the Railway Units, also under the General Manager, would carry out the new construction and the repairs. The General Manager is responsible to the D. of R. for the technical portions of that officer's duties.

Enough has been said to show that, besides the regular disciplined Units moving from one place to another, there is also required in each branch a large administering and maintaining staff of officers and subordinates, more or less stationary in the positions allotted to them. This organization requires to be directed by R.E. officers; but the subordinates may be partly formed of regular Units split up and partly of quasi civilians under Military Law, either raised at the time or previously enlisted in a special reserve.

Having thus roughly outlined the organisation in War, let us examine what our organisation should be in Peace. It should correspond exactly to the organisation for War. The nucleus of everything required in War should exist in Peace, with the machinery all ready for its expansion. It is not fair to ask any man to accept the post of Chief Field Engineer, Director of Railways, Director of Telegraphs, or Director of Survey and to create these large departments in forty-eight hours. These officials, with the nuclei of their departments, should in peace time be at the War Office, responsible

to the member of the Headquarter Staff to whom they are responsible in war; thus the Chief Field Engineer and the Directors of Telegraphs and Survey would be under the Chief of the General Staff, the Director of Railways under the Quartermaster-General, in peace as in war. Their peace duties may be defined as follows:—

CHIEF FIELD ENGINEER.—Questions of establishments of Field Troops and of Field, Fortress, Balloon, and Bridging Companies: training of these Units for war duties; establishments of District Engineering personnel for war; technical manuals and administrative regulations; patterns and quantities of stores for Field Engineering; reserves of stores, and questions of reserves of personnel; estimates for and expenditure on training. All questions affecting Field Engineering.

DIRECTOR OF TELEGRAPHS.—Questions of establishments of Telegraph Companies, etc., etc., similar to duties of C.F.E. in his branch.

DIRECTOR OF RAILWAYS.—Similar duties to the above in Railway Branch; also all movements of troops by rail, agreements with Railway Companies, etc.

DIRECTOR OF SURVEY.—Similar duties to the above in Survey Branch; also production of all maps required by War Office.

We now come to the question of the surplus officers. It has been shown that a considerable number of officers and subordinate employés are required in war who do not belong to any Unit. Two questions therefore arise:—

(1). How are the surplus officers to be employed and trained in peace?

(2). Whence shall we obtain in war the skilled subordinate employés required outside the regular Units?

Taking (1) first, every encouragement should be given to officers to accept outside employment in the way that many now accept it. The training obtained in these outside appointments is excellent, and makes the officer more valuable when he returns to the Corps. For Railways or Telegraphs, it is absolutely essential that an officer should at some period be employed on a Commercial Railway or in the Post Office Telegraphs.

But these outside appointments are a precarious source of employment; the number offering must vary from time to time. It is therefore necessary that a branch of State work, which will give an all-round engineering training and a knowledge of engineering administration, should be handed over to the R.E. Officers required for war but surplus to peace establishment. It does not require much discussion to decide what this work should be. It stands to reason that Fortifications should be built by Royal Engineers; and as Barracks are in many places intimately connected with fortifications

and give an excellent all-round training, these are the works for the surplus officers to carry out as a Department on civil lines.

The present arrangement of two departments existing side by side and both responsible for work in the same places, one military and one civil, fortifications, small barrack and other works, lands, etc., under the former and new Barrack Construction under the latter, each with its own staff and stores, would appear to be uneconomical and wasteful of public money. The Barrack Construction Department should afford employment for the surplus R.E. Officers.

But, contrary to the custom of the past, the surplus officer Department must not in any way control or deal with the work of the other branches of the Corps, viz.: Field Engineering, Railways, Telegraphs, Surveys. In the past the Head of the Barrack and Fortification work was Head of the other branches of the Corps work and directed the war training, with the result that the mass of work involved in the peace Department overshadowed the more important but less apparent necessity of war training; officers and men were in many cases entirely cut off from war training and employed on the peace works. The officers who were so busy on these peace works had little time to study the proper organisation and development for Field Engineering, Railways, Telegraphs, and Survey, and to direct the proper policy for studying and working on these branches.

The Head of the peace Department of surplus officers should be under a member of the Headquarter Staff who does not exist in war, *e.g.* the Master-General of Ordnance, and should only obtain the services of officers or Units in other branches with the consent of their Heads. Thus there will be no possibility of the surplus officer peace Department again absorbing all the war branches.

So much for the organisation at Headquarters. In the districts it would be similar. On the Staff of every G.O.C.-in-Chief in a Command would be :—

(1). A "Chief Field Engineer," commanding all Field Engineering and Fortress Units, supervising their training, carrying out for the General all engineering works in connection with the manœuvres and training of his troops, responsible to the Colonel of the General Staff.

(2). An "Engineer for Works," commanding all surplus R.E. Officers, and carrying out for the G.O.C. all peace works, *i.e.*, barracks, permanent fortifications, lands, etc., responsible to the Brigadier i/c Administration.

(3). Where telegraph companies exist an "O.C. Telegraph Companies" to act as Director of Telegraphs to the G.O.C.

(4). Where Railway Companies exist an "O.C. Railway Companies."

Now as to the vexed question of specialisation. It is not required, at least only to a limited extent. It is not necessary to divide the Corps into the five hard-and-fast branches denoted above, nor would it be advantageous to do so. We must be "*Jacks of all trades and masters of one.*" If we were divided up the establishment of the Corps would be much increased.

All Branches must draw their personnel from a common pool controlled by the representative of the Corps in the Adjutant-General's department, and the pay of all must be the same. But this important proviso should be made, that at the War Office, where the policy of each Branch is worked out and controlled, the Head of every Branch and also his Staff must be men who have spent 50 per cent. of their service in that branch; *e.g.* an officer who has spent half of his time in Fortifications and Works and a quarter as a Field Engineer should not be appointed D. of T. To the Head Office should be appointed experts to control and guide those outside in the way they should go, but specialisation should not be carried any lower down the scale. The result of the proposed system would be that nearly every officer would alternate between one particular Branch and the F. and W. Branch, in the latter becoming jack of all trades, in the former master of one.

As regards pay and conditions of service, no alterations are necessary; let us leave well alone. We get the right class of officer and we enlist excellent men, because the pay has been fixed at the minimum rate which will attract them. In spite of our extraordinary organisation in the past we have acquitted ourselves fairly well. If we could get a really good organisation we should in the future do fifty times better.

It remains to answer question (2)—Where shall we obtain in war the skilled subordinate officers and employés required outside the regular Units?

The Telegraph and Railway branches must induce civilian employés on telegraphs and railways to join a special Reserve to come out in War. This class is comparatively limited and careful arrangements must be made in peace to secure a sufficient supply. With the Field Engineer personnel however the case is different. The general practitioner engineer or artisan is a drug in the market and can be secured at market rates at very short notice.

This concludes a rough outline of an organisation for the Corps. The *main point* is to maintain in peace at the War Office a Chief Field Engineer, a Director of Telegraphs, a Director of Railways, a Director of Surveys, and a Director of Fortifications and Works; and to let each Head work out the salvation of his own Branch, under the member of the Headquarter Staff to whom he is responsible in war.

THE ORGANISATION OF ROYAL ENGINEERS FOR THEIR DUTIES IN WAR.

By Bt. Colonel G. K. Scott-Moncrieff, c.i.e., R.E.

A few years ago, when in China and associated there with the engineers of several other armies, I was asked by one of our German colleagues if we would explain to him the organisation of the Corps of R.E. Two of us therefore sat down with him, the *Supplement to the R.E. Journal** before us, and endeavoured to explain the intricacies of the Bridging and Telegraph Battalions, Submarine Miners, Field and Fortress Companies, and so on. He asked us many questions, and as we endeavoured to explain, his face assumed a more and more puzzled expression; and though he was too polite to say so, he evidently thought that however excellent our material the organisation was utterly chaotic.

To us, who were endeavouring to explain matters, it appeared that there was little to be said in defence of our organisation, and that in this, as well as in many other respects, we, in the British army, were "muddling along somehow." A comparison of our organisation of military engineers with that of even a third-rate European power is sufficient to show anyone that we have a very great deal to do before a satisfactory state of affairs is arrived at.

It is, however, easy to act the captious critic. It is far more difficult to suggest remedies which shall be in accordance with the requirements of the army in war and yet be within the limits of administrative possibilities in time of peace.

A War Office Committee under the distinguished presidency of Field Marshal Sir Evelyn Wood has recently been sitting to consider this matter. What the conclusions of this Committee are I do not know. But as the R.E. Institute has invited papers on this very question, I venture to join the number of those who have already contributed articles.

Necessity of Considering the Matter from the Peculiar Standpoint of the British Army.

Although I have alluded above to the organisation in foreign armies, I must qualify my remarks by saying that it is not sufficient in all things to follow their lead. Our military reformers have a tendency to follow, in matters chiefly of military millinery, the lead of the nation that has been most victorious in a recent campaign. After the Crimea and Italian Campaigns everything in the British army was

* Now the *R.E. Monthly List.*

modelled on a French basis, even the British soldier's shako being an imitation of the French *kepi*. But when France was beaten by Germany in 1870 German methods, tactics, helmets, etc., were first and the rest nowhere. Nowadays we are bidden to turn our eyes to the Far East, and *Punch's* recent skit on the British policeman dressed in Japanese fashion has a certain significance behind the jest.

Fortunately all this has not much affected the Sapper, except possibly in the bewildering variety of headgear (I have had fifteen different patterns during my service); officers and men are much the same stuff as they used to be.

In considering the case as it is affected by the peculiarities of the British army, I begin by a few axioms.

1. The British army being a voluntarily enlisted body of men, the majority of the men in the infantry come from the labouring class, and they are neither so intelligent nor so well educated as are the average conscripts of foreign nations. Although the British soldier is, by virtue of his voluntary service, probably a better fighting man than one who is forced to serve, yet in every company of foreigners there is probably a higher proportion of intelligent educated men than in a British company. Hence there is the greater need in our service for a goodly proportion of engineer soldiers recruited from the intelligent artisan class.

2. The British soldier has frequently to fight with savage or semi-civilised foes in superior numbers. The paucity in our numbers must be compensated for by skill in weapons, fortification, and other devices of the brain.

3. The British Empire being scattered all over the globe, the garrisons at distant spots must be based on the possibilities of operations in adjoining countries. Therefore such garrisons must have a due, though not an excessive, proportion of engineers.

The broad deduction from these axioms is that, whatever may be the proportion of engineers to other arms in the armies of civilised nations, it is essential that in the British army that proportion must be comparatively high. Taking as a unit the infantry division, it appears that in most European armies the proportion varies between 2 and 3 per cent. In the Swiss army it is 4·21; in the Japanese 4·10 per cent.; in the Russian army in Manchuria last year it seems to have been 5 per cent. In the British army, if we include the drivers of a Field Company, the proportion is 2·62; but if we consider only the dismounted men (who are really the skilled engineers) the proportion is no more than 1·87 per cent.

Hence we see that, although the engineers in a British division ought to be at least as numerous as in the Russian and Japanese armies, and indeed, if the above axioms are worth anything, the British sappers ought to be in a relatively higher proportion—yet as a matter of fact they are only 1·87 instead of at least 5 per cent.

DUTIES IN THE FIELD.

The above argument is still further strengthened when we consider that in the British army there are certain duties necessarily devolving upon the R.E. which in other armies are carried out by other corps. Allusion has been made by Capt. J. E. E. Craster, R.E., in one of his recent papers in the *R.E. Journal* on this subject, to the "water-tight compartment" in the German army and its practical disadvantages. As pointed out by him, the British engineers are trained for general duties. They may be individually specialists and should be employed accordingly when necessary; but they are available, with some trifling exceptions, for general duty, and it is their pride that they are "handy men." Especially in savage countries they are called upon to do work beyond the scope of military engineering pure and simple. Roads, waterworks, and military buildings, for whose construction and maintenance no provision is contemplated in foreign armies, are regularly and definitely accepted in the British army as among the duties in the field of the R.E. In some of our campaigns (*e.g.*, Afghanistan, 1878–80) these formed the bulk of the work done by the engineers. If we have another campaign in Afghanistan it is certain that similar works will furnish a large field for employment. In most foreign armies these works would be carried out by civil engineers or architects. The possibility of having to undertake such works in war therefore furnishes a very strong argument for the employment of the R.E. on civil or quasi-civil works in peace.

In addition to all duties on lines of communication, camps, fortified forts, and bases of operations, there are others of a tactical nature in which the engineers of an army have a distinct *rôle*. The late Colonel R. Home, R.E., in his *Précis of Modern Tactics*, pointed out these latter duties some 30 years ago; but it is only recently, chiefly owing to the skill with which the Japanese used their engineers in attack, that these principles have come into prominence. The rapid application of fortification to pivot points in the battlefield, the hasty improvement of positions gained, the demolition or removal of obstacles, are all matters in which the engineer soldier must be trained to co-operate with other arms. To carry out these duties properly it is absolutely necessary that with every body of infantry and cavalry there should be a due proportion of engineers, whose tools and other implements necessary for their work should be carried in the way best adapted to the locality and in a manner which will enable them to be always available when needed. The conclusion arrived at is that with each brigade of infantry there should be a field company and with each cavalry brigade a field troop of R.E.

I may perhaps add that in the operations of the 3rd Cavalry Brigade and the 7th Infantry Division in Ireland this year the tactical

use of the R.E. was fully recognised with much advantage generally. It was, however, a new tactical feature to many officers who were engaged in these operations.

Besides the duties above indicated there is another, alluded to by Colonel Kenyon in the August number of the *R.E. Journal*, viz. :— the telephone service. From the experience of the Irish manœuvres this year it is evident that infantry, cavalry, and artillery are quite capable of working their own telephone service with the simple and effective apparatus obtained this year, supplemented by various improvised methods of carrying the wire. But skilled electricians, instrument repairers, etc., are required in the R.E. companies, and it is most essential that some part of each R.E. field troop and company should be devoted to this service. I do not however agree with my old friend Colonel Kenyon that the title of the R.E. field units should be changed. To call all these units "telegraph companies" might give rise to the idea that they were specialists in one branch only and not the all-round useful men they ought to be. Let the existing telegraph companies concentrate their energies on the work they have hitherto carried out on lines of communication and in camps; but the field troops and companies should supply the skilled expert assistance to the other arms, who are well able to work their own telephones in the field.

Field troops and companies must also carry apparatus for the water supply of camps, etc.

ORGANISATION OF EQUIPMENT IN FIELD UNITS.

From the above considerations we see that the equipment of field units should include

1. Tools for all probable military operations.
2. Explosives for anticipated demolitions.
3. Telephone apparatus, with means of repairing and testing.
4. Water supply gear.

The equipment should further be so subdivided that each section of the troop or company may be complete in itself, and thus able to proceed independently with the corresponding unit of the cavalry or infantry brigade to which it is attached. There may be in addition a small headquarter reserve of equipment.

The distribution of trades of the sappers and the best methods of equipping them are subjects hardly within the scope of this paper; but something may be said about the transport of field units. At home this mainly consists of vehicles of a special pattern, which permit of a limited number of sappers riding on them. Pack animals are allowed to a very limited extent.

In the Indian Sapper and Miner companies the whole of the transport is on pack animals, subdivided in 3 lines, into the details of

which it is unnecessary to enter. This organisation is good in so far as it recognises the essential need of pack transport with a sapper troop or company. But it is imperfect in so far as it does not provide for a more rapid rate of progress than that which can be produced by the marching of men.

It is most desirable that the equipment should, in civilised countries, be a combination of wheeled vehicles and pack animals. The former should be able to take a limited number of sappers at a trot over ordinary roads in order to strengthen pivot points, destroy a bridge, etc.; while the latter are necessary to accompany sappers over ground where carts cannot follow.

The transport of a company and its drivers are a variable addition to the integral parts of the company, which are the skilled workmen and the tools. European drivers, horses, wagons, etc., may, under certain conditions, be entirely dispensed with, the war efficiency of the unit being still maintained. It is possible that in the future a solution of the transport question may be found in automobiles, combined with pack animals of some sort, which are almost indispensable. In any case cyclists are most useful. When I commanded a field company I had a bicycle club among the men, and gave certain privileges to the members provided they allowed their machines to be used on the march, etc. I think this added materially to the war efficiency of the unit, for it provided a means of rapid movement for the sappers. I consider that this is an important point in connection with field troops, for much of the work that is allotted to mounted sappers, in civilised countries at least, could be done by cyclists, with a corresponding reduction in horseflesh.

Before dismissing the question of the organisation required to link the sapper and his tools, I must refer to another important point. Each field company is now equipped with 2 pontoons and superstructure. This of course involves two teams of horses with their drivers. It would, I think, be better to have in lieu a separate bridging company, with about 50 yards of bridge material, attached to each infantry division. This is the organisation in the German and Japanese armies.

If the field company or companies of a division have to make the bridges for an advancing column they cannot take their place with other troops as tactical units. An example of this occurred in the Irish manœuvres of 1904. A bridge train had been extemporised in one of the field companies, and an important river, about 100 yards wide, was bridged at the beginning of a long day's operations. The force that crossed the bridge had to work over a difficult country where they needed their sappers badly; but the sappers were tied to their bridge, not only until all the force had passed but subsequently until the bridge was dismantled, and their services as a tactical unit were lost for the time.

It is of course admitted that bridging companies should be taught other fieldworks, and that the "general service" company should be thoroughly instructed in bridging. But the ideal organisation of sappers with an infantry division is a company for general service with each brigade and a bridging company for the division generally.

Whether our bridging companies are organised in the best manner in respect of equipment and horses is doubtful. Our pontoon wagons require six-horse teams, yet the Japanese have a pontoon drawn by one horse. A Japanese pony, a miserable creature compared with an English draught horse, certainly cannot drag the same load as the latter. Either therefore the Japanese have hit upon some very much lighter pontoon than ours, or our pontoons have too many horses. It is true we overload our draught horses with heavy and unnecessary harness, but I think also we do not use the proper stamp of animal. We do not want the same class that is required in horse or field artillery. A heavier and more powerful animal is needed, more of the Clydesdale or Shire stamp; two of these would walk away with a pontoon wagon. There is also no necessity for postillion driving.

It is admitted that a half-bred Clydesdale costs much more than the average army draught horse, but the initial cost would be compensated by fewer numbers. It would probably not be worth while to keep up, in our Remount Depôts, a supply of such draught horses for R.E. purposes only. But what about the Army Service Corps? A heavier class of draught horse would be most valuable and economical to them.

So far then I have suggested that the engineer requirements of an infantry division are two field companies and one bridging company. There remain a few small miscellaneous detachments.

Every general of division should have a field printing press to enable him to issue copies of orders, and a field lithograph press to enable him to circulate copies of plans and sketches. These are most important adjuncts. For discipline and interior economy the small *personnel* concerned might be attached to the bridging company; but their services should be utilised under the direct control of the C.R.E. or the Colonel on the General Staff.

A small detachment with a search light plant, preferably two such plants, might well be added. The total number of the various miscellaneous detachments need not be more than 30 men and they might all be attached to the bridging company.

The whole of the three companies on war strength, exclusive of drivers whose numbers would vary with the country, would consist of 18 officers and 450 rank and file. There would also be a lieut.-colonel as C.R.E. and an adjutant with sergeant-major and clerk. The proportion of sappers to a division 9,000 strong would thus be 5 per cent. This allows of 150 sappers to each field company, 120

sappers to the bridging company, and 30 to miscellaneous detachments. Including drivers the strength would be about 600. The whole should constitute a "Field Brigade of R.E."

Search light companies, telegraph companies, balloon sections, and field parks belong to the organisation for lines of communications.

FORTRESS COMPANIES.

Having never served in a fortress company I feel some diffidence in approaching the question of its organisation. I do not, however, go so far as Colonel Kenyon in his advocacy of their abolition or amalgamation with fortress artillery.

A fortress company differs from a field company in that the former do not hold in peace the tools required for war and do not possess transport and drivers (the latter always a variable item as previously pointed out). In all other essentials the companies are identical. There is not, for instance, the distinction between them that there is between field and garrison artillery. Thus it is possible to transform a fortress company into a field company at once by issuing to it the necessary equipment, transport, and drivers.

The duties of engineers in fortresses would appear to be :— (1) Electrical work in search lights and communications, (2) Construction and repair of defensive works.

There are, however, certain fortresses where it is not desirable to keep field companies, but where the fortress companies must be prepared to take the field with other arms in event of expeditionary forces being required in adjacent countries. This applies to such places as Hong Kong, Malta, and perhaps some others.

Otherwise there seems to be no reason why the strength of the fortress companies should exceed 5 per cent., at most, of the rest of the garrison.

This would give about 9 fortress companies at home, and a similar number abroad. I would suggest that these 18 should be organised in 6 Fortress Engineer Brigades, each of 3 companies, viz. :—

(1). *Channel Brigade*, headquarters Portsmouth ; Companies or detachments at all English Channel fortresses from Dover to Falmouth.

(2). *North-Eastern Brigade*, headquarters Chatham ; Companies or detachments at all North Sea ports or fortresses from the Firth of Forth to the Thames.

(3). *Irish or Western Brigade*, headquarters Belfast ; Companies or detachments at all the Irish Channel ports or fortresses from Greenock to Cork.

(4). *Mediterranean Brigade*, headquarters Malta ; Companies at Gibraltar and Malta.

(5). *East Indian Brigade*, headquarters Singapore; Companies or detachments in China, Singapore, Ceylon, and Mauritius.
(6). *West Indian Brigade*, headquarters Bermuda; Companies or detachments at Bermuda, Barbados, Jamaica, and possibly Capetown.

As Esquimalt and Halifax are being taken over by Canada, these stations are not included. Egypt ought surely now to be able to have native sappers, as in India.

OBJECT OF BRIGADE ORGANISATION.

The term "brigade" for field and fortress groups is used in default of a better term to express an organisation similar to a brigade of other arms, especially of horse or field artillery.

The grouping of field batteries has only come into vogue of recent years and is an acknowledged advantage. The duties and responsibilities of battery commanders have not been impaired or altered, but the brigade system admits of better training and supervision. In India it has not been carried out (at least it had not been when I left 18 months ago) and the defects, which there exist, of single battery organisation have frequently been pointed out to me by senior artillery officers. Exactly the same defects exist in our company organisation. It is not so bad now as it was some few years ago (I remember, for example, two companies in the same station with different drills, different patterns of saddlery, different vehicles, etc.); but still there is a want of cohesion. One C.R.E. may take an interest in military details and frequently supervise the companies at drill, field works, riding, etc.; another may leave these details severely alone, as though they were no part of his duty.

Now, however capable the company commander may be, his company will never take its place in line with other arms unless the C.R.E. sees that it is properly worked. The influence that a C.R.E. has with the general and his staff will necessarily be much greater than that of a junior officer. The C.R.E. should be the responsible authority on the tactical use of the Engineers in a division, just as the brigade commander of the artillery is with respect to that arm. The C.R.E. should not only see that the prescribed annual courses of the companies are carried out, but that they are carried out in accordance with definite tactical schemes, that they touch the training of other arms, and that they suit the conditions of the locality. Company officers cannot do this. How often we see sapper companies sent off into a corner by themselves, carrying out work which may benefit them but does no good to anybody else; this is most pernicious.

As regards drills it is perhaps unnecessary to say that the proposed grouping of units is not intended to relieve company officers of the

responsibility for drills and exercises which now devolves upon them. With infantry the company is now recognised as the tactical unit, and this is the case even more definitely with engineers. Battalion drill is very necessary and useful in training recruits; but it is so seldom required by engineers in war that it need not be practised by their service companies in peace. Drills should be carried out by company officers and limited to what is really needed. There is plenty of varied instruction to be obtained in the limited time available; and I have never yet seen a company in which there was not room for improvement in company drills, riding, driving, signalling, judging distance, bayonet fighting, and physical training. In all these matters the C.R.E. ought only to exercise general supervision.

It would be a very great advantage, too, if promotions and transfers could be arranged either in brigades or among companies of the same class, instead of in the Corps at large. At present it is most disheartening for company commanders to have constant changes. A more decentralised system of promotion would be much more satisfactory.

The headquarters of each field engineer brigade would be the headquarters of the division of the army to which it is attached, and the sub-district C.R.E. would be its commander. The companies need not necessarily be all at one spot; they could be quartered in the district with the infantry brigades to which they are attached.

GENERAL QUESTION OF STRENGTH IN PEACE.

Taking all the field and bridging companies at a peace strength (exclusive of drivers) of 100 each, field troops at 30, and fortress companies (including electricians for coast defence) at 100, we have, according to the above proposals, for 4 cavalry bridges and 9 infantry divisions:—

4 field troops at 30	= 120
27 field and bridging companies at 100	=2,700
18 fortress companies at 100	=1,800
Total	=4,620

The present strength of dismounted men in field troops and companies, fortress companies, and coast defence electricians is 5,041. Thus there would be a balance of about 400 men in favour of the proposed organisation. Against this, however, there would be an increase of some 200 drivers and a considerable increase in horses. But the substitution of a heavier class of horse (as suggested above) would bring down the number both of horses and drivers; so that generally I think the proposals would result in public economy.

EMPLOYMENT IN PEACE.

The best utilisation of Sapper skilled labour in time of peace is a most difficult question, and space does not permit of its discussion here. It would be in every respect desirable that any engineering works carried out by the State should, in part at least, be entrusted to the R.E.; but unfortunately any such arrangement is subject to the necessary interruption caused by military training.

Field troops and companies can also be most advantageously employed in peace as instructors in field works and surveying to the cavalry and infantry brigades to which they are attached.

CONCLUSION.

The suggestions made above affect only the bulk of the units of the Corps, viz., those in the bridging, field, and fortress companies.

A proposal which increases the bridging at the expense of the fortress companies will possibly meet with adverse criticism. But those who object will, I think, recognise that the proposals correspond with the recent organisation scheme for the whole army, viz., the maintenance of eight infantry divisions at home and one in S. Africa, plus certain troops for coast defences and colonial garrisons. As regards the reduction of fortress companies I *do* not deny that, as they exist, they are usefully employed in peace; but I submit that in respect of war organisation they are in excess, while the field units (including bridging companies) are too few.

I have not touched upon survey companies, railway and telegraph companies, field parks and depôts; as far as I know, these seem to be suitable. Nor have I said anything about militia or volunteers, as the length of this paper has far exceeded the limits of my original intentions. I need only say that although engineer militia and volunteers are organised in battalions, they should be allotted to brigades and divisions of the home defence army in exactly the same way as advocated above for the field and fortress companies of the regular forces.

CAMP OF INSTRUCTION AND MANŒUVRES OF THE 3rd CAVALRY BRIGADE IN IRELAND, 1905.

By Bt. Lieut. Colonel H. R. Gale, R.E.

CAMP OF INSTRUCTION.

The Training of the 3rd Cavalry Brigade during its Camp of Instruction at Lusk, near Dublin, brought into prominence the possibilities of the Royal Engineers becoming an Instructing Body for the rest of the Army.

Owing to the great increase of late years in the technical training of all branches of the Army, the Royal Engineers are not alone in possessing knowledge of subjects which require some scientific education, such as Surveying, Fortification, and Bridging. It seems necessary, therefore, that we should consider the question of our future position in the Army, and make sure that our expert knowledge and our capabilities are fully utilized in the future; otherwise some people in other branches of the Army may come to the conclusion that they can do without Field Engineers and that some battalions of Pioneers will suffice for all their needs.

For these reasons, even more than for the actual engineering interest of the work done, a short description of the Camp of Exercise at Lusk may be of interest to the Corps.

The Camp commenced on Saturday, 8th July, on which day 4 Cavalry regiments and 1 Brigade of Royal Horse Artillery marched in from Dublin and the Curragh. One regiment, the 11th Hussars, made the whole march of 44 miles from the Curragh in one day. The 5th (Field) Company, R.E., under Major F. E. G. Skey, had already been a week in camp, preparing stores and carrying out part of their own Field Works' training. Sunday was devoted to rest and shaking down into camp life; and the fire mains of the Remount Establishment had also to be connected up to the water supply to supplement the 1-inch and 1½-inch pipes to the various camps, which were found insufficient in size.

By 8.30 on Monday morning, the Naval portion of the concentration was also complete. This consisted of:—The Transport *Kansas*, 5,000 tons, an old Atlantic cattle-steamer, hired for the work; 6 horse-boats and flats, to hold 7 or 10 horses each; and H.M.S. *Donegal*, 1st class armoured cruiser, which arrived from Portland and dropped anchor inside Lambay Island in the small hours of the

morning. The first work of the *Donegal* was to take the Government Steamer *Evelyn Wood*, containing the horse-boats, alongside and hoist the boats out of her, the *Evelyn Wood* having no derrick strong enough to take their weight. By 8.30 a.m. the horse-boats had been towed the mile and a half between the ships and the shore by 3 steamboats which the *Donegal* had brought.

The instruction which then commenced was divided into four sections:—

1. Embarkation.
2. Bridging.
3. (*a*). Swimming (men and horses).
   (*b*). Rowing.
   (*c*). Field Entrenchments and Demolitions.
4. Detached Duties;—Reconnaissance, Outposts, etc.

A separate Unit was detailed for each Section, and changed every day. The 12 working days of the Course, after deducting one or two for schemes of combined operations, allowed of each unit having two or more days' practice in each section. Work usually began at 6 a.m., which meant reveillé at 4.30 a.m. so as to allow time for looking after horses, breakfasting, and marching the 2½ miles between the camp and the beach.

The Camp was on the Government Remount Farm, close to the village of Lusk, 12 miles north of Dublin. The portion of the coast used for the Instruction consisted of 4 miles of sandhills, bounded on the north by the low rocky promontory of Rush and on the south by a similar headland at Portrane, the whole being sheltered from the east by the Island of Lambay. In the middle was Rogerstown Inlet, the tidal estuary of a small stream, with a narrow entrance in which the tide-run was very strong. This entrance, about ½ mile long, answered well for Bridging, Swimming, and Rowing, giving excellent practice in strong currents, and, at the hours of slack tide, in still water also.

1. EMBARKATION.

In the Embarkation Section, the *Donegal* at first did most of the work. Her crew supplied working parties on the shore and on the *Kansas;* worked the winches on the latter and the 3 steamboats which towed the horse-boats to and fro; put crews into the horse-boats; and, in fact, carried out all arrangements between the Transport and the Beach. The Military working parties in the Transport and on shore at first confined themselves to the handling of the horses and to pulling on the shore-lines when required, as contemplated in the "Regulations for Embarkations" and carried out at Clacton in 1904. But as the practice proceeded, the Naval working parties were considerably reduced; and, at the end, it was

found that the troops were quite able to supply all the labour, with the following exceptions :—

(i.). A small party on the Transport to work the winches,
(ii.). The crews of the steamboats,
(iii.). One seaman to each horse-boat and lifeboat,
(iv.). A small Naval Party on shore to superintend the anchors, buoys, lines, and other hauling-in arrangements.

In real operations this would have set free all but a small part of the *Donegal's* complement for the much more important duties of guarding against attack from the sea, beating down opposition to a disembarkation, or retarding pursuit in case of a re-embarkation.

The Embarkation work and most of the Disembarkation was carried out at the flat sandy beach near Rush ; but part of the disembarkation was done in Rogerstown Inlet, where the steeper slope of the sand allowed of bringing the boats nearer the water's edge. Work was carried on irrespective of the tides, but Rogerstown Inlet could only be used near high water on account of the shallowness of the bar. The day's work generally resulted in somewhere about 100 horses being shipped and landed again, with the addition, on some days, of guns, pom-poms, wagons, etc. Every day, also, from 15 to 30 tons of forage were landed from the *Kansas*, which had brought a supply from Liverpool where it could be obtained better and cheaper than locally.

The hours of work were from 6 a.m. to 4 or 5 p.m., and on one day to as late as 9 p.m. The reasons which prevented more being done in the time were chiefly as follows :—

(1). There were only two gangways and derricks on the *Kansas*, available for the hoisting of horses.
(2). The anchorage of the *Kansas* was a mile and a half from the shore.
(3). One or more of the 3 steamboats had frequently to be used for other work, or was under temporary repair of small damages.
(4). The extremely flat foreshore made it very difficult to keep the horse-boats afloat, especially when embarking on a falling tide.
(5). The distance between high and low watermarks was nearly 500 yards. The steamboats, towing horse-boats, had to drop the latter in water from 4 to 6 feet deep, often 300 or 400 yards from the water's edge ; the horse-boats had then to be hauled in to where they could be filled or emptied, in water 2 to 3 feet deep ; this was slow and heavy work, on account of the great length of lines lying on the sand and cutting into it.
(6). The want of small steam or petrol boats, suitable for work between the ships and the shore.

The actual loading and unloading of the horse-boats, and slinging horses into and out of the *Kansas*, took up a very small proportion of the whole time. At the beginning of the practice a pair of horse-boats took from 5 to 15 minutes to load; at the end, this time had improved to under 2 minutes. This improvement was in spite of the fact that, at the end, the men were in marching order and rode their saddled horses on to and off the boats; while, at the commencement, the men were in the lightest of clothing and led their horses with no saddles on them. The emptying and filling of a pair of horse-boats alongside the Transport could be done, at the end, in the very short time of 4 minutes.

Over 1,000 horses were embarked and disembarked during the whole practice.

2. BRIDGING.

The Bridging Section was superintended by an R.E. Officer as Instructor, with Assistants from the 5th (Field) Company, R.E. The following were regularly practised:—

1. Barrel-piers and rafts, with several different sizes of barrels.
2. Flying-bridges, of pontoon or barrel rafts, running on wire cables.
3. Boat-piers.
4. Trestles.
5. A foot-bridge of ladders and planks supported on single barrels, steadied by means of spars lashed across it at each barrel. These spars quite prevented the awkward rolling to which such narrow bridges are subject.
6. A raft to carry a gun, made of a waterproof water-tank stuffed with hay and with the edges gathered and lashed on the top.
7. A raft to carry one man, made of camp-kettles, in two rows of 7 each. Each row was lashed to light battens, and other battens were lashed across to connect the rows and give the man a seat. The tops of the kettles were fitted on with grease so as to make them watertight.

The 5th Company made a jetty of trestles and planks, and also a broad gangway of plank bowstring-girders, both of which were very useful for landing the forage from the *Kansas*. The hay-stuffed mattress was quite capable of taking a Horse Artillery gun and two or three men across the Inlet, the wheels being taken off and laid over the gun on each side. The solitary paddler of the "Dixie" raft became quite a feature of the waterside.

3. SWIMMING AND ROWING.

The Swimming and Rowing for men were superintended by a Lieutenant and Assistant Instructors from the *Donegal*; the Swimming for horses by the Riding-master of one of the Cavalry regiments.

Many men were taught to swim; and towards the end of the practice the standard of rowing had become quite good, though not quite sufficiently so to warrant a challenge to the *Donegal*.

The continual practice of all the horses at Swimming was so effectual that, during the Camp, 1,000 out of the total of about 1,500 were swum across the Inlet away from home, with a man guiding each; the distance was 70 to 80 yards. A good deal of swimming was also done by the horses during the embarkation work, when they were often allowed to jump out of the horse-boats in comparatively deep water, half a mile or so from shore. Some horses even swam a considerable distance with saddles or harness on, though this was considered too hard a test to be habitually practised. The only horse drowned during the operations was one which was jammed by the tide under a small private jetty in Rogerstown Inlet, while at swimming practice.

ENTRENCHING AND DEMOLITIONS.

The Sub-Section for Field Entrenchments and Demolitions was superintended by an R.E. Officer, with Assistants from the 5th (Field) Company, R.E. Instruction was given in the simpler forms of field-works and gun-cover likely to be useful to Cavalry and Horse Artillery; and also in Demolitions such as could be carried out by Cavalry Pioneers.

The ground available being very sandy and loose, it was difficult to construct satisfactory works without revetments, for which there was not much material available. Much instruction was, however, given in the best shapes of trench and in the methods of handling many different kinds of explosives.

4. DETACHED DUTIES.

The wide stretch of open sand at low water gave opportunities for drill under Section 4; but otherwise the country was not very well adapted to detached duties, being somewhat hemmed in by the sea and the various estuaries and being also cut up into very small enclosures.

LECTURES.

Lectures on various subjects were a great feature of the Instruction. Some were to all ranks, in the open; others to Officers and N.C.O.'s only. For the former, a deep hollow amongst the sandhills formed a fine theatre, the lecturer's voice being heard almost as well in the "Gallery" as in the "Stalls."

The subjects treated were:—

(1). The work of the British Army, with special bearing on Landings;—3 lectures by T. Miller Maguire, LL.D.

(2). Embarkations;—by Lieut.-Colonel Telfer-Smollett, author of the Prize Essay of the R.U.S. Institution for 1904.

(3). Penetration of Modern Firearms ;—by Colonel L. C. Jackson, R.E., C.R.E.

A method of quickly lighting up obstacles in front of a position by means of bonfires—with practical demonstrations ;—by Colonel L. C. Jackson.

(4). Wireless Telegraphy ;—explanation of the installation which was in regular operation between the Camp and H.M.S. *Donegal ;* also description of the lecturer's trip inland with a light cart carrying the necessary instruments, when he succeeded in getting communication with the *Donegal* from a distance of 10 miles ;—by Lieut. Rigg, R.N.

In addition to the C.R.E., other R.E. Officers were employed as Staff Officers or Instructors in the Embarkation, Bridging, and Field Entrenchments Sections. The 5th (Field) Company, R.E., also supplied numerous Assistant Instructors, as well as carrying out the more technical work in connection with the Bridging Section.

It will thus be seen that the Instruction given at the Camp was practically divided between the Navy and the R.E. In these days of scientific training for all branches, there seems to be a great, if hitherto somewhat neglected, field for the Corps of Royal Engineers as advisers and instructors. It is true that we are no longer alone in possessing knowledge of engineering matters. But the correct inference to be drawn is not that we are no longer necessary and can therefore be abolished or reduced to the position of Pioneers ; it is rather that, with the fullest measure of scientific education and training for ourselves, we should cultivate and be given every opportunity, by constant and regular work in conjunction with the other arms, to cultivate a teaching faculty which will enable us to pass on our knowledge to the rest of the Army.

THE SHANNON MANŒUVRES.

The Shannon Manœuvres, from the 8th to the 19th August, gave the 3rd Cavalry Brigade opportunities of using, in a practical way, the knowledge of swimming, boating, and bridge-making which they had acquired at the Camp of Instruction at Lusk.

The great natural frontier formed by the river Shannon and its lakes between the Provinces of Leinster and Connaught was utilized for the purposes of the Scheme, which was a most realistic one.

The 4 Cavalry regiments and the Brigade of Horse Artillery were divided into two equal forces, which acted as the small regular mounted forces of two States, Leinster and Connaught, which, at the commencement of operations, were on the verge of war. Ulster and Munster were at first neutral ; but later on the latter joined

Connaught with a small force of Mounted Infantry, and made a great difference to the progress of the Scheme.

The first few days were spent in watching the 50 miles of border consisting of the Shannon and Lough Rea from Roosky to Banagher, which neither side was allowed to cross, except with a few spies. All the bridges and ferries were held to be defended on both banks by permanent forts, and no one except an undetected spy was allowed to cross them.

Then came war, followed by many small crossings of river and lake. These were effected by cyclist scouts in boats, and by mounted men either swimming or in boats with their horses swimming behind them. The small parties which crossed by these methods from both sides succeeded in blowing up railways, canal-locks, and bridges, and obtained and transmitted much accurate information of the doings of the enemy.

As the situation developed, the Scheme was worked out so that the Leinster Commander, whose original wish and intention had been to take the initiative, was delayed by the supposed slow mobilization of his imaginary main army and thus prevented from doing more than hinder the Connaught Force in its designs of invading Leinster. The invasion took place on the 15th and 16th August, near Shannon Bridge.

The only army equipment for crossing rivers which was in the possession of the Connaught Force consisted of two of the light collapsible-boat pontoons which are carried by Field Companies, R.E.; these were in charge of 3 sappers. This Force was therefore dependent on its own resources, and on those of the country as far as the limited amount of money available would permit. This put out of the question a continuous bridge over a broad, deep, and often boggy river like the Shannon.

Three rafts were therefore made out of barrels from Guinness's Brewery Depôt at Ballinasloe, decked with planks from the local saw-mill. The light pontoons formed a fourth raft; and in addition a river barge, used by a farmer for moving hay from the riverside water-meadows, was hired. A rope was stretched across the river at a point where its breadth was about 80 yards and its banks and bottom were sound; this was used to pull across rafts loaded with men holding the head-ropes of their horses, which swam alongside. A cart track, about 500 or 600 yards distant, was the only place where wagons could be brought over the boggy country to the water's edge; here the river was broader, with a slow current, but had not a sound enough bottom to allow of horses crossing. The pontoon-raft and the hay-barge decked with planks were accordingly used at this point as boats for ferrying over the transport of the Force; each took one, or sometimes two, unloaded vehicles at a trip, being poled or rowed across.

The work was begun at 1 a.m. on the 15th August. By midday on the 16th the whole Force, except about 6 wagons, had been put across; it consisted of 2 Cavalry regiments, 200 Mounted Infantry, 1 battery of Horse Artillery, and about 50 wagons and carts. Owing to the fear of some of the planks giving way and letting the wagons damage the light pontoons, most of the wagons were taken to pieces as well as unloaded, which involved a great expenditure of time.

On the 16th the two Forces came into contact near Moate; and there was considerable fighting, ending in a rear-guard action by the Leinster Force, which retired in the direction of Tullamore. Operations were then stopped, and the two Forces marched to Tullamore and camped there.

On the morning of the 17th there was a conference at Tullamore in the Town Hall, lent for the purpose; and the troops then marched for the Curragh and Dublin, which they reached on the 18th and 19th.

The Shannon is, perhaps, the most difficult obstacle in the British Islands; and the fact that a force of the size mentioned was able to cross it, almost without the help of special troops or equipment, shows what can be done by special training in such work.

The Manœuvre Map, covering the central third of Ireland, was a great feature of the operations. It consisted of sheets of the new 4 miles to the inch Ordnance Map, which were mounted and put together without outside assistance by the Staff of the 3rd Cavalry Brigade. Sufficient copies were provided to allow of one to every man. This issue was immensely appreciated by the rank and file, who entered most keenly into the operations and discussed movements and intentions with the greatest interest.

The back of the map was covered with maxims and other useful information for the soldier; and the whole folded up between strong covers into the size of an ordinary notebook, fitting easily into any coat-pocket.

Motors, owned by members of the Motor Volunteer Corps and others, enabled the Directing Staff to cover all parts of the area of operations, which was some 50 miles by 30 or 40 in extent. Cars constantly travelled 100, and sometimes up to 150, miles in a day.

THE CAMPAIGN IN ITALY, 1796—1797.

A Study of the Strategical Influence of Fortresses in War.

By Capt. H. F. Thuillier, R.E.

"The Italian Campaign demonstrates in the most signal manner the vast importance of fortresses in war, and the vital consequences of such a barrier to arrest the course of military conquest. The surrender of the fortresses of Coni, Alessandria, and Tortona, by giving the French a secure base for their operations, speedily made them masters of the whole of Lombardy; while the single fortress of Mantua arrested their victorious arms for six months, and gave time for Austria to collect no less than four powerful armies for its deliverance. No man understood this better than Napoleon; and accordingly, without troubling himself with the projects so earnestly thrust upon him of revolutionizing Piedmont, he grasped the fortresses and thereby laid the foundation for his subsequent conquests. Without the surrender of the Piedmontese citadels he would not have been able to push his advantages in Italy beyond the Po; but for the bastions of Mantua, he might have carried them, as in the succeeding campaign, to the Danube."

The above passage* succinctly describes the influence which the pre-existing fortresses in Northern Italy exercised over the strategic events of that brilliant and memorable campaign. It is proposed to shew, by following the course of the operations, how that influence was exercised, and the manner in which Napoleon, then only on the threshold of his great career, made use of the conditions existing in the theatre of war and adapted them to his ends.

Opening Situation.—The Army of Italy, when the young General Bonaparte took over the command at the end of March, 1796, was stretched all along the Mediterranean littoral, from Nice to Savona, guarding the narrow space between the sea coast and the summits of the Ligurian Alps. Its headquarters were at Nice. The allied Austrian and Piedmontese armies opposed to them were distributed as follows:—Beaulieu, commanding the Austrian army of 30,000 men and 140 guns, was on the extreme right of the French; his centre

* From Alison's *History of Europe*, Vol. III., p. 120.

was between Novi and Gavi; his right wing, under d'Argenteau, near Acqui; his left wing in rear between Lodi and Pavia. He was also in communication with the English fleet under Jervis and Nelson in the Bay of Genoa. Colli, with the Piedmontese army of 20,000 men and 60 guns, was opposite the French front and covered Ceva and Coni.

Opening of the Campaign.—Bonaparte's plan for the opening of the campaign was to thrust his force between the two armies, separate them, and defeat them in detail; and then to push his attack on the Piedmontese King and detach him from the alliance, thus leaving himself free to concentrate the whole of his forces against the Austrians.

In the beginning of April his columns began to move. Their strength was approximately 42,000 men, of whom about 5,000 were cavalry. They were in four divisions; two, under La Harpe and Meynier respectively, formed the advanced guard commanded by Massena; and the other two, under Augereau and Sérurier, formed the main body. The division of Sérurier did not take part in the first battles, and the numbers that actually crossed the mountains with Bonaparte were 28,257 men and 60 guns in the three divisions and 5,342 cavalry.* In addition to the above, about 10,000 troops guarded the lines of communication into France and furnished magazines and depôts for supplying men to the active divisions.

Montenotte.—The first movement of the French was to concentrate their forces on the extreme right. Thereupon Beaulieu moved with his centre to Genoa and thence along the sea coast to Voltri. His right under d'Argenteau was advanced to Montenotte, where it came in contact with a small French force. Bonaparte, leaving a brigade from Meynier's division to oppose Beaulieu at Voltri, immediately advanced with the remainder of Massena's command and the division of Augereau, and, crossing the Col di Cadiboni, fell on the Austrians at Montenotte and completely defeated them.

This victory opened to the French the plains of Piedmont, and, by piercing the centre of the Allies, completely separated the Austrian and Piedmontese armies; the former concentrated at Dego to cover the road to Milan, and the latter around Millesimo to protect the entrance into Piedmont. Bonaparte, in possession of a central position, resolved to attack them both at once.

Millesimo and Dego.—On the 13th April Augereau attacked the Piedmontese at Millesimo, while Massena and La Harpe moved towards Dego. In the fighting which took place that day and the next the French were successful; the Allied armies, losing many prisoners and guns, retreated; and Bonaparte moved Augereau's division forward to the heights of Monte Zemolo. Beaulieu retired

* Bouvier's *Bonaparte en Italie.*

to Acqui, on the road to Milan, and Colli towards Ceva, to cover Turin.

Monte Zemolo.—After this battle La Harpe's division was placed to keep the remains of Beaulieu's forces in check, while the weight of the French army was moved against the Piedmontese troops. The latter were driven from the heights of Monte Zemolo, which was occupied by the French forces. This ridge was the last barring the way into the plains of Piedmont, which were then entered.

Colli, after repulsing Sérurier's division, which had attempted to turn his flank, took up a strong position in front of the French.

Bonaparte's position was now far from favourable. The Austrian army was in his rear and might easily resume offensive operations, while the English fleet in the Bay formed a standing menace to his line of communications with France by the Corniche Road. Piedmont contained numerous fortresses, some of them strong, and the French had neither heavy guns nor siege equipment wherewith to reduce them. To penetrate far into the country without securing them would have been extremely hazardous.

Mondovi.—Notwithstanding these disadvantages, Bonaparte did not hesitate to push on with vigour his attack on the Piedmontese. The latter were assailed and driven out of Mondovi with loss; on their retiring to Cherasco they were followed up, and that town also was occupied by the French.

Treaty with the Piedmontese and Acquisition of their Fortresses.—At this the Court of the King of Sardinia* began to feel much alarm for the safety of their capital, Turin, and proposed negotiations for peace. Bonaparte however insisted that as a preliminary the fortresses of Coni, Ceva, and Alessandria, with their artillery and stores, should be given up to him, and, after some demur, this was agreed to on the 27th April. A treaty of peace was then made between the King of Sardinia and the French Republic, by which Nice, Savoy, and part of Piedmont were ceded to France, and free passage through the former's kingdom granted to the French troops.

The advantages gained by this treaty and the possession of the fortresses were of enormous advantage to Bonaparte. By them he gained a great quantity of artillery and stores and a firm and solid base in Piedmont; also a new and direct line of communication into France, safe from the molestation of the English fleet. Having thus secured his rear he was able to turn his undivided attention to the destruction of the Austrians, and to enter with confidence on that brilliant campaign, which resulted in the conquest of all the states of Northern Italy and ended in the following year in the dictation of the victor's terms almost within sight of the Austrian capital.

The valuable effect that may be exercised by fortresses in a purely

* Sardinia and Piedmont were then united under one crown.

aggressive campaign is here illustrated. How to avail himself of this effect no commander has known better than Napoleon. An examination of his great campaigns of conquest in Germany and Austria shews that in every case, even when he was advancing from victory to victory, he invariably took care to secure his line of communications and to form advanced bases and points of support by taking and holding existing fortified places or by constructing new ones. For this purpose in the Marengo campaign he prepared an entrenched camp at Stradella; in the Ulm campaign he formed reserve camps at the fortresses of Strasburg and Mainz, and fortified Neu-Brisach and Huningen; in the Austerlitz campaign he chose Augsburg as his advanced magazine and fortified it, and when he advanced to the Inn he used the fortress of Braunau for the same purpose; the same proceedings may be observed in the Jena and Eylau campaigns. "This method of ensuring the reinforcement of his army by the establishment of direct reserves, and of securing his base by fortifying the strong places, is one of those precautionary methods which this audacious but careful general always took."*

Renewal of Operations against the Austrians.—On the completion of the treaty Bonaparte lost no time in pursuing the discomfited remains of Beaulieu's army, which had retired behind the Po in the hopes of covering the Milanese territory. Being reinforced by 8,000 men of the corps of Kellermann, he crossed the Po at Placentia, and, having forced the Grand Duke of Parma to capitulate, marched towards Milan, which was entered on the 15th May after a severe combat at the bridge of Lodi on the Adda River, Beaulieu retiring behind the Mincio.

Advance to the Adige.—After a slight delay at Milan Bonaparte resumed his operations against Beaulieu, and on the 28th May entered Brescia in the territory of the Venetian Republic. Beaulieu took up a defensive position on the Mincio, and garrisoned Mantua with twenty battalions of his best troops. Bonaparte, however, at once attacked and drove Beaulieu from his position, and sent Massena's command against the town of Verona, which it entered on the 3rd June. Thus Bonaparte secured the line of the River Adige, to the possession of which he attached great importance. Beaulieu retired and entrenched himself at Reveredo in the mountains of the Tyrol, where Bonaparte was unable for the present to follow.

Siege of Mantua.—The fortress of Mantua, strong by reason of its natural and artificial defences, was so situated that its possession was necessary to the French in order to secure their conquests in Lombardy and also essential to a further advance into the Tyrol. The latter could not be attempted if the garrison of Mantua were in a position to threaten the French communications; nor was

* Yorck von Wartenburg's *Napoleon as General*, Vol. I., p. 209.

Bonaparte's army of 45,000 men strong enough to permit of the advance being made and at the same time of forces being detached for the blockade of Mantua (for which at least 15,000 men would be required) and for the safeguarding of the line of communications. Nothing remained therefore but to reduce Mantua before proceeding further; accordingly immense efforts were made by Bonaparte to capture it, and by the other side, who fully realized its importance, to effect its relief.

At this juncture the Austrian Government detached Wurmser from the Army of the Upper Rhine with a force of 30,000 men to relieve Mantua and restore affairs in Italy.

Bonaparte, knowing that Wurmser could not arrive before the middle of July, utilized the interval to overrun Lower Italy, leaving 15,000 men before Mantua and 20,000 on the Lower Adige to cover the blockade. He returned from this excursion in time to meet the onset of Wurmser.

First Campaign for Relief of Mantua.—The operations which ensued are of the most fascinating interest. The judgment, daring, and energy shewn therein by Bonaparte were such that the campaign of 1796 alone, if he had fought no other, would have placed him among the greatest of modern commanders, and in none of his later and more ambitious campaigns were these qualities displayed in greater measure.

The junction of Wurmser's force with that of Beaulieu brought the Austrian total up to 60,000. To meet this Bonaparte altogether had but 55,000, of which 15,000 were engaged on the siege of Mantua and 10,000 on the line of communications and garrisons in the conquered provinces, leaving only 30,000 available for operations in the field.

Fortunately for him the Austrians, acting under the direction of the Aulic Council, divided their forces, Wurmser with 40,000 men proceeding down the eastern side of the Lake of Garda on to Verona, while Quasdanovitch was despatched with 20,000 round the upper end of the lake to descend by the western side upon Salo. If these two forces could succeed in enclosing the French army they would infallibly crush it by their great superiority of numbers.

Without the slightest hesitation Bonaparte raised the siege of Mantua on the 31st July, the cannon being spiked and the stores of the besiegers thrown into the lake; and then concentrated his army, including the force lately employed on the siege, at the lower end of the lake, where it was between the two advancing Austrian armies and in a position to attack and defeat either in detail. Massena's command was at Rivoli between the Adige and the eastern shore of the lake, but was retreating before Wurmser. The French army on the next day (1st August) moved swiftly against Quasdanovitch on the western side, defeated him, and drove him back towards the mountains. Meanwhile Wurmser, pushing Massena before him, advanced down the

eastern side and entered Mantua the same day. The following day he crossed the Mincio and advanced against the French, with a view to enveloping them while Quasdanovitch again resumed the offensive.

Castiglione and Lonato.—Bonaparte, with whom Massena's command had now affected a junction, immediately faced his army round; and on 3rd August vigorously attacked Wurmser at Castiglione and Lonato, completely defeating him.

Continuing his vigorous movements, he again drove Quasdanovitch northwards; and, turning once more on Wurmser, engaged him at Medole on 5th August and drove him beyond the Mincio. On his further advance to Peschiera and Verona, Wurmser retired again to the Tyrol and resumed his former station at Reveredo. So ended the first campaign for the relief of Mantua.

The result had been that Wurmser had been driven back with the loss of nearly 20,000 men and 60 pieces of cannon, and the spirit of his soldiers had been broken by fatigue and defeat. On the other hand he had interrupted the siege of Mantua and supplied it with a garrison of fresh troops. Moreover the French had been obliged to sacrifice the whole of their siege train, and the town could now only be taken by the slow process of blockade.

We cannot but admire the judgment and resolution of Bonaparte in making up his mind to this sacrifice. It is an example of the manner in which he always held fast to his ultimate aims and set aside secondary objects. In this case the immediate, though secondary, object was the capture of Mantua, but the ultimate aim was, as it must always be in war, the defeat of the enemy's main forces. The concentration of the whole of his available force upon the latter was undoubtedly the right course, and an examination (which space does not permit of here) of all his possible alternatives would shew that it was the only judicious one.* None the less it is only a master mind which can clearly distinguish the great from the minor issues, and unerringly select amid the stress and turmoil of war the correct course to adopt, and which further has the resolution to follow it come what may, even when it entails a great sacrifice.

After this struggle the troops on both sides remained in a state of repose for three weeks. Bonaparte did not attempt to collect a second battering train for the siege of Mantua, but contented himself with a simple blockade; in maintaining this during the autumn months his troops became extremely sickly from the pestilential atmosphere of its marshy surroundings.

Wurmser employed himself assiduously in reorganizing and recruiting his forces, while Bonaparte received considerable reinforcements from the army of Kellermann and the interior of France.

* For an examination of the possible alternatives open to Napoleon, see *Napoleon as General*, by Count Yorck von Wartenburg, Vol. I., p. 69.

Second Campaign for Relief of Mantua.—At the end of August the numbers on each side were nearly equal, both amounting to nearly 50,000 men. Wurmser, under the instructions of the Aulic Council, began to put into operation a new plan of attack on the French; this consisted in leaving 20,000 men under Davidovitch to guard Reveredo and the valley of the Adige, and descending himself with 30,000 by the gorges of the Brenta to Bassano so as to reach the plains of Padua. In fact he was again about to commit the error of dividing his forces into two columns while Bonaparte occupied a central position equidistant from both; with this difference, that instead of a lake, they had a mass of impassable mountains between them.

Bonaparte at the same time assumed the offensive by ascending the Adige. Foreseeing the possibility of a descent upon Mantua during his absence, he left Kilmaine with 3,000 men to occupy Legnago and Verona, and he himself with 30,000 ascended the Tyrol by the valley of the Adige and the road on the western side of Lake Garda. On the 4th September the Austrian positions were attacked and their troops driven headlong through Reveredo, and again followed up towards Trent, which place was entered by Bonaparte the next day, while the discomfited remains of Davidovitch's corps retired behind the Lavis.

Wurmser, on hearing of this, pushed on the faster with his force, with the intention of seizing Verona, raising the siege of Mantua, and preventing the return of Bonaparte into Italy. Bonaparte, who received by treachery intelligence of these designs, left the division of Vaubois alone in the Tyrol to make head against Davidovitch, and himself with 24,000 men descended the defiles of Brenta to attack Wurmser before he could carry out his intention. Wurmser's rear guard was caught up and driven back at the gorges of Val Sugana, and his main body routed by the divisions of Massena and Augereau at Bassano. During the confusion of this defeat the Austrian divisions got themselves separated from each other; Quasdanovitch with 3,000 men was thrown back towards Friuli, while Wurmser with 16,000 took the road to Mantua. The latter was vigorously followed up by the French, and, after several stubborn actions, was driven within the walls of Mantua and shut in there by the end of the month. There were thus left only 15,000 of the 50,000 with which the Austrians had commenced the campaign, namely 12,000 under Davidovitch, who had taken refuge in the defiles of the Tyrol, and 3,000 under Quasdanovitch at Friuli. So ended the second Austrian attempt to relieve Mantua.

After these exhausting efforts both parties remained in inactivity for a considerable time, during which the Austrians were energetically employed in repairing their losses, and the French in drawing forces from the other side of the Alps.

Third Campaign for Relief of Mantua.—By the end of October a new Austrian general, Alvinzi, who had assumed command of the troops in Friuli, had assembled 40,000 men under his standards, while the corps of Davidovitch was raised to 18,000 men.

To oppose this mass Bonaparte had 12,000 men under Vaubois on the Lavis in front of Trent; 20,000 on the Brenta and the Adige, observing Alvinzi; and 10,000 guarding the lines round Mantua.

On the 1st November Alvinzi attacked the French opposed to him, but was repulsed. On the same day Davidovitch drove back Vaubois to the plateau of Rivoli, and this necessitated the retirement from before Alvinzi of the main body under Bonaparte. Alvinzi followed up the latter and gained a victory over him at Caldiero on the 11th November.

Bonaparte's position was now desperate. His army was it is true in a central position, the main body being at Verona, and the corps of Vaubois at Rivoli keeping back Davidovitch. But their numerical inferiority was very great.

Arcola.—At night on the 14th November Bonaparte left Verona as if in retreat, but turning to the left marched on Ronco on the Adige, where he crossed the river and proceeded to attack Alvinzi's force in flank by the village of Arcola. After three days' desperate fighting among the marshes and causeways surrounding that place Alvinzi was forced to retire to Vicenza without having effected a junction with Davidovitch, who had pressed back Vaubois towards Verona.

Without losing an instant Bonaparte turned on Davidovitch and forced him to retire into the Tyrol.

The third attempt to relieve Mantua thus ended in failure, though the losses of the victors were nearly as great as those of the vanquished. The results also were less decisive, and, though Mantua had not been relieved, Wurmser had taken advantage of the confusion and interruption of the blockade to make sorties and to introduce convoys of provisions which enabled him to maintain his position longer.

Negotiations for an armistice were now set on foot, but came to nothing. Both sides obtained large reinforcements of men and made great preparations for a renewal of the contest.

Fourth Campaign for Relief of Mantua.—At the beginning of January, 1797, Bonaparte had 46,000 men under arms, of whom 10,000 blockaded Mantua and the remainder were on the line of the Adige from the Po to Monte Baldo.

The Austrian plan again consisted in dividing their forces; Alvinzi himself with 35,000 men advanced to the Upper Adige, and on the 12th January attacked the French at Monte Baldo; while a subordinate force of 15,000 advanced from Bassano by the plain of Padua with a view to raising the siege of Mantua, and on the same day drove in the French vedettes towards Legnago.

Bonaparte, who received intelligence of the plan, moved to Rivoli with the whole centre of his army to support Joubert, who was there struggling with immensely superior numbers.

Rivoli.—On the following day was fought the battle of Rivoli, in which the French arms achieved a decisive and glorious victory. On the same night Bonaparte took Massena's division and hastened with the utmost speed to the assistance of the troops on the Lower Adige. He arrived on the evening of the 15th in the neighbourhood of Mantua in time to prevent a junction between Wurmser and the troops under Provera who had approached to raise the siege. On the 16th severe fighting took place, after which Wurmser was forced back into Mantua and Provera was surrounded by superior forces and compelled to surrender with 6,000 men.

Thus in three days, by his admirable dispositions and the extraordinary activity of his troops, did Bonaparte not only defeat two Austrian armies of much greater force, taken together, than his own, but took from them 18,000 prisoners, 24 standards, and 60 pieces of cannon. Such was the loss of the Austrians in killed and wounded that they were totally disabled from keeping the field, and the French were left in undisputed possession of the whole peninsula.

The remains of Alvinzi's corps retired in opposite directions, one part towards Trent and another towards Bassano. Bonaparte followed them up vigorously, and finally drove them with further loss beyond the Tagliamento.

Fall of Mantua.—This was the last effort of which Austria was capable, and Mantua did not long hold out after the destruction of the fourth army destined for its relief. The half of its once numerous garrison was in hospital; they had consumed their horses; and the troops, who had been for months on half rations, had nearly exhausted all their provisions. Wurmser therefore capitulated, the siege having lasted since the middle of June, a period of seven months.

Campaign against Papal States.—Having achieved this conquest, Bonaparte turned against Rome, and, after completely defeating the Papal troops, concluded the treaty of Tollentino, on terms most humiliating to the Holy See.

"Such was the campaign of 1796, glorious to the French arms, memorable in the history of the world." *

Invasion of Austria, 1797.—Early in the following spring Bonaparte resumed offensive operations against the Austrians, who had raised a fresh army under the Archduke Charles for the defence of their country. Within a month he had defeated the latter, driven him across the Julian Alps and through Carinthia, and concluded an advantageous peace at Leoben, within a couple of marches of Vienna.

* Alison.

It can hardly be doubted that but for the obstinate defence of Mantua this operation would have been carried out in the autumn of 1796. The necessity for taking that place and completely securing his rear caused a delay to Bonaparte of over six months.

It is true that the possession of this fortress did not save the Austrians from ultimate defeat. That however does not prove the uselessness of fortresses, but only shews the limitations in their effect. The four great efforts made to relieve the place and defeat the French while they were still tied by the necessity of blockading it were sufficient for their purpose under ordinary circumstances. One of the reasons for their non-success was the pernicious habit of the Austrians of dividing their forces in the presence of a concentrated and enterprising enemy. But, with their superiority in numbers, even these tactics would have been successful against any one but Bonaparte. It was only by the most extraordinary vigour and boldness that the latter managed to defeat them. The strategic gain brought about by the defence of Mantua was very great, but the external forces failed to turn it to advantage.

This illustrates the maxim, which can be proved in countless instances from history, that fortresses cannot take the place of an efficient field army. Nor can they by themselves arrest the advance of a victorious invader. The utmost that can be expected of them is to delay, check, and weaken the adversary, and thus afford time and opportunity for the defender to organize and assemble his field armies, by whose operations alone can ultimate victory be gained.

WITH THE PONTOON TROOP IN NATAL, 1899—1900.

By Bt. Colonel J. L. Irvine, R.E.

PART I.—COLENSO.

On the mobilization of the Army Corps for South Africa in October, 1899, it was not anticipated that bridging operations in Natal would be necessary, but full provision was made for the passage of the Orange and Vaal Rivers. Every available pontoon and article of bridging equipment was sent to the seat of war from Chatham, Aldershot, and Woolwich; and "A" Pontoon Troop, R.E., was brought up to the regulation war strength and despatched to South Africa. No sooner however had the invasion of Natal and the investment of Ladysmith taken place than it was realised that the force advancing to the relief of that town must be provided with means for crossing the Tugela, which, from its rise in the Drakensberg at Mont aux Sources until its discharge into the Indian Ocean, is a rapid, uncertain river, flowing between steep banks, and liable during the rainy season (November to March) to rapid and sudden alterations of level.

Accordingly, "A" Troop, under my command, on its arrival at Capetown, was at once ordered to re-embark and proceed to Natal; the number of pontoons with it was increased from 16 to 30 and superstructure was added in proportion. Disembarking at Durban on the 28th November we proceeded with the equipment, in three trains, to Pietermaritzburg. The men were all accommodated in open goods trucks, each of which was fitted with benches to seat 60 men.

The journey up country was most delightful after our long sea voyage, as the train went snorting and puffing round sharp curves and up steep gradients through the bold and picturesque scenery of Southern Natal. In the low lands near the coast we passed through semi-tropical vegetation with plantations of bananas, pineapples, and orange trees, while higher up were the bare flat-topped hills and the grass-covered slopes of the veld. The whole country was intersected by deep ravines and dongas. One of the most noticeable of these, passed soon after leaving Pinetown (where the Princess Christian Hospital was afterwards established) was Krantz Kloof, a deep wide valley, hewn by nature out of the hard rock, and with almost precipitous sides which rise hundreds of feet above the Umgeni River flowing quietly at their base.

We met with great enthusiasm and hospitality all the way. At Durban the inhabitants loaded the men with cigarettes, bananas, bread, buns, etc., all most acceptable to them after ships' rations. On

our way up country, when the train stopped to water the engine, committees of ladies brought tea round. All hailed the arrival of the troops with gladness, for the nightmare of the threatened Boer attack on Pietermaritzburg, and possibly too on Durban, was still fresh in their thoughts. At Pietermaritzburg, after dinner had been served out and disposed of, a committee of ladies, many of them English refugees from Johannesburg, came round and distributed lemonade, tobacco, pipes, matches, etc., to the men; and they also provided writing desks, note paper, envelopes and stamps, all of which were very much appreciated.

Our stay at Maritzburg was longer than we expected, but it enabled us to add to our equipment all articles which the special circumstances of the case required. We provided ourselves with twelve Weldon trestles, steel cables for suspension bridges, travellers and other gear for aerial tramways, extra rope and cordage, differential tackles, additional blocks, and a variety of small stores. Experiments were also made as to the best method of carrying the pontoons and superstructure on ox wagons; and after perilous journeys over the worst ground in the neighbourhood, it was decided to carry three sections of pontoons and one and a-half bays of superstructure on each wagon.* This was a cumbersome and topheavy arrangement, but it was necessary in order to reduce transport; and, beyond giving a great deal of extra labour in packing and unpacking wagons, answered very well during the Campaign. The weight of pontoons and superstructure was approximately 4,500 lbs., which, with the weight of the ox wagon (30 cwt.), made the total load about 8,000 lbs. While at Maritzburg we also drew the horses for N.C. Officers, and a very rough lot they were—Colonial or Argentine ponies—some entirely unbroken; and also our water cart and mules.

At last orders to proceed to the front arrived; and after a busy day entraining our equipment and horses, and returning all kits, spare blankets, etc., to store, we started in three trains at 10.30 p.m. on the 10th December and reached Estcourt at 6 a.m. next morning. We then had a very busy day detraining our equipment and packing it on the ox wagons, which, with their teams, were here supplied to us. Our first experience of ox transport came next day, when, on parading at 4.30 a.m., we found that neither conductors (Colonials) nor drivers (Natives) appreciated the value of military punctuality,

* Some of our pontoon wagons were sent out from England in a different ship from ourselves, and had not arrived at Capetown when we left. We only had 13 pontoon wagons with us, so had to provide transport for 17 other pontoons and also for the trestles, stores, etc.

In the British service each wagon carries a bi-partite pontoon (capable of being separated into two sections), one bay of superstructure (*i.e.*, the material to make the roadway between two pontoons), and a few other stores.

though my best endeavours had been spent the previous evening in instilling this virtue into the chief conductor. However, by dint of hustling we at last got them all off at 5 a.m. and reached the rendezvous, where we were soon joined by our escort of the 13th Hussars. We made a goodly column in ourselves with our trestle and thirteen pontoon wagons, each with a span of ten oxen, and fifteen ox wagons with their teams of sixteen bullocks, and one water cart with four mules. We covered three quarters of a mile in column of route when the oxen kept their proper distances; but as this is not the custom with these animals, we soon lengthened out to about a mile. This was the first time I had seen ox transport and I was very much impressed with the quiet patient manner in which these beasts work and with the energy and goodwill of the native drivers and leaders. The drivers use their whips with great dexterity, and, with most uncouth sounds, urge on the oxen to renewed exertion. One soon learns the use of "Hambake" (go on) and "Ann hou" (stop), and with these two expressions one can get on fairly well as long as it is a case of "follow my leader" or formation in line; but when more difficult manœuvres, such as formation in column of sections, are attempted, the native, whose brain is incapable of great understanding and who does everything at a run regardless of any obstacle in his way or expostulations from the "baas," generally brings about rather amusing, if at the time somewhat exasperating, complications.

It was a twelve-mile march to Frere; owing to the heat, it was a very trying one to the men, who were not yet acclimatised and were moreover carrying their greatcoats and kits. We arrived there at 9.30 a.m. and settled down into camp near the scene of the armoured train disaster a week or two before.

At 9 a.m. next day we marched to Chieveley under an escort of two squadrons of Bethune's Mounted Infantry. The Naval guns had been bombarding the Boer position on the hills above Colenso for the two days previous; but never a shot did the enemy's artillery fire in return, nor were their infantry seen in any of the trenches. Was it possible, as some averred, that the Boers had retired? Hardly so, but we were to know the next morning, as an attack had been decided on. A Council of War was held at 5.30 p.m., after which I was informed that the Pontoon Troop would not be required next day and would be held in reserve, though possibly it might be wanted in the afternoon for the passage of the Transport.

Friday, December 15th, was a momentous day for the Natal Army. The infantry marched out at 4.30 a.m., and a quarter of an hour later we moved off and took up our position in rear of the low hill from which the Naval guns had lately been busy bombarding the enemy's lines. The Boer position extended for about three miles in our front, and consisted of an amphitheatre of hills, rising gradually higher and higher, of which the little village of Colenso might be

considered the arena. Their right rested upon Grobelaars Kop and their left on the formidable-looking Hlangwane Hill; beyond these two flanks the hills stretched east and west in an unbroken line and formed an impassable barrier. In front of the whole position, but curving in rear of Hlangwane, flowed the swift Tugela River, spanned close to Colenso village by the road bridge. The Ladysmith road ran north from the road bridge over Grobelaars Kop. Everywhere the active enemy had dug shelter trenches, on which our guns seemed to have produced small effect. Right in the centre of the "front row" of the amphitheatre rises Fort Wylie, a low but commanding kopje on which we had built a small work when it had been considered possible for us to hold Colenso. All along the river bed and up the sides of Hlangwane the country was covered with mimosa bush. On our side the ground sloped in a gently undulating and open plain, without cover of any description, from the high ground at Chieveley railway station to Colenso village, round which the Boers had placed their advanced trenches, and to the river. A stronger position than the enemy held it was impossible to imagine, but everywhere along the river it was the same thing, the same impenetrable barrier of almost inaccessible hills. Their weak point was Hlangwane Hill which was on our side of the Tugela. The Boers did not hold this in any great strength, as they do not like to fight with their backs to a river; but they garrisoned it with 800 picked shots and two or three guns, and it was naturally so strong with its steep slopes, its mimosa bush, and its deep and treacherous dongas, that we did not make any serious attempt to storm it. As we learnt afterwards the Boers had omitted no precautions in strengthening their position; everywhere along the faces of the hills were deep and numerous trenches kept cunningly below the sky line. The Ladysmith road was crossed by elaborate earthworks, and as the road curved upwards its sides were hollowed out into glorified rifle pits from which a murderous fire could be brought to bear on an advancing foe. The guns were most skilfully placed and carefully hidden, and protected by strong epaulments.

How little did we think of all this as our troops, with their usual British confidence, advanced towards the river. I took up a position on Naval Gun Hill, almost in rear of the centre of the attack, and watched the movements with intense interest. On the left was General Hart's brigade making for the drift, and on the right General Barton's. General Hildyard's brigade in the centre moved on Colenso village and the road bridge, while General Lyttelton's brigade remained in reserve. On the right the cavalry and mounted infantry made a wide detour to try and turn the Boer left on Hlangwane. Haze and distance made it difficult to see what was taking place on the flanks, but immediately in front of us Hildyard's brigade was slowly advancing in single lines about sixty or eighty

yards apart and with six to ten paces interval between the files, an excellent formation.

Our guns opened fire at 5.25 a.m., but for nearly an hour not a shot was sent in reply. A thought of defeat never entered our minds. Turning to an officer standing near me, I asked him what he thought we should be doing in the afternoon. "Doing," he replied with surprise, "why of course we shall be taking tea in Ladysmith"; and this was the feeling that pervaded the whole force.

A regular roar of musketry fire burst from the Boer lines at 6.10 a.m., dispelling in a most complete manner the theory that the position had been evacuated. The smokeless powder, and the deep trenches in which the Boers were hidden, made it almost impossible to locate their fire; but one could see that the enemy were in their trenches at Fort Wylie. Our guns poured in shell after shell, but no effect appeared to be produced and the fire of the Mauser rifles went on as merrily as before. The Boer guns joined in the fray, from Grobelaars Kop, the Ladysmith road, the kopjes near Colenso, and Hlangwane Hill; but amid the roar of guns and the crack of the rifles a new sound was heard, a metallic bang, bang, bang, quite unlike the explosion of any other powder; we soon learnt to know this as the sound of the Vickers-Maxim gun (afterwards christened the "Pom-pom"). And so the fight went on, outbursts of rifle fire alternating with the deep booming of the guns. At 7.45 a.m. the fury of the battle seemed to reach its climax. At 9 a.m. heavy firing burst out on our left, and our guns and infantry fell back; but surely this could be only temporary, for a few minutes later one saw the Boers galloping down from one of the near kopjes. At last apparently our fire was beginning to tell, and our Naval guns turned their attention to these fast moving horsemen; but they dodged the shells with complete success. The moment a shell had burst half a dozen left their cover and galloped across the open space till they reached the shelter of Fort Wylie; boom went the gun again, and another half dozen left their cover and were lost to view; and it was soon apparent from the redoubled fury of the rifle fire that these men were not in retreat but were reinforcing the firing line. Soon rumours of disaster began to reach us; a wounded man of the Dublin Fusiliers told us how they plunged into the river and, finding it "ten feet deep," half the leading company were swept away and drowned; the report of the drowning was confirmed by subsequent arrivals, who however reduced the number to half a dozen; another wounded man told of the "bloody butcher's shop" they went into; and worse still, a rumour crept round that the 14th and 66th Batteries of artillery had suffered heavily.*

* Later we heard of the loss of the guns and of the gallant attempt made to recover them.

The stretcher bearers and ambulances soon began to arrive at the Dressing Station with their melancholy burdens, and the medical officers were hard pressed to attend to the wounded, whose sufferings were accentuated by the great heat. It was bad enough for us who had nothing to do but to look on quietly; what must it have been for the poor wretches lying wounded on the battlefield, or, if able to walk, toiling wearily back from the fighting line, leaning heavily on a comrade's arm. The more serious cases were brought back on stretchers by men of the Stretcher Bearer Corps, mostly refugees from the Transvaal, who had specially enlisted for this purpose; and right well they did their duty.

At 11.30 a.m. rumours of a retirement reached us and an hour later we got orders to return to our former camping ground. The retirement was carried out in a perfectly quiet and methodical manner, and reminded one most forcibly of a return to camp after a field day at Aldershot, only on a more realistic scale. A feeling of gloom and disappointment pervaded all ranks, and this was more marked next day when the actual losses were known and we heard of the valuable lives that had been sacrificed. The only relieving feature for the remainder of the day was some violent cheering which took place about 9 p.m. It was caused by the return to camp of the Colonel of the Inniskilling Fusiliers, who up till then had been missing. Our only comfort was that, in spite of the withering fire to which our troops had been exposed, they had all behaved according to the best traditions of British soldiers; and although forced to retire owing to the unexpected strength of the position, they were confident that before long they would turn the tables on their foes.

An armistice for the burial of the dead was proclaimed next day, and this solemn rite was performed in a silence that contrasted most strangely with the roar of the previous day's battle. The Boers boasted that their losses did not exceed two killed and thirty wounded; however much of an exaggeration this may be, it is probable that their casualties were not heavy, for their firing line was difficult to locate and they were all concealed in deep narrow trenches, offering a very small target to our artillery. Our men, on the other hand, had to advance over perfectly open ground, and during both the advance and the retirement they were exposed without cover to the merciless fury of the enemy's fire.

The Boers busied themselves all day deepening and extending their trenches, and making a gun epaulment on one of the hills to the west of Grobelaars Kop, where they brought a gun into position to bombard our camp next day. In this evil design they were however frustrated, for, on the termination of the armistice at midnight, part of our force (among them the Pontoon Troop) marched back to Frere, while those remaining at Chieveley retired behind the railway

line out of range of the guns. It was a glorious night for a march, with an almost total eclipse of the moon.

The next month was a period of comparative inaction. For the first fortnight the heat was intense, and the Blau-krantz River, from which we drew our water supply, gradually dwindled away and eventually ceased running altogether, causing some anxiety; but the pools furnished enough to keep us going, though the water was of a very inferior quality, and wells were dug wherever there were any signs of the existence of a spring. At last the rains came with a vengeance and the dried-up Blau-krantz soon became a roaring torrent.

PART II.—SPION KOP.

In the meantime the 5th Division, under Sir Charles Warren, had arrived at Estcourt. On the 9th of January, 1900, it marched to join Sir Redvers Buller's force at Frere. This was unfortunately one of the wettest days we had experienced; the rain came down in one ceaseless rush from early in the evening of the 8th until the afternoon of the 9th; the drift over the Blau-krantz near the railway station was almost impassable, and a large crowd collected to watch the efforts of the native drivers to get their mule or ox teams through the roaring waters, against the rush of which they were barely able to stand up. By the following morning the rain had cleared off. The country was still very soft and sticky, but it improved during the day. It is extraordinary what a few hours of the hot African sun will do in drying up the rain-sodden veld.

The whole force, with the exception of General Barton's brigade at Chieveley and a small garrison at Frere, commenced a fresh advance towards the Tugela. Leaving early on the morning of the 10th of January, the mounted troops and General Lyttelton's brigade pushed forward and eventually occupied without resistance the heights overlooking Potgieter's Drift. The troops from Chieveley followed, and in the evening the 5th Division and the remainder of the troops at Frere, the garrison excepted, moved off. We were ordered to rendezvous at 5.45 p.m. at the "nek" on the Springfield road, but it was three hours later before we started, a block having occurred at the drift below Pretorius' farm near Springfield.

On the way to the rendezvous three of our wagons got imbedded up to the axles and had to be dug out, the ground being very soft and treacherous after the rain; this was not the only experience of the kind we had, as it recurred two or three times during the march. An incident that enlivened the long wait was the arrival of a "steam sapper," which came snorting at full speed up the hill, scattering men right and left, spitting out flame and fire and looking in the semi-darkness like some inhabitant of the nether regions. It was possessed with good intentions and was anxious to render service by hauling

wagons across the drift; but unfortunately in this instance good intentions did not act as paving stones, and no sooner had it reached the top of the hill than, coming across a soft place in the road, it ignominiously imbedded itself and took no further part in the show. At last at 8.45 p.m. we moved off, getting along slowly and with constant stoppages. It was very dark, and before long we were overtaken by a heavy thunderstorm, which soaked to the skin everyone without greatcoats and made the roads so slippery and muddy that marching was very difficult and most laborious. The march was interrupted by constant stoppages and at last, about midnight, came to a halt altogether. After waiting for about an hour I rode forward to ascertain the cause of the delay and soon found that the drift over a small spruit was the difficulty. Never have I seen such amusing confusion; on the right-hand side was a deserted G.S. wagon, half tilted over and with its off fore wheel in a deep hole; on the left was a bullock wagon with its near wheels firmly imbedded in the mud, from which a double team of oxen, amid the cries of the drivers, the vociferations of the conductors, and the loud cracking of the whips, was trying unsuccessfully to extricate it; in the middle, between these two, was a narrow tongue of hard ground, towards which carts and wagons were pressing from all sides, doing their best to jostle each other out of the way. One Officer and one Conductor were particularly loud in their protestations, and if a ready command of forcible language had been a password, they would not have been kept long waiting. The Officer was in charge of ammunition carts and he kept on informing the crowd "My regiment is fighting at the front and I'm d ——d if they shall run short of ammunition"; this was so often repeated that we really began to think that there was fighting going on. His efforts were ably backed up by the Conductor, and by dint of their united energy the ammunition carts were at last brought up to the drift. But, alas for the disappointments that attend our best endeavours, the second cart that tried to cross, instead of keeping quite straight, went too much to its right and got firmly imbedded in a hole, from which no efforts of the mules could draw it; and the passage then became completely blocked. Our poor friend was absolutely crestfallen at this contretemps when victory seemed so near. Seeing it was hopeless to get our wagons over that night, we made ourselves as comfortable as the wet ground would allow us and tried to snatch a brief sleep.

At the first glimmer of dawn I explored the spruit and soon found a spot where a pontoon bridge could be put in; it was quite a narrow place, just under fifteen yards (*Photo* I.). Our wagons were first passed over and then the bridge was opened to the public and used throughout the day. On the completion of the bridge, half the Troop went forward to the next spruit, a mile or so further on, and formed a bridge there; the 17th (Field) Company, R.E., was also working at this

drift. During the morning, with the help of an infantry working party, the wagons that had stuck at the first drift during the night were unloaded and drawn out and the holes filled up with stones, the traffic then resuming its ordinary course.

By 4 p.m. we had taken up both bridges and received orders to join General Talbot-Coke's brigade at Springfield bridge; so we pressed on and got into his camp at 9.30 p.m., having some difficulty in the dark in finding our proper place.

Next morning at 9 a.m. we got orders to advance. Having collected our oxen, which were out grazing, and packed our baggage, we moved out of camp; and halting at the bridge (which by some oversight the Boers had not destroyed) until the advance guard was ready, we marched to join Sir Charles Warren's force at Springfield, four miles or so further on. Here we again found a drift causing delay, so put in another bridge for the passage of the infantry.

During the next three days comparatively little was done beyond reconnoitring; but supplies were pushed up to the camp at Spearman's Hill, where Sir Redvers Buller and the Headquarter Staff had joined General Lyttelton.

On the 16th January at 4 a.m. the Pontoon Troop moved out about 2½ miles and formed up for the day, taking up a position unseen from the Boer position on Spion Kop. Leaving again at 5.30 p.m. we were very cleverly piloted by a guide, who kept us behind folds of the ground until, an hour later, we halted behind a nek overlooking the Tugela. Soon after 8 p.m. an advance took place, the troops having come up in the meantime; two companies of the Queen's led the way, followed by a squadron of the 13th Hussars and the Pontoon Troop, and then the remainder of the Division. There was a track down the side of the hill, difficult to follow in the dark and rather rough; but with the exception of one wagon, which, leaving the road, went into a hole and turned over, we got safely down the hill and on to a low-lying piece of flat ground. Here we were suddenly thrown into confusion by some cavalry from Spearman's Hill, sent to join us, cutting into the head of our column. After some little delay and a good deal of forcible language, we got on to the right track again, and formed up about 12.30 a.m. behind one of the hills overlooking Trichardt's Farm* on the banks of the Tugela. Here we snatched a few hours' sleep.

At 6 a.m. on the 17th I accompanied Sir Charles Warren and his Staff to the crest of the hill immediately in our front. From here we got a grand view of the country: on our right front were the bold and precipitous outlines of Spion Kop, gradually lowering until they reached two conical hills which overlooked Potgieter's Drift and

* Mr. Trichardt was a Dutchman who had thrown in his lot with the Boers.

acted as sentinels to the Boer position on Brakfontein; almost in rear of Spion Kop, and running out north, was the flat-topped spur of 'Ntabamnyama, also ending in a little conical turret of rock; below again were other ranges of hills, while at our feet lay Trichardt's Farm, apparently deserted, and the quiet flowing Tugela. How peaceful it looked on this beautiful day in the early morning light; the only sign that we were not the sole occupants of the country was the appearance of a single figure moving slowly towards Wright's Farm on the north bank of the river, showing that that at least was inhabited. We did not realise that we were on the eve of one of the hardest and most deadly struggles of the campaign, wherein our officers and men needed all that mettle and courage which is so pre-eminently their birthright. We then moved down nearer to Trichardt's Farm; and after a careful reconnaissance, decided on a position for a pontoon bridge, about 300 yards below the farm (itself 200 yards from the river) and just below an island that would give holding ground for the anchors.

The Pontoon Troop was ordered to advance, the artillery posted on the heights, and the West Yorks told off as a covering party and to line the south bank of the river. These preparations made, we undertook the task set us with some apprehension of its difficulties.* At 8 a.m. the wagons formed up and were unpacked under cover of the farm buildings, and half a battalion of the Devons helped us in the work of getting the equipment to the river. A brisk musketry fire burst out from Wright's farm, and was replied to by our covering party and by our artillery on the hills. The enemy soon found it too hot for them, and left hurriedly after about a quarter of an hour's firing; not, however, before they had done some damage, for Private Perry of the Devons was shot through the heart as he stooped to lift a pontoon. The men were told off into two parties, one under Lieut. J. W. Skipwith arranging for a ferry, the other under Lieut. R. Ommanney taking charge of the arrangements for the bridge. While superintending the unpacking and portage of the material a message was brought to me that the banks were nearly impracticable, being 25 feet high, almost perpendicular, and with an outcrop of rough rock. This was unpleasant news, but orders were imperative, and as far as one could see the banks were as bad or worse in other places; so, smoothing off the surface as far as possible and keeping

* Although all enquiries had been made we had been unable to ascertain the true nature of the river. The general impression gained was that the banks were high and precipitous; the velocity anything from six to ten miles an hour; the bed rocky and giving no hold for anchors; and moreover that the river was liable to sudden floods, which came down like a wall, carrying everything before them and sometimes rising twenty feet in the night. Fortunately for us this description proved generally incorrect, though it may be true in time of excessive rains.

them off the rocks as much as we could, we slid the pontoons* down; they plunged into the river, nose first, and suffered no damage except that they got a small tear or two and took in a few gallons of water over their bows.

A small backwater under the lee of the island was chosen for the launching place. Further out in the river the current gradually increased until it ran at about four miles an hour. The first six pontoons launched were formed into a ferry, which was completed at 9 a.m. Each pontoon carried from 20 to 25 men and in this manner a regiment was ferried across in three-quarters of an hour. At 9.30 a.m. the West Yorks crossed and occupied Wright's farm, by this time deserted by the enemy; they were followed by the leading regiments of General Woodgate's brigade. In the meantime a "medium" bridge (No. 1) was being formed just below the island; the first portion was made along shore and swung into position, the remainder, in the strong part of the stream, being constructed by "forming up."† The total length of the bridge was 70 yards. It was completed by 11 a.m., when, a zigzag path having been made down the cliff, the remainder of General Woodgate's brigade began to cross. On the completion of the bridge, ferrying was stopped and the pontoons passed up stream, and the 17th Company, R.E., commenced a ramp a few yards down stream to allow of the passage of wagons. These

* Pontoons are made of a light wooden framework, with a thin sheeting of wood covered with waterproof canvas, and this of course is very easily torn by friction against rocks or stones.

† A pontoon bridge is usually constructed either by "forming up," *i.e.*, by taking out each pontoon in succession and connecting it with the portion of the bridge already built out; or by making the bridge complete alongshore and "swinging" it into position. A pontoon consists of two sections, a bow end (11′ 6″ long) and a stern end (9′ 6″ long), coupled together, but each of them capable of being used separately, and each having a bouyancy of about 7,000 lbs. To form a bridge, pontoons are placed lengthwise in the stream and are connected by baulks 15′ long. The distance between the centre lines of two adjoining pontoons is termed a "bay." "Chesses" are laid across these baulks and form the roadway, and they are "racked down" with "ribands." Bridges are of three descriptions, heavy, medium, or light. The heavy bridge is made with three sections of pontoons coupled together, and, as a rule, with nine baulks; it has a safe flotation of 18,000 lbs. The medium, which is the normal bridge, consists of two sections and five baulks, and can safely carry a load of 12,000 lbs. In both these cases the roadway is 9 ft. 3 in. wide. The infantry (or light) bridge is made with one pontoon section, the roadway being 4 ft. wide; it will carry infantry in file and led horses. In all bridges every alternate pontoon is held in position by up and down stream anchors. In "forming up," these anchors have to be placed by an anchor boat. In cases where the banks are steep, trestles have to be used in lieu of pontoons for the inshore bays, in order to form a ramp, which should not exceed a slope of 1 in 7. Trestles can also be used to bridge a dry ditch or shallow stream, where the depth of water is insufficient for the proper flotation of pontoons.

ramps were completed by 2 p.m. when the bridge was dropped down stream and anchored in the new position. Some cavalry and the lighter military vehicles (field and machine guns, ammunition and water carts) then began to cross, the vehicles being passed down and up the ramps by hand and the teams walked over. There was only one accident; two mules fastened together fell into the water and were drowned. At 6.30 p.m. General Hildyard's brigade crossed, and after this the passage of artillery and carts recommenced and continued all night.

In the meantime the C.R.E. of the 5th Division organised a large infantry working party, and ramps were commenced to admit of a second bridge (No. 2) for heavy traffic near the upper end of the island (*Photo* II.). The ramp on the south side ran along the side of a donga, and by noon was sufficiently advanced to allow of a trestle bridge (at a slope of 1 in 7) being constructed from its end to the island below; this bridge was 20 yards long. From the end of the bridge the boulders were cleared away and a road made across the island. The north bank was separated from the island by 35 yards of water; but the full force of the stream was concentrated into this small space and the torrent rushed past like a mill race at the rate of about seven miles an hour, making the construction of a bridge a matter of some difficulty. The north bank too was a difficulty, rising perpendicularly to a height of 30 feet; but fortunately there was no rock and, beyond the labour of digging, no obstacle to the construction of the ramp, which had to be cut along the side of the cliff, making a difficult right-angled turn for wagons coming off or going on to the bridge. The construction of this bridge was rather slow, owing to the strength of the stream; the anchors had to be firmly planted behind rocks or secured to holdfasts driven in on either bank. The central boat was held by three cables, those on each side of it by two, and the remainder by one; and a trestle was put in at the shallow end. On account of the current, which tended to pull the bows of the pontoons under water, and also because of the large traffic the structure had to bear, a "heavy" bridge was put in. The ramp was completed at 7 p.m. and the bridge connected up with the northern bank; from that moment for twenty-six and a-half hours an uninterrupted stream of heavy traffic poured over the bridge.

It was with some anxiety that I watched the crossing of the first few lumbering ox wagons with their heavy loads, especially over the trestle portion* which had never before been subjected to the searching test of actual experience. The timbers creaked and groaned; but, to my relief, they were only taking their bearings, and in a few moments all doubt as to their standing were removed. The

* These were Weldon trestles, made hastily from our own design at Pietermaritzburg.

wagons were all driven down the trestle ramp on the south side and then across the island; to go over the pontoon bridge the spans had to be taken out and the wagons passed over by hand, as the sharp turn off the bridge and up the far ramp was impossible for oxen. Generally speaking, on this and other occasions, we found that horses crossed without trouble under all conditions; oxen soon got accustomed to the work and passed without difficulty as long as the roadway was dry, but when wet and slippery it was almost impossible to get them to move; with mules matters were not so easy. However, even with mules, it was more often the native drivers than the mules that were afraid. The native, when he saw what was before him, hardened his heart, stretched out his legs to their full extent, tightened the reins, and, throwing his body back and putting his full strength into his efforts, shrieked loudly and discordantly at his team, to which by this time he had imparted his own fears. By making the driver drop his reins, put away his whip, and either remain perfectly quiet or dismount altogether, and by leading the two front mules or all of them if enough men could be found, the teams were generally got across fairly easily.

All artillery and light vehicles finished crossing the lower bridge (No. 1) soon after daylight on the 18th January, but the upper bridge (No. 2) was in constant use until 9.30 p.m. without an accident of any kind taking place. At 2 a.m. on the morning of the 19th one of Sir Charles Warren's staff officers arrived with instructions that a bridge might be required at Venters Spruit; so Lieut. Skipwith went back with him to headquarters and brought orders at 4 a.m. to break up the lower bridge and to send material forward for a trestle bridge 45 yards long. We at once dismantled the lower bridge (No. 1), and packed up the necessary trestles and superstructure, and at 7.45 a.m. Lieut. Skipwith started with two detachments* for Venters Spruit, three miles distant. At 2 p.m. a trestle bridge of seven bays (35 yards) was completed across the deep spruit, and ramps made by infantry working parties. Two companies of the Somerset Light Infantry arrived during the morning as a bridge guard, and immediately set to work to dig trenches and to take other precautions for defence.

We occupied Trichardt's Farm, which boasted tables and chairs, a bedstead or two, a good kitchen range and other luxuries, and for the next day or two lived a quiet and almost luxurious life. In another farm near by, denuded of all furniture except the family coffin,† there was an excellent supply of half ripe peaches, which, when stewed, formed a most welcome addition to our somewhat homely diet of "bully" beef and biscuit.

* The Pontoon Troop is told off into bridging detachments, each detachment consisting of one N.C.O. and seven men.

† It is the custom in the Dutch farmhouses to keep a coffin ready to meet contingencies.

In the evening I rode over to headquarters at Venters Spruit to see our detachment there and to get orders. The encampment in the dusk was a very remarkable sight; the whole force was collected and closely packed together in a sort of punch bowl, with camp fires flickering all round; the centre of the punch bowl was cut in two by the narrow and deep spruit, now almost dry, but with evident traces that at times a roaring torrent rushes along its rocky bed; while a barrier of hills completely hid the force from the Boer position.

Next morning, the 20th, the only excitement was the passage across the bridge of the prisoners taken by Lord Dundonald's force at Acton Homes. We then made our first near acquaintance with "brother Boer," whose representatives we found to be unprepossessing in appearance, with ill-fitting dirty clothes, battered wideawake hats, and scowling and furtive-looking features. The remainder of the morning was passed quietly in the cool verandah of the farmhouse; and amid its quiet scenery, with the doves cooing pleasantly all round, it would have been difficult to believe that a battle in real earnest was going on a mile or two away, had it not been that the artillery and infantry could be seen in front taking up their positions on the hills and that the cooing of the doves was interrupted from time to time by the booming of guns and the crack of rifles.

Quite a large luncheon party unexpectedly turned up, our numbers being increased to ten by the addition of six officers, who were passing through with three companies of General Woodgate's brigade, and of a well-known war correspondent, who was fully prepared to do justice to our meagre fare. Our rations for three were eked out with porridge and stewed peaches; and our quarter bottle of whisky and half bottle of limejuice, judiciously mixed with large quantities of water, made everyone feel that they had had a good meal. The rub came in the evening when there was next to nothing for dinner.

We got cheering news of the fighting. Bastion Hill and two other positions had been taken, all was going well, and our casualties were not heavy. Convoys went backwards and forwards over the bridge, and everything was as we expected it to be. On January 21st, more convoys, just enough to keep us busy. At 5 p.m. the ambulances arrived with the wounded, which included eight officers, five of whom, only slightly hurt, came to tea with us; it was rather a blow to them, when they rejoined the ambulances, to find that the other wounded were having a much better meal of both tea and bovril. But after two days' rather scanty rations they were still hungry and, equal to the occasion, went for a second "spread."

Skipwith and his party rejoined in the afternoon, the bridge at Venters Spruit being no longer required. Our food supply was increased by a present of a fish from the officer in charge of our guard, an enthusiastic sportsman who spent his few leisure hours fishing in the Tugela. But we were never destined to taste this fish;

it did not appear at dinner, and on enquiry we learnt that the cook "did not think it fit to eat" and threw it away.

The following morning, leaving Skipwith and his two detachments in charge of the bridge (No. 2), the remainder of the Troop marched at 6 a.m. to Potgieter's Drift. Immediately after leaving Trichardt's Farm we met General Talbot-Coke's brigade *en route* to reinforce Sir Charles Warren's force in front of Spion Kop.

Simultaneously with the advance on Trichardt's Drift, General Lyttelton's brigade moved on Potgieter's Drift, under Spearmans Hill and Mount Alice; and, crossing the drift with some difficulty, occupied the kopjes in front, facing the Boer trenches on Brakfontein. The drift was little more than 2½ to 3 feet deep, though one correspondent, who had a fall when crossing, described how he and his horse had to swim for their lives in eight feet of water; but the stream was running pretty strong, and had it not been for the help rendered by the 37th (Field) Company, R.E., with their pontoons some men might have been carried away.

After settling into camp at Potgieter's we made a "heavy" bridge (No. 3) near the drift, floated it down stream, and then swung it across, utilising the existing pont as a portion of the bridge and the ready-made cutting as an approach to it. The river was here 70 yards wide and ran at one and a-half miles an hour, having fallen and slightly decreased in velocity during the previous few days of dry weather.

On the morning of the 24th we started making a suspension bridge, thinking it might come in useful; but at 10 a.m. General Lyttelton gave me orders to make a bridge higher up the river to help the King's Royal Rifles in their attack on the two sugar-loaf hills on the eastern extremity of Spion Kop. Sending back orders to collect the oxen, and giving Lieut. Ommanney instructions to follow with the material, I reconnoitred the south bank of the river, along which there is a rough wagon track. Eventually I settled on a position for the bridge (No. 4) at the western bend of a large loop which the river makes towards Brakfontein. While waiting there for the arrival of the troops, the King's Royal Rifles and the Scottish Rifles passed on the way to a drift a little higher up the river. As the track was very rough we had great difficulty in getting our wagons up. Three of them turned over when crossing a small, but very steep and difficult, donga, and had to be unpacked and reloaded. At 2 p.m. we commenced to unpack the wagons; and having carried the pontoons down the high and steep bank, we formed an "infantry" bridge (No. 4) along the bank and then swung it across the river, 75 yards wide, into position. It was finished by 4 p.m. and we then had our dinner, for which we were quite ready, having breakfasted at 7 a.m. The ramps were afterwards dug, and completed by 8 p.m.

While the work was in progress we watched with intense interest

the battle that was taking place on Spion Kop, not realising indeed that it was a life and death struggle, but still appreciating its severity. On the extreme left our troops toiled slowly up a long steep slope until they reached a point that was marked by a few small trees silhouetted against the sky line, where there appeared to be some slight confusion, and where from time to time men were seen to make rushes for cover. From there the crest line of the hill was lost to our sight, but the southern face, rocky and most precipitous, was in full view. The shells were bursting on this position, and the rapid movements of the men, who were there seeking what was apparently but indifferent shelter, gave some idea of the fury of the fire on the small plateau above. Shell after shell came pouring mercilessly from two or three directions, searching out, like fiends incarnate, every nook and cranny that afforded the least protection, and one's heart bled for the poor fellows who were so nobly laying down their lives for their Queen and country on that bare hilltop. About 6 p.m. the intensity of the fire increased tenfold, and the position held by our troops was absolutely ablaze with bursting shells, the flames from which showed up plainly now that the sun had set and twilight was beginning.

Further to the east we saw the gallant King's Royal Rifles cross the plain intervening between the river and Spion Kop and commence the steep ascent of the conical hills on the left of the Boer position. Slowly they began, in widely extended order, what would at any time be a difficult climb up the steep sides and over the occasional outcrops of precipitous rocks, but what now, in the great and parching heat, and fully equipped as they were with rifle and ammunition, must have been an enormous effort. In spite of all difficulties they carried on and were at last lost to our sight near the top; and from the musketry fire we could tell that they had found and engaged the enemy. Darkness soon hid the battlefield from our view, but before long the more slightly wounded began to arrive at the bridge head, where a blazing beacon was lit as a guide. At first we heard that everything was going well; then that the casualties had been heavy, that Colonel Buchannan Riddell of the K.R.R. had been killed at the top of the hill, and that other officers and a goodly proportion of the men had been killed and wounded; and finally that a retreat had been ordered, and that the hill was to be evacuated.

The ambulances arrived at the south bank of the river and the wounded were attended to as quickly as they came in, and all through the night a stream of men returning from the front crossed the bridge. Orders were sent during the night to remove the bridge (No. 4) as soon as it was considered that all stragglers had come in. The dismantling was commenced at 7 a.m. and, when completed, a light Berthon boat was left with a small party to help anyone who might have missed his way during the night.

At 6 a.m. on the 25th orders were brought to break up both this bridge (No. 4) and the one at Potgieter's Drift (No. 3) and to return to Trichardt's Farm as soon as possible. Leaving Lieut. Ommanney with the light bridge, I collected a working party of 200 men of the 4th Brigade, and at 10 a.m. started dismantling the heavy bridge at Potgieter's. This was completed and the pontoons packed on the wagons by 12.30 p.m. Lieut. Ommanney and his men having meantime rejoined me, the camp was struck and packed, and the loaded wagons sent up to await the arrival of the remainder of the troops on Spearman's Hill.

The road up Spearman's Hill was quite the steepest and worst we meet with during the advance through Natal; it was strewn with loose boulders and furrowed by streams of water that poured down it during rains. All attempts to mend it were hopeless; the surface could not be got to bind, and wagons coming down with their hind wheels held fast by the powerful brakes tore deep ruts. All wagons going up had to be double-spanned; so with our long convoy it was a tedious business, and took us over two hours to get to the top. We then pushed on to Trichardt's Farm, arriving at 5 p.m., glad enough to get in and to have our dinners, as we had had no food since breakfast at 6 a.m.

A site for a second bridge was selected a little way up the stream and round the bend of the river, where it would be covered from the Boer guns on Spion Kop. The drawback to the site was the bank, as there was a strong outcrop of rock with a drop of from six to eight feet. The C.R.E. of the 2nd Division undertook to have a ramp made and also a roadway for wagons to the river bank, and at 9.30 p.m. we again paraded for work. The night was as dark as it was possible to be, and although we lit a small fire to help us we found it absolutely impossible to launch the pontoons. In the dark one could not see what one was doing, and the perpendicular ledges of rock made the carrying of the heavy pontoons down the bank both difficult and dangerous. The men too were dead tired. So at midnight, finding that little progress had been made, the completion of the bridge was deferred until dawn. Ommanney and the sergeants went on working until 1.30 a.m., and got all the wagons taken along the river side until it was possible to turn them, and brought them back to the tail end of the main bridge (No. 2) at Trichardt's Farm.

At 4.30 a.m. next day (26th) we set to work again. The pontoons were brought down the ramp bridge on to the island, and there unpacked, launched, and formed into rafts, which were rowed up in the slack portion of the stream and formed into a "medium" bridge (No. 5). The bridge was completed by 6.40 a.m. and the ramps were afterwards made by the 17th Company, R.E.

During the day a constant stream of artillery and ammunition wagons and baggage passed over the heavy bridge (No. 2) and the

drift below was also in constant use. All our spare equipment was sent to Spearman's Hill and the place cleared as much as possible. At 6 p.m. all the necessary pontoon wagons, etc., were parked ready on the island and at the tail of the trestle ramp on the south bank of the river. As soon as it was dark the retirement of the force in front of Spion Kop began. A large bonfire was made on the island to guide the returning troops, as the night was very dark and there was a thin drizzling rain. Until 2.30 a.m. there was a continuous passage of artillery and other wheeled traffic over the bridge (No. 2); yet with the exception of one accident (an ammunition cart with its two mules fell over the embankment on the north side and into the river below) everything was got safely across, although at times there was a good deal of trouble with the mules in the ambulance wagons. From 2.30 a.m. there was a lull in the proceedings for half an hour, and then the infantry of the 5th Division began to cross and went on without intermission until 6.30 a.m.

Meanwhile all the cavalry and the infantry of the 2nd Division were crossing the medium pontoon bridge (No. 5) thrown across that morning. The passage commenced at 8 p.m. and continued without intermission and without accident until 5.30 a.m. next day. At 6 a.m. this bridge was broken up into rafts, floated down stream, and packed on the wagons, the Troop being assisted by fifty men of the 17th Company. Each wagon was sent away when loaded, and the island cleared as quickly as possible.

On the appearance of daylight it was found that one of the mules belonging to the overturned ammunition cart was alive; one of our drivers went into the water and cut it loose, and it got safely to land, little the worse for the accident; he also cut the drowned mule loose and let it float down stream.

At 6.30 a.m., on the completion of the crossing of the 5th Division, the dismantling of the heavy bridge was commenced; its superstructure had been much worn by the heavy traffic over it all night.

Before the dismantling was completed a message came down that we were to try and save the ammunition. This was not so easy as the wagon was overturned and was bottom upwards in three feet of water in the swiftest part of the stream, and, in addition, the brake was screwed up tight and could not be reached under water. But after working at it for three-quarters of an hour, we got it out without damage and fastened it to the rear of our wagons. We were again interrupted in our work; for just as we were going to get out the last pontoon, four stragglers appeared on the opposite bank, where they were shortly joined by two more; so we had to send across to fetch them. When the pontoon bridge was all packed up and sent away, the trestle bridge was dismantled. As the last lashings were being made fast on the last wagon (at 8.35 a.m.) the Boers seemed to see us for the first time, and opened fire with a big gun which had been

brought up on 'Ntabamnyama during the night. They only fired one shot before we got away, but it was excellently placed, the shell skimming just over our heads and falling into the donga behind. Just before this happened an A.D.C. came to say that another straggler was on the opposite bank. Taking a coil of rope Lieut. Skipwith went down to the river and, wading in as far as he could, threw the rope across to the straggler, who fastened it round his body, and was then hauled through the strong current and got to shore half drowned.

The whole force bivouacked about a couple of miles in rear, where they were behind a nek and under shelter from artillery fire. During the morning orders were sent to ferry a burial party across the river to Spion Kop; two pontoons were told off and left camp at midday, looking very proud of themselves after their recent hard work, going as if to an inspection parade with their detachments sitting inside them and large new red cross flags floating from their bows.

In the afternoon the 5th Division retired on Springfield and the 2nd Division took up positions overlooking the river. Thus ended the first crossing of the Tugela.

(To be continued).

SOME MILITARY ASPECTS OF AUTOMOBILISM.

By Capt. R. S. Walker, R.E.

I have been induced to prepare the following notes on the military aspects of automobilism, as they have from time to time occurred to me, by the thought that my experience with automobiles has been unique, and that I look at it from quite a different standpoint to that of those who have been brought up with the movement at home.

My first experience was in South Africa, under most adverse conditions, when we expected and got out of various cars of second rate manufacture more than they were ever dreamed to be capable of; naturally, we had many breakdowns, so we picked up our experience in the best possible way. After the war, as I was known to take an interest in automobiles, I had the privilege of pulling to pieces nearly every make of car that found its way into the country, large numbers of them from America and Germany. This experience, added to that gained in driving over the bad South African roads through drifts and across country, made the roads seem quite strange when I came home and started Continental tours.

On these trips also my experience has been somewhat unique, about 15,000 miles in 6 months, a large portion of the time alone. I did not stick to the main roads, but visited out-of-the-way places in France, Switzerland, Italy, Austria and Germany; burst a tyre from the heat in Italy; nearly got snowed up in the Tyrol; followed the whole of the Italian manœuvres; and tackled the mountain tracks of Bohemia.

I have driven very little in England up to date, and found the conditions quite strange to me. I therefore think my motor experience has been more akin to military requirements than that of most owners of cars; and I give my opinions, for what they are worth, in the hopes that others may find time to elucidate the many, as yet, undetermined points, and be saved from disappointment should they subsequently come across the difficulties to which I call attention.

I must tender my thanks to Messrs. Ludwig Löhner and Lindemann, and to Capt. R. K. Bagnall-Wild, R.E., to whom I am indebted for much of the material for preparing this article.

Part I. suggests a use for automobile engines; II. to V. deal with the details of various types of machinery; VI. and VII. with special types; VIII. with the military requirements of an automobile and a description of a car designed to meet these requirements during the war; IX. with unsolved problems.

I. A USE FOR AUTOMOBILE ENGINES.

The development of automobilism has incidentally put into military hands a very useful article, viz., an engine of large power for its weight and of comparatively simple construction.

When one considers the numerous things which have to be done by manual labour during and after a day's march, which could far better be done mechanically, thus saving the men from unnecessary fatigue, one realizes what a benefit the automobile industry has been to the army.

Any of the forms of power used to propel automobiles could be carried in the field by R.E. Field Troops and Companies, the weight of the motor, etc., being counterbalanced by the diminished pump equipment.

Taking as a basis a 3-B.H.P. unit, the weight of an outfit complete with accessories could be reduced to about 2 cwt. for petrol, $3\frac{1}{2}$ for steam, 5 for petrol electric, and $6\frac{1}{2}$ for steam electric. Assuming an all-round efficiency of 50%, such a motor would supply over 150 gallons of water per minute at a height of 10 ft. or *all* the wants of a Division for a day in 10 hours. A centrifugal pump with flexible coupling would probably be found the handiest to use; this and a petrol motor would weigh no more than a service lift-and-force pump.

The motor could be used for numerous other purposes, *e.g.* :—

with a circular saw, for felling trees, cutting up firewood, etc.;
with a small lathe, drill, emery wheels, etc., for wagon and automobile repairs (as Q.F. guns and automobiles come into use, the field workshop will have to become more elaborate; this is compensated for by the saving in forage, farrier and veterinary equipment);
with a blower, for several forges;
with a small pulley, to act as a winch, for helping wagons, etc., out of bad places; with derricks, for lifting weights, to pull boats, etc., across rivers, to pull carriers across suspension cables, to haul down balloons, and in numerous other ways. (This winding drum in the case of a petrol or electric motor would be a pulley about 3 or 4 inches in diameter).
with a drilling machine, for boring holes for blasting; possibly also to save the manual work of the jumper men in telegraph air-line work.
with a dynamo, for supplying electric power.

It sounds at first a very roundabout way of doing things to suggest that the engine should be coupled to a dynamo, and that the pump

saw, etc., should in turn be driven by an electric motor. But a point well worth considering is that electric transmission is so flexible ; the motor will run in any position providing lubricating arrangements are properly designed, and it is hard to conceive making a coupled steam or petrol engine equally flexible. Then we have the advantage that our electric motor can be run faster, and so be lighter and more portable, and the power plant can be a fixture on its own cart. Lastly, an electric outfit can be used for other purposes, for which a prime mover cannot, viz. :

with incandescent lamps, to load trains and wagons, to repair roads, railways, etc., to illuminate ground in case of a night attack.

to replace dynamo exploders, being capable of firing through much worse circuits (the dynamo for a 3-H.P. set would not weigh much more than a service exploder).

with search lights, the use of which will I think be found essential to reap the benefits of a successful battle, a result now-a-days usually impossible because of darkness. (A 3-H.P. outfit is sufficient to run a 1 ft. projector, which, although not powerful enough to be of much use in English fogs, is certainly enough for a clear atmosphere, such as exists in many countries we may be called upon to fight in).

If a heavier search light equipment be adopted, its engines might be used in the daytime for pumping, etc. A 2 ft. projector would require a plant weighing about 10 cwt., a 3 ft. one of 20 cwt.

It is doubtful if a petrol motor is the best type. When in order it can be started at once, and requires little fuel, attention, and water. The only drawbacks are that it will not stand an overload without pulling up ; and that it is not at present as well understood as the steam engine, and gives frequent trouble and will continue to do so until it is understood. Even if we duplicated our motors they would probably both jib at the same time for the same reason ; so that it would seem best for the present to pin our faith in steam, which every engineer understands ; it gives warning before it breaks down, and if it is working at knocking-off time to-day may be counted on to work first thing to-morrow, which cannot be said of the petrol engine when taken away from the congenial climate of Europe.

Eventually, however, the petrol engine may oust steam because of its simplicity and the greater economy in fuel.

The power unit, in whatever form, could easily be fixed on any cart or wagon, as was done in many cases with steam electric and petrol electric outfits in South Africa. By specially designing the equipment the difficulties of pack transport even of a boiler could be got over, though the petrol engine is undoubtedly the readiest to

adapt to this form of transport. A 3-H.P. petrol electric outfit could be loaded as under :—

1st mule. Engine, fan, petrol tank, carburetter, tools, etc.; base to fix engine and dynamo to for running.
2nd „ Dynamo and instruments.
3rd „ Cable.
4th „ Electric motor centrifugal pump and hose.
5th „ Projector, tripod, incandescent lighting gear, tools, etc.
6th „ Saw, drills, emery wheels, spare parts, hose, etc.
7th „ Water;

in addition one mule for petrol per 50 hours the engine is likely to be used.

Other uses will occur where mechanical power could be used in the field, to the saving of men, who can ill be spared from outposts and other military duties. All officers of Engineers know how grudgingly the necessary fatigue parties for pumping, etc., are granted; and it would seem that the adoption of some such equipment is justified, especially as it will not increase the loads we have to carry nor the necessary trade qualifications of the men.

II. REMARKS ON STEAM MOTORS.

In considering the various forms of motive power, I will assume an acquaintance with the forms in general use and confine myself to calling attention to points which forced their attention upon me in various ways.

Steam is the form of power best known, and as such was naturally the first adopted for automobiles. In the heavier classes it may be said to thoroughly hold its own, but in the light class its use is most uncommon; this is chiefly the outcome of the mechanical ignorance of owners of cars, and their absence of concern for their motor, which would be fatal in the case of steam cars. But whether the petrol engine is sufficiently perfect to justify its lead is a moot point. It is a remarkable fact that in America, where roads are bad and the load a rapidly varying one, the steam car is more frequently used. With a steam car, if you stick on a hill you can get up a good head of steam and do another sprint, and so on till you get to the top; in sailing down hills you can fill up with water and regain normal conditions; this is a great advantage in bad country, and means that the boiler only needs to be sufficient to steam continuously at about half the power of maximum load. A steam engine can be double-acting, and economically regulated; the parts can be inspected whilst running, and incipient faults can generally be detected in this way; these faults are easy to diagnose, and the remedies are mostly simple and easy to carry out. A steam car may be said to have an infinite number of "speeds." For military purposes a steam car has great

advantages in its silence (several times cars passed within 100 yards of blockhouses on a still night without being heard).

On the other hand, if good water is not to be had, great care is necessary; the engine, boiler and furnace want continual attention, which is much more than that for petrol engines; it takes about ten minutes to get up steam, and if petrol or paraffin is used for fuel you will consume about twice the quantity required for a petrol car to do the same work.

Boilers of flash or semi-flash type, although they do not scorch, all seem unsatisfactory, and are very complicated and difficult to repair; the latter remarks also apply to water tube boilers. Undoubtedly the simplest boiler is the cylindrical with vertical fire tubes, a type which everyone will scorch to begin with; but once a man is used to it, he can keep his water at the proper level, even without a gauge glass; such a boiler can generally be repaired in the field.

The Klinger gauge glass is the only satisfactory one. Superheaters, although simple in themselves, cause trouble with lubrication; this may be got over to a certain extent by using plenty of graphite with the cylinder oil. Leaky glands also seem to be more common with superheated steam; on the whole it seems an unnecessary complication, which is not justified by practice.

For military purposes a paraffin furnace would be a great boon (paraffin being so much easier to store and safer to handle); unfortunately it has a nasty habit of decomposing in the parts of a burner and eventually choking the tubes, etc., it passes through. The only paraffin burners we had, which worked satisfactorily, were of the steam paraffin jet types; a very good burner was such an one from an American launch by Shipman, but the boiler was heavy, and it is hard to see how the principle could be adapted to the cylindrical fire tube boiler.

The petrol furnace used in America, with small petrol holes, round central air holes, corresponding to the boiler tubes, is the best up to date; but it is a demon in high winds; the only way to cure blowing back seems to be a live steam jet in the chimney.

In some of the small engines ball bearings have been introduced. For military work, this is not an advantage; repairs may have to be executed in the field, and looking for a ball in a dusty road is like looking for the proverbial needle.

Although they have not yet been used in automobiles, steam turbines of the de Laval type are worthy of military consideration. These little motors, running at 30,000 revs., weigh little; unfortunately the speed is too high, and the reducing gear does weigh something. They require absolutely no attention beyond filling their oil tank periodically, and they govern perfectly. We had one running nightly for 14 months with steam at all sorts of pressures, and often very wet, and it was as good as new at the end. The remarks about

saturated steam above do not apply; and when used with a condenser, no separator is required as no oil enters the steam chamber.

In considering a steam electric outfit these simple machines are not to be lightly put aside. As at present made a steam dynamo of 3 H.P. would weigh more than mentioned in I. above; but there is a great deal of cast iron in the base, covers, etc., etc., which could equally well be of aluminium or thin steel, so that the weight could be very considerably reduced. A 3-H.P. set weighs now, I think, from 2 to 3 cwt., and could be reduced to from 1 to 1½ cwt.

Condensers are a military necessity to increase the radius of action; probably the beehive and fan would answer all requirements.

Automatic devices should be avoided. They only serve to give a false idea of security, invariably get out of order, and require a great deal of work before they can be put right again or got rid of (which is sure to be their ultimate fate). I do not include safety valves in the above remarks, though even they may prove a delusion; I remember one night, with a Search Light plant, finding the pressure gauge hand hard against the zero stop on the wrong side; I started the engine very hurriedly; next day I discovered that a genius, who had had the safety valve off to clear the tube, had plugged it up with cotton waste! The pop safety valve might be a serious nuisance; it has a nasty knack of going off like a fog horn, which, besides frightening horses, would give the show away on a night reconnaissance (just the job for a steam car) when one would be likely to keep a full head of steam ready to dash away with.

III. EXPLOSION MOTORS.

The Otto cycle may be said to have been adopted in all successful explosive motors of modern design with one exception, and that exception is not yet on the market.

The theory of explosive motors has not received nearly so much attention as that of steam, and consequently we are continually brought face to face with problems which no one seems able to solve. Ask any mechanist what he thinks of an explosive engine, and he will say they are all right when they run, but they're devils once they begin jibbing. He will probably not admit that he does not understand them as well as steam, but this is the case; and so long as it is so, the explosive engine will never be given a fair chance; it is damned by its driver before he tries it!

At first sight, by the side of steam, the petrol engine is simple, but when we analyse matters we see that this very simplicity is a sign of its crudeness. Were efficiency of no importance we could design an equally simple steam engine. An explosive engine is noisy, which is bad from a military point of view.

The weight of an explosive engine, as against that of a double-acting steam engine, is much greater, there being only one working stroke

in four; for equal mean pressures and speeds the cylinder would be about 4 times as heavy. On the other hand, the weight of fuel used, allowing for the present worse efficiency, is about ¼ that of coal; no boiler is necessary; the small quantity of water required for cooling is also a great advantage, and with pure fan cooling none would be required. An explosive engine requires practically no attention when running.

If we could use petroleum as our fuel, as already stated in II., it would be a great advantage. At present there are two ways of turning the liquid used into gas; firstly, by squirting it into the hot cylinder; secondly, by vaporising it outside and admitting it through a valve. The vaporising, in the case of petrol motors, is combined with the admixture with air in the carburettor. No paraffin vaporiser is at present reliable enough for automobile use.

There are many types of carburettor; and the present tendency is to simplify them and do away with all adjustment, *i.e.*, no matter what the state of the air to have the same sized air and petrol openings. This is very nice for those who wish to turn the handle, start their car, and never bother any more about it; but will not do for military purposes, where we want always to get the most out of our engine, provided it does not get over complicated. With different air and different petrol we have different proportions in which they should be mixed to get the best results; if anyone does not believe this, he should drive a car with a Longuemarre carburettor from just before to just after sunset in a hot country, and try the effect of varying his mixture. There should be levers for hot and cold air, petrol, throttle, and ignition. In some carburettors air is admitted after the mixture has been formed; this may re-condense the petrol, and the place of admission must be carefully chosen.

In the cylinder good material is essential, as there is a great tendency to wear from the obliquity of the connecting rod, which does not occur in steam engines. When once a cylinder has worn oval, new rings will soon fail to make a tight joint; and the result will be considerable loss of power, firstly due to loss of suction, secondly to loss of compression and consequently of explosive force, and lastly to leakage of the explosive mixture past the pistons.

The efficient cooling of cylinders is a great point, and I venture to state that no petrol car has sufficient cooling arrangements for a hot country. Owing to bad roads, I have frequently been unable to travel faster than the wind, and most of the time with the engines working at full load; this on a hot day travelling down wind is the equivalent of running the motor at full load in a boiler house. How many cars would stand that for long? Once, to avoid this, I left Pretoria for Johannesburg after dark; and although the whole distance is only 40 miles and we completely changed the cooling water once, we had to stop two other times for about ¾ hour each time to cool down;

the last 10 miles was at right angles to the wind and on fair roads, so that we travelled faster. Fan cooling is therefore essential.

Dry batteries in a hot country are no good for ignition purposes, they soon get dry!

Accumulators, unless you carry your own dynamos, are difficult to charge; and owing to the rough roads they splash, get dust in them, and rapidly deteriorate.

Sparking coils must be kept well away from hot parts and the sun; otherwise the paraffin may melt and put them out of action.

Magnetos, when standing in the open, may get damp and be difficult to start.

Other ignition troubles, which may be ranked next to tyre troubles, are known to all automobilists; and I am of opinion that, for a military car, there should always be a second form of ignition.

IV. ELECTRIC POWER TRANSMISSIONS.

The chief advantages in the military application of electricity to the propulsion of automobiles seem to be:—its simplicity, the reliability of all electrical gear, the silence with which it works, and its flexibility. Under the latter heading it is worth noticing the following:—suppose two automobiles are together, and the source of power in one fails, the other can supply it with power; and if the other's motors break down, it can couple itself to the first, and supplying the power, be towed by it. Its flexibility also shows itself in the fact that, like steam, an electric automobile may be given large numbers of "speeds." The source of power can be used for all the purposes enumerated in I., for which purposes other forms of transmission do not so readily lend themselves; and thus an automobile tool cart would not need to carry the extra power outfit suggested in I.

The disadvantages are:—faults as a rule do not give warning; and when used near paraffin or petrol there is a slightly increased danger of fire from sparks.

The source of power may be a dynamo, a battery, or a combination of both. As regards the dynamos, they may be direct coupled to a petrol motor, or driven by a chain or gearing.

Accumulators are very heavy for their power, and require a charging plant always near at hand; for these reasons they are not suitable for military purposes. There is, however, a way in which they can be used, which has a great fascination, viz., as a supplement to the primary plant, so as to take the peaks of the load diagram, *i.e.*, help the engine take the car up a bad hill and be re-charged on the down grade; in this way the engine might always be working at full load and maximum efficiency, and be of smaller power, and in the case of a breakdown the battery might save the situation. Unfortunately, the extra weight, as accumulators now go, more than makes

up for the saving in engine power, and the gain in efficiency is swamped by the extra power required to carry the battery. If the weights of accumulators are ever reduced, the question will be worth re-considering, but the other disadvantages of accumulators would then also have to be taken into account; they need ventilating, and dust gets in at the ventilation holes; shaking damages the plates and splashes the liquid; and there is a great tendency to over-discharge.

Electro motors have one great advantage over petrol and even steam engines, in that, for the same power, the slower they run the more force they exert at the wheels.

In one or two types of electric cars, we find a front wheel drive, to which electric transmission is easier adapted, and a few remarks on this are not out of place.

Firstly, the whole car is pulled instead of being pushed, and so the frame can be built a bit lighter; secondly, there is much less chance of side slip (not altogether unknown with iron tyres); thirdly, it is easier to steer the front wheel clear of obstacles on the road. The only objection is that the front wheels are the steering ones, and do not move parallel to each other; so that, if the motor is not a part of the wheel, it must either be directly geared to it, and moved with it, or the drive must be through cardans.

If we adopt a military front drive, we can then either have a single motor and differential shaft, driving the wheels through gearing and cardans, or two motors either driving similarly or each gearing into the wheel and turned with it; the latter would seem to be the simplest.

Whilst on this subject it may be remarked that there are many occasions, in bad country, especially in mud, where one set of wheels will not grip but fly round, when the others which cannot be driven would grip; and it is worth considering whether, in a military car, we should not have all four wheels drivers, thus utilising the whole weight of the car for adhesion; the extra weight consequent on splitting up our power might be justified in practice.

V. MISCELLANEOUS MECHANICAL NOTES.

Besides the systems already enumerated, in America two other systems have been experimented with, it is said with success; and although for military purposes, for the reasons already stated, I advocate a steam or electric system, these systems with a petrol engine may be found to be more efficient than the usual form of transmission. The systems are hydraulic and pneumatic transmission.

Briefly the engine works a compressor; there is a reservoir, which has the advantage of a battery of accumulators (hence the economy); and the power is reconverted in water or air motors at the wheels. In the case of air this transmission weighs virtually nothing (tanks for

storage and connections) besides the compressor and motors, which altogether should not be more than the weight of change-speed gears, chains, differentials, etc., let alone the reduced size of the prime motor. It would be very quiet also, and the exhaust air could be used to prevent the dust rising.

As regards the various forms of mechanical transmission most points are now understood. Belts for military purposes are out of the question because of their liability to get wet. Chains stretch, and provision must be made for shortening them and altering the length of drive. There is a very good American chain which can be opened anywhere, and a link taken out or put in; this is also useful in case a link breaks (care must, however, be taken or the whole chain will tumble to pieces, a nice contingency on the roadside at night!); many spare parts and a complete spare chain should be carried. If a chain gets out of pitch it should be discarded at once.

It is worth noting that with a chain drive two or three different-sized driving pinions may be carried; and the gear can thus be easily altered in a very short time according to the nature of the country and the work to be done.

Toothed, bevel, and worm gears by good makers may all be relied on, and with raw hide are fairly quiet.

The form of change-speed gear usually employed is objectionable from a military point of view for the following reasons:—unless you have a very careful driver, and Tommy is seldom that, they will wear badly; they are also apt to become very noisy, and a bad driver changing speeds makes a great deal of noise.

There is a thoroughly mechanical gear, the crypto, used on many American cars, which has none of these disadvantages.

In considering gear there is another question, and that is the number of speeds required. In rough country with hills, etc., changing speeds is a great nuisance, and a two-speed gear is far easier to drive than a three or four-speed one. I am of opinion that the saving of the driver more than makes up for the loss of time and petrol. As an example, on a three-speed car, going towards Johannesburg from Pretoria, I counted the number of times I changed speeds, and had exceeded 100 and given up counting long before getting half-way; the whole journey on a two-speed car only necessitated 10 changes of speed; the relative differences in time are difficult to compute.

The above remarks on change speed gears of course only apply to petrol cars simple.

Cardan transmissions, although very simple and reliable, are not needed for military cars, unless to allow the frame to rack with a counter shaft drive.

Pipes for steam, air, water and petrol, and their valves, require to be looked at periodically, and blown through to clear out sediment or

other obstruction; they must also have numerous bends to make them flexible. It is advisable to paint the different systems in different colours to facilitate tracing them.

Electric conductors must be well insulated; kept away from hot parts and the sun; never allowed to rub against or be rubbed by anything. All joints should be thoroughly insulated, and connections easily accessible for testing and cleaning purposes.

All bolts and nuts require frequent attention. All bolts should have lock nuts as well as split pins.

Parts of the car should be such that in case of damage they can be repaired even with inferior material. For example, in South Africa, a certain car had springs by Lemoine, undoubtedly the best spring maker; these springs were gripped in a sleeve which was only just large enough to take the same section spring, and could not be made larger; the front springs were broken going over a drift, and every smith of note was set to work to try and make a pair of springs; we succeeded with one, but a second which would hold, even driving carefully, could not be made, and the car had to wait till springs could be obtained from France. Many similar accidents might occur; and although there might be duplicate parts at the base or an advanced depôt, it would be much better to be able to make shift with something to be obtained locally rather than to have to wait.

It is needless to say that all threads should be Whitworth, Gas or B.A.; and that the number of sizes of bolts, and in fact of all parts, should be reduced to a minimum; in the Pretoria design we succeeded in reducing the bolts to two sizes.

All parts of engine, etc., should be easily accessible, and capable of being removed or replaced without needing a pit.

To ease the shock on engines, chains, and gears on starting, where an electro motor is not in use, it will probably be necessary to introduce a spring drive of some sort.

Brake blocks expanding inside a drum fixed to the wheels are the best form. Band brakes are nearly always on, and brakes on the engine, etc., are bad as they strain all the transmission gears unnecessarily. A tyre brake could be used on metal wheels.

Lubrication should as far as possible be regulated by sight feed lubricators, a separate way to each part.

Clutches should be water tight for passing through rivers.

Every tool and spare (in reason) which can be required should have its allotted place in the car, and those most often required should be very easily got at.

As regards tyres, first and foremost rubber will not stand hot climates and moisture is a great enemy to it. In South Africa pneumatic tubes and covers, even when not in use, got very quickly porous from these causes, and tyres cannot be counted on to last more than two or three months for tubes, and six months for

covers. Solid tyres, which also have other drawbacks, would perish similarly.

Next come punctures, which will be more liable to occur on service than in peace, for two reasons,—(1) the roads will be upset, there will be many shoe nails, etc., on them, and (2) you will have to go up many country lanes and cross country; any cyclist who has followed large foreign manœuvres will support this. Punctures always mean loss of time. Suppose you puncture when near the enemy (if pneumatic tyres are used they will stretch barbed wire, strew nails, etc., on purpose), and jack up the wheel; you may get caught in the act, and then it is no good being able to travel 50 miles an hour. On the other hand, if you run on your rims, you may have to do so for miles and will ruin the tyres; you will have to drive slowly for fear of side slip (I had the pleasure of turning upside down in South Africa from this cause), and possibly smash a wheel or spring, and you may even get caught then.

Single tubes are not quite so bad as double ones; but when they puncture, they take ages to repair; and you probably pull the tyre to pieces if you run far on it deflated.

Pneumatic tyres for large wheels would also be very expensive, and very difficult to repair. Imagine levering on a 5 ft. cover!

The great advantage of pneumatic tyres comes in for very high speeds, but a military car will not as a rule be called upon for them. If such a contingency is contemplated, a set of pneumatic wheels of small diameter could be carried, and changed when such high speed is required; or ordinary cars could be kept for the purpose.

VI. THE LÖHNER-PORSCHE SYSTEM.

This is a petrol electric car, and consists of an ordinary petrol motor with pump, fan, and cooling arrangements. In place of the flywheel is a dynamo, the armature of which revolves, the field magnets sliding on a shaft in a position similar to a clutch of an ordinary car. The commutator is vertical and outside. The brushes are of carbon and very accessible. By this means the effects of vibration are minimized. The whole is covered from below to keep out dust and mud. There is a special governing arrangement, which consists of a spring equal in strength to the torque at full load. As the work increases the current supplied to the motors increases, the torque increases and the field magnets are slightly displaced; this increases the air gap and thus decreases the volts, with the result that (within limits) the dynamo runs at constant watts. By this means the engine is always running at full speed and full load unless you wish to throttle it, and an infinite number of speeds is obtained. For hills of a steeper grade than 7% a low gear can be obtained by changing the motors from series to parallel. Under the footboard is the

commutator, which is worked by a lever from the outside. Whenever this lever is moved or the brakes put on, the current is shut off. The various movements correspond to going backwards, starting the engine with the accumulators or charging the accumulators, high speed forward, low speed forward, five degrees of electric brake and finally the back wheel brake.

The motors are fixed to the rims of the wheels by metal spokes, the field magnets being inside and fixed to the axle-tree arm. The commutator is also vertical. The whole runs on ball bearings and is contained in a dustproof cover. Most parts of dynamo and armature are interchangeable. The steering pivot is inside the field magnets and aligned with the wheel contact on the ground, the wheels being vertical. This obviates any chance of twisting the car round should one motor give out.

The steering is the ordinary irreversible type. The brakes are on the back wheels, and electric ones on the front wheels; the latter form practically obviates all chance of skidding.

Any form of body can be fitted to the chassis, since there are no chain wheels or differentials in the back portion of the car to hamper its construction.

The combined efficiency of dynamo and motor is 75% to 80%. The ordinary running pressure is 50 to 150 volts, and the current 116 to 232 ampères. Four cells are sufficient to start with high tension ignition, and seven with magneto. The weight of each front wheel complete with motor is $2\frac{1}{2}$ cwts.

The chief advantages seem to be;—any shape body can be used; a greater efficiency at full load; a greater mean speed unless purposely throttling; always working at full load; easy to start the car; easy to start engine; the engine not strained at starting or on irregular ground; the strain on the driver owing to change speeds entirely removed; the gearing most reliable; the chances of side slip materially reduced; the steering very easy, and the front wheels vertical at the same time; the wear and tear of gears done away with; slightly reduced weight; and less liability for the wheels to slip round on greasy or sandy surfaces.

On the other hand the driver requires more knowledge; and there is a slightly increased chance of fire.

Power Required.—The mean loss in the dynamo connections and motor is about 25%, as against 50% with gear transmissions in an ordinary car. With gears of, say, 40, 25, 15 and 8 miles per hour, and an engine speed of 1,000 revs., the mean speed of the engine of a petrol car on a road, assuming throttling is unnecessary, would be about 800 revs., so that the average unused power of the engine is about 20%. In the L.P. System you are always working at full load. Thus, for the same mean speed of gear, in the case of the L.P. system you need an engine of about $\frac{100}{75} = 1{\cdot}3$ times the mean power required

at the wheels, and in the case of an ordinary gear about $\frac{100}{80} \times \frac{100}{50} = 2{\cdot}5$ times the mean power, or about double the former, assuming everything else to be equal. In practice, however, the efficiency of the smaller engine is not so great, and the theoretical advantage seems to be reduced in other ways, so that it requires an engine of about $\frac{3}{4}$ the power to get the same effects with the petrol-electric system.

The petrol consumption is probably much the same in both cases.

As regards weight, that of the L.P. engine will be about 25% less. The armature of the dynamo acts the part of flywheel, and is about the same weight as a flywheel of an ordinary engine the same size. The field magnets correspond to the clutch, but are a little heavier. The motors and connections are but slightly, if any, heavier than the change-speed gears, cardan or chains and differentials, so that on the whole a saving in weight is obtained. All this weight is on the driving wheels.

Engine without Flywheel.		Dynamo.	Motors and Wheels.	Total Weight.	Engine with Flywheel.		Gears.	Total Weight.
H.P.	cwts.	cwts	cwts.	cwts.	H.P.	cwts	cwts.	cwts.
15	3	2	5	10	24	6	3	9
30	8	3	5	16	48	15	7	22
70	20	5	5	40	100	40	20	60

VII. THE HART TWO-CYCLE MOTOR.

This motor is of much the same construction as a four-cycle one, except that the valves are merely openings in the cylinder. There are five valves; one for the admission of the mixture to the crank chamber, one for the admission of the mixture from the crank chamber to the cylinder, one for the admission of pure air to the connection between the crank chamber and the cylinder, and two for the exhaust. These valves are periodically covered and uncovered by the piston which is its own slide valve. *Fig.* 1* shows the end of the suction stroke. The carburettor is connected to the crank chamber, in which suction is created by the upward movement of the piston and the chamber is filled with mixture. Just at the top of the stroke air is admitted to the portion connecting the chamber and the cylinder, which is thus filled with air and not mixture. On the downward stroke the inlet valve closes and the mixture is compressed slightly. Near the bottom of the stroke the exhaust and then the inlet valves are opened. The exhaust escapes, and mixture is forced into the cylinder, being diverted from the exhaust ports by a baffle on the piston. The pure air leads and saves firing the charge; it also helps to scour the cylinder. The mixture does not escape past the

* On page 413.

exhaust ports, because it is only at atmospheric pressure at the end of the stroke. On the upward stroke the mixture is compressed and fired as usual.

The chief advantages of this system seem to be:—Reduced weight; smoother running; lighter flywheel; with absence of valves, springs, cams, etc. On the other hand it would appear that the piston rings would be liable to catch in the ports; that these would erode and so wear out the cylinder; that they would always be difficult to get at, and too much lubricating oil might get into the cylinder.* As regards the weight these engines will weigh considerably less. The power per explosion for cylinder volume will be about the same as with a four-cycle motor. But there are twice as many explosions; therefore for the same number of revolutions you will get twice the power; at the same time the fluctuation of energy will be about half. Hence the whole weight of engine ought to be about half that of a four-cycle one. These engines are built to run up to about 1,000 revs., which is as fast as most four-cycle engines run.

Engine.	H.P.	Cyls.	Engine.	Flywheel.	Total.
			cwts.	cwts.	cwts.
Hart	25	2	—	—	3
Ordinary	25	4	4	1	5

It is very difficult to get reliable data, so that the above must be taken as an approximate comparison.

VIII. REQUIREMENTS OF A MILITARY AUTOMOBILE.

Automobilism has grown so much of late that it is absolutely necessary to subdivide it into many branches, and the expert in any one branch has hardly time to be up to date in the others. My experience has been almost exclusively with one class, and so I shall chiefly confine my remarks to that class.

The classification I adopt is:—

(1). Tractors and long trains.
(2). Lorries and trailers.
(3). Central power transmitted through long trains.
(4). Fast light cars.
(5). Cycles.

The ways in which the above lend themselves to military use may be briefly summarized as:—

(1), (2), and (3) for supply columns, 2nd line transport, heavy guns, ammunition columns, to save infantry on the march, and to save the horses of field and horse artillery, etc.

* Mr. Lindemann now informs me that the engine will not be put on the market in its present form for this very reason.

(4) and (5) for scouting, surprises, carrying small bodies of men or urgent stores quickly, carrying staff, orderlies, etc., and for telegraph linemen.

(4) also for carrying Generals, towing machine guns or R.E. tool carts or cable carts, etc., as trailers; and as a source of power for pumps, electric light, etc.

The chief disadvantages of automobiles of the different classes are:—

(1) and (2) are rough on the roads; (1) require wide and good roads, and (2) fair ones.

(3) are more complicated than (1) and (2), but save the roads and are an easier load for bridges.

(4) pneumatic tyres are out of the question for general military work (suppose you puncture on a greasy road, just when you want to run away); frames are not strong enough to stand rough work; the engine is invariably too low, and the wheels too small.

(5) are heavy to push, and noisy.

In my opinion, however, a military car of class (4) can be designed. Its requirements are:—The wheels should be ordinary gun wheels; the springs very flexible; the motor very powerful, quiet, and capable of running hours at full load with the car stationary; the car should have a large radius of action, and be capable of going across country, carrying with it its own gear to bridge small obstacles up to 15 to 20 feet; the motor must be at least above the level of the axles, when the springs are depressed; the low gear should be such that a man can walk up a steep hill or across a ploughed field alongside the car, and the high gear as much as nerves will stand on a medium road (probably not more than 20 miles an hour), unless a second set of pneumatic tyred wheels is carried.

There should always be on the car as many men as possible; they can help it over bad places (I never regretted picking up a peasant in Italy or Austria, where the side roads are very bad and sometimes almost impassable; and in South Africa we used to send extra men on horses, whenever possible, to help push out of mud holes, etc.; of course with large wheels the need for this will diminish). There should be a winding drum and rope to help self and others out of bad places. Last, but not least, the design should be simple, get-at-able, and easily admit of dismantling and packing in a small space for transport by sea or rail.

Such a car sounds impossible to those who only think of the present type of scorching machine, but it is bound to come for civilian country purposes as well as for military; when makers have time to think of the future they will see this. If I were agent for such a car, I could sell hundreds in Austria where the roads are not as good as in England.

Before the end of the war in South Africa we got out a design for such a car, and commenced building it. The body work can be seen

from the accompanying *Plate*. The springing would require testing on the road before being accepted as sound, though from what one could see in the shops it seemed all right. The weight of car with engines would have been about 2 tons. Length overall 18 feet; track 5 feet 8 inches, wheel base 9 feet. Seating accommodation for up to 28 men, and a well for carrying stores. The steering was by ordinary irreversible gear, but with side lever instead of wheel, as being handier for slow speeds and out of the way; and the steering pivot and wheels were both canted to meet at the turning point on the ground and ease steering. This or a similar body might be found quite serviceable. It could be dismantled and packed into a very small space and could be very rapidly re-assembled.

In deciding on the form of transmission to be adopted in military cars, the first question to be answered is, in what countries will they be used? Presumably for us this will be in any part of the world. It is also to be presumed that there must be little, if any, alteration to adapt them to different localities. The nature of fuel, except as regards safety, is immaterial, since in most countries it will have to be specially carried.

If a petrol engine alone were used, it would be connected to a counter-shaft with differential gear through a change-speed gear, and the wheels driven by chains. If a steam engine were used, it would drive the wheels direct from chains, either using one engine per wheel or a counter-shaft with differential.

An electric system pure is out of the question. If a petrol electric system were used, the motors would drive the wheels through chains or simple gearing, one motor being used for each wheel, or only motors for the back wheels.

At present the comparison between paraffin and petrol seems to be unfavourable to the former in all cases.

As regards weight, we have to assume that we may be called upon to work at altitudes where only 50% of the power is to be obtained from a petrol engine*. The petrol engine, therefore, must have a B.H.P. of $\frac{100}{50} \times \frac{100}{80} \times \frac{100}{50} = 5$ times the average power at the wheels. In the case of a steam engine, the efficiency of the drive may be assumed to be as much as 80% and the loss due to higher altitudes *nil*, so that an engine with $1\frac{1}{3}$ times the average power at the wheels would suffice. With the petrol electric system the efficiency is $75\% \times 50\%$, which means an engine of $2\frac{2}{3}$ times the mean power at the wheels. A steam electric outfit would require an engine of $1\frac{1}{3}$ times the mean power.

The relative weights of engines, gears, etc., are rather difficult to calculate precisely, but it is assumed;—that the weights of engines and all gear varies nearly as the H.P.; that a two-cycle engine weighs a

* This would occur at about 7,000—8,000 feet.

little more than half a four-cycle one of the same power, and a steam engine about $\frac{1}{5}$ that of a four-cycle petrol one; that the boiler is at least 6 to 8 times the weight of the steam engine; that the high altitude petrol engines have their gears designed to take their full horse power; that dynamos, motors, etc., weigh about the same as the ordinary transmission gear, this being roughly twice that of the engine itself.

As regards the petrol consumption, it is assumed that it varies with the power in petrol engines of all types, and for the same power it is the same at all altitudes; when used in a boiler furnace the consumption is about four times that in a petrol engine power for power.

As regards the starting torque it is assumed that $\frac{1}{3}$ the power can be utilized at the wheels of a petrol car, half of it in a steam car, and practically all in an electric car.

The result of the above assumptions are tabulated with the resulting relative weights of the three systems.

System.	Relative Engine Power.	Engine and Gear.		Relative Weight.	Relative Petrol Consumption.	Relative Starting Torque.	
		Weight Factor.	Relative Weight.			Abroad.	Europe.
Petrol 4-cycle, Europe	2·25	1·4	3·1	2·4	1·9	—	·4
„ „ Abroad	4·5	1·3	5·8	4·5	1·9	·4	·8
„ 2-cycle, Europe	2·25	1·1	2·6	2·0	1·9	—	·4
„ „ Abroad	4·5	1·0	4·5	3·5	1·9	·4	·8
Steam	1·0	1·8	1·8	1·4	3·3	·4 to ·8	·4 to ·8
Petrol Electric 4-cycle, Europe	1·2	1·5	1·8	1·4	1·0	—	1·0
„ „ „ Abroad	2·4	1·4	3·3	2·5	1·0	1·0	2·0
„ „ 2-cycle, Europe	1·2	1·1	1·3	1·0	1·0	—	1·0
„ „ „ Abroad	2·4	1·0	2·4	1·8	1·0	1·0	2·0
Steam Electric	1·2	2·1	2·5	1·9	4·0	1·0	1·0

REMARKS.—Column 4 = Col. 2 × Col. 3; Column 5 = $\frac{\text{Col. 4}}{1{\cdot}3}$.

The figures in Column 3 are necessarily only approximations, arrived at as stated in the text.

With steam cars the petrol consumption is large. The extra care necessary to drive and maintain them accounts for them not being used in civil practice. Similarly petrol electric cars are practically unknown, because the extra knowledge of electricity which is required frightens people. For military purposes, however, these extra complications are more than compensated for by the diminution of gearing and the increased starting torque, reduced petrol consumption in the case of the petrol electric system, and silence in the case of the steam system.

From the above it would appear that for Europe a four or, better still, two-cycle petrol electric system would be the cheapest; for cars that have to be used at high altitudes a steam system, until such time as a two-cycle motor can be built which can be altered to run at any altitude, and then the extra weight will be compensated for by the diminished consumption of fuel. A fact which must not be lost sight of, when considering a petrol engine, is that, when running in Europe, the engine for high altitudes would be capable of doing double the work an equivalent steam one would. The petrol electric system would weigh much the same as a steam one when a dynamo was carried for supplying electric power in any of the ways suggested in I.

In considering the power required it is proposed to assume the following requirements :—

I. Travelling at 2 miles an hour up a slope of 1 in 4 on a poor road with a full load.

II. Travelling light across country.

Case I.—The tractive force required is assumed to be 400 lbs. per ton; a steam engine running at 600 revs. with a speed reduction of 6:1 is also taken as a basis for calculation.

Then $$\frac{\text{H.P.} \times 33{,}000 \times 6}{5 \times 600} = 2 \times 2 \times 400$$

and H.P. to overcome the resistance of the road is 24 to 25.

Besides this the H.P. to raise the car up the hill is

$$\text{H.P.} = \frac{2 \times 2 \times 2240 \times 2 \times 1760 \times 3}{4 \times 60 \times 33{,}000} = 12.$$

So that in the case of steam an engine of 45 to 50 H.P. will be required; this is equivalent to one of 100 or 200 H.P. for a petrol car, and 50 or 100 H.P. for a petrol electric one.

These powers are large, but such engines are used in racing automobiles, and are compact and light.

Case II.—No data of the tractive force required across country are available, but it is assumed that the conditions of Case I. are so trying that very few places would necessitate the detachment pushing or roping being resorted to.

For the Pretoria design it was originally intended to make use of the engine and boilers of two damaged cars and a spare boiler, using

chain drives on to sprockets on each back wheel, the sprockets being connected to the wheels through springs so as to save the shock of the engine and to facilitate starting. Each wheel was thus driven separately, and no differential gear was required. This would probably meet all requirements for a steam car.

As regards a petrol electric system for the type of car suggested, it is impossible to put the motors in the wheels. Some form of reduction would be necessary; and I am inclined to think that the lightest, and at the same time the most efficient, way would be to mount the motors close to the wheels, gearing into inside teeth on the wheels, the whole being boxed in to make it dustproof. With raw hide pinions this car could be made very quiet. If each wheel had its own motor, there would be a great advantage in going over bad country; this would probably make up for the slight increase in weight. A reduction of 1 to 12, the wheels being 5 feet in diameter and the motor running up to 1,500 revs. per minute, would give a top speed of about 20 miles an hour. Were small pneumatic wheels used as an alternative, of say 30 inches diameter with a speed reduction of 1 to 2, you could attain a speed of about 60 miles per hour.

In a military car using a dynamo of the Löhner-Porsche system, an arrangement could easily be fitted to hold the field magnets in certain positions corresponding to voltages at which it might be required to work the dynamo for any particular purpose.

IX. UNSOLVED PROBLEMS OF THE PETROL MOTOR.

The theoretical study of the petrol engine seems to have been put on one side, as a result of the race to supply the demand for cars; and makers have been content to accept the motors of other firms or copy them as nearly as they can, or at the most to get at rough proportions from practical trials.

A time will come, however, when scientific institutions will take up the subject and make complete and systematic experiments. A small petrol motor does not cost much, and the experiments could probably be made just as well with small as with large engines, at any rate for the ground work.

In South Africa, when trying to master the theory of oil engines in general and the petrol engine in particular, many anomalies and debatable points came to my notice. Some of these points may have been threshed out since I studied the matter; if so, I, and possibly others, would like to know with what result; if not, some officers of the Corps may find time to go into the matter and earn the gratitude of the world at large.

To begin with fuel. What oil gives the greatest force on explosion? (1) by weight, (2) by liquid volume, (3) by volume of mixture in the cylinder.

Alcohol is said to give better results than would be expected of it, due to the moisture contained. Some oil engines get better results by squirting water into the cylinders. But a petrol engine seems to work best in a dry atmosphere. Why?

How does the chemical composition of petrol vary, and what is the result of such variation? There is a great difference in petrol, even of apparently the same density.

In a carburettor, should not the oil inlet be regulated, not the air? We want to get as full a cylinder as possible, so should not throttle any air inlet. The petrol hole is altered in some forms of carburettors. If the hole is too large, we weaken the mixture and get a carbon deposit, or petrol runs to waste; if too small, we weaken the mixture.

Is it advantageous to dilute the charge with some exhaust products?

What is the effect of varying the compression? What is the best compression? How is compression effected by speed? It seems generally to be accepted that the greater the compression the greater the explosion; 90 lbs. seems to be the most in use. Why stop here? Why not use such a compression that the mixture will fire itself, as in the Hornsby-Ackroyd oil engine, and make up for throttle regulation by an auxiliary air inlet?

What are the effects of the atmosphere? Temperature firstly alters the density, then the quantity of moisture and petrol vapour which the air will hold. The last two effects have already been touched on, the former will follow. It may also have an effect on the temperature of mixture before and after explosion, and so affect the power which is a function of these temperatures.

By decreasing the compression space, which can generally be done by adding a plate on to the end of the piston, till you get the designed compression at mean barometric pressure, the loss due to altitude is diminished; this is done by Messrs. Tangye to all oil engines they send to Johannesburg, and we did it to all engines we used in the Transvaal, with the result that we got about $\frac{2}{3}$ of the power they would give at home. Now if we take such an engine from 5,000 ft. to the coast the compression will rise from 90 to 135 lbs., for which it is not designed, and the compression plate must be removed.

For military purposes we want an engine that will run at much greater altitudes, in India possibly treble, and then we will not be able to get half the power. This is a very serious aspect of the petrol engine, and requires thoroughly studying. The only way of getting over it seems to be the compression of our mixture by forced draught, or in a separate chamber to a fixed pressure, as in some two-cycle motors. By increasing valve inlets, all pipes for air and mixture, using mechanical inlet valves, etc., we may reduce the evil; but even then we will have to devise some means of altering our cylinder volume (*i.e.*, compression space) to suit the barometer without having to dismantle the engine each time we rise or fall 1,000 feet.

It is known that, up to a certain point, the greater the temperature of the cylinders the greater the efficiency of the motor. What is this temperature? Does it vary? Why should we not have a simple thermometer in the jacket, and keep the jacket water temperature as constant as possible by regulating our cooling fan speed or pitch?

What are the effects of altering the times and durations of admission and exhaust? How can the best adjustment be made in practice? There should always be a series of marks on the flywheel, and a pointer corresponding to the valve settings, etc.

How does the pressure rise after ignition? Does it vary with different forms of ignition, with varying compression, cylinder temperature, and mixture?

Is a series of sparks any better than a single one? A long than a short one? A high tension than a low tension one? What is the best tension?

It is claimed for magnetos that as the engine speed increases so the time of ignition is automatically advanced. Is this so?

Besides the above it would be extremely interesting to have records of the tractive force required with different wheels and tyres on bad roads (*i.e.*, bad from a military point of view).

HART TWO-CYCLE MOTOR.
(*See page* 405).

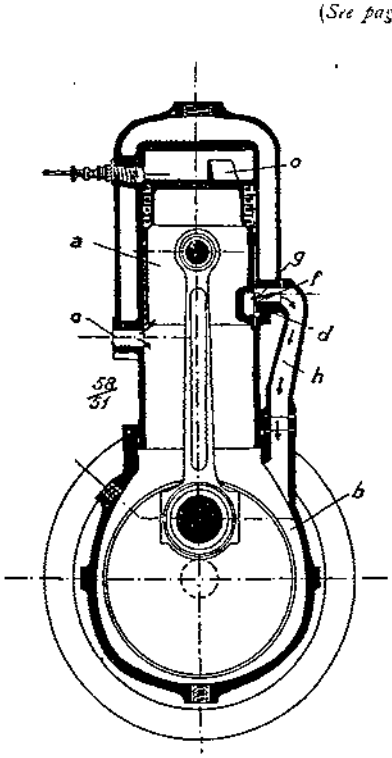


Fig. 1.

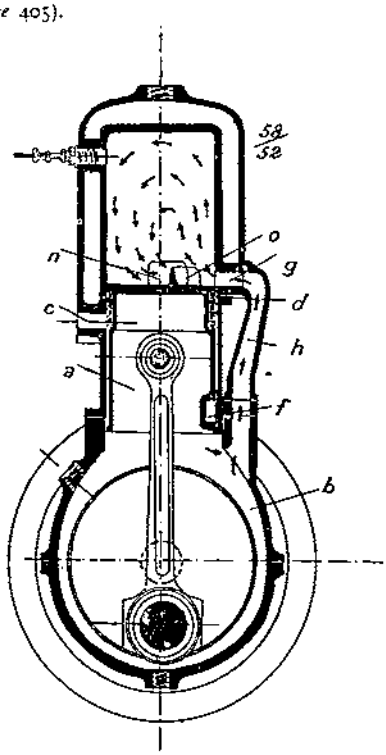


Fig. 2.

TRANSCRIPT.

THE JEWELL SYSTEM OF FILTRATION OF WATER, AND ITS APPLICABILITY TO INDIA.*

Extracts from Report by MAJOR P. E. DIXON, R.E.

THE Jewell System of Filtration of Water is a process of mechanical filtration, first introduced in America, and consists of the utilisation of a coagulent to precipitate the impurities in the water, and also of mechanical devices for the cleansing of the filtering medium.

The system has been largely adopted in the United States and Canada, no less than 200 towns now employing it. It is being gradually introduced also on the Continent of Europe and elsewhere. There are two installations in England, at York, where however it is not utilised to the full extent, and at Wolverhampton. There is also an installation in India, at the Kolar Goldfield in Mysore.

There are three principal methods of water purification,—coagulation, subsidence, and filtration; and the Jewell system is a scientific attempt to combine the three in one system. The coagulent employed is sulphate of alumina; a weak solution is added to the unfiltered water, the sulphate of alumina is decomposed and hydrate of alumina is formed, a gelatinous flocculent precipitate of greater specific gravity than the suspended particles in the water. The larger flakes of this gradually settle down in the subsidence tanks, carrying with them from 40 to 75 per cent. of the suspended matter and bacteria. The finer flakes remain and enter the filter where they are retained by the upper layers of sand in the filter bed; and they there form a gelatinous film which takes the place of the natural organic film that forms in the ordinary slow sand filter and performs such an important part in the operation of filtration. Thus the use of the coagulent fulfils two objects—first, the precipitation of the greater part of the impurities in the subsidence tank, and secondly, the formation of the gelatinous film necessary in the sand bed.

With the aid of these two actions of the coagulent it is found possible to accelerate the rate of filtration to an extraordinary extent: while the ordinary sand filter will pass from 50 to 75 gallons per square foot per day, this process will pass as much as 2,000 or 3,020 gallons.

* Communicated by the Director-General of Military Works in India.

This of course necessitates much more frequent cleansing of the filters When the filtering film has become too thick and dirty for filtration to be economically continued the sand bed is washed: this is done by reversing the flow of water and forcing a back current of filtered water upwards through the sand, which at the same time is violently agitated by revolving rakes, so that all the deposited film is removed with the accumulated dirt and the sand particles are thoroughly cleansed and restored to their former purity. The filtration is then resumed, and after a very short time a fresh film forms on the sand bed and the filtrate is as good as ever.

A solution of fixed strength is prepared beforehand and added to the unfiltered water mechanically in any proportion desired. The proportion used may vary from ¼ to 6 grains per gallon, according to the turbidity of the water or the rate of sedimentation required. Sulphate of alumina alone is now generally used and it is more economical than common alum. There is no danger whatever to health in its use as it is practically all precipitated and left behind in the subsidence tank.

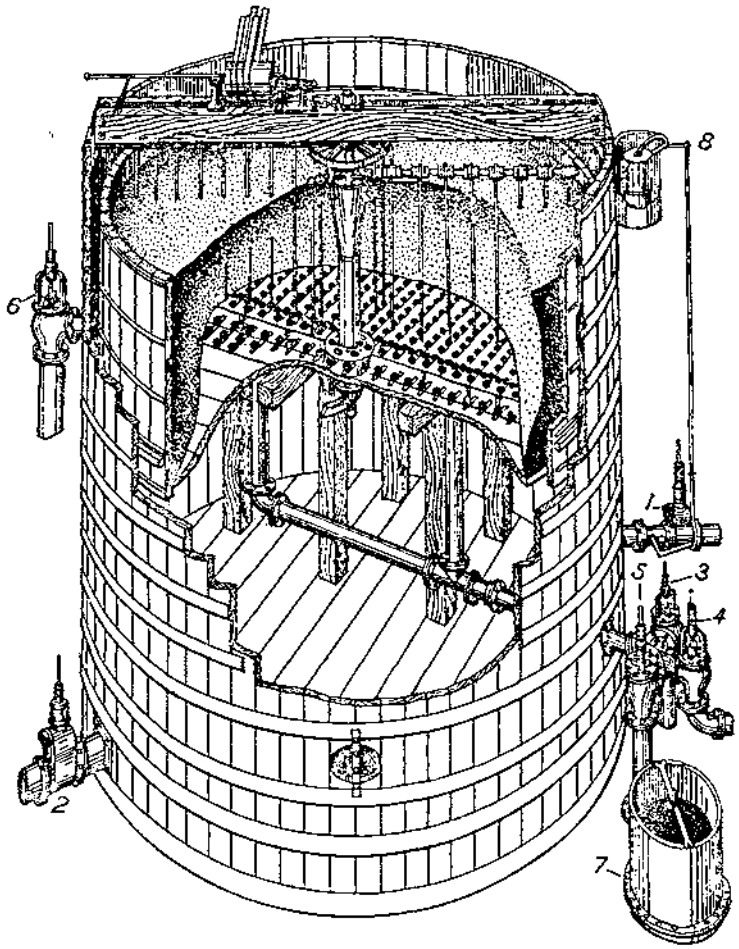
The filtering medium is sharp river sand, 20 to 40 meshes, and the average depth is 4 feet. A large filtering head is required, from 6 to 14 feet; this results in the compacting of the sand bed, making it almost sandstone. Only 2 feet or so is carried above the sand bed, the remainder is negative head which is found to give better results.

From the bacteriological experiments, conducted everywhere where the system is in use, it is found that it is most efficient in removing bacteria.

Type of Jewell Filter.—Mechanical filters are of two types—*Gravity*, where the water passes through the sand bed by the action of gravity, and *Pressure*, where it is forced through by pressure. Both have their advantages. The Jewell filter is of the former type. Its distinctive features, as compared with other mechanical filters, are the agitating device for raking the sand bed during washing; and the weir wash device by which the upward flowing wash water, with all the suspended dirt and impurities, falls over the edge into an annular space surrounding the filter. The sedimentation basin may be attached to the filter or may be a separate basin elsewhere; where the water to be filtered is excessively turbid, both are desirable.

A type drawing of a Jewell filter with subsidence tank underneath is attached, showing the whole of the mechanism of the interior. The filter consists of two concentric cylindrical tanks of hard wood, the inner one containing the sand. Iron or steel or masonry can be used instead of wood if desired. The inner or smaller tank only extends half way down the interior of the outer or larger, and the lower portion of the latter forms the sedimentation basin. There is an annular space between the outside of the inner tank and the upper part of the outer, and the top of the outer tank is also higher than the inner one. The inner tank rests on a ring round the interior of the outer tank, and there is no communication between the annular space and the sedimentation basin below. At the bottom of the inner tank is arranged a system of bronze strainers below the sand, through which the filtered water flows. In the centre

of the tanks is a pipe communicating from the sedimentation basin below to the top of the sand bed.



1—Inlet Valve. 2 and 6—Washout Valves. 3—Rewash Valve. 4—Wash Valve. 5—Delivery Valve. 7—Weston Automatic Controller. 8—Regulator.

15 FT. DIAMETER JEWELL GRAVITY FILTER, WITH SUBSIDENCE BASIN.

Above the tanks is the agitating apparatus. This consists of a revolving beam, carrying two rakes with the teeth so disposed that when the apparatus revolves in the forward direction they are rigid and dig down into the sand, but when the motion is reversed they bend up on hinges and drag along the surface without penetrating. The tanks are in communication with the outside by means of a number of valves for the ingress and egress of the water, the uses of which will now be described.

Process of Filtration.—When the filter is working in the ordinary way the valves 1 and 5 are open and 2, 3, 4 and 6 are closed. The unfiltered water, with the sulphate of alumina added, enters by valve 1, fills the

sedimentation basin below, and, flowing very slowly through it, deposits the greater part of the alumina with most of the impurities and bacteria. It then rises through the pipe up the centre and overflows on to the top of the sand bed; the remainder of the alumina is deposited and forms a film, and the water filters through this and the sand bed, and through the bronze strainers below, to valve 5, and thence to the clear water storage tank, Valve 5 is fitted with a special apparatus, called the "*Controller*," marked as 7; this automatically regulates the discharge of the filter so that it can be varied according to requirements. The water is allowed a head of about 2 feet above the sand bed, and this is fixed automatically by a "*Regulator*," shown as 8, which is connected with the inlet valve 1.

Process of Washing.—When the filter has worked a certain time, usually 24 hours, it gets clogged and has to be washed. Valves 1 and 5 are first closed, and valve 6 opened. Valve 4 is then opened and filtered water pumped in through it: this water passes backwards along the outlet pipe and upwards through the bronze strainers and the sand bed, rises above the latter and, overflowing over the top of the inner tank, falls into the annular space and is carried away by valve 6. At the same time the rakes are revolved, thoroughly stirring up the sand and allowing the water to circulate entirely throughout it and cleanse it completely. At first the water comes out thick with mud and dirt, but after five or ten minutes it becomes clear again and the washing is complete. The revolution of the rakes is then reversed until they rest on the surface of the sand bed without penetrating. Valves 4 and 6 are then closed and 1 opened, and the filtration is resumed. The filtrate is run to waste through the "*Re-wash*" valve 3 for the first half hour, to allow time for the gelatinous film to form on the sand bed and come into operation again. Valve 3 is then closed and valve 5 opened and the filtrate run into the clear water tanks for use.

Washing of Subsidence Basin.—At certain intervals it is necessary to remove the deposit from the subsidence basin. This is done mechanically at the same time as the washing of the filter bed. Valve 2 is opened and the subsidence basin emptied. Valve 6 is kept closed, so that the wash water cannot escape by the annular space between the tanks, but rises until it overflows with violence down the central pipe: this ends in a curved shoot which can be revolved, and the wash water is thus projected all round the interior surface of the subsidence tank with such violence that all the deposit is washed away and carried off by valve 2.

Sterilisation.—In spite of the washing, the sand grains in process of time collect an organic coating, particularly if the unfiltered water carries with it any oil or greasy matter. This can be removed in a few hours by placing a small quantity of soda ash on the surface of the sand bed, and forcing in live steam through the wash valve 4, so boiling the sand bed with alkali and removing all traces of organic matter. This is only required from one to three times a year.

Installation at York.—The supply of water at York is taken from the river Ouse, which during floods is liable to become extremely turbid. Up to 1899 this water was filtered by the usual process of subsidence reservoirs and slow sand filters; then the supply was found insufficient

and extensions were proposed; but after exhaustive inquiry it was found cheaper and better to introduce "roughing" filters on the Jewell system between the existing subsidence reservoirs and the filter beds. No coagulent is used, as the sedimentation takes place in the subsidence reservoirs, and the filtration through the gelatinous film is provided in the slow sand filters. The Jewell filters are made of cypress wood, bound with iron hoops, and they are 17 feet in diameter and 10 feet high. Quartz sand to the depth of 4 feet is placed in each filter, and the unfiltered water is delivered by gravitation from the subsidence reservoirs on to the top of the Jewell filters, and flows through them, also by gravitation, on to the slow sand filter beds at a lower level. The washing is carried out every 24 hours with rough filtered water and takes about 15 minutes.

Originally four filters with a capacity of 3,000,000 gallons per day were erected, and now three more have been added.

Installation at Wolverhampton.—At Wolverhampton the water-supply was derived from deep wells of exceptional purity in the valley of the Cosford Brook, but in 1901 the supply was found insufficient and the water of the brook itself had to be drawn upon. This was frequently turbid and of course required filtration; so two Jewell filters with a capacity of 1,000,000 gallons per day were erected. The water is drawn from the brook and delivered to the filters by pumps. After treatment with 1 grain per gallon of sulphate of alumina the water flows through the subsidence tanks and filter beds to the clear water tank. The rate of filtration is 2,900 gallons per square foot per day, and the filters are washed every 12 hours. The pumps are worked by two small electric motors, and another one is employed to drive the agitating rakes. The filters are almost automatic in their action, only one skilled workman being employed to look after the pumps, motors, and generators, to mix the coagulent, and to superintend the filters.

Installation in India.—The one installation of the Jewell system at present in operation in India is at Bethmangala in the Kolar Goldfield under the Mysore Government. It consists of four Jewell Export Filter Company's gravity filters of a capacity of 2,000,000 gallons per day, with the necessary pumps, etc. The water is pumped from an artificial lake to a specially constructed subsidence basin, from which it flows by gravity on to the filters. One grain per gallon of sulphate of alumina is used as the coagulent, and the process is as already described.

Cost.—It is practically impossible to give any useful figures as regards the cost of installation or maintenance of this mechanical filtration. The accessibility of the place, the turbidity of the water, the value of the land, and the local cost of labour and material, are all factors which operate to cause wide variations.

Comparison of Systems.—The following advantages over the slow sand system of filtration are claimed by the Jewell Export Filter Company for their filters:—

1. Capacity to treat very turbid water.
2. Capacity to remove a large percentage of colour.
3. Occupy a relatively small area.

4. Protection from weather, frost, etc.
5. Freedom from risk of vegetable growths.
6. Rapid and easy cleansing without risk of contamination by workmen.
7. Sand bed easily sterilized.
8. Absolute control of each separate filter with knowledge of its condition.
9. Water can be sent straight to the consumer with the least possible delay.
10. Adapted for treating water for hardness, plumbism, or removal of iron.
11. Reduction in size of subsidence tanks.
12. Facility of construction and extension.
13. Low initial cost.
14. Low cost of maintenance.

Adaptability for India.—There seems no reason why the Jewell system should not be as suitable for adoption in India as elsewhere. The advantage of requiring less space than the slow sand system is, however, not likely to count for much where land is cheap. Also the mechanical appliances and skilled staff required for this system are a disadvantage in a country where skilled labour is expensive and difficult to obtain, while the unskilled labour required for slow sand filters is just the reverse. The only method to adopt in deciding as to the suitability of this system in India is to treat each place where the filtration of water is required as a separate case, and to consider the comparative advantages of the two systems on their own merits.

REVIEW.

TACTICAL INFERENCES FROM THE BOER WAR AND THE GROUP ATTACK.

By A. von Bogulawski, Lieut.-General.

The author in his preface lays stress on the immutability of the fundamental principles of war. He insists on the interdependence of the arms of the service, so that one cannot be neglected without detriment to the others. But infantry must always carry out the preponderating part in the fight; and so military leaders as well as writers have unceasingly striven to discover the most favourable form for the attack, acknowledged to be the most difficult part of infantry tactics.

It was thought that some definite conclusion had been reached when the War in South Africa, 1899–1902, appeared to introduce new elements for consideration.

Chapter I. is a sketch of the development of German infantry tactics introduced from time to time as the outcome of the experiences of the War of 1870–71.

At first the preference was for strong lines of skirmishers, composed of complete sections; these were followed by supports in ranks at open intervals, with groups closed or at open intervals. Advance was to be by rushes of 50 to 80 paces. But it was soon recognized that supports, deployed in open formation, were a danger to the firing line, and so these formations were suppressed;—rushes were reduced to 50 to 60 paces.

Then came various measures for fire discipline, prescribing when volleys were to be used, and when independent fire, with a named number of rounds.

About 1877 long range fire was advocated; but after some time opinion reverted to the principle that, in the attack, firing should be postponed till within the shortest possible range.

Then came the regulations of 1888, which forbade a normal form of attack, giving merely general indications for guidance but more or less prescribing a strong firing line. Cohesion of the final rush was to be ensured if possible by the direct command of the Officer in Chief Command. The mixing of units was to be avoided as much as possible, but troops were to be trained to fight in any formation or fronting the wrong way.

Constant improvements in guns and rifles prevented the subject being put aside, and, as usual in peace time, very erroneous and misleading conclusions were evolved. A tendency arose to insist too much on the ballistic and technical element, to the neglect of the tactical one and of psychological conditions. This resulted in the advocacy of wider extension, and, while still adhering to dense skirmishing lines, an endeavour to compass enveloping attacks that diminished the depth of the attacking force and added materially to the difficulties of supreme

command. Then came the idea that salvation lay in enveloping the defender and establishing superiority of fire; the fire fight was to be the only arbiter, and some went so far as to declare an attack across the open to be impossible. Next came the view of a highly placed Officer, who maintained that superiority of fire was only to be obtained by the skilful exchange of the strategical for the tactical *rôle;* that is the concentrated advance of several columns endeavouring to converge their fire.

The opinion was even advanced that a sort of siege practice should be adopted, and advantage be taken of nightfall for the attackers to dig themselves in. The author contests this idea; and considers that every great leader has endeavoured, and will endeavour in the future, to end a fight when possible in a day. History proves that this has frequently not been the case.

He disputes the idea, now advanced, that the defence has gained anything by virtue of improved weapons, which, he contends, augment the power of the offensive in like proportion.

"Even with the oldest blunderbusses the defender had the uncontestable advantage, when in a previously occupied or at all fortified position, of using his piece more coolly and accurately than the attacker who was more or less in motion. The same applies now. How can circumstances have changed when the weapons on both sides are approximately the same?

"In the beginning of the attack, in the pause in the fight (which is a characteristic of war at present), finally in the rapid fire preceding the final rush, the prospects of the attackers are the same as ever. It is only when the attacker does not know how to use his weapons, or attacks clumsily, that the new weapon bestows on the defender a durable superiority. By clumsiness we mean unsuitable formations, improper use of ground, and defective fire preparation.

"One point must not, however, be left out; that is, the moment when the attacker makes his rush without firing, either in the final storm or in one of his so-called 'forward springs,' or even in the bringing up of supports, then the rapidity of fire and low trajectory of the projectiles claim their advantage and cause in a short time a large number of casualties and consequently have great effect. The art of the attacker consists in not letting his fire dwindle, even though he cannot produce the same effect as the defender. At this moment it is not possible completely to balance the defenders' fire."

But to counteract this the author has an expedient of his own, which consists in firing without halting in the advance.

He does not believe in the endeavour to balance the superiority of the defence by importing measures of fortress warfare into the field. "True! the possibility of digging-in at night has been proved on manœuvres, when a position some 450 m. from the defenders has been entrenched." But, he asks, "Who is the enemy who will allow working parties in front of him at that range, without destroying them by fire or even by a sortie immediately their presence is reported by his patrols?"

He then draws a comparison between siege warfare and field warfare, pointing out that in the former the first infantry position is 1,000 m. and not 450 m. from the enemy, and that if the attacker can get to within

450 m. the defender is probably worn out. Digging-in at this range only leads to fruitless night fights and renders a part of the troops incapable of action next day.

It is quite a different thing to secure important points at some distance from the enemy, or artillery positions. But to recommend siege measures on the battlefield as of general application to overcome the difficulties of the attack appears to be a mistake.

Chapter II. begins:—"The tactics of a campaign bear the imprint of the prevailing strategical idea," and the possibility of strategical offensive in combination with tactical defensive in general is denied. Of course defence is never devoid of offensive incidents, and attack is not all offensive but comprises some defensive incidents; and to be able to change one attitude for the other betokens the skill of the subordinate leaders.

"The Boers advanced into Natal on the strategical offensive, but they were not tactically offensive in any great action. They took up position and beat off the attack with great success; but did not use their advantage, and so produced no result. The attempt of Joubert on Pietermaritzburg came utterly to grief.

"Nevertheless some consider that this conduct,—which was purely traceable to the absence of a thoroughgoing strategical thought to make use of the initial superiority of force with united forces in one direction—was a new practical incorporation of the idea 'Strategical offensive—tactical defensive.' The impossibility of this procedure was sufficiently manifested in the course of the war. The strategical advance snuffed out, and we soon saw the Boers thrown back on to the strategical defensive, in which in the end they succumbed. This was the position of affairs to the attentive observer at the turn of the year 1899–1900."

The author does not think the Boers' conduct of the Campaign was incorrect in the circumstances when the leaders found that their forces were not adapted to great tactically offensive movements. "A Bonaparte or a Frederick might perhaps have succeeded with this mob in carrying out an attack with concentrated forces on Durban or Cape Town and in teaching them the offensive by victory—but Joubert was not a Bonaparte."

From October, 1899, to the arrival of Lord Roberts the misapplied strategy of the Boers failed completely, even when opposed to "the in many ways unskilful tactical attacks of the English." A comparison is drawn between the prescriptions of the English and German drill books, in which there are few divergences, owing to the influence the latter has had on the former.

"However, the English had become accustomed to fight savage or half-civilized peoples, whose attacks they shattered with ease. That the training of the English infantry in the use of ground and in shooting was not up to the mark is well known. The English officers belong to the cultured class and their heroism is unquestioned, but their knowledge of war and practical training leave much to be desired. Training of leaders and troops can only be carried out by exercises and manœuvres in accidented country and not by drilling in garrisons. The English, whose laws forbid trespass in the country, which belongs to private owners, were in the same condition as the French before 1870, who were only able to

manœuvre at Châlons. The English army is above all a recruited army, and the ranks hold many unworthy elements; nevertheless it is a national levy, and in the ranks is implanted the consciousness of belonging to the great English Empire, to that race which, by its power and tenacity, has overthrown many hundred millions of other races and held them in subjection. All the more remarkable is it that in the course of the war many weak elements have become apparent."

"Opposed to it was a quite exceptional army. A modern militia, as it has been called by the lovers of militia, it certainly was not; but it was the levy of a warlike people, whose physical and moral characteristics differentiate it from European nations. The older generation had been in conflict with the English, the younger with the native races, and were trained by these experiences and especially also by hunting to be good shots. Hardened by work and toughened by fatigue the Boers also enjoy magnificent eyesight. Their feeling towards the English was that of the victors of 1880, towards the natives that of masters. But they lacked organization and discipline—not every man left the 'Laager' to take his place in the shelter trench, and many disappeared at times to go home and tend their farms."

The Mauser was superior to the Lee-Enfield; the artillery, however, largely composed of Q.F. guns, was far inferior in number to that of the English. The peculiarities of the country are duly noted and insisted upon, because "they must be properly weighed in gauging the tactical conditions."

Chapter III. is an examination of some of the fights in the Boer war. The middle of October, 1899, found the Boers crossing the border mountains in several columns into Natal and moving concentrically on the English camps at Glencoe and Ladysmith; strength about 20,000 against 9,000 British at the two places named and some 3,000 at Durban and Maritzburg. Some 12,000 Boers were operating against Kimberley and Mafeking. A weak force had pressed into Cape Colony.

The author then describes and comments on certain engagements, selected as being representative. Amongst others:—

Colenso (15th December, 1899).—The forces engaged were reckoned as:—English, 15,600 and 44 guns, including 14 naval; Boers, variously reported as 3,000 and 5 guns, not over 5,000, and 10,000. The British losses, excluding missing, were 143 killed, 756 wounded, total 899, or 5·8%. Erstorff gives 70 officers and 1,040 men, of whom 28 and 203 respectively were prisoners; Müller counts 1,197 men and 66 officers, of whom 15 and 348 were prisoners; Gilbert gives 1,300. "The Dublin Fusiliers lost 23·9%, the Connaught Rangers, 16%. Compare this with the loss of 54% by the *Garde Schützen* battalion at St. Privat; the 1st Battalion 50th Regiment at Wörth, 43%, 16th Regiment at Mars-la-Tour, 68%, the 52nd, 52%. Moreover the regiments of the Guard Division at St. Privat and the 10th Division at Wörth each lost quite as heavily as the whole of Buller's corps at Colenso. These figures speak volumes. They disclose the fact that the fire effect of the newest weapons cannot possibly be taken so high as credited to them by the experience of the rifle range."

Spion Kop (23rd–24th January, 1900).—The British losses are put at

1,437 killed and wounded, equal to 7% of those engaged. Gilbert gives 1,150 men. Prisoners and missing are included. Assuming 1,000 lost out of a possible 5,000 actually engaged on Spion Kop itself, this gives 20%. Lindenau says the Royal Lancasters and Lancashire Fusiliers lost 17 and 17·2% respectively. The author says: "The losses were not inconsiderable, but still they fall much below those suffered by the Germans in the war of 1870. That the English failed is not traceable to the effect of modern weapons, but to bad leading, unfavourable ground and conditions."

Modder River (28th November, 1899).—The forces engaged are put at:—British, 9,000 men and 22 guns including 4 naval; Boers, about 7,000 men and 10 guns. The British losses were 24 officers and 462 men, or about 5⅗%. Boer losses variously reported as 100 and 350 men.

Magersfontein (11th December, 1899).—British, 12,000, of whom 9,000 only were engaged; Boers, 7,000. The British losses were 895 killed and wounded, something over 7%; one battalion of Highlanders lost 35%, the other 23·4%. Boer losses variously stated at 200 and 600. The author's criticism on this fight is very severe. The night attack was planned beforehand and was directed against the left flank of the Boers. But as the reconnaissance was *again* thoroughly defective the attack was in the wrong direction. Had the left flank of the heights been taken the remainder of the Boer position would have been untenable. He considers our formation to have been bad, and the attempt to deploy under fire disastrous. A close formation, he admits, was requisite to keep the troops in hand in a night attack; but he holds it unnecessary to jam two battalions close up to one another in a compact mass, and pronounces it out of the question to advance without a few scouts some 50 to 60 paces in front. At the first outburst of fire the troops should have dashed to the front and overrun their enemy without waiting to deploy. The numerical superiority of the British artillery did not make itself felt and the Boer device of refusing the artillery duel proved a valuable expedient for the defender. The British cavalry might have found something to do far out on the flanks. As at Spion Kop, if the Boers had made a vigorous counterstroke they would probably have destroyed the bulk of the British force.

The second phase of the Campaign began with the arrival of Lord Roberts. Strategically it is marked by the advance against Cronje, whose rounding up and capture compassed the relief of Kimberley, Ladysmith, and Mafeking, the capture of Bloemfontein, the advance to and occupation of Pretoria, and the movement of Buller into the Transvaal.

"The strategic movements of the British were conducted with firmness and decision. Tactically the British front was often over-extended, and an European opponent would have attempted to break through; but Roberts had thoroughly gauged the Boer lack in offensive tactics. The bootless strategical position of the Boer leaders, who had been carried away by their desire to capture Ladysmith, was brought into its true light by the course of the second phase of the Campaign."

The third phase is dismissed in a few words as the engagements contribute no evidence of value to the author's object; but it is worthy of

notice that "The Boers remaining in the field eradicated in a great measure the defects of their forerunners, viz., lack of discipline and offensive power. The Commandos were organized in companies and these again in sections. The election of officers was abolished. There is not much to be discovered in the way of a so-called 'Boer attack'; but there were many cases of plucky sudden assaults, such as Tweefontein, 24. 12. 1901, and Tweebosch.

"The Boers had become robust and well-proved soldiers by long continued fighting; on the other hand the British, who at length were obliged to turn out 300,000 against this small people, had a large proportion of badly trained worthless troops. Nevertheless the traditional stubbornness of the Anglo-Saxon race and its innate patriotism manifested itself as of yore, and the terrible difficulties involved by locality and climate must not be forgotten."

Chapter IV. discusses the inferences from the war. The first was that the *Frontal attack is no longer possible.*—The author contests this; saying, "It is not alone the modern firearm that has caused the repulse of the English attacks, but faulty direction, deficient leading, also (often) insufficient energy in pursuing the fight and want of systematic arrangement. Unsuitable formations, special nature of the enemy and of the terrain also played a great part. It is not to be denied that, in many moments of the fight, the volume, range and rapidity of the Boer fire became a preponderating factor; but we do not think to err in stating that the results would have been identical with the single loader. Indeed it is possible that the same results would have ensued had the defenders been armed with muzzle loaders. How often the above-mentioned factors of terrain, leading, etc., have been the deciding ones all history of war shows. So, in proclaiming the combination of front and flank attacks to be the best, it is an error to characterize the frontal attack once and for all times to be impossible."

The second inference was that *Our tactics of attack must be changed.* This the author contests vigorously, alleging against it the numerous false inferences drawn from the experience of former wars. "Let this be a warning not to draw conclusions or to introduce forms which are based more on superficial notice than on well-formed conception of war and a knowledge of its ruling factors. This exhortation becomes more and more in season as actual war experience diminishes in the army."

Chapter VI. deals with practical results and experiments in Germany. It is very difficult to give a *précis* of this part, in which the author falls heavily on several would-be reformers, and criticizes their deductions in detail as follows:—

THE ATTACK.

(1). *Conduct of Skirmishers.*—He objects to creeping forward and running from cover to cover. "It demands individual heroism to leave cover. To move on alone and uncheered by companions produces more hesitation than witnessing casualties, which are better endured in company. The number of 'hesitaters' will increase in a greater proportion

than the casualties due to the enemy's fire. The 'Living Survivor' is often more encouraging to the retreating comrade than the 'Brave Dead.'"

He objects to the thin line of skirmishers altogether; and says the defender will probably not fire on it, or will drive it back by similar thin lines or else sweep it away by mass fire or brush it away by counter-attack. The point is that a thin line cannot produce sufficient fire effect, moreover the constant advance of reinforcing groups will equalize the losses with those of an originally thick line. He objects to the section and group leaders lying down, and treats the idea of an officer lying down with great scorn.

(2). *Bringing up the Supports.*—The author seems to think that Company Columns, being separated by large intervals, offer a smaller target to shrapnel than men scattered all over the field. He objects altogether to deployed second lines, who are certain to shoot their comrades in front.

(3). *The Final Rush.*—The Boer War has further established that the final rush is the most difficult part of the attack. Eye-witnesses state that the attack was often shattered close in front of the defenders.

"The reformers wish to dispense with drums and bugles, so as not to attract the attention of the enemy. In advocating this they are setting at defiance the experience of many thousands of years; for in no other moment are the clear word of command, the bray of the horn, and the roll of the drum of more importance."

"The storm should not be begun till the defence is shattered, but this moment is not always recognizable. The pause in the defender's fire, to deceive the attacker, is one of the lessons worth learning from the Boer War, although it has often been practised before, especially by savages." The theory is contested that the enemy should be driven out of his position by fire effect without a charge. "The enemy cannot be driven out by fire alone, but he must be stormed out; otherwise, a couple of dozen skirmishers might keep an attacker at bay by magazine fire while the main body makes good its retreat. A storm must be carried out, and the Boer War tells us that delay under fire is probably as costly as a rush. The way out of the difficulty consists in 'Firing on the march.'" Such firing is objected to because it must be unaimed; but firing at 1,000 to 1,500 m. ranges is also unaimed, and yet it is not objected to.

Chapter VII.—Extent of front and battle tactics.—The author objects to wide extensions; and, after citing many instances from 1870, confirms his objection on the grounds that wide extensions add enormously to the difficulty of command, especially as regards bringing the reserve into action at the critical moment. Extensions wider than 150 m. for the company and 400 m. for the battalion are not advisable.

Chapter VIII.—Moral springs of action—Use of fire—Tactical and fortificational rules of defence.—The author bewails the degeneracy of the race, and traverses the opinion that men should be given more latitude and initiative. He doubts that the Boers are better marksmen than the Germans, but their merit lay in "No waste of ammunition,—shoot at short range." The wide deployment of the Boers is only to be copied on rare and exceptional occasions. Except in a few isolated

occasions the Boers were always on the defensive. The spirit of attack was only manifested in the guerilla stage.

Chapter IX. contains notes about the other arms.

ARTILLERY.

The lesson to be learned is not to overestimate results by experience of the artillery range. The single gun emplacements of the Boers were suitable to their tactics. Shields must give way before steel-bulleted shrapnel; the shielded Boer guns held their own against inferior unarmoured pieces. The defender in a well-fortified position does well to decline the artillery duel and reserve his fire for the infantry attack. The occupation of artillery positions without previous reconnaissance, as at Colenso, leads to disaster. The union of the arms must be preserved, and infantry must press on and get engaged so as to make the defender disclose his position.

CAVALRY.

The author does not think much of the English cavalry. They only delivered one charge, and conducted reconnaissance with incredible carelessness. But they did well in turning movements in the advance on Bloemfontein and Pretoria, also in the relief of Kimberley. Reviewing the latest prescriptions for cavalry, he thinks the English have gone too far in depreciation of the cavalry charge. Scouting and reconnaissance are much more difficult since the introduction of smokeless powder, so scouting cavalry must often resort to the dismounted fight to arrive at reliable information. This is one of the most tangible lessons of the war.

SAPPERS.

That sappers can be dispensed with the Boers have taught us. Still the sappers must be the teachers of the infantry, and should therefore bestir themselves unceasingly to perfect the practical adaptation of field fortification. For this, thorough tactical comprehension and knowledge of shooting are indispensable. The concealment of trenches is always to be kept in view, and practical experiments with ball cartridge should be carried out to ascertain to what extent tiers of fire trenches may be used. The Boers had no engineer officers and so formal attacks on Kimberley, Mafeking, and Ladysmith were out of the question. They were right to evacuate Pretoria; for had they held it, they must have concentrated all their available forces there. The English would have besieged *en règle* and brought the war to an end with the fall of Pretoria.

THE TRAIN (A.S.C.).

Laudatory in every respect.

SUMMING UP AND CONCLUSION.

1. A frontal attack over the open is difficult, and therefore to be avoided as much as possible. It is in no way, however, to be considered as impracticable with proper troop leading and adequate preparation.

2. The tenet that open spaces under hostile fire cannot be crossed is mischievous, tending as it does to weaken the spirit of adventure.

3. Advance by groups is permissible in special natures of *terrain*, and especially in small actions or in incidental combats of a great fight. This must not be confounded with the proposed *Group Attack*, which, generally speaking, involves too wide an extension in battles, reduces the influence of the leaders, and introduces a premature confusion of units.

4. Initial fire power is too feeble (alluding to thin skirmishing lines). Reinforcement by driblets does not help matters. Therefore, whatever be the *terrain*, strong shooting lines should be developed from the beginning; these to be brought forward in section rushes, requiring careful practice. The distance of each rush in open ground to be not less than 50—60 mètres, in broken or hilly country according to localities.

5. Reinforcing detachments, according to circumstances, help with their fire or carry along the shooting line with them.

6. In the open the storm to be delivered at a charging pace with magazine fire on the march. Bayonets to be fixed at 500-600 m. from position. The last 30-40 mètres to be covered at the run without firing.

7. The units of the second and third lines follow, neither in groups nor in extended lines nor in ranks nor sections (unless an obstacle necessitates such formation), but in Company Columns or in line. In this way as the 2nd Section is behind the 1st, a line of half the length is formed. The closed bodies of the 1st line (supports) keep about 200 m. behind the firing line.

8. The units told off for the storm must however be brought close up to the firing line, unless the firing line itself breaks away by its own initiative and, seizing a favourable moment, carries the position with a rush.

9. It is permissible to increase the extension of the company to 100-150 m. and of the battalion to 400. Should circumstances demand the development of full fire power every man of the battalion can fire.

10. To fire at the shortest possible ranges is to be impressed continually on leaders and troops. No need therefore to lay down a range.

11. For superior officers the principle of "Strong Reserves" is to be continually rubbed in. The art of Napoleon I., to wait for the throw till a crisis is manifest, must be again brought to life.

The writer concludes by remarking that his experience covers the period from the smooth-bore musket to the magazine rifle.

As this pamphlet embraces a large measure of criticism in leading up to its inferences, it has been thought indispensable to review it at length in deference to the position and reputation of the author. It is to be regretted that the descriptions of the actions are illustrated by very indifferent sketches of the battlefields; the imperfections are traceable in the rendering of the story. Criticism of so high an authority as the author is not to be ventured on with impunity; but it seems to the translator that he has not quite caught the atmosphere of the veldt in the picture he draws of the engagements and their attendant circumstances. To say that all will agree with the inferences drawn from the South African campaign would be to assume surrender of independent thought to the moral influence exercised by an eminent military writer.

J. A. FERRIER.

NOTICES OF MAGAZINES.

ENGINEERING NEWS.

September 14th, 1905.

DOUBLE-TRACKING OF RAILWAYS.—This number has among its contents two articles containing some observations on this important subject. Considering that of the American railway mileage only some seven per cent. has two or more roads, it is at once seen that there is a likelihood of much doubling work having to be done. The New York Central, by the way, has the most double line.

Up to the present the tendency has been to work trains on a single line up to the absolute maximum of capacity before having recourse to a second track, but managers are inclined to consider whether this is the most economical course. It has been generally assumed in America that the limit of economical capacity on a single line is some 50 to 60 trains daily (including a proportion of passenger trains), if the line is well provided with sidings. But the *possibility* of handling such a number of trains is a different affair from the most desirable and profitable service.

Some calculations which were brought before the Railway Master Mechanics Association in June last shewed surprisingly what a large proportion of the working hours of an engine working on a single line was apt to be spent in sidings waiting to pass trains, and unless traffic can be kept running very regularly delays of this nature must be considerable when the density has reached a certain pitch.

The regulation of traffic has, in fact, a very important bearing on the question of double-tracking. Short sections of double line at some points may enable crossings to be made there with a comparatively large margin of time, and certain lines, just as the Cape Government Railway has done, have adopted the expedient of doubling their road on each side of junctions so as to relieve and obviate congestion at those centres. Again, certain lines which have alternative routes have adopted the plan of using one line for up and the other for down traffic; or indeed there may be several routes, a very useful thing in case a rush has to be handled.

Where double-tracking has actually been decided on, the question of the most advantageous alignment comes up. Sometimes an entirely fresh double line may be constructed to shorten the route or obtain better gradients; or again, if the existing line is favourable to traffic in one direction it may be feasible to site the new one so as to favour traffic the other way; but the capital cost of simply widening may be less. All these considerations must be weighed. Or again it may be more

profitable to construct an entirely new route. In America these things do not seem to be done by halves: but there are fewer difficulties in the way of putting through a railway project in any case, particularly if all the work is in one State.

As regards the contract work on a widening, it seems to be usual to make the contractor responsible for avoiding any interruption to traffic, and if flagmen and signalling arrangements are necessary that he should pay for them, taking account in tendering. There was some idea of embodying a penalty clause in the standard contract form, but it was abandoned as it was found that it would mean bigger quotations to cover possibilities.

In the case of electric inter-urban lines, it is remarked incidentally that a service of 30-minute trains with passing places at 15-minute intervals is as much as can be worked, and nearer passing places are not reckoned feasible. This sounds not much of a service, but apparently most of the trains are high speed and few stop.

C. E. VICKERS.

JOURNAL OF THE R.U.S. INSTITUTION.

September, 1905.

THE COMFORT OF TROOPS ON ACTIVE SERVICE, a lecture delivered by Capt. E. D. Swinton, R.E., deserves study by all soldiers. There are two ways of dealing with the problem:—"To lessen the inevitable hardships and discomforts of war upon the soldier by hardening him beforehand, and so training him that he will not feel them"; and to take the soldier as he is, and do the best to "temper the wind to the shorn lamb." The author considers it from the second standpoint.

He commences by saying—"The main object of an army in war is to beat the enemy in battle. To effect this a concentration of superior force at the right time and in the right place is necessary. To assist in this object, it should be the endeavour of each individual to do his utmost to ensure in every possible way the efficiency of the fighting machine, in that its numbers should be maintained and its physical, mental, and moral state kept as high as possible. The strategy and tactics of a campaign may be admirably conceived and carried out, and yet the whole operations miscarry if these desired conditions are wanting. The army may be brought to the right place at the proper moment, but may fail in its enterprise, owing to reduced numbers, poor physical condition, and the bad *moral* which often results."

Munson is quoted as showing that, 'as a general rule, in protracted wars armies suffer much less from wounds and deaths incurred in action than from disease; a fact which conclusively shows the necessity for a proper military knowledge of hygiene.' Also that wars are becoming shorter, and with improvement in the effectiveness of arms the proportion of casualties is increased; so that there is a tendency to an approximation

of the rates from wounds and disease. A tabular statement shows the comparative losses in 12 campaigns since 1800, varying from 25 (disease) to 1 (casualties) among the Allied Forces in the Crimea to 3 to 1 amongst the British in the recent Anglo-Boer conflict and 1 to 1 for Oku's army during 9½ months of the war just concluded.

The diseases observed during continued warfare are chiefly produced by atmospheric exposure, exhalations from the soil, evil condition of latrines, and poor food; some of these, moreover, lead to excessive fatigue and consequent bad *moral*, which themselves are predisposing factors. The two principal diseases are enteric and dysentery.

Capt. Swinton divides the advice that follows into four main heads:—I. Sanitation and Hygiene (Water supply, conservancy, clothes and equipment, marches and fatigue); II. Shelter (Bivouac, tents, huts, entrenchments); III. Food Supply (Rations, fresh meat, cooking, requisitioning, supplementary rations); IV. *Moral*.

Under water supply a useful warning is given that the area round a well which must be guarded from contamination is a circle with a radius *at least* four times the depth of the well, the exact extent depending on the geological formation. As regards conservancy, the experience of Colonel G. H. Sim, R.E., is quoted—'The favourite food of the hot weather fly seems to be human excreta; and next to that, almost every article of human consumption, whether cooked or uncooked, especially milk, sugar, jam, meat, bread and butter.' Everything therefore depends on keeping the excreta covered and all articles of food protected. Sir Frederick Treves, in his *Behind the Lantern*, draws attention to the time expended by the Japanese medical officers in *preventing* disease in comparison with the time spent in *curing* it. Under the subhead for clothing an interesting list is given of the articles issued to the British and Indian troops and followers for the Thibet Expedition. In reference to fatigue it is well pointed out that men are more easily tired out by lack of sleep than by physical exertion, so that every effort compatible with safety should be made to let men have sleep.

In dealing with shelter, the author gives another useful warning against excavating inside tents or shelters in a malarious country or where wet weather is probable, since freshly disturbed earth is likely to produce fever. He recommends a cruciform trench as the most comfortable and easily defended pattern for a small picquet, this shape also requiring less material for roofing than a circular or square post. Proper stress is laid on the necessity for surface drainage.

As to food supply, it is said that meat should be cut up and issued to units *before* starting on a march, in order to save time and worry at the end. Men prefer messing in small squads. *Every man* should be taught how to cook the *rations he is likely to get on service.*

On the subject of *moral* one great secret of keeping troops in good mental condition is to interest them by explaining operations and by giving them reasons for orders.

The lecture concludes with some Odds and Ends, or tips, such as how to make a saltcellar, candlestick, and shade out of a bottle.

A. T. MOORE.

RAILWAY GAZETTE.

August 18th, 1905.

SUPPORTED RAIL JOINT.—The N.E.R. are trying a supported joint for bull-headed rails. Sections of old 82-lb. rail on their sides bridge across under the foot of the 90-lb. rail, between two special chairs, one end of this piece of supporting rail being bent down to prevent creeping. As it happens, the foot of the 90-lb. rail exactly fits the hollow of the 82-lb. rail.

September 1st, 1905.

A GERMAN IMPRESSION OF BRITISH RAILWAYS.—By Herr W. Cauer, Railway Engineer and Professor, University of Berlin.—It is always interesting to hear a candid account of ourselves as others see us, and Herr Cauer's remarks are worth reading, though he recognises that comparison with German lines affords no absolute criticism owing to the difference in local conditions. Primarily, the German Railways are State owned or State controlled. The facilities to the public are therefore not so good, and the management is directed to "equalizing commercial fluctuations, promotion of industrial and agricultural activity (*i.e.*, a protective *rôle*), and, last but not least, the production of a surplus for the national treasury."

What first impresses the foreigner is the magnitude of our passenger traffic, and particularly the facilities afforded to suburban residents. It may be not out of place to remark that short distance suburban traffic, though it has got to be handled, does not pay so magnificently at all.

As to through traffic, Herr Cauer cannot have been very lucky, for he seems to have been impressed with the necessity for changing trains to get to certain minor places, and says English people do not seem to mind having to change. Now I should think that, compared with the Continent, through carriages were very numerous in this country. Of course long distance international trains have no place Time-tables, especially Bradshaw, strike the stranger as difficult, particularly as regards the distinction between a.m. and p.m. figures.

He remarks that the greater use of terminal stations and of stations in the centre of towns in England is doubtless due to greater competition. According to what he says, luggage, etc., is generally handled on the Continent at special platforms, which "simplifies the movements within the station," *i.e.*, keeps the platforms more clear; but of course the separate handling of luggage and the fact that cabs do not come into the stations makes getting away at the end of the journey more difficult.

The English employé is on the average more intelligent and more trusted than the German, whose organization follows military lines, as indeed the employés are ex-soldiers. The signalling arrangements are perhaps operated under more rigid rules there, and their mechanism is certainly more complex, because the man is trusted less. Signals are always worked by two wires, the counterweight is not relied on solely for returning the arm to the Danger position.

For all that, the arrangement of signals in Germany is generally simpler, because fewer are made to suffice: as a matter of fact English

practice differs greatly on different lines, some of which make a much smaller number of signals suffice than others. He says that in some stations here the complexity of the signals is very great—"home, distant, starting, advanced starting, shunting, backing, siding, calling-on, dwarf and disc signals—some of which are practically the same"—yet by night there is no difference between home and distant signals.

In Germany it is considered sufficient to interlock signals and switches, but in England switches are locked with switches. This is a dark saying, for one does not see how interlocking can be perfect unless it provides against conflicting roads being set, and setting a road is always a preliminary to lowering the signal which controls it.

As usual the arrangements for handling goods traffic impress the foreigner, mainly from the fact that expeditious despatch has to be ensured: but I must confess that it is a surprise to hear him say ". . . the geographical simplicity . . . makes it possible to send more through cars." Surely the difficulty in England is to make up through loads!

Although shunting and marshalling yards are not so large here, because the number of routes to be sorted for is not so great, he compliments us on our arrangements, especially the show sidings like Edge Hill, Aintree, and Shildon.

The handiness with which trucks could be handled by the lever brake, as compared with the screw brake, gives him cause for comment.

September 8th and September 15th, 1905.

Each of these numbers contains a letter from a correspondent in China on the present condition of new lines constructing in that country.

C. E. VICKERS.

REVUE D'HISTOIRE.

September, 1905.

OUR EARLIEST INSTRUCTIONS FOR FIELD SERVICE.—These were drawn up in 1732 by Bombelles, and were tested in camps of exercise. They formed the basis of the instructions afterwards issued by authority. They are here printed for the first time (122 articles) with the notes and corrections of Belle-Isle and of the author.

TABLES OF THE FRENCH ARMIES DURING THE WARS OF THE REVOLUTION.—These were compiled about 60 years ago at the Ministry of War, but are now printed for the first time. They extend over 10 years (1792—1801), and show when the several armies were formed, broken up, or combined, what was their territorial area, and who commanded them. They do not show their strength or composition; but nevertheless they will be useful to every student of the wars of the Revolution.

THE CAMPAIGN OF 1797 ON THE RHINE.—The condition of Moreau's army as regards pay, provisions, and clothing is examined in detail, as Moreau attributed his delay in taking the field to his deficiencies under these heads.

E. M. LLOYD.

CORRESPONDENCE.

SUBMARINE MINING.

SIR,

Submarine miners past and present will, I am sure, feel very gratified on seeing Sir Richard Harrison's letter in the *R.E. Journal* of September. It would certainly seem a pity if the work of such a large section of the Corps, now on the point of abolition, should remain unrecorded except in the archives of the War Office. Besides, there is much to chronicle not contained in official reports or in bare figure records, if a true picture of the Submarine Miners is to be presented.

Every day's delay will render such a work more difficult, because, with the passing away of the actors, there will be no opportunities of collating the necessary information.

It does not seem to me possible in the limits of an article to do justice to the subject. Perhaps a series of articles, published in sequence, might cover the necessary ground. But a book giving a "History of the British Submarine Miners" would appear to me to be the thing required. It is hoped that someone who has been in close touch with Submarine Mining may find time to produce such a work; and if one does, he can, I am sure, count on the thanks of all who were at any time engaged in that branch of the Corps and on their assistance in supplying information about the many points that may arise.

No suggestion has ever been more appropriately made than that of Sir Richard Harrison; and I hope that it will have the result which he intended.

Yours faithfully,

W. M. HODDER,

Lieut.-Colonel.

The Editor, "R.E. Journal."

RECENT PUBLICATIONS.

Port Arthur: A Monster Heroism, by R. Barry. (8vo. New York).

From the Yalu to Port Arthur, by O. E. Wood. (8 × 5½. 7s. 6d. Kegan Paul).

The Battle of Wavre and Grouchy's Retreat, by W. Hyde Kelly, R.E. (9 × 6. 8s. Murray).

Moscow: A Story of the French Invasion of 1812, by Fred Whishaw. (6s. Longmans, Green).

Story of the Campaigns in the Peninsula, from July, 1808, to end of 1810, by Lieut.-Colonel H. M. E. Brunker. (7½ × 5. 7s. 6d. Forster, Groom).

Guide to Military History for Military Examinations. Part 1, Peninsula War, 1808–10. By Capt. G. P. A. Phillips. (7 × 5. 3s. Gale & Polden).

Die Angriffe der drei Barkiden auf Italien. Drei quellen-kritisch-kriegsgeschichtliche untersuchungen, von Konrad Lehmann. (10 mks. Teubner, Leipzig).

Guerres Contemporaines de la France et de l'Étranger, et Expansion Coloniale Européenne, 1792—1901, by Paul Charbonnet. (Folio. Paris).

The Decline and Fall of the British Empire: A brief account of those causes which resulted in the destruction of our late Ally, with a comparison between the British and Roman empires. Appointed for use in the National Schools of Japan, Tokio, 2005. (12mo. pamphlet. Oxford).

Les Armées et les Flottes Militaires de tous les États du Monde: Composition et répartition en 1905. (8vo. 1 fr. Berger-Levrault, Paris).

Taktische Unterrichtsbriefe, von Oberst Griepenkerl. 6te auflage. (8vo. Berlin).

Taschenbuch zum Gebrauche bei taktischen Ausarbeitungen, Kriegspielen, taktischen Übungsritten, Manövern und im Felde, von Gen.-Maj. Franz Rohr. 17te auflage. (12mo. Vien).

Engineer Field Manual: Part 1, Reconnaissance, 1905; Part 2, Bridges, 1904; Part 3, Roads, 1905. Professional Papers of the Corps of Engineers, No. 29. (12mo. Washington).

The Duties of the General Staff, by the late General Bronsart von Schellendorff, revised by Major Bronsart von Schellendorff, Great General Staff. Translated for the General Staff, War Office, by Major H. A. Bethell, R.F.A., Major J. H. V. Crowe, R.F.A., and Bt. Major F. B. Maurice, Sherwood Foresters. (8½ × 5½. 5s. Wyman & Sons).

Military Hygiene, by Lieut.-Colonel R. Caldwell, R.A.M.C. (10s. 6d. Ballière).

Nelson and the Twentieth Century, by Arnold White and E. H. Moorhouse. ($7\frac{1}{2} \times 5$. 5s. Cassell).

The Life of General Sir Andrew Clarke, by Colonel R. H. Vetch, C.B. ($9 \times 5\frac{1}{2}$. 15s. John Murray).

Text-book of Topographical and Geographical Surveying, by Major C. F. Close, C.M.G., R.E. ($10\frac{1}{2} \times 7$. 3s. 6d. Wyman & Sons).

Instruction in Photography, by Sir W. de W. Abney, K.C.B. 11th edition. ($7\frac{1}{2} \times 5$. 7s. 6d. Iliffe & Sons).

Cement and Concrete, by L. C. Sabin. ($9\frac{1}{2} \times 5\frac{1}{2}$. 21s. Constable).

A Treatise on Concrete, Plain and Reinforced, by F. W. Taylor and S. E. Thompson. (Chapman & Hall).

The Voyage of the "Discovery," by Capt. R. F. Scott, C.V.O., R.N. 2 vols. ($10 \times 6\frac{1}{2}$. 42s. Smith, Elder).

Great Japan: A Study of National Efficiency, by Alfred Stead, with a foreword by the Earl of Rosebery, K.G. (9×6. 10s. 6d. Lane).

The Risen Sun, by Baron Suyetmatsu. (9×6. 12s. 6d. Constable).

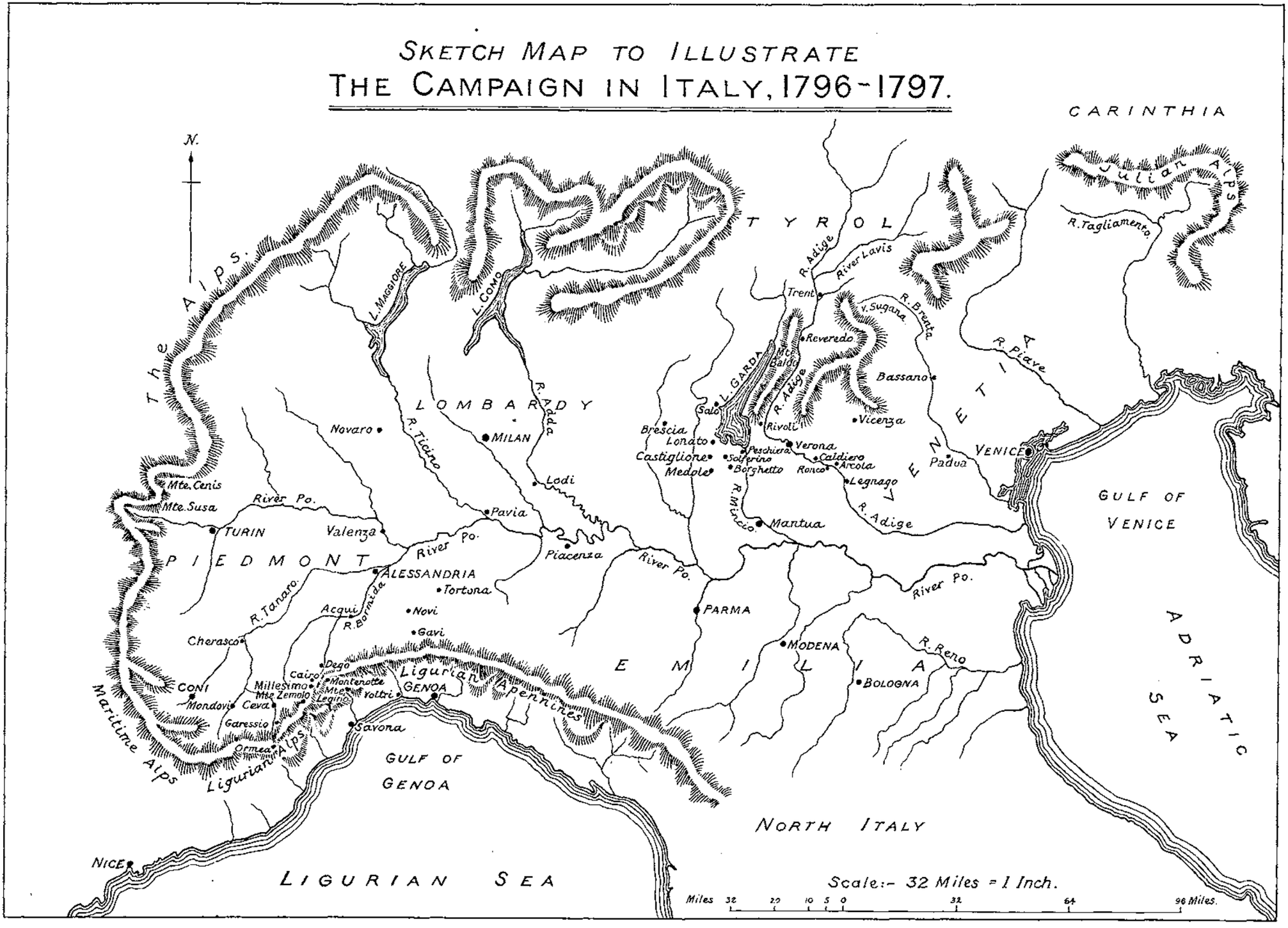
The Central Tian-Shan Mountains, 1902—1903, by Dr. Gottfried Merzbacher. Published under the authority of the R.G.S. (9×6. 12s. Murray).

Egypt, Burma, and British Malaysia, by W. E. Curtis. (9×6. 7s. 6d. Revel).

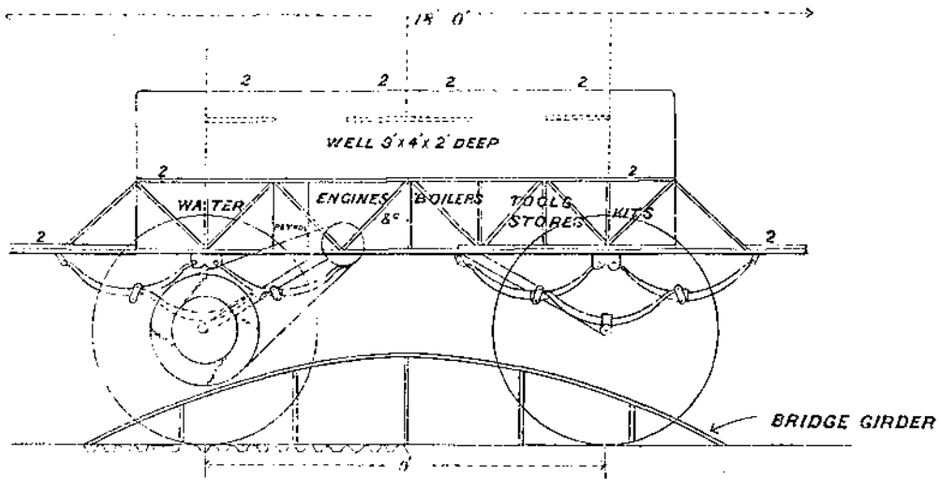
Cars and How to Drive them. Edited by Hon. J. Scott-Montagu, M.P. 2 vols. (7s. *The Car, Illustrated*).

Wild-Fowl, by L. H. de Visme Shaw, W. H. Pope, and A. Innes Shand. (5s. Longmans, Green).

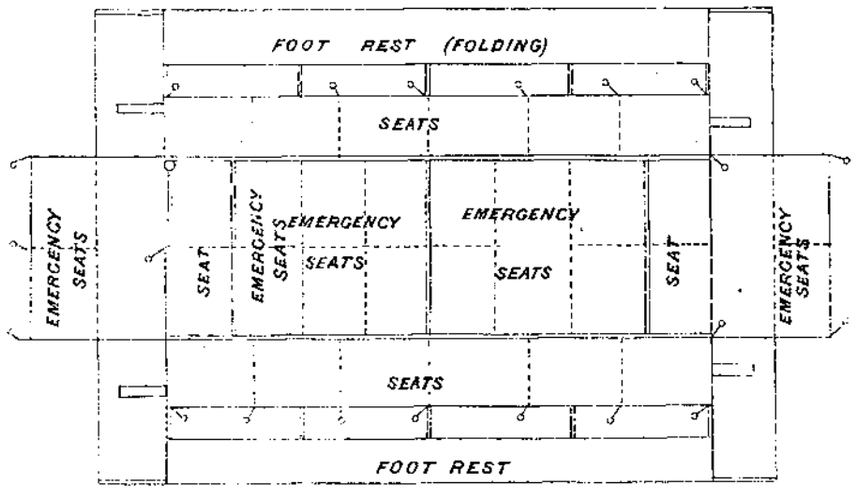
SKETCH MAP TO ILLUSTRATE THE CAMPAIGN IN ITALY, 1796-1797.



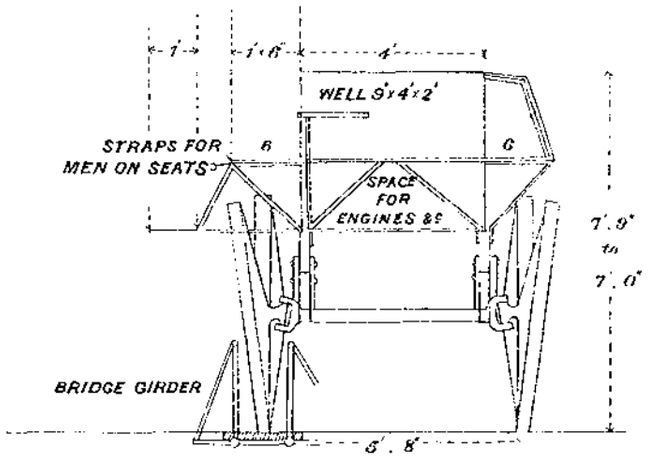
PRETORIA AUTOMOBILE DESIGN.



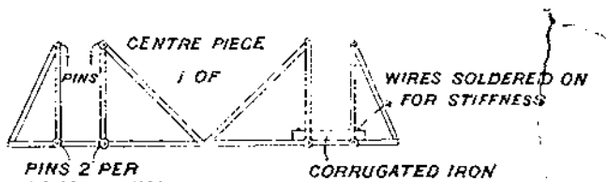
ELEVATION OF CAR ON PORTABLE BRIDGE.



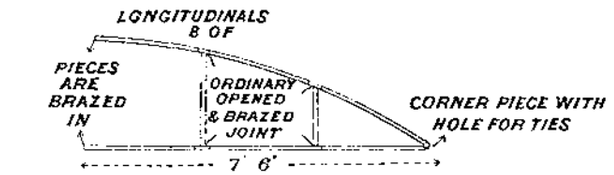
TOP PLAN OF CAR



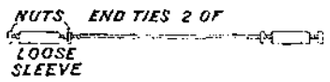
END ELEVATION OF CAR



CROSS SECTION OF BRIDGE AT CENTRE



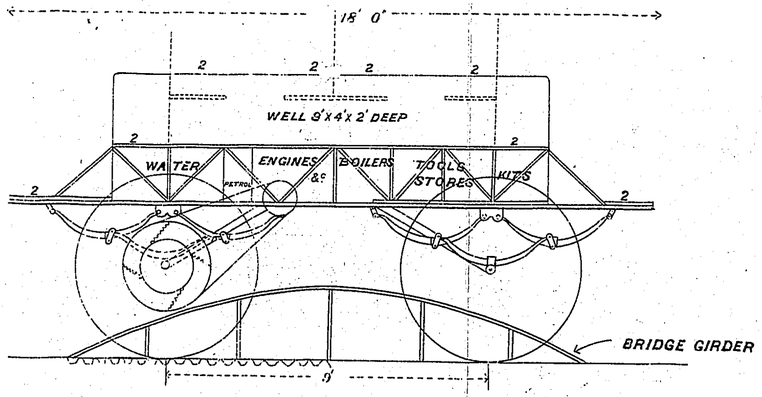
PART ELEVATION OF BRIDGE



NOTES *The figures 2,2,6,6, refer to number of seats*

All parts of Portable Bridge made of 1 inch bicycle tubing, except where otherwise stated.

PRETORIA AUTOMOBILE DESIGN.



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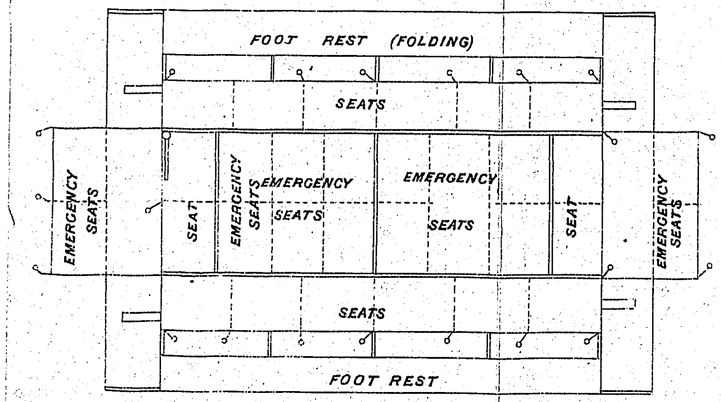
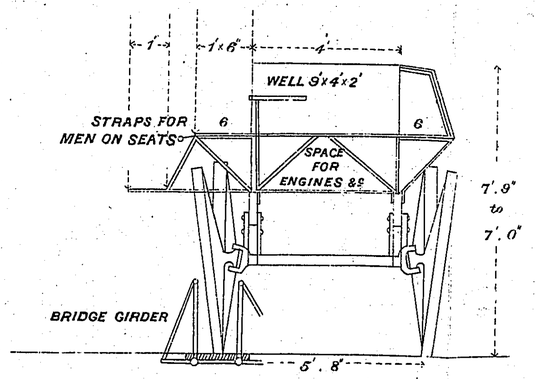


TOP PLAN OF CAR



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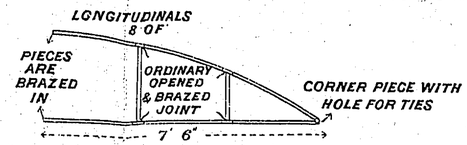
CROSS SECTION OF BRIDGE AT CENTRE



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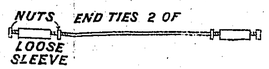

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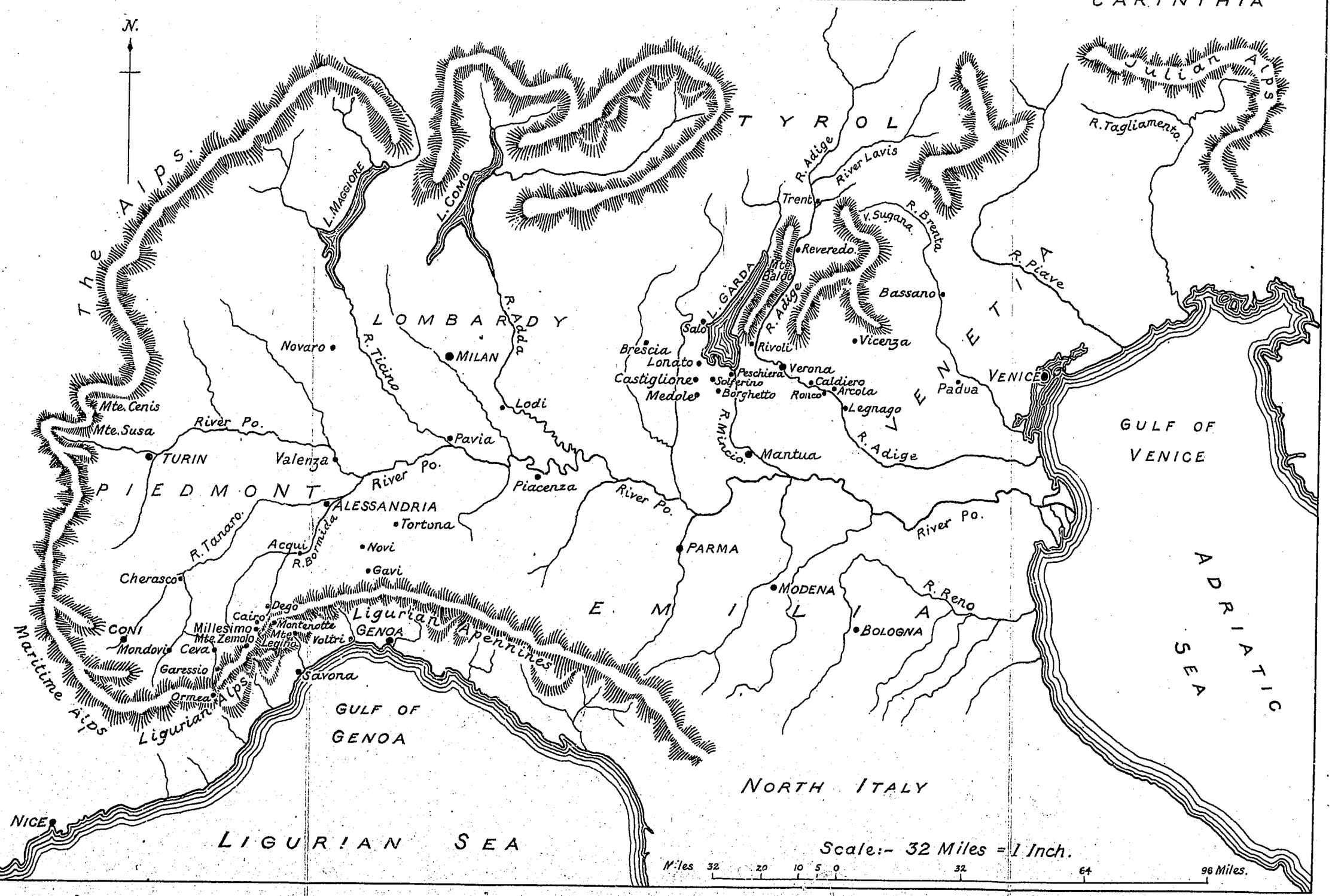
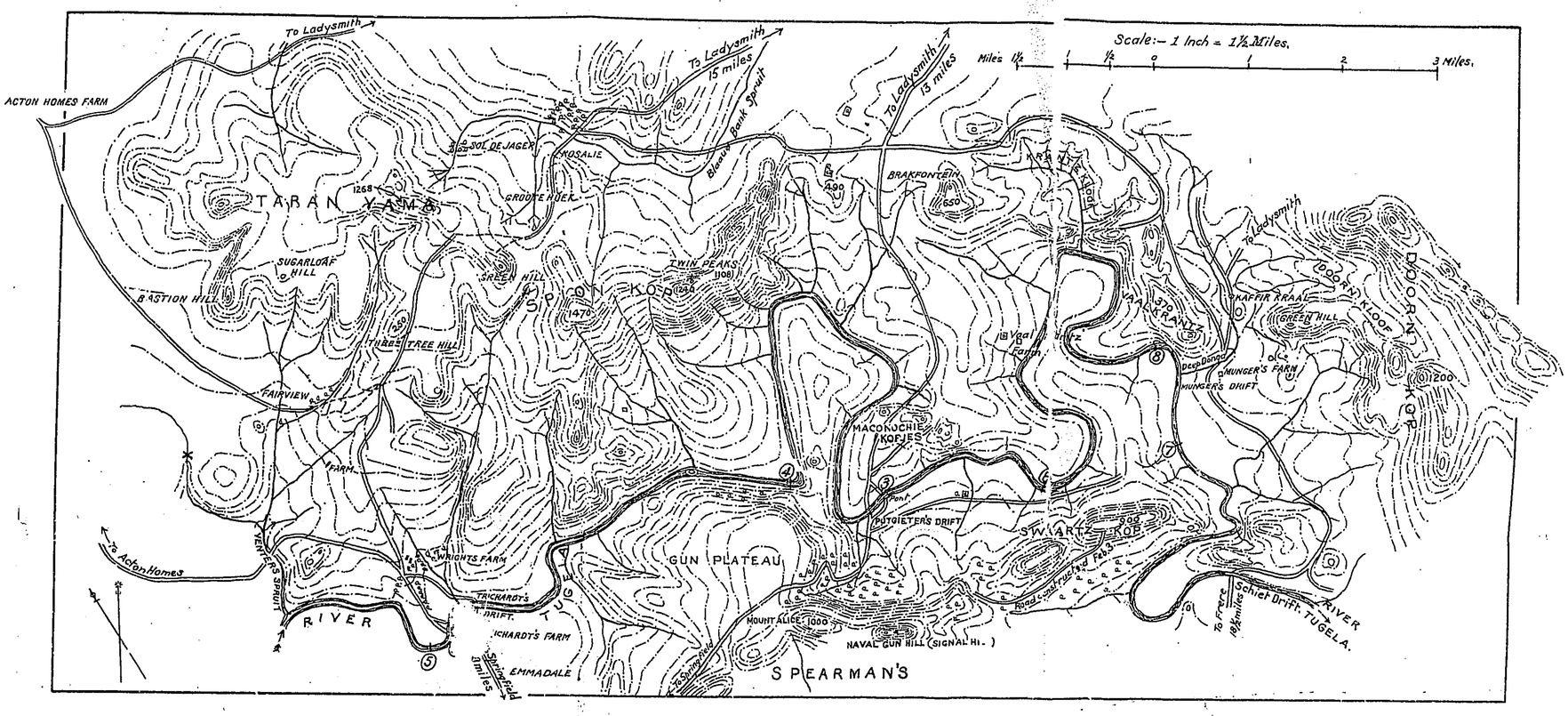


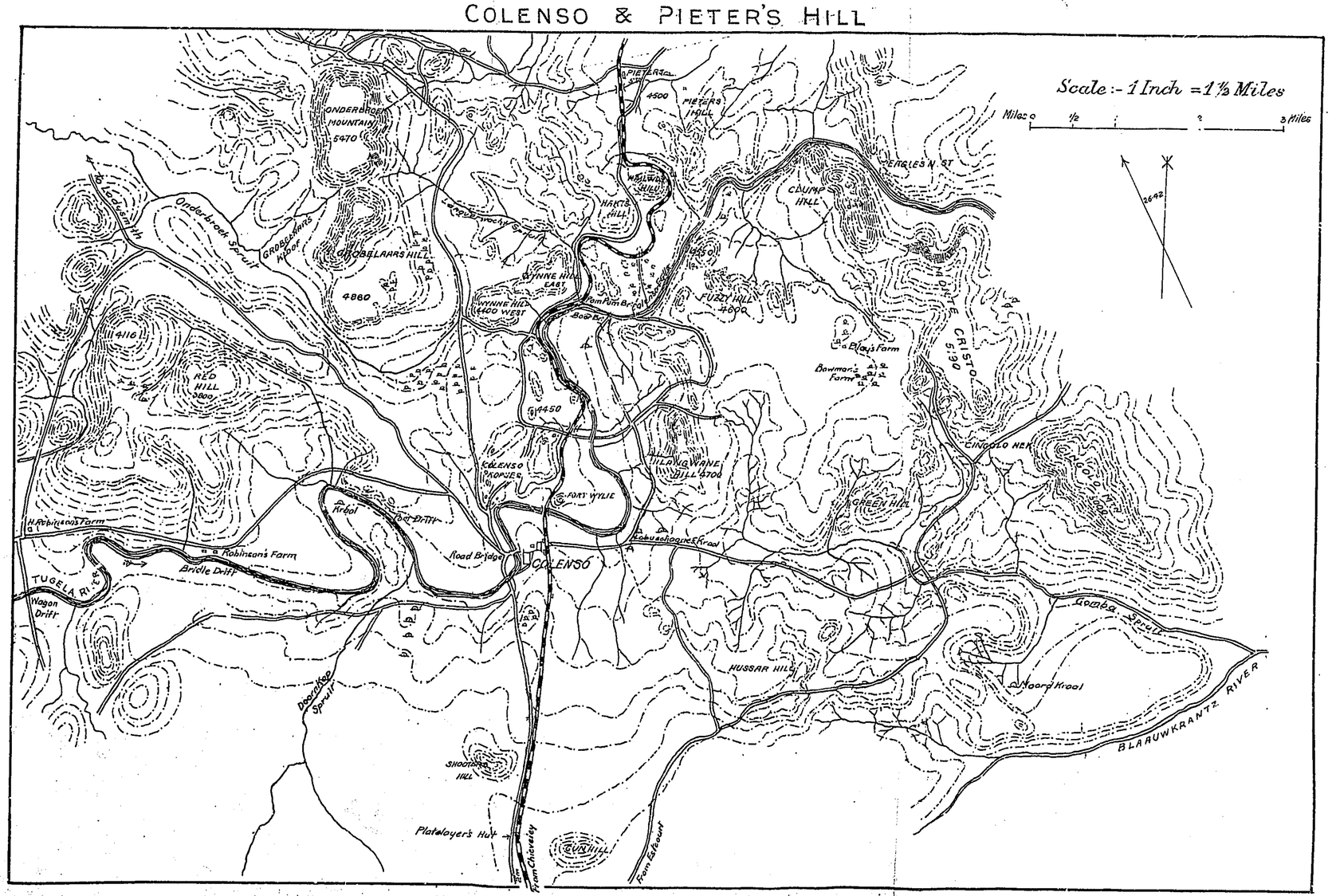
THE PONTOON TROOP IN NATAL, 1899 - 1900.

(Figures in circles as ③ refer to sites of pontoon bridges)

COLENSO, SPION KOP & VAAL KRANTZ.



COLENSO & PIETER'S HILL



REFERENCES TO PONTOON BRIDGES.

Nº	Date	Description
1	$17\frac{4}{00} - 19\frac{4}{00}$	Medium
2	$17\frac{4}{00} - 27\frac{4}{00}$	Heavy
3	$22\frac{4}{00} - 25\frac{4}{00}$	Heavy
3 (rebuilt)	$1\frac{2}{00}$	Heavy
3 (reduced)	$4\frac{2}{00} - 9\frac{2}{00}$	Medium
4	$24\frac{4}{00} - 25\frac{4}{00}$	Infantry
5	$26\frac{4}{00} - 27\frac{4}{00}$	Medium
6	$1\frac{2}{00} - 6\frac{2}{00}$	Medium
7	$5\frac{2}{00} - 7\frac{2}{00}$	Medium
8	$6\frac{2}{00} - 7\frac{2}{00}$	Medium
9	$21\frac{2}{00} - 20\frac{2}{00}$	Heavy
10	$25\frac{2}{00} - 27\frac{2}{00}$	Pont
10	$27\frac{2}{00} - 3\frac{3}{00}$	Heavy

NOTE. In the official account of the action at Vaalkrantz, bridges Nos. 3, 6, 7, 8 were known as Nos. 1, 2, 3, 4 respectively.

The x on the Venter's Spruit marks site of Trestle Bridge constructed on $19\frac{1}{00}$.

Lieut.-Col. W. H. JAMES,

P.S.C. (Honours), Late R.E.

Formerly at 5, Lexham Gardens,

now at

BUSHMEAD HALL, BEDFORD,

SINCE JULY, 1903.

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