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CONTENTS.

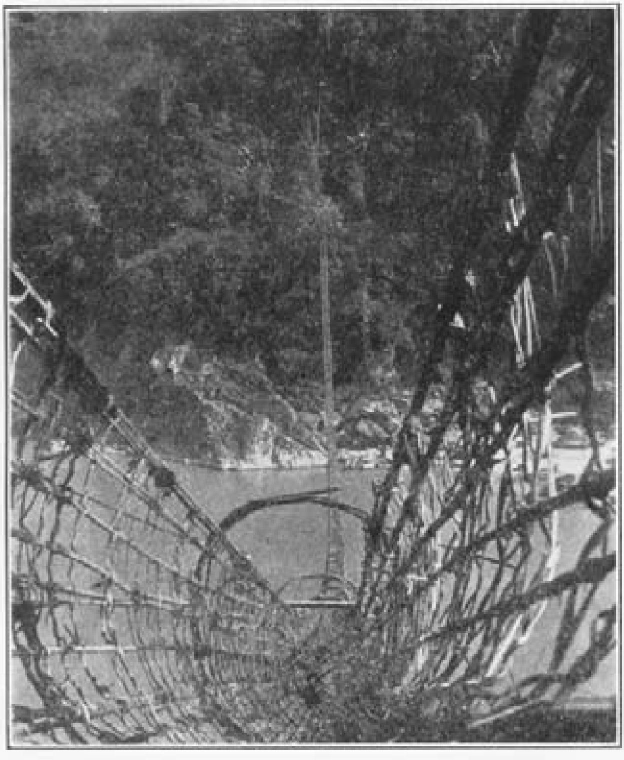
Authors alone are responsible for the statements made and the opinions expressed in their papers.

ABOR SUSPENSION BRIDGES.

By Lieut. A. F. Chater, R.E.

In a recent number of the *R.E. Journal* an article appeared dealing with bridges of various designs constructed by the natives of the Kachin country. The author stated that cane suspension bridges up to 80-ft. span were met with. The accompanying photos will be of interest to readers as showing up to what spans these bridges can be constructed.

No. 1 gives the end elevation of the largest of the bridges spanning the Dihang River. The span is about 700 ft. Dip 50 ft., height above river 50 ft.

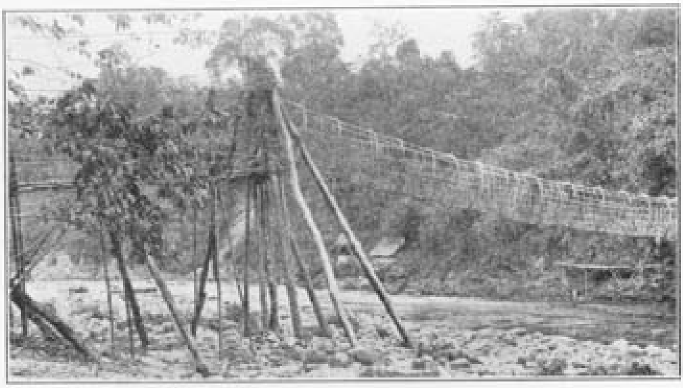


1. End Elevation of Bridge over River Dihang.

Abor Suspension Bridge

Nos. 2 and 3 show a smaller bridge of the same type and give a good idea of the design.

I will only add that rope, wire, nails, or iron of any description find no part in the construction, the only materials used being bamboo, cane, and timber found in the jungle on the site.



2. ABOR BRIDGE OVER A TRIBUTARY OF THE DIHANG.

3. ABOR BRIDGE OVER A TRIBUTARY OF THE DIHANG.

Abor Suspension Bridge

CONCENTRATION OF TROOPS BY RAIL.

By MAJOR H. F. E. FREELAND, M.V.O., R.E.

THIS paper is an attempt to put together very briefly the more important considerations which govern the preparation of a scheme for the concentration of a Force of all Arms by rail, and to indicate generally how such a scheme can be presented in an intelligible manner to those who will be required to put it into operation.

The subject is approached from the Indian standpoint, and it is not proposed to investigate the functions of a railway in the enemy's country, or the organization and working of the temporary lines which it may be found desirable to construct after the concentration of the Field Army on the Base of Operations has been concluded.

It should be remembered that the railways of India, except in the case of the main lines in the vicinity of and leading to the great sea-ports and capitals of provinces, are for the most part single lines of the 5-ft. 6-in. or metre gauges, and that distances in India as compared with those in the British Isles are very great. A further difference of conditions exists in that every force that is to take the field in India must be accompanied by its animal transport, mules, camels or bullocks as the case may be, and to concentrate this species of transport on the Base with all its equipment and forage greatly adds to the number of trains which must be run during the period of concentration.

In order that all the difficulties may be searched out in peace time, very close and harmonious co-operation between Army Headquarters and the various Railway administrations is essential. It has accordingly been the practice of recent years for an R.E. Officer with Railway Traffic experience to be attached to Army Headquarters for the purpose of working out the railway details of all such schemes in consultation with an officer of the Quartermaster-General's Branch. This arrangement has proved eminently satisfactory, and it would appear desirable that such an appointment should be made permanent, in order that existing schemes may be constantly under review and may be brought up to date as new railways are built and conditions alter in other directions; moreover it is very important that the officer who has been responsible for a scheme in peace time should also take a leading part when it is put to the test of war.

Assuming then that a connecting link between the army and the railways has been arranged for in the shape of this Special Officer, the next question is how is he to set to work. It will be admitted that all schemes for concentration must primarily be based on the requirements of strategy, which will definitely determine the number of days, after the outbreak of war, available for placing a force of a given strength in a certain strategic position on the map, so that it may co-operate with other forces in taking up a defensive line or acting on the offensive against the enemy. Working back, the Line of Communications by road must then be tested, and an estimate made of the number of days which will elapse between the time the first troops leave the Railway Base and the last troops and transport arrive at the strategic point.

Having obtained a very clear idea of strategic requirements and of the capacity of the Line of Communication roads, the Special Officer may then commence to estimate the capacity of the Railway on which the Base Station is situated. It is obviously unsound to carry troops and transport to that station more rapidly than they can be cleared from the platforms and station premises, and it is also questionable whether it is advisable to take full advantage of the capacity of the Terminal Railway when by so doing the Line of Communication roads will become heavily congested. The curtailment of civil traffic to an infinitesimal quantity, as is certain to be demanded on the occasion of a great military concentration, will cause economic and political unrest, if not serious hardship among the population of the country in the vicinity of the Base, and it is wise to mitigate such conditions, as far as it is possible to do so. Bearing this important consideration in mind, and before the Military Authorities can be expected to state their requirements as to the number of trains per diem into the Railway Base it is necessary to know how many vehicles per train railways will consent to haul and precisely how many men, animals, guns, etc., can be loaded in the different classes of rolling stock.

Prior to 1910 all concentration schemes in India were based on a maximum load of 30 broad gauge vehicles per train; how this figure was arrived at is not on record, but it was a most inconvenient limit in that it necessitated the breaking up of units far more than was reasonable or desirable. For example on the 30-load basis a British Infantry Battalion occupied $1\frac{1}{3}$ trains and other units were similarly affected. Recently however, the majority of broad gauge railways have agreed to increase the load from 30 to 45 four-wheeled vehicles and all schemes are now drawn up on this basis; the change meant, of course, some reduction in speed, but the balance of advantage is on the side of the greater load, which somewhat decreases the number of trains and consequently the number of engines required to haul them.

This decision was not arrived at without a great deal of argument for and against, but, in view of the fact that the great broad gauge lines of India are now equipped with a very large proportion of powerful locomotives capable of hauling 800 to 1,000 tons, that the increased load makes it possible to send whole units to the front in one train and that the period of railway concentration is appreciably shortened, there is little doubt that the change was justified.

In order to ascertain precisely how many men, horses, mules, camels, bullocks, carts, guns, limber and wagons, could respectively be accommodated in each vehicle of the different classes of rolling stock, extensive entraining experiments were carried out on the North-Western Railway in the Spring of 1910.

Railways are constantly increasing the number of goods and coaching vehicles in their possession to meet rising traffic, and the design changes greatly as time goes on and conditions alter; it will not be safe to assume that, because a certain number of axles, for example, could be loaded in an open truck five years ago, therefore those figures can be accepted to-day. Loading and unloading experiments must therefore be carried out from time to time, and apart from their actual usefulness in determining the capacity of railway vehicles, and in practising units in the art of getting in and out of trains smartly, they enable the military and railway staff to estimate the time required and discover any defects that may exist in the design or equipment of the vehicles themselves. As an example may be quoted the case of horse wagons; these are equipped with movable breast-bars, which, when the vehicles are in use for carrying goods, are carried on brackets over the wagon doors. They are attached to the walls of the wagon by chains, but experience proved that the attachment was too weak, for when the cavalry soldier, in the act of loading his horses, had repeatedly barked his shins over the suspended bar, he adopted the simple expedient of wrenching it from its fastening and depositing it out of harm's way on the platform before commencing loading operations; the next time the vehicle was required for loading animals, the bar was generally missing.

The loads of trains and the capacity of rolling stock have accordingly been brought up to date, and are detailed in Load Tables and Field Service Regulations, and the Q.M.G.'s Branch is therefore in a position to estimate the precise number of trains required to place any given force with its transport on the Base of Operations.

Thus, after full consideration of the foregoing conditions, Army Headquarters can decide what is the minimum number of trains into the Base Station which will fulfil requirements, and the Terminal Railway will be asked whether they can do it. The Terminal Railway, it should be explained, is that on which the Base is situated; all other lines will act as feeders to it and will not be congested at any point in such a degree as the main artery near the Base.

It will now be the business of the Special Railway Officer, above referred to, to explain matters to the Terminal Railway Officials, and by personal investigation to ascertain whether their equipment and other facilities are sufficient.

The first matter for consideration is the working capacity of the line near the Base in trains per day. The line may be single or double, according to the density of the normal civil traffic; it may be taken however, that a single line will in most cases meet requirements, and will be used here for the purposes of illustration.

What, then, is the capacity per 24-hour day of a single line in trains running at an average speed of 18 miles an hour, this being the speed at which a load of 45 four-wheeled loaded vehicles can be hauled under normal conditions of grade and weather, assisting engines being supplied where gradients necessitate them.

The number of trains per day depends on the time taken to run over the longest distance between stations, and from this an approximate estimate of the total can be arrived at. Assuming that all trains will be run at a level speed, and that the longest distance between stations is $10\frac{1}{2}$ miles, the maximum *theoretical* number of trains that could be run would be one each way in $2\ (10\frac{1}{2}\times\frac{60}{18})=70$ minutes or in other words 20 trains each way in 24 hours.

In practice, however, one train a day, the mail, will be run at a much faster speed; time allowances also must be given for empty trains returning *from* the Base to cross the loaded trains *to* the Base, and also to give a margin to cover the far-reaching effects of any train running behind its scheduled time. For these reasons it is customary and necessary to deduct 25 per cent. from the total theoretical maximum and the figure 20 thus becomes 15, a maximum which in the case under investigation should never be exceeded.

Of these 15 trains one will be the mail for postal, urgent military and railway services, and for civil traffic generally; one will be a mixed train for civil traffic, railway coal and stores, small military details and detachments and the like; and if supplies have been previously accumulated at the Base, probably two trains will be required daily for military supplies throughout the period of concentration. This leaves 11 trains per diem for troops and transport, and the question now is, will this number satisfy the requirements of the military situation. If the answer is "No," the Terminal Railway is called upon to increase the capacity of the single line by interpolating crossing stations on the long runs or to double the line till the desired limit is arrived at.

Who should pay is always a problem of some difficulty, but it has been satisfactorily solved in the past and will always be so, as long as it is recognized that a perfectly sound scheme of concentration is in the nature of an insurance on the part of Government against the effects of a disastrous war.

As soon as the Terminal Railway and Army Headquarters are in agreement in the matter of the capacity of the line near the Base, the Special Traffic Officer in consultation with the Quartermaster-General's representative will work out a rough scheme and having done so it will be his particular duty to explain it to the Locomotive and Traffic officials of the Terminal Railway, with a view to ascertaining whether sufficient engines and rolling stock exist to carry it to a successful conclusion. No estimate of engines and rolling stock can be made with anything approaching accuracy till the Scheme has been roughed out in such a way that the Terminal Railway can be advised of the maximum number of trains which will be required to run over each of its engine runs daily, and of the composition of those trains.

In any concentration on a large scale it is certain that civil traffic in both passengers and goods on the main lines of advance near the Base must be greatly curtailed partly to make room for troop trains and partly to release engines and rolling stock for the more important work in hand. As years go on and the railway communications of India extend, there is less and less reason to fear any difficulty in accumulating sufficient vehicles to compose the trains and engines to haul them. There is a considerable margin now above actual requirements and with the exception of the Terminal Railway near the Base, it is not likely that civil traffic on Indian Railways will be reduced during the period of concentration.

There is no royal road to the solution of the rolling stock conundrum, it must be worked out according to the requirements of each scheme, but as regards engine power, a rough-and-ready rule may be applied. If one engine is allotted per 70 train miles or per 80 train miles per day, according as the concentration is a long one of several weeks or a short one of a few days, plus an allowance of 15 per cent. for locomotive purposes, the total will be sufficiently accurate for practical purposes; shunting, banking and assisting engines should, of course, be separately estimated for according to the requirements of each scheme.

Rolling Stock can be borrowed by the Terminal Railway from Foreign lines, but it is not desirable to replace deficiencies in engines in this manner, if it can be avoided. Borrowed engines must be sent up, manned by their own crews, who will take some time to learn the rules of a strange road, and they will not work as keenly as if on their home line.

Practically the only other question, which will require careful examination before getting out the detailed scheme, is that of water supply both for engines and for the staff. Engines cannot work at high pressure without good water any more than a man can work without food, and this difficult and technical question must be solved by each Locomotive Superintendent as soon as he is made aware of the rough requirements of each scheme. There are for example, localities through which railways run where good water in large quantities is not obtainable, and this fact will necessitate the main line of advance being carried round by a circuitous route rather than hazard a breakdown owing to a failure of the water supply on the more direct line.

As soon, then, as the Special Traffic Officer has satisfied himself that there will be no difficulty in the matter of engines, rolling stock and water, and leaving for subsequent investigation the actual entrainment and detrainment facilities, the existing inadequacy of which will not be permitted to limit the speed of concentration, he can proceed to draw out the detailed scheme, including as it does the time tables, graphic diagrams, and military documents necessary to explain it to those who will have to put it into operation on the outbreak of war.

First it is essential to have a very clear understanding of the requirements which the timing of each military train must fulfil. It will be necessary to arrange for a long halt of about three hours in every 24 for men and animals to have rest, food and water during a long journey, and certain convenient points will be selected at which supplies can be collected and water and conservancy facilities provided. Short halts of about 30 minutes each are also required every morning and evening for a light meal for the men and for watering animals; if possible these short halts should be arranged for at stations where railway requirements necessitate shunting, changing and watering engines, etc. Then there are certain minimum time allowances which must be given for railway business, *e.g.* 20 minutes for changing engines, 8 minutes for watering one and 15 minutes for two engines, 5 minutes for crossing two trains and 2 minutes halt for trains at all roadside stations; this time for all trains to halt at all stations should be given in the time table, although it is not necessary for a train to be brought to a stand, if the line is clear for it to go through.

Secondly, it should be decided that in the time table, which will be brought into force on the outbreak of war for concentrating an army on the Base, all trains will be run at the same speed with the exception of one mail train daily. The more nearly trains can be run at the same speed, the greater the number that can be put on the time tables and the less confusion there will be owing to slow trains lying side tracked to give way to those timed at a faster speed. In selecting the routes of the main line of advance it is of paramont importance, that, when there is more than one Base, an independent well-defined route should be allotted to each. It will be apparent with a little consideration that if the same line of advance is used for more than one Base a delay in concentration on one Base will affect that on the other, and it is therefore most desirable that the train movements should be separated as far from the Bases as the network of Railways will allow.

But the most important matter in connection with all concentration schemes is the system under which trains are to be grouped. In the past it has been customary to provide for a continuous succession of trains to the Base, running one after the other as close as the capacity of the line will allow, but it has been considered that this arrangement is likely to be unsatisfactory in practice in that an accident will throw back through the whole scheme and lead to great confusion. Accordingly the "Block" System, whereby the Force to be concentrated is divided into groups of convenient size, has been evolved with the object of restricting a breakdown to the group during which it occurs, subsequent groups or "Blocks" being retarded till communication has been restored.

A "Block" is a group of units composing a force, and will be so comprised that it can concentrate on the Base within a given period; a complete infantry division, for example forms a convenient Block.

"Blocks" are arranged in a normal order, which will not be departed from except in emergency; this is a necessary proviso because Railways want to make plans for the return of the empty rolling stock of one "Block" to stations from which the next is to be moved and any ill-considered change in the "Normal" order must increase the already difficult problem to be solved by Railways. If however, a change in the military situation demands it, the preconcerted order of "Blocks" can be altered with far less confusion and disorganization than if the scheme were one of continuous movement.

In arranging the normal order of "Blocks" technical troops will usually be pushed through first, followed by some of the transport and it has been found desirable to commence the first "Block" slowly with a few trains on the first day and gradually working up to full pressure on the 3rd or 4th day, so as to accustom the Railway Staff to the movement.

The accompanying Train Graphic (*Plate* I.) which will be explained later, gives an illustration of the allotment of trains to a Transport Block moving on an imaginary base.

The Special Traffic Officer, remembering all these details, will now proceed to construct the working Time Tables for the use of the railway men who will control the movement. He will in all cases work back from the Base, and as he goes further back to the junctions of the Terminal Railway with foreign lines, it will be necessary for him to get into very close touch with the Traffic officials of those lines in order that the Time Tables may be thoroughly practical. The *Working Time Tables* will be prepared in the form familiar to all railways, and need not be enlarged upon here; the rest of the documents comprising the scheme, however, need some explanation, for it is essential that they shall be drawn out and printed in such a form as will be intelligible to all those who may be called upon to put the scheme into practice.

From the Working Time Table will be prepared an *Abstract* (see next page) giving only such information as is necessary for Staff Officers and Officers Commanding units; it is usual to issue with it a skeleton map of the line or lines of advance, a distinctive colour being used for each, if the Concentration is on more than one Base.

From the Working Time Table will also be drawn out the Train *Graphic* for the use of Military and Railway Staff Officers, and as already stated, a specimen is attached in which a fictitious Base has been assumed for purposes of illustration (*Plate* I.).

ABSTRACT TIME TABLE.

Station.		Mail. 1	Mixed. 3	A.	B Supply.	C Supply.	D.	E.	F.	G.	H.	J.	K.	L.	M.	AA.
Lahore	*d*															
Amritsar	*a* / *d*															
Ludhiana	*a* / *d*															
Umballa	*a* / *d*															
Etc.																

The marginal notes on the specimen Graphic will explain the conventional signs used thereon, it is only necessary to add a few words on the method of distinguishing between trains. In India the usual procedure is for Railways to allot odd numbers for "up" and even numbers for "down" trains, but for various reasons it has been decided to distinguish between military trains by letters instead of numbers. Accordingly the letters A to M are set apart for trains to the Base and N to Z from the Base; if there happen to be more trains *to* the Base than letters A to M, the extra trains will be lettered AA, BB, CC, etc.; a similar rule is applied to lettering trains *from* the Base.

In addition to the lettering for time-table purposes military numbers are assigned to trains on the Graphic; these military train numbers run consecutively through the Block in the order in which trains are timed to arrive at the Base, and are necessary for the purpose of tracing each train through the various Military Tables and documents (to be detailed hereafter).

As soon as the groups of units composing an army have been allotted to Blocks, the Special Traffic Officer must consider the question of their most convenient order of arrival at railhead. As a general rule it is the distance which trains have to travel which will determine their arrival, for those which start from the most remote localities will necessarily arrive last, unless they are started some time before the conclusion of the previous Block, a procedure not to be recommended for the excellent reason that it swallows up the safety interval, which, as has been explained, is the main principle of the Block System.

The facilities existing at entraining stations form another factor in the calculation; it will rarely be desirable to equip a troop entraining station with platforms in excess of what may be necessary for ordinary civil traffic, and for the movement of troops in peace, and certainly it will never be sound to provide additional platforms for the sole purpose of conveniently forming a Block.

Detraining facilities at the Base Station will also have their influence on the order in which trains are timed to arrive, but the design of the terminal yard is generally worked out so as to give a considerable margin above estimated requirements in order to meet unforeseen delays in movement which are more the rule than the exception in actual practice.

The above are the chief considerations which have to be borne in mind in placing the trains of units in a Block; there are however many other details which the Special Railway Officer will have to remember, and perhaps the most important of these are that good long intervals should be given between the arrival times of trains carrying animal transport or A.T. Carts, and that supply trains are best timed to arrive at railhead during the night so that wagons can be placed in position for unloading at an early hour next morning.

PLAN OF MOVEMENT. SCHEDULE. BLOCK________

Train No.	Unit.	Train of Unit.	Timing.	Entrains at			Halts at Engine Changing and Rest Camp Stations.															Detrains at		Timing.	Return of Stock.		Utilized for Train.	See Stock Table Page.
				Station.	Day.	H. M.	Day.	Arrival.	Departure.	Day.	Arrival.	Departure.	Day.	Arrival.	Departure.	Day.	Arrival.	Departure.	Day.	Arrival.	Departure.	Day.	H. M.		Departure. H. M.	Destination.		
							Note.—These columns are for Rest Camp Officers, Loco. Foremen, etc., and in lieu of the Graphic.																					

Assuming that the Working Time Tables and Graphics have been got out, and approved by the various Army and Railway Departments, the next step is for the Special Officers to compile *Concentration Tables* for each Block giving the composition of each train, the unit which will occupy it, and when and where the entrainment will take place.

These Tables together with an *Abstract of Rolling Stock required daily* at each entraining station, are required by the Traffic Managers of each railway involved in the movement in order that they may elaborate their schemes for collecting stock at the proper place and time.

The only other documents relating to the Concentration Scheme are tabulated for the information of the units of the Force and are called *Plans of Movement* (see page 228); they give complete details of the movement of each unit from the starting station to destination.

All these Time Tables, graphics and rolling stock tables are so compiled as to be explanatory the one of the other, and as the same symbols to designate a particular train are used in each document the details can at once be checked from one to another.

Thus the scheme for concentration is prepared in an easily intelligible form for the use of those who will be responsible for its operation on the outbreak of war; no scheme, however, can be expected to succeed unless a special War Staff is organised for the Terminal Railway and each individual member of it well instructed in peace time in his duties during the concentration.

The best way of organizing such a War Staff seems to be that at the Headquarters of the Railway should be located a Concentration Railway Officer, who may well be the officer who has drawn out, or is responsible for the revision of the scheme, and who should be under the direct orders of the Manager or Agent of the line. He should deal personally with all Concentration matters in peace time, and on war being declared should direct the whole movement in consultation with an officer from Army Headquarters, holding the appointment of an A.Q.M.G. With these two should be associated a Senior Supply Officer for the purpose of detailing the allotment of wagons day by day to the stations where supplies are ready to be moved up to the Base. At the Headquarters of the District, on which the Base Station is situated, the District Superintendent of the line will be located, and associated with him should be a *Senior* Railway Concentration Officer detailed by Army Headquarters; under the orders of the District Superintendent, Assistant Superintendents should be told off to the Base and to important halting and entraining stations, and with them again R.C.O.'s detailed by Army Headquarters. This means that there should be a responsible Railway Official at each important point, and at his elbow a selected Military Officer with whom to consult. It has not been found desirable in practice to allow the Officers Commanding units to have direct access to the Subordinate Railway Staff; the subordinate will usually be more influenced by the forcible way demands are made than by a consideration of the resultant effect of carrying them out, and what may be exceedingly convenient and desirable in respect of one solitary train may have a disastrous effect on the whole movement.

It cannot be too strongly insisted that a well-trained and tactful R.C.O. is an imperative necessity at each important entraining and detraining station during a great Military Concentration, but one without training or constitutionally unable to appreciate the Railway point of view is far worse than useless. The Railway Manual (War) summarizes the duties of the R.C.O.'s as follows :—

"(i.). To be the intermediaries between the Army and the technical administration of the Railway.

(ii.). To see that the ordinary working of a railway is carried on in such a manner as to ensure the greatest Military efficiency.

(iii.). To see, on the other hand, that the demands of the Army on the railway, which must always be addressed through the Railway Control Establishment, are, subject to military exigencies, so regulated as not to disorganize the working of the railway system as a whole.

This summary gives a very clear idea of the responsible position of an R.C.O., and it is evident that the third duty is not one which can be intelligently carried out by an officer whose only experience of railway operation is gleaned by travelling as an ordinary passenger from one place to another. It has been the practice of recent years to send some of the students at the Quetta Staff College to a Railway Headquarters for the purpose of giving them some insight into the difficulties of traffic operation, and it would be well if this procedure could be extended to selected Regimental Officers also.

As soon as the Terminal Railway, which is most affected, is put in possession of the details of the scheme, there are many questions which must receive fuller and more careful attention, and it will fall to the lot of the Special Traffic Officer at Railway Headquarters to examine them.

He must decide first of all how the necessary *engines and rolling stock* are to be collected at the right places, or in other words he must get out a definite subsidiary scheme for changing from peace to war conditions and for closing down civil time tables and introducing the Concentration Service on the main lines of advance.

In order that the change may be effected without confusion, as long notice of concentration as possible is desirable; the necessity of this notice will necessarily vary directly as the magnitude of the movement. Not only have engines and rolling stock to be moved up from distant points or possibly borrowed from foreign railways, but station and running staff have also to be collected from areas unaffected in order to strengthen points nearer the Base on the main lines of advance.

All this preparation on the part of the Terminal Railway will take time to carry through, but before war actually breaks out there will, it is thought, be a period of what may be called, "tension" during which the railway will make all preliminary arrangements, so that when the actual warning to concentrate is given, very little will remain to be done. The Special Traffic Officer will in peace time compile detailed instructions for the principal District Superintendents concerned, and everything will be ready for the issue of the Time Tables, Graphics, Concentration Tables, and Plans of Movement.

The accommodation provided for *detrainment* of troops, transport and stores and for the many railway requirements at the Base Station must be investigated and brought thoroughly into line with the scheme. A sketch plan (*Plate* II.) shows what may be considered a convenient arrangement for a Base yard at the railhead of a single line, and would be deemed to provide adequate facilities for the fictitious scheme which has been worked out earlier in this article. It will be particularly observed that the sketch plan allows for an entirely separate yard for military stores, and that in all cases large clear areas are provided in the vicinity of detraining platforms for forming up and for collecting transport without blocking the roads.

The facilities required at *entraining* stations must also be examined, and all preparations made to meet the most difficult case that may occur: there are certain obvious requirements which need not be enlarged upon here and it is only necessary to call attention to one, namely that it is always better to provide such facilities as will enable a whole unit to entrain at one station and will obviate the shunting on of extra vehicles at roadside stations to the train after it has left the starting station. It should be easy to arrange for this even with a long train of 45 four-wheeled vehicles except in the case of supplies, which will take a longer time and greater space in loading; shunting on of supply wagons on the road will be inevitable, but loss of time can be greatly minimized by the intelligent grouping of stations where supplies are to be loaded so that a full train load can be made up from two or three stations daily early in the train's journey.

An endeavour has been made to show how the problem of concentrating troops by rail on a Base of operations is now tackled in India, and it will be as well to briefly recapitulate.

Having first ascertained strategic requirements and the capacity of the Line of Communication by road beyond the Base, test the main line of advance by rail near the Base, and determine the daily maximum number of trains which can be run in practical working on that line.

If Army Headquarters are satisfied with this number, find out from the Terminal Railway whether their engines and rolling stock are adequate to carry out the movement for protracted periods and if not whether they can be supplemented by borrowing from other lines.

If the Military situation demands a greater number of trains per day than the existing line can hold, the capacity of the line must be increased by interpolating crossing stations on the longest station-to-station runs, or even by doubling the track.

Having, then, brought Military requirements and Railway facilities into agreement, allot the units of the Force to be concentrated into Blocks of convenient size, work out the detailed Time Tables, Concentration Tables, and Plans of Movement, and issue them to those who must in peace time take such steps as are necessary for the successful carrying out of the scheme on the outbreak of war.

All this would appear to be plain sailing, but in actual fact an enormous amount of weighty argument must be indulged in between Army Headquarters and the various railway administrations before a suitable compromise can be arrived at. If the parties concerned merely sat down and wrote letters about a scheme of concentration the process of evolution would be interminable, but, as has been said, the co-ordination between them has been insured by the appointment of a soldier, with practical railway experience, who devotes his whole time to attaining the object in view, and who by reason of his dual experience is enabled to intelligently explain the views of one party to the other.

Some practical experience of the efficiency of these methods of working out a Concentration Scheme was obtained on the occasion of the assembly and dispersal of troops for the Delhi Durbar in 1911. The conditions, it is true, were somewhat different from the real thing, as the force concentrating on Delhi was not accompanied by the due proportion of transport, and it was therefore not necessary to adopt the Block System of working. The various Military and Railway documents and tables were prepared precisely as they would be in case of war, but, as the civil traffic was not suspended—quite the reverse in fact—and rolling stock had to be economized, the concentration of the force of 45 battalions of infantry, 13 regiments of cavalry and 114 guns occupied as long as seven days in all.

Considering that the railways in the vicinity of Delhi were abnormally congested at the time of the concentration and dispersal of this force, and that of 81 troop trains in and 91 out, only four arrived and two left over an hour late, the scheme may be looked upon as having worked out successfully. As remarked upon by Capt. C. S. M. C. Watson, R.E., Special Traffic Officer in charge, all such schemes, made out long in advance will inevitably undergo small alterations up to the last moment. In this lies one of the chief advantages of the "Block" system, in that changes in one Block can be made without in any way affecting the others.

The Graphic is an illustration of a fictitious scheme, and has been adapted from a similar one used by Capt. Watson in a lecture given in Simla in 1911 on this subject.

ELECTRIC LIGHTING FOR MOTOR CARS.

By LIEUT. G. L. HALL, R.E.

THE many obvious advantages of electric over other forms of light for motor vehicles, have been realized since their earliest days, but a large impetus has recently been given to this method of lighting by the perfecting of the metal filament lamp, which, consuming as it does less than one-third of the power required by the older carbon filament type for a given candle-power, is peculiarly valuable where economy of space and a minimum of weight are of primary importance.

Current for the lamps may be supplied either by a battery alone or by the combination of a battery and dynamo. In both cases the secondary type of battery is the only one which is suitable. The employment of a battery alone has been the general practice until recently. In such cases it has been usual to employ electric lamps only for the side and tail lights, whose aggregate candle-power is small. If, however, it is desired to supersede the ordinary acetylene head lights, the use of a battery alone becomes unsatisfactory. About 10 candle-power is all that is required for side and tail lamps together, but to provide an efficient driving light and to replace the ordinarily very powerful acetylene lamps necessitates very much more. In fact, a pair of 40 candle-power bulbs in suitable reflectors may be taken as a reasonable equipment for cars of moderate power. A battery which could perform this total duty without very frequent re-charging would be extremely bulky and expensive. If, however, a dynamo can be installed on the car, which will perpetually keep the battery fully charged, a much smaller one will suffice, and the plant will be self-contained; a very great advantage, especially in districts where the charging of batteries is uncertain and expensive.

Many dynamos for this purpose are now on the market, which are designed to be fitted to the car and to be driven by the engine. It is the object of this article to explain the electrical difficulties which exist in the practical realization of such an arrangement, and to outline the manner in which these difficulties are in certain cases overcome.

The first point which naturally suggests itself is this. Electric lamps are designed to work at a certain definite pressure (expressed in volts), and any considerable variation in this pressure will result in inadequate light if the pressure is too low, and in the destruction of the lamp filament if it is too high. On the other hand, the pressure at which the ordinary dynamo works varies under ordinary conditions directly as the speed at which it runs. The problem then is to arrange for a dynamo, which is driven by an engine whose speed varies over a wide range, to give a pressure which shall only vary within the small limits permissible at the lamp terminals. The case is, in fact, very similar to that of ordinary railway vehicle lighting, and as will be seen later is solved by some makers in very much the same way. Certain difficulties however arise in the case of road vehicles which are not experienced in train lighting, partly because of the lack of that skilled attention which the latter receives, and partly owing to the rougher usage to which all parts of a road vehicle are subjected. On the other hand, the added complication due to the frequent reversal of the direction of running in the case of railway vehicles is absent in connection with a motor car, whose engine, at least, runs always in the same direction.

Batteries will be necessary in conjunction with the dynamo, if only to ensure continuity of light when the car is at rest, or is travelling at low speeds; under which circumstances the dynamo will not be running fast enough to generate sufficient pressure to feed the lamps. In practice, the ideal which is sought is to maintain the dynamo pressure approximately constant at car speeds of from 10 to 15 miles per hour upwards.

A diagram of the general arrangement is given in *Fig.* 1 which shows the generator connected to both battery and lamps. When the pressure of the dynamo exceeds that of the battery a charging

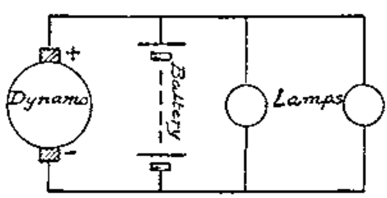


FIG. 1.—*General arrangement of Car-Lighting Equipment.*

current will flow from the machine to the battery and lamps. Whenever the speed of the generator drops so much that its pressure is below that of the battery, the latter will take up the load. Under these circumstances a current will naturally tend to flow from the battery through the dynamo and to run the latter as a motor. This may be obviated (as in the case of central station batteries) by an automatic cut-out device, which allows a current to pass through it in one direction only, *i.e.* from the dynamo to the battery, and breaks the circuit between them in the event of any tendency towards a reversal of current caused by the battery pressure exceeding that of the dynamo. Such systems as do not employ this reverse current cut-out in one form or another, either employ a centrifugal speed-operated switch or arrange that the power taken from the battery to motor the dynamo shall be negligible.

There are in practice three distinct ways in which a constant pressure at the dynamo terminals can be secured, and examples of them all can be found on the market. These systems are—(1) Variable speed dynamos whose pressure and output are kept constant by purely electrical devices; (2) dynamos driven by a variable speed engine through a form of centrifugal clutch, which never allows the speed of the machine to rise above a definite value; and (3) variable speed dynamos whose pressure is kept constant by a combination of electrical and mechanical devices. Some examples of these will be taken and their principle explained as far as can be done without going too far into technical details.

1. Electrically Regulated Dynamos.

Electric regulation can be accomplished in many different ways, and a large number of distinct types are at present on the market. Of these, the simplest, though not necessarily the most efficient, are machines of the constant field type; that is machines in which the primary strength of the magnetic field is independent of the pressure at the dynamo brushes. This may be accomplished either by separately exciting the field coils by means of a battery used solely for this purpose—a fairly obvious drawback—or by using permanent magnets to supply the magnetic field in which the armature rotates. Examples of this latter class are found in the *Lodge* and the C. Jarrott and Letts *C. J. L. Magnetolite* machines. In these systems steel permanent magnets are used of very much the same type as those employed for ordinary ignition magnetos. The principle on which they maintain a fairly constant pressure and output is shortly as follows:—

As soon as the speed of the dynamo reaches a certain value a charging current will flow through the battery, rising rapidly in value until a point is reached when the demagnetizing effect of this current flowing through the armature so weakens the main magnetic field that the pressure and charging current remain approximately constant however much the speed of the machine increases. This effect, technically known as armature reaction, is the underlying principle of all electrically regulated variable speed machines. It is caused by the magnetic field set up by the passage of the current through the windings on the dynamo armature, part of which magnetic field directly opposes the main field (produced in this case by the permanent magnets) and therefore weakens it. The natural result of this reactive tendency of the armature current is that the dynamo now generates a lower pressure than it would have done had the main field remained at its original strength. There is, in fact, a state of war between (1) the natural tendency of the dynamo to generate a higher pressure as its speed increases; and (2) the increased armature reaction due to the heavier current which this higher pressure naturally implies. The practical result is, in short, that there is a limit to the amount of current which the machine will send through a given external resistance.

A practical difficulty in connection with all permanent magnet machines is the possibility of the weakening or destruction of their magnetism. Apart from the effect of the vibration of the car, the de-magnetizing effect of the armature current would appear to be necessarily to some extent permanent and cumulative, so weakening the magnets as to render them, in time, useless. The use of wound electro-magnets is not, of course, open to this criticism.

Both the *Lodge* and *C.J.L.* systems employ reverse-current cut-outs, which keep the circuit open until the dynamo pressure exceeds that of the battery. The former is designed to run at 6 volts and the latter at either 8 or 12.

The *Bleriot* dynamo is of the electro-magnet type, and the field is compound wound, the windings being arranged differentially. That is to say, the magnetic field in which the armature revolves is produced by two distinct windings, one of which is in series with the load, the other being connected across the dynamo terminals and so arranged that the magnetic field produced by it shall oppose that produced by the series winding. A diagram of the arrangement is given in *Fig.* 2. The shunt winding may be regarded as the normal

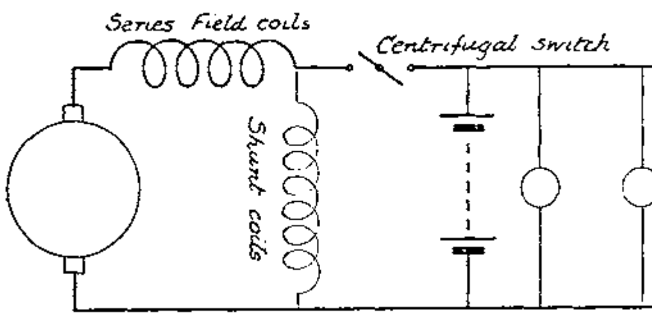


FIG. 2.—*The Bleriot system.*

exciting coil, the series winding being inoperative until the generator begins to send out a charging current. As soon as the necessary speed is reached the centrifugal switch closes and the dynamo is automatically connected in series with the battery. A current will now flow through the series coil, and since this is wound to oppose the shunt coil, the main field of the generator will be weakened. The heavier is the current through this series coil, the more marked is the de-magnetizing effect, with the result that a large increase in speed will only mean a comparatively small rise in pressure and the charging current will be kept within reasonable limits. It will be noticed in *Fig.* 2 that the machine is connected in "long shunt"; that is to say, the current from the positive brush of the dynamo passes through the series windings before it reaches the shunt coil. This implies that a much greater voltage variation can be allowed at the brushes than is experienced at the dynamo terminals, and consequently that a better compensating effect is produced by the series winding than would be the case if the shunt coils were connected directly across the brushes. The machine must never be allowed to run the lamps unless the battery is also connected in. This is important, not only from the point of view of efficient voltage regulation, but also because of the danger of a reversal of the polarity of the dynamo which might occur should the shunt coil not be fully excited. This system is designed to work at 12 volts.

Remarkably close voltage regulation and steady lamp current are obtained in the case of the *C.A.V.* dynamo, manufactured by C. A. Vandervell & Co., which is somewhat similar in principle to the well-known Rosenberg train-lighting machine.

The general arrangement of the dynamo is shown in *Fig.* 3. It is a

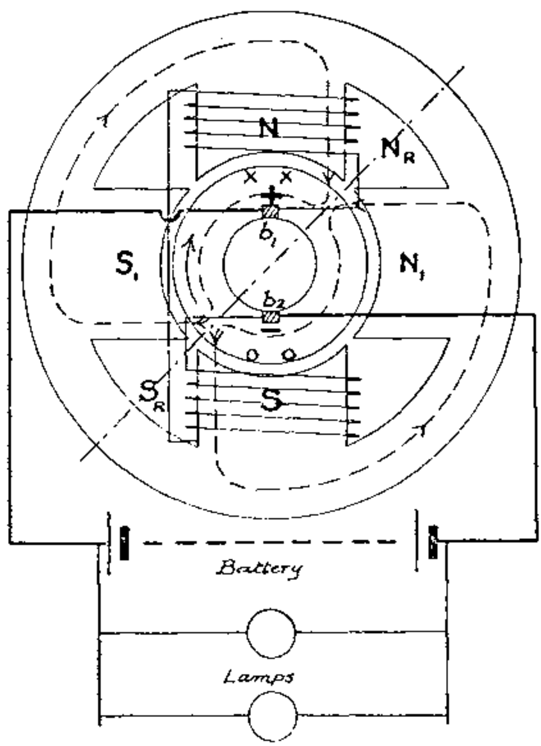


FIG. 3.—*The C.A.V. Dynamo.*

2-pole machine, but is constructed with two sets of pole pieces NS and N_1S_1, at right angles to each other. The former pair are excited by windings connected across the brushes $b_1 b_2$ and also to the battery terminals. The unwound poles $N_1 S_1$ may be regarded as the two ordinary poles of the machine, and the brushes are set in the neutral axis* with respect to these poles, that is to say at right angles to the neutral axis of the wound poles NS. At the moment of starting, the poles NS are fully excited by the battery, and as the armature begins to revolve, its windings cut the magnetic flux flowing across from N to S. Now since the brushes are set at right angles to the neutral axis of these wound poles, there will, for the moment, be no potential difference between them, but a comparatively heavy local current will flow in the windings which are, in turn, short-circuited by the brushes. The reason is, that, during this momentary period of short-circuit, the windings in question are not in any neutral axis (as in the case of the ordinary dynamos) but are in the working axis of the poles NS and are therefore subject to the maximum inductive effect of this field. The position of these windings is shown at X, O in *Fig.* 3.

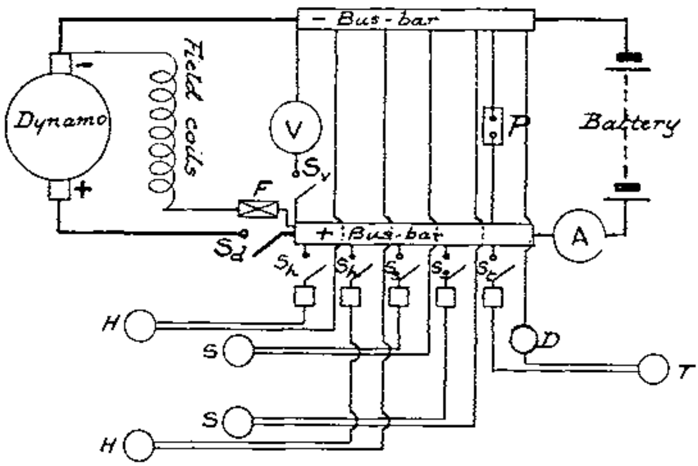
This short-circuit current at once begins to cause re-active effects. A secondary magnetic field will be produced round the windings in which this short-circuit current is flowing, which will cause a magnetic flux at right angles to that produced by the wound poles NS, namely in the direction $N_1 S_1$, the strength of this latter flux being materially increased by the presence of the unwound pole pieces. It is the resultant of these two fluxes which constitutes the working magnetic field, and causes a difference of potential between the brushes. As the speed of the machine rises, and the pressure at the brushes overcomes that of the battery, a charging current will flow to the latter. This charging current, flowing as it does throughout the whole armature, and not being confined to the few coils X, O (as was the original short-circuit current) will in its turn set up a magnetic field directly opposing the flux from the wound poles NS, on which flux, it will be remembered, the whole excitation of the machine depends. The result will be, as in all these electrically regulated machines, that the de-magnetizing effect of the armature current will oppose the natural tendency of the pressure to rise with the speed, and furthermore that the current cannot possibly exceed a certain maximum value, which depends on the ratio of the field and armature ampere turns. When the current through the armature reaches such a value that the flux in the armature along the axis $b_1 b_2$ is equal and opposite to the primary flux NS, then this limiting value is reached. This will be obvious, since if the flux NS is destroyed, the action of the machine ceases. The underlying principle is, in fact, the differential action of two nearly equal forces. Suppose that, with the normal armature current flowing, the flux NS is 10 per cent. stronger

* That is to say, the armature coils which are for the moment connected to the brushes by way of the commutator are lying in the neutral axis with respect to $N_1 S_1$.

than the opposing armature flux along the same axis. The current under these circumstances cannot possibly rise more than 10 per cent. above its normal value, however much the speed rises, since an increase in current value of 10 per cent. will imply a corresponding increase of 10 per cent. in the armature flux (or approximately so provided that the iron is not saturated) and the two fluxes will now balance, and the action of the machine will cease.

The battery must be kept connected to the brushes whenever the generator is in use, if only in order that the shunt windings may always be fully excited. The result of this is that the battery will motor the armature whenever its pressure exceeds that of the dynamo. This is arranged for by the provision of a free-wheel roller clutch which will allow the armature to overrun the driving pulley at low speeds. The system is designed to work at 4, 6 and 12 volts.

Fig. 4 shows the practical arrangement of the various circuits on the car, and may be taken as typical of these installations. The



H, H—Headlamps.
S, S—Sidelamps.
T —Tail lamp.
D —Tell-tale lamp (in series with T).
A —Battery ammeter.
V —Bus-bar voltmeter.
P —Plug for inspection lamp.

S_h—Headlamp switches.
S_s—Sidelamp ,,
S_t—Tail lamp switch.
S_v—Voltmeter ,,
S_d—Dynamo ,,
F —Fuse in Dynamo Field circuit.

FIG. 4.—*Wiring diagram for C.A.V. system.*

bus-bars, switches, instruments, etc., are contained in a small switch-board which is mounted on the dash-board and is under the immediate control of the driver. The dynamo may be arranged in any convenient position; it is frequently placed under the bonnet, and is generally belt driven. The battery should be mounted in such a way as to be readily accessible, as, although there will be no necessity to remove it for re-charging, it should nevertheless be frequently examined and periodically replenished with electrolyte to make up losses from evaporation, etc. A word of warning in this connection may not be out of place. Many makers of these lighting sets are apt to give the impression that the use of a charging dynamo on the cars renders any attention to the battery superfluous. One maker goes so far as to say that "it requires practically no attention." It is almost unnecessary to point out the danger of this doctrine, and it may, in practice, be taken as axiomatic that the life of any secondary battery will vary directly as the amount of careful attention which it receives.

The *Trier and Martin* machine is another which gives extremely good regulation over a wide range of speed. It is very similar in principle to the Leitner train-lighting dynamo. A diagram of this machine is given in *Fig.* 5. It will be seen that, although the

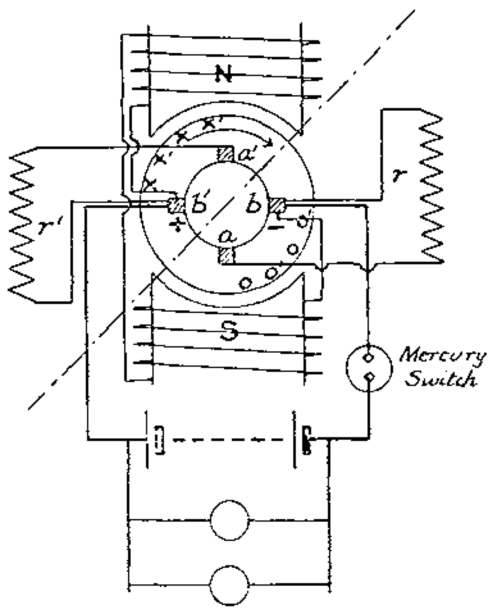


FIG. 5.—*The Trier and Martin Dynamo.*

dynamo is a two-pole machine, it is provided with four brushes, the intermediate ones *aa'* being set at right angles to the ordinary ones *bb'* ; *ab* and *a'b'* are respectively connected through the resistances *r* and *r'*. The magnetic field in which the armature revolves is produced by an ordinary shunt winding, its axis lying along NS.

The rotation of the armature in the field NS causes, in the ordinary way, a difference of potential between *b* and *b'*, *b* being the negative and *b'* the positive brushes respectively. It will be noticed that with an undistorted field (the machine being on open circuit) the brushes *a* and *a'* are at equal potentials.

Under these circumstances a current will flow from *b'*, *r'*, *a'*, armature coils *x'o'*, back to *b'*, and at the same time from *a*, *r*, *b*, armature coils *xo*, back to *a*. The magnetic effect of these currents will be to assist the shunt coils and to *strengthen* the main field, the flux density being therefore a maximum when the dynamo is on open circuit.

Directly, however, the machine is put to work on closed circuit, armature reaction, as usual, distorts the main field and lowers the potential difference between *b'a'* and *ab*. The current flowing between the interconnected brushes is consequently weakened and the strength of the main field falls.

A few moments' study of *Fig.* 5 will show that, when this distortion has reached 45° (as indicated by the chain-dotted line), *b'a'* and *ab* will be at equal potentials respectively. No current will therefore flow between them and the main flux will be again reduced in strength. A further distortion will cause a current to flow in the *reverse* direction through *r* and *r'*, the brush *a'* now having a more positive tendency than *b'*, and therefore also relieving the latter of a portion of the main current. This reverse current will naturally still further weaken the main flux.

The result, then, of the current through the resistances *rr'* and through the armature coils concerned—varying as it does from a maximum in one direction through zero to a maximum in the other direction—will be to continually weaken the main flux as the speed and output of the machine rise, thus keeping the E.M.F. and lamp current very nearly constant over a wide range of speed.

An automatic cut-out is fitted in this system of the centrifugal mercury type and is designed to put the dynamo in circuit at a predetermined speed. The standard pressures used are 8 and 12 volts.

Sparkless commutation is no doubt more easily obtained in this type than in the *C.A.V.* at the expense, however, of an extra pair of brushes and a somewhat more complicated design.

2. Mechanically Regulated Dynamos.

Mechanical regulation pure and simple may be considered as falling under one of two heads, firstly systems which depend on constant torque and secondly those which depend on constant speed. Those who have studied train-lighting systems are familiar with the constant torque principle in the well-known Stone machine, where the dynamo is driven by a belt which is allowed to slip when the *output* of the dynamo reaches its predetermined maximum. That is to say, the belt will not communicate more than a certain definite torque to the dynamo pulley. For many reasons such an arrangement would hardly be suited to the case of road vehicles, and manufacturers of purely mechanically regulated machines incline more to the constant speed principle.

Of these the *Lucas* system is a good example. The connection between the dynamo pulley and the armature shaft is made by a coned clutch, the latter being keyed to the shaft on which the pulley is free to revolve. At all speeds up to the maximum for which the dynamo is designed, the clutch is held in by springs and the armature is therefore driven by the pulley. The arrangement is so far very similar to the ordinary cone transmission clutch between engine and gear-box. At the maximum speed allowed, the clutch is automatically slipped by the action of a centrifugal governor contained therein which acts against the clutch springs. The dynamo will now continue to revolve at a uniform rate of speed.

3. Dynamos both Electrically and Mechanically Regulated.

Of the systems which employ a combination of electrical and mechanical regulation, few are of much practical value for motor-car purposes. It is not proposed to discuss any in detail, but merely to outline a few of the methods which have been employed.

A common device is the use of a field regulator, by means of which the current through the field windings is automatically varied with the speed of the machine. This arrangement consists essentially of a resistance in series with the dynamo field windings, this resistance being automatically varied by some form of centrifugal governor. The system is simple and practical, but some difficulty seems to be experienced in making the mechanism strong and simple enough for working conditions on the road.

Other systems of this class generally rely either on automatically moved brushes—which is hardly compatible with sparkless running—or else on reducing the number of lines of magnetic force cut by the armature as the speed rises. This is done in one type by varying the air gap between the armature and the pole pieces, and in another by moving the armature axially, thereby in effect reducing the length of the pole pieces. The controlling mechanism in both cases consists of the usual centrifugal governor.

The relative merits of mechanical and electrical regulation may be fairly left to individual decision. At the present time electrically regulated machines appear to be more popular for road vehicles, while, at any rate in this country, mechanical control is more extensively employed for train lighting.

SYNCHRONIZATION OF CLOCKS AND THE IMPORTANCE OF CORRECT TIME.

By MAJOR W. A. J. O'MEARA, C.M.G., LATE R.E.

"Our whole terrestrial being is based on Time, and built on Time; it is wholly a movement, a time-impulse; Time is the author of it, the material of it."—*Carlyle.*

INTRODUCTION.

THE decision of the Executive Committee of the British Science Guild to have a paper read before the Guild on the question of the "Synchronization of Clocks and the Importance of Correct Time" is, in itself, a sufficient indication that the subject is well worthy of consideration. Apart from that fact, however, little thought is required to determine that the recognition of the value of adhering to correct time is not restricted to scientists, but that such recognition is shared nowadays, to a very considerable extent, by the public generally.

I have thought that it would not be uninteresting to outline the more important stages which have led up to the present extensive use of approximately correct time.

The importance of time seems to have been recognized by ancient peoples, for it is understood that the obelisk of El Karnak, a monument to the great Queen Hatshefin (XVIII. Dynasty—circa 1,700 B.C.) was utilized as a gnomon, whose shadow was doubtless conveniently used to indicate the approximate time of day. Yet the earliest actual written reference to time appears to be in the seventh chapter of the book of Job, which contains the following words:—

"As a servant that earnestly desireth the shadow
And as an hireling that looketh for his wages."

These words (read with reference to the preceding and succeeding verses) apparently relate to the measurement of time by the length of a shadow.

SUNDIALS.

The earliest form of sundial dates from about 540 B.C. About 340 B.C., a Chaldean astronomer, Berossus, appears to have effected an improvement: he utilized the shadow of a bead upon a dial, upon which curvilinear lines were depicted to indicate the hours. Of course, the hours as indicated by this primitive instrument would be of unequal length, but in equatorial latitudes the inequalities would not be so marked as in this country. So far as can be traced, the earliest public Time Service was given by a sundial which was captured from the Samnites by Papirius Cursor, and which was publicly set up in Rome about the year 290 B.C. It may be thought by some that this sundial was exhibited merely on account of its interest as a war trophy, but judging from references to it, it appears to have been regarded as a public time register. It was certainly not constructed for the latitude of Rome, but the importance of the accuracy of the readings cannot at that epoch have caused any serious inconvenience in connection with the business and domestic life of the city. Even in these more enlightened days there are still people who buy sundials in curiosity shops and set them up in their grounds without enquiring into the question of their suitability for the *locus in quo*. It was not until 164 B.C. that the Romans made a sundial suitable for their own latitude.

CLEPSYDRÆ.

After this time it seems to have become apparent that the Clepsydra then utilized for timing speeches in various assemblies could be graduated so as to indicate divisions of time, and the first water clock, which was in all probability calibrated by comparison with a sundial, was constructed in 135 B.C., and this device, together with sand clocks and other devices, heralds the advent of portable timekeeping *machines*. However, notwithstanding its imperfections the sundial has existed through many centuries, and one form known as "the meridian dial" is still in use. This sundial serves to indicate solar noon, and provides a suitable means for checking clocks in localities where the telegraph is not available for sending time signals. The increasing desire for greater accuracy in timekeeping is shown in the improvements which have been effected in even this, the earliest form of timekeeper. The latest form of a sun clock is that recently introduced by Mr. Steward, of the Strand, viz.: the Ferguson Solar Chronometer. The instrument is of a universal type, that is to say, it is suitable for use in any locality; and it will enable the local time or the standard time of any country to be read without computation or reference to correction tables, the sun's apparent time being automatically corrected so that the shadow on the dial indicates true "clock" time. Incidentally the instrument may also be used as an astronomical compass to ascertain the true North as distinguished from the magnetic North.

Returning now to the period of portable time machines, particularly to the Clepsydra, it must have become apparent to the users that water clocks did not admit of equal divisions on the scale or dial, because the water would not run out with a uniform velocity. This difficulty was surmounted later by using a syphon carried on a float so that the "head" of water remained constant. This improvement is generally attributed to Ctesebius, of Alexandria, who lived about 150 B.C. As soon as it was discovered that a column of dry sand, whatever its height, will pass through a minute hole with absolutely uniform velocity—if the angle at the waist of a sand-glass be made to conform to the natural angle of repose of the sand, it naturally followed that the sand-glass displaced other forms of portable time-keeping machines.

The several different methods by which time is reckoned—for instance, Solar Time, Mean Solar Time, Sidereal Time, and Local Time, are familiar to us. The march of civilization, including the advent of railways and improved and speedy methods of inter-communication, however, has practically abolished the observance of Local Time and we now have the world divided into Time Zones, in which the time on one meridian, generally reckoned as an integral number of hours from Greenwich, is adopted as *Standard Time* for that zone. It appears to me that the use of the term "Zone" in this connection is hardly correct, and that it would be more correct in the nature of things to refer to the area concerned, as a "Lune."

Greenwich Mean Time.

The Greenwich meridian appears to have been adopted early in the XIXth century as the prime meridian for all civilized countries, and Greenwich Mean Time is now the standard for Great Britain, France, Belgium, Holland, and Spain. Mid-European Time (the next zone or lune meridian, 15° East of Greenwich) one hour fast of Greenwich, is adopted for Germany, Austria-Hungary, Sweden, Norway, Denmark, Switzerland, Italy, etc. In some places Local Time is still observed, *e.g.* in Russia, where St. Petersburg time is in use (1 min. 13 sec. fast of East European standard time) and in Ireland, where for some peculiar reason Dublin time is employed (25 min. slow of G.M.T.). Recently, however, some of the Irish Chambers of Commerce have expressed a wish to adopt Greenwich Time.

Time Machines.

It is generally believed that clocks driven by weights were invented either by Pacificus, Archdeacon of Verona, in the IXth century, or by Gerbert, Archbishop of Magdeburg, in A.D. 996. It is recorded that in 809 Haroun Al Raschid made a present to Charlemagne of a curious clock which struck the hours by letting little metal balls fall on a bell. This, however, is thought to have been one of the Clepsydræ family. We then find that in the XIIth century a clock impelled by weights and wheels was sent by the Sultan of Egypt to the Emperor

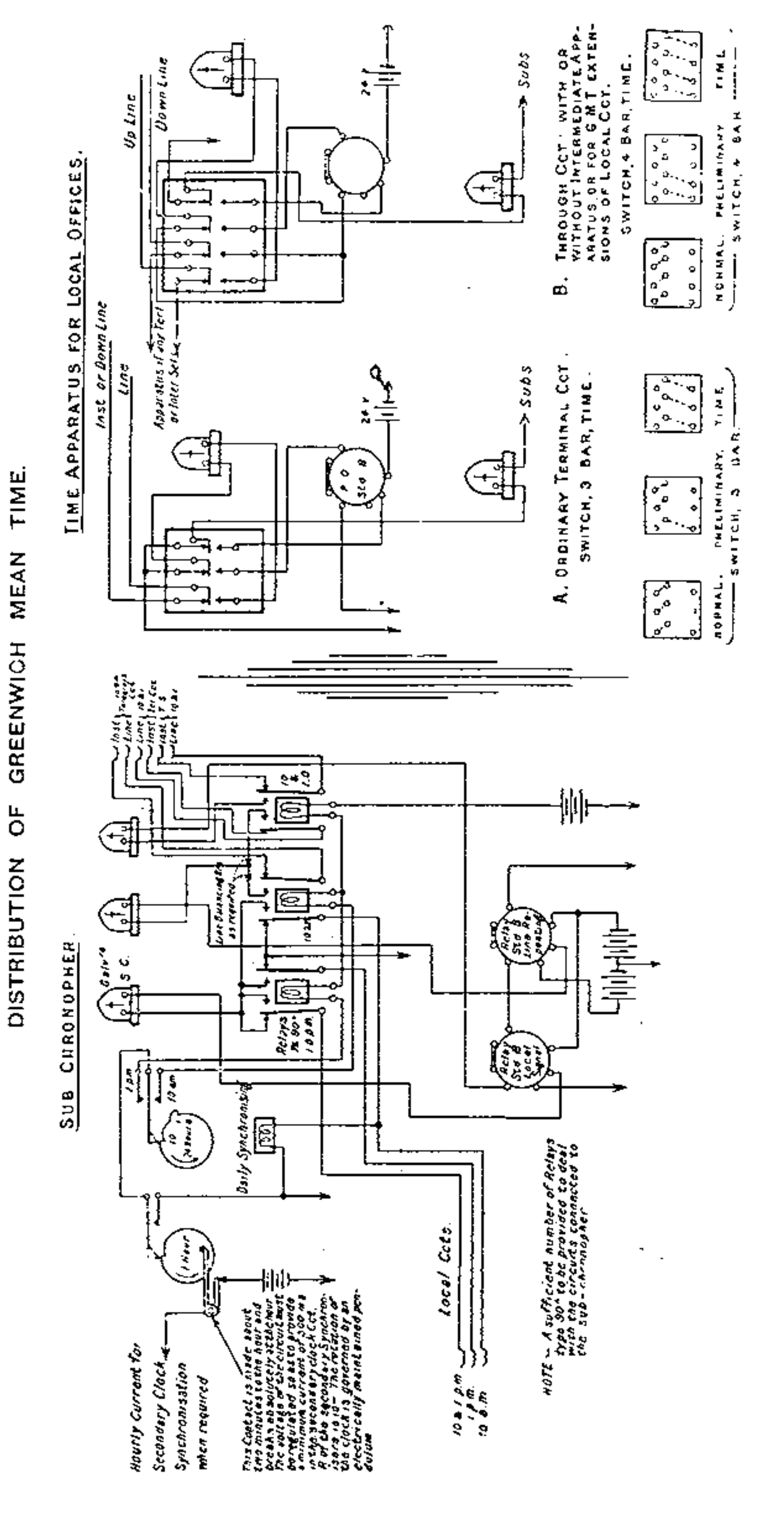
Frederick II. Later on, in 1292, there is a reference to a clock in Canterbury Cathedral costing £30. Then there followed a clock made by Henry de Vick for Charles V. in 1370, which had a balance, and so on; one can trace the development of the art of watch and clock making by fairly easy stages down to the present time, when time-keeping devices are so numerous and so cheap that there are few persons who do not possess some article indicating the hour of day. The modern clocks, too, are constructed with such skill, and are of such excellence in timekeeping, that, provided they be properly adjusted and periodically corrected, they can be implicitly relied on.

SYNCHRONIZATION.

I now come to the principal part of my paper. The Executive Committee of the British Science Guild, in their first report, referred to the question of clock synchronization, and pointed out that the observance of uniformly correct time was a *sine quâ non* for the proper conduct of business. I may say that in the Post Office this fact has always been recognized, for in the first place many operations in connection with the despatch and reception of mails have to be conducted in different departments, all tending towards one end, that is the catching of trains at definite times. While the increase in rapidity of communication by means of railways demanded certain exactitude of timekeeping, the introduction of the telegraph called for even a finer degree of accuracy, wherefore in Telegraph Offices it is essential that there should be absolute uniformity of time between the various sections of an office where the transmission of a telegram is concerned. A telegram in the course of transmission from the town in which it originates to the town in which it is finally delivered, passes through a succession of processes, in each of which it is carefully timed, primarily to ensure that it shall take its proper place amongst the others with which it may converge upon a particular route, and also to ensure that as little time as possible may be lost between the several operations necessary, from the time it is handed over the Post Office counter to the time when its text is delivered to the recipient. An idea of the necessity for *strict accuracy* in the timing of telegrams may readily be obtained when it is considered how many business transactions, notably those relating to stock and share dealing, produce, ship brokerage, etc., depend upon the time at which a telegram is handed in to the Post Office for transmission. The importance of such accuracy in connection with "betting" telegrams will also be remembered. As is well known, the time of "handing in" a betting telegram altogether decides whether the bettor expressed his opinion as to the relative merits of the contestants, or in other words "backed his fancy," before the struggle for supremacy commenced. It is, therefore, a matter for congratulation that the accurate timing of telegrams *conduces* to honesty in transactions of this character. Such accuracy, in itself, is not, of course, an effective means of preventing fraud. I remember an incident which occurred in my own experience. In my young days I had to visit a certain place at which racing stables were situated, and in this connection I learned of an extensive scheme of fraud which was being perpetrated on ignorant yokels. In a public house, arrangements were made for a clock to be kept behind time, and betting was continued right up to the advertised starting time of races, as shown by that clock. In adjacent premises an accomplice received telegrams announcing the results of the races, and he, by means of a code of signals, communicated the results to the persons offering the bets; these individuals were thus in possession of results whilst still offering bets on them. Such frauds as that referred to can readily be made impossible by the adoption of regulations designed to ensure that clocks in public places are maintained so that they register standard time.

Distribution of Greenwich Mean Time.

Returning to the matter of correct time in the Post Office, I may perhaps with advantage explain how in the past this has been achieved. Since the early days (1852) of the Telegraph Companies, the Post Office has received an hourly signal transmitted automatically from the Mean Solar Clock at Greenwich Observatory, and at 10 o'clock every morning the signal has been re-transmitted by telegraph to every telegraph office throughout the Kingdom, thus enabling all Post Office clocks to be re-set by hand. The telegraph wires were soon found to be a convenient means whereby watch and clockmakers could be served with a daily time signal, and as the manual transmission of the time was not sufficiently accurate to meet their requirements, which comprised the determination of the rates of marine chronometers and the checking of their own regulators, something in the nature of automatic transmission became necessary. To achieve this object, an instrument, called the Chronofer, was designed by Mr. C. F. Varley, about 1865. This device was really of the nature of a multiple switch whereby wires radiating from the London Office in Telegraph Street to various provincial towns were connected either to their telegraph instruments, or bunched together in groups on relays, which were operated by the receipt of the signal from the Observatory. The operation of the multiple switch was effected by means of a spring motor, which, from about two minutes to 10 o'clock to two minutes after, caused the switch to change over. This spring motor was controlled by an electrical contact on a clock. Hand-operated switches were used to extend the London wire by means of


DISTRIBUTION OF GREENWICH MEAN TIME.
SUB CHRONOPHER.
TIME APPARATUS FOR LOCAL OFFICES.
A. ORDINARY TERMINAL CCT.
SWITCH, 3 BAR, TIME.
B. THROUGH CCT. WITH OR WITHOUT INTERMEDIATE APPARATUS, OR FOR G.M.T. EXTENSIONS OF LOCAL CCT.
SWITCH, 4 BAR, TIME.
NORMAL. PRELIMINARY. TIME.
SWITCH, 3 BAR.
SWITCH, 4 BAR.
Up Line
Down Line
Inst. or Down Line
Line
Subs
24 V
Daily Synchronising
Local Ccts.
Hourly Current for Secondary Clock Synchronisation when required
Relays Pk 90ᴬ 10 p.m.
Relay Std B Local
Relay Std B Line Repeating
NOTE.—A sufficient number of Relays type 90ᴬ to be provided to deal with the circuits connected to the sub-chronopher.

a local wire connected between the Post Office, and the premises of those who desired to use the signal. I may add that the Time Signal from the Observatory was made to synchronize automatically the clock controlling the Chronofer. I propose to deal with the question of automatic synchronization presently. It is interesting to know that the Chronofer as installed in those early days is still in existence and is still doing useful service. However, notwithstanding amplifications and additions which have been made from time to time to meet the growing needs of the service, the growth has of recent years become so great that the Chronofer has become much overloaded. The temporary disturbance of the telegraph wires has also resulted in such inconvenience to telegraph traffic that it has now become necessary to devise a new method for the distribution of time, and to replace the present Chronofer by apparatus of more modern and efficient design.

New Distribution System.

The Hourly Signal will continue to be transmitted from the Mean Solar Clock at Greenwich Observatory to the Central Telegraph Office in London, where it will be received upon a main relay forming part of the new Chronofer apparatus. The local side of this main relay operates other relays, which will transmit the hourly signal to London renters, and will ring bells, etc., fixed in various administrative and operating departments of the group of buildings associated with the G.P.O. headquarters.

Certain main distribution circuits, normally used for telegraph purposes between London and provincial centres, will be connected to the tongues of groups of switching relays, which normally retain these circuits in connection with their telegraph apparatus, but which, when operated by control circuits from a special electrical clock, will transfer the telegraph circuits from the telegraph apparatus and bunch them on the tongue of a transmitting relay, so that a positive current which forms a preliminary or warning signal, will be sent out on all distribution lines. On the receipt of the Greenwich signal, the operation of the main relay will cause the transmitting relay to reverse the current on the lines momentarily, the reversal constituting the distributed time signal. At certain provincial offices similar apparatus, but on a smaller scale, will be installed for secondary distribution over other circuits radiating therefrom to individual offices, wherein hand-operated switches as before will control the arrangement of the local circuits for transmitting the signal to renters.

Special switching devices will be introduced in the new Chronofer to enable certain Admiralty stations to continue to send reporting signals from their standard clocks (in one case from a time ball), which signals will follow one another in succession over a second wire from London to the Observatory so as to enable the Astronomer Royal to check the performance of the clocks. Distribution to the provinces will take place at 10 and 1 o'clock, and at provincial sub-chronofer stations the switching relays will be joined in groups for the 10 o'clock or 1 o'clock signal or for both signals, according to the service required in any particular town. The controlling clocks are set so as to operate the switching relays from one minute before to one minute after the hours named. This scheme is of course extremely elastic, and will enable growth to take place unhampered by considerations regarding the use of long and expensive telegraph wires. I may say that instead of having upwards of 200 such circuits radiating from London there will be only about 20.

SYNCHRONIZATION METHODS.

(*a*). *Signals.*

Having briefly, but I hope adequately, covered the historical side of the subject, and having endeavoured to show how correct time is obtained and distributed over the country by means of the facilities which are afforded by the vast network of telegraph wires which the Post Office has available for the purpose, I now propose to indicate how and in what manner the knowledge thus distributed is utilized. To do so I must go back some few years to the early attempts which were made to correct clocks and the means generally adopted for that purpose. One of the methods earliest in use was to make the Time Signal operate a visual or audible signal, and I may say that in many cases that practice still obtains. In certain instances it is difficult to see the reason for the retention of such palpably absurd methods, whilst in other cases very good reasons exist, as I propose to explain presently. But first of all I may mention that watch and clock makers who deal with chronometers, and what may be called precision timepieces, *i.e.* timepieces requiring to be transported in surveying operations or for navigating purposes, do not, as a rule, use the Time Signal for the physical correction of their regulator clock or the timepieces under test, but as a means whereby their daily error or "rate" may be ascertained. It will be readily understood that the regulation of chronometers to anything beyond a close approximation to correct time would be a very lengthy process, if not, indeed, a practical impossibility, but if the rate be determined and found constant, and if recorded so as to be available when reference to the timepiece is necessary, the ultimate result will be as good as if the instrument was absolutely correct. For the determination of the clock error nothing can be better than a single stroke on a gong, or some such audible signal. I may here mention that the firing of a gun as is customary in a good many places, is useful as an audible signal only for places in close proximity to the gun, owing to the relatively small velocity at which sound travels. However, the public probably find the announcement that the hour is approximately 1 o'clock (the usual time for gun fire) convenient.

(b). Visual and Audible Signals.

For exact work the gun fire should be placed in the category of visual signals, for it is the flash that should be noted. It is astonishing how little real consideration is given to the question of the relative values of audible and visual signals. I may quote an instance of an important city in the North, where a great public clock, which, I believe, is the standard for the city, is corrected by hand and therefore may sometimes be appreciably out of time; and this clock is provided with a bell upon which the hours are struck, and the 1 o'clock stroke, whilst prepared for by the mechanism of the clock, is released by the 1 o'clock Greenwich signal, quite regardless of the fact that, apart from the mechanical lag in the striking gear, the sound of the bell must take an appreciable time to reach the outskirts of the city. Quite considerable expenditure must have been incurred in providing the special mechanism involved, and a comparatively large sum is paid annually for the signal, whereas, for a much smaller capital and annual expenditure, the clock itself might have been automatically synchronized and the bells left to take care of themselves, as has recently been done at Aberdeen Town Hall, where the synchronizing gear is so arranged that *all* the hours are struck exactly at the right time. I learn that owing to the peculiar system adopted in the former case, the 1 p.m. stroke has been heard whilst the clock was already engaged in chiming the quarters!

Coming now to the visual signals, the most important in this class is, of course the Time Ball, and many of these are still in use. They are, in fact, the standard means for observatories to announce a certain hour, usually 1 o'clock, to observers within a radius of visibility. The most important duty of Time Balls lies in the means they afford to ships for checking the rates of their chronometers. For this purpose the Admiralty Dockyard stations round our south and south-west coasts have been provided with Time Balls, some dropped by the Greenwich signal at 1 o'clock, others dropped every hour by an electrical current sent out from a regulator clock which is corrected to agree with Greenwich Time. I should like to refer particularly to two Time Balls which are of some historical interest. That erected on the eastern turret of Greenwich Observatory in 1833 appears to have been the first public time signal in this country, and it has since been dropped at 1 o'clock every day (except when the weather conditions were such as to render it unsafe to raise it preparatory to its drop). The other was erected by the Admiralty at Deal in 1855 at the instance of Sir George Airey, for the benefit of the shipping lying at anchor in the Downs. This is still doing its work, and is worthy of note because it not only gives the time to the ships, but also, by means of a return signal automatically transmitted, informs the Astronomer Royal that it has done so, and whether correctly or otherwise.

Another class of visual signal consists of the deflecting needle of a galvanometer, so often seen in watchmakers' shops. This may be satisfactorily placed in a shop window, for the interest of the passers-by as an advertisement of the fact that a Time Signal is received at that establishment. Whether the signal is utilized or not is of course another matter, but even when placed inside, for use, inasmuch as it requires two observers, one to see the signal and another to observe the clocks, with the very considerable risk of personal error occurring between them, it cannot be of, what one might call *scientific* value.

PHYSICAL CORRECTION.

I now come to the physical correction of clocks. There are many methods, the first being of course hand correction, which may be dismissed at once as haphazard and quite unscientific. There is however one really scientific method of what I may call electro-manual correction, devised by Sir George Airey, which is in use to-day, notably, amongst other instances, on the Mean Solar and Sidereal clocks at Greenwich, and also in the clocks at the Admiralty stations. The Admiralty clocks have two pendulums, beating seconds, one suspended immediately behind the other. The one is entirely free on its suspension but is normally latched to one side by a detent, which is released by the arrival of the Greenwich signal; the other, which controls the clock, has fixed to it a permanent magnet, which, with the beat of the pendulum, swings just clear of the poles of an electro-magnet fixed to the case. On the release of the free pendulum, should the clock be absolutely to time, both pendulums will beat in phase with each other, but, if there be any variation, the difference in phase may be read on a suitable scale, and then a current sent round the electro-magnet in such a direction as to attract or repel the permanent magnet; the effective centre of gravity being thus altered, the clock pendulum is accelerated or retarded until it is in phase with the pendulum. These clocks are also provided with electrical contacts to enable them to report their performance automatically to Greenwich. The Mean Solar and Sidereal clocks at Greenwich are corrected in the same way, save that, as their performance is observed on electrically operated seconds indicating dials enabling the clock error to be compared with a transit observation, the free pendulum is not required. There is, of course, in this system, as in all systems where a personal element is introduced, the risk of personal error. There may be an observation error, and the correcting current may also be kept on too long, or not long enough, and even though these errors may amount to but fractions of a second, their possibility precludes the method from being considered an ideal one for general use. I cannot do better than quote the remarks of the British Science Guild Committee contained in the report previously referred to: "The correction of clocks by hand is quite out of date and untrustworthy, and we are unanimously of opinion that some form of direct physical control by electrical synchronization from a central time authority is essential." At the same time it must be admitted that, where the minute correction of fine clocks such as are usually found in observatories and the like places where their correction is in the hands of skilful and trained observers, the foregoing method offers possibilities for closer correction than could be obtained by automatic means.

This brings me to attempts which have been made and methods which have been adopted for direct automatic control.

Automatic Correction.

One of the earliest methods adopted for automatic control was that due to R. L. Jones (1857), some time Manager of the Chester Railway Station. This was a development of Bain's original electrical pendulum in which the pendulum bob was made in the form of a solenoid, in the centre of which was a permanent magnet fixed to the clock case. By means of contacts, electrical currents were caused to alternate through the solenoid in unison with the swinging of the pendulum, so that the coil was given a to-and-fro movement along the magnet. The beats of the pendulum caused the wheels of the train to rotate by means of a ratchet and pawl mechanism. Mr. Jones employed the same type of pendulum, but caused the contacts to be made by the pendulum of another clock, with which, therefore, the coil pendulum beat in sympathy. The exploitation of Mr. Jones's patents was in the hands of the Magnetic Telegraph Company, and I have succeeded in obtaining some figures as to the extent of the system and the costs involved where it was adopted. The figures are not without interest. I find that in Liverpool (1865) a 4-dial turret clock on the Town Hall and a 6-dial clock on the Victoria Tower were thus controlled, £10 per annum being paid to the Magnetic Telegraph Company for each, by way of royalty, rent and maintenance charges. These were, together with a clock in the Magnetic Telegraph Company's Office, controlled by a clock at the Liverpool Observatory. There were also in Glasgow (1864) a number of public clocks (10) similarly controlled from the Glasgow Observatory. The cost of the connecting wires in

Glasgow was £40 a mile for wires carried over the houses, and the cost of converting an ordinary turret clock to the sympathetic system was said to be £10, and if the striking gear was also synchronized an additional £15 was required. The royalties amounted to £5 per annum for a public clock and £1 for a private clock, the Magnetic Telegraph Company charging in addition 10s. per annum for batteries and maintenance—which charges were, however, subject to a reduction where a number of clocks were concerned. This system which was also in use in London and Edinburgh, was further developed by Messrs. J. Ritchie & Son of the latter city, and whilst it was really an admirable one, it would hardly compare favourably with most modern systems if current consumption be considered, requiring, as it did, currents to be transmitted every second. I may say that the Post Office has both at Glasgow and Edinburgh a number of these clocks still in use.

Another method, which I believe was originally devised by Mr. C. V. Walker, of the Electric Telegraph Company, was introduced on the South Eastern Railway in connection with the first arrangements for the distribution of Greenwich Time which took place over that Railway. In this system the clocks were made to gain slightly and a disc on the minute arbor was so cut as to allow a pivoted lever to drop when the clock reached the 60th second—sometimes of every hour, sometimes of every twenty-fourth hour,—in such a manner that a detent at the extremity of the lever blocked the escape wheel, thus arresting the clock. The pendulum continued to swing meanwhile, until the arrival of the Greenwich signal energized an electro-magnet, whose armature withdrew and re-set the lever so as to allow the clock to progress as before, but set to correct time. This method has the radical defect that in the event of the failure of the Time Signal, the clock remains arrested unless released by hand, for which auxiliary apparatus is usually provided. Unfortunately, it is practically impossible to guarantee that the wires carrying the signal shall be absolutely immune from occasional interruption. There are several clocks of this type in use at the present day—one at Aldershot (where, by auxiliary electric contacts it controls switches to enable the Greenwich signal to fire the 1 p.m. gun), and also in one or two Post Offices in the North of England. This, too, is the method used for correcting the control clock for the present Chronofer to which I have previously referred.

About 1850 Mr. Alexander Bain (to whom I have previously referred) arranged for a method of what has been aptly termed "forcible correction." This was effected by causing an electro-magnet to move an arm carrying a V-shaped notch so as to engage exactly at the 12 o'clock position with a pin in the long hand of a clock, and thus set the hand to exact time. Mr. F. J. Ritchie, F.S.A., in a paper read before the Society of Arts in 1878, refers to this method, and also mentions that his firm adopted an arrangement (on a similar principle to that of Walker) whereby a movable block was interposed in the way of the pin on the hand so as to arrest the amount of gain accumulated by the clock—the clock having been regulated so as to gain slightly—the obstructing block being sharply removed precisely at the 60th second of the hour. This method of Ritchie's is worthy of note, as upon it is based the present method successfully in use by the Post Office.

Coming nearer to the present day, the Standard Time Company originally made use of a forcible correction method devised by Mr. Lund, whereby two pins, carried upon separate arms capable of revolution through an arc of about 70 degrees, were caused, by the operation of an electro-magnet, to bear upon a block attached to the minute hand, which was moved backwards or forwards, according as to whether the clock was fast or slow; the hand being released when in the correct position. This method of correction was ultimately abandoned for another, which "zeroised" the hands by the action of a shaped piece, attached to an armature, upon a suitable cam fixed to the centre arbor. As a matter of fact, the majority of the methods for zeroizing clocks by means of a synchronizing current in use at the present time, depend upon the action of a lever or roller caused to come into contact with and push round a spiral cam or its equivalent. With certain restrictions, this method—a fairly obvious one—is reasonably good.

When it was decided that the Post Office should consider the question of extending the application of the time current for synchronizing clocks, the methods previously in use, some of which I have described, were very carefully analyzed, and, after experimenting at some length, several rather important conclusions were arrived at, amongst others that the periodic checking of a gaining rate—as in Ritchie's method—was fundamentally correct. If an attempt is made to move a slow clock forward, backlash that must perforce exist in any train of wheels has to be dealt with; such an attempt would disengage the teeth of the train from their driving position, which space would afterwards have to be gathered up when the correcting power ceased to apply; the obvious result being to leave the clock incorrect. This, of course, does not occur where setting back or checking a gain is concerned, for the engagement of the teeth of the train is not disturbed. Again, the adoption of the Walker system, whilst doubtless useful for seconds-indicating clocks—there are but few of these in the Post Office—entails alterations and additions approaching to a partial reconstruction of the clock, and is therefore comparatively expensive to apply, unless the clock be specially constructed for synchronization; but nowadays one does not, as a general rule, design clocks specially for synchronization, because a purely electric system with but one synchronized master clock meets the case more satisfactorily and more economically. The problem which had to be considered was the synchronization of clocks that were already in existence. Further, an important desideratum recognized was that whatever be the method adopted, the additional part or parts to be added to a clock must be of such design as to be readily incorporated in all the classes of clock that are in use in the Post Office, from 10-in. timepieces up to comparatively large 36-in. dial clocks, and above all, the apparatus and its fixing must be reasonably cheap.

Post Office System.

A small electro-magnetic detent was therefore designed in the Engineer-in-Chief's Office, G.P.O., which can be readily attached behind the dial of any timepiece and in which the magnet has no positive work to do. The pin in the armature is arranged to project through a hole in the dial in such a way that periodically, when the minute hand reaches the 60th minute, it engages with a flattened pin riveted to the hand. With the magnet unenergized, the pin on the hand easily pushes the detent pin forward, and, because of the different arcs in which the pins move, ultimately clears it. If, however, the magnet be energized, the armature is simply locked in position (which, of course, requires much less effort than actually to move the armature through any distance) and then, by the engagement of the pins, the clock is held up, the hands meanwhile slipping on their arbors without stopping the train, until at the cessation of the current, the hands are allowed to progress. I may add that the electrical resistance of the synchronizers used on Post Office installations is 10 ohms, and that all the clocks in a building are connected in series, the voltage at the master clock being regulated so as to afford a current value of about 250 milliamperes in the circuit, whatever be the number of clocks. Actually, 100 milliamperes are ample, but it is found to be safer to allow a wide margin.

The Post Office has not standardized any fittings for correcting turret clocks. These are usually made to order, one at a time, and they vary so much in detail that an attempt to apply a standardized attachment might prove rather expensive. The same principle, however, is employed. It will be recognized, of course, that with a large turret clock there is some justification for a rather more expensive fitting than would be the case for the more numerous small clocks, yet the cost of applying the method I have described does not nearly approach the figures quoted in connection with the Jones sympathetic system to which I have already referred. It may be interesting to note that, for a number exceeding twelve clocks in one building, the cost of the Post Office system, including all wiring and a Master

Clock which I shall presently describe, averages approximately no more than £1 per clock.

The Master Clock adopted by the Post Office for transmitting the correction currents differs considerably from that described by the committee of the British Science Guild in their second report. At that time the Post Office used, tentatively, a clock of the Vienna Regulator type, to which was added certain extra parts to enable it to be synchronized daily by the Greenwich signal, and also to send out in its own local circuit the hourly correction currents to the secondary clocks. This type of clock required to be wound up periodically, and of course was fulfilling a function for which it was not primarily designed, being therefore something in the nature of a makeshift. The Post Office, however, uses a Master Clock which is more of the nature of a time-controlled switch than a clock. This consists of a pendulum, electrically driven on the Hipp principle, which, through a pawl and ratchet wheel, drives a worm gear connected to a very simple train of wheels, embodying 1-hour and 24-hour wheels. The 24-hour wheel is provided with cams which operate, at the proper time, electrical contacts controlling automatic switches for the proper reception of the 10 and 1 o'clock Greenwich signal. The hour wheel carries a pin which, once an hour from the $58\frac{1}{2}$ minutes before the exact hour, depresses a lever to make the circuit for the hourly correcting signal. The lever is released, and thus breaks the circuit, precisely at the 60th second of the 60th minute of the hour. The arbor of the ratchet wheel carries a heart-shaped cam, by means of which an electro-magnet armature provided with a roller extension zeroises daily the whole of the train. It is obvious that synchronizing by a cam in this case, on the quickest moving member of the train, is not open to the objection which would apply, as I previously remarked, to the same method applied directly to the minute arbor of a clock. Incidentally, I may mention that this Master Clock is identical with the control clock utilized in connection with the new Time Distribution scheme for Sub-Chronofer Stations to which I referred earlier in the paper. In view of the fact that telegraphic interruptions *do* occur occasionally, the electrical circuits are so arranged that a false synchronizing signal will be rejected by the clock, and the entire failure of the signal cannot interfere with the normal movements of the clock.

So far as the Post Office is concerned, where the equipment of a new building or one hitherto not adequately provided with clocks is concerned, a purely electric system whose master would be automatically synchronized is now invariably installed.

As a matter of fact, the provision of the timekeeping arrangements for Government buildings has devolved upon H.M. Office of Works, which has equipped many buildings, including Post Offices, with the Magneta Clock system. The Master Clocks in connection with these installations are wound up daily, and the necessary corrections are made at the same time, that is to say, at the present time they are not automatically controlled.

I do not propose to enter into considerations as to the relative merits of the several excellent electric systems available to-day. Claims are made by each system that it possesses higher efficiency, better timekeeping qualities, and greater economy than the others, so that a choice must be largely governed by individual opinion. In my opinion, an ideal system should consist of a Master Clock, which should be entirely independent of personal attention for winding or correction, and which should lend itself readily to automatic correction, connected to secondary clocks in which the moving parts should be as few as possible and coupled with driving mechanism of the rotary type—akin to an ordinary electric motor. It is true that ratchet and pawl mechanisms, as used in many electric systems, have been brought to a wonderfully fine degree of perfection by many able and skilled inventors and designers, nevertheless, I am of opinion that for absolute satisfaction a motor mechanism is the ideal one. I am led to this opinion because of past experience with electric clocks in the Post Office. In 1896, when the Post Office acquired the Telephone Trunk wires the need was felt for large clocks indicating periods of $\frac{1}{4}$ minutes, and Mr. Kempe, the Electrician to the Post Office, designed clocks which were operated by rotary armatures to meet this requirement. These clocks, made more than 15 years ago, are still in use, and are doing their work quite satisfactorily, much more so, I feel sure, than if they had been driven by ratchet work, which would have involved some measure of adjustment to take up wear and more or less variable springs which are almost inseparable from that type of gear. These particular clocks, designed some time before the electric clock industry had reached its present stage of perfection, are unique, inasmuch as, in addition to the ordinary hour and minute hands, they were provided with a third concentric hand which revolved once a minute in four jumps of quarter of a revolution, each representing $\frac{1}{4}$ minute. The clocks were made in two sizes with 24-in. and 5-in. dials, similar driving mechanism being employed in both sizes. They are now, however, being replaced by other instruments, one of which indicates to the operators the lapse of periods of three minutes,—the unit time for trunk conversations—and another which is caused to print on a ticket the time elapsed between the commencement of a conversation and its termination.

I should also like to say that where Master Clocks are synchronized, the method adopted, whether a zeroising method or a modification of the Ritchie method such as is often used, arrangements should be made that the operation be *entirely* automatic, and not dependent upon manual adjustment in the event of any failure of the original.

In either case it is easily arranged for, and I am surprised to find that cases actually exist where the failure of signal has stopped the system.

General.

I hope I have now shown in as concise a manner as is compatible with lucidity how standard time is obtained, how it is distributed, and how it is used.

The importance of punctuality is widely recognized, and we are ready to admit that "Time is the Soul of Business." It can then only be a matter for wonder that comparatively so little has been done to ensure that the hour of day indicated by our clocks, both public and private, shall register the correct time. The tailor is careful that his yard measure is a true one, and the grocer that his weighing appliances register correct weight. Everything that we have, everything that we do, everything that we see, is governed by some measure. We ourselves, or the law for us, insist that these measures, save one, *Time*,—shall be true; yet Time is, and should be, inseparable from its brothers of *length and mass*. This sense of incompleteness is all the more striking when one considers how comparatively little used are the ample facilities which the national possession of the telegraph system of the country places at our service for distribution. However, before I bring my paper to a close, I may perhaps be allowed to refer to one great branch of our human existence where correct time is fully appreciated, and where any increase in the facilities for accurate and wide distribution is welcomed and made use of without stint. I refer to our Navy and our Mercantile Marine. Our ships, both those upon which we largely depend for our trade, and those which defend our shores, are increasing in numbers and value daily. The navigator, whether he be in mid-ocean or sailing round a coast, must at all times be in a position to locate the whereabouts of his ship. Under the latter circumstances, the task may often be a simple one, owing to the existence of visible stationary objects; but in the former case, a means of ready reference to standard time is essential to the navigator, if he is to fix his position accurately.

Fortunately, recent developments in telegraphy have provided means whereby time signals can be transmitted to every part of the wide ocean, and the navigator now has the benefit of both the radio-telegraphic station on the Eiffel Tower and the German station at the mouth of the Elbe, for obtaining standard time, Paris time in the former case (for, although France now uses Greenwich time commercially, yet Paris time is employed for maritime purposes) and Greenwich time from the latter; which are radiated far and wide for the benefit of all who have means for listening to them. From the Eiffel Tower, signals are despatched in the forenoon and again at midnight. Three groups of warning signals are transmitted by hand, and each group is of a distinctive character, so that listeners may be prepared for the actual time signal, which is sent automatically, and in order that there may be no doubt as to the signal, the time signal is repeated thrice at intervals of two minutes, that is, at 11, 11.2, and 11.4 a.m.; and midnight, 12.2, and 12.4 a.m. The cost of the apparatus necessary for the reception of these signals on ships unprovided with radio-telegraph apparatus, is from £10 to £20, not a large sum when compared with the immense value of the service thus obtained. Aerials having an elevation of about 20 metres are sufficient for vessels within a radius of about 200 miles. The facility afforded by radio time signals is of immense value also in surveying operations, as providing means for obtaining most minute differences in longitude.

In concluding, I desire to acknowledge my indebtedness to the archives of the British Horological Society for much of the historical matter embodied in this paper.

AN ENGINEER OFFICER UNDER WELLINGTON IN THE PENINSULA.

(Continued).

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

The English troops—Napier tells us—were now distributed in Badajoz, Elvas, Campo Mayor and other places, and this eventful campaign of two months terminated.

On the whole, it has been unfortunate, though relieved by the victory of Talavera. The general loss of the British—Napier goes on to state—was considerable. Above 3,500 men had been killed, or had died of sickness, or fallen into the enemy's hands. 1,500 horses had perished from want, exclusive of those lost in battle; the soldiers were depressed, and a heart-burning hatred of the Spaniards was engendered by the treatment all had endured. To fill the cup of disaster the pestilent fever of the Guadiana, assailing bodies which fatigue and bad nourishment had already predisposed to disease, made frightful ravages; dysentery, that scourge of armies, raged, and in a short time several thousand men died in the hospitals.

The British General had learnt a lesson which was not forgotten during the rest of the war—that no reliance was to be placed on Spanish co-operation. At the same time, he was determined to protect the Spanish peasantry from the predatory excursions of his soldiers, as was made manifest to the whole army by his orders on the subject. Thus under date September 7th, 1809; "Notwithstanding the repeated orders given out upon the subject, the soldiers of the 4th Division of Infantry plundered beehives, in the neighbourhood of Badajoz: it is impossible these outrages can be committed daily, without the officers obtaining some knowledge of it. The officers with the army do not appear to be aware how much they suffer in the disgraceful and unmilitary practices of the soldiers, in marauding and plundering everything they lay their hands upon. The consequence is, the people of the country fly their habitations, no market is opened, and the officers, as well the soldiers, suffer in the privation of every comfort and every necessity, excepting their rations, from the neglect of the former, and the criminal misconduct of the latter." And again, September 12th; "The 4th Division having again, in three instances plundered beehives, etc., etc.," severe punishment was meted out to the entire division, "till the soldiers shall have been discovered who have been guilty of these outrages."

During the pause that ensued, while the army was settling into quarters about Badajoz, some interesting occurrences are thus briefly alluded to by our diarist.

Sept. 9th. We this day received the Gazette account of the Battle of Talavera; His Majesty's thanks in General Orders, and also letters from our friends in England.

Sept. 17th. Dined for the first time with Sir Arthur Wellesley; after dinner we drank his health as Viscount Wellington, when he first assumed the title.

Oct. 7th. This day Lt.-General Sherbrooke was invested with the Order of the Bath for his services at Talavera.

BADAJOZ, *September 12th*, 1809.

MY DEAR FATHER,

. . . I have also received a letter from you in which you were kind enough to desire that I would draw upon you for what money I might want; I beg to return you many thanks for your continued and more than fatherly goodness and forethought on my account; but am happy that I am able to go on without troubling you at this moment. From the nature of my duty as Adjutant, Qr.-Mr. and Paymaster to the R.M. Artificers, and indeed from the known good conduct of our officers, I can get whatever money I want from the Ordnance Paymaster, subject to a settlement at the end of our campaign; should it soon close I fear I shall be a little in want when we arrive in England; but if it continues a few months longer I trust I shall be pretty clear with the agents. This you can account for when you recollect the expense I have been at for horses, etc., and indeed although we endured for some time every privation of meat, drink, etc., short of absolutely starving, yet even at that moment we spent a good deal of money from the avidity with which every morsel of anything eatable was bought up at any price. Since I have been Adjutant I have lived with Col. Fletcher, and indeed manage the table, etc.; this is of course more expensive than living with another of our officers when attached to divisions, but at the same time it is more comfortable, as the Col. always gets a quarter near Sir Arthur's, and as the nights begin to get colder it is pleasanter sleeping in a house than in the field with the troops. It is now extremely warm in the day and rather cold in the night, which is very unhealthy and may perhaps account for the number of our sick, which is more than 10,000 including the wounded we left behind at Talavera. Our cavalry still continues in a very bad state. General Cattin Craufurd has this day joined us with seven or eight new regiments but for what purpose it is impossible to say; we begin to suspect that Ministers are mad enough to think of continuing to support the allies we have found in this country; if so I doubt not we shall do our duty in the next general battle, but should not be surprised if it ends in our ruin; we cannot afford to gain another victory at the price we paid on the field of Talavera. Out of less than 18,000 men which was our total that morning, 5,300 were either killed, or wounded, or taken before the action ended, and we have been obliged to leave 2,200 and odd behind at Talavera who of course have fallen into the enemy's hands (by the bye we have heard from Boothby of ours who lost his leg ; the French Army are vying with each other who should show our wounded the greatest attention). At Plasencia we left 600 sick, at Oropesa 200, and they are daily dying in the hospital at Elvas. You will think this a gloomy account, but I assure you it is perfectly correct, and so far from being in the dismals or melancholy, whilst writing this, you must know that I am in high spirits, that the weather is fine, and that we all feel not a little proud and gratified at the very handsome manner in which the King has been pleased to notice our conduct and to acknowledge it in General Orders to the rest of the army. I really think we ought all to have medals as well as the officers commanding corps; but at all events we expect to have Talavera on our appointments, etc.

I wrote to you last from Truxillo, since that we marched to Merida, and from thence, after halting 10 days, we arrived here on the 3rd instant. The army are all near this town. . . . Head Qrs. are here. This place is very strongly fortified for a Spanish town; but its situation is rather unfortunate, being commanded on most sides; it is about 120 miles from Lisbon to which city runs a good and level road. I suppose we shall halt here until the French choose to drive us from hence. This is a good large town and has never been plundered; everything may be had, but unreasonably dear. . . .

I have some idea of drawing a plan of the Battle of Talavera upon thin bank paper as soon as I have time and sending it in a letter to him—(Sir W. W. Wynn) do you think he would like it? You have not told me how Hollyhock goes on; I begin to think I shall still want him before this year is ended. I wish much I could get a newspaper sent; it is the greatest curiosity we can get! If we are not likely to quit this country soon, I wish much to have a newspaper at least once a week; I would write to Mr. Wharton about it, but I fear it would be very uncertain from him; the person at Foreign Department of the Post Office is the best if you know them. I sometimes see *Bell's Messenger* of one of our officers; therefore I do not wish that. Is it possible to get the Cambrian, Shrewsbury, or Chester papers to see the Welsh news also?

Your loving son,
RICE JONES.

While at Badajoz, Rice Jones took the opportunity of inspecting the neighbouring fortress of Elvas, on the Portuguese side of the frontier, and Fort La Lippe—so called after that distinguished soldier, the Count La Lippe, who had been sent at the request of the Marquis of Pombal, in 1762, by the British Government, for the purpose of reorganizing the Portuguese Army and commanding it during the war with Spain. The fort bearing his name is the sole remaining memorial of his work in Portugal: he designed it, and superintended its construction.

Elvas, previous to the French invasion, must have been a pleasant town. Beckford, on his visit to it in 1787, found the ramparts "laid out and planted much in the style of our English gardens, and forming very delightful walks."

Badajoz—apart from its military importance, was not without interest; for it was there that the Italian traveller, Baretti, met his old friend, Dr. Merosio, whose English wife could boast of the most extraordinary adventures that probably ever befell a woman of gentle birth. She had been in the four quarters of the world, and could speak several languages, including that of the native Indians in the neighbourhood of Goa, where she had resided as a maid-of-honour to the unfortunate Marchioness Tavora who was beheaded at Lisbon in 1758. She had also been in Japan with her first husband, a Dutch physician, to whom she was married at Batavia. After her return to Europe, she had been taken in a Portuguese ship by a Salee pirate, and would probably have passed her whole remaining life in captivity had she not been an Englishwoman; for, as such, she was redeemed along with the crew of an English vessel called the *Litchfield* which had been wrecked on the Barbary coast. After three years' captivity, she had been landed at Gibraltar, whence she wrote to her husband that during her residence in Morocco she had become a great favourite with the Sultana, and that the presents her mistress had made to her at parting would more than suffice to enable them to pass the remainder of their days in comfort. "A narrative of her life," adds Baretti, "would make a fine book, and if I see her in Italy, I will spirit her up to it, and offer her my services towards the work."

On October 8th Lord Wellington, accompanied by Col. Fletcher and Col. Murray set off for Lisbon, where they were followed by our author and several of his brother officers, halting at various places on the way, with varying accommodation. Thus at Vendas Novas, "We were billeted upon an Estalagem (Inn) where we were tolerably comfortable; we were obliged to sleep upon straw beds, but procured a very fair kind of dinner." Crossing the Tagus at Aldea Gallega, the party landed at Lisbon on the evening of October 12th—"went to my old landlord, No. 12, Rua Larga de San Roque, who invited me to take up my abode in his house again, which invitation I was induced to accept."

The following entries all have reference to those extensive defensive works for the protection of the capital, and—if the necessity arose—for covering the embarkation of the British Army, which became known as the "Lines of Torres Vedras," and which Lord Wellington decided on constructing, after consultation with his Chief Engineer, Col. Fletcher.

"The determination to commence these works," (the Lines of Torres Vedras) says Sir John Jones, "may be dated from the Battle of Talavera, when it became apparent to the Duke of Wellington that the contest would, in the next campaign, devolve on the small body of veteran British and newly-raised Portuguese troops under his command, and a defensive system of warfare ensue."

Oct. 14th. Rode to Fort St. Julian to sketch the ground intended to be occupied with a work. *Oct. 15th.* I was this day employed in drawing a plan of the ground I sketched yesterday. *Oct. 16th.* Colonel Fletcher accompanied Lord Wellington on an inspection of the country towards Sacavem and Castanheira. *Oct. 23rd.* Col. Fletcher accompanied Lord Wellington to Setubal. *Oct. 25th.* This being the 50th anniversary of our Gracious King's accession to the throne, we went to the Opera where a suitable ballet was performed. *Oct. 27th.* Lord Wellington left Lisbon to join the army at Badajoz. *Nov. 2nd.* The Col. and all the other officers (Royal Engineers) who have arrived from the army set out for Sobral, leaving myself and two others in Lisbon.

LISBON, *October 22nd*, 1809.

MY DEAR FATHER,

I have been for some time most anxiously expecting to hear from you; your last letter being more than two months old. . . . As I know you are extremely good, and particularly about writing, I begin to think some of your letters have miscarried. I hope to God nothing has happened to prevent your writing.

You will no doubt be surprised to find this letter dated from Lisbon until I inform you that Lord Viscount Wellington set out from Badajoz for this place on the 8th instant, accompanied by a few of his staff, the Qr.-Mr.-Genl. and our Chief in whose suite I have travelled thus far, together with Capt. Chapman. There are a number of reports on the subject of this visit. I know that his Lordship and the Col. have been riding all over the country for 30 miles round, and have nearly knocked up Col. Fletcher's stud; from which it is easy to conclude that the ground to be occupied for the defence of Lisbon is a material part of the Commander of the Forces' business at this place. I will also tell you what is an impenetrable secret at present even to our officers; viz., that *all* our Corps are ordered from the army to a place called Castanheira, about 30 miles higher up and on the same side of the Tagus as this city. The Col. talks of setting out for Castanheira to-morrow or the next day; I of course shall accompany him, and understand there are a great number of works in contemplation. These measures look too much like a determination on the part of Ministers to defend Portugal to the last extremity; that extremity will certainly arise as soon as the French are able to advance in any force, and we shall then very likely have just such a scramble to get off as the army at Corunna had last year. If we are obliged to fight another battle I do not doubt but the victory will be ours; but an army in the state of ours at this moment cannot afford to purchase victories at the rate we paid for that of Talavera. These are not more my sentiments than those of almost every officer in the army—not excepting the Second in command, the Staff or Chief Engineer.

The above is the state of politics here; we are looking most eagerly for yours in England. We daily hear of new ministries, partial changes, etc., but know not what to think will be the result. The Ambassador, Mr. Villiers, quits this country shortly, and Sir Rt. Wilson goes home on leave, I believe, in the same packet with this letter; he talks of returning in two months.

In my last letter I mentioned my intention of sending Sir W. W. Wynn a sketch of the scene of action at Talavera, and had actually begun upon it when I was suddenly ordered to this place, since which time I have been unable to do anything more towards its completion. . . . Since writing to you last, I continue in good health, although I feel rather weakened or debilitated, which can easily be accounted for from the very exceptional heat we always experienced in Spain during the days, and the comparatively great cold of the night, which latter circumstance we of course felt more in consequence of sleeping out without cover and being in want of meat and drink. I have however great reason to be thankful I continue so well as I do, the army being in general in an unhealthy state still. Our future operations are likely to be for some time in a good country with plenty of provisions, etc., and, I fancy, without being eaten up by the rest of our army. I shall now conclude, begging you will be so good as to give my best love to my dear mother and to my dear brothers and sisters. . . . Since my last letter I have had the pleasure of remembering three of them on their birthday. . . . You see I keep a correct Roster.

I am, my dear father,
Your loving son,
RICE JONES.

During the next few months, Jones was actively employed on the construction of the works at the western extremity of the Lines of Torres Vedras. The actual commencement of these celebrated defences took place on the following dates, respectively:—St. Julian, November 3rd; Monte Agraça (the great redoubt in the centre of the position, overlooking Sobral), November 4th; Torres Vedras, November 8th.

Reverting to the Diary:—*November 29.* Rode to Sobral, where I mustered and paid the artificers. Returned to Lisbon after looking at the works.

December 9th. My dear father's birthday, may he enjoy very many and happy returns of it. The army began to move from Badajoz to the north of the Tagus. Sold the horse I bought at Zaza la Mayor for 30 Dollars.

LISBON, 11*th November*, 1809.

MY DEAR FATHER,

I am quite at a loss to account for my not having received a letter from you yet, and the more so as I know you are very regular about writing. The last letter I received from you was dated the 17th August immediately upon the receipt of my letters from Talavera; since that time I have written to you from Truxillo, from Badajoz, and lastly from this place on the 22nd ult. Three Packets arrived here a day or two ago, having been due for some time; they have brought letters to the beginning of this month; I fancied I was certain of receiving a letter at least amongst the three Packets, and you may perhaps conceive my disappointment at finding none. I assure you I begin to feel quite uneasy, fearing that something or other has happened to prevent you writing. To hear from you is the only comfort I can enjoy in this country, and I am now very melancholy at times in consequence of my present deprivation of that pleasure.

Lord Wellington left us here on the 27th ult., to join the army at Badajoz, and has since that gone to Seville. Our troops occupy their old line from Merida to Badajoz, and a most unfortunate line it has been for us. In one of my last letters I told you how very unhealthy the army were, and I now understand that the sickness increases rather than diminishes, so that if we occupy our present ground long (which is notoriously unhealthy even for the natives) our army will soon be in an extremely bad state to take the Field. Officers in a state of severe illness arrive here daily from the army, and many have been obliged to go to England. All the officers of our Corps, who, as I before informed you were ordered from the army, are now distributed at Fort St. Julian, Torres Vedras, Sobral and Castanheira; at three former places works are now throwing up; at the latter we are making accurate plans of some positions. I am the only officer here except Hamilton who continues so lame since he was wounded at Oporto that he cannot walk about, even in the house, without difficulty. I have had a good deal to do here since the Colonel has been gone; all his correspondence necessarily passes through Lisbon, where the Depôts of all kinds, as well as the heads of departments, are; for this reason, principally, the Colonel left me here when he went away; although I believe he was fearful that my health would perhaps suffer by much exertion out of doors, and thought I could be useful here, which I trust the event has proved. I am a good deal better and stronger than when I first came here; I have not yet been ill, although I am in general far from well; I am taking Bark at present. The Colonel behaves extremely kind to me in every respect. Although I volunteered accompanying him as usual, he would not allow me, until the doctor says I am stronger.

I am not certain whether I told you in my last letter that I am in my old Quarters; my landlord very civilly kept them for my return, and insisted upon my occupying them, without another billet. I am billeted on the same house as the Colonel, which is usually the case; but, however, as our accommodations were not on the grandest scale, I determined to comply with my landlord's kind wishes. With assurances of my best love to my dear mother, and to all my dear brothers and sisters,

I remain, your affectionate son,

RICE JONES.

P.S.—Be so good as to make my compliments, etc., which I generally trouble you with, to Sir W. W. Jones and all the family. Let me know what is going on in England and also in Wales. We cannot imagine what will become of us amidst all the changes, etc., which are taking place.

LISBON, *December 16th*, 1809.

MY DEAR FATHER,

It was with great pleasure that I received your kind letter of the 20th ult. two days ago, and found you all still enjoyed your health; many thanks for the enquiries and directions you have sent me. I am now very well thank God, and feel as strong as ever. I had quite forgotten that Mr. Steed was in the Royal Dragoons; they are quartered at Belem, about 3 miles from this city. I will call upon Mr. Steed when I ride that way next, for I like much to see any of my own, or of my dear father's acquaintances; I recollect him very well when I was a Cadet. I am very much obliged for the news you give me; you cannot imagine how eager we all are to know what is going on in England; our fate will depend, I suppose, in great measure upon the stability of the Ministry. If you are in London, will you have the goodness to see if it is possible to send me a weekly newspaper; I understand the only way of ensuring its regular arrival is by getting it from the person who is at the Foreign Branch of the General Post Office. I sometimes see *Bell's Messenger*, but as it belongs to another of our officers, it very often happens that he is not quartered with us, and we then, of course, miss it. I believe there is one weekly paper (I think the *Phœnix*) which has the Gazette Promotions in it, but of this I am not certain. You will very likely think that the Promotions will not much concern me; but I must remind you that I do not expect to be many months of my present rank in the Service. As I form part of the Colonel's family, he will, I know, be glad of my getting a paper, for he has only Motley's Portsmouth one, which arrives but seldom, and then about a month or two in arrears.

Col. Fletcher has been here about nearly a fortnight, but is now gone again upon his circuit of the Works in this vicinity; he has determined upon my remaining here as the most central spot to conduct his correspondence. Everything in our Department goes on as well as can be wished in this country; but it is said that such was not the case with the Army before Flushing. Pray tell what is said about it in England; we of course wish to know how the Corps get on in other parts of the world; but are very seldom favoured with intelligence. Capt. Goldfinch remains here to superintend and report upon the works the Portuguese have been throwing up near here. Ross is gone back to join the army; he begged his compliments to you and my dear mother. The Colonel talked, whilst he was here last, of endeavouring to obtain Lord Wellington's permission to join the army when he next returned to Lisbon, as by that time (about three weeks or a month) the Works will be so far completed as not to require his presence. If he goes, I shall of course go with him, for he has repeatedly promised me that if he is in action I shall be so likewise. The others, I fancy, will remain until everything is completed. The Colonel has some anxiety to join the army, thinking it probable the French may receive the reinforcements which will undoubtedly be sent them, sooner or later, to enable them to attack us before April or May. Be that as it may, I am glad our army has quitted Spain—I hope for ever; it has been an unfortunate country for British armies. On your Birthday (which I assure you did not pass without many a sincere wish that you may enjoy many, very many happy ones yet) the army began their march towards Portalegre, and are to cross the Tagus at Villa Velha and Abrantes; the latter place is to be once more Head Quarters; our advance will be at Castello Branco; Abrantes being only 90 miles off, with a good road, plentiful country, and some good positions for defence, and the river Tagus navigable all the way up, is in every way a preferable situation to the banks of the unhealthy Guadiana, from Merida to Badajoz. I do not doubt but our troops will soon be restored on the banks of the Tagus to that health which they almost all lost on the banks of the Guadiana. I am as unfortunate as ever in horses; a beast of a baggage-horse that I bought whilst on a reconnoitring expedition in Spain, was upon my arrival here completely knocked up, as well as myself. Ever since I have been endeavouring to recover him for a march, but to no purpose. I was therefore glad to accept 30 dollars for him yesterday, as he was daily getting worse. I gave 60 dollars for him; you will therefore perceive my loss is 30. I expect I shall be obliged to give about 80 dollars to replace him. My servant William behaves extremely well; he has been very ill indeed, but is now tolerably well recovered. . . .

Your very affectionate son,

RICE JONES.

P.S.—I now learn that part at least of our army are to march through Leyria, and very probably thro' Coimbra; this is to me utterly inexplicable; however, a few days must inform us when and wherefore these movements are made.

December 17th. Taken ill this evening. *December 22nd.* The first day I have been able to dine at the Mess since Sunday, having been confined by a sore throat. *December 27th.* Rode to Torres Vedras through Loisa to the left of the Cabeca de Monte Chico. Mustered and settled with the artificers, and afterwards went round the works. *December 29th.* Rode from Torres Vedras to Sobral, thro' Runa, Ribaldeira, and Dous Portas; settled with the artificers. *December 30th.* Rode from Sobral to Aruda, from thence to Castanheira. *Sunday, December 31st.* Went to Carrigada with Chapman; fixed upon the Quinta of the Conde de Loisa for our quarters. Rode to Lisbon to dinner.

And here a few words of explanation with respect to the manner in which the works were constructed may prove of interest to the non-professional reader. Major-General Sir John T. Jones, R.E., who, as a captain was employed on the Lines, tells us that the position and nature of the several works having been determined on, these were pressed forward; and that the young officers of Engineers, now, for the first time, placed in charge of extensive districts "exerted themselves with a zeal which knew no limits, and everywhere throughout the Lines a spirit of honourable emulation proved highly advantageous to the progress of the work." The peasantry of the country were put into requisition as labourers; overseers, directors, and artificers were furnished by a detachment of British infantry, and "no petty cavils about official forms of expenditure were allowed to impede the supply of materials and stores."

It was a novel *rôle* for young officers, and the duties proved excessively arduous; but there were compensations. To quote from Sir John Jones:—"The British officers, spread singly over a space of

150 square miles of country, and billeting themselves in the best and most convenient houses, were everywhere treated with civility and kindness by the inhabitants, and a general readiness was shown by the upper classes to admit them to the familiar society of their families, which led to many sincere and disinterested friendships being contracted between the individuals of the two nations. Indeed it is but a tribute of justice to the Portuguese gentlemen and peasantry of Estramadura to state that, during many months of constant personal intercourse, both public and private, the latter ever showed themselves respectful, industrious, docile and obedient ; whilst the former in every public transaction evinced much intelligence, good sense, and probity, and appeared in their domestic relations kind, liberal, and indulgent, both as masters and parents."

In order to realize the anomalous nature of the situation created, we must try and picture what the attitude of our own people would have been, *vis-à-vis* of a number of young Portuguese officers placed in charge of the defensive works which were being constructed along the south coast of England at the time of Napoleon's threatened invasion. The truly admirable behaviour of the Portuguese, of all classes, under very trying circumstances was worthy of commendation.

(*To be continued*).

TRANSCRIPTS.

SPECIALIZATION OF ENGINEER SERVICES IN THE AUSTRIAN ARMY.

We are indebted to the Army Council for the following:—

(1). The attached paper may be of interest, as typical of the tendency to specialization of engineer duties, which has been lately noticeable in the Austrian Army. The Engineer Staff and the Military Works Department have long been separated from the so-called "Technical Troops," to which all ordinary engineer duties in the field were allotted.

(2). Until the beginning of this year the "Technical Troops" consisted of—

(*a*). The Railway and Telegraph Regiment.
(*b*). The Pioneer Troops.

(3). The Railway and Telegraph Regiment has, in the course of this year, been split up into two distinct regiments—

(1). The Railway Regiment.
(2). The Telegraph Regiment.

These two regiments, have been allotted to a newly organized formation, known as the "Communication Troops Brigade" which includes, besides the Railway and Telegraph Regiments, the Army Air Corps, and the Automobile Service. The Brigade occupies a peculiar position, in that, for all matters other than discipline, it is directly under the orders of the General Staff of the War Office.

(4). The remaining "Technical Troops" known as the Pioneer Troops are now to be divided into two distinct branches, under the designation of Sappers and Pioneers respectively, for land and water duty respectively. Although it is admitted that the work of the two branches must to a certain extent overlap, it is claimed in the Austrian military press that increased efficiency, especially under the conditions of the newly introduced two-year service, will result.

Reorganization of Engineer Troops.

(From *Fremdenblatt*, July, 1912).

The 15 battalions of Pioneer Troops are to be divided into two separate independent branches, viz.:—

(*a*). Pioneers (Pioniertruppen), for all river and stream work.
(*b*). Sappers (Sappeurtruppen), for all land work.

There will be 14 sapper battalions and 8 pioneer battalions. In addition there will be special formations for bridging and submarine mining (in connection with rivers). There will be two Inspector-Generals, one of sappers, and one of pioneers.

(1). The duties of the pioneers will include bridge-building of all kinds, work in connection with barges and water transport of all kinds, (except marine). Care of water lines of communication. To a smaller extent, demolitions, use of explosives, field fortification, care and construction of roads.

(2). The duties of the special formations will be—

(a). The Bridging Battalion —construction of semi-permanent bridges, employment of the transportable iron bridging material.

(b). The River Submarine Company—all work connected with the mining of rivers.

(3). The duties of the sappers will include all work connected with the attack and defence of fortresses, field fortification of all kinds, demolitions and the use of explosives, construction of temporary and semi-permanent bridges, care and construction of roads. To a smaller extent, railway and telegraph work.

(4). The sapper battalions are to be consecutively numbered from 1 to 14. Each battalion will consist of three companies, except No. 14 which will have four.

The pioneer battalions are to have the numbers 2, 3, 4, 5, 7, 8, 9, 10. Each battalion will consist of four companies. The missing numbers 1 and 6 will be represented by the new special formations, viz. the River Submarine Company and the Bridging Battalions. These are to be formed from the present cadres which now form part of No. 1 and No. 6 Pioneer Battalions respectively.

The new organization is to come into force forthwith.

A. H. OLLIVANT.

War Office, S.W. *Major, G.S.*

REPORT ON ARTIFICIAL ILLUMINANTS, OTHER THAN ELECTRIC, SUITABLE FOR BARRACKS, WORKSHOPS AND LARGE OPEN SPACES.

(*Concluded*).

By CAPT. L. N. MALAN, R.E.

C.—ACETYLENE.

1. *General.*—Acetylene and its uses is fully discussed in *Acetylene* by Leeds and Butterfield, published by Griffen & Co., so that only a brief description is necessary in this report.

2. *Nature of Calcium Carbide.*—Acetylene is a gas produced by the action of water on calcium carbide. Calcium carbide (CaC_2) is a solid that can only be made on a commercial scale in the electric furnace in which lime and coke are subjected to great heat; and it is therefore beyond the power of the user to manufacture. No heat possible of attainment short of the electric furnace has any effect whatever on carbide, but when treated with a liquid that is essentially water, or that contains water, an inflammable and on occasions an explosive gas is at once evolved. Carbide must therefore be stored in air-tight tins or drums to which no moisture can in any way penetrate, for in the absence of this precaution the storage of carbide will always be attended with considerable risk of fire, a point which should by no means be overlooked. Special rules for its storage are given in the above-mentioned work, to which a reference may be made.

3. *Generation of Acetylene.*—When water meets with calcium carbide, acetylene (C_2H_2) and lime (CaO) are produced, the chemical formula being—

$$CaC_2 + H_2O = C_2H_2 + CaO.$$

One pound of good carbide should produce about 5 cubic feet of acetylene.

This reaction is one of extreme rapidity, and is in consequence always accompanied by heat, and this heat, while not affecting the carbide itself, tends to polymerize the acetylene into tar, which coats the carbide and checks the further generation of gas. In any generating chamber in which the above reaction may take place, it is therefore very desirable that the water shall always be in excess, as a safeguard against excessive heat.

4. *Nature of Acetylene.*—Acetylene once set free ranks simply as an inflammable, moisture-laden, somewhat impure, illuminating and heat-giving gas which has to be dried, purified, stored and led to the place of combustion; it is in this respect precisely analogous to coal gas, like which when mixed with air in certain proportions it is explosive. To obtain an explosive mixture with air, coal gas has to be present as 7·9 per cent. of the volume of the mixture, acetylene and air are explosive when the former is only 3·35 of the volume.

It is therefore of the utmost importance to prevent leaks of acetylene, and to guard against any explosive mixture being formed in the pipes or generating apparatus.

Acetylene is soluble in many liquids, of which an exhaustive table is given on page 179 of the work already referred to, and it is therefore important that the liquid seals of the generating apparatus shall be such that acetylene is soluble to the least degree attainable, the best of all being a saturated solution of calcium chloride.

Acetylene, as ordinarily prepared, is a powerful toxic poison chiefly on account of the sulphuretted hydrogen and phosphine present, and it has moreover, unless perfectly pure, an exceedingly penetrating and unpleasant smell.

A well-designed generating plant should, however, produce acetylene sufficiently pure to have no worse a smell or greater toxic action than ordinary coal gas, and acetylene is superior to coal gas in that it is said not to vitiate the atmosphere nearly to the same degree.

Copper should never be used in connection with acetylene, as it reacts on this metal to a marked and dangerous degree.

5. *Waste Products.*—The waste product or sludge consists of lime more or less impure. It is easy to remove from the apparatus while still wet, but once it is allowed to dry it hardens and can only be removed with difficulty, and this should never be allowed to take place. It is said that the sludge can successfully be used in mortar for building purposes, or for the lime washing of outhouses and cattle pens or as a garden manure, but no case of such use can be quoted here, the sludge generally being treated as useless and thrown away.

6. *Generators.*—Acetylene generators may be classified under two distinct heads, "Non-automatic" and "Automatic," which, in turn, may be of two distinct types, "carbide to water" and "water to carbide."

In the non-automatic type the whole of the carbide put into the apparatus is decomposed into acetylene and sludge as soon after the charge is inserted as is natural in the circumstances, and the gas is stored until required for use. On the other hand, in the automatic type the fundamental idea is that acetylene shall only be produced in response to a demand for gas and that when the flow of gas through the mains ceases, generation of gas shall also cease. The former type of apparatus necessitates a gas holder sufficiently large to contain all the gas that may be required before the next charge of carbide is inserted and more gas made, while in the latter type the gas holder need only be sufficiently large to equalize the pressure in the pipes. Each type has its merits and may be employed according to local conditions, the automatic plant being more convenient for small installations, while a very large plant such as that required for a public supply is certainly better if non-automatic.

The chemical reaction of carbide and water may be brought about in two ways, (i.) by adding carbide to the water, or (ii.) by adding water to carbide, these being the principles of the two types that bear these names. Since water is a liquid, it is more convenient of the two substances to control with the regularity required, at any rate, in the automatic plant; while on the other hand carbide is usually obtained in lumps of irregular size and shape, which alter directly moisture attacks them and produce a damp muddy mass which it is manifestly more difficult to feed by mechanical means and yet keep under perfect control. Assuming, however, that these mechanical disadvantages have been successfully overcome, the plan of adding carbide to water will always ensure water being in excess, and this has already been shown to be the more desirable state of affairs. In the water-to-carbide type of generator means should be provided to ensure that water shall be in excess in the actual place where the decomposition of the carbide takes place.

7. *Manufacture of Acetylene.*—The various methods of generating acetylene are fully discussed, and many different plants described in the work referred to at the beginning of this section. It will therefore suffice only briefly to describe the various stages of its manufacture.

A generator usually consists of a compartment or compartments in which water and carbide are allowed to react on one another and produce acetylene. The acetylene then passes through the condenser or washer and thence into the pressure regulating holder, from which it flows to the pipes through the purifier. For the reason that a purifier will naturally act best when the gas is passing at a uniform rate, instead of by rushes as it does from the generating chamber, the proper place for the purifier is, as stated, after the regulating holder. It is indispensable that all acetylene plants should be provided with a safety valve, in the form of a vent pipe open to the outer air, that will enable the gas in the holder to pass harmlessly away should generation for any reason still proceed after the consumption has ceased.

It will be seen from the above that acetylene plants are simple, easy to maintain and require no further attention, than cleaning out and recharging when required. They contain no engine or moving parts liable to get out of order, and automatic plants reasonably cared for are moreover always ready to produce gas when wanted and do not require starting or stopping by other agency than the turning on and lighting of any of the burners attached to the system.

8. *Siting of Plants.*—Acetylene plants on account of the inflammability of the gas should invariably be installed in an outhouse or shed away from the main building, which should never in any circumstances be entered with a naked light or when smoking. All artificial lighting, when necessary, should be from the outside in a similar way to the lighting of a magazine.

In dimensions automatic plants vary according to pattern and capacity but except in cases of unusual size may generally be comfortably housed in a room not exceeding 10′ × 10′.

9. *Illuminating Power.*—In light giving powers per given volume acetylene is far superior to coal or other gas. While 1 cubic foot of coal gas per hour will under the best conditions with a mantle only give 20 candle-power, acetylene burnt at this rate in an open flame will give a light of from 30 to 50 candles, and with a mantle 140 candles is said to have been reached. Acetylene, moreover, burns with a luminous flame without smoke, and is in this respect superior to any other flame illuminant in common use.

10. *Pipes and Fittings.*—The pipes required to bring acetylene up to the burner are on the above account much smaller than those required for coal gas, and may be from ¼ in. upwards in size.

Pipes and fittings must be of the very best workmanship and material, and better and more carefully laid than is necessary in the case of coal gas.

The pressure required at the burners may be taken as 4 in. of water column as a maximum, and to ensure this a pressure of 12 in. in the generator should always be sufficient.

The burners employed with acetylene are of special design and are made in sizes to burn ½ or 1 cubic foot per hour. The orifices for the egress of gas are very small and in order to prevent these small holes being choked with carbon deposit the burners are so arranged that the actual flame cannot reach the orifice itself. Acetylene may also be employed with the incandescent mantle, as referred to above, but is not commonly so used.

11. *Suitability of Acetylene.*—Acetylene, although not more expensive to install than air gas, is undoubtedly more costly to maintain and cannot be considered as altogether suitable for lighting barracks.

The light given is, however, a very steady and pleasing one and produces little heat; it is therefore very well suited to private houses, and places where artistic effect is of any importance.

12. *Costs.*—A small acetylene plant at Tidworth cost complete £42 for 21 lights of 24 candle-power each, or £2 per point, while a larger plant at Longford Barracks comprising 250 lights aggregating 4,245 candle-power cost to install £800, or £3·2 per point.

The plant at Tidworth is said to cost 7·7 pence per 1,000 candle-power hours, while the following figures are given for the plant at Longford for one year:—

95	10-c.p. burners	for	99,036	burner hours or	9,90,360	c.p. hours.
66	15-c.p.	,, ,,	51,074	,, ,,	7,66,110	,,
44	20-c.p.	,, ,,	58,174	,, ,,	11,63,580	,,
25	25-c.p.	,, ,,	32,408	,, ,,	8,10,200	,,
15	30-c.p.	,, ,,	73	,, ,,	2,190	,,
11	40-c.p.	,, ,,	1,340	,, ,,	53,600	,,
					37,86,040	

The costs for one year are given as—

	£	s.	d.
Carbide 9·27 tons at £16 per ton	148	6	3
Sundries	2	1	3
Labour at 6d. a day	9	2	6
Maintenance pipes	4	0	0
,, burners	5	12	0
Interest on capital	22	0	0
Depreciation	17	10	0
Total	£208	12	0

This works out at about 1s. 1d. per 1,000 candle-power hours. Figures were also obtained from the Railway workshops of the Great Western Railway at the Severn Tunnel Junction which show that for about 3,780,000 candle-power hours per annum 7¼ tons of carbide are required or 7·6d. per 1,000 candle-power hours for carbide alone, the cost including interest, labour and depreciation at rates similar to those given for Longford being about 11½d. per 1,000 candle-power hours.

It may therefore be said that acetylene will not cost much under 1s. per 1,000 candle-power hours to maintain, while the initial cost may be anything between £2 and £3 per point. Where mantles are employed with acetylene the cost per 1,000 candle-power hours can be reduced to about 8d.

13. *Flares.*—Acetylene is also used to a great extent in flares for the lighting of large areas and open spaces, and many portable and convenient forms of such apparatus are now on the market, giving light up to 2,500 c.p. a piece, and said to cost only 4d. per hour to work.

14. *Searchlight.*—A portable searchlight has lately been brought out by Messrs. Chance Bros., of 148, Edmund Street, Birmingham, in which acetylene and oxygen are employed.

The plant (known as the Sunrob Portable Searchlight) comprises the following fittings, inclusive of one hour's charge :—

Name of Part.	Weight.
Projector complete with lamp and reflector ...	34½ lbs.
Lense 30°	5½ ,,
,, 10°	4½ ,,
Oxygen generator	14¼ ,,
Kneeling board for directing	5¼ ,,
Rods for elevating and traversing	3½ ,,
Tripod	9½ ,,
Accessory Box with tools	2½ ,,
Tubes, rubber (2 in number)	1¾ ,,
Pump	1 ,,
Total	82¼ ,,

Charge for one hour's run—

Acetylene charge each	$0\frac{12}{16}$ lbs. 8d. each.
Oxylithe ,, ,, ...	$1\frac{14}{16}$,, 4s. 9d. each.
Average say ...	3 lbs. complete charge.
Total weight with 1 charge ...	85 lbs.

The body of the projector is constructed to carry two types of burners :—

(1). Single batswing burner for acetylene only.

(2). Zirconia disc in conjunction with oxy-acetylene.

The latter gives a more powerful light said to be equivalent to a 10-ampère electric arc produced in a projector of similar size. The life of the zirconia disc is said to be somewhat uncertain and renewals cost 6s. each.

The lamp which only weighs 85 lbs. complete with one charge is very portable and may be traversed and elevated from under cover, by means of the rods supplied.

The price is £110 complete, and the plant costs about 6s. an hour to run, exclusive of labour, depreciation and interest.

D.—OIL.

1. *General.*—Lighting by oil is one of the oldest methods of artificial illumination, and dates back to very early times. Various kinds of animal and vegetable oils have in the past been employed, but at the present time oils other than kerosene or other products of petroleum are only used to a limited extent. Kerosene, which is one of the heavier distillates of petroleum and has a specific gravity of about 0·810, requires a liberal supply of air for its complete combustion, and is employed in many different forms of lamp.

2. *Wick Lamps.*—The oldest and commonest form in general use is that in which oil is brought to the burner by the capillary action of a wick. Such lamps may be of the circular, single, and double wick, or of the Argand type, which on the whole is perhaps the most satisfactory.

The Argand principle can be applied to the ordinary upright burner, in which case a tubular wick is supplied with air by a central air passage, the air being forced into intimate contact with the oil vapour from the wick by means of a diffuser. This principle is also adapted to inverted lamps designed to give a more powerful light and their action may be said to be substantially the same as that of the regenerative gas burner described in Section A.

Oil lamps of the above types consume about 45 to 50 grains per candle-power hour, while with kerosene of specific gravity 0·800 is equivalent to from 1,120 to 1,244 candle-power hours per gallon. With kerosene at 6d. per gallon, 1,000 candle-power hours will cost from 5·35d. to 4·8d., exclusive of depreciation and upkeep of lamps, labour and renewal of wicks and chimneys, or say from 8d. to 9d. inclusive of these.

Oil lamps require a considerable amount of labour to keep clean, and are seldom so well kept in barracks as to burn at their highest efficiency. The cost per given amount of light including labour, depreciation, maintenance and in efficiency is therefore almost impossible to exactly determine but is certainly something more than the above figures.

3. *Mantle Lamps.*—Lamps are also made to burn oil efficiently under an incandescent mantle, the earliest form of such a lamp being the Kitson system. In lamps of this class the oil is contained in a strong tank under a pressure of about 50—60 lbs. to the square inch, and is injected through a fine tube into a chamber where it is heated by the waste heat of the lamp itself. The vapour thus produced is forced out by its own pressure through a small jet into an atmospheric burner when it draws in sufficient air to ensure its complete combustion with a non-luminous flame.

Incandescent oil lamps are made in two general forms known as the "System" or "Installation" and the "Self-Contained." In the former case several lamps are supplied with oil from one central tank by means of fine bronze or copper tubing, it being claimed by makers that as many as 500 lamps can be supplied from the one tank or set of tanks. The latter form carries in its own oil tank sufficient oil for 16—24 hours burning. These lamps require to be started by warming up the burners until hot enough to vapourize the oil, the usual method employed being by burning a measured quantity of spirit in a cup fitted to the lamp for the purpose. It is claimed that in 1½—2 minutes the burner will be sufficiently hot and the oil may be turned on.

These lamps are made in sizes from 300 to 1,000 candle-power each, and cost from £5 for a small "Installation" lamp complete with tank and pump, to £9 10s. for a large "Self-Contained" pattern. It is claimed that with these lamps, including renewal of mantles and labour, 1,000 candle-power hours cost under 1d., a claim which may reasonably be taken as not far from the truth, if depreciation and interest be excluded.

4. *Flares.*—Another type of lamp burning oil, of which a well-known form is the Wells Light, is somewhat similar to the above which indeed is but a modification of it suitable to the requirements of a mantle. In this lamp oil is forced from a tank by a pressure of air of about 20 lbs. to the square inch into a casing surrounding the burner. The oil is here vapourized and forced out through a jet into the combustion chamber where it draws in the air required and burns with long solid luminous flame sometimes as much as 3 ft. in length and having an illuminating power up to 3,500 candle-power. This lamp also requires to be started by heating the burner, which may readily be done by burning a piece of waste soaked in oil.

These lamps, which are self-contained and weigh from 30 to 350 lbs full, are only suitable for illuminating large areas out of doors, and for this purpose their use at the present day is well recognized. Lamps of this type, which vary in price from £7 7s. to £17 15s. according to size, will give from 500 to 3,500 candle-power with a consumption of oil of about 1 gallon per 1,000 to 1,200 candle-power hours, which is much the same cost as that of the ordinary oil lamps already discussed.

5. *Oil Gas.*—Oil gas has been used as an illuminant from the earliest times both in the form of the natural product as it comes out of the ground, or as manufactured by the retorting of oil. It is not, however, in common use except for special purposes such as the lighting of railway carriages, ships, buoys and lighthouses, for which it is particularly suitable on account of the fact that it suffers less deterioration from compression than any other form of gas. Oil gas is also used for the enrichment of coal gas. A description of its manufacture is therefore out of place in this report, but further details may if required be found in *Petroleum and its Products*, by Sir Boverton Redwood.

E.—Mineral Spirit.

1. Besides air gas which has already been dealt with in Section B, mineral spirit is used in a variety of forms of lamps for illuminating purposes, from the small domestic hand lamp to the costermonger's outdoor lamp of tin.

2. In general principles the reservoir is filled with an absorbent material into which only as much spirit as can be absorbed is poured. The spirit is vapourized and burned at a jet either with or without previous admixture with air, according to the type of lamp used.

A simple form consists of a reservoir from which a tube extends downwards terminating in an Argand burner. The vapour, from the saturated contents of the reservoir being heavier than air, flows downwards under sufficient pressure to draw in the air required and burn with a steady flame.

Lamps of the above nature are suitable for domestic and other uses, but are not well adapted for use in barracks.

3. A useful and efficient form of vapour lamp suitable for domestic use is known as the "Petrolite" lamp which requires petrol of specific gravity 0·680. This lamp is similar in principle to the above, but is provided with a long glass chimney to produce a sufficient draught to draw up air through the saturated absorbent contents of the retainer to the burner. The resultant mixture is then mixed with the further amount of air required and is burnt under an incandescent mantle. These lamps are safe, as if the chimney is broken or the lamp upset, the necessary draught is then cut off and the light goes out. Their cost amounts to about 5d. per 1,000 candle-power hours.

4. Another but different form of mineral spirit lighting is that known as "Simpetrol System A," which is suitable for small installations up to about 10 lights, and is more or less portable.

This system is similar to that already described under Section D, paragraph 3, with the exception that petrol is used instead of oil. The petrol forced by air pressure in the tank passes through a fine copper tube to a coil over the burner, where it is heated and vapourized, and then burned under a mantle in a Bunsen burner.

A plant of this make consisting of 4,300 candle-power lights installed in a Sergeants' Mess at Tidworth has given no trouble. The initial cost was £18, and it is reported to cost 1·1d. per 1,000 candle-power hours to maintain.

APPENDIX I.

Comparative Table of Approximate Costs of Various Illuminants per 1,000 Candle-Power Hours.

Electricity at 4d. per unit.
Coal gas at 3s. per 1,000 cubic feet.
Petrol at 10d. per gallon.
Carbide at £16 per ton.
Kerosene at 6d. per gallon.

	Pence.	Smallest Unit in Candle-Power.
Electric flame arc	1	*
Incandescent high-pressure oil	1¼	300
Incandescent high-pressure gas	1½	60
Petrol air gas	1½—2	25
Incandescent low-pressure gas	3	30
Electric open arc	3	*
Electric closed arc	4	*
Petrolite vapour lamp	5	40
Tungsten electric glow lamp (metallic) ...	5	32 at 220 volts.
Regenerative gas burner	5½	100
Alternating arc lamp	6½	...*
Tantalum electric glow lamp (metallic) ...	7½	22 at 220 volts.
Acetylene incandescent mantle	8	70
Oil lamp	8—9	Variable.
Argand gas burner	10	10
Acetylene flame burner	12	15
Flat flame gas burner	14	10
Carbon filament electric glow lamp ...	14½	5

* The candle-power given by an electric arc is not exactly determinable, being dependent on point of view, shading and other variable factors. The minimum candle-power from an unshaded arc lamp may be taken at about 250 c.p.

APPENDIX II.

Books Consulted.

"Petroleum and Its Products," Sir Boverton Redwood: published by Griffen & Co., 1906.
"Acetylene, Its Generation and Use," Leeds and Butterfield: published by Griffen & Co., 1910.
"Petrol Air Gas," Henry O'Connor: published by Crosby, Lockwood & Son, 1909.
"The Art of Illumination," Louis Bell: published by Constable & Co., 1903.
"Service Chemistry," Lewes & Brame: published by Glaisher, 1906.
Cantor Lectures—Modern Methods of Artificial Illumination delivered by Leon Gaster, A.M.I.E.E., 1909.

Firms and Installations.

Coal Gas.

Aldershot Gas Works.
Bland Light Syndicate, 29, Little Trinity Lane, Queen Victoria Street, London, S.W.
Webb Lamp Co., Ltd., 11, Poultry, London, E.C.
Humphrey & Glasgow (Carburetted Water Gas), 38, Victoria Street, London, S.W.

Air Gas.

Machine Gas Co., Welsbach House, Grays Inn Road, London. (Installations in barracks at Tidworth, Fort George and Lydd).

Strode & Co. (Aerogen), 67, St. Paul's Church Yard, E.C. (Army Accounts Building, Aldershot).

Non-Explosive Gas Co., 13*a*, Commercial Road, Pimlico, London, S.W. (Private installation near Oxford).

Loco. Gas Co., 15, Newman Street, Oxford Street, London, W.

Drake & Gorham, 66, Victoria Street, London, S.W.

National Air Gas Co., 18, Buckingham Palace Road, London, S.W. (Concert hall at Tidworth).

Centenary Gas Co., 109, Hope Street, Glasgow. (Gymnasium at Tidworth).

North British Plumbing Co. (Mitchellite), 15, Carteret Street, Westminster, London, S.W. (Institute at Tidworth).

British and Colonial Lighting Co. (Simpetrol System C), 216, Tottenham Court Road, London, W. (Barracks at Bordon Camp).

Praed Safety Gas Co., 20, Victoria Street, London, S.W. (Barracks, Fort George, Inverness).

Victor Gas Machine Co., 358, Cathedral Street, Glasgow.

Mercury Safety Gas Co., 140, Bath Street, Glasgow.

Safety Gas Co., 117, Middlesex Street, London, E.C.

Litz Safety Gas Co., Victoria Works, Great Malvern, Worcestershire.

Acetylene.

Thorne and Hoddle (Incanto System), 151, Victoria Street, London, S.W. (Installation near Sandhurst).

Allen & Co., 106, Victoria Street, London, S.W. (Loco. sheds, Severn Tunnel Junction, G.W.R.).

Acetylene Corporation, 49, Victoria Street, London, S.W.

Wakefield & Co. (Carbic Light), 27, Cannon Street, London, E.C.

Imperial Light Co., 123, Victoria Street, London, S.W. (Installation at Dalwhinnie, N.B.).

Chance Bros.' Lighthouse Works near Birmingham. Sunrob Portable Searchlight. (Trial Plant at S.M.E., Chatham).

Oil.

A. C. Wells & Co., 102, Midland Road, St. Pancras, London.

United Kingdom Lighting Trust (Kitson: Empire and Washington Patents), 231, Strand, London, W.C.

Mineral Spirit.

Petrolite, Ltd., 202, High Holborn, London, W.C.

British and Colonial Lighting Co. (Simpetrol System A), 216, Tottenham Court Road, London, W. (Sergeants' Mess at Tidworth).

REVIEW.

MILITARY HYGIENE AND SANITATION.

By Colonel Melville, R.A.M.C.—(Edwin Arnold, 1912. 12s. 6d.).

This book is founded on lectures delivered by the author while Professor of Hygiene at the Royal Army Medical College. It is primarily intended for medical officers, but contains much on physical training, marching, equipment, and other subjects that should be of interest to all officers. Engineer officers may learn something from the chapters on water supply, ventilation, barracks, and so on.

An interesting feature of the book is the particulars as to the practice of foreign armies. It gives the medical view of questions such as the construction of barracks, water supply, sewage disposal, and others in which medical and engineer officers are concerned jointly. Officers not of the R.A.M.C. will not always agree with what is said on matters within their own province; in a book of over 400 pages there are naturally numerous points of detail open to comment. But the author recognizes that the army exists to defeat an enemy, and that military sanitation is not an end in itself but one out of many means of increasing the prospect of success. Perfect health in an army is no advantage if its preservation prevents the performance of the army's work. A corollary is that the first duty of a medical officer is to look after the healthy efficient man; the treatment of the sick is a secondary matter. A hospital full of sick men condemns the medical officer in charge of the healthy. Another is that sanitation is a matter of proportion, a form of insurance in which the premium asked may be out of proportion to the advantages offered. Where public money is concerned there is a temptation with a view to theoretical perfection to recommend expenditure which no private owner would consider for a moment. But the spirit that has come over the Army in recent years appears repeatedly in the book; success in the field is the aim and the business of the R.A.M.C. as of every other branch of the Service. Being intended for medical officers, parts of the book must necessarily be expressed in very technical phraseology. But nine-tenths of it is intelligible to laymen, and it is a pity that in such a large proportion of the book the author has not avoided the unnecessary use of medical terms. Had he done so the book would have appealed to a wider circle of readers and might have been recommended with more confidence to all officers.

A.M.H.

NOTICES OF MAGAZINES.

REVUE MILITAIRE DES ARMÉES ÉTRANGÈRES.

December, 1911.

THE CHINESE ARMY IN SPRING, 1910.—In 1906 plans were formulated for the reorganization of the Chinese Army, according to which this force should consist at the end of 1912 of 36 divisions and one guard division. At the beginning of 1911 the actual strength of the army was 175,000 men, out of a theoretical total of 220,000, divided as follows:—13 complete divisions and 19 mixed brigades, or in other terms, 260 battalions, 58 squadrons, 171 batteries, 72 companies of sappers, 66 transport and supply companies, 169 machine guns. The increase since 1910 was 32,000 men. Training is steadily progressing, but *esprit de corps* is somewhat lacking. The reserves of this army are at present existent on paper only and the transport and supply services and the arsenals leave much to be desired, China is entirely dependent on the foreigner for military uniforms and equipment, and the existence of large reserve supplies of ammunition is problematic. The chief trouble is the absence of a definite grant of funds to the army; the viceroys are mainly to blame for this, as they fail to produce the money from their provinces for the soldiers who are quartered in them.

January, 1912.

MILITARY NEWS OF DIVERS COUNTRIES.—*Italy*.—A consulting committee, consisting of a lieutenant-general as president, six members of parliament, four military and three naval officers, and the presidents of the Italian aero and the touring club, has been formed to assist the War Office in matters referring to the science of navigating the air.—As a result of the war, the forces of the Italian army have been increased by 24 battalions of infantry, 3 rifle battalions, 5 squadrons of cavalry, 6 field artillery batteries, 12 mountain artillery batteries, 12 companies of fortress artillery, and 6 companies of engineers.

February, 1912.

THE NEW BRIDGING EQUIPMENT OF THE GERMAN ARMY.—A German engineer officer points out the following advantages in a report on the new bridging equipment:—(1). It renders the whole equipment of the German Army in bridging *matériel* uniform, hitherto the Bavarian and Prussian Armies had different types of equipment. (2). The new *matériel* has greater capacity, better stability, a more simple construction, and greater mobility than the old. (3). The boats can support 6,000 instead of 4,000 kilogrammes. (4). The new pontoon can carry 18 armed men, besides those rowing, the old could only carry 12. (5). The new material allows of a bridge 200 metres long, which will take heavy howitzers, being built for every army corps.

A. H. SCOTT.

Rivista di Artiglieria e Genio.

April, 1912.

Military Photography from Aeroplanes and Dirigibles.—Aerial locomotion will exercise a great influence on military operations, because, apart from its offensive value (by dropping projectiles from above), it will be of the greatest importance for reconnaissances—both strategical and tactical. Everything however depends upon the eye and the memory of the observer, who, if acting as pilot at the same time, is probably less quick in grasping and retaining in his memory the details of a military situation. This necessitates the employment of photography for purposes of reconnaissance. But in order that it should succeed, circumstances and the machines in use for the flight, etc., should be carefully taken into consideration, and it is not sufficient to take on board any kind of photographic apparatus as the negatives obtained would show insufficient or too bright images, and the camera itself would not be easy to manage and would be more of an encumbrance than of use.

Aerial military photography may either be used for taking rapid views of the ground—by taking a collection of photographs with horizontal plates and uniting them so as to form one plan—or it may be used for taking panoramic views, in which case the plates will not be horizontal. Taking photographs from an aeroplane will present greater difficulties than taking them from an airship owing to its greater velocity and less available space.

It is essentially necessary to fix the scale of reduction, and for military purposes a scale between $\frac{1}{5000}$ and $\frac{1}{10000}$ is convenient: in fact with the last scale trenches of only 1 metre may be seen with lines of $\frac{1}{10}$ of a millimetre in thickness. It follows therefore that from aeroplanes at a height of 1,000 to 1,200 m.—since at a lower elevation they would run the risk of being struck by rifle bullets and at a higher elevation the observations would be indifferent especially if the aviator is alone—the objective should be from 12 to 16 c.m. At 1,200 metres of height an objective of 12 c.m. would give a reduced scale of $\frac{1}{10000}$, and one of 16 c.m. a scale of $\frac{1}{7500}$; the last with a plate 13 × 18 would reproduce a zone of ground of 975 × 1,350 m. So that with an apparatus 13 × 18 with an objective of 16 c.m., with 12 maps taken horizontally a stretch of ground 1,350 m. in width and 10 k.m. in length can be portrayed in the few minutes required to traverse such a distance.

A photographic apparatus called the Ortho-Protar Zeifs, by which instantaneous pictures can be taken, is described with the following characteristics:—Size 13 × 18. The aviator can control the movement of the shutter and change of plates by pressing a button.

The photographic apparatus, in monoplanes, will be placed in such a position as to have freedom of view, and so that the optical axis may be as far as possible vertical. The vibrations of the motor are obviated as far as possible by elastic cushions. The observer must have both his hands free to be able to take the photographs, to change the plates, etc.

In the case of photography from a dirigible the altitude should be not less than 2,000 m. so as to be beyond rifle fire. To maintain the same relation of reduction in the picture of the ground beneath the line of route, an objective varying from 20 to 30 c.m. should be adopted and it is convenient to use an apparatus 21 x 21. The camera will be of a trunco-pyramidal form suspended outside the car and furnished with an automatic shutter. With a camera of this kind at a height of 2,000 m. with an objective of 20 c.m., if a 21 x 21 plate be used with an area of ground 2,100 metres in width can be taken at a scale of $\frac{1}{10000}$ and dozens of plates can be used in a day. There is in fact no limit to the number of negatives that can be taken on board a dirigible.

For developing the usual materials give good results when the temperature is not too high, but those in which glycerine is little used give the best results. For developing in the summer, under a tent, or on board ship at a high temperature, the plates should be kept for five minutes in a solution of formaline of 5 per cent. and then washed.

For photography from anchored balloons the same materials may be used as those for panoramic views from dirigibles.

In the sieges of the future, small balloons carrying suspended photographic apparatus with an inclined axis will be much used for taking views of the adversary's works. They can be easily managed and can be sent up from the advanced position, and if struck by the enemy's projectiles, the loss is limited to the material.

FRANCE.—ORGANIZATION OF THE MILITARY AERONAUTIC SERVICE.—*France Militaire* of the 7th—8th April, publishes the orders for military aeronautics of last March; these comprise the *personnel* for aerial navigation, troops, and establishments.

Superintending the whole, there is a permanent Inspector-General of Military Aeronautics who corresponds directly with the War Minister. The *personnel* for navigation comprises officers and men taken from the various corps. The troops consist of: (*a*), Seven aeronautic companies; (*b*), some aeronautical sections whose number is determined by the War Minister; (*c*), 1 company for transport. These detachments can be united, the composition of the reunited detachments being established by decree.

The officers of these troops are also taken from the various corps of the army and are placed on a supernumerary or seconded list.

The following shows the composition on a peace footing of the units:—

Aeronautic Companies.—Captains 1, lieutenants and sub-lieutenants 2, total 3. Officers' horses 3. Adjutants 1, sergeants 11, corporals and privates 91, chief artificers 5, total 108.

Aeronautic Sections.—Captains 1. Officers' horses 1. Sergeants 3, corporals and privates 55, total 58. Troop horses 6.

Transport Companies.—Captains 1, lieutenants and sub-lieutenants 2, total 3. Officers' horses 3. Adjutants 1, sergeants 12, corporals and privates 114, total 127. Troop horses 130.

E. T. THACKERAY.

CORRESPONDENCE.

A FIELD DRAWBRIDGE.

DEAR SIR,

In my article in the August *R.E. Journal* on "A Field Drawbridge," I mentioned (line 3 from bottom of first page) that there was a tendency on the part of the movable portion of the bridge to creep sideways. A very simple and effective means of preventing this has been discovered, and this consists in putting a figure of 8 wire loop in a groove round the moving and the stationary transom.

There is an obvious misprint in line 16 of the same page, where "*15 ft.* behind it" should read "*3 ft.* behind it."

Yours faithfully,

E. K. MOLESWORTH,

Bangalore, August 22nd, 1912. *Capt., R.E.*

The Editor, *R.E. Journal.*

"THE STORY OF JERUSALEM."

SIR,

Your reviewer's appreciative notice of Sir Charles Watson's *Story of Jerusalem* is, for many of us, marred by his treatment of the Old Testament history in its account of the slaying of Goliath. This is by no means "generally discarded" as he supposes. It may be so by the school to which presumably he belongs, and which is much in evidence nowadays, particularly in the fugitive literature of the day, but it is undoubtedly received as historical by the many who form the broad, deep, and influential stream of sound religious opinion and belief.

By making David an Amorite instead of a Semite the reviewer does not answer his author's question, "How to account for the sudden rise to greatness of the Israelite monarchy under David, and how did a simple shepherd boy obtain the influence over men which enabled him to carry his ideas into effect."

"The author should re-read his history in the light of modern biological research." That is exactly what the reading people among us are habitually doing; and we get many and highly interesting side lights on the Bible history.

Again, "The Semitic races have never produced great rulers." Well—we are concerned here with *one* Semitic race—Israel. Was Moses not a great ruler? More—was he not among the greatest? Or among minor rulers, were not Joshua, Samuel, Hezekiah, Judas Maccabeus, rulers of note? Exclude the two greatest kings who ever reigned—for in moral and ethical importance none other approach them—from the Semitic line and it becomes easy to say that "Semitic races have never produced great rulers."

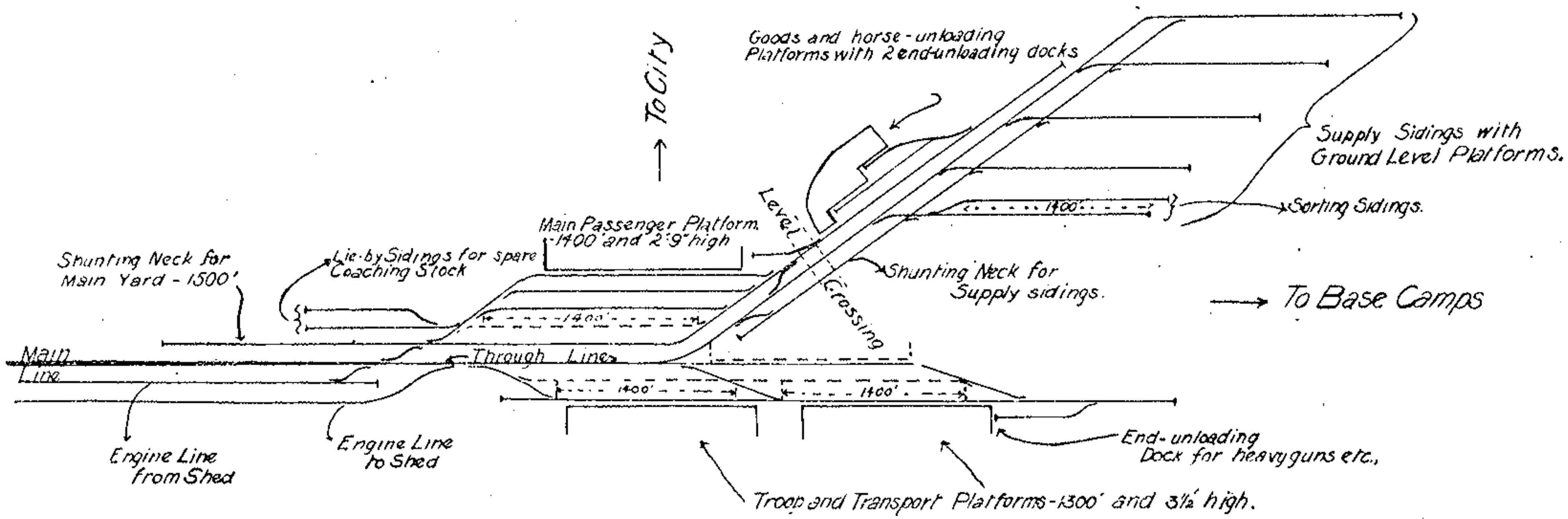
Lastly, "The subjection of the somewhat servile Semitic people to the virile and energetic Northern character" seems not to be confirmed by history. Let us quote the Tel-el-Amarna letters—"the *Amarna* letters tell us that the 'Abiri (or Hebrews) in the South of Palestine destroyed all the rulers" (Condor). This does not look much like "subjugation" for the Hebrews!

That David was "ruddy and of a fair countenance" may have given rise to the supposition that he was not a Semite or true son of Abraham. But the mystery of dark and fair meets us every day in our own experience. Dark parents will produce the fairest blonde. Dark and fair children are not uncommon in the same family. The fair complexion of David may have come from his great-great-grandmother, Rahab of Jericho; and the fair strain thus (and not unlikely by other intermarriages) introduced into the Royal line may have reappeared and become a recurring feature in it.

D.C.W.

September, 1912.

The Editor, *R.E. Journal.*



SKETCH PLAN SHOWING CONVENIENT ARRANGEMENT OF A BASE YARD.

CONCENTRATION OF TROOPS BY RAIL.

PLATE I.

BLOCK L-A