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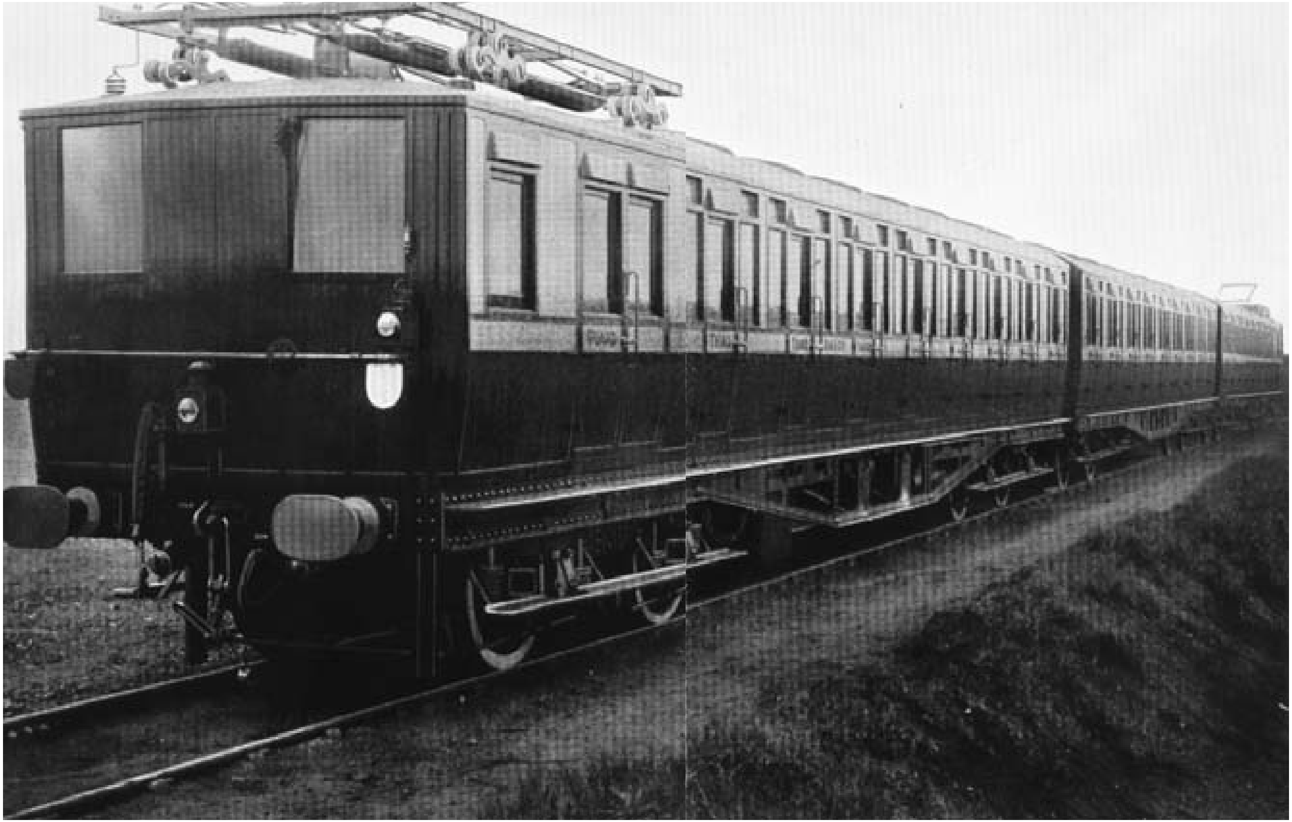

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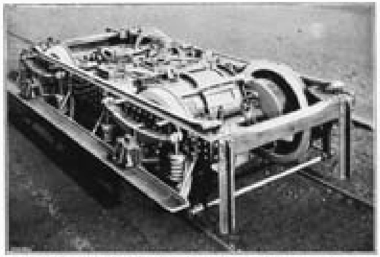

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ELECTRIC TRACTION

ELECTRIC TRACTION ON RAILWAYS.

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THE subject of railway electrification is one involving so many interests and covering so many branches of engineering, as to make it impossible for me, in a single article, to do anything but briefly summarize the principal points dealing with electric traction on railways. I think it will be more interesting and useful to deal generally with the whole subject, rather than to deal in detail with a single one of the very many numerous points connected with this important engineering problem.

The question, generally, can be divided into two entirely different problems, the one dealing with the electrification of lines already constructed, whereas the other is concerned with the selection of a system of traction for new lines which are either proposed or are already under construction.

The former problem is the one which is most generally met in Great Britain, and which therefore presents the greatest interest in this country, whereas in our colonies and many foreign countries, the latter is the one which presents the greater importance.

When dealing with this question it is naturally necessary to carefully consider and weigh the various conditions which obtain, when making investigations as to which system of traction should be adopted for a new line, or when discussing the problem as to whether advantage can be reaped by replacing steam traction by electrical haulage on an existing system. Amongst the conditions which have to be considered may be mentioned such points as whether coal is produced in the country, the price at which such coal can be landed on the steam locomotives, and, where coal is expensive or has to be imported from abroad, whether sufficiently large and continuous water powers are available for supplying the requisite energy necessary for operating the lines under consideration by means of electricity instead of steam.

As far as new lines are concerned, a very serious point arises as regards the nature of the country, that is to say as to whether it is level or mountainous, for in the latter case—owing to the special features possessed by electric locomotives—the adoption of the latter enables very much severer gradients to be allowed for, than would be possible if it were proposed to construct a main-line railway to be operated by steam.

The cause of this very important difference in construction between a railway intended to be operated by steam and electricity, is accounted for by the fact that, for the same weight on the driving wheels, an electric motor can exert a much greater tractive effort than the steam engine, in consequence of the electric motor exercising a steady torque on the driving wheels, which the steam engine does not and cannot do. In the case of the steam locomotive, the ratio of maximum tractive effort to weight on the driving wheels is not much over 16 per cent., whereas experience with electric locomotives has shown that in their case this ratio can be taken at nearly double the amount, namely from 25 to 30 per cent. With electric traction it is possible and easy to drive every axle of a locomotive by means of an electric motor, and no mechanical coupling is necessary between the wheels, whilst, with steam adhesion, this can only be obtained by mechanically coupling the wheels of a locomotive. For mountain work, particularly in the United States of America, steam locomotives of exceptional weights have to be used; thus the heavy trains in operation on the Atchison Topeca and Santa Fe line are hauled by a Decapod, the engine of which weighs 128 tons without the tender, while the latter weighs 72 tons, or a total weight of engine and tender of 200 tons. This weight is by no means exceptional; there are many locomotives in America which exceed it.

In the case of the locomotives I have mentioned, not more than 90 tons are available on the driving wheels, which, on the basis of 16 per cent., would give just over 13 tons available for tractive effort. Compare this with the electric locomotives on the New York Central Railroad, the total weight of which is 95 tons, 70 tons of which are available on the drivers, and taking 30 per cent. of this as a maximum tractive effort, we find 21 tons, or nearly double that which was possible with the steam locomotive, including the tender of over double the weight. But there is another important factor which must enter into consideration, namely, that as far as steam locomotives are concerned, the limit of size of a single locomotive has been reached, and this may be said to be somewhere in the neighbourhood of 2,000 H.P.

There is nothing as regards finality in connection with electric locomotives, which have the additional advantage that, in consequence of the properties of the series wound type of electric motor, they can at starting and for some considerable time, according to their design, stand overloads of 100 per cent. or more without damage.

Before considering more in detail the various reasons which have brought about electrification in the past, or will bring it about in future, or before entering into a discussion of the various details, it may be as well to point out that the only argument which lies at the bottom of electrification, either of existing lines or of new lines, is of a financial nature. Electricity must either reduce working expenses, increase the gross receipts, decrease the capital expenditure required in the construction of a given line, or enable a larger number of trains to be operated over an existing system than will be possible with steam. This means saving the additional capital expenditure which will be required for increasing the number of tracks and station platforms, which would be involved if a train service were increased whilst retaining steam operation. In any case where it is impossible to definitely prove that some such financial advantages exist, as have been referred to above, there can be no question of considering electric traction.

The principal advantages from this point of view in connection with long-distance lines arise in the case of new lines from (1) the cheaper construction, possibly owing to the feasibility of adopting more severe gradients with steam than with electric traction, and—in the case of existing steam-operated lines—in consequence of the saving in operating costs (which can be obtained where coal is expensive and water power abundant); and (2) the further benefits ot rendering a country self-supporting and not dependent on export coal from other countries. Incidentally, the installation of electric traction under these conditions offers additional advantages of rendering electric power available for manufacturing and other purposes along a railway system, which might otherwise never have been developed.

In this investigation of the subject of electrification there is however a very serious point to be borne in mind particularly by the military engineer, namely that where railways are built for electric traction and entirely operated electrically, the risks of interrupting traffic in case of war may be much more serious than if steam locomotives are utilized. It is evident however that there are only certain cases in which this consideration applies, and the proper weight can only be given to it when all the various contingent circumstances have been seriously weighed and carefully considered by those best able to judge on the spot of their relative value.

Having thus briefly summarized a few of the advantages presented by electric traction in the case of long-distance lines, we will consider in a similar way both the advantages which will accrue to British railways by the electrification of their suburban lines, and also what are the reasons which will weigh most in the minds of the railway authorities in favour of such a change.

In this connection it should be clearly understood that the only lines on which electric traction, as far as this country is concerned, can at present be discussed, are those so-called suburban lines on which the distance between stations are comparatively restricted from ½ to 1 mile, and over which a very frequent service of trains have to be operated. Thus, in the case of London, one may roughly call the suburban system of a railway anything which is within say 20 or 30 miles of Charing Cross. The principal advantages of electric traction in this case are due to the property possessed by electric motors, which will enable them to produce what is called rapid acceleration, or, in other words, to obtain the maximum travelling speed in a very much shorter time than is possible with steam. Thus taking the extremes, whilst the maximum which has been practically possible with steam, is to obtain a speed of something like 27 miles an hour in 50 seconds, the experiments at the General Electric Company's works in America have shown that it is quite feasible with electricity to obtain a speed of 40 miles an hour in 30 seconds. This latter acceleration is of course much too high from the point of view of personal comfort to the travelling public, and with electric traction on suburban systems it is more usual to obtain anything from 25 to 32 miles an hour in 30 seconds.

This property enables the average speeds of trains to be very considerably increased, and, according to circumstances, anything from 25 to 50 per cent. to be deducted from the time required for travelling between any two stations on the suburban line. Thus in the case of the Brighton Railway (for the electrification of which I am responsible), on the run from London Bridge to Victoria and *vice versâ*, we shall save 11 minutes; for whereas with steam it takes at the present moment 36 minutes to do the distance, with electricity we shall be able to easily maintain a service with stopping trains, running the distance in 25 minutes. There are however many other advantages of equal importance which must be taken into consideration when discussing the question of electrification of suburban systems.

The increase in the speed of travelling possible with electricity will be useless, unless much more frequent services are at the same time installed than are usually adopted with steam practice, and again in this instance electricity comes to the aid of the railway manager.

Steam locomotives may be considered very economical when they run long distances and haul heavy trains for such distances with few or no stops, or in other words when they exert tractive effort during the majority of the time they are running; thus a steam locomotive only uses something in the neighbourhood of 4 lbs. of coal per H.P. hour, or according to the weights of train anything from 35 to 60 lbs. of coal per train mile.

The moment the locomotive is utilized for suburban work this state of things entirely disappears, for experience clearly shows that the amount of fuel burnt during the time a suburban locomotive is in actual service, is very little less than that which would be burnt by such a locomotive if it were running and exerting tractive effort during the whole time that it was in service. In other words, the amount of fuel consumed per train mile, or per ton mile, is very much greater in the case of a locomotive doing suburban work than of the main line engine above referred to. It clearly follows that it must be more economical to have as few and as large suburban trains as possible, rather than to have a larger number of smaller trains, for the cost in the case of a steam locomotive is nearly proportional to the train mileage, practically irrespective of what the ton mileage hauled may actually be. In the case of electric traction the case is quite different, for here the amount of energy consumed is proportional to the ton mileage, and under these circumstances there is very little difference in the operating expenses caused by running a much larger number of small trains, rather than a small number of large trains. It will therefore be seen that electricity enables a general manager of a railway not only to increase the average speed of travelling, but also the frequency, which, as I have shown, is absolutely essential if full benefits of increased speed are to be fully realized.

Up to the present in discussing electric traction we have only compared electric and steam locomotives, and it must now be pointed out that electricity enables the use of what is known as the multiple unit control, that is to say the equipment of a given number of carriages with motors, each motor car hauling, or being capable of hauling, a given number of trailers, and a unit train being made up of one or more motor coaches and trail coaches as may be considered best.

The multiple unit system of control thus enables any number of these unit trains to be coupled up and driven by one man just as if they constituted but one train. Such multiple unit trains can be made up of any number of coaches as desired, and owing to the comparatively reduced maximum speed at which trains of this description have to travel, it is admissible for a motor coach to push a trailer coach, and thus to form a unit where found advisable consisting of one motor coach and one or more trailer coaches equipped with controlling apparatus, so that the train can be driven by motormen from either end. The use of multiple unit trains and their great advantages are at once appreciable when the question of termini have to be considered, as is practically always the case when railway electrification is under discussion. At the present moment, taking a terminus like Victoria Station, it takes six minutes after the arrival of a train alongside the platform before the same platform can be available for another train. This is due to the fact that after a train has arrived the lines have to be cleared, in order to enable the engine to be backed on to the train in readiness to take the same out again, and that as soon as this has been done, the line has to be kept clear for the engine which brought the train to be run out again to a particular siding, on which it has to wait until another train is brought in, which it has to haul out.

With the multiple unit system of electric traction this loss of time entirely disappears, as all that is required is the time at which it takes the motorman to take off his switch handles and walk from one end of the train to the other. This time is probably less than would be required to empty and fill a train, but provided properly designed carriages are used with side doors, and not with the American form of end doors, from $1\frac{1}{2}$ to 2 minutes is the maximum time required for any train to occupy a platform. The enormous benefits conferred by this saving of time will be appreciated from the fact that at a terminus such as Victoria Station, at the crowded hours of the day, it is very difficult, not to say impossible, with steam traction to add a single train to the existing services, a very severe handicap on a railway, considering the constant demand of the travelling public for increased train facilities, particularly during the rush hours of the day.

In other words, the introduction of electric traction will enable a railway—taking into consideration the small proportion of long-distance trains compared with suburban trains—to more than double the number of trains on a given system, without either increasing the number of tracks or the station accommodation. The cost of operating and maintaining electric trains is certainly smaller than that involved with steam trains, but the advantages I have shown which are possessed by electric traction are so great as to make it unnecessary at the present moment to discuss economies which will undoubtedly result in consequence of railway electrification. For as already mentioned in order to make electric traction successful financially, the number of trains must be considerably increased, and under these circumstances it can be safely stated that although smaller trains will be operated, the total train service can be doubled by means of electrification without involving any appreciable increased working expenditure besides that required for electrically equipping a system, which figure is a very small one when compared to the expenditure which would be necessary if increased services had to be put into operation and hauled by steam.

The introduction of electric traction on the suburban system of one of our great railways, as for instance on the London, Brighton and South Coast Railway, would bring many other advantages in its train, some of which are of the utmost importance. Supposing for example a time when the whole of the suburban line between Victoria, London Bridge, Sutton, and Croydon are equipped with electric traction, and that all the local trains running to Sutton or Croydon are operated electrically, the question will have to be considered as to what shall be done with the main line trains after they reach either Sutton or Croydon. At the present moment most of the trains divide at these two stations, one portion running to the City and the other to the West End terminus. Such a division involves loss of time, time which would be no greater if from this point electric traction were adopted instead of steam for hauling the trains respectively to Victoria and London Bridge. The cost involved by such a change would be very slight, as the electrical equipment, overhead system, feeders, switch cabins, etc., will already be available and will not have to be increased in order to handle main line traffic. The advantages of such a step are obvious, because thereby the immensely valuable space now occupied by locomotive sheds, locomotive repair shops, coal sidings, turntables, ash pits, water towers, and suchlike, would be rendered utilizable for other purposes, and furthermore considerable time would be saved at the termini owing to the fact that an electric locomotive, when standing, does not use current, and if switched off can be left by itself without any attendant, ready for instant use, whereas this is not the case with a steam locomotive. There is however one very great advantage which would be reaped by such a change, and which is, I think, not sufficiently appreciated by many engineers, namely the great saving in corrosion of steel work which would be effected by the absence of the gases caused by steam locomotives. What this corrosion may mean, may be seen by the fact that some bridges have had to be renewed within 10 years, where they are subjected to the hot gases and sulphurous vapours emanating from steam locomotives. As long as steam is employed it is practically impossible to paint steel structures with any reasonable chance of success where they are within a few feet of steam locomotives, whereas, if electricity were adopted, they could always be properly painted and kept in working order and their life immensely prolonged.

In considering the advantages of electric traction, it must not be forgotten that electric locomotives are not only more efficient than steam, but that they cost less to maintain and that the hours of service which can be got out of an electric locomotive per annum are much greater than those which can be obtained from any steam-driven locomotive.

This experience has shown that in the case of steam locomotives operating suburban trains, out of the total life of a locomotive, which may be taken at about 25 years, only about 28 per cent. of this time is utilized in actually hauling trains. Although it is only exercising drawbar pull during 28 years of its total life, it is consuming fuel and wearing itself out during, approximately, 76 per cent. of its life, the remaining 24 per cent. being spent by it in repair shops and in generally being overhauled and maintained. In Germany it is found that the average working hours per locomotive average out at about 12·8 hours per day, but that out of this, two hours per day are necessary for replenishing the engine and for getting it under steam, as well as for raking fires and cleaning smoke tubes at the end of a day's work. A further hour is required every day to take in additional fuel and water, and when the fire is out an additional hour for washing out the boiler, so that out of the 12·8 hours in which it is actually supposed to be engaged in doing work it is only effectively in use 8·8 hours. Figures show that, as regards the Prussian Government Railways, out of a total number of steam locomotives owned, 22½ per cent. are not available as they are undergoing repairs, from which it will be seen that out of the total number of steam locomotives owned, only

54 per cent. are actually in service. The repairs of steam locomotives as a rule are most important in connection with their boilers, which puts the whole locomotive out of service, whereas with electric locomotives, repairs are of such a nature as not to put them out of service for any considerable time, as most defects or worn-out parts can quickly be replaced without laying up the engine, which is not the case with steam locomotives.

The calculations which have been made by the Prussian Government have led them to conclude that, having equal work and allowing an equal amount for reserves, 36 per cent. less electric locomotives are required than would be necessary if steam locomotives are employed.

I hope that I have been able to show that, as regards electric traction in this country, there is undoubtedly a great deal to be said in its favour from every point of view, as far as the electrification of local and suburban lines is concerned on which there exists a very intense and heavy traffic, and that as far as foreign countries are concerned there are many cases where the equipment of long lines may prove exceedingly satisfactory.

Having thus briefly examined what is the actual position as regards the introduction of electric traction on railways under varying conditions, we will briefly consider the course followed by electric traction after its first practical introduction at the technical exhibition in Berlin in 1879. Here a small electric locomotive, built by Messrs. Siemens Halske, hauled a few small trailer coaches carrying 12 or more passengers in all along a narrow-gauge line laid in the exhibition grounds, current being supplied from one rail and returned to the other. The successful operation of this small experimental line soon led to the adoption of electric traction on a larger scale in connection with tramways in Germany and in Ireland. In Germany, between Frankfurt and Offenbach, in Ireland, at the Giant's Causeway and between Bessbrook and Newry. It was however in America that the great future for electric traction was first realized on a large scale, and its introduction on the very well-known West End tramway system at Boston about 1889, was the starting point for what may be called the wholesale electrification of all existing tramways in America. The increase in traffic and decrease in working expenses resulting from electric traction, were such as to speedily open the eyes of European financiers and tramway men to the great benefits to be derived from electrification. Germany, France, and England soon followed suit, the first great success being achieved in England by the Bristol Tramways Company, for the equipment of which I was largely responsible, and from that date to the present time so much has been done that practically speaking nowadays there does not exist a town of any size in the United Kingdom which has not its own electric tramway service.

The development of the electric motor was very rapid in consequence of the large demands produced by electric tramway construction and equipment, with the consequence that in a few years motors were produced which only a short time beforehand would have been thought quite impossible, and the result of this experience was that the general knowledge of how to get over difficulties and to improve efficiencies in outputs, was very largely increased. It is not therefore surprising that the City and South London Railway Company, when faced with the problem of what method of traction to employ on the first deep level tube built in the world, as well as the Liverpool Overhead Railway, when faced with the proposition that in consequence of fire risks steam haulage on their system was impossible, both immediately decided to adopt electric traction. Shortly after this the Baltimore and Ohio Railway Company, having built a long tunnel under the City of Baltimore in order to avoid difficulties due to ventilation, decided to haul the whole of their trains through this tunnel by means of electric locomotives, and these were each equipped with four 6-pole motors, each motor being built to give out 360-H.P. for one hour. The total weight of this locomotive was 85½ tons, its normal drawbar pull was 42,000 lbs., and at starting it was able to give a drawbar pull of 60,000 lbs. In the United States, as is well known, there were a very large number of steam railways built solely for hauling local services, such as the various elevated railways in New York and Chicago. These, before the advent of electric tramways, had done very fine business, but with the increased speed and frequency produced by electric traction on tramways they soon found themselves obliged to introduce electric traction themselves. The results which they anticipated from this conversion have so far been nearly universally realized in the United States. It may be said at once that although electric traction on railways has not been introduced till comparatively recently, it had been thought of in the early days, and as far back as 1885 an electric locomotive, built by Mr. Leo Daft, had been experimentally operated for some months over the lines of the Manhattan Railway in New York.

The success obtained by electric traction on railways soon resulted in many other railways adopting this method of haulage, particularly in those cases where steam was either not available or was impossible, as for instance in the case in Paris with the Orleans line, in connection with its new terminus at the Quai d'Orsay.

The beginning of this century first brought home to the railways the very disastrous competition which the introduction of electric traction enabled tramways to create, and it may be said with truth that it is the electric tramway which will be largely responsible for the introduction of electric traction on most of the suburban systems of our main line railways. It is to this cause that must be traced the adoption of electricity by the Lancashire and Yorkshire Railway for its line from Liverpool to Southport, as well as the electrical equipment by the North-Eastern Railway of their line between Newcastle and Tynemouth, and in both cases the result appears to have come up to the expectation of the railway company's officials.

In considering the problem of railway electrification, it is necessary to point out that there would appear to be only two rational courses which can be pursued by a railway in order to meet tramway competition. The one would involve the entire shutting down of the whole suburban system, no trains stopping within say 15 miles of the terminus. This would mean that a very large number of lines, sidings, and stations which can only be used for suburban traffic would have to be shut down and their capital value, representing a very large figure, written off, as well as the decrease of gross receipts (a very large item) which would result from the entire abandonment of local traffic.

What tramway and motor omnibus competition means, can be gathered from the statement that five railway companies—the Great Northern, the London and South Western, the London Brighton and South Coast, the Great Eastern, and the South Eastern and Chatham —carried between them nearly 35,000,000 passengers less in 1907 than they did in 1903, and this loss of passengers accounted for the loss in money of over £177,000. It should be noted that this loss is constantly increasing, owing to the extension of tramway systems, and the reduction of local traffics by railways can only greatly increase the loss, whilst but very slightly decreasing the working costs of the system, and it would therefore appear that, even if the Board of Trade and the Government could allow railways to entirely abandon the whole of their suburban traffic, the losses resulting from such a step, both as regards receipts and writing off useless capital expenditure, would be such as to make such a solution a most unpractical one.

The one method of dealing with this difficulty is by increasing the average speed and frequency of the trains, which, as has been shown, can only be done by electrification. Experience has shown that in Great Britain at least, the average speed of tramways cannot exceed about 10 miles per hour, that under favourable conditions of railway traffic the limit of tramway travel is about 5 miles, and that everything beyond 5 miles will come back to the railway, provided electrical service is introduced. Facilities for travelling always increase the travelling habits of the people, experience in this country amply confirms that of other countries, and conditions are such that if all that can be secured by the railway companies in consequence of electrification is simply to recuperate their lost ground, such a step will be amply justified. Probably the greatest electrification of a railway which has ever been carried out has taken place in New York City, where for about 30 miles outside New York both the

New York Central and the New York New Haven and Hartford Railways are running electrically, the local trains being operated on the multiple unit system, whereas trains going long distances are operated by steam until the electric zone is reached, when electric locomotives take the place of steam. The primary causes of this change was the dangers caused by the long tunnel through which both railways have to pass on their entry into New York, and the necessity of entirely doing away with steam if these dangers were to be avoided. The results obtained by this conversion have been entirely satisfactory to the railway companies, and Mr. Smith, the third vice-president and general manager of the railway, informed me last summer that electrification had been the salvation of his railway. The railways already opened have given such satisfactory results that the Illinois Central Railway, which has an enormous passenger traffic in Chicago, has decided to operate the whole of its suburban system by electric traction, a step the importance of which can scarcely be appreciated at its proper value. But it is not only in America that large things are being considered, for Germany, with its very excellent State-owned railway system, has been carefully watching events, with the result that after most thorough investigation of everything that has heretofore been done, the Prussian Government has definitely decided to convert the whole of the Berlin urban and suburban railway system to electric traction at an expenditure of some £10,000,000 sterling.

Having thus generally considered the reasons which should in the near future bring about the very general adoption of electric traction on railways, we will now discuss the various systems by which electricity can be most satisfactorily utilized for traction purposes.

For all practical purposes there are three systems, and three only which can at the present be considered for traction purposes, and which are as follows :—The continuous, or direct current system; the three-phase system; and the single-phase system.

The first of these systems is that which has so far been most generally adopted; it involves the use of continuous current motors of a series type, generally very similar in design and construction to the electric tramway motors, which are so well known to everyone. These motors are operated in groups of two or four, by means of what is known as a series parallel control, by which the motors are first started in series with each other, and afterwards—when speed has been obtained—put into parallel.

The usual difference of potential or electrical pressure between the terminals of these motors is from 500 to 600 volts. Motors have been constructed at the terminals of which it is possible to employ 1,000 volts, and by keeping a group of two motors of this description constantly in series it has been possible to utilize pressure of 2,000 volts with continuous current motors. It is evident that in this case all the controlling apparatus and the lighting circuits must be insulated to 2,000 volts, and furthermore, even supposing 200-volt lamps were used for lighting purposes, ten such lamps would have to be put in series, as otherwise a motor generator would have to be insulated on the coach or on the train, in order to convert a high pressure continuous current into lower pressure continuous current. It is claimed by some designers that motors can be constructed to satisfactorily operate at 2,000 volts, and by putting two of these in series it might be possible to utilize a line pressure of 4,000 volts, but such construction has never yet been carried out in practice.

It must be noted that the introduction of such high pressures would introduce very serious dangers in maintaining and looking after motor equipments, as there must always be a liability of getting a shock with the full line pressure when touching any part of the apparatus, and furthermore all the motors and the apparatus generally would have to be insulated to withstand the working pressure. It must further be noted that in order to regulate the speed of continuous current motors, it is necessary to regulate the pressure between the terminals of the motors, and that for a considerable stage of the operation this can only be done by absorbing volts by means of resistances, which is necessarily an inefficient mode of doing this. This method of traction has been utilized in connection with railway work, and requires the use of a third rail, insulated and situated above the level of the ordinary rails, which serves to conduct current to motors on the train.

In the case of the Baltimore and Ohio line, the railway authorities at first used overhead conductors to bring the current to the train, but the construction proved so cumbersome that it had to be abandoned in favour of the third rail system. The reason for this will be easily appreciated when we recollect that for starting an electric train, according to the weight of the equipment of the train, anything from 800 to 2,000 kilowatts may be required, which, at the normal pressure utilized at the present moment for continuous current work, would amount to from 1,600 to 3,500 ampères. From this it is seen that (considering that more than one train will frequently have to start and take its supply from the same conductor) the size of this will have to be such as to make it impossible under such conditions to utilize anything but the third rail system of conductors at the pressures usual with continuous current motors. In other words, as far as railway work is concerned, the continuous current system makes the third rail essential.

Where earthed returns are used, the Board of Trade where it has jurisdiction limits the return drop to 7 volts. With the very large currents required in railway work this practically means the adoption of a fourth or insulated rail, as has been done by the District and Metropolitan and the Great Western Railways in London. The very large amounts of energy required for railway work have to be distributed over considerable distances, and in order to secure both economy as regards first cost, as well as economy in generation of current, it is necessary to reduce the number of power stations as much as possible, or, in other words, to centralize the same to the utmost possible safe extent. Under these conditions, in order to transmit economically as well as to reduce the size and quantity of feeder cables required, the current is usually generated in the form of alternating current. Generally two or three-phase currents are used, and these are transmitted at varying pressures according to circumstances. The usual maximum generating pressure for economical machine construction is somewhere in the neighbourhood of 11,000 volts, and the current is frequently distributed at this pressure and transmitted to sub-stations, where the pressure is reduced to from 350 to 500 volts, according to circumstances, by means of static transformers, and then converted by means of rotary converters into continuous current at the pressure of 500 to 650 volts, at which it has to be supplied to the line. Instead of static transformers and rotary converters, motor generators can be used, the motors being wound for the pressure at which three phase-current is supplied, provided this does not exceed some 11,000 volts.

For long-distance transmission this pressure is not sufficient, and in this case the pressure at the generating station is transformed up by means of static transformers to whatever transmission pressure has been settled upon.

In order to increase the efficiency of the cables and decrease the size of the sub-station converting plant, in many cases recourse has been had to storage batteries having anything from 1,000 to 5,000 or 6,000 ampère hours capacity, and such installations have for example been put down in the case of the Lancashire and Yorkshire Railway, and given very good results.

Only careful calculations in every individual case can possibly give the amount of sub-station plant which would have to be put down, but, generally speaking, it can be stated that experience has shown that the sub-station plant is anything from one and a-quarter to twice the capacity of the plant installed at the generating station.

The second system is the three-phase system, which has been used with quite satisfactory results on some long-distance railways in Switzerland and Italy, as well as several short mountain lines in Switzerland. In this case the current is usually brought to the motors by means of overhead conductors, two in number, the rails acting as a third conductor; at all points and crossings the overhead conductors which carry different phases have to be separated from each other by insulating material, and furthermore the collecting device on the top of the cars or locomotives have also to be insulated in a similar way from each other. Experience has shown that

3,000 volts is the safe maximum pressure to be utilized between two such working conductors. It therefore follows that for long-distance lines, sub-stations containing static transformers will have to be put down in order to reduce the pressure to that at which the current has to be supplied to the working conductor.

The last method, and the one which has recently been most perfected, is that known as the single-phase system. In this method single-phase alternating current motors fitted with commutators are employed, the design of which is in every way very similar to the latest form of continuous current traction motor, and which in fact are so constructed that they can equally well be operated either by continuous or alternating currents. The maximum pressure at which the current is supplied to the terminals of these motors varies, according to their type, to from 300 to 750 volts, this latter pressure being that at which the compensating repulsion type of motor, as designed by Dr. Eichberg and constructed by the Allgemeine Elektricitats Gesellschaft, can operate at. The motors constructed by most of the other makers are what is called the series type, and in this case it has not been practical so far to use current at greater pressure than 300 volts at the terminals of the motors.

In this case the current has been supplied at a pressure as high as 22,000 volts to the working conductor, from which it is collected by means of sliding contact or bow collectors, and transmitted to static transformers on the car, which transform the current to the pressure at which it is utilized in the motors. All the controlling and auxiliary apparatus is in the low-tension circuit, and the same applies to lighting and heating. All the speed regulation is done by means of varying the steps of the transformer, by which the voltage of the motor terminals can be varied as may be required. The single-phase motor has the advantage of possessing practically all the qualities of the continuous current series traction motor, and is therefore most eminently suitable for traction work, and it will be seen that, as regards line pressure, there is no reason why anything up to 25,000 volts should not be used. As a matter of fact, it may be supposed that for ordinary suburban work about 10,000 volts would be found sufficient. The advantages of this pressure will easily be realized when it is seen that it is about 20 times higher than that which has heretofore been the working pressure in connection with continuous current railway working, or, in other words, trains requiring current of from 1,500 to 3,500 ampères at 500 volts, on the basis of 10,000 volts, would only require from 75 to 175 ampères. It will also be obvious that, taking 10,000 volts as working pressure, this can be generated directly in the machine, transmitted and utilized in the overhead line, all at the same pressure, thus doing away with substations and all necessity for static transformers, and the necessary and complicated switch gear required by same.

In comparing the single-phase system with the continuous current, it may be stated that the single-phase motor is from 15 per cent. to 25 per cent. heavier than the corresponding continuous current motor, and in addition to this there is the weight of the electrical transformers. It follows that, for the present at least, single-phase equipment of a train must be more costly than the corresponding continuous current equipment, as regards the question of weight of a complete train equipped with single-phase motors, which will, under ordinary conditions, probably not be more than 10 per cent. heavier than the same train equipped with continuous current plant. There is no reason to anticipate that cost of maintenance should be materially greater with single-phase than with continuous current apparatus, and I think it will be admitted that, if there are any material advantages from a railway point of view to be gained from the addition of 10 per cent. in weight of the trains, no railway man would hesitate one moment in adopting such additional weight.

Taking the cost of current at anything from one-third of a penny to one half-penny, such additional weight would only mean an extra cost of something like ½d. per train mile, which is quite insignificant when we consider the fact that locomotive charges at the present moment on our railways amount on the average to about 1s. per train mile, of which fuel is accountable for about half. In considering these figures it must be recollected that they are for the average train mile on our railway systems, and that considering the bad conditions under which locomotives work when hauling suburban trains, if figures were available only for this branch of the service they would probably come out much higher.

The only disadvantages claimed against the single-phase system, as compared with the continuous current system, are :—

(1). The additional weight and consequent increased first cost.

(2). A slightly lower efficiency of the motors.

The only rational basis of comparison is one instituted between two trains which are identical except for the system of electrical equipment. The maximum difference between the two systems under these conditions may be taken as represented by an increase of about 10 per cent. in the total train weight. The cost of the single-phase train equipment is certainly higher than that of the equivalent continuous current plant, but this item cannot be considered by itself and independently of the whole system. For the continuous current motor means converter, sub-station plant, and additional cost in feeding and distribution. No general rule can be laid down as to what this may mean, and each case will have to be investigated on its own merits, but for any comprehensive large scheme there should be a saving on the complete installation—including power and sub-stations—of from 20 to 50 per cent. It must be remembered that even if power is purchased from outside, in making the selling price the entire capital cost, as well as cost of maintenance of the sub-station plant, would have to be provided for in the price at which power is purchased.

As regards efficiency, although it is true to say that for the smaller sizes continuous current motors are more efficient than single-phase motors, it must not be forgotten that if the power generated were taken into consideration the continuous current system involves losses in the sub-station transformation, not existing in the case of the single-phase system. With the net results that as regards this point there is little, if anything, to choose between the two systems, the results appear to be in favour of the single-phase system.

Having thus discussed the various systems available for electrification purposes, we will now examine what, from the ordinary railway man's point of view, is the system which will best meet his complex requirements.

It is obvious that the whole question of the selection of the system to be adopted narrows down to the choice of one of two recognized systems, *i.e.*, the continuous current requiring the use of a third rail and the high-tension single-phase current employing an overhead working conductor; the choice principally depends upon the consideration of the three following points :—

(1). The advantage or disadvantage of the third rail, as compared to overhead construction.

(2). The first capital cost of installing the continuous current third rail system, as compared to the single-phase system, taking into consideration the total cost, including power station, sub-station, transmission and distribution system, as well as equipment of line and rolling stock.

(3). The comparative economy in operation and maintenance of the continuous current and the single-phase system.

As regards the first point, at the time when electrification of the L.B. & S.C. Railway was being considered, the chief engineer of the company, Mr. C. L. Morgan, carefully considered the matter, and reported that :—

The third rail continuous current system was especially objectionable for the following reasons :—

(*a*). In the event of a derailment of a train the third rail would almost certainly be disturbed and thus add to the consequent dislocation of traffic.

(*b*). The line could not properly be packed and maintained without great risk to the platelayers; or as an alternative this work would have to be done during the short time at night when the passenger trains had ceased running and the current cut off, but this could not be done on most of our railways if goods were also worked by electricity, as the largest portion of the goods traffic is worse at night.

(*c*). Damage would be certain to arise with consequent dislocation of traffic in unloading materials at night for repairs and renewals.

(*d*). The third rail cannot be fixed in station yards and for "through crossings" without being foul of gauge, but if so fixed it would be a source of great danger to the staff engaged in shunting and marshalling operations.

(*e*). In cases of a heavy fall of snow considerable interruption of traffic would probably ensue.

(*f*). In many cases the structural alterations to, and probable reconstruction of, station platforms and bridges would become necessary to allow of a third rail being kept clear of gauge.

(*g*). Considerable expenditure would become necessary in alterations to, and diversions of, point rodding and signal connections, and on the London viaducts this would apply to water and gas mains.

It is true that this report was based on the consideration of the ordinary third rail, and that recently, particularly on the New York Central, the protected under-running system of third rail has been successfully put into operation, and this system differs materially from that adopted on the North-Eastern and Lancashire and Yorkshire, and on other European lines so far electrically equipped. This new system does not however obviate the disadvantages inherent in the third rail system.

From the point of view of the servants of the company this system possesses advantages, for on crossing or walking along the line, they would be less liable to damage by electrical shock, although the grave inconvenience in crossing the line, involved mechanically by the presence of the third rail and the structures supporting it, would not be removed; on the contrary, if the third rail system as adopted on the New York Central were installed, the height of the third rail structure would be considerably increased, with consequent increase of difficulties to the staff of the railway.

The increase in height necessitated by a protected third rail, in which the contact is made on the lower portion, would render it far more objectionable than the ordinary third rail as adopted in this country, from the point of view of greatly increasing the difficulties of getting the necessary clearances between the bridge girders, station platforms, and rolling stock, as well as from considerably prolonging the gaps which would be necessary at points and crossings, since with the under-running protected form of third rail it would be quite impossible in most cases to find room for the erection of any contact rails wherever points and crossings had to be dealt with. That this is the case is amply proved by the New York Central Railroad, where, at most of their points and crossings, very heavy and cumbersome overhead structures have had to be erected to carry an overhead third rail, in consequence of the aforesaid gaps, with a consequent complication of having to fit the motor coaches or locomotives, as the case may be, not only with third rail shoes, but also with a contact arrangement for collecting current from overhead conductor rails.

It must furthermore be recollected that any derailment which might occur would, to a certainty, involve very serious damage to the third rail, and a very considerable time would be necessary to put this right again, as the adjustment of the exact position of the third rail relatively to the position of the running rail has obviously to be made with the greatest accuracy.

As already stated, it is important to maintain the relative position of the third rail and the track rails, and this is rendered difficult by the fact that as a rule the third rail is only connected to every fifth or sixth sleeper; this renders the maintenance of the accurate relative position of the third rail and track rail exceedingly difficult in practice.

Mr. A. D. Williams, an American engineer who has carefully investigated the question of the third rail, states that it has proved a great source of danger and difficulty in connection with wrecking operations after an accident; this would particularly be the case if by any chance some coal trucks were to get off the line, with the certain result of a heavy short circuit between the third rail and the permanent way, no matter what the system of third rail construction adopted. Such a short circuit might even result in the coal being set on fire, with the additional dangers and risks of fire added to those of the live conductor. After an accident of this kind the third rail could not be replaced until the track had been permanently fixed; this would take a considerable time, and meanwhile the whole electric traffic on the damaged section would be dislocated and would have to be handled by steam.

The erection of a third rail, no matter what system, will considerably interfere with the mechanism of the discs and rods at the cross-over roads and in goods yards, as well as with mechanical fogging arrangements.

The use of a third rail necessarily means the adoption of low pressures, and hence very large currents, which may amount to several thousands of ampères, have to be dealt with by each third rail conductor. Every gap in this conductor which would occur at level crossings and at all points and cross-over roads, which in the case of our suburban lines are exceedingly numerous, would involve the laying of very heavy "jumper cables" to connect the different sections of the third rail. These cables would not only add to the original cost of the work, but experience has shown that they are liable to give constant trouble and to be very costly to maintain.

Experience has also shown that where third rails are utilized, having a high degree of conductivity, the material is such as to be liable to very rapid corrosion, and this is a point which at the present moment is considerably exercising the minds of many of the electric railway authorities in this country. Furthermore, experience particularly on the Metropolitan Railway, has shown that the wear of the third rail is a very considerable item. There are cases in London where the weight of a third rail, owing to the wear and tear and atmospheric and electric corrosion, has decreased 10 per cent. in four years.

The installation of a third rail, no matter on what system, makes it essential that the third rail and the permanent way should be looked after and maintained by the same staff. This has been thought by some to be an advantage; many experienced railway authorities think it to be the reverse, as it is certain to bring about complications between the electrical staff and the permanent-way staff of a railway, each of which in the ordinary course have their own particular duties to look after.

The above deals sufficiently with the disadvantages of the third rail, and all that need be said about the overhead conductor is that the disadvantages mentioned in connection with the third rail are entirely absent as regards the overhead conductor. The single-phase system has the additional advantage that it can be economically extended to long-distance lines, should this be found desirable in future.

Now to deal with the second point mentioned, viz., the first capital expenditure. We will first briefly deal with the comparative cost of the overhead construction and the third rail. In this connection it should be pointed out, that in the case of the Brighton Railway they are under obligations to the Board of Trade not to exceed a drop of 7 volts, if they use an insulated return continuous current system. Neither the Lancashire and Yorkshire nor the North Eastern Railway Companies are bound to such a clause, and the drops on these systems are considerably greater than anything that will be tolerated by the Board of Trade in the case of the L.B. & S.C. Railway. Under these circumstances the Brighton Company would have been forced to use two insulated rails, similar to the system adopted by the District Railway. In any case it would have been very unwise for them not to adopt such a system, as serious corrosion of pipes of all descriptions, cables, etc., might certainly be expected, particularly in a congested area such as London. Taking into consideration the fact of the very complicated nature of the points and crossings which must necessarily be encountered in a large suburban system such as that of the L.B. & S.C. Railway, it is evident that, notwithstanding the very strong and therefore expensive overhead system adopted, there can be but very little to choose between the cost of the overhead and the third rail systems, and it is quite possible that in the end this latter might prove the more expensive of the two.

In the continuous current third rail system, in addition to the power station plant, sub-station plant is required where the use of rotating machinery is essential. In order to convert the high tension alternating current supply from the power station into low pressure continuous current, continuous current converter plant has to be provided, and experience has shown that the amount of this sub-station plant, including storage batteries, amounts to from 125 per cent. to 200 per cent. of the power-house plant. Against this must be placed the fact that the single-phase equipments of the trains themselves are more expensive than the equivalent continuous current equipments, although the difference is relatively small.

Furthermore, in a large continuous current installation expensive low-tension feeders are essential. These will not be required where the high-pressure single-phase system is in use.

It is quite impossible without all the factors and local conditions to directly compare the cost of the continuous current and single-phase systems, but it can generally be shown that the single-phase system, when the whole installation is considered, from the power station down to the trains and line equipments, is considerably cheaper than the equivalent continuous current installation.

In connection with the last point, viz., the costs of operation and maintenance of the two systems, it must be pointed out that, as regards the question of costs of operation, whilst it is true that the amount of energy consumed at the train may be slightly greater in the single phase than in the continuous current system, this is more than balanced by the losses due to conversion from high tension alternating current to continuous current in the sub-stations, which takes place in the continuous current system. In addition to this the cost of current must necessarily be greater in the case of the continuous current system, owing to the capital charges and labour and maintenance charges involved.

The illustrations accompanying this article have been kindly lent me by the courtesy of *The Engineer* and *The Electrical Review*, as it was thought that they would give additional interest, as being typical of the subject discussed in the article. It will be noted that the illustrations represent the new trains designed by me, and constructed by the Metropolitan Amalgamated Carriage & Wagon Company, to be operated on the South London line of the L.B. & S.C. Railway.

An illustration is also given of the single-phase railway run at Spindlersfelde, equipped with Winter-Eichberg motors, and constructed by the Allgemeine Elektricitats Gesellschaft Company of Berlin. The illustrations also show the three-phase line belonging to the Italian Government, and equipped by the Ganz Company, which runs on the Valtellina line between Lecco and Sondrio, and third and fourth rail construction on the Metropolitan District Railway.

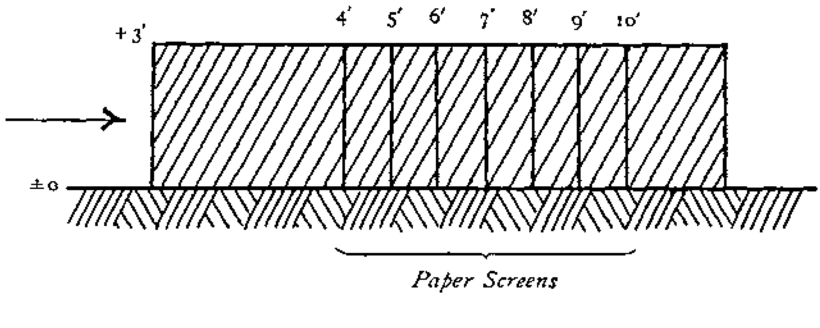
PENETRATION OF THE RIFLE BULLET INTO SNOW.

By Major J. C. Matheson, R.E.

The recent severe weather at Chatham brought with it a heavy fall of snow, and advantage was taken of this to try the penetration of the service rifle bullet into a snow parapet. Two butts of snow were made, one loosely thrown up, the other well consolidated by the men trampling it down.

Longitudinal Section through Butt.

Butt 4′ 6″ wide.



The results of the trials are shown in the following tables, and may prove interesting.

Unrammed Snow. Range, 33 Yards.

Round.	Penetration.	Remarks.
1	9′ 2″	
2	9′ 4″	
3	9′ 11″	
4	7′ 0″	
5	Through 7′ screen, not through 8′ one.	Not found. May have emerged from side of butt.
6	9′ 6″	Emerged from right of butt and found on ground 2′ away.

Rammed Snow. Range, 40 Yards.

Round.	Penetration.	Remarks.
1	5′ 3″	
2	4′ 9″	
3	4′ 8″	
4	4′ 4″	
5	4′ 5″	
6	Through 4′ screen, not through 5′ one.	Emerged from right of butt. Found on ground 8′ away.
7	ditto	Emerged from right of butt. Not found.
8	6′ 0″	Found lying at right angles to line of fire.
9	5′ 7″	
10	5′ 1″	Found lying at right angles to line of fire.
11	4′ 9″	ditto ditto ditto
12	Through 4′ screen, not through 5′ one.	Not found.

The difference between the penetration into the unrammed and rammed snow, is very marked, the maximum in the former being just under 10′, and in the latter 6′.

In the case of the rammed snow the second six shots were fired into a different portion of the butt from the first six. There is a difference of 8″ in the average penetration. This may be accounted for by a difference in the degree of ramming.

None of the bullets were set up or deformed.

*FRENCH AND ENGLISH METHODS IN FIELD TELEGRAPHY.**

By Major E. G. Godfrey-Faussett, R.E.

Personnel.

The French regulations contemplate the connection of headquarters of armies to the various army corps, to the cavalry divisions, and to the line of communications. No provision is made for telegraphic communication inside the army corps, still less the infantry division. The units provided may therefore be suitably compared to our air-line and cable companies, whose duty it is to connect the headquarters of an army to our large divisions and to the line of communications. The special case of the cavalry division is provided for, with us, by wireless telegraphy.

One company of the 24th Battalion of the 5th Regiment of Engineers forms part of each army, and consequently serves three to four army corps. The company may therefore be compared conveniently with one air-line and one cable company of our organization, taken together.

The war strength of the French company is 10 officers and 293 N.C.O.'s and men, without drivers; whilst that of a pair of companies in our service is 12 officers and 293 N.C.O.'s and men, or oddly enough almost identically the same strength.

The French company is organized into a headquarters, 6 sections (each of 2 detachments), total, 12 detachments and a park. Ours have 2 headquarters and 7½ sections (each of 2 detachments), total, 15 detachments.

Capabilities.

Miles of wire carried :—

French :—

Field cable	143
Light cable	35
Bare wire	124
Total	302

* Authorities :—*Instruction Pratique sur l'installation des Communications Electriques dans le service de la Telegraphie Militaire*, première partie; *Handbook of the French Army*, 1906; *Vade mecum de l'officier d'état major en campagne*, July, 1908.

English :—

Cable	... ...	90
Air line	... ...	60
	Total	150

The French unit therefore carries just double the mileage of line, but this is largely accounted for by the company park; in our organization, spare cable and air line, of which 400 per cent. or 600 miles for the two companies is provided, is brought up by army transport as required.

As regards instruments, the French company carries no less than 96 sets; our pair of companies 45, with a reserve of 25 per cent., *i.e.*, 11.

For rate of construction the French regulations lay down that a greater pace than 2 to 3 kilomètres, say 2 miles an hour, must not be expected. This is about our pace for air line in easy country; cable in similar country would go twice as fast.

The rate of working is given at 400 words an hour. This is not an easy thing to compare, as it depends largely on the length of the messages; with us a single message of 400 words should be dealt with in 20 to 25 minutes; perhaps 500 to 600 words an hour would be a fair average rate when all was going well.

MATÉRIEL.

The instrument in general use is what we should call a "Direct Recorder." There are two or three patterns, of much the same type as the "Instrument Morse Recording Set," which left our field units some 20 years ago. They also have "parleurs," or direct sounders, but apparently relay working is not used. No mention is made of duplex working or of any high-speed apparatus in the field regulations. The "voiture poste," or office wagon, is used, each section having one.

The "parleur telephonique" is comparable with our vibrator, but the buzzer forms part of a primary circuit, and the key is joined up similarly to that of a single-current set, bridge to line, front stop through the receivers to earth, back stop to secondary, and also to complete primary circuit. The buzzer has a small condenser in leak, and one of the receivers is a loud-sounding one to act as a call.

Batteries are of the Leclanché portable type—in the older pattern the solution is held in sponges, in the newer it is mixed with gelosine, a permanent vegetable substance.

An "Aubry" telephone is used for short lines. It consists only of a receiver, which is held alternately to ear and mouth. The 1899 Field Set has an Ader microphone, a mechanical vibrating call in the primary circuit, and two receivers.

Lines.—Chief reliance is placed on field cable, which is supported off the ground as much as possible—the shortest route is not chosen if supports exist along one not much longer. As a rule supports are not less than 45 yards apart, and the cable is not strained very tightly.

Light cable is used for temporary work. The bi-metallic wire is used for the repair of existing permanent lines. There is nothing answering to our air line.

Vehicles.—The wagons used are of four classes, all drawn by three horses driven from the box. The "working wagon" carries tools for a detachment and for repairing permanent lines. The "office wagon" is somewhat similar to our old office wagon, now surviving as a printing wagon. The "light wagon" carries men and kits, and the "pole wagon" 200 poles.

There is also a 2-wheeled cart for paying out cable, drawn by one horse.

The material is carried as in the following table :—

	Morse Sets.	Parleurs.	Telephones.	Aubry Receivers.	Field Cable, miles.	Light Cable, miles.	Bare Wire, miles.	Poles.
2 working wagons	2	—	2	2	—	—	10	24
1 office wagon	3	2	2	—	—	$\frac{1}{8}$	—	—
2 light wagons	4	4	4	—	—	$2\frac{1}{2}$	—	—
1 paying-out cart	1	—	—	1	3	—	$1\frac{3}{4}$	—
Total per section (2 detachments)	10	6	8	3	3	$2\frac{5}{8}$	$11\frac{3}{4}$	24
Company of 6 sections	60	36	48	18	18	17	$68\frac{1}{2}$	144
Park—10 cable wagons	—	—	—	—	125	$18\frac{1}{2}$	50	500
3 pole wagons	—	—	—	—	—	—	$5\frac{1}{2}$	600
Total per company	60	36	48	18	143	$35\frac{1}{2}$	124	1244

A *detachment* is organized as follows :—

Officer in charge (responsible for route)	1
Sergeant (responsible for work)	1
Distributors (issue material, and keep check of amount used)	2
Payers out (one pays out cable, the other two guide it to the side, make joints, and make holes for poles)	3
Builders (first squad builds the line, working 100 yards in rear of wagon. Second squad strengthens it, working ¼ mile in rear)	9
Operators	2
Bicyclists (as orderlies and for breakdowns)	2
	20

For working with light cable the normal detachment is as follows :—

Sergeant (in charge)	1
Payers-out	3
Builders	4
Operators	1
	9

In addition to the companies described above, there is a service of light telegraphs with the cavalry. Each of the two regiments of a cavalry brigade has a detachment of four men, one bicyclist and three on horses, and there is a 1-horse cart with each brigade.

New lines of more than 1,000 yards length are not contemplated as a rule ; the organization is intended primarily for the repair of existing lines. The material is normally carried in the cart, and consists of 2 Morse recorders, 2 "parleurs," 3 telephone sets, 2 Aubry telephones, 3,000 yards of light cable, and 10,000 yards of bi-metallic wire (bare). One telephone, 2,000 yards of wire, and the necessary tools can be carried in wallets by a detachment who work on foot.

To each cavalry division is attached a further detachment of six bicyclists, who carry tools and material for the destruction and repair of existing lines.

A PROPOSED TENSION BRIDGE.

By CAPT. E. N. MOZLEY, R.E.

THE object of this article is to advocate the trial of a certain modification of tension bridge, in preference to the usual suspension type. The modification consists in the independent support of each road transom, by two pairs of straight ties from the tops of the two piers, as in the sketch below, where only three road transoms are shown.

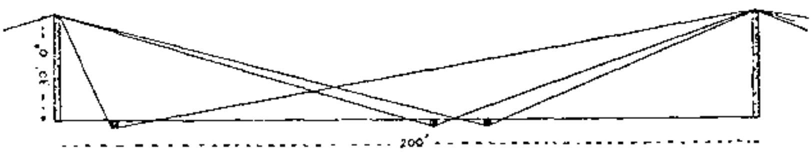


FIG. 1.

The advantages claimed for this method over the ordinary suspension bridge type are as follows :—

(1). Elimination of vertical oscillation through the omission of any curved tension members liable to distortion.

(2). Elimination of the liability of the bridge to collapse suddenly. This liability is always present in the suspension type in the event of the failure of a cable or cables on one side. It is true that if each side of the bridge is supported by several cables, the failure of one may not involve the remainder, but the tendency is to do so.

(3). No large cables are involved. This is a matter of importance, as they are rarely available on service.

(4). Distinct saving of time. If the comparison be between the two types, each making up its own tension members (on General Aylmer's principle), the type now advocated would save a lot of time—provided that as many men as necessary were available, which would probably be the case. For the suspension bridge will have more wires in a cable than a tension bridge in its thickest tie, and as the rate of straining each wire cannot be greatly increased by adding men, it follows that the ties for a tension bridge will be finished long before the cables of a suspension bridge.

There appears also to be a considerable saving of time during the actual erection of the bridge (compare the time-table given later on with that given for a 200′ suspension bridge in Part III., *Military Engineering*).

(5). Simplicity and speed of adjustment. With the help of an overhead traveller, each transom can be adjusted by taking in its own ties at the anchorages.

(6). If only a few men are available for construction, a bridge of the type now advocated could be built, where the heavy work connected with the cables of a suspension bridge would be very difficult.

In comparison with the tension bridges, shown in Part III., Section 9, the advantages are :—

(1). Elimination of compression members, which, in the sizes there required, are not often to be had.

(2). Much larger possibilities of span.

(3). Very great saving of time.

(4). Greater simplicity of construction.

(5). The large working parties required for strutted tension bridges are not required.

The chief disadvantage of the proposed type, is that it usually requires about 30 per cent. more wire than a suspension bridge.

CALCULATIONS.

The calculations are quite simple. The ties to each transom from the two piers are calculated in turn from the ordinary statical problem, shown in the sketch :—

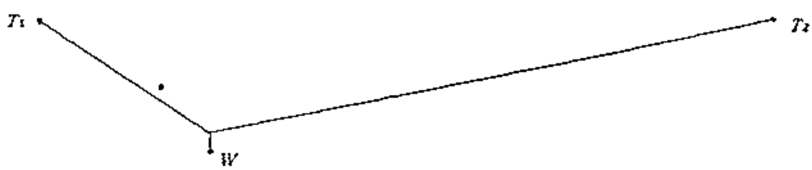


FIG. 2.

The frames, anchorages, etc., are calculated in the usual way.

CONSTRUCTION OF TIES.

These are built by General Aylmer's method (*Professional Papers*, Vol. XX., 1894).

CONSTRUCTION OF ANCHORAGES.

Two methods are possible. In the first all the ties are brought to the same anchor log, whose distance in rear of the frame must be calculated so as to bring a vertical pressure on the frame.

The alternative is to lead each tie to its own separate anchor log—or even to a picket holdfast—correctly placed with reference to the frame as before. This method might be very suitable if jumpers in rock had to be resorted to, or if the soil were very hard a short distance below the surface. It also provides against general anchorage failure.

Frames.

These may of course be made in the usual way, but the following alternative is worth trying :—

Sheer legs, with a chain or strong wire lashing at the crutch, are substituted for a rectangular frame. The tips of the legs are capped, as shown, with a stout baulk overlapping the tips 6″ at each end.

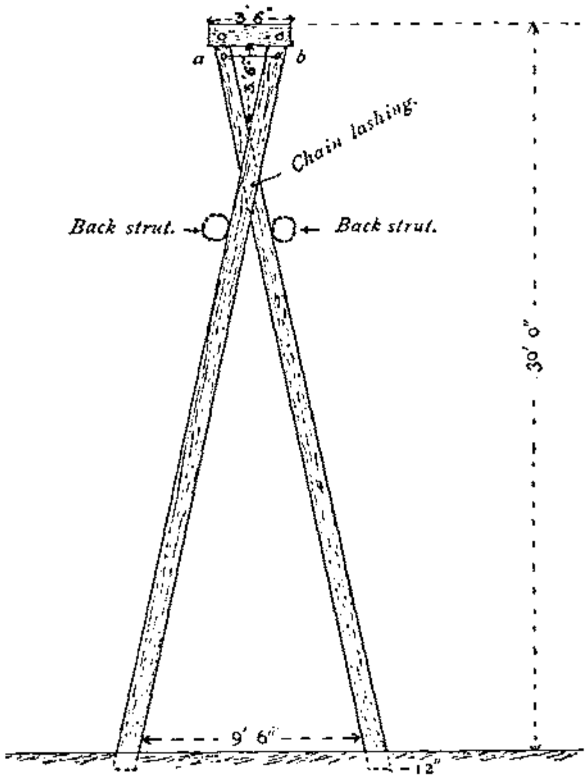


Fig. 3.

Auger holes may be bored through each leg 6″ from the tip, and through the cap where it rests on the leg. The cap is then prevented from shifting by wire lashings through the two pairs of auger holes respectively. Any tendency of the tips to splay outwards is prevented by a wire lashing (*ab*) between them, well windlassed, and by subsequently nailing boards across above the crutch.

If a sheer leg frame is as efficient as the ordinary one, it is clearly to be preferred, as it needs only half the spars (5 instead of 10), much fewer fastenings, and is correspondingly easier and quicker to build.

Back struts and back guys would be used, but side struts would not be needed.

The butts of the legs should rest on small plank foundations.

Another advantage which sheers have over rectangular piers is that their feet can be more easily shifted, and that they can without danger be allowed to tilt a few degrees from the vertical, if undue stresses on back struts or guys call for it.*

METHOD OF PLACING TIES AND TRANSOMS.

If possible, work should proceed from both ends at once.

We will consider the work at one end :—A man sits on the top of the sheers with a lashing to haul up the ties. The ends of the two ties carrying the first transom are sent up to the top of the sheers from the bridge side, and are passed by the man there down on the other side, and thence back to the anchorages, where they are temporarily made fast. The two ends on the far side are also lifted up over the far sheers and made fast temporarily at the far anchorage. Simultaneously the ties to the first transom on the far side should be lifted over the two sheers and temporarily made fast to the two anchorages. Enough slack should be left in the ties, to enable men standing at the pier to pull them down towards themselves—as in the sketch—and fix the transoms, or this may be done while the ties are being passed over the sheers.

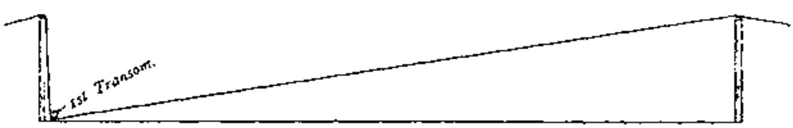


FIG. 4.

The transoms are best fixed to the ties by using stout wire, which is made fast to the tie close to the transom with several turns to prevent slipping, taken over the transom and made fast again to the tie on the other side in the same way.

* While the sheers are being erected, all the ties should be got across the gap and laid on each side of the central line in the order in which they will be needed.

As soon as the transom has thus been fixed, the four ends of the two ties supporting it are pulled in till the transom hangs in the right position, and are then permanently made fast. The roadway (except ribands) is next laid out to it. From 8 to 12 men are needed at each end of the bridge for placing ties and transoms. The above operation, including lifting the ties on to the sheers, fixing the transom, adjusting it, laying the roadway, and anchoring the ties, can be done in two hours if the ties have previously been got across. This estimate applies to 15′ bays. Therefore if both ends are being built out simultaneously, the bridge can be built at the rate of 15′ an hour. Twelve feet an hour would be a conservative estimate. The ties must be placed on the caps systematically. At one end the ties to transoms nearest the pier must be placed outwards from the centre, thus :—

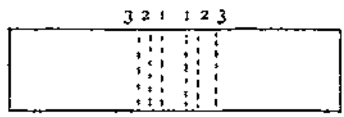


FIG. 5.

1—1, 2—2, 3—3, etc., representing the ties to the first, second, and third transom from that pier.

At the other end they must be placed inwards from the ends of the cap, thus :—

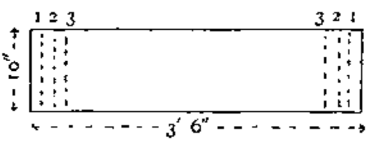


FIG. 6.

This will prevent ties crossing.

Ties must of course be placed in the same order at the anchorages.

The main work, and that which regulates the rate of construction, is the placing of ties and transoms. While this work is being pushed forward, other parties will be employed at the following jobs, working at both ends :—

Two parties, each of two men, ribanding down the roadway.

Two parties, each of four men with "treble and double" tackle, to adjust ties at the anchorages.

Two parties, each of four men, to fix straight horizontal wind-ties from points on the bank each side of the bridge to the ends of successive transoms.

Two parties, each of four men, to fix straight inclined ties under the bridge, so as to assist against vertical oscillation.

One party of four men, to place a traveller running between the crutches of the sheers.

This traveller is essential when the time comes to adjust the levels of the bridge after the roadway has been laid. It consists of a stout wire stretched as tightly as possible between the crutches of the sheers and made fast to the anchorages. A snatch block runs on this wire, and a "double and single" block and tackle hangs from the snatch block. It is perhaps better to have two such wires and two blocks and tackles. In that case the wires should pass over cross-pieces firmly lashed to the sheer legs, about 5′ below the crutch; the snatch blocks should be rigidly connected by a stick lashed to them.

Such a traveller takes four men about four hours to fix. When the level of any transom has to be altered, the traveller is run over it and the weight of the transom taken by the tackles. The ties to the transom can then be taken in or let out at the anchorages. The adjustment of the levels of the bridge after it has been completed should not take more than 15 minutes for every transom whose level has to be altered.

A few points may be added:—

Wire or chain must be used for ties. Cordage stretches so much as to be almost impossible to bring up to the requisite level.

Careful arrangement of ties is necessary; if once they get disorganized much time will be lost.

Nails may be driven into the caps to divide up the space for the ties, in order that they may not override each other, and a long spike into each end to prevent ties slipping off the cap as they are being placed.

If the cap extends sufficiently beyond the legs of the sheers, two men may sit on it, one at each end, and they can place the ties between them.

The height of piers should be as great as possible; this is more important for tension than for suspension bridges.

The ties can be got across the gap by stretching a line across from bank to bank, with a snatch block running along it, connected to each side by lead lines.

A draw vice, made fast to the main anchorage, and gripping the wires of a tie, will easily tighten the tie and even lift the transom to which it is attached.

The sheer legs should be braced together, and to the back struts, by frequent planking or spars.

The feet of the sheers must be so placed that the cap is at right angles to the axis of the bridge.

On one point this tension bridge is inferior to the suspension type. It requires from 25 per cent. to 35 per cent. more wire in its ties than the other does in its cables and slings together. This inequality however only exists if each tie is made throughout of the same number of wires. It is evident that, except for the centre transom, this is uneconomical, as the portion going to the nearer pier takes a greater stress than does the other. If required, the ties may be made in two pieces (meeting at the transom), each of the necessary length and number of wires. This modification would not be at all necessary except for ties to the first two or three transoms at each end, as the remainder have an approximately equal tension in their two parts.

The following rates of work, tested with cadet labour, will be of interest :—

Four men can strain seven strands of No. 11 wire between holdfasts, 300′ apart, in one hour. This works out to about 500′ per man-hour ; but the rate varies, to a small extent, according to the distance between holdfasts.

The wire was always strained from one end, but was unrolled from both alternately.

One man can put on one binding of fine wire for a 7-wire cable in $1\frac{3}{4}$ minutes.

Twelve men, working in four parties, can place and tighten two new ties to any transom already in position in $1\frac{1}{2}$ hours.

A 200′ tension bridge, with 30′ sheer legs as piers, and 15′ bays, to carry infantry in fours, should be completed in the following time :—

Construction of independent anchorages, one for each tie (60 men)	4 hours.
Construction, erection, and staying of sheers (40 men)	
Getting all ties across gap (15 men)	
Placing ties and transoms, including traveller (28 men)	17 hours.
Ribanding roadway (4 men)	
Fixing wind ties (8 men)	
Fixing ties below bridge (8 men)	
Adjusting bridge (16 men)	2 hours.
Total	23 hours.

Finally, as an actual comparison between the rate of construction of tension and suspension bridges, the following facts and estimates are given :—

Exclusive of the time taken for making the ties, a 165′ tension bridge for infantry in single file was erected by cadets in *818 men-hours*. A suspension bridge for the same span and load was erected by cadets in *1,039 men-hours*.

Now the 200′ suspension bridge for infantry in file, described in Part III., is estimated to take 1,800 men-hours.

Comparing the 818 men-hours of the 165′ tension bridge with the 1,800 men-hours of the 200′ suspension bridge, we may assume :—

(1). That if sappers had been available the tension bridge would have been completed in two-thirds of the time, *i.e.*, in 545 men-hours.

(2). That if the tension bridge had been built to carry infantry in file it would have taken 30 per cent. more time, *i.e.*, 545 + 162 = 707 men-hours.

(3). That, finally, if the span of the tension bridge had been 200′ it would have taken half as much time again as a 165′ bridge, *i.e.*, 707 + 354 = 1,061 men-hours, as compared with the 1,800 men-hours estimated in the textbooks.

TERRITORIALS OF THE ROMAN IMPERIAL ARMY, 1ST CENTURY, A.D.

By COLONEL O. E. RUCK, LATE R.E.

IN the January issue of the *R.E. Journal* some historical details were quoted regarding the ancient employment of Territorial troops by the Romans, Circa B.C. 100. Further research records much of the life history and progress of the movement.

By A.D. 100 the expansion of limits of Empire to far distant lands necessitated an increased number of men trained to arms to garrison and hold the same.

In B.C. 224, the year of the city 529 A.U.C., Italy alone supplied 50,000 cavalry and 700,000 infantry, strong and hardy peasants being eager to serve;[1] but by the end of the 1st century A.D., the lands being now chiefly cultivated by slaves,[2] it was not quite so easy to raise recruits except by the use of the utmost rigour.[3] Frequently compulsion (*coercitio*) was requisite, and those who held back (*refractorii*) had to be forced to enlist under threat of corporal punishment (*damno et Vergis*).[4]

Somewhat more than a little coaxing had to be resorted to, many cutting off their thumbs, or fingers, to render themselves unfit for service; hence the expression, "*pollice trunci*," *i.e.*, poltroons; but this did not save them from punishment.[5] On one occasion Augustus put some of the most refractory to death;[6] at other times they were fined, imprisoned, and sold as slaves.[7]

The first mercenary soldiers employed in the Roman Army are said to have been the Celtiberians, of Spain, A.U.C. 537, B.C. 216. In the Imperial Army however an increasing number of foreigners came gradually into the ranks. These were now composed to a large extent, both as regards the mercenary soldier as well as Territorials, of the poorer citizens, and it is reported that these causes were partly responsible for the decline in power of the Roman arms which developed after these changes in organization took place.[8]

No mild, emollient, or rose-water methods of attracting Territorial recruits appear to have been prevalent. A day was appointed on which all those male adults of suitable military age should be present

[1] Pliny, III., 20. [2] Livy, VI., 12. [3] Dio., LVI., 23. [4] Livy, IV., 53. [5] Suet., Aug. 24, Val. Max., VI. [6] Dio., LVI., 23. [7] Cic., Cœcin. 34. [8] Livy, II., 45.

in their various local centres.[1] On the day appointed the several consuls, seated in their curule chairs, held a levy (*delectum habebant*). With the assistance of the military tribunes they then determined, by lot, the order in which the tribes should be called up. Care was taken to select first those individuals who had lucky names (*bona nomina*), such as Valerius, Salvius, etc.[2] The nominal rolls thus prepared were written down on tablets ; hence, *scribere*, to enlist, to levy, to raise.

It is only fair to mention that for certain wars, and under certain commanders, there was the greatest alacrity to enlist,[3] but this was not always the case.

To sweep up from the provinces those recalcitrant Territorials who, from one cause or another, failed to appear at the general levy, selected officials, called *conquisitores*, were sent forth to scour out the countrysides, being supported by a special purpose force termed *coercitio* or *conquisitio*, *i.e.*, a press or impress.[4]

When on the occasion of a sudden national emergency, or when a war in course of waging had rapidly developed into a more serious business than had been previously anticipated, a levy called *conjuratio* had occasionally to be made ; the *conjurati*, or men thus raised, were, however, not considered on the same military footing as their more highly-trained comrades in arms.[5]

[1] Livy, XXVI., 31. [2] Cic., Dio. I., 45. [3] Livy, X., 25, XLII., 32.
[4] Livy, XXI., XXIII. [5] Livy, XLV., 2.

SWALLOW HOLES IN CHALK.

By COLONEL W. PITT, LATE R.E.

(A brief abstract of this paper appeared in the *Journal of the Royal Geographical Society* for February, 1909.)

THE following notes refer particularly to an area in the north-eastern corner of Hampshire, lying between Alton and Basingstoke. I spent the latter part of the summer of 1908 in this neighbourhood. My attention was very soon attracted by the great number of swallow holes in every direction, and knowing little or nothing about their life history I sought for information on the subject. Fortunately there appeared in the *Geographical Journal* for September, 1908, two papers on the "Formation of Valleys in Porous Strata," one by Mr. F. J. Bennett and the other by the Rev. E. C. Spicer, and from these I learnt a good deal that I wanted to know. The following notes are intended to supplement the information given in the papers mentioned. Subsequently, endeavours have been made to learn more regarding swallow holes from the standard works on geology and elsewhere, but with singularly little success. This is rather remarkable considering that large areas of the country are riddled with these holes, which are sufficiently obvious to attract the attention of the most unobservant. Probably the information does exist, but I have not been fortunate enough to come across it.

Under these circumstances I propose to describe in some detail the swallow holes in the area referred to above, in the hope that the particulars given may be found useful by others more competent to deal with the subject than myself.

It will first be necessary to give a general description of this part of Hampshire. The area examined is covered by two of the Ordnance Survey 6-inch maps, Hampshire, Sheet XXVII. S.W. and Sheet XXVII. S.E. and therefore measures 6 miles from west to east, and 2 miles from north to south. The western half is occupied for the most part by a plateau from 500′ to 650′ above sea level, and the eastern half by a ridge running up to a maximum height of 740′. Towards the north-west the plateau runs off at about the same level in the direction of Herriard and Basingstoke. To the south-west it drops sharply into a valley, followed by the Alton and Basingstoke Light Railway. To the north and east the plateau and ridge slope away gently, but very steeply on the south and south-east, into the valley of the Wey. The formation of nearly the whole area is the upper chalk with flints, but in the south-east corner the steep scarps descend to the middle and lower chalk, and finally, just outside the area, we get down to the greensand of the Wey Valley at a level of about 350′ above the sea. The dip is generally towards the north. The details given above are clearly illustrated on the 1-inch Geological Survey map, Sheet No. 284. This map shows a large portion of the area under consideration as being covered by "clay with flints and loam," and the margin of the clay is clearly defined. Now on comparing the boundary line of the clay with the contours some interesting facts will be noticed. In the first place, nowhere is there any clay shown below the level of the 500′ contour except two small patches in the south-east corner, and these are only just below 500′. And secondly, where it is on a spur the clay cap invariably runs over the point of it, and similarly the clay recedes from the head of a valley. These facts indicate that at one time the whole of the chalk was covered by a clay cap, possibly before it was raised to its present level, and that the absence of clay is due to denudation. It should however be pointed out that the distinction on the Geological Survey map between a covering of clay and no clay is somewhat arbitrary. In some places the cap is as much as 10′ thick, and dies out gradually to 2′ or 3′. Where the map shows no clay the soil is thin, sometimes only 1′ thick over the chalk, and consists of loam and flints. Frequently the surface is composed of little else but flints. It seems to be very difficult to mark out a line on the ground in such a manner that it may safely be said that there is clay on one side of it and not on the other. Probably on the whole the map is sufficiently accurate to justify the deduction drawn above.

The valleys are absolutely dry, I believe, at all times. There are no signs of any streams, and after long heavy rains I have not seen water running anywhere. Ponds are few and far between, and probably all artificial. The clay cap appears to be pervious everywhere. In fact, the water supply is a very troublesome matter in the neighbourhood. Most of the farms and other houses are dependent on rain water collected from their roofs. Some have wells, but owing to their great depth seldom use them. The obvious question is, where does all the rainfall go to? It is very difficult to answer this. A certain amount finds an outlet to the south at the junction of the lower chalk and greensand, and forms the source of the river Wey, about 2 miles to the south of the area under discussion. To the north there are two streams, the Loddon and the Whitewater, distant about 3 miles. Both have their source in the chalk, but as almost immediately afterwards it dips below the London clay, it is hardly likely that much of their water supply comes from the chalk. East and west there are no streams for many miles. The sum of the volumes of the three rivers mentioned amounts only to a very small fraction of the rainfall of the chalk area between them, and we are therefore driven to the conclusion that the bulk of the rainfall is absorbed in subterranean reservoirs below the saturation level of the chalk, and that the surplus finds an outlet at some considerable distance. The country generally presents the normal characteristics of the chalk formation. There are the dry valleys, and the slopes generally are rounded and gentle, though in places narrow valleys with steep sides are to be found. I do not propose to enter into the vexed question of the manner in which these valleys were formed, whether by erosion due to the flow of water off the ice cap when it existed, or by subsidence caused by solution, further than to say that the present aspect of the valleys seems to me to indicate solution rather than erosion. Lord Avebury, in *The Scenery of England*, gives a diagram of a valley of erosion in chalk, which is a very flat U section. It is rather difficult to see how erosion can have caused it to assume this form; solution seems a more probable explanation. In one place only I noticed on a rather steep hillside signs of slipping, due apparently to subsidence caused by subterranean solution. Terraces in this part of Hampshire are conspicuous by their absence. I only discovered one, on the Alton Golf Links. It is well marked and about a quarter of a mile in length. It is not horizontal, but follows roughly the slope of the bottom of the valley on the side of which it appears, approximately about 1 in 30. Incidentally I may remark that it is difficult to accept Scrope's theory* that terraces on the sides of chalk hills were formed artificially for purposes of cultivation. Vast areas of the mountain sides in the Riviera, Himalayan Valleys, and elsewhere have been terraced with this object, but in these localities there is little if any ground the slope of which is sufficiently flat to admit of tillage without terracing. The terraces on the slopes of chalk hills are found in close proximity to extensive flat or nearly flat downs, and it can hardly be imagined that at the time the terraces are supposed to have been made there was such a demand for arable land that an agricultural population was driven to increase its area by such an expenditure of labour as would have been necessary. Scrope gives an instance, also quoted by Lord Avebury, of a terrace which he actually saw formed by the plough, but I do not think this is sufficient evidence to establish his theory. Similar terraces are to be found in limestone country, notably in the Isle of Purbeck, where the labour required to form them would have been far greater than in a chalk district.

The area under consideration in this paper is heavily timbered. There are numerous woods, some of them of great extent. The timber is beech and oak, mostly the former, which grows to a large size. Apart from the woods the land is arable and pasture, the grass predominating. A remarkable feature of the district is the enormous size of the fields; many are from 80 to 100 acres in area. There is practically no unenclosed or common land remaining.

Having now described the nature of the country in some detail, I will come to the swallow holes. As already stated, the area under

* Scrope's "Terraces of the Chalk Downs," *Geol. Mag.*, Vol. III., 1866.

discussion measures 6 miles by 2, and is therefore 12 square miles in extent. On the 6-inch Ordnance Survey map there are marked within these limits 118 swallow holes. They are called on the map "old chalk pit." Literally this is correct; they are old, they are in chalk, and they are pits, but with few exceptions there is nothing to show that they have ever been used for the purpose of getting chalk. There are some obvious "chalk pits" in the ordinary sense of the term, but these are not included in the number given above. Chalk has undoubtedly been excavated from some of the swallow holes and used for building cottages and for dressing arable land where the clay cap is so stiff as to render this necessary.

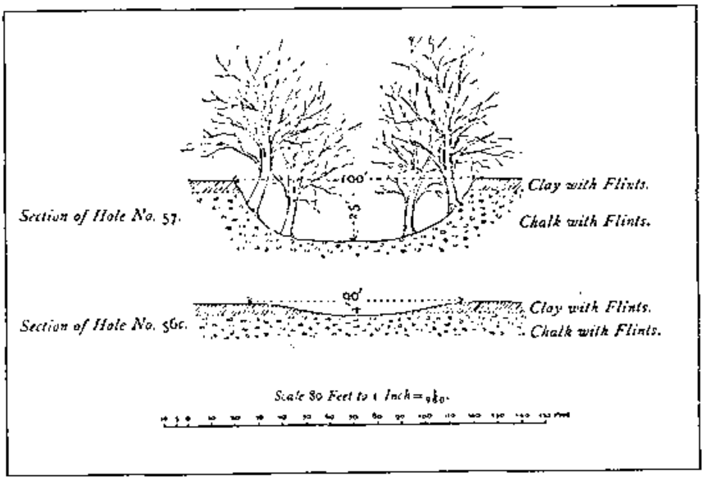
It is quite easy to see where chalk has been taken out, because in every case where this has happened a cart road has been formed down the side of the hole. Without a road the chalk could only have been got out with the aid of a crane. The holes are all very much alike in appearance and dimensions; usually they are roughly circular or elliptical in plan, and the greater diameter is from 100′ to 200′. The depth seldom exceeds 30′. In section they are shaped like a crater with steep and sometimes nearly perpendicular sides, and a flat or slightly rounded bottom. Almost without exception they have trees growing in them, generally beeches, which are often of great age and size.

In the foregoing remarks reference has been restricted to those swallow holes which are indicated on the Ordnance Survey maps. In addition to these there is a considerable number of others which are of almost greater interest, being apparently in the early stages of their existence. Scattered about the fields there are numerous singular basin-like depressions. Unfortunately I was very much occupied with other work whilst in the neighbourhood, and was only able to plot and measure a few of them, which I have marked on the map. They differ from the mature swallow hole in having gentle rounded slopes instead of scarped sides, and have no trees or bushes growing in them. Often the depression is so slight as to be hardly noticeable, and where it occurs in a cornfield it can only be seen when the corn is cut. Below are the dimensions of those actually measured :—

No.	Length. Feet.	Breadth. Feet.	Depth. Feet.
48 *a.*	62	62	2
„ *b.*	53	31	4
„ *c.*	51	36	1
„ *d.*	95	90	5
58 *a.*	100	80	7
„ *b.*	100	80	5
„ *c.*	110	90	4
54 *a.**	170	150	6′ 6″

* This hole is on sloping ground; the depth stated is the mean.

The accompanying sections show the two kinds of swallow holes. These shallow depressions bear a remarkable resemblance to dew ponds, except that they are quite dry. I have discovered no dew ponds in this part of the country. A suggestion presents itself that the dew ponds so common on chalk downs elsewhere are really immature swallow holes which have been puddled with clay so as to make them hold water. I am not competent to express an opinion as to whether this is the case or not, but offer the suggestion as worthy of consideration. It is a remarkable fact that there is no relation between the lateral dimensions of these shallow holes and their depth.



One would naturally expect to find some relation between the position of swallow holes and their surroundings, but with one exception I have failed to trace anything of the kind. They occur with equal frequency on level and on sloping ground, where the clay cap still exists, and where it does not. The exception however is rather remarkable, and it is this—that hardly any swallow holes are found in woods. Something like a third of the area I have examined is woodland, but of the 118 swallow holes marked on the map only three are actually in woods, though several more are to be found on their margins. Possibly some more of the shallow holes may exist in the woods hidden by the undergrowth; the mature ones could however hardly escape detection. The inference that suggests itself, assuming that the fact noted is not merely a coincidence, is that the woods now existing are of great age, and by keeping the rain off the ground have checked the formation of swallow holes by solution and consequent subsidence.*

* Since these notes were written I have, whilst shooting in the covers, noticed a few shallow holes.

None of the swallow holes examined exceed about 30′ in depth. In his paper referred to above the Rev. E. C. Spicer mentions that some of the holes in the chalk of the Chilterns are 80′ deep. It seems reasonable to suppose that there is a direct relation between the depth of the holes and the period of time during which they have been in course of formation. If then we could ascertain the rate of subsidence, we might possibly be able to fix approximately the date at which the chalk was raised to its present level, had nothing interfered with the progress of sinking. We must however bear in mind the glacial period and its resulting ice cap, beneath which there would be little if any solution and subsidence. The date arrived at might therefore be that of the disappearance of the ice. There are other possible modifying factors, such as a wide variation in the annual rainfall. It seems reasonable however to assume that, speaking generally, the depth of the holes varies as their age. If this is true the holes in the Chilterns are more than twice as old as those in the part of Hampshire under consideration.

The swallow holes described differ in many respects from those in the neighbourhood of West Malling and Maidstone, referred to by Mr. F. J. Bennett. The upland chalk in which they are found can never have been under the artesian conditions which he describes, and consequently upward hydrostatic action of water under pressure can have had nothing to do with their formation. There is no evidence of the existence of subterranean streams. In none of the dry valleys are there any bourne holes. Apparently therefore we must attribute the swallow holes entirely to the rain falling on the surface, soaking away more rapidly in certain spots owing to crevices in the 300′ or so of chalk down to saturation level, carrying with it chalk in solution and thus causing subsidence. The valleys may have been formed in the same way with the aid of a certain amount of erosion, due to water running over the edge of the ice cap on the summits. There is no connection apparent between the swallow holes and the valleys, except possibly in one case, where the holes, numbered 12, 13, 4, 5, 6, 7, and 8 on the accompanying map, certainly do follow more or less, in the order given, the line of the bottom of a valley. On the other hand, there is a ring of 11 holes, all actually on or very close to the 700′ contour line. I should however be sorry to suggest that there is anything in this beyond a mere coincidence.

I have assumed in the foregoing remarks that the solution theory is sound. It would seem however that the evidence in support of it, to be derived from a study of the swallow holes and valleys in the particular district described, is not conclusive. I have no alternative theory to put forward, and would suggest that much valuable information might be gained by trenching a section across a typical hole and carrying it down into the chalk to some depth below the bottom.

THE R.E. HEADQUARTER MESS.

(*Continued*).

By Lieut.-Colonel B. R. Ward, R.E.

In addition to the portraits and busts already described, there are various pictures and curios in the Mess, reminiscent of campaigns or of distinguished officers of the Corps extending over a period of 130 years.

Our oldest pictures consist of a couple of water-colour sketches by Capt. William Booth, R.E., executed in 1778 and 1785 respectively. These sketches—the only contemporary relics we possess of the period of the American Revolutionary War—represent the camp of Hardenberg's Regiment of Hanoverians in 1778, and a view of Point Carleton, near Shelburne, in Nova Scotia, taken on the spot in 1785. Hardenberg's Regiment of Hanoverians appear to have been at Minorca in 1778.

The occasion of the second sketch was a tour of inspection in Nova Scotia undertaken by Lieut.-General Archibald Campbell* in 1785, to inspect a site on which it had been decided to form a settlement of United Empire Loyalists—the term given to those inhabitants of the United States who remained loyal to the crown.

It has been estimated that about 40,000 of these Loyalists migrated to Canada within a few years of the second Treaty of Paris in 1783, and over 10,000 of them were settled at Shelburne.

A portrait of Capt. W. H. Robinson, R.E., one of the first of the Canadian cadets from Kingston to be commissioned in the British Service, is hanging in the same room as the Shelburne sketch. Capt. Robinson, who was born in St. John, New Brunswick, in 1863, and who came of United Empire Loyalist stock, was killed while leading an assault on a West African stockade in 1892. A brass has been placed in Rochester Cathedral to commemorate this officer—the first Kingston cadet in the Imperial Service to be killed in action.

Two engravings of pictures by J. S. Copley, hanging in the entrance hall, commemorate incidents in the Siege of Gibraltar, which formed such a prominent incident in the American Revolutionary War.

* Porter's *History of the Corps*, Vol. II., p. 397.

One of these represents the combined attack by the French and Spanish fleets on the Line Wall defences, and is entitled "The Siege and Relief of Gibraltar." The other illustrates the sortie made by the garrison on the 27th November, 1781.

The Napoleonic wars are commemorated by the bust of Vauban, already described, and also by a copy of the now rare engraving of the Waterloo Banquet at Apsley House on the 18th June, 1836. The Duke is supported on his right by King William IV., and on his left by the Prince of Orange,* who commanded the 1st Corps of the allied army on the 18th June, 1815. He is represented standing under a portrait of Charles I., by Vandyke, directly facing him being the silver centrepiece presented by the Government of Portugal, the table being flanked by two magnificent candelabra presented by the Emperor of Russia.

The engraving was presented by the N.C.O.'s Mess at Chatham in 1888.

Another picture commemorative of the Napoleonic epoch is an engraving dated 1819 of the picture by J. Isabey of the Congress of Vienna. The Congress sat during the years 1814 and 1815, until it was dramatically brought to a close, or rather interrupted, by Napoleon's return from Elba, and the Hundred Days.

The Crimean War is portrayed by a series of 12 large water-colour sketches by J. Ferguson, from the original drawings by Major Michael Biddulph, R.A.

An elaborately carved inkstand, presented to the Mess by Sir Andrew Clarke, recalls the second Sikh War of 1848–49. A copper scroll on it bears the following inscription :—"This zinc shell, fired by the Sikhs, was picked up during the action on the battlefield of Goojerat by Lieut. Henley Maxwell, Bengal Engineers. The wood came from a Sikh gun-carriage. The whole designed into this inkstand by that officer, the workmanship being executed by his native sappers."

The sack of the Summer Palace at Pekin in 1860 is represented by three articles, a beautiful square of embroidered silk about 2′ 6″ × 3′ mounted under glass, and presented by Lieut. J. Curling, R.E., in 1873, and a small Dutch or French oil painting representing a lady bargaining in a fishmonger's shop. Both of the foregoing were originally obtained by Lieut. (now General Sir) R. Harrison, R.E.

The third article is the magnificent carved throne now standing under the portrait of the King in the Mess Room. This we owe to Chinese Gordon, who at the time commanded the 8th Company, R.E., which was attached to Sir John Michell's Division in China in 1860.

To Sir John Michell was entrusted the duty of burning the

* Afterwards King William II. of Holland.

Emperor's Summer Palace at Pekin. During that operation the troops were allowed to keep such articles as they could rescue from the flames. Gordon took the throne from the throne room, had it packed up, and confided it to the care of the first company, R.E., going home, to present to the Mess of the Corps. The first to come home was the 23rd Company, then commanded by Major (afterwards Sir) G. Graham (with Pritchard and Harrison as subalterns). The woodwork only was brought home. The cushions were added by the Mess.

The Zulu War of 1879 is commemorated by an artist's proof of De Neuville's fine picture "Rorke's Drift"; and the second Ashanti expedition is represented by a royal stool taken from King Prempeh's house at Kumasi in 1896. It was presented to the Mess by the R.E. officers of the expeditionary force.

The stool is the symbol of royalty among the Ashantis, the Golden Stool representing to them the Ashanti power. King Prempeh was incarcerated as a political prisoner in 1896; but as the Ashantis still had possession of the Golden Stool, the removal of the King had not the same effect on their minds that the loss of the Stool would have produced. The rebellion of the Ashantis in 1900 may indeed primarily be traced to the search for the Golden Stool which was inaugurated that year by the Governor of the Gold Coast. In the absence of the Golden Stool—for to this day its hiding place is unknown—the wooden stool in the Mess may symbolize British rule over the Ashanti territory.

A suit of Dervish chain-mail armour, spears, and other trophies sent from Omdurman by Lord Kitchener in 1898 recall the end of the operations in Egypt, which commenced with the bombardment of Alexandria in 1882.

Three South African mementoes are kept in the small room adjoining the S.M.E. Library. One is a large two-handled brass measure, inscribed:—

IMPERIAL BUSHEL
GOVT. OF THE TRANSVAAL
1889.

The second is a Boer Artillery busby taken at Pretoria and presented by Lieut. C. H. Ley in 1901, and the third is the Orange Free State flag—the Vierkleur—that was flying over the Town Hall at Bloemfontein when the British troops marched in on the 13th March, 1900. This trophy was presented by Major W. A. J. O'Meara, C.M.G.

Over the fireplaces in the entrance hall hang two interesting examples of Japanese cut-velvet pictures. These were presented to the Mess by Major K. Miyabara, of the Imperial Japanese Engineers, who was stationed at Chatham for a course of Military Engineering in 1903–04, and again from 1906–08. Recalled early in 1904 on account of the Russo-Japanese War, he served throughout the Siege of Port Arthur as adjutant to the Chief Engineer at the headquarters of General Nogi, being awarded the 4th Order of the Rising Sun and the 5th Order of the Golden Kite for his services during the siege.

Many of the officers whose portraits and busts have been already described are also represented by means of engravings. Thus a portrait of Lord Napier of Magdala hangs in the entrance hall, one of Sir William Denison upstairs, and the small ante-room contains an engraving of the statue of Sir John Jones in St. Paul's Cathedral, as well as portraits of Burgoyne, Drummond, Sir Lintorn Simmons, and Sir John Bateman-Champain.

In addition to those officers commemorated by portraits in oils, engraved portraits of the following are hanging in the Mess:—

Colonel Colin Mackenzie, C.B., F.R.S. (1753–1821), of the Madras Engineers, a famous Indian surveyor and antiquary (*Dictionary of National Biography*, Vol. XXV., p. 138).

Major-General Sir James Carmichael Smyth, Bart., C.B., K.C.H. (1779–1838), C.R.E. at Waterloo (*D.N.B.*, Vol. LIII., p. 185).

Colonel A. W. Durnford, killed while covering the retreat at Isandlwana on the 22nd January, 1879 (*D.N.B.*, Vol. XVI., p. 264).

Lieut. Thomas Rice Henn, killed while in command of a party of Bombay Sappers covering the retreat at Maiwand on the 27th July, 1879 (*D.N.B.*, Vol. XXV., p. 422).

Capt. W. J. Gill, killed in the Sinai Desert on the 11th August, 1882 (*D.N.B.*, Vol. XXI., p. 355).

Major-General H. Y. D. Scott, C.B., F.R.S. (1822–1883), the architect of the Albert Hall (*D.N.B.*, Vol. LI., p. 26).

Colonel C. E. Harvey (1833–1885), a well-known figure at Chatham, where at the time of his death he held the appointment of Assistant Commandant (*R.E. Journal*, 1885, p. 111).

Major-General Sir Edward W. Ward, K.C.M.G. (1823–1890), Master of the Mint at Sydney.

Herr J. H. Sawerthal, Bandmaster, R.E. Band (1819–1893), (*R.E. Journal*, 1893, p. 133).

General Sir Wilbraham O. Lennox, V.C., K.C.B. (1830–1897), (*D.N.B.* Suppt., Vol. III., p. 92).

Major-General Sir W. Crossman, K.C.M.G. (1830–1901), (*R.E. Journal*, 1901, p. 185).

And, lastly, a portrait of General Todleben, the famous defender of Sebastopol and director of the attack on Plevna.

MEMOIR.

THE LATE COLONEL JOHN ROBERTS HOGG, R.E.

By 'A.T.S.'

JOHN ROBERTS HOGG was born in London, 1838, his father, John Hogg, M.D., being a physician practising there. He obtained his commission in the Royal Engineers on the 1st October, 1857.

In December, 1860, he went to Corfu, and during the latter part of his service there was engaged in the demolition of the fortifications in connection with the transfer of the Ionian Islands to the Kingdom of Greece. He returned home in June, 1864.

Soon after this Hogg was sent to Chatham, where he was engaged in some interesting work on one or two of the Medway forts, which had been recently built on a thick bed of concrete laid in the mud without piles. The unequal weights of the superstructure and armament caused the foundation bed to sink unequally, dipping towards the river front, and it was decided to remedy this by equalizing the weight as far as possible. Hogg carried out this work ably, and with as much success as the circumstances admitted of.

He was next sent to Devonport in 1866, and remained there for over four and a-half years. After a tour of foreign service he went to Chatham again in 1878, remaining there for over five years. Here, as well as during his previous service at Devonport, he distinguished himself by his ability and energy in carrying out important work on the fortifications then under construction.

Of his services at these stations Colonel R. H. Vetch, C.B., R.E., writes: "I was stationed with Hogg at Plymouth in 1868; he was then employed under Capt. Ponsonby Cox on the land defences. Hogg took great interest in his work and was most indefatigable. The contractors had failed, and Capt. Cox had asked to be allowed to carry on the work himself without any contractors. It was a big job, comprising all the forts from the Tamar to Crown Hill. Cox had some difficulty in persuading the authorities to agree to his proposal, but with the support of Colonel Cunliffe Owen, the C.R.E., he ultimately succeeded, and permission was given.

"Of course the work thrown upon Cox and his officers, J. R. Hogg and A. G. Clayton, was enormously increased and was very onerous. The provision of labour and the purchase of materials and stores, and everything in the nature of plant and workshops, had to be arranged for by the officers, while the innumerable checks which the finance branch of the War Office and the Treasury devised for the safety of the public purse entailed a vast amount of clerical work and accounts. Capt. Cox was as proud of his officers as they were of him when the result showed that considerable savings were being made on the estimates for contract work, while at the same time the work was being much better done.

"Ten years passed before I was again quartered in the same garrison as Hogg. It was probably the record of his work at Plymouth that led the authorities to send Hogg to the Chatham district to supervise the construction of the Chatham land defences, which were being executed by convict labour. Again he was absorbed in his work, but the slow rate of progress made by the convicts and the small amount of money provided annually took the heart out of the work and fretted him a good deal. He must have compared the work at Chatham very unfavourably with that which he helped to do at Plymouth."

Hogg was promoted Lieut.-Colonel 1883, and was sent to Portsmouth as Sub-District C.R.E., being placed on half-pay in 1888. While on half-pay he was employed by Sir John Pender on a mission to North America, to make enquiries as to the prospects of certain projected railways in Texas and Mexico, and to examine the country through which they were to run. This was a task requiring no little tact and discernment, but Hogg acquitted himself of it to Sir John Pender's entire satisfaction.

In 1889 he was appointed Colonel on the Staff and C.R.E. at Malta, remaining there for five years. During this period extensive works were in progress under the Imperial Defence Act in the re-modelling and re-armament of the defences. The fine new barracks at Imtalfa were also designed and built, and much other work was in progress. On leaving Malta he was for a time on half-pay, and retired in November, 1895.

Hogg was particularly well acquainted with, and deeply interested in, the subject of fortification, as being, together with engineering work generally, the branches of his profession to which his talents were chiefly directed, and he had carefully studied the problems and practice of fortification both at home and abroad. He was a successful amateur photographer, and left a collection of beautiful photographs of places he had visited. Personally, he was a man of a somewhat quaint and original character, extremely reserved and retiring, but kind and considerate, simple and straightforward, a staunch and loyal friend and comrade. He married late in life and leaves a widow to mourn his loss. His later years were unhappily clouded by a distressing malady, which he bore with unfailing patience and gentleness. He died at Ealing on the 27th November, 1908. R.I.P.

The writer desires to thank the numerous officers who have kindly furnished him with information and assistance.

TRANSCRIPTS.

FIELD KITCHENS IN THE GERMAN ARMY.

By COLONEL E. HARTMANN.

(Reproduced by kind permission of the Author and Messrs. Mittler).

PREFACE.*

IN proportion as the fighting strength of our modern armies has been increased, the difficulties of provisioning them have likewise been enhanced, and one of the first questions to be considered is how to provide the men with food. For though the commissariat, with its assistant branches of the Service, may and does overcome these difficulties by procuring the various kinds of food at the proper time and in the proper place, further difficulties not infrequently arise among the troops owing to the fact that the raw food-stuffs supplied by the commissariat have still to be prepared and converted into palatable and nutritious dishes.

This work of preparing the dishes is, among all armies, left to the men, and the cooking is done either individually or collectively by the aid of a common cooking appliance, on which the food is prepared and cooked for a whole section or squad, as is mainly the case among the mounted troops.

This mode of procedure however generally possesses this great drawback, that the men when at rest are often obliged to wait an exceedingly long while until they obtain their meal, for the provisions must first be obtained and distributed before the actual cooking can be done, with the frequent result, both in times of peace as of war, that it is not until long after sunset when the men—thoroughly fatigued and hungry with the exertions of a long day's march after a skirmish or a battle—have a chance of getting a meal, and this not infrequently one of a rather questionable character.

Thus it came to be recognized as an indisputable fact that the task of nourishing the troops, and thereby essentially promoting their fighting capacity, is materially facilitated when the single trooper can obtain his meal, ready cooked and prepared, from a field kitchen, and need no longer go to the trouble of preparing it himself.

For little doubt exists that if in the wars of the past the strength of an army was already considerably diminished in consequence of sickness and disease after the very first marches, it may principally be ascribed to the character of the food which the men prepared for themselves. Were this drawback to be removed for the future, it would be beyond a question that the various divisions of an army would be enabled to take part in the very first engagements of a decisive character in a far greater numerical strength than is at present generally assumed.

To introduce a reform in this direction has thus become a matter of

* Based on official material, with the permission of the Royal Minister of War.

imperative necessity, and after specially constructed and transportable field kitchens had been tried among various armies, their absolute and complete practicability was clearly demonstrated during the Russian-Japanese War, when it was particularly the transportable field kitchens, in which the food was cooked and prepared during a march or in the course of a battle, that gave the most satisfactory results. By means of these the men could be provided with a good hot meal after a long march, immediately on reaching their point of destination, or even in the very midst of an engagement.

The German Regulations for the Field Service of October 22nd, 1908, Section 6, run as follows:—

"It is the noble and grateful privilege of the officer to devote his unceasing care to the welfare of his men. All commanding officers must strive to constantly maintain among their men a love of duty, since it offers the very best security for the successful accomplishment of their work."

This love of duty however—it is a fact beyond a doubt—is increased by nothing so much as good food. For it is a well-known axiom among the men that the stomach is the source of all courage, and that a hungry soldier is good for very little, since his fighting capacity is naturally diminished by poor or insufficient nourishment. Hence the officer's care must for the main part concentrate its attention upon the food question.

Again, since the tactics of war have undergone a change, it stands to reason that likewise the requirements of the various divisions of an army have to be adapted to the new conditions, both as regards the individual responsibility of each combatant and his requirements in the way of nourishment. As a result of these considerations the Military Administration finally deemed it advisable to introduce field kitchens.

1st Public Competition.

In order to obtain a field kitchen which in its form and construction would prove suitable to German conditions, the Royal Prussian Ministry for War in the October of 1905 submitted the question of constructing a system of transportable field kitchens for the Army to a public competition, subject to the following conditions:—

1. The field kitchen, while constructed of an adequately strong and durable material, must yet be light enough to permit it, even when charged, to be drawn if need be by a small horse, either along soft ground or across a rugged tract of land in the wake of infantry. The gauge to be 1,530 mms. from tyre to tyre.
2. The copper must be capable of containing 150 litres.
3. The field kitchen must be arranged in such a manner as to allow of the food being prepared and cooked while the vehicle is in motion.
4. It must be possible to cook all varieties of field fare in the field kitchen, in particular vegetables; at the same time any danger of the food being burned must be absolutely excluded.
5. There must be no difficulty in the way of cleaning the copper.
6. It must be possible to heat the field kitchen with all kinds of available fuel, such as wood, peat, coals, straw, etc.

7. No special box is required for the driver; however, there must be room to store the man's baggage (15 kgs.) and also a box of 0·25 cbm. space for the supply of oats (18 kgs.) for the draught animal.
8. The vehicle must be fitted out with a very simply constructed but absolutely reliable brake appliance.

Of the great number of models of field kitchens—about 40—which were submitted as a consequence, but a small proportion adequately complied with the required conditions, and were admitted to a closer test. Of these again but two seemed to come up to the actual requirements, possessing distinct advantages both as regards the construction of the vehicle and also the cooking arrangements.

Meanwhile the suggestion had been offered to the effect that the weight of the baggage carried by the infantry might be reduced by storing a certain amount of the provisions, ordinarily carried by the men, in the field kitchens. However, this could only be realized if the kitchen were fitted on to a double two-horse vehicle, to either of the two parts of which one of the two horses could be harnessed, each part being capable of being used independently of the other, instead of being, as originally planned, fitted to a single-horse, two-wheeled cart, transportable if need were by human beings.

2ND PUBLIC COMPETITION.

In the August of 1906 therefore the Military Administration decided to submit the question of procuring a transportable field kitchen for the Army to a second and more limited competition, those firms being particularly invited to take part whose models at the first competition had shown distinct advantages over those of their fellow competitors with regard to both arrangement and construction, the following being the special conditions to which the competition was subjected:—

1. The field kitchen must be constructed as a four-wheeled, two-horse vehicle, the hind carriage of which must be easily detachable from the fore carriage, and when detached it must be possible to put a horse to each, and to employ either or both parts independently.

The hind carriage must be capable of containing—

		Weight of about
Each stored in a separate chamber	Kitchen utensils	5 kgs.
	Two extra rations (for the horses) in a feed-bag	12 kgs.
	Fuel (light firewood) for 1 day ...	20 kgs.
200 extra allowances (for the men) in a separate chamber		160 kgs.
If possible together in a separate chamber	Four extra rations (for the horses) in a feed-bag	24 kgs.
	Driver's baggage	15 kgs.
	Spare stores	14 kgs.

The separate chambers must be provided with lock and key.

The aforementioned rations and allowances have been considered on the average.

2. The total weight of the fully charged and equipped field kitchen, exclusive of the men (its durability being in nowise impaired), must not exceed 1,100 kgs.

   The kitchen, drawn by two horses, must be capable of following in the wake of infantry along both soft or rugged ground, and at a trot along good roads.

   The proportion in weight between the fore and the hind carriage must be approximately 2:5; the hind carriage however, when fully charged and equipped, must not weigh more than 700 kgs.

3. The gauge (from tyre to tyre) is to be 1,530 mms. The distance of the greatest depth of the ground from either fore or hind carriage to be at the very least 400 mms.; notwithstanding, the centre of gravity must be sufficiently low as to remove as far as possible any danger of the vehicle being upset on a rough road.

   The hind carriage or the copper is to be on springs.

   In the selection of the wheel, reference is to be had to wheel-type n/K of Ambulance Carriage 95. In the same way, the shaft, pintail, and trace are to be adapted in their construction, as far as possible, to type 95 n/K.

4. The vehicle must be fitted out with a reliable brake contrivance acting on the hind wheels, and, if possible, manageable from the driver's box.

5. The vehicle must possess a seating accommodation for both the driver and cook.

6. The copper is to be made of nickel, preferably stamped, and capable of holding 150 litres, and must possess moreover a broad brim.

7. The field kitchen must offer the possibility of cooking all varieties of field fare, particularly vegetables; any danger of the food being burned to be absolutely excluded. This last to be obtained by making use of a bath of glycerine or other fluid of the like properties, especially as to the vaporization and freezing points.

8. The copper must present no difficulties in the way of a quick and easy distribution of the food; nor must there be any difficulties with regard to its being cleaned. (It is however not desired that it should possess a waste tap).

9. The lid, which must close absolutely tightly, as well as the parts protruding beyond the rim, are, if possible, to be isolated for the better retention of the heat.

   It must be fitted out with ample safety appliances, such as valves, manometer, an instrument to record the state of the fuel, etc. Provision must also be made to prevent the valves from being stuffed up by remnants of food.

10. The introduction and utilization of bright shining parts, that would be visible from afar, are to be avoided; as also care must be taken to prevent the various parts of the vehicle from creating too great a noise when the vehicle is in motion.

11. Should the general weight permit of it, it would be deemed advisable if the following improvements could still further be introduced :—

(*a*). The possibility of heating or boiling 70 litres of water, for the purpose of preparing tea, coffee, etc., in one or several vessels. Care must be taken to prevent this extra supply of water from evaporating too quickly.

The weight of this vessel, or these vessels, including contents, must be contained in the total weight of the kitchen, viz., 1,100 kgs.

(*b*). An increase in the size of the boiler, making it possible of holding 200 litres instead of 150.

(*c*). In either fore or hind carriage an additional chamber for the storing of further provisions.

If the conditions of this second competition have been thus detailed, it has been for the sole purpose because, firstly, this having been a limited competition, they were only submitted to those firms who at the first competition had given proof of their capability by submitting models of an acceptable construction and arrangement; secondly, because they show to what extent the experience gained during the first competition had already been made use of.

General Survey.

It can be no part of this article to enter into a full and detailed examination of the various models of field kitchens which were submitted as the result of this competition.

Only a small number complied with the required conditions. They may be divided into three groups, viz. :—

1. Solid-framed vehicles, fore carriage not detachable from hind carriage.
2. Fore carriage detachable from hind carriage, but the former alone to be practically utilized.
3. Fore carriage detachable from hind carriage, each practically capable of having a horse put to it, and thus being employed independently of the other.

The first two may be passed over at once as far as their practical utility is concerned; of the third group, but two models approximately complied with the required conditions.

At the same time it may be noted that the consumption of fuel among many of the models submitted was an exceptionally large one.

Among the vehicles submitted for the closer competition of April, 1907, there was also a Russian model, the copper of which, as in several other field kitchens, was suspended in a steam bath as a means of preventing the food from being burned. This contrivance however did not prove practicable :—

(*a*). Because the weight of the kitchen was unnecessarily increased by the quantity of steam required.

(*b*). Because the steam bath evaporated during the cooking process and constantly required to be renewed.

(*c*). Because the steam bath froze in cold weather, the kitchen not being in use, and thus burst the sides of the copper.

(*d*). Because the constant refilling of water caused the settling of fur, thus impairing the cooking process, and which fur, if not removed from time to time, gradually rendered the kitchen useless.

(*e*). Because, in spite of manometer and valves, the constant danger of an explosion is coupled to steam.

(*f*). Because the kitchen could not be employed as a self-cooking apparatus.

Among the other kitchens sent in for competition, various kinds of boiling fluids were employed for the purposes of the bath, all of which were retained in the further experiments.

The under frame of the vehicles was partially a fixed and partially a balancing one. The former system made it difficult for the kitchen to turn the corners of narrow roads; the latter tended to impede the speed of the vehicle. Kitchens constructed since have been fitted out with a system of limbering on springs, which, while avoiding the drawbacks, united the advantages of the two other systems.

The vehicle is composed of a fore and a hind carriage. Attached to the hind carriage is the light frame, made of pressed sheet-steel girders or supports fitted to the axletree by means of plate springs. The extremely reliable brake is served from the rear. On the fore carriage is a fairly large-sized limber box, which, while not on springs, forms the seating accommodation for the driver and the cook. This part of the vehicle is likewise supplied with a brake. Both carriages are joined to each other by a system of coupling, which possesses the following noteworthy advantages:—

1. The fore carriage may be detached from or attached to the hind carriage in the shortest space of time possible.
2. The presence of an ample locking angle permitting the vehicle to turn within even a very narrow road.
3. The possibility of employing a large limber box without impairing the motion of the vehicle.
4. Avoiding any danger of the shaft striking the horses, since its pressure upon the animals is relieved by the peculiar spring contrivance of the coupling.

A second shaft which when not in use is stored beneath the vehicle, and which makes it possible to drive both the fore as the hind carriage singly and independently of the other. A set of supports, suspended to the frame, and which can be easily set up, allow of the carriages being firmly fixed to a spot when detached and not in motion.

It is further worth noting that the vehicle may be driven with complete ease across hills and ditches, at right angles or in an oblique direction, without unnecessarily taxing the strength of the horses, both fore as hind carriage adapting themselves to the nature of the road, be this ever so rugged and steep.

In consequence of the stereotype plates having been kindly placed at my disposal by the manufacturers of the cooking contrivance, *The Economiser Cooking Stove Works of A. Senking* at Hildesheim, I am enabled to reproduce the field kitchen (Views 1—4) as finally constructed, the result of repeated trials and improvements, and in the form now actually introduced.

Though mindful of the importance which attaches to the form and shape of the vehicle proper, it is after all the kitchen, that is to say the cooking contrivance, which is of main importance.

The cooking contrivance, fitted to the hind carriage of the vehicle, consists of a copper capable of holding 200 litres and another smaller copper forming a coffee cooking contrivance holding 70 litres. The various other chambers at the side and beneath serve for storing of the fuel and the kitchen utensils.

The copper is double sided ; it consists of a seamless drawn, all nickel inner copper, with a hard soldered top closed by a double-sided steam-tight lid, and an outside copper made of copper. As a medium for the bath, boiling oil, etc., may be employed.

Attached to the outer copper is an expansion tube for the purpose of receiving the overflow of the heated bathing fluid. This expansion tube runs up and along the side of the chimney and terminates in a thin, open tube surrounding the chimney near the top. The bath requires neither manometer nor safety valve, while at the same time all danger of an explosion is excluded. A special contrivance serves to measure the degree of the bath.

The lid of the copper contains a safety valve, terminating in a specially formed bell, which prevents any solid parts of the food from boiling over.

The range proper, made of wrought iron, consists of a vaulted bottom, a cylindrical body, and a solid top plate. Fitted to the bottom is the fire-place, which extends in the form of an arch, and which is supplied with an adjustable tight-closing fire door. The extension of the fireplace in the form of an arch permits the radiating heat of the fire to act upon a larger surface of the copper, while it prevents an injurious effect resulting from the thin flames, and guarantees an increase in the durability of the fireplace, as of the bottom of the copper. Air is passed through between the exchangeable sides of the fireplace and the frame of the range, so as to prevent the frame from being overheated. At the back of the cylindrical part of the frame of the range a contrivance is attached to increase the heating power by guiding the fuel gases through a horizontal chimney tongue.

The rectangular top plate is turned up into an angle at three of its sides in order that remnants of food, water, or other fluids run off, and so avoid getting into the copper or other vessels.

As for the grate, one side of it is formed into the shape of a hook, while it is fitted in in such a manner as to allow it to expand at pleasure, which is of vast importance with regard to its durability.

The ashpit turns on hinges and opens at the bottom ; the admission of air may be regulated by adjusting the drop by means of chains. This peculiar method of suspending the ashpit enables it to close itself automatically as soon as it strikes against any obstacle, while, simultaneously, any possibility of it losing its form or being destroyed is done away with.

The screw coupling between the inner and the outer copper, as also the secure screws for the copper into the top plate of the range, are fitted out with red brass nuts incapable of rusting, while at the same time they may be easily tightened or loosened.

The smaller copper or coffee boiler, placed to the left of the main copper, is rectangular in section and is made of pure nickel. It is tightly closed by means of two half-lids. Between the two lids is the safety valve. Above the fire door is a tap and a rabbet for the purpose of filling the soldiers' flasks.

The sieve arrangement is of pure nickel and assures a thorough extraction of the coffee. Fireplace and grate are constructed on the same principle as the copper.

Copper and coffee boiler possess a common chimney capable of being turned down. The mouths of the chimney are separated by tongues, and may be wholly or partially shut by means of adjustable dampers. The fireplaces may be used simultaneously or independently of each other; each may be regulated by itself. The cross section of the chimney shows it to be oval at the bottom, circular and conical in form at the top. A ring attached to the chimney serves as a support to the lid of the copper when the latter is opened, and a support to the chimney itself when it is turned down. By means of one of the screws in the lid the chimney can be kept firmly in a horizontal position.

On the side of the copper, to the right of it, is a chamber for the fuel. It outer form is similar to that of the coffee boiler; within it contains two separate compartments in which coal and wood may be separately stored. The one for the coals contains a coal shovel, poker, and a rake to clean the flue and the fireplace. Beneath this chamber is a drawer containing a wooden stirrer, with a measure for measuring the contents of the copper, two meat choppers, a sharpening iron, six plates, three cups, and three can openers.

Between the chamber containing the fuel and the coffee boiler there are five other chambers, both in front and in the rear of the copper. The chamber in the rear of the copper can be opened by turning back a lid, to which a ladle and fork are attached. The large chamber to the right of the chimney contains the coffee mill, the coffee filter, and a vessel for ground coffee, as also for tins containing coffee beans, salt, pepper, and spices. Just to the rear of the chimney is a small chamber for the reception of tools and extra fittings; beneath it is a larger chamber for the meat-chopping machine. To the rear of the coffee boiler is a separate space for the reception of an air-tight wrought-iron tin can, containing a supply of the fluid required for the bath. A further free space between the copper and the chamber containing the fuel may be got at from the top, and is suitable for the drying of fresh wood. All these chambers and vessels are secured against any transmission of heat from the body of the range by means of a constant stratum of air.

The two rings at the back of the chamber containing the fuel are intended to hold the lantern. Within the compartment for the storing of the wood there is on one side a contrivance to attach the hatchet.

The vessels fitted to the hind carriage are made of wrought iron, and are protected against rust by having been zinced over or galvanized. The body of the range is coated over with a dark and suitable coat of

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

HILDESHEIM

paint. The surfaces of the copper and coffee boiler are galvanized brown.

All these chambers and vessels may be closed by means of hasps or turn buckles and padlocks.

The weight of the kitchen, with equipment, without stores and provisions, amounts to about 850 kgs.

The limber box is made of wood and fixed to the axletree by means of two clip plates. It contains various pigeon holes for the reception of 200 extra allowances (for the men), the extra ration (for the horses), and the stores. The lid opens by being turned backward and is lined with sheet iron. The box, to which a waterproof bag is tied, containing 20 kgs. of oats (part of the extra rations for the horse), affords seating accommodation for the driver and the cook. To either side of the guard irons are strapped the knapsacks belonging to these men; at the back is a space for the saw and the folding forage ladder and tilt.

The Result of the Trials.

As a result of the thorough driving and cooking tests to which a number of the models were subjected, a field kitchen was finally obtained, the chief characteristics of which may be summed up as follows:—

A four-wheeled vehicle for two heavy horses.

Fore carriage detachable from hind carriage, and each with a horse attached, manageable by itself.

A copper holding 200 litres in a boiling bath.

Coffee boiler capable of holding 70 litres of water for the purpose of making tea or coffee, or to dilute and increase the quantity of food that has grown thick as the result of having boiled too long.

Both coppers may be heated singly or simultaneously.

The fore carriage contains:—

200 third extra allowances (for the men), provisions of food for daily use.

Three extra rations for the draught animals.

Folding canvas water pail, saw, pickaxe, axe, hatchet, and other carriage tools and fittings.

Stores and stable supplies.

Driver's and cook's baggage.

The hind carriage contains:—

The cooking contrivance.

Cooking utensils, including meat-chopping apparatus and coffee mill, fuel.

The boiling bath surrounds the whole of the inner copper, and absolutely prevents the danger of the food being burned, while it enables the advantageous utilization of the self-cooking apparatus, and serves as a heating apparatus.

The range may be heated by means of coal, patent fuel, wood, peat, etc., and that in the course of a march without necessitating a stop.

While the food is cooking (1 to 1½ hours) the ashpit and damper are closed. In consequence of the heat stored up in the copper, and owing to the bath, the food continues to cook as in a cooking apparatus, and is ready at the end of the normal cooking time.

The food still possesses, even after 12 hours (provided the copper has not been opened in the meanwhile), a temperature of 140° Fahr. Should the need exist of keeping the food for a longer time, all that is necessary is to make up the fire again every 12 hours or so, when the food will still be palatable even up to a period of 72 hours.

The copper may be easily cleaned.

The kitchen, which, including the total outfit, provisions, and filled coppers, does not weigh more than 1,310 kgs., may and is able, owing to the advantageous form of its construction, which does not require a complete counterpoising or balancing, to follow infantry wheresoever this be necessary, even along unbeaten roads.

Owing to the fact that the fore carriage may be easily detached from the hind carriage, and each be driven independently, it is possible, especially at night, to provide the troops facing the enemy with warm food.

Furthermore, while the food is being distributed, or the kitchen is being cleaned or re-filled or heated, the fore carriage may be sent back for fresh provisions.

The use of the kitchen as a self-cooking apparatus offers the following advantages :—

(*a*). The preliminary cooking may be done at night or early in the morning before the troops march off.

(*b*). Smoke during the march, which might tend to annoy the troops and prove a means of observation to the enemy, is done away with.

(*c*). The consumption of fuel is smaller than in the case of a constant heating.

THE FIELD KITCHEN IN THE MANŒUVRES.

Several of these field kitchens had already been put into practical use during the manœuvres of 1907, but during the Imperial manœuvres of 1908 in Alsace-Lorraine a larger number were practically introduced.

With regard to the results obtained, the *Cologne Gazette* of October 9th, 1908, wrote as follows :—

"In consequence of the new Field Service Regulations and similar Orders, our Army Provisioning Service has been thoroughly reorganized, the advantages of which reorganization, even though but on a small scale, we had already an opportunity of recognizing last year; a far better occasion of studying them, and on a far more extended scale, was offered us during the last Imperial manœuvres. We are alluding to the introduction of transportable field kitchens, in which the Emperor has taken a great interest, and which, carrying along as they do meat-chopping apparatus, coffee mills, and butchers' knives, have already proved themselves practically serviceable years ago in the Russian Army. It was in the course of the past year however that, for the first time, four of these field kitchens, of various designs, were taken along into the Imperial manœuvres by a battalion each of the 55th and 74th Regiments respectively. After a final model had been determined upon, a sum of 1,000,000 marks was formally voted in the Army Estimates for 1908, for the purpose of field kitchens for the Army. For it had become evident, in the most convincing way possible, that the presence of field kitchens during manœuvres and in the field was a most excellent means of increasing the health and strength of the troops, and, with these, their fighting ability. As a result, these field kitchens have been subjected on this occasion to a considerably larger series of tests, and that on a far more extended basis. Thus two whole brigades—the 59th Brigade Infantry (30th Division of Infantry of the XV. (Blue) Army Corps) and the 66th Brigade Infantry (33rd Division of Infantry of the XVI. (Red) Army Corps)—were now completely equipped with field kitchens, so that the practical test could be undertaken with a total number of 50 field kitchens. He who annually has taken part in the great manœuvres will certainly have had ample opportunity of seeing for himself, in the course of the bivouacking, that the troops, after an exhausting day's march, possibly followed by an engagement, have, partially owing to fatigue, partially in consequence of a direct antipathy against doing their own cooking or of the bother of cleaning their cooking utensils, partially, too, because the camp provisions arrived at too late an hour, and that thus the opportunity of turning to rest was delayed, have, be it repeated, preferred, rather than cook the contents of their tins, either to eat them in the raw state, or even to throw them away altogether. Some of the men, indeed, frequently will rather rest satisfied with a crust of bread than do any cooking, and have but one thought, namely, that of turning in as quickly as possible.

"No one can deny this who has had any experience of men in the field. The result is however that the fact of this insufficient means of nourishment causes the men to grow ill-humoured as soon as they have to undergo any great fatigues, while at the same time it lessens their power of resistance.

"What a different thing was it on this occasion, during the late Imperial manœuvres, for the men belonging to the brigades that had been fitted out with field kitchens! These regiments, after breaking up their camps early in the morning, had to do some pretty severe marching through rough and rugged tracts of land, and it was not till noon that at times the engagement could take place, and they knew it would be late in the night before they would have any opportunity of turning in to rest. Notwithstanding fatigues and hardships however these men remained in good spirits, kept up their strength, and were able to conclude their day's work in the most satisfactory manner.

"Even on the last day of battle, when the Heights of Memersbronn, held by the Red Division, were stormed by the Blue Division, the field kitchens of the 59th Brigade Infantry followed the troops at some distance from the scene of engagement; they remained under cover in the rear of a village, and were so near that immediately after the close of the engagement the troops could be supplied with food. Among some of the sections of these troops tea or coffee was distributed of evenings, and there is no saying how refreshed those of the men were who, while doing duty at the outposts, were served with hot coffee, the kitchen almost approaching the picket chain. It was particularly the men belonging to those regiments that had brought field kitchens along into the manœuvre who attracted general attention in consequence of their bright, ever-contented manner, even in the very midst of great fatigues.

"The practicability of these field kitchens, which consist of limber box and kitchen cart, and which are in no way meant to supersede any private cooking, has again been clearly demonstrated during the Imperial manœuvres, all the more as these kitchens offer further advantages for the troops that cannot be undervalued. For the transportable field kitchens, beyond the fact that they save the men the trouble of cooking for themselves, and that they enable a regular and constant supply of hot tea or coffee, still present the further advantage of a more rational utilization of the provisions, since less of the quantity and quality of these last is wasted than when they are distributed among a large number of the men in camp previous to the preparation of the food. Furthermore, these kitchens grant the possibility on the field, where much difficulty is often caused by the lack of good water, of utilizing larger quantities of otherwise poor water; while again by means of them the drying of firewood, which during rainy weather is often wet and damp, is facilitated; lastly, they are able to supply the men in the field with warm water for washing purposes, a fact of vast importance certainly since it is in the interest of the bodily cleanliness of the troops.

"If necessary, the coppers, fitted out as they are with manometers, may also be employed in the kitchens of the barracks. All these facts recommend the introduction of field kitchens throughout the Army."

Thus we see how these field kitchens have fully proved their practicability in the course of these manœuvres; and if a final decision in the selection of a definite model was only arrived at after a long series of trials, extending over many years, during which the models were subjected to severe driving and cooking tests both in hot and cold seasons of the year, on plains and in the mountains, on morasts, on sandy and on rocky soil, it may be regarded as a proof that the Military Administration was determined to consider most carefully every eventuality that might arise in the hour of need, that it was ever conscious of all the responsibility attaching to its decision, and that therefore it is deserving of our absolute confidence with reference to its final choice.

It will be the foot troops who will, in the first line, require to be fitted out with field kitchens; to these at a later date the field artillery may be added. As for the cavalry, it will be a question of a later consideration whether they too shall receive field kitchens in place of their self-cooking contrivances; as also whether the field ambulances, *inter alia*, are to be relieved of a part of their present cooking utensils by the substitution of field kitchens.

MIRRORS FOR SEARCH-LIGHT PROJECTORS.

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An article in the October number of the *Rivista Maritima* deals with mirrors for search-light projectors.

The writer points out that the Russo-Japanese War gave considerable impetus to the consideration of metallic mirrors; that very little has been heard of them lately, but that probably experiments are still being made. No definite conclusions have however been arrived at.

Unbreakable qualities in a mirror are of great importance, but the essential part of the projector is the mirror, and an inferior mirror cannot be accepted merely because it is unbreakable. If the best mirror is fragile it must be adopted and easy replacement provided for.

The reflecting surface of the silvered glass mirror is of course also metallic, but in this case the glass is a necessity to protect the silver from tarnishing, and it also serves to form the parabolic surface which has been found difficult with metal.

In this discussion it will be assumed that the shape of the mirror is equally good in all cases.

Metals vary in their reflecting power, and this also varies with the colour of the rays. In Diagram I., which is taken from the experiments

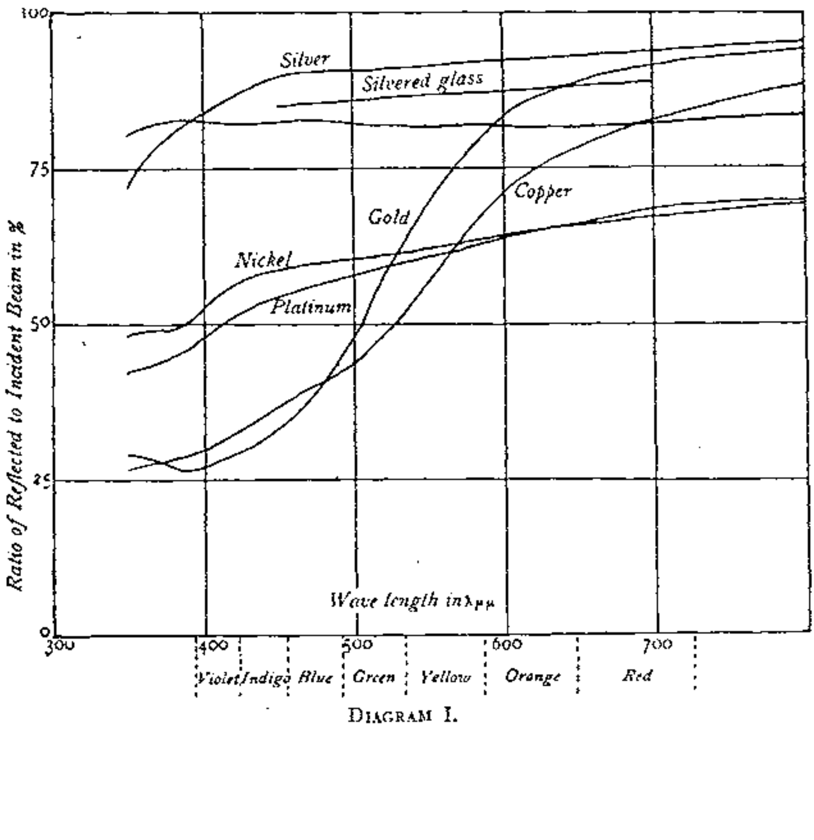

Diagram I.

by Rubens and Hagen, the abscissæ are the lengths of the waves of light, and the ordinates are the relations between the incident and reflected light.

The rays of light which are visible are those between 400 and 700.

It is obvious from this diagram that silver is the best reflecting surface, and the only metal which approaches it is gold.

Gold can easily be deposited on a form and keeps its surface untarnished; for silver the glass protection is necessary, and in its passage through the glass and back again after reflection, a certain quantity of light is absorbed according to the quality and thickness of the glass.

We may take it that about 3 per cent. of the light is lost in each passage through the glass, so that we must deduct 6 per cent. from the ordinates of the silver curve, Diagram I., and so get the curve for a silvered glass mirror shown in Diagram II.

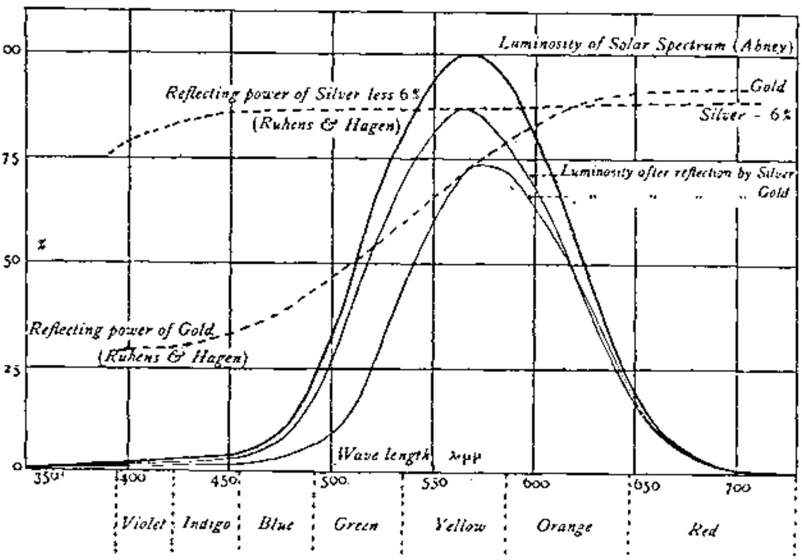

Diagram II.

The silvered mirror still shows its superiority over the gold, for whilst reflecting almost equally well all rays, it has a distinct advantage for the rays between 500 and 600, which are those more efficacious for the visual phenomena.

It is necessary to study mirrors in relation to the light with which they are to be used. Recent reliable data on the distribution of the luminous intensity in the voltaic arc are not available, but as the arc has a tint very nearly the same as that of the sun, it may be assumed that the composition is the same in both cases.

The curve of the luminosity of the solar spectrum, in Diagram II., represents approximately the distribution of the photometric intensity of the normal spectrum of the sun, and also, it is assumed, of the arc.

If now we multiply all the ordinates of this curve by the corresponding ordinates of curves of power of reflection of the gold and silver mirrors, we obtain curves of luminosity which, with their areas, represent the total reflected light of the two mirrors.

Integrating the three curves between 400 and 700, which practically represents the limits of the visibility of the spectrum, the areas may be represented by

Solar or arc light	5,380
After reflection by silver mirror	4,625
After reflection by gold mirror	3,700

The silver and gold mirrors reflect respectively 86 and 70 per cent. of incidental light, or the silver mirror gives a beam 25 per cent. more powerful than the gold.

The silver mirror really gives better results in practice than these figures would indicate, because, although in intensity the two beams (as measured, say, in candle-feet) may be the same, the superiority of the silver mirror is very marked with lower wave lengths, and the latter are those which affect the eye most. We should therefore expect to get a longer range with the silver than the gold mirror.

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It seems strange that, in spite of the incontestable superiority of the silver mirror, some people assert that the gold is equally good. It is true however that no reports of definite comparative trials have been published.

A competent officer of a foreign Navy, who carried out trials for his Government, expressed to the author the decided opinion that the silver mirror is equal to a gold mirror of 1½ times the size, and an experienced officer of the Italian Navy assured him that there is no great difference between the mirrors. The author suggests that such a diversity of opinion could perhaps be explained, if the circumstances, under which the experiments were made, were known. The opinion may be based on the visibility of a far distant object affected by the conditions of the atmosphere, and the colours of the object and background.

We can consider the influence of colour by taking a limited case which could not occur in practice, but which will serve as an illustration.

Take two projectors identically the same except that one has a gold mirror, the other a silver. Direct the beams in two identical objects of yellow colour, and such that their surfaces can only emit rays between 530 and 700. Since only these rays can be emitted, the other rays of the beam of incidental light have no effect—as if they did not exist, and therefore the illumination of the two objects may be expressed by the areas of the two curves between 530 and 700, or

Silver mirror	3,600
Gold mirror	3,150

Assume now similar conditions for the background, that it is green and only emits rays between 400 and 560.

The illumination of the background may be expressed by

Silver mirror	2,250
Gold mirror	1,465

The difference in illumination between the object and background is therefore

Silver mirror	1,350
Gold mirror	1,685

And since under illumination objects lose their colour, and only make their existence known by the difference of their illumination and that of their surroundings, and since the silver mirror lights up well both background and object, the latter will be more visible when the gold mirror is used and the difference in illumination of object and background is greater. A case of this nature is that of a yellow house surrounded by green foliage.

But such conditions of superiority of the gold mirror cannot exist when it is used on the sea. The sea illuminated by a beam from a projector appears completely black, and as a background absorbs all luminous rays; the ship, painted white, buff, or black, is an object which reflects equally all rays of the spectrum, and there will be reflected from the object, in a measure more or less reduced according to its power of absorption, a light identical in composition to that of the incidental beam, and it is the total of this light which makes the object visible against the black background of the sea. All rays are useful, and therefore in this case the superiority of a silver mirror is obvious.

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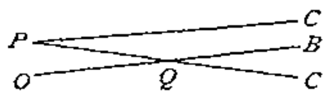
The space through which the beams travel can however influence an opinion on their relative merits.

The yellow beam of the gold mirror is less affected by the presence of damp vapour, which as one knows absorbs particularly rays of minor length beyond the green towards the violet.

The white beam richer in these rays becomes attenuated, but can never fall below the power of the gold beam, which has already lost these rays in reflection from the mirror.

The light carried to the object is therefore always greater with the silver mirror than with the gold, but tends to become more equal when the object is distant and the atmosphere damp. But it follows that, because the silver beam loses more light on the way, it illuminates the atmosphere more and makes its course more visible. The luminous pencil dazzles the observer, but above all affects the contrast between object and background.

Suppose P is the projector, PCC the beam, B the object, O the observer, about 10 mètres from P. Then he sees B through a stratum QB of the atmosphere beaten by the beam.



It follows that the background against which the object is seen is no longer black, as the sea illuminated by the beam is, but becomes light, whitish, and so much more so as QB becomes deeper.

The effect of contrast between object and background is therefore less, and the visibility of the object is consequently less; this explains why the object is more visible at the edge of the beam than in the middle, and why the object is more visible when the observer is placed so that the line joining the object and observer makes about 30 degrees with the beam.

With the gold mirror these disturbing conditions are less accentuated, and other conditions being equal, the visibility of the object is greater.

To sum up:—

(*a*). Silvered glass gives a beam about 25 per cent. more powerful than gold.

(*b*). Given that the gold mirror gives a beam poorer in green-violet rays, under conditions of colour of the object the gold mirror may be slightly superior to the silver.

(*c*). The effect of the atmosphere tends to equalize the power of the beams when the air is very damp.

(*d*). The gold mirror illuminates the atmosphere less, and therefore presents the disturbing influences to an observer near the projector in a lessened form.

It may be noted with regard to the last that the same effect can be produced by observing through a yellow glass, and the same impression with a silver mirror as with a gold can be obtained by using an appropriately coloured glass.

The author concludes that it would not be bad practice to provide yellow glasses for use under certain conditions.

E. G. Godfrey-Faussett.

NOTICES OF MAGAZINES.

JOURNAL DES SCIENCES MILITAIRES.

February 1st, 1909.

A further instalment of the article on "Automobilism" considers motor wagons and their use. The provision of a good commissariat has always been a matter of the greatest importance, and no one now denies the advantage, for convoys, of mechanical over animal transport. At present infantry regimental transport is too small and slow to need motors, but cavalry divisions and cyclists' baggage trains are quite a different matter. Heavy wagons will be very useful for posts off a railway line, though they will only be able to take reduced loads on account of the bad roads. Motor wagons must fulfil the following conditions:—(1), A strong motor; (2), metal-shod wheels for weights above 3½ tons, pneumatics for smaller weights; (3), total weight not to exceed 7 tons on account of liability to use on bad roads. If possible, trailers should be used, as a vehicle capable of carrying 4 tons can carry 3 and drag 3 simultaneously. Motive power should theoretically be electric, but the accumulators are too heavy, unless Edison's latest invention is successful. Steam may possibly be used, the weak points of such motors being the boiler. In the field motors must be capable of travelling on broken country roads, and, if possible, across country. A full description of the Renard train follows. Among its advantages are less wear to the road surface and no expense for india-rubber tyres.

The subject of this number's "Ideas on Instructing an Infantry Regiment," is protection. Protection is defined as the art of maintaining liberty of action. McMahon's army in 1870 is instanced as a case in which liberty of action was lost several days before the final catastrophe. It is the duty of the cavalry to ensure strategical liberty. The indispensable minimum of tactical liberty is that which ensures time and space for making dispositions for action. Advanced guards should be strong and pushed well forward. Making them strong is to make them bold, and not so likely to waste time making minute explorations of every inch of ground before any contact whatever has been made. In all circumstances advanced, flank, and rear guards should halt at every stop on convenient positions for resistance. Advanced guards do not manœuvre. They form a screen behind which the main body manœuvres. Flank guards are to prevent the movement of the main body being interfered with. They must therefore hold out to the last. After a retreat outposts should be furnished by the main body, not by the rear guard. Outpost sentries should never be single, specially with young soldiers and reservists.

Experience shows that if sentries are alone they tend to drift together. When attacked, outposts must not retire unless in danger of being captured as their capacity for resistance is greater than is generally supposed. The question of providing protection for troops in action is often overlooked. Detachments should be posted on all sides; an *échelon* formation which can hinder a flank attack by attacking its flank in turn, is the best. The results of any observations made should be communicated to other arms. The cavalry outposts act in the same way as the infantry, but can operate over a greater sphere. On account of the great services rendered by the mounted scouts attached to Russian infantry, 12 men per regiment are to be trained to act on the same lines in the French Army. They should be kept to scouting duties as much as possible, and should never be used as despatch carriers when cyclists or other means are available. To be defeated is a misfortune, perhaps unavoidable; to be surprised is shameful and can never be excused.

February 15th, 1909.

The Latil train is a rival to the Renard. It consists of a motor mounted on two wheels, which, attached to any carriage provided with two ordinary wheels, forms a special vehicle. As the driving mechanism is concentrated on the front axle, boxes can be hung about the rear axle, thus giving a dead weight of 2·7 tons to carry a useful load of 5 tons.

Considering the types of transport, horses are recommended for regimental wagons, as these must be taken right into camps, and these are often only connected to main roads by lanes impassable for motors.

The two types especially suitable for heavy transport are motor lorries carrying 2 tons and worked by 2 men, and Renard trains carrying 12 tons and worked by 3 men. The speed in each case is 7½ miles an hour.

Motor transport for hospital work is strongly recommended. It is of course quite out of the question for the preliminary work of collecting the wounded under fire, but motor ambulances running 10 miles an hour would soon remove the wounded from the collecting stations on the battlefield to the field hospitals in rear. On account of their speed, far smaller numbers would be required, which, considering the great crowd of vehicles with an army, would be an additional advantage.

Motors might also be used by the pay and postal departments. Germany uses light motor cars and motor bicycles for the latter.

The article on the Russo-Japanese War considers night attacks. According to a Japanese officer the Japanese infantry is the best in the world. Fortification, according to him, is not used for the defence, but as a means of resting during the advance; and as each step in the advance is fortified, strong reserves can be dispensed with. The Japanese practice, in peace, night attacks in absolute silence, directing them by luminous signals from the officer's pocket lamp. They prefer the German system of artillery fire to the French sweeping system.

Accounts of three night attacks are given—two Japanese at the

Sha-ho, and the successful Russian attack on Putiloff Hill, when 11 guns were captured. In the first case the Russians apparently had no outposts; in the second they mistook the Japanese, who were wearing white caps, for their own troops. The ground was first carefully reconnoitred and the direction of attack marked by branches of trees. Each unit had its point of assembly and point of direction laid down. In the attack on Putiloff Hill, the Japanese held their fire till the enemy was within 50 paces, hoping to crush him by fire at such a short range. But it was too close, and the Russians were completely successful, and also repulsed three counter-attacks made on the night of 17th to 18th October.

Almost all Kuroki's attacks at the Battle of Sandepu were delivered at dawn after a night march.

At Tashichiao the Russians built new epaulments at night; next day the Japanese bombarded the old ones, whose positions had been pointed out by their spies on the previous evening.

In "Instruction of an Infantry Regiment" the preliminaries of an action are considered. The "fog of war" is noticed, and the author insists that it will rarely lift. The Russian idea that it would do so, resulted in large reserves being kept, which came into action too late or not at all; whereas the Japanese generals, accustomed to carrying out their own plan without paying much heed to the enemy's intentions, threw every man into the fight, and though only equal in numbers to the enemy had far superior strength in action.

March 1st, 1909.

An article on artillery recommends three-gun batteries. It is argued that a battery's value in action depends entirely on the way its commander fights it, however well trained the men may be. It is impossible to command a four-gun battery by shouted orders, particularly if the captain's observing station is on the leeward flank of the guns. Telephones and signals are not in ordinary circumstances desirable; two guns are not enough for ranging, while often the fourth shot is unnecessary, so three guns are "necessary and sufficient" for that purpose. Eliminating the extra gun would increase the supply of ammunition available for the other three. There are two possible units in practice, the battery and the gun and its ammunition wagon. With shielded guns the section commander must take cover behind an ammunition wagon and cannot supervise more than one gun, consequently a two-gun section is obsolete. With three guns and six wagons, more spare numbers could be carried than with the present four guns and six wagons. These men would be very useful for running guns into action by hand, ammunition supply, and entrenching. With the present cone of dispersion for shrapnel, three guns can sweep the hundred mètres front allowed to a battery as effectively as four.

The German guns are severely criticized. They cannot in practice change their target for a new one to a flank without altering the positions of the guns themselves. The French artillery being able to traverse their gun considerably without altering the position of the wheels can very easily alter their direction, consequently they have not the same need of keeping batteries in reserve.

The advice on the training of infantry considers the "preliminary combat" in this number. No fixed distances for frontage are any longer laid down. Troops should never be crowded into trenches so closely that they cannot take cover till actually wanted. Otherwise they suffer heavy loss for no reason, as the fire of a smaller number will be quite enough to prevent an enemy's advance. Mingling units in the firing line should be avoided as far as possible. It is better to allow each company to provide its own supports and reserves rather than to put a whole company in the firing line, with another company in support and another in reserve. The best formation for approaching is in a lozenge. To have two lines of companies, tends to result in two companies forming the firing line and two the reserve on every occasion, whatever the circumstances. Gun fire is effective up to 5,000 yards. Under artillery fire relief may be obtained by a short movement to a flank, as the German guns cannot easily alter their direction. Rifle fire is effective up to 1,400—1,500 yards. Every effort should be made to keep hidden, as "visibility draws fire, and fire provokes an answer." In Manchuria fire was often opened at long range; on distant localities more frequently than at definite targets. Field fortification is most important, but care should be taken that, on the offensive, it does not spoil the dash of the attack. Machine guns should be adjuncts of the infantry and cavalry. Night attacks must be practised.

Under the heading of "The Military Month," the selection of sergeants is considered. A corporal's duty is principally to set a good example to his squad, whereas a sergeant must use his intelligence more in carrying out his duties. Consequently, a good corporal is by no means necessarily a good sergeant, and the promotion of sergeants might be quite well made without considering whether a man had first got his corporal's stripes.—It is said that telephones are to be used by batteries at the practice camps this year.—A new model siege gun is about to be manufactured.

H. L. WOODHOUSE.

JOURNAL OF THE MILITARY SERVICE INSTITUTION (U.S.A.).

PHYSICAL TRAINING OF OFFICERS.—This article, by Colonel Charles Richard, Medical Corps, U.S.A., is a criticism of the methods existing in the U.S. Army for obtaining a state of physical efficiency in the higher ranks.

The test for field officers takes place annually and consists of riding or walking a certain distance in a given time. It usually resolves itself into a few weeks' violent training immediately before the test, followed by a period of comparative inactivity during the remainder of the year.

Colonel Richard objects to this test for two reasons. Firstly, because the officers who undergo it are not necessarily in a hard condition all the year round, and secondly, because the test not unfrequently causes a strain on the heart, from which it may never recover.

In place of this the author proposes that each officer should devote so many hours a month as a matter of routine to physical exercise, and that a certificate should be sent in every month certifying that this has been done. The object of this is, of course, to keep officers in continuous training for active service.

Should any officer be unable to satisfactorily carry out this physical training, Colonel Richard suggests that he should be brought before a Retiring Board.

The nature of the exercises suggested includes walking, riding, and the other usual outdoor recreations, amongst which the author considers golf to be the best.

This enforced system ot physical training seems to be intended only for field officers and those engaged in staff, departmental, and other possibly sedentary duties, as, it is argued, junior officers employed in performing ordinary regimental duties meet with sufficient exercise in their everyday work to keep them fit.

The Mountain Troops of Europe.—By Capt. C. de W. Falls, 7th Regt., N.G.N.Y.—Capt. Falls contributes an article on the mountain troops of Italy, France, and Austria, in which he describes their origin, organization, and duties.

After the conclusion of the Treaty ot Frankfort, France began to protect her frontiers with powerful fortresses constructed regardless of expense, the main object in view being to protect herself against her victor, Germany; however, under the new grouping of the European Powers, France soon realized that Italy would have to be regarded as a possible foe. Hence, she began to strengthen her Alpine frontier, roads, strategic railways, and forts being built to defend it.

Italy was unable to keep pace with this, firstly for financial reasons, and secondly, because her defensive scheme for her frontiers was not fully developed.

As a counterpoise theretore she originated her Alpine Corps, recruited from men belonging to the mountain districts.

Some years later France, who had by this time realized that ordinary line troops, which had up till then been employed on mountain work, were quite useless for the purpose, followed Italy's example. Twelve Chasseur Battalions were theretore converted into Chasseurs Alpines, each battalion having a strength of six companies, with mule transport. Mountain batteries also were organized.

Some time after this Austria, following the lead set by France and Italy, organized her famous Edelweiss Battalions, so named after their distinctive badge—the edelweiss, the mountain plant that only grows high up in the mountains.

These three countries—France, Italy, and Austria—alone have an establishment of special mountain troops, whose sole duties are to protect their mountain frontiers. Other nations have sections of mountain territory in their defensive lines, but do not train any special troops for the work, which is carried out by whatever detachment may happen to be stationed on the spot.

Thus, practically, the whole of the Swiss Army is more or less trained to do mountain work; also that part of the German forces which may be stationed in the region of the Bavarian Alps, and those of Spain quartered in the Basque provinces.

The general lines on which the training of all the mountain troops takes place are much similar, but the French and Austrians appear to be much harder worked than the Italians. The training season begins about May, as soon as the snow in the upper valleys has sufficiently disappeared to allow the manœuvring of troops. The training includes divers military duties such as artillery and rifle practice, intelligence service, reconnoitring, roadmaking, and improvement of communications. Towards the middle of September the detachments return to their winter quarters, leaving only a few men at the outpost stations. The men left at these outpost stations are frequently cut off from all communication with the outer world—except by telegraph—for weeks together. Though the training of all the troops is much similar, there are great differences in *personnel*, uniforms, etc.

The French seem to have the best individual material, and the intelligence of their rank and file is much above that of the Austrians and Italians. Their clothing is good though their equipment is somewhat bulky.

The Italian uniform is very ill adapted, being showy, heavy, and much too conspicuous; their equipment also is very bulky. Considering that they were the originators of the frontier troops, they do not seem to have progressed much. The Austrian outfit, judged all round, seems to be the best.

In physique there is little to choose between the three; and all are remarkably fine—in the opinion of the author they are the finest troops that he has ever seen.

Their feats in the passing of mules and guns up and down precipices are considered miraculous, and from all points of view they seem to be a very efficient organization.

Utilization of the Night.—This article, translated from the French by Capt. Read, 12th U.S. Infantry, brings to notice some cases where night fighting took place in the recent Russo-Japanese War, and draws attention to the importance of this kind of operation for gaining positions which could not be taken by day.

In most of the instances quoted the actual attack took place either just after nightfall or just before daybreak, but there are others where the attack was made during the night in almost complete darkness, and it is with these latter that the article is chiefly concerned.

An account, believed to be very authentic, is given, showing how the Japanese captured some Russian guns after having taken a line of trenches and bayoneted their defenders.

At the close of the retrograde movement of the X. Corps, during the Battles of the Sha-ho, which movement was completed on the 13th October, Colonel Smolenski's Regiment of Artillery was situated in gun emplacements near Cha Ho Pow, with three companies of infantry as a local support. Part of the Gerchelmann Corps was holding a ridge in front of them.

During the night the Japanese, who had annihilated the portion of the above-mentioned corps in front of them, worked their way up to the batteries, where they arrived just before daylight. They then captured the batteries at the point of the bayonet. This catastrophe was due on the one hand to no information having been sent back to the artillery to let them know what was going on, and on the other to the fact that the Japanese, advancing in the uncertain light of a misty morning in uniforms which they had taken from the regiments that they had just annihilated, were taken by Smolenski to be Gerchelmann's troops withdrawing, and were not fired on by the Russians till they were within 150 yards.

It is pointed out also that guns have very little chance of escaping from hostile infantry which it has allowed to get within very short range, especially if, as in this case, the guns are loaded with shrapnel instead of case.

That the guns were loaded with shrapnel was due to the fact that they were firing over what they thought was their own infantry retiring at the spot where they supposed the Japanese reserves to be.

Another instance quoted of an assault being made in the dark is the attack that was made on Lone Tree Hill.

This hill had been lost by the Russians on the 15th October, and General Kuropatkin, considering it essential that the hill should be recaptured, ordered General Poutilov to do so.

The attack was ordered to take place at 6 p.m., to avoid the losses which would take place if attempted by daylight. It was made on three sides of the hill simultaneously, and in such darkness that the summit was barely visible. The Russian left came under a heavy fire during their advance, but made no reply until they reached the Russian trenches, where after a hand-to-hand encounter they turned the defenders out.

Their right and centre approached to within 50 yards of the trenches without being fired on, the Japanese no doubt thinking to repel them with short distance fire. They were however bayoneted and put to rout.

The Russian losses, though not numerically stated, were very small compared to those sustained by the Japanese, who left 1,300 dead on the hill.

Three unsuccessful attempts were made by the Japanese to retake the hill between midnight and 1 a.m.

The above instances serve to show the possibility of executing decisive night attacks, and how, under such circumstances, the sidearm regains the value it had before firearms reached their present state of perfection.

The objection to such night attacks is of course the extreme difficulty of directing them—for instance, the only orders that could be issued to guide the centre attack on Lone Tree Hill were to "march on the moon."

The author points out that the Russians were generally outmatched by the Japanese in these night attacks, and that the study of them during peace had been systematically ignored by the Russians.

A. J. Swinton.

Kreigstechnische Zeitung.

September, 1908.

As a result of the increased value of engineers, proved by the Russo-Japanese War, engineer brigades are being allotted to each of the Siberian Army Corps, the composition being :—

A. Field Army.

(1). Omsk Engineer Brigade :—

4th East Siberian Sapper Battalion.
1st East Siberian Field Balloon Battalion.
Field Engineer Park at Omsk.

(2). Irkutsk Engineer Brigade :—

2nd, 5th, 6th East Siberian Sapper Battalions.
2nd and 3rd East Siberian Pontoon Battalions.
2nd East Siberian Military Telegraph Battalion.
2nd East Siberian Field Balloon Battalion.
2nd East Siberian Wireless Telegraph Battalion.
Field Engineer Park at Irkutsk.

(3). Amurland (Priamur) Engineer Brigade :—

1st and 3rd East Siberian Sapper Battalion.
1st East Siberian Pontoon Battalion.
1st East Siberian Military Telegraph Battalion.
3rd East Siberian Field Balloon Battalion.
1st East Siberian Wireless Telegraph Battalion.
Field Engineer Park at Amurland.
East Siberian Engineer Siege Park.

B. Fortress Troops.

Vladivostok Sapper Battalion.
Vladivostok Marine Mining Battalion.
Vladivostok Fortress Telegraph Company.
Vladivostok Fortress Balloon Company.
Nikolajewsk Sapper Company.
Nikolajewsk Fortress Telegraph Company.
Amur Marine Mining Company.

The organization of an East Siberian Pontoon Battalion (2 companies) is:—

	Peace Establishment.	War Establishment.
Cavalry drivers	77	326
Combatants	490	739
Transport non-combatants	99	109
Total non-combatants	138	148
Total of troops	638	847
Horses	332	847

A Telegraph Battalion consists of:—

	Peace Establishment.	War Establishment.
Transport soldiers	214	431
Total non-combatants	273	490
Total troops	898	1,115
Horses	223	465

The efficiency of these units is said to be much improved by this new reorganization.

A. H. SCOTT.

LE BULLETIN.

January 15th, 1909.

FIELD SERVICE REGULATIONS, GERMAN ARMY.—*Protection, Outposts.*—The line of resistance is usually the position of the outpost companies. These furnish piquets to their front varying from a squad to a section, each with its sentries and patrols. The local reserves are furnished independently of the outpost companies.

MODERN MILITARY INSTRUCTION.—An outline is given of a work bearing this title, by Capt. Maivetet of the French Army. The subject, treated in a most interesting manner, is studied under three headings:—

(*a*). Man and his action in war, from the physical and moral points of view.

(*b*). The regulations dealing with the training of the modern soldier.

(*c*). The particular part played in this training by the gymnastic instructor.

The first instalment commences with a psychological study, showing the emotions undergone by the human being confronted with the dangers of war, and the process of accustoming him to subordinate them to his sense of duty. The importance of the action of the reflexes in its bearing on peace training is discussed, as also the varying factors, patriotism, *esprit de corps*, cohesion, and discipline, etc., which go to augment moral force.—(*To be continued*).

ATTACK AND DEFENCE OF FIELD FORTIFICATIONS.—By Major Fritsch, Professor at the Berlin War College. A review is given in this and succeeding numbers. The chiet *rôle* of field fortification is to enable a small force to contain a far superior one, so as to set free a preponderating force elsewhere for offensive action. Recent wars in South Africa and Manchuria have shown the futility of uniform dispersion of forces over a wide front. When large forces are concerned the danger and loss of time involved in turning movements, and the magnetism which attracts two hostile bodies towards each other, make it improbable that the opponent will avoid a defensive position prepared beforehand; this dictum is certainly borne out by the Russo-Japanese War. It is therefore of the utmost importance to have such positions fully prepared for defence before the enemy appears on the spot. The author discusses the questions of siting of trenches, nature of artificial cover, the use of dummies, and hasty entrenchments.

January 31st.

FIELD SERVICE REGULATIONS, GERMAN ARMY.—*Protection* (*continued*).—Infantry patrols sent out in advance of the sentry line should, on returning, let the sentries know briefly what they have observed. In siege warfare outposts gradually merge into the first line as the defensive circle becomes more and more restricted.

MODERN MILITARY INSTRUCTION (*continued*).—The work of military organization in developing cohesion and *esprit de corps*. The abuse of the latter. The general condition of the soldier on joining his regiment. At 20, the age of enrolment, his physical condition is still imperfectly developed, and often deteriorated by the nature of his employment or the peculiar circumstances of his existence. He may be more or less affected by previous illness. His moral state is still more backward, for moral maturity is only reached about 30 years of age. From a psychological point of view, much depends on the class of society to which he belongs—under the two main headings, peasant classes and working classes. Each has its own peculiar characteristics, the former being hardy and brave, but dull witted and suspicious; the latter active, self-reliant, and *débrouillard*, but independent and undisciplined. It has been well said that these two classes form, respectively, the muscles and the nerves of the army.

ATTACK AND DEFENCE OF FIELD FORTIFICATIONS (*continued*).—The author discusses at some length the action in the field of heavy artillery by which he understands 6″ and 8″ howitzers. A *résumé* of engineer equipment and organization is given. The majority of German army corps have only one 3-company battalion of field engineers, carrying tools for itself alone (a certain number of full-sized entrenching tools now form part of infantry 2nd line transport), and 800 lbs. of explosives per company. All other stores and tools required are obtained from the siege park.

The Engineer Siege Park contains :—

4 vehicles of special engineer tools.
4 vehicles of mining stores.
48 tool carts.
50,000 sandbags.
500 wire cutters.
Escalading stores.
Shields.

The first *échelon* of the park carries entrenching tools for one-third of a division, stores for the construction and destruction of obstacles, 2,000 lbs. of explosives, rockets, corrugated iron, steel shields, sandbags, rope, wire, spikes, nails, etc.; also portable search-light projectors and—presumably—engines. Communication troops include balloon troops and telephone detachments. The balloon troop attached to an army is composed of two balloon sections and two gas sections. Only one of the two balloons carried can be sent up at a time as there is only one windlass cart. The average height to which the balloon is sent up is 600 yards, giving a sphere of observation of 4 to 10 miles radius. It is suggested that dirigibles will, when perfected, be free from almost all the faults of the captive balloon.

'E.R.'

MILITÄR WOCHENBLATT.

No. 150.—December 5th, 1908.

A provisional training manual in the passage of obstacles has been recently issued in France. It is divided into three parts:—(*a*), The passage and destruction of ordinary obstacles; (*b*), the passage and destruction of trenches; (*c*), the passage and destruction of entanglements. Except in a few cases, operations are to be carried out by night The principles enunciated are very simple, and the simplest way of carrying out a task is to be considered as the right way; success is only ensured by rapid execution and little talk; the exceptional methods must however also be known and practised. Some of the details given are interesting, *e.g.*, the wearing of special clothes by "destruction-sections," the colour of which is similar to that of the locality of the obstacles; the wearing of india-rubber shoes or wrapping up the feet in bandages, and in some cases blackening the men's hands and faces. Ladders and mélinite play a great *rôle* in the passage and destruction of the obstacles.

In order to encourage officers to perfect themselves as balloonists, the Italian Government states that wounds or illnesses contracted by officers whilst travelling on airships or balloons — even when on private journeys—will be reckoned as having occurred whilst on duty.

Italian officers and men who take part in speed or endurance contests on foot, on horseback, or on bicycles, are to receive exceptional additional pay, and officers who hunt can claim refund of transport expenses.

Under the title of "Armour in the Construction of Fortifications," a review of Lieut.-Colonel Piarron de Montdésir's book is given. This officer, who is a lieutenant-colonel of the French Engineers and a professor at the French Staff College, deals principally with the tactical and not with the technical side of the question. The book is divided into three parts; in the first part he deals with the development of "Fortification cuirassée" from 1815 till 1900; in the second with the existing fortifications in French and other countries, whether land, coast, or mountain defences; and in the third with possible future developments. The lessons to be learnt from Port Arthur are also dealt with in Part II.

No. 153.—*December 12th*, 1908.

A new grey-green uniform is to be issued to Italian troops by army corps, starting from the north, so that the XIIth Army Corps in Sicily will get it last. The officers will adopt the new uniform after all their men are equipped with it. This uniform is to consist of a jacket, vest, cap with peak and chin strap, and trousers. The latter fit into a pair of long laced boots, which, whilst being more pliable than a jack boot, are cheaper than boots and gaiters.

No. 155.—*December 17th*, 1908.

The new cavalry uniform—which is on probation—is being worn by one squadron of the "Florence" Lancer Regiment in Rome. It wore better in recent manœuvres than the old uniform.

No. 158.—*December 24th*, 1908.

Till quite recently there were no Turkish military journals, *i.e.*, papers in which the leading questions in military art were freely discussed. In the last two months however their number has increased to eight, which are:—

1. *Djeridei Askerijé*—an official organ for the promulgation of orders and notification of appointments.
2. *Medjmuai Fununi Askerijé*—a supplement to No. 1, published fortnightly by the General Staff. It chiefly contains translations from foreign military newspapers.
3. *Djeridei Bachrije*—a fortnightly naval paper, with an illustrated supplement every month.
4. *Asker*—a bi-monthly publication.
5. *Seif u Kalem* (pen and sword)—These last two are military magazines, edited by officers of the Turkish Army for the education of their brother officers.
6. *Ordu*—a weekly Adrianople paper.
7. *Makessi efkjari askerijé*—or *Military Reflections*, which is published weekly.
8. *Haftalig risalei askerijé*—a weekly semi-official paper published in Saloniki for the special benefit of the IIIrd Army Corps, and similar to the *Militär Wochenblatt.*

A work called *Muharebe dersleri* is also being published in six parts, viz.:—

1. Infantry fire tactics, and the company, half-company, and section commanders' handbook.
2. Infantry control in action.
3. How does a battery commander choose a position for his battery?
4. Field artillery in action.
5. Tactics of the three arms.
6. Tactical exercises for officers of all arms (with solutions).

Besides these, much literary activity is noticeable in military circles.

A. H. Scott.

NATURE.

December.

WIRELESS TELEGRAPHY (*p.* 225).—The new wireless telegraph station at Bolthead, South Devon, was opened on December 11th. The station belongs to the Post Office, is about 15 miles S.E. of Plymouth, and is 350′ above the sea level, a height considerably greater than that of the Marconi station in Cornwall. The work was begun about six months ago, and cost about £10,000.

The range of the station is 250 miles. It will establish public communication with all vessels carrying wireless telegraphic apparatus, irrespective of the system of which they may have been installed. The apparatus is on the Marconi system. The aerial, which is 160′ high, consists of two central conductors and four arms radiating to small poles placed around the main mast, thus being of what is now known as the "Umbrella" type. Power is obtained from a 3-kw. alternator supplying current at 100 volts 50 cycles, which is transformed up to 15,000 to 20,000 volts. The alternator is coupled to a direct-current machine, which can be run either as a motor or as a generator driven by an 8-h.p. oil engine when it is required to charge the cells; in this case current can, at the same time, be taken from the alternator.

The signalling is effected by a key in the generator circuit controlling a magnetic key, which only allows the alternator circuit to be open when the current is at zero. This is now usual with wireless telegraphic work when the power is supplied by an alternator, in order to avoid sparking at the contacts of the signalling key. The sparking gap is of the standard Marconi type, and can be varied in length from 2 mms. to 8 mms.; it is completely enclosed to deaden the noise.

The receiving apparatus consists of a Marconi magnetic receiver which gives telephonic signals in the usual way, and a coherer circuit for "calling up," which is disconnected when receiving signals on the magnetic receiver. The coherer circuit can also be used in connection with a Morse inker. The normal wave length is 600 mètres, but this can be varied, and apparatus is provided to enable the circuits to be timed accurately in order to obtain the clearest signalling.

Everyone will welcome this further evidence of the development of the utility of wireless telegraphy, the traffic dealt with having increased in volume, and the ships carrying Marconi apparatus having increased in number.

EARTHQUAKES (*p.* 184).—Dr. Knott's work on this subject is confined to the physics of earthquakes, and gives an impartial statement of the principles on which seismograph instruments are constructed; they vary according to the purpose for which they are required.

The periodicity of earthquakes is discussed at some length, with the general result that there is little evidence of the reality of any of the periods believed to have been established.

STELLAR EVOLUTION (*p.* 191).—Professor Hale's work on this subject is an account of the study of stellar evolution, and of the methods and apparatus applied in attacking the various problems at the new solar observatory on Mount Wilson, by means of its new equipment. Professor Hale looks upon the evolution of stellar systems, not as an entirety, but as a part of the general scheme of evolution which begins with the Beginning, and at present ends in the social systems which govern man. The great differences between the old and the new astronomy are pointed out with reference to the changes introduced by the application of photography. The sun is discussed as a typical star, and a description of the evolution of the spectro-heliograph, in which the author has played so great a part, is given.

A chapter on stellar temperatures illustrates the extreme delicacy of the apparatus with which Nichols, working at the Yerkes Observatory in 1900, was able to detect the heat radiations received from Arcturus and Vega. The former was found to send us heat equivalent to that given by a candle about 6 miles away, and Vega less than half that amount, if there were no absorption by the atmosphere.

The nebular hypothesis is discussed, and some interesting points are made on stellar development and the various stellar classifications in the light of recent research. The results obtained in the Mount Wilson laboratory, imitation of sunspot phenomena, seem to favour the view that a temperature classification of the stars on the basis of the relative intensities of the lines in their spectra is perfectly possible.

The making of the 60″ reflector in the Mount Wilson workshops is described and some possibilities of the new 100″ reflector now under construction are reviewed.

W. E. Warrand.

Neue Militärische Blätter.

Berlin, 15th December, 1908.

Volunteer Army of the United States.—The General Staff of the United States Army has lately worked out a Bill, to be laid before the next Congress, which provides the organization for the formation of a Volunteer Army. In case of war the United States Army would then consist of three parts:—The Regulars, the National Guard, and the Volunteer Army. The latter would be formed during the course of a war or if war was imminent, but the consent of Congress is necessary, and—although formerly enlisted for two years—this army would now be dissolved as soon as possible after the danger of war has been averted or peace concluded. As soon as the President calls up the Volunteers, the Secretary for War would publish the rules and regulations for the recruiting of the men and the organization of the Army. Organization and discipline in the Volunteer Army follow on the same lines as in the Regular Army. The organization of machine-gun detachments, of hospitals, hospital trains, hospital ships, as well as of the whole sanitary and remount services, and the rest of the administration in rear of the Volunteer Field Army, would be left to the President to decide in accordance with the requirements of the moment. Similarly it rests with the President—though subject to the consent of Congress—to appoint the officers required to effect the organization of units less than a brigade. The number of Volunteer generals is however laid down in the proportion of a brigadier to 4,000 men, a major-general to 12,000, and a lieutenant-general to 36,000 men. The Volunteer officers are, in the first instance, to be drawn from the Regular Army, and—on the recommendation of the Governors concerned—from the organized Militia of the various States and territories. But the number of Regular officers is limited in the case of infantry, cavalry, and artillery regiments to five each, and to five for every 12 companies of coast defence artillery. It is expected also that a large number of former officers, under officers and men of the Regular Army, will join as soon as the Volunteer Recruiting Depôts are formed, and it will then be possible to appoint them at once to those depôts with higher rank and increased pay. Though full information regarding the details of the above scheme are not available, there are several points of interest which are worthy of notice.

The difficulties—which were experienced by the Federal Government at the outbreak of war in 1861—have evidently not been forgotten by the American General Staff, but their efforts to remedy their existing deficiencies have not met with much success.

It is recognized that the Militia Forces of the several States and territories cannot be employed, for Federal purposes, outside the boundaries of their respective territories, and that the peace organization of these forces must be broken up on a general mobilization.

It is expected that the ranks of the new Volunteer Army will be filled up by the officers and men of the Militia Forces, who will volunteer for active service, but who will not submit to efficient training in peace time. It would be interesting to know whether the Regular units will be utilized to form the nucleus of the new Volunteer units, or whether they will take the field as intact Regular units, as in 1861.

It is noticed that a proportion of Regular officers will be drafted into the Volunteer units, and that the appointment of officers to the higher commands is reserved in the hands of the President, but "subject to control" by Congress. There seems some danger, in this control of patronage in the higher ranks by Congress, of the appointment of popular political magnates to the higher commands, rather than of their being filled by the selection of officers of scientific military attainments. The scheme merely provides for a paper organization, which leaves the complete formation of a field army to be deferred till after the outbreak of war, dislocates all organization in peace time, and relegates the formation of the indispensable auxiliary services to the time of emergency.

22nd and 28th December, 1908.

Under the heading "What can we Learn from the Japanese from the Night Operations in the Russo-Japanese War of 1904–5?" the writer discusses some points of very great importance, brought out in a book entitled *Training of Infantry in Night Operations*, and written by a Japanese officer, Lieut.-Colonel Tachibana.

The writer commences by drawing attention to the general unpopularity of night work, and says it is well known that many very able officers lay no value on night fighting, and even oppose night operations at manœuvres. "The night is no man's friend, and at all night work—even in peace—one has a certain uncomfortable feeling as one becomes aware of the dull noise of approaching masses of men, till at last from the mist or the darkness of the night a black something takes shape and rolls nearer like a broad wave of sinister menace, and finally threatens to fall on us with levelled bayonet and nerve-shattering yell." The writer points out that there was a time when it was asserted that the introduction of accurate low trajectory firearms put an end to all hand-to-hand fighting, or at least limited it to very exceptional occasions. The Russo-Japanese War—in which two nations were struggling for their existence with almost inhuman tenacity and national enthusiasm—has however proved exactly the opposite, more especially with night fighting. The German *Combined Training* says that night practices are indispensable, particularly night marching, even off the road. Troops must be prepared beforehand for the fight by night, but this can only be done by practising night fighting in its very details. The soldier must first acquire some precision in the use of his weapon, for its use by night makes such high demands on the man that he must not only know how to use it independently under all circumstances, but must also be practised in physically overcoming the greatest obstacles.

Going into the details of the training more closely, there are first and foremost two senses—hearing and vision—the sharpening and development of which are of especial importance for night fighting. Every man must be practised in distinguishing by sound alone, the step of an armed soldier fully equipped from that of the casual passer-by. The former has a heavy regular tread; the latter a lighter, freer, irregular pace. In the stillness of night the soldier must learn how to distinguish when detachments on the march halt and again move off. The men's powers of hearing must be so increased by long and careful practice that the direction and distance away of an approaching body of troops can be fairly accurately estimated. The writer agrees that this requires a sensitiveness which can only be expected from a fraction of the men. The men should be given practical examples in observing how, in marching through the dry undergrowth in woods, the cracking of branches and the rustling of the foliage can be heard at a great distance; how marching on hard stony ground is audible further off than the sound of marching on sand or turf; how wind affects sound; and how to some extent undulations and hollows muffle noise. The eye must be accustomed to the dark, and to distinguishing objects which generally appear quite different in the dark. In mist all objects appear much larger than they actually are. Distances appear greater. Practice must be given at finding one's bearings by the moon, the pole star, and the compass, "so that before all things the front is never lost." The writer then proceeds to detail the precautions necessary in an advance by night. Bayonets are to be fixed and the rifles carried at the short trail. All this is first to be practised without arms, then with bayonet-fighting muskets, and then—when sufficient precision has been obtained—with the rifle. As regards equipment, the difficulties must also be surmounted progressively, first without the pack, then with it empty, and then with it fully loaded; further, the practice must be commenced on level ground, then on broken ground, and finally on a site covered with artificial and natural obstacles. "Preparatory exercises ensure studious use of the obstacle course by day as well as in the dark." Fire is only to be opened under exceptional circumstances at particularly favourable targets, and care must be taken not to fire too high. Success in night fighting is only attained by regardlessly pressing on to the hand-to-hand fight, and therefore it is of the greatest importance to lay particular stress on bayonet fighting, so as to prepare the men adequately for night fighting.

For duty on patrols and in the outpost line, the writer says that particularly careful training is necessary of specially suitable and selected men. but he does not remark that the duty will fall very heavily on these men, As soon as a suspicious noise is observed, the man must immediately prostrate himself noiselessly and seek to determine the direction and distance of the approaching enemy. Indians can ascertain the approach of even single men at the distance of a mile, so why cannot German soldiers, or at least the most adept amongst them, learn to do the same? Woods, which furnish the patrols with cover from view by day, are to be avoided at night, also villages and farms. Note must be made of anything which will help to guide the patrol on the return journey, but the writer appears to overlook para. 261 of the German *Combined Training*, which advocates, as with us, the return of the patrol by another route.

Patrols should avoid collision with the enemy's patrols, but if one is encountered, "the patrol must at once climb trees and keep themselves hid in the foliage, or, if there is no time for this, throw themselves on the ground and let the enemy's patrol go past them; if this last course also is impossible, they must surprise the enemy and noiselessly cut them down."

In the case of marches across country of fairly large bodies of troops in close formation, the closed column of sections is the most suitable formation. The position of the commander is in front of the middle of his column, which he directs "by signs, whistles, or hissing sounds." The writer has nothing new to say about arrangements for keeping up communication or for conducting the march generally, but "in the assault the front ranks hold their rifles at the charge; the rear ranks, on the other hand, hold theirs upright in front of the breast, in order not to wound their front rank men with the sharpened bayonet."

The writer observes that in the Russo-Japanese War it was found inadvisable to fire at the retreating enemy after a night assault, as their own people from another detachment might be in pursuit and would suffer.

There is nothing to notice in the lessons drawn by the writer for the defence, but he finishes by saying that unfortunately the German soldiers do not come up for their service so excellently trained physically as the Japanese, with whom in all classes of the people great value is attributed to sport and physical exercises. He considers it would be wrong to make the training in night work the subject of an inspection. No decisive battles have been fought by night, but in siege warfare and in the fighting round advanced positions the Japanese gained by night some striking successes.

In a notice of the training of our newly formed Officers' Training Corps, the critic observes that the chief aim seems to be to establish the apparent worth of all our reforms by numbers only; the inner worth of all portions of the newly-formed army is then to follow of itself!

In the issue of this magazine dated 15th January, 1909, the second of a series of articles on "Technical Means of Obtaining Intelligence" appears, dealing with airships. The writer describes the historical progress of military airships, and—after a reference to the efforts of Father Lorenzo de Guzmao in Lisbon in 1709, and the brothers Montgolfier in 1783 in Paris—he observes that in the Wars of the Revolution and of the First Republic there existed a regular balloon detachment. Its originator was the Engineer officer Meusnier, the inventor of the ballonet, an airbag for the preservation of the tight form of the balloon. He also pointed out the right methods for building a dirigible airship, but success was unobtainable through lack of mechanical motor power. Meusnier, together with Coutelle—whom he got promoted to captain—formed the *aérostiers militaires*, which were unquestionably successful before the fortresses of Charleroi, Nancy, and Ehrenbreitstein, and before and during the Battle of Fleurus (26th June, 1794). At Fleurus the divisional commander himself reconnoitred from an elevation of 500 mètres. The reports were fastened to arrows provided with red rags and shot to the ground, and it is said that the excellent use made of the Reserves was entirely due to these reports.

In 1794 the *école aérostique* was founded at Meudon, but it was closed by Napoleon in 1799. Napoleon was never able to appreciate the captive balloon, and the whole apparatus of a balloon detachment of that period was certainly most clumsy.

Before Venice, in 1849, the Austrians strove to throw explosive shells into the town by means of small free hot-air balloons. They also foreshadowed the manner of waging war from dirigibles in the future, by trying—with the assistance of the wind—to span a greater distance than their guns could carry.

In 1852 Henry Giffard attempted to construct a dirigible in Paris, replacing Meusnier's hand-power by the steam engine. An air balloon with an engine below it heated by a fire, is in any case a somewhat unsuitable design, but this attempt also failed through the excessive weight of the engine in comparison with the velocity obtainable. After the statical problem of the dirigible has been solved, this question of proportion of weight, next to that of the reliability of the motor, is of the first importance. While with animal propulsion we get about 10 cwts. for 1 horse-power, there are at the present day airship motors available in which 1 horse-power is got for 3 kilogrammes.

In 1859 we find the captive balloon in use at the Battle of Solferino, and later in the American Civil War. In 1866 the Austrians had provided a balloon detachment in case Vienna was besieged. During the war of 1870–71 balloon units with captive balloons were improvised by both sides. "But neither ours, which were used before Strasburg and Paris, nor the enemy's had any noteworthy results to record as regards observation." On the other hand, 65 free balloons left Paris during the siege and rendered excellent service. They were all spherical balloons of about 2,000 cubic mètres capacity, filled with ordinary gas; 164 persons, 400 carrier pigeons, and 215 cwts. of letters in this manner left the fortress, although it was closed to the outer world. Only five balloons fell into German hands, and two were lost at sea. Gambetta escaped in a balloon from Paris, which was fired at by German cavalry, but not seriously damaged, though Gambetta was slightly wounded. The writer here observes that a balloon hit by artillery fire will in most cases sink somewhat slowly, in case it does not catch fire, and points to the case of the two balloons in the last Gordon Bennet race.

After 1870 captive balloons were put to the practical test of war by French, Italians, and English in their colonies. "England took a step in advance when she gave up the manufacture of hydrogen in the field and introduced compressed hydrogen in steel cylinders." "In the South African War England used mobile, light field balloon units with great success, as at the Tugela, Modder River, Spion Kop, and Paardeburg."

The long duration of battles in the Russo-Japanese War favoured this means of obtaining intelligence. The Russians, the only military Power which still persevered in preparing gas in the field, manufactured their hydrogen, only when required, from aluminium and caustic soda. If only this question of a light, travelling, efficient gas-making arrangement was satisfactorily solved, an important step would be taken towards the application of dirigibles in the field. For the emptied gas cylinders, each weighing 1 cwt., mean bad ballast; one filling of the Zeppelin requires, roughly, 3,000 gas cylinders, each of 1 cwt., but this, of course, is an exceptional case.

Since the withdrawal of the troops from the Far East, Russia has taken up the reorganization of modern field balloon units, based on the experiences of other countries and also of those of the Russo-Japanese War. Russia also possesses eight fortress balloon detachments and a Balloon School.

The writer also refers to the English balloon organization.—*To be concluded.*

An article on "National Defence" in the Belgian Army has been translated in *La Belgique Militaire* of the 3rd January, and is quoted and criticized at some length in the *Neue Militärische Blätter* of the 15th January. The critic observes: "Although the evils of the antiquated system of allowing substitutes have long been evident to both the Parliamentary parties," hitherto neither has been brave enough to undertake its abolition and face the odium to which it would be subjected by the "propertied" classes. The introduction of the volunteer system with premiums in 1902 promised a middle course between the preservation and the abolition of the previous substitute system; but the improvement was really one in name only. The critic concludes by saying that the situation is, at the time of writing, still tense. The Ministry does not wish matters to lead to a dispute not only in the Party, but partly also among its members. It apparently wishes therefore to postpone the whole scheme of reform until the next election in 1910, and the financial situation seems to favour such a course.

Technical Means of Obtaining Information.—The issue of the 23rd January contains the concluding article on the above subject. France has four companies of *aérostiers* with the engineer regiments, as well as a park at Belfort, Verdun, Epinal, and Toul. The centre of French military ballooning lies in the School of Aeronautics at Meudon. Turning to France, the writer observes that the first trials with captive balloons after the war of 1870, undertaken by the Guard Pioneer Battalion, were soon given up; in 1884 Capt. Buchholtz, of the Railway Regiment, appears as the head of an experimental station for captive balloons, which had taken up its home on the old Berlin Eastern Railway Station. Then the balloon detachment with the Railway Regiment at Schöneberg was established in 1886. The year 1901 brings the formation of the Airship Battalion contemporaneously with the move to the Tegel ranges. Two points to be noted in the development of Germany's balloon troops are the introduction in 1892 of the arrangement for filling balloons in the field, and in 1895 of the "Dragon" balloon. Till then, as described, hydrogen was made when required and the filling took three hours. "To-day, 20 to 30 minutes after the balloon detachment turns off from the column of march, the first balloon report from the observing officer can be in the leader's hands!" The hydrogen is carried, compressed at 150 atmospheres pressure, in steel cylinders of 5 cubic mètres contents. The Dragon balloon followed this achievement; it was constructed by Bartsch von Sigsfeld (who came to grief coming to ground in a balloon in Holland) and Parseval. To-day this balloon is in use in 15 States. The captive balloon could hardly be used in a wind of a velocity of 10 mètres per second, as the anchoring cable would be put to too much strain, and the pitching and swinging of the basket would make observation impossible. On the other hand, observation from the Dragon balloon is still possible for an experienced balloon officer, even in a tolerable storm, and the strain on the cable is considerably less. The shape of the Dragon balloon is a half upright cylinder, ending at top and bottom in a hemisphere. At the lower end are, beside the ballonet, the steering bag and the tail. By its position obliquely upwards into the wind the Dragon balloon opposes a minimum resisting surface to the wind in comparison with the spherical balloon. Moreover the wind, impinging on the lower surface of the balloon, tends to lift it "like a dragon," while it depresses the spherical balloon. So that the balloon can assume a more horizontal position in strong winds and a steeper slope in light winds, the anchoring cables pass through one running pulley and can be arranged to suit the degree of wind pressure. The Dragon balloon contains 600 cubic mètres.

The following comparison between the buoyancy of hydrogen and ordinary gas is made:—A cubic mètre of gas possesses a buoyancy of 0·7 kilogrammes; a cubic mètre of hydrogen, on the other hand, has a buoyancy of 1·2 kilogrammes about, or nearly double that of gas. Buoyancy is defined as the difference of weight between the gas weighted by the balloon envelope, basket, detachment, and cable and the air displaced by the balloon. At present, in Germany, one balloon detachment is provided for each army, consisting of 15 6-horsed limbered wagons, 2 wagons with gear, each with 1 balloon, 1 cable wagon, and 12 gas wagons (2 balloon fillings). Two balloons are not sent up, but the second balloon and the second filling only provide a reserve. Two more fillings and a third balloon are carried with the "gas column." As regards the cable wagon, the Germans, contrary to the French, only use the hand winch with regard to its greater suitability for the field and mobility. The drum has 1,000 mètres of wire cable, "which is considerably more handy to use than the hemp rope used in many armies." The cable consists of 10 sections of 100 mètres each, connected with cable fastenings, so that the length of cable can be adapted to the wind, an advantage when changing position with a high balloon. It also lightens the task of changing damaged portions.

The German balloon detachment possesses the mobility of a field battery, an unconditional necessity. Its place is, as a rule, at the rear of the advance guard. The commander and the observing officer belong to the staff of the commander of the army.

For practical reasons the height of the balloon is restricted to the minimum required, the average height being about 500 mètres.

The useful radius of observation varies between 3 and 7 kilomètres, with "Trieder" glasses up to 12 kilomètres.

The writer discusses the advantages and disadvantages of the use of the balloon, and considers that when the other means of reconnaissance have established the enemy's advance on his position, when the deployment on both sides commences, and when the other means of reconnaissance can no longer serve in their effort to clear up the situation, then the moment has arrived for the balloon to be used.

The observing officer should report what the cavalry can find out only slowly or not at all, *e.g.*, direction of the enemy's advance, deployment, his distribution from front to rear, fortifications and obstacles, covered artillery positions (particularly of heavy batteries), reserves, where the flanks rest, the result of our own fire, the progress of our own turning movements, the enemy's bivouac fires, direction of his retreat.

The great importance of a uniform equipment for field and fortress detachments is obvious. The writer claims that Germany has got this, and that other States are striving energetically to obtain it.

E. G. WACE.

RIVISTA DI ARTIGLIERIA E GENIO.

December, 1908.

PHOTO-TOPOGRAPHIC MAP OF A PORTION OF THE COURSE OF THE TIBER.—Major Moris, who was the first head of the photographic section of the

Brigati Specialisti of Engineers, was the first to recognize the importance of photo-topography for military purposes, and instituted an important series of experiments.

The construction of maps of the area within the city of Rome being completed, it was decided to construct a map outside the city which might be of practical use, and a map of a course of the Tiber for 50 kilomètres was selected for the purpose. A preliminary reconnaissance was made in order to study the ordinary roads and the localities which would be useful for intermediary bases. The Tiber not having on its banks a good highway suitable for carriages, it was decided to make use of the river.

In order to obtain all possible advantage from the waterway, it was found convenient to carry all the material on rafts which were towed to Monte Stimigliano, where the material was disembarked and a floating aerostatic station formed. It was then necessary to descend the Tiber for 500 or 600 mètres and to anchor on one or the other banks of the river, or possibly in the middle of the stream if the banks were difficult of access, to inflate and ascend the balloon with its apparatus, and to make the photographs.

At the bottom of the rafts there were stored 100 cylinders, each containing 3 cubic mètres of compressed hydrogen, and on the right and left the material, consisting of planks, spars, etc., etc. On the deck, the materials for a wooden anti-malarial hut were stored. The car for manœuvres and the cases containing the photographic and aerostatic materials were also placed on the rafts, together with the mattrasses, cooking utensils, and other necessaries. The two rafts were coupled together by tresses.

The party consisted of 12 men, specialists and boatmen, commanded by Lieut. Benedetti, and towed by a benzine launch, started for Stimigliano on the morning of the 18th May. After a day of easy navigation they arrived at the station of Monterotondo, where they passed the night. They proceeded on the following morning, and after overcoming with much labour the confluence of the torrent Farfa with the Tiber, they arrived late in the evening at Passo Corese, and on the third day they anchored at Monte Stimigliano, near the small railway station.

Here all the materials were disembarked and a planked floor was constructed 7 mètres in width and 10 mètres in length, on which the anti-malarial hut, intended to serve as a photographic laboratory by day and as a dormitory by night, was erected.

A spherical balloon was used, the envelope being of sufficient strength to sustain the worst causes of instability caused by pressure of the wind.

Photography.—The camera used was provided with a Zeiss lens, which allowed a photograph to be taken instantaneously by the machine whilst in movement. The shutter of the camera was under the control of the operator at the station and was worked by electricity. The apparatus was enclosed in a wooden triangular case suspended from the balloon by three steel wires 10 mètres in length, to allow of the oscillations being sufficiently slow to guarantee the clearness of the image. The connecting wires were of steel with insulated covering.

Gas.—As the hydrogen generator could not easily be transported over the cultivated fields, the gas was conveyed in Fenix cylinders filled at Rome from the electric office of the specialists' brigade.

On the morning of the 20th May the balloon was inflated and everything prepared for the ascent. At the first station the elevation was 600 mètres. A map having been photographed, the balloon was brought down by the aid of four men in 10 minutes. The frame containing the map was taken out and developed in the hut, the negative showing the best results.

After weighing anchor the descending navigation was commenced, and after crossing the Tiber the raft was again anchored at 500 mètres where the second station was established.

After developing the photographs and verifying that there was no discontinuity between the maps last taken and the preceding ones, they passed to the third station, and so on.

The number of calm days was not great, and the time for work was limited, as from 8 to 9 in the morning it was not convenient to commence work because of the strong shadows projected on the ground, and after 1 or 2 o'clock owing to the strong wind that prevailed.

It was found necessary to work with the greatest possible speed, profiting by favourable weather to execute all the photographic work that was possible; and in a second period with the aid of photography to go over the ground, fixing the serviceable points necessary for the triangulation and for the reduction of the maps to a scale agreeing with their adjustment.

It was necessary for special cases of work to acquire a practised eye; to estimate rightly the distance from one station to another and the height of the balloon; to avoid losing the time that would be taken up by direct measurement, and to judge when errors occurred, if the machine was in a horizontal position or inclined, verifying in doubtful cases by the development of the maps before proceeding further.

During the work several difficulties had to be surmounted, such as the recovery of the machine in high winds, the transport of the gas cylinders, the necessity of developing with the aid of ice owing to the excessive heat, and many others; difficulties which were overcome from time to time by the experience acquired by the *personnel*.

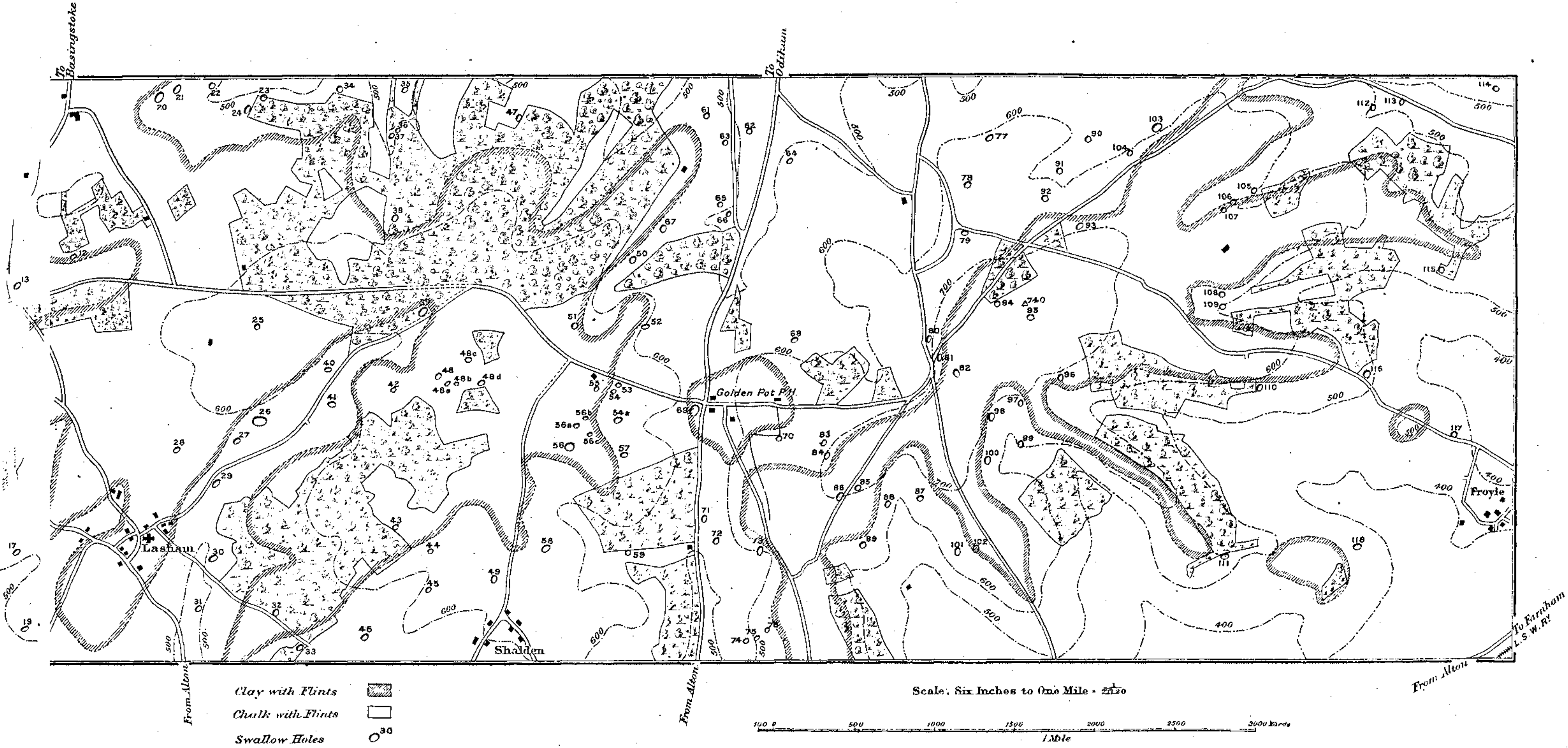
The number of stations averaged from 6 to 10 in a day; in days of exceptional calm they succeeded in doing as many as 12. The total number of stations was 90. After five or six stations, the balloon had to be reinforced by a couple of cylinders of gas, and on the following morning, before commencing work, with five or six cylinders. Further, after four or five days' work the gas in the balloon was used up and had to be re-inflated, so that the total quantity of gas consumed was 470 cubic mètres.

The work, owing to several days of strong wind and other days of rain, lasted for about a month, and on the 16th June, after the last station had been made above the Grillo Bridge, they returned to Rome. After making the necessary corrections in the laboratory to bring the maps to a scale of $\frac{1}{3500}$, they were printed and mounted in a panorama which met with the full approval of the military and civil authorities.

EDWARD T. THACKERAY.

NORTH EAST HAMPSHIRE NEAR ALTON.

MAP SHOWING SWALLOW HOLES.



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