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

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Rail Transportation of Girders in India

THEORY OF ARCHED MASONRY DAMS.

PAPER I., VOL. II., R.E.P.P., 4TH SERIES.

We are requested by Capt. A. ff. Garrett to state that Lieut.-Colonel W. R. Morton has called attention to an error in equation 24 of page 18 of "The Theory of Arched Masonry Dams" published as a *Royal Engineer Professional Paper* in 1908.

This equation should read :—

$$Z=\frac{6N}{l^2e}\cdot\frac{2d\,(n+2)-l\,(n+1)}{n^2+4n+1}.$$

$(2n-1)$ in the denominator of the right-hand member as printed, should be $(2n+1)$ and the equation then reduces to the above expression. Fortunately this does not affect the numerical results as worked out in the paper.

RAIL TRANSPORTATION OF GIRDERS IN INDIA.

By CAPT. W. E. BARRON, R.E.

THE following short account of a nice little bit of work carried out recently in the writer's district, may prove of interest. It consisted of the transportation by rail of four lattice girders, 139′ 6″ overall length and 10′ 6″ depth, for a distance of 80 miles (Phillaur to Umballa Cantonment) on the North Western Railway, at an average speed (including stops for water and to allow a passenger train to pass) of 10 miles per hour. The trip took 8 hours from start to finish.

The maximum speed at any time was about 17¼ miles per hour, when, fearing that the "whip" on such long girders would lash the tail bogies off the rails, we slowed down to a running speed of 15 to 16 miles per hour.

The girders were recovered from the East Beyne Bridge in the Lahore Engineering District, which was having its girders replaced by others of a later and stronger type. They were then specially mounted on bogie frames by the Carriage and Wagon Department of the railway, and were taken to Umballa to form the new road overbridge being erected there in place of a very busy level crossing.

Photo No. 1 is, probably, unique, and represents the four 140′ girders passing over the 100′ girders of the old Sutlej Bridge, just outside Phillaur. The train consisted of an engine, 3rd class composite brake van, composite 1st and 2nd class carriage for the subordinate staff with the train, 1st class reserved carriage for the Assistant District Traffic Superintendent, the writer's carriage, a dummy truck, the four girders, another dummy truck and a brake van, a total length of some 1,000′ odd, more or less.

Photo No. 2 shows more clearly the actual arrangements at the end of the girders, and the staff who travelled with the train, with the exception of the driver and loco. foreman who were busy watering the engine. The staff consisted of (front row) District C. and W. Superintendent, the writer, one of his assistant engineers (seated), Assistant District Traffic Superintendent (with his leg on a tie bar), and back row, Mr. Millett, Bridge Inspector, in personal charge of the train, the guard, and the carriage and wagon inspectors of the Saharanpur and Lahore Districts.

The total height of the girders from rail level to over rivets was 14′ 1½″. They consequently infringed all our standard running dimensions, and had to be specially sanctioned as a running train by the Senior Government Inspector of Railways, Lahore Circle.

A fuller account of the work will be sent later when it is complete, with other photos, not at present available or taken.

A similar piece of work has never hitherto, the writer believes, been attempted in this country. It was, what is more important, successfully carried through without the slightest interference with the ordinary traffic, over a busy portion of the line of which only 70 odd miles, of the length travelled over, had been recently doubled.

MEMOIR RELATIVE TO THE SCHOOL OF MILITARY ENGINEERING AND THE CORPS OF ROYAL SAPPERS AND MINERS.

THE following original memoirs by Capt. and Bt. Lieut.-Colonel (afterwards Sir C.) Pasley on the S.M.E. at Chatham, and the Corps of Royal Sappers and Miners, have recently been presented to the R.E. Institute for inclusion in the R.E. Museum. They are of particular interest owing to the celebration of the Centenary of the S.M.E. in 1912.

No. 1.

ACCOUNT OF THE ESTABLISHMENT WHICH HAS LATELY BEEN INSTITUTED FOR INSTRUCTING THE CORPS OF ROYAL SAPPERS AND MINERS, AND THE JUNIOR OFFICERS OF ROYAL ENGINEERS IN MILITARY FIELDWORKS.

The Duty of Engineers in Garrisons is to construct Permanent Works of Fortification, and sometimes Military Buildings.

Their chief duty on actual service, is to throw up the various Fieldworks which may be required for the protection of the Army, when acting on the Defensive and in offensive operations, the management of a Siege comes peculiarly under their charge.

The Stores belonging to the Department consist principally of intrenching and Artificers' tools, to which are added Sandbags and other materials useful in Fieldworks, and Pontoons, etc., for the Passage of Rivers.

The nature of permanent works of Fortification, is so different from that of Fieldworks, and the method of executing them is also so widely different, that the Practical experience acquired by a Young Engineer in any Garrison, is of little or no use to him when he is ordered upon service.

Hence arose the necessity of an Establishment for Exercising the Junior Officers of the Corps of Royal Engineers, in the construction of Military Fieldworks.

Upon actual service it often happens, that it may be necessary to throw up lines for the protection of an Army, extending over a great tract of Country, in which case, one Officer of Engineers may often have a District of several Miles allotted to him.

In a Siege the duty of an Engineer is still more arduous. He has large working Parties put under his direction, who are to act within range of the Enemy's Guns, in order to avoid which, the works are marked out and commenced in the dark, which increases greatly the difficulty of making a proper arrangement.

The men who are usually employed in fortifying the position of the Army are either Peasants, or Soldiers of the Line. In a Siege Soldiers of the Line, are always employed under the direction of the Engineers. In respect to these men, the services of some thousands of whom may be required at the same time, the whole of them are totally Ignorant of the nature of the work which they are required to execute, and they must be constantly overlooked and directed even to the minutest Details.

Consequently it is not sufficient that the Officers of Engineers themselves understand their Duty thoroughly. They cannot possibly direct such a great number of Men, without the assistance of a body of N.C. Officers and soldiers, under their own immediate command, who understand the details of all the various operations to such a degree, as to be able to act as Overseers and Foremen of the Working Parties. Hence the necessity of having a well-instructed Corps of Sappers and Miners, that is to say, of men trained to all the various Field duties of the Royal Engineer Department.

In extensive operations it is also almost always necessary to employ a proportion of Officers of the Line as Assistant or acting Engineers. But without well-instructed Sappers and Miners to assist in executing the practical details, such Officers must necessarily be much embarrassed in their new duty; and their Services comparatively speaking, will be of little value; no matter how active or intelligent they may naturally be.

It is an acknowledged truth, that for want of men trained to the duties of Sappers and Miners, the greatest confusion, blunders, and Delays have often taken place in our Sieges, and that many valuable lives have been lost, particularly of Officers of Engineers, who have unavoidably been obliged to expose themselves in a manner that otherwise would have been unnecessary in teaching the working Parties the most simple parts of their duty under the Enemy's fire. One Officer for instance was killed in showing a man how to picket down a Fascine at the first Siege of Badajoz another at Burgos in placing a Gabion. Owing to this Defect a British Army was literally incompetent to carry on a regular Siege against a resolute enemy, with any reasonable prospect of Success.

Having made these preliminary remarks as to the necessity of an Establishment for instructing the Corps of Royal Sappers and Miners, and the Junior Officers of Royal Engineers in Military Fieldworks, I shall now proceed to describe the course which has been Adopted.

The men generally commence by cutting a quantity of brushwood which they are taught to manufacture into Fascines, Gabions, hurdles, and Pickets, of the dimensions most useful in Fieldworks.

They are exercised in making Parallels and Approaches such as are used in a Siege.

They afterwards make Batteries of various kinds Elevated, or Sunken, with Fascines and Sandbags.

They are taught to lay Gun and Mortar Platforms.

Also to make Field Powder Magazines.

They are taught the various kinds of Sapping in use, viz. the Flying Sap, the regular Single Sap, and the Double Sap, with the application of them in the formation of Approaches, Parallels, and Batteries, when exposed to Musquet Shot.

They are exercised in Military Mining, in the method of Sinking Shafts, and driving Galleries, and Branches, of the Dimensions most convenient on real service, also in forming the Chamber of a Mine, with the operations of loading, Tamping and Firing.

Every thing is explained, but we have had no explosions except of a few pounds of powder, a sufficient quantity for experiments on a great scale not having been granted.

Our Mines require a considerable quantity of woodwork to support the Earth, but the Frames, etc., are carefully removed and preserved after one set of men has been trained, so that the same timber will serve for many successive Shafts and Galleries.

On the ground at Upnor where our works are chiefly carried on, part of our Parallels, Approaches, and Batteries, are always left to serve as a Model, by which the Officers and Men may see the nature and Progress of the operations of a Siege on a great Scale; the rest of our temporary Fieldworks are destroyed from time to time, and the ground levelled for fresh experiments.

The Fascines and Gabions, after being used in the temporary Fieldworks, are taken to pieces, and delivered over to His Majesty's Victualling Office to serve as firewood for the Public Benefit, so that no part of our brushwood is unprofitably wasted.

The Fieldworks executed are principally those used in a Siege, because there the greatest promptitude, arrangement and expertness are required, and a man who understands Batteries, Approaches, and Parallels, will easily comprehend every other kind of Fieldwork.

In a moral view I conceive this arrangement also to be of great importance. For on a little reflection it may appear evident, that the Recruits on first entering the Corps, must necessarily acquire a bold and enterprising turn of mind, by having their attention constantly occupied with Batteries, Saps, Mines and other works of attack only. And first impressions with young Officers and Soldiers may often decide the character both of individuals and of Corps.

The only thing practised which is not common in a Siege, is the method of using Sods in the revetment of Fieldworks.

From the Practice carried on in the above operations, many improvements have been made in the executive part of the various Field duties of the Royal Engineer Department, and a number of defects or errors have been detected in the rules laid down by the Foreign Authors on Fortification, who formerly were our only guides.

In addition to what has already been detailed, the men are taught the management of Pontoons, and the method of making a Military Bridge of Casks upon a plan much superior to any that is to be found in Books.

The art of constructing Military Bridges in general is likewise explained. In this important branch of knowledge, our Practice has led to decided improvements. By trifling additions or alterations made in the common Pontoon Equipage, which neither increase the expense nor the weight of it to any degree worth noticing, the bridge may be formed in half the time that was before practicable, and its strength has been considerably augmented. The bridge of casks above mentioned has also been reduced to a system; it is in nowise inferior to the Pontoon Bridge either in strength or safety; and means have been found for forming and monœuvring it in the most deep and rapid river without the assistance of Boats.

Knotting and Splicing, being useful on many occasions, form a part of the course of Instruction.

After every operation in which they are employed, the men are examined in respect to the nature and use of it, and are also made to give an account of all the technical terms, such as the Interior, Superior and Exterior slopes of a Parapet, etc.

They are likewise exercised in marking out upon the ground Parallels, Approaches and Batteries, and in putting up Profiles to show the form of the supposed work when finished.

The method of levelling ground either horizontally or according to a certain given slope is also taught.

In order to qualify the men for acting as Overseers and Foremen of working Parties, they are taught practical Geometry and the Principles of Plan Drawing. This is done on a very economical system. They draw chiefly on slates, only two Plans have hitherto been done on Paper, viz. the Plan and Sections of a Battery, and the Plan Section and Elevation of a small building. This is a branch of Instruction which I consider of the most essential importance, it not only renders the men more useful in the field, but also in Garrisons when employed on the permanent works; for everyone knows that it is of the greatest use to all Artificers to be able to work from Plans and Models.

At Plymouth, the last station where I was quartered, the Civil Artificers of the Royal Engineer Department, owing to their own superior knowledge in this branch of learning, held the Royal Military Artificers in the greatest contempt. This will not be the case in future.

The proportion of men who from their previous education and ability, are qualified for going through the course of Practical Geometry and Plan Drawing, does not on an average exceed one in three, and this is the description of men out of whom the N.C. Officers, and eventually the Sub-Lieutenants of Companies will be chosen. But as it would create great confusion if one part of the men were at work, whilst the others were at study, it has been found expedient, also to endeavour to improve the remainder as much as possible. Those who come entirely uneducated or imperfect are taught to read and write, and others are instructed in Arithmetic. A man of good abilities who arrives totally Ignorant generally learns to read and write before he quits the Establishment. Those who go through the course of Geometry and Plan Drawing, proceed afterwards to the study of Mensuration.

The teachers and assistants are all N.C. Officers or privates. The Practical Geometry and Plan Drawing are taught according to a system composed by me, for this express purpose. The other branches of learning are conducted according to the Reverend Dr. Bell's system, which has lately been introduced into the Army, by the authority of His Royal Highness the Commander-in-Chief.

The men after remaining a certain time at this Establishment are either sent on Service, or drafted to the various Companies in Garrisons. It is my wish that they should never be changed in less than Six Months. The average number of men doing duty here has hitherto been about 250.

The only permanent Officer of Engineers at present attached to this Establishment is an Adjutant, who makes arrangements regarding the executive details of the various duties according to general directions received.

The Officers of Engineers who attend for the purpose of Instruction, are charged with the superintendence, and are responsible for the proper execution, of the various operations carried on. They also personally examine the men, or are responsible that it is properly done by qualified N.C. Officers. They make daily and detailed reports of progress, in which they are ordered particularly to mention those N.C. Officers and Privates, who distinguish themselves by their superior Activity, industry, or Intelligence.

The Sub-Lieutenants of the Corps of Royal Sappers and Miners, who are sent here for instruction, also assist in superintending the fieldworks, etc., and make reports of a similar nature to the above, when employed on any duty where an Engineer is not present.

The list of Men recommended by the Officers is read out in public orders once a fortnight, which occasions great zeal and Emulation. I have frequently known the same men recommended every time that these lists were made out, by four or five different Officers.

These recommendations together with general good conduct, and ability shown in the Regimental Schools, are always kept in view, when any opportunity occurs of having N.C. Officers, or Privates promoted to a higher rank.

The Officers of Engineers also assist in all Regimental and Parade duties relating to the discipline of the Men, in the same manner as is Practised in Regiments of the Line. One day in every week besides Sunday evening is set aside for general exercise, in which the usual manœuvres of a Battalion are performed; the men being previously instructed in the Drill, as far as the Manual and Platoon exercises (inclusive) at Woolwich, under the Senior Adjutant of the Corps.

I consider the Drill of great importance not only to the discipline and respectability of the Corps, but also for another reason. Although the men are seldom likely to be called upon to use their arms in the Field; there is no class of Soldiers in whom greater courage is required in order to do justice to their duty. And there can be no doubt but that a confidence in the use of arms adds to the courage of an Individual in all cases and in all situations, because although he may not be actually engaged in personal contest, he feels that if it came to that point, he would be equal to any adversary. If there were not so great a Demand of Men for Service, it would in my opinion be desirable to devote more time to the Drill.

When the Officers of Engineers are not occupied in Military or Field Duties, they have a course of Study laid down for them, calculated to improve them in the Science of Attack, upon which the art of Fortification is founded. They are required to present Memoirs relative to the various operations of a Siege stating the number of Men, Materials and Tools, and the distribution of them, as also the time necessary for completing each particular operation on a great scale.

The being able to make such arrangements and the knowledge of these Details, is of the utmost importance to the success of an enterprize, but it is absolutely impossible for any Officer to acquire them from Study or Theory alone. For instance if a Fortress is to be attacked, an Engineer who has been at this Establishment on a hasty Examination of the woods in the neighbourhood, will be able to say whether they will furnish a sufficient quantity of Fascines and Gabions, etc., also what time will be necessary for cutting and manufacturing the brushwood, and how many men and Tools ought to be employed.

It may easily be conceived how little capable of giving any just opinion upon such simple though necessary arrangements, the Officers of Engineers must formerly have been, who were often sent to assist in conducting a Siege, without ever having seen either a Fascine, or a Gabion made or used.

To this want of Practical experience on the part of the Officers themselves, add the total ignorance of the working Parties, whom they were to Direct, and it is difficult to conceive any duty more embarrassing than that of an Engineer upon actual Service. To an Officer who felt deeply for the Credit of his Corps, and the success of His Majesty's Arms, it was a truly distressing Situation.

The above is an ample statement of the nature, and object of the Establishment for Instructing the Corps of Royal Sappers and Miners, of which I have had the honor of being appointed Director.

The allowances granted to the Officers, N.C. Officers, and Privates employed at this Establishment will be seen by referring to His Majesty's Warrant for the formation of it, Dated 23rd April, 1812.

(Sd.) C. W. Pasley, *Capt., R.E.,*
and Brevet Lieut.-Colonel.

Chatham Lines,
5th August, 1813.

No. 2.

Observations on the Present Organization of the Corps of Royal Sappers and Miners.

The Corps of Royal Sappers and Miners is raised for General Service, and by virtue of His Majesty's Warrant must always be commanded by Officers of the Corps of Royal Engineers.

The Inspector-General of Fortifications, acting under the Master-General of the Ordnance, has the immediate command of both Corps.

The present Establishment of the Royal Sappers and Miners, consists of Four Battalions of eight Companies each.

Every Company is allowed 5 Serjeants, 5 first Corporals, 5 Second Corporals, 70 Privates, and 3 Drummers.

There is only one Commissioned Officer of Sappers and Miners per Company, a Sub-Lieutenant who is always raised from the ranks.

In addition to the above Establishment, each Battalion is allowed an Adjutant and 2 Staff-Serjeants.

The Corps at present is incomplete none of the Companies being filled up, except those which are serving in the Peninsula, and in Canada. For this reason, only two Adjutants as yet have been appointed, both of whom are Second Captains of Engineers.

The Senior Adjutant who is likewise Quartermaster resides at Woolwich, and has the charge of the Recruiting Service of the Corps. He also equips and disciplines the Recruits on their arrival at that place, and the general details and arrangements of the whole Corps, such as posting N.C. Officers and Privates to Companies, etc., are transacted through him.

The duties of the Adjutant at Woolwich have been modelled upon the System followed in the Royal Artillery, where there is an Adjutant to each Battalion.

After the Recruits are drilled a certain number of months at Woolwich under the Senior Adjutant, and are considered perfect in their facings, in marching, and in the Manual and Platoon exercises; they are sent down to Chatham to be instructed in the Field Duties of the Royal Engineer Department, where they are also further advanced in the Drill.

The Recruits enlisted are principally Artificers of various trades, or Miners. A very small proportion of Labourers is also allowed to enter the Corps under certain restrictions. The whole of the Men without distinction of trades are trained as Sappers, Miners, and Pontooneers, and it is my opinion that a sub-division of men of these descriptions into different Corps, as is the case in some foreign armies, would be very prejudicial to His Majesty's Service, inasmuch as it would give rise to a more numerous and expensive Establishment of Officers and Men, particularly of the *former*, without producing greater efficiency.

It may also be observed, that when the duties of any Military Men such as Engineers, Sappers, Miners, etc., are so intimately connected as to require them always to be done in concert, they should only form one and the same Corps. If they are divided, one Corps must necessarily always be subordinate to another, which will injure its discipline and reputation, and its Officers will in a great measure be inefficient, and consequently despised by the rest of the Army.

As a Proof of this I shall give one striking instance in the British Service.

The Officers of the Royal Artillery Drivers, who form a distinct Corps, are always commanded by the youngest Subaltern of the Royal Artillery. In consequence of this circumstance, no young man of spirit or education will willingly enter the Corps of Artillery Drivers, although the Pay and Allowances are much greater than those of the Royal Artillery. On account of their subservient situation, the former class of Officers are not so well received in society, and the men whom they command, although an equally important and useful body of Soldiers, are neither so well disciplined nor respectable as the Gunners of the Royal Artillery.

I consider Artificers upon the whole are the best men for the Corps of Sappers and Miners; particularly Carpenters, Wheelers, and Blacksmiths. An Artificer is generally better educated and more intelligent than a Labourer of the same natural abilities. He is therefore a fitter subject for the Engineer Department, where the N.C. Officers are always required to act as Overseers, and where it is often necessary even to employ Privates as such. As far as regards personal exertion, and the power of enduring fatigue, Artificers in general are not inferior to Labourers.

It was before stated that the Corps of Royal Sappers and Miners is commanded by Officers of the Royal Engineers. It has hitherto been the custom to attach only one Captain of Engineers to each Company, and that generally in a very temporary manner.

This arrangement is certainly not sufficient to ensure the proper discipline of the men upon Service. It is now universally agreed that each Company ought to have its full complement of Officers in the Field, although in garrisons a smaller number may suffice. Sir Richard Fletcher, the Commanding Engineer in the Peninsula, has therefore attached a number of Subalterns of Engineers to each Company, in addition to the Captains, and the same has been done by me at Chatham, but to diffuse the benefits of this System throughout the whole Corps will require a general Order from higher authorities.

One captain and at least two Subalterns of Engineers ought to be permanently attached to each Company, in addition to the Sub-Lieutenant. This will form a very efficient establishment of Regimental Officers. I have reason to believe that Lieut. General Mann has it now in contemplation to carry some measure of this kind into effect.

Like everything new it will not be universally well received at first, for many of the Officers of Engineers, from the former habits and custom of the Corps, have a great aversion to all Regimental and Parade duties, which they were taught to consider as a kind of drudgery beneath their Profession. This prejudice has however been gradually wearing away. It is now allowed to be absolutely necessary that a portion of the Officers of Engineers shall do Regimental duty with the men, and nothing which is for the good of His Majesty's Service either is a degradation, or ought to be considered as such.

In the Establishment at Chatham, where all the young Officers are employed in Regimental Duty, no such prejudice exists. On the contrary, a mutual attachment has invariably taken place between the Officers and Men, and they are always anxious to go on Service together.

I need scarcely mention that the present Corps of Sappers and Miners were formerly styled Royal Military Artificers. The Establishment and organization of the Corps remains the same, only that it has been augmented and improved, much more attention having been paid to the discipline of the Recruits, and great care having been taken in their Field Instruction which before was totally neglected, in consequence of which omission they were of little or no use upon service.

Owing to the many defects of the Military Artificers who considered themselves rather as Civilians than as Soldiers, the late change in the title and uniform of the Corps may be considered beneficial, as they must tend to obliterate the memory of the old Artificer. Both the name, Dress and habits of the present men are certainly much more martial and soldierlike. But I must confess although I prefer the title of Sapper and Miner to the former one, for the above reason, yet I still consider the present name unsuited to the Corps.

It appears to me a very great defect that the Officers and Soldiers of any Department should have a different name. Much of the acknowledged indiscipline of the Old Artificers may be ascribed to this cause. The Engineers although constantly doing duty with them, would not allow that they themselves were Artificer Officers, and therefore did not consider their own reputation at all affected either by the good or bad conduct of their men, whom they consequently felt no scruple in totally neglecting.

A very great improvement has no doubt taken place lately in the Military duties of the Royal Engineer Department, and more may be expected, but I conceive that as long as the difference of title remains, the Engineer Officers in general (excepting those who may be attached to Companies for the time being) will still take little interest in the reputation of a Corps styled Sappers and Miners.

Everything which tends more intimately to unite together any body of Officers and the Men whom they command, must necessarily promote the discipline and efficiency of the whole as a Corps, and any distinction, though but in name, which tends to disunite them, must I conceive be in some degree pernicious. I am therefore persuaded that it would be highly for the benefit of the Service if the title of Sappers and Miners were altogether abolished and if the body of Men so styled were in future considered an integral part of the Corps of Royal Engineers, and known by no other appellation. There would then be no prejudicial distinction between the men and their officers, and each individual, let his rank be what it will, would therefore enter with greater zeal and alacrity, into every duty that could promote the reputation of the whole.

Should this salutary change of name ever take place, I feel confident the British Royal Engineer Department will become in a few years the best organized Military Establishment of its kind in the World.

The Royal Sappers and Miners are always armed in Garrisons. A question has arisen whether it is proper that they should carry Arms in the Field or not. It appears to me of importance that they should.

It may often be necessary upon Service to attach a party of them on a particular duty to a considerable distance from any other Troops. In that case, if they are armed, they may defend themselves, without harassing the rest of the Army. If they are not armed, they must either be protected by a Detachment of Soldiers of the Line, or they are liable to the most serious disasters. It would for instance be a mortifying circumstance, to hear of a detached Company of Sappers and Miners, being surprised and cut to pieces by a few of the enemy's Dragoons or of their being prevented from executing their orders by a dozen armed Peasants. The latter is a thing often likely to occur, even in a friendly country. Such operations as the destruction of a Bridge, the breaking up of Roads, and in short a great number of similar services, in which Detachments of Sappers and Miners are likely to be employed, are always highly offensive to the Natives of the District, whose prosperity they injure, and consequently they cannot possibly be carried into effect by men without arms, in any country which is the Seat of War. As a proof of this, in Sir John Moore's retreat in Galicia, a body of armed Peasants actually assembled in considerable numbers to oppose a British Engineer who was preparing to destroy a Bridge at some distance from the main body of the Army. But when they found that he was determined upon effecting his object, and had drawn up his Party to attack them, if necessary, they desisted from the attempt. It need scarcely be mentioned, that if this Officer and his Men had been unarmed, he must have returned without executing his Orders, to the prejudice of the Service.

This case, and many others of a similar nature, which are likely to occur in the course of a Campaign, appear to me to point out the necessity of arming the Corps of Royal Sappers and Miners in the Field, or at least that Arm Chests should always accompany them, ready for distribution when occasion required. I shall not urge as a plea for this measure, the assistance which the men of this Corps might render to the Army in Action, because on every Service there would always be more than sufficient employment for them, in their own peculiar and more important branch of duty, without requiring them to act as Infantry Soldiers. Indeed, one principal advantage of the Corps of Royal Sappers and Miners is, that it will do away the embarrassing necessity which has hitherto constantly occurred on all occasions, both in the Field and Garrisons, of weakening and to a certain degree disorganizing the Regiments of the Line, by taking away their Artificers and Miners, and attaching them to the Royal Engineer Department.

(Sd.) C. W. PASLEY, *Capt., R.E.,*
and Brevet Lieut.-Colonel.

Chatham Lines,
5th August, 1813.

A FEW NOTES ON THE SIEGE OF DELHI.

By GENERAL SIR F. R. MAUNSELL, K.C.B., COLONEL COMMANDANT, R.E.

THE perusal of an article in a recent number of the *R.E. Journal* in which the Siege of Delhi was alluded to at some length, prompts the writer, as one of the senior surviving R.E. officers present at that siege, to contribute a few notes which may not only prove of interest but which may also help to bring into prominence some points scarcely alluded to by historians of the Mutiny.

The Siege of Delhi may be divided roughly into three periods; the first, when the original force of some 3,800 men was desperately holding its ground against the daily attacks of the enemy; the second, after the first reinforcements had arrived, with the assurance that in due course sufficient would arrive to allow of assuming the offensive, and during which time also siege material was being collected; and finally the third period when the arrival of the siege train enabled the attack on Delhi itself to be vigorously pushed on until the city was ultimately captured.

This of course precluded any project of the engineer work of the attack which left only details to be worked out on the ground from being prepared in anticipation. Some have asserted that such a plan was prepared by Colonel Baird Smith whilst still at Roorkee, and knowing Delhi, as he did, far better than most men, it is quite possible that he indicated on the Roorkee plan the general site which was afterwards used. But to have done more than this was at the time absolutely impossible, as both the force available and the conditions of a practical project were unknown. The writer can speak with some authority on this point as the plans of all fortified places were kept under his charge at Roorkee, and the plan of Delhi showed no detail of the many buildings, walls, trees and copses which afforded such dense cover on the site ultimately chosen, and a knowledge of such details was absolutely indispensable when considering the scheme of attack. Moreover, the plan itself does not seem to have been taken to Delhi as it was not forthcoming when asked for by the Engineers who were assisting Capt. Taylor later on in thoroughly examining this ground.

Some confusion also has been caused by the unusual position of Colonel Baird Smith. Although nominally Chief Engineer at Delhi, and as such responsible to the General for all schemes for which sanction had to be obtained, his numerous more important staff duties, as well as the illness from which he suffered, practically forced him to delegate to Capt. Taylor the actual duties of Chief Engineer, and this the latter virtually became. Luckily Taylor's engineering skill had long been appreciated in Upper India where the Great Trunk Road was known as "Taylor's Road," and in addition to this Lord Lawrence had selected him, on account of his experience at the Siege of Mooltan and his known ability, as the *homme nécessaire* to find the way into Delhi. All this must have been well known to Baird Smith, and have satisfied him that he could safely leave the whole plan of the attack entirely in the hands of his subordinate. It must also have proved a source of great relief to him when he had, in his turn, to back with his authority so daring a project, and to obtain for it the unwilling consent of an over-anxious general weighed down by the responsibilities of so difficult a crisis.

But this unusual relegation of duties has led to some misconception amongst writers, and even General Warrand in his article on Delhi in the January, 1908, number of the *R.E. Journal* says, "To the former (Baird Smith) belongs the credit of evolving the daring plan of attack * * * to Taylor belongs the credit of successfully carrying out the difficult details of Baird Smith's great plan." The writer has the best of reasons for knowing that this is incorrect, and that Taylor not only elaborated the details but also evolved the plan of attack itself.

So many years have now elapsed since the Siege of Delhi, that it is perhaps difficult to realize how great were the dangers and difficulties which had to be overcome before such a plan could be worked out. Although from the very first the capture of the city was the ultimate goal in view, the besieging army for over a month consisted of a small British force holding on like grim death to a fortress of some 6 or 7 miles of rampart, and faced by an enemy vastly superior in numbers and occupying an arsenal and its environments. The only hope lay in the arrival of reinforcements which would enable what was really a defensive position to be turned into an attack. When all possible succour had arrived it was evident that a regular siege with approaches, etc., was out of the question, and that other procedure would have to be adopted. There was little more ammunition than would suffice to form practicable breaches, and if the place were not taken when that was expended the British force would be very much at the mercy of a powerful and resourceful enemy. It was, moreover, evident that a successful attack must be by surprise, and must be carried out with all speed and care so as to save the loss which delay might occasion and which would undoubtedly prove far greater than that suffered in a rapid attack.

There was but one site which allowed of such an attack, and this was covered with buildings, trees, copses, etc., and occupied by the enemy who might at any moment turn it into a strong position. The attack itself was, moreover, a difficult military operation even under the most favourable circumstances, and one which required the utmost care and precision. But it was the only way to success, and it was because he foresaw the probability of its having finally to be resorted to, that Taylor, from the first day of his arrival to the time of his taking over the responsibility of all the works, had been examining the ground so as to gauge its adaptability for such an attack. As it was in the hands of the enemy, it was at the constant risk of his life and with many hairbreadth escapes that he carried out this examination, sometimes passing well within their lines and picquets and being nearly a mile away from any succour. The only officer of higher rank who ever accompanied him on his hazardous scoutings was General Nicholson, who threw himself enthusiastically into the work, its very audacity being just what he loved.

We were, of course, more or less aware all along that Taylor was studying the ground. In fact he used some of us (and especially one who was living on the site at the time of the outbreak) to take measurements, etc., at different times. But no one knew what he was actually planning until the stirring week of strenuous and ceaseless action. Nor does the above apply to the Engineers only. The writer is convinced that others in the force had an even less clear conception of what Taylor was doing, and that this accounts for the otherwise inexplicable remarks or assertions made by some historians.

Even after the preliminary reconnaissance had shown how best the buildings and communications might be used, several points had to be kept carefully in view when framing the plan of the attack. In the first place it was of vital importance that, from the time the position was first taken up to the assault, everything should be completed within a limited time of say 10 days.* It was also necessary that, after the lines for men, guns, batteries, etc., had been laid out, the way to get to them should be clearly indicated, so that the parties might be set to work or placed *in situ* during the night, unhampered by having to find their way round buildings, walls and trees, and without arousing the suspicion of the enemy, picqueted close by and on the watch.

Such a task needed an expert of exceptional skill and physical strength, involving as it did many hours of constant labour both by day and night. But it was the *sine quâ non* of a practicable project, and was only complete when the position of the chief breaching battery was marked out within 160 yards of the ramparts.

After the necessary consent of the General had been obtained to the scheme, great care was required so that the position might be taken up with the rapidity and caution which were so essential for the success of the attack. This was only rendered possible by the enemy's blindness in leaving such excellent cover untouched when it might so easily have been rendered almost impregnable, by the

* It actually occupied 7 days from the 8th to the 14th September, 1857.

ample time that had been available for scouting, by the threatening aspect of the British right, and finally by the supine attitude generally of the force which completely put the enemy off his guard, and which was so suddenly transformed into vigorous action.

Although the successful discovery and choice of the site for the chief breaching battery was really the crown of Taylor's labours, the scantiest reference only is made to it in contemporary documents. Colonel Baird Smith in his report writes that "Capt. Taylor pushing a reconnaissance found a place for the great battery and we adopted it." It has always seemed to the writer that this scarcely does justice to the arduous and dangerous task to which Taylor had been so long devoting himself. More than ordinary precautions were necessary to make quite sure that the troops could seize the positions by night, and rapidly put them in a state of defence so as to hold them against the inevitable counter-attack *next morning*. This of course involved a far more thorough reconnaissance than would have ordinarily been necessary and yet the work finds no recognition in histories of the siege. As regards the site itself of this battery, no praise can be too high for the skill and daring with which it had been chosen. Had it been in any way unsuitable, it would have given the enemy time and opportunity for a sortie in great force and the whole plan must have failed. Had it failed, the fate of the Delhi field force would practically have been sealed, as many a long day must have passed before any succour could have arrived, and, in fact, it was over six months after the fall of Delhi that the force from England was strong enough to capture Lucknow.

It was therefore this battery that practically opened the door to Delhi and, although the greatest credit is due to those whose reckless courage put the seal on the great work, still greater praise is due to the man who, with equal courage, forged the key by which the door was opened. It was for this reason that Sir George Chesney—our Brigade-Major at Delhi and, as such, one well able to apportion the work done—said, when introducing Sir Alexander Taylor at Cooper's Hill College, "This is the man who took Delhi, thereby saving the British Empire in Northern India." Doubtless those who wrote or reported on the glorious issue had no clear conception of the desperate nature of this preliminary work and therefore scarcely referred to it.

Although Taylor had thus by dogged pluck and unremitting labour pieced together his splendid scheme of attack, he was more than fortunate in having in Baird Smith a chief who was not only able to grasp the practicability of so daring a project, but who was, by his great influence and personality, able to convince General Wilson. The latter, being a distinguished Artillery officer, was well aware of the terrible strain that the siege would throw upon the artillery and engineer working parties, and was in consequence more keenly alive to the risk of such a scheme and to the almost insuperable difficulties it seemed to offer. But his able staff (one of whom was subsequently nominated Viceroy of India) all agreed that the chance of success lay in its adoption, and this finally determined him to give his approval. The greatest responsibility, however, devolved upon Colonel Baird Smith, of course, and all honour is due to him, for had he not boldly faced and overcome all opposition the assault and fall of Delhi might have been deferred with disastrous results.

The fame and services of Colonel Baird Smith stand on a higher platform—to use the words of General Taylor—than that of the military engineering scheme on which the fame of the latter rests. His work was of the highest importance, touching such matters as policy, the maintenance of the British power at the time and later on, correspondence with the Government, etc., and the endless considerations and decisions necessary both to carry on the siege, and also in connection with the reinforcements that might be expected. Such duties were all important and enabled him to play the part of a trustworthy and able counsellor to an anxious and harassed General who, leaning very much upon him, efficiently filled for months, and finally carried to a glorious issue, a command and a responsibility so great that three generals in command before him had succumbed in a few days in succession.

Although in virtual charge of all defensive work on the right of our position on the Ridge from the day that it was first occupied, the writer had but little communication with Colonel Baird Smith, and this was early in the siege and in connection with some arrangements at Roorkee. A day or two before the assault, also, he received a note from the C.E.'s quarters in camp saying "all goes well with you." Appointed Director of the Right Attack upon Delhi, under the direct instructions of Capt. Taylor, he traced on the 7th–8th September, under the latter's directions and after he had chosen the site, the first battery whose guns were to crush the Mori Bastion and to deprive it of its command over the left or main attack. The guns on its left flank commanded the ground between the Kashmir Gate and our main attack, and without them the construction of the breaching batteries would have been impossible. As it was the work was hazardous in the extreme. Another object of battery No. 1 was to lead the enemy to suppose that the attack would be developed on the right flank. In this it was entirely successful, and desperate were the efforts the mutineers made to crush the attack on the right. This battery was thus, as intended by Capt. Taylor, a key to the whole attack.

In connection with the above notes a few words may not be out of place regarding General Nicholson. He was the embodiment of what one might look for in a great soldier and man, whose aspect, somewhat reserved though impetuous, spoke of command and success and inspired an abiding respect and confidence. It is said that a warlike tribe started a religion of which he was the quasi-deity. He was the best known of those officers charged by Lord Lawrence with the disarmament of all the regiments in the Punjab. He also pursued and destroyed one large body of rebels which had revolted and started for Delhi. Later on he led a force from Delhi against a strong body of mutineers which was moving to attack or capture the siege guns *en route*. He captured, instead, all their guns and drove away the remnant. He at once grasped and cordially seconded Taylor's work, associating himself with him both by day and night, running the same hairbreadth risks, and fully comprehending and entering into the whole scope of the scheme. No one else had the same personal knowledge of the exact project, and it was the very audacity in placing the great breaching battery within almost a stone throw of the rampart that charmed him. His frequent passing between the siege site and headquarters was to expedite the requirements of men and material.

Nicholson's death was a very great loss. He had always hoped ardently for a command in the field for which he was so eminently fitted, but little scope for such a command could exist until Delhi fell. Even when dying he did not forget the man with whom he had been so closely associated throughout the siege, and his words "Taylor took Delhi" and "if I live the world shall know it" show how fully he appreciated the value of the work in which he himself had taken so exceptional a part. Possibly, also, he realized that he alone could ensure its recognition, as he knew that no other officer of higher rank had witnessed it, and that Taylor was the last man to speak of it as reflecting any credit upon himself.

Although the Engineering aspect has been principally dealt with in these notes, the actual work done by the Engineers in marking out the ground was simple enough and of no particular interest. The real interest of the Siege of Delhi centres in the heroic and hazardous way in which the scheme of attack was slowly pieced together, and in the gallantry—equally displayed by all—which enabled a much-tried General to utilize to the fullest extent the inadequate means at his disposal, and a handful of British soldiers to crown with success a desperate undertaking which saved not only the lives of thousands of their fellow countrymen, but the future existence itself of the British Empire in India.

In conclusion, it seems to be a curious fact that the most striking feature of the Siege of Delhi has never been noticed. It is surely unprecedented in warfare that, not only in the face of but also almost in the midst of a watchful enemy, what was obviously the site for the final struggle was completely surveyed, and the position of every gun, of the attacking force itself, and of all the approaches were clearly marked out on the ground, and the action finally carried out exactly as originally planned.

ROLL OF THE CORPS.

By Capt. H. Biddulph, R.E.

In the list of R.E. officers published by the R.E. Institute in 1898 the two following names appear :—

437. Elliott, Theodore Henry...	2nd Lieut. 7. 5. 10. Lieut. 1. 5. 11. 2nd Capt. 18. 11. 20.	Peninsula. 1811–13.	Permt. h.p. 19. 10. 26. d. in London. 2. 4. 42.
523. Elliot, Francis Edward ...	2nd Lieut. 1. 8. 14. Lieut. 1. 7. 15.	—	Retd. (joined the line) 8. 2. 26.

As both these officers had the distinction, (probably unique for Royal Engineers) of serving in India between 1815 and 1820, the following additional information may be of interest :—

The E.I. Register for 1815 (2nd edition) shows that Lieut. T. H. Elliot, R.E., went to India in the capacity of Military Secretary and Aide-de-Camp to the Rt. Honble. Hugh Elliot, Governor of Madras. The Registers for 1816, 1817, and 1818, have the same entries.

The Register for 1819 shows Lieut. F. E. Elliot, R.E., as private secretary, military secretary and aide-de-camp to the Rt. Hon. Hugh Elliot. The Register for 1820 (1st edition) shows Lieut. T. H. Elliot, R.E., as Military Secretary and Aide-de-Camp, and Lieut. *E. F.* Elliot, R.E., as private secretary. The Rt. Honble. Hugh Elliot vacated office in that year and no further information is available therefore from the E.I. Registers.

If however we turn to the Military despatches of the Pindarry and 2nd Mahratta War (1817–19) we find that Lieut. T. H. Elliott, R.E., took the field as 2nd Aide-de-camp to H.E. Lieut.-General Sir T. Hislop, Bart. (C.-in-C. Madras), C.-in-C. of the Army of the Dekkan, and in this capacity was present at the Battle of Maheidpore, 21st December, 1817, and at the attack and capture of Fort Talneir, 27th February, 1818. The following are extracts from Sir T. Hislop's despatches :—

(1). "Camp on the Soopra, opposite Maheidpore, 23rd December, 1817.

* * * * *

Wounded.

* * * * *

C.-in-C.'s personal Staff. Lieut. Elliott, Aide-de-Camp, slightly."

* * * * *

(2). "G.O. by the C.-in-C. dated Headquarters of the Army of the Dekkan, Camp at Talneir, 28th February, 1818.

* * * * *

The C.-in-C. had on this arduous occasion to deem himself most fortunate in experiencing the able, zealous and valuable services of his Aide-de-Camp, Lieut. Elliott of the Royal Engineers, of which in consequence of the Wounds he received early in the battle of the 21st December last, H.E. had to lament the privation during the remainder of the day. * * *"

In Lake's "Sieges of the Madras Army, 1817-19," among the names of the Engineer officers present at the attack on Talneir is included that of "Lieut. T. H. Elliott, Royal Engineers, doing duty."

It is also possible that this Lieut. T. H. Elliott, R.E., was present at the famous Battle of Seetabuldee, 26th—27th November, 1817, for in the autobiography of Lieut.-General Sir J. B. Hearsey (who as adjutant of the 6th Bengal Cavalry was present and took part in the desperate cavalry charge which helped to turn the fortunes of the day) the following occurs in his account of that battle :—

"There were four of us officers present, viz.: Capt. Elliott (this officer was an A.D.C. to Sir J. Malcolm and had been left at Nagpoor sick when Sir John had passed the Residency there on his way to Indore), Lieut. Clark, 24th Madras N.I., Dr. Niven of the same corps and myself. We were standing opposite to each other talking when the very first cannon shot from the small hill struck off the heads of Clark and Niven, splashing Elliott and myself with their brains. I told Elliott that we had better step back one or two paces to get out of the immediate line of fire."

Sir J. Malcolm was an officer of the Madras Army, and served as a Brigadier-General commanding the 3rd Division and Political Agent to the Governor-General during the War. No other officer of the name of Elliott (or Elliot) appears in the Madras or Bombay Army Lists of 1817, and though there is one Lieut. Elliott of the Bengal Native Infantry, he is shown as doing duty with the Bengal Pioneers and is not likely to have been an A.D.C. to a Madras officer. Sir J. Malcolm was present at the Battle of Maheidpore ; and it is possible that Sir J. B. Hearsey writing after the lapse of some 40 years thought that Elliott was Malcolm's Aide-de-Camp instead of Hislop's.

On 19. 10. 26 Capt. T. H. Elliott was placed on the permanent h.p. list of the *Royal Engineers ;* on 20. 3. 27 he was promoted Major *unattached*, *British h.p.*, and given the rank of Lieut.-Colonel in the Army on 23. 11. 41.

Lieut. F. E. Elliot was placed on the h.p. list of the *Royal Engineers* 1. 4. 17, restored as Lieutenant, R.E., 12. 1. 25, promoted Captain *unattached*, *British h.p.* 10. 6. 26, exchanged with John Tobin as Captain into the 11th Foot on 28th August, 1846, and sold his Captaincy the same day to Lieut. Jas. Howard Fetherston (*vide London Gazette*). Finally it is to be noted that these officers have their names spelt as Elliott or Elliot indiscriminately, and that from about 1820 onwards F. E. Elliot's name is given in the Army Lists as E. F. Elliot.

Perhaps some readers of the *R.E.J.* can give further particulars as to the Indian Services of these Officers, and of their relationship to each other and to the Rt. Honble. Hugh Elliot.

THE PHOTOMETRY OF SEARCHLIGHTS.

By CAPT. A. D. ST. G. BREMNER, R.E.

AS there is very little in the Electric Light Manual on the above subject, the following may perhaps be of interest and use, presuming a knowledge of Volume II. of the Manual :—

The Science of Illumination has been based upon an arbitrary and utilitarian system of units, derived from the light-giving powers of certain standard light sources.

Luminous Intensity (I) admits of the most ready and accurate measurement of all the photometric quantities, and its units form the basis of definition of the remaining units of the system.

Since 1st April, 1909, the following simple photometric relations have been accepted :—

1 International candle	= 1 Pentane candle (British Harcourt lamp).
" "	= 1 Bougie decimale (French candle).
" "	= ·104 Carcel (French colza-oil lamp).
" "	= 1·11 Hefner unit (German amyl-acetate lamp).

·90 International candle = 1 Hefner unit.

Luminous Flux (ϕ) denotes quantity of light, and its unit is the Lumen, which emits unit I within unit solid angle.

Unit solid angle is the angular space subtended at the centre of a sphere by an area of its surface equal to the square of its radius.

The total angular space about a point $= 4\pi$ or 12·5664 solid angle units.

The value of the Lumen used here is that derived from the International candle.

The light of a source whose average intensity in all directions is 1 candle-power (c.p.) = 1 mean spherical c.p. or 1 spherical candle. This term is commonly used as a measure of mean luminous intensity, but it obviously refers to a definite quantity of light flux with a value of 12·5664 lumens.

Illumination (E) denotes the density of the light flux falling on a surface, and its unit is the candle-foot = 1 lumen per square foot, or the illumination received by a surface at every point 1′ distant from a source of 1 c.p.

An illumination of 1 lumen per square metre = 1 lux or metre-candle, and is most commonly used on the Continent.

1 Candle-foot (Cd.-ft.) = 10·75 Luces, using International candles.
= 11·94 Luces, using Hefner units.

The Intrinsic Brilliancy (i) of light sources may be expressed as the lumens emitted per sq. ft. of radiating surface, or more commonly the c.p. per sq. in. of surface exposed in a given direction.

Mutual Relations of Photometric Concepts and Units.

Concept.	Symbol.	Unit.	Defining Relation.
Intensity	I	Candle-power ...	$I = \frac{d\phi}{d\omega}$
Quantity	ϕ	Lumen	$\phi = I\omega = 4\pi I_{ms}$
Quantity / Mean Intensity ...	I_{ms}	Spherical candle...	$I_{ms} = \frac{\phi}{4\pi}$
Illumination ...	E	Candle-foot ...	$E = \frac{\phi}{A}$. $E = \frac{I \cos\theta}{l^2}$
Brilliancy	i		$i = \frac{I}{a}$

Note.—ω = solid angle units. A = area illuminated (sq. ft.). a = apparent area of source (sq. in.).

If a small screen of area A is placed normally to the rays coming from a source of light of intensity I at a distance l, the quantity of light falling on the screen will be, by the law of inverse squares :—

$$\phi = \frac{IA}{l^2}$$

$\frac{A}{l^2}$ is a measure of the solid angle subtended at the source.

ϕ given out in a small solid angle ω can therefore be expressed as $\phi = I\omega$

If I is the same in all directions, the total ϕ emitted by the source $= \frac{4\pi l^2 I}{l^2} = 4\pi I$

The illumination E at any point is the ratio of the quantity of light falling on a small area surrounding the point and normal to the rays, to the magnitude of that area :—

$$\therefore E = \frac{\phi}{A}, \text{ but } \phi = \frac{IA}{l^2}$$

$$\therefore E = \frac{I}{l^2}$$

If the rays are at an angle of incidence θ with the normal to the surface, then from the law of cosines :—

$$E = \frac{I \cos \theta}{l^2}.$$

M. Violle has shown that the intrinsic brilliancy (i) of the crater of a carbon arc remains sensibly constant, being limited by the temperature of volatilization (3,500°—4,000° C.).

If the "i" of a fully developed arc is about 190* c.p. per sq. m.m. of crater area, the intensity of an arc (150 amps.—60 volts, crater diam. = 2·5 c.m.) will be about 100,000 c.p.

Reflection.

The ratio of light reflected by any surface to that incident upon it is known as its coefficient of reflection. This coefficient has a value dependent upon the physical character of the surface and when its reflecting power is selective, upon the colour composition of the incident light. Thus a surface of high reflecting power for red might show a high reflection coefficient under the light of the carbon filament lamp and practically zero reflection coefficient under the green light of the mercury arc. Coefficients of reflection are best stated in terms of daylight, and special determinations or a due allowance should be made when dealing with light of any other colour.

The following table gives approximate results collected by Bell :—

Material.	Co-efficient.	Material.	Co-efficient.
Highly polished silver ...	·92	Light pink paper	·36
Mirrors silvered on surface	·7—·85	Yellow cardboard ...	·30
Highly polished brass ...	·7—·75	Light blue cardboard ...	·25
Highly polished copper ...	·6—·7	Brown cardboard ...	·20
Highly polished steel ...	·6	Plain deal (dirty)	·20
Polished gold	·5—·55	Yellow painted wall (dirty)	·20
Burnished copper	·4—·5	Emerald green paper ...	·18
White blotting paper ...	·82	Dark brown paper ...	·13
White cartridge paper ...	·8	Vermilion paper	·12
Ordinary foolscap	·7	Blue-green paper ...	·12
Chrome yellow paper ...	·62	Cobalt blue	·12
Orange paper	·5	Deep chocolate paper ...	·04
Plain deal (clean)	·4—·5	Black cloth	·012
Yellow wall paper ...	·4	Black velvet	·004
Yellow painted wall (clean)	·40		

* 130 c.p. according to Ives and Luckiesh, 1911.
250 c.p. is considered possible in America.

COLOUR COMPOSITIONS.

The following table gives values for the primary colour elements determined by Ives :—

Source.	Red %.	Green %.	Blue %.
Average daylight	100	100	100
Blue sky	100	106	120
Overcast sky	100	92	85
Afternoon sunlight	100	91	56
Direct current carbon arc	100	64	39
Mercury arc	100 (?)	130	190
Tungsten lamp	100	55	12·1
Tantalum lamp	100	49	8·3
Carbon lamp	100	45	7·4
Flame arc	100	36·5	9
Gas flame, open fish tail burner ...	100	40	5·8
Hefner lamp	100	35	3·8

MIRRORS.

Glass is an excellent material for mirrors, as it is capable of taking a high polish, and when silvered possesses excellent reflecting properties; for a long time, however, all efforts to manufacture parabolic mirrors of sufficient accuracy from glass were unsuccessful.

The mirrors had therefore to be made with a spherical surface. This necessitated the use of small effective angles; for as soon as the ratio of mirror diameter to focal length exceeded a certain value, the deviation of the reflected light from parallelism became so great that no advantage could be gained by increasing the effective angle.

A great advance was made by Mangin, in 1876, who eliminated spherical aberration almost entirely, by giving the glass the form of a concavo-convex lens, instead of making it of uniform thickness, as long as the mirror diameter was not greater than its focal length.

On the other hand, the effective angle was only about 60° on account of the comparatively great focal length, and the mirror therefore reflected only a small part of the light emitted from the source.

In 1886, however, Schuckert, at Nuremburg, succeeded in manufacturing true parabolic glass mirrors by a method patented by him and Munker.

The disadvantage of the great liability of glass mirrors to crack (especially Mangin type) has led to many experiments with metallic mirrors, but so far little success has been obtained. A gold plated metallic mirror shows the most promising results, but it is not so good in clear weather and has not the same dazzling effect as silvered glass patterns.

Parabolic Mirrors.—It is found that the light of the full moon will illuminate a torpedo boat at about 1,000ˣ range sufficiently for effective gun fire. The E of the full moon at the earth's surface=·01358 candle-feet. It varies between ·0166 cd.-ft. and ·01 cd.-ft.

In order to produce this E at 1,000ˣ, the I of the source of light must be 122,220 c.p. The sunlight in London varies between 30 and 40 cd.-ft.

The most powerful source of light at present available is an electric arc taking about 150 amps., and the curve of its light distribution is shown in *Fig.* 1. The line of greatest intensity makes an angle of about 45° with the axis of the carbons.

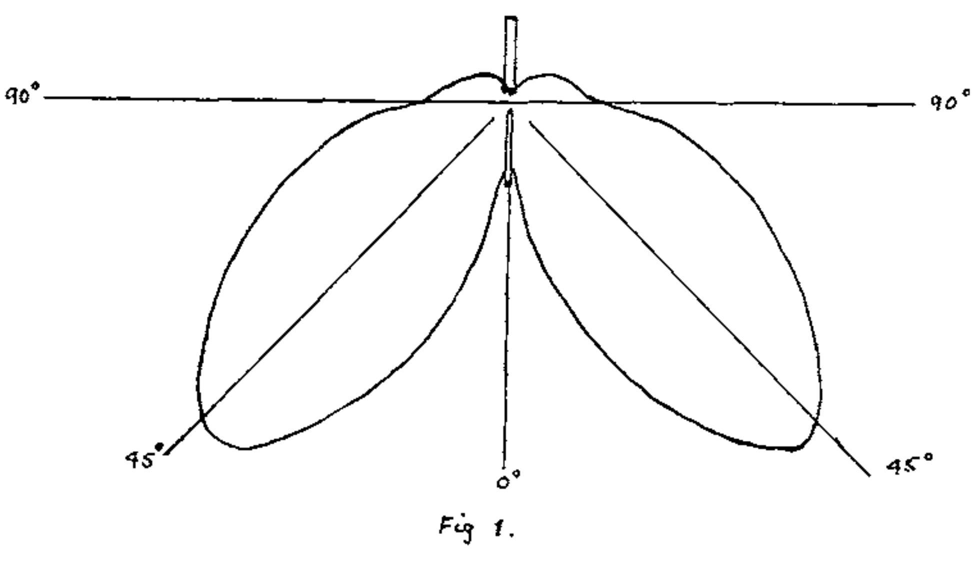


Fig 1.

The solid angle subtended at the arc by the edge of a mirror is called the effective angle of the mirror.

If a point source of light is placed at the focus of a true parabolic mirror, all the rays falling on the mirror will be reflected parallel to the axis.

In *Fig.* 2, let BAH and BDH be paraboloid and spherical mirrors respectively, with F as the focus and centre respectively.

The effective angle of both $= \angle BFH = \omega$.

If a point source of light of intensity I is placed at F, the ϕ on the spherical surface$=\frac{IA}{l^2}$, where l=radius of sphere.

$$= \frac{I}{l^2} 2\pi l \times l \left(1 - \cos\frac{\omega}{2}\right)$$

but $1 - \cos\frac{\omega}{2} = 2\sin^2\frac{\omega}{4}$

$$\therefore \varphi = I 4\pi \sin^2\frac{\omega}{4}$$

$4\pi \sin^2\frac{\omega}{4}$ is a measure of the solid angle subtended at the source.

The paraboloid receives the same quantity of light.

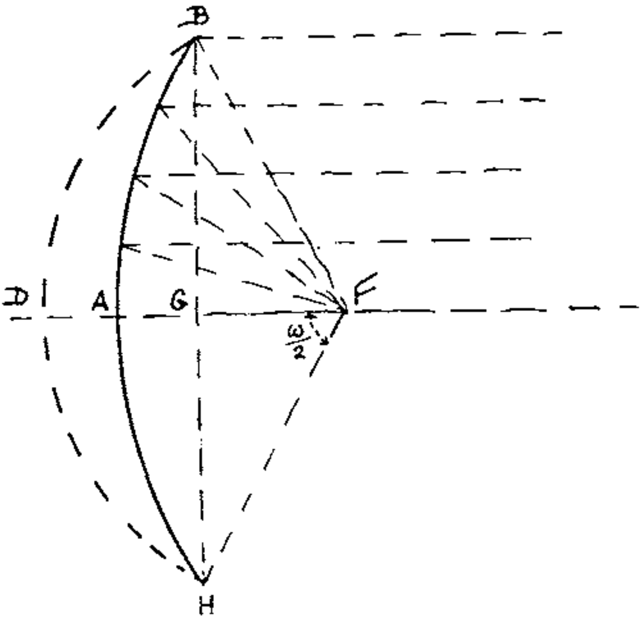


Fig 2.

If the source of light is a circular disc of diameter $d = ac$ (*Fig.* 3), and the focal length $= f$, rays coming from the centre F will be reflected parallel to the axis, and those coming from other parts of the source will be reflected with a certain deviation from parallelism which is greater, the greater the distance from F. Thus, a ray coming from a to the vertex will be reflected to c, and thus the angle aAc gives the conical angle of the reflected beam.

This angle is β where $\tan\frac{\beta}{2} = \frac{d}{2f}$

At a great distance R from the mirror, a surface will be illuminated having a diameter $P = \frac{Rd}{f}$

This surface will be illuminated (supposing perfect reflection from mirror) by original ϕ of light $= I 4\pi \sin^2\frac{\omega}{4}$

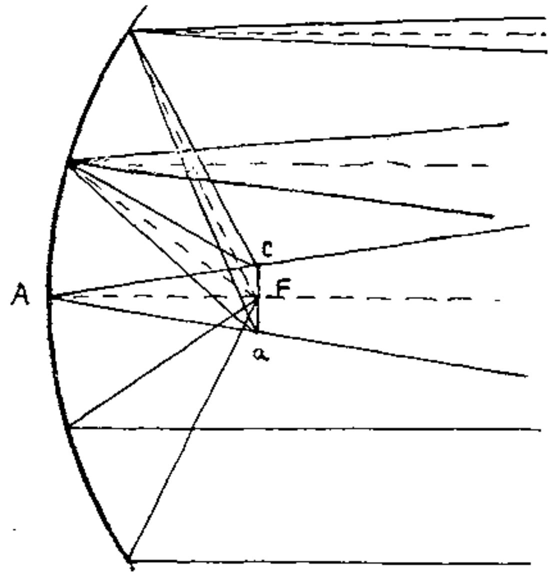


Fig 3.

If beam were parallel, ϕ at R would be distributed over area $=\frac{\pi D^2}{4}$, where D=diameter of mirror, but as light is distributed over a larger area, the candle-feet will be less by ratio $\frac{D^2}{P^2}$

If no mirrors were used and the surface P were illuminated by the same source of light emitting rays equally in every direction,

$$\therefore \phi = I 4\pi \sin^2 \frac{\beta}{4}$$

$$\therefore \frac{\phi \text{ with mirror}}{\phi \text{ without mirror}} = \frac{I 4\pi \sin^2 \frac{\omega}{4}}{I 4\pi \sin^2 \frac{\beta}{4}} = \frac{\sin^2 \frac{\omega}{4}}{\sin^2 \frac{\beta}{4}},$$

which gives a measure of the increased effect, *i.e.*, the intensification (I_1) of the mirror.

In practice, the relation is slightly different, since only that part of the light falling on the vertex of the mirror is reflected at $\angle \beta$, while for every other part of the surface the dispersion is smaller.

In practice, we can with sufficient accuracy write $\frac{\sin^2 \frac{\omega}{4}}{\sin^2 \frac{\beta}{4}} = \frac{D^2}{d^2}$

$$\therefore I_1 = \frac{D^2}{d^2}$$

The obscuration caused by the negative carbon was at first minimized by having the carbons at 20°—30° with the vertical, thus giving a greater I in one direction, but this plan is suitable only with mirrors of small effective angle.

Horizontal carbons are now most generally used and possess advantages even for mirrors with effective angle of 83°, as the light from the $-^{ve}$ carbon is reflected from the $+^{ve}$ crater and increases the total φ from the latter.

If I_m is the mean intensity of that part of the light falling on the mirror, the amount of light reflected (neglecting all losses)

$$=\varphi=I_m 4\pi \sin^2\frac{\omega}{4}$$

If this were uniformly distributed over a cone of vertical angle β, a surface of diameter P and area $4\pi R^2 \sin^2\frac{\beta}{4}$ would be obtained at distance R and the illumination of the surface would be :—

$$E=\frac{I_m 4\pi \sin^2\frac{\omega}{4}}{R^2 4\pi \sin^2\frac{\beta}{4}}=\frac{I_m \sin^2\frac{\omega}{4}}{R^2 \sin^2\frac{\beta}{4}}$$

Since the φ on the surface $=\varphi$ on the mirror, the intensity at the surface $=I_R=I_m\frac{D^2}{d^2}$

But the beam is not uniform, being greatest at the centre and falling off rapidly at the edge. The greatest difference in brightness occurs when the mirror is truly parabolic, but the manufacturer can introduce definite alterations in the form of the mirror, tending to make E uniform. An increase of the central illumination up to 35 % above the mean intensity of the beam is advantageous.

The determining factors for the distribution of intensity and for the intensity of the beam as a whole, is the intensification, *i.e.*, the correct choice of the effective angle and the angle of the beam.

As upper limits, take 140° for the effective angle and 3° for the angle of dispersion. These figures for the service 90 c.m. projector are 112° 44′ and 2° 44′ respectively.

Now I_m and $\sin^2\frac{\beta}{4}$ are both proportional to area of crater, but area of crater increases in proportion to the electrical energy without great increase in intrinsic brilliancy, so that the ratio $\dfrac{I_m}{\sin^2\frac{\beta}{4}}$ remains about the same with increasing current strength. With a larger quantity of light there is therefore no appreciable gain in penetrating power.

If the I in the zone of greatest illumination is divided by the watts and the result plotted as in *Fig.* 4 against the watts, for small lamps using a small number of watts, a considerable increase in "i" of the crater takes place with increasing current but the area of crater does not increase in the same proportion as the total ϕ.

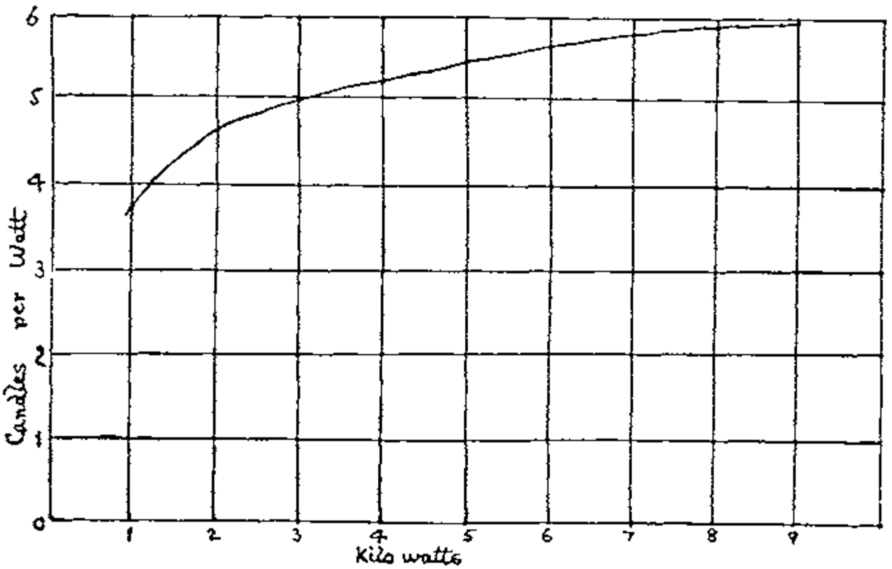


Fig 4

But at higher currents, the increase in "i" is very small and there is greater irregularity in the form of the crater, so that practically there is no increase in penetrating power obtainable by increasing the current beyond a certain value.

Searchlights.

The intensity of a searchlight is defined as the ratio of the total quantity of light reflected from the mirror to the solid angle of the cone of light.

The total quantity of light reflected (assuming no loss on reflection) is $\phi = \frac{\pi}{4} id^2$

The solid angle subtended by the source at the centre of the mirror $= 4\pi \sin^2 \frac{\beta}{4}$

$$\therefore \text{ the intensity } I_s = \frac{id^2}{16 \sin^2 \frac{\beta}{4}}$$

Since β is a small angle we can put

$$\sin\frac{\beta}{4}=\tfrac{1}{2}\sin\frac{\beta}{2}=\tfrac{1}{2}\tan\frac{\beta}{2}=\tfrac{1}{2}\left(\frac{d}{2f}\right)$$

$$\therefore \sin^2\frac{\beta}{4}=\tfrac{1}{16}\left(\frac{d}{f}\right)^2$$

$$\therefore I_s=i/^2$$

But for different sizes of mirrors the ratio of diameter to focal length is approximately constant,

$\therefore I_s=CiD^2$, where C is a constant.

Let O=observing distance, *i.e.*, distance from observer to target, and L=distance of illumination, *i.e.*, distance from light to target.

When the maximum "O" for a given "L" and size of searchlight has been determined, the value for other sizes can be calculated. As mirrors of 90 c.m. diameter are now in general use, this size may be taken as the standard. In order to obtain a maximum "O" with a given "L," a definite intensity of illumination is required for the given target, and equals $E=\frac{CiD^2}{L^2}$

In order to see the target at the same "O" equally well with another searchlight S_1 we must have $\frac{Ci_1D_1^2}{L_1^2}=\frac{CiD^2}{L^2}$

$$\therefore L_1=\sqrt{\frac{i_1D_1^2L^2}{iD^2}}=L\frac{D_1}{D}\sqrt{\frac{i_1}{i}}$$

If O=L, call this the radius of action=R.

The brightness of the image of the target formed on the retina of the observer's eye will be directly proportional to the illumination of the target and inversely proportional to the square of the distance, *i.e.*, to $\frac{E}{R^2}$. Substituting for E as above, we have the brightness proportional to $\frac{CiD^2}{R^4}$

To obtain an equally bright image of the same target with another searchlight S_1 we must have the brightness proportional to $\frac{Ci_1D_1^2}{R_1^4}$,

$$\therefore R_1=\sqrt[4]{\frac{R^4i_1D_1^2}{iD^2}}=R\sqrt{\frac{D_1}{D}}\sqrt[4]{\frac{i_1}{i}}$$

If the beam is spread out horizontally by dispersing lens, the E of the target will decrease by the ratio of the angle β of beam when concentrated to angle λ when dispersed.

In addition, the mean horizontal intensity is to be considered and not the axial intensity of the beam, as with a concentrated beam. The mean horizontal $I = 65\%$ of the axial I approx.

The radius of action R_s with dispersed beam can therefore be obtained by the formula

$$R_s^4 = \frac{\cdot 65 R^4 \beta}{\lambda} \text{ or } R_s = R\sqrt[4]{\frac{\cdot 65\beta}{\lambda}}$$

It is assumed that the target is illuminated with the zone of greatest brightness and that the light and observer are sufficiently far apart to prevent the latter being dazzled by the former. *Table* I. (page 35) gives interesting comparative details.

For a more complete calculation we must take into account (1) the area of the target, (2) its reflecting power, (3) the absorption of the rays by the atmosphere.

The ϕ of light reflected from the target is directly proportional to its area and to its reflective power, which is defined as the ratio of ϕ actually emitted from the target to that which would be emitted if it had a perfectly white surface.

As regards (3) above, the apparent brightness of a target at range R must be decreased in the ratio $1 : (1\text{-}p)^R$, where p denotes the absorption caused by passage through 1000^x of atmosphere.

When lights are being tested, the magnitude of the atmospheric absorption is usually not known. The comparison of two lights must be carried out therefore at the same time and under the same conditions, as the absorption may be anything from 2% to 50% or even more.

It is clear then that the radius of action furnishes an extremely unreliable measure of the capabilities of a searchlight.

If one of the lights has 36% greater brilliancy than the other, the R of the first is only $109{\cdot}3^x$ greater than the R of the second, when the latter is 1369^x. In order to increase the R from 3284^x to 5612^x (10%), it would be necessary to increase the *i* of the source of light by 46%.

It is very difficult to distinguish differences in distance as small as 10% at night when all surrounding objects are in darkness, and it is equally difficult to distinguish with the naked eye differences in illumination of a distant target as large as 30%.

The only way, therefore, of forming a true estimate of the value of a searchlight is to carry out careful photometric measurements.

In *Table* II. (page 36) there are given values of intensity obtained with various searchlights, partly by photometric measurements and partly by actual tests in the open. It is of course only possible to speak of approximate values in such a case as this.

For further information, the following books may be consulted :—

The Electric Arc	Mrs. Ayrton.
Illumination and Photometry ...	W. E. Wickenden.
Searchlights	F. Nerz.

to which I am indebted for much of the foregoing.

TABLE I.

Diameter D of Mirror. cms	Focal Length of Mirror. cms	Normal Current. Amps	Diameter of Crater. m/m	β = Angle of Reflected Beam.	$\frac{D}{D_{90}}$	$\sqrt{D}$	$\sqrt{\frac{D}{D_{90}}}$	$\frac{i}{i_{90}}$	$\sqrt{\frac{i}{i_{90}}}$	$\sqrt[4]{\frac{i}{i_{90}}}$	* Relative Distances of Illum'n. Yards	Radius of Action of Searchlight. For small objects in yards. † R with conc'd Beam.	R with angles of dispersion. 10°	16°	30°	45°	For large objects in yards observed at ‡ Ismid.	Nürnberg.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
35	17·5	20	9	2°56′	·389	5·916	·624	·68	·825	·908	941	1674	1093	980	843	755	7650	4700
40	20	30	9·4	2°42′	·444	6·325	·666	·76	·872	·934	1149	1839	1180	1058	903	810	8320	5140
45	20	40	10	2°52′	·500	6·708	·707	·86	·927	·963	1368	2000	1312	1171	1067	903	9140	5640
60	25	60	12·1	2°47′	·666	7·746	·8165	·914	·956	·978	1870	2351	1530	1362	1160	1050	10,710	6630
60	28	70	13·5	2°46′	·666	7·746	·8165	·944	·972	·986	1904	2373	1542	1372	1170	1060	10,820	6670
75	31	80	15·3	2°50′	·833	8·66	·9128	·966	·983	·9915	2403	2660	1739	1550	1312	1192	12,100	7500
90	38	100	18	2°43′	1·000	9·487	1·000	1·000	1·000	1·000	2950	2951	1914	1699	1455	1312	13,450	8320
90	42	120	20	2°44′	1·000	9·487	1·020	1·018	1·010	1·005	2950	2951	1914	1699	1455	1312	13,450	8320
110	52	150	23	2°33′	1·222	10·488	1·105	1·066	1·030	1·015	3610	3280	2087	1860	1575	1432	14,890	9200
120	55	150	23	2°24′	1·333	10·954	1·153	1·066	1·030	1·015	4060	3445	2165	1925	1645	1486	—	—
150	65	150	23	2° 2′	1·666	12·247	1·291	1·066	1·030	1·015	4930	3762	2278	2030	1730	1563	17,500	10,786

* The distances at which searchlights of the respective diameters must be placed in order to render a target just visible when the observer's distance from the target is 2,950 yards.

† The distances at which it is possible to discover torpedo boats or to see whether artillery fire is too high or too low. For effective gun-fire reduce by 33 per cent.

‡ The distance at which it is possible to distinguish large light-coloured buildings.

Two lights superimposed will have a range equal to that of a single light of half the dispersion.

TABLE II.

Diameter D of Mirror.	Current.	Voltage.	Watts.	Candles per Watt.	Intensity in Candles of Rays incident on the Mirror.		Mean Intensity in Candles of Reflected Rays.	Diameter d of Crater.	Intensification of Mirror D^2/d^2.	Intensity of reflected beam in candles at great distances, neglecting atmospheric absorption.	Focal Length of Mirror f.	Angle of Dispersion.	Diameter of Beam at 1000x Distance.	Illumination in Candle-feet with absorption of 9·5 % per 1000x at distances of:	
cms	Amps.	Volts.			Max.	Mean.		m/m			cms		Yards	1093x	2187x
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	20	43·5	870	3·6	3130	2500	2250	9·3	1854	4,170,000	18	2°58′	51	·382	·0779
40	25	44	1100	4·18	4500	3600	3240	9·4	1811	5,840,000	18	2°59′	52	·530	·01089
	30	44	1320	4·32	5670	4500	4050	9·5	1773	7,200,000	20	2°43′	47	·600	·0134
	20	43·5	870	3·6	3130	2500	2250	9·3	2341	5,265,000	20	2°40′	46	·438	·0988
45	30	44	1320	4·32	5670	4500	4050	9·5	2244	9,540,000	20	2°43′	48	·795	·178
	40	45	1800	4·63	8320	6660	5990	10	2025	12,140,000	20	2°52′	50	1·046	·226
	40	45	1800	4·63	8320	6660	5990	10	3600	22,400,000	25	2°18′	49	1·875	·418
60	50	46	2300	4·82	11,000	8820	7940	10·9	3030	24,000,000	25	2°30′	44	2·000	·447
	60	47	2820	4·98	13,900	11,100	10,020	12·1	2459	24,450,000	25	2°47′	48	2·035	·456
	60	47	2820	4·98	13,900	11,100	10,020	12·1	3840	38,100,000	31	2°16′	39	3·165	·712
75	75	49	3675	5·22	19,100	15,300	13,770	14·3	2744	38,100,000	31	2°38′	46	3·165	·712
	90	51·5	4680	5·4	25,300	20,200	18,450	16·7	2020	38,100,000	31	3° 6′	54	3·165	·712
	60	47	2820	4·98	13,900	11,100	10,020	12·1	5532	54,850,000	31	2°16′	39	4·580	1·025
90	75	49	3675	5·22	19,100	15,300	13,770	14·3	3950	54,850,000	38	2° 8′	38	4·580	1·025
	90	51·5	4680	5·4	25,300	20,200	18,450	16·7	2900	54,850,000	38	2°32′	44	4·580	1·025
	100	53	5300	5·44	28,800	23,100	20,800	17·5	2640	54,850,000	38	2°43′	47	4·580	1·025
90	125	55·5	6660	5·6	37,400	29,900	26,900	20	2030	54,850,000	42	2°44′	48	4·580	1·025
	150	59	8900	5·8	51,300	41,100	36,900	23	1530	54,850,000	42	3° 8′	55	4·580	1·025
110	150	60	9000	5·85	52,200	41,800	37,600	23	2287	86,350,000	52	2°32′	44	7·20	1·612
120	150	60	9000	5·85	52,200	41,800	37,600	23	2722	102,400,000	55	2°24′	42	8·53	1·912
150	150	60	9000	5·85	52,200	41,800	37,600	23	4300	162,000,000	65	2° 2′	36	13·48	2·700

Note:—Col. 8 × Col. 10 = Col. 11. Col. 14 = $\frac{1000 \times \text{Col. } 9}{\text{Col. } 12}$

SOME NOTES ON ARTESIAN WELL BORING.

As the use of the artesian well for water supply is becoming daily more widely recognized, the writer has ventured to jot down these notes which are the result of experience obtained while sinking two bore holes in a division at a home station.

The wells were intended to secure to outlying forts a good supply of fresh water, and were sunk on the "trial and error" principle. The only men available were three engine drivers, none of whom had any previous experience of well boring.

The only plant available in store was a set of 1″ square boring rods in 10′ lengths, with 3 tools for a 3¼″ bore hole—a T chisel, a clay auger, and a "shell." The latter is a tool fitted with a valve at the lower end and is designed for removing *débris* from the bore hole. A search round the other division stores, however, resulted in the discovery of a 1-ton double-geared crab with a drum 18″ long by 8″ in diameter. An obsolete pumping station yielded a 3½-B.H.P. Tangye oil engine on loan, while the scrap heap was responsible for three lengths of 3″ steam barrel, each about 20′ long, and an old S.M. "sheaf-winding cable." The remaining gear was made in the shops or purchased locally.

The steam barrel was made into a tripod to carry the overhead gear. The detail of the head of the tripod is shown in the *Plate*, and should be noted. It is essential that the sheaf be rigidly held and not permitted to sway, otherwise the tool and rods will not drop truly vertically into the bore hole.

The crab was fitted to be driven by power and was driven continuously by the oil engine. The rope—a 2½″ manilla—was given one, two, three or more turns round the drum according to the number of rods to be lifted. The boring tool was "jumped" by "surging" the rope on the drum of the crab.

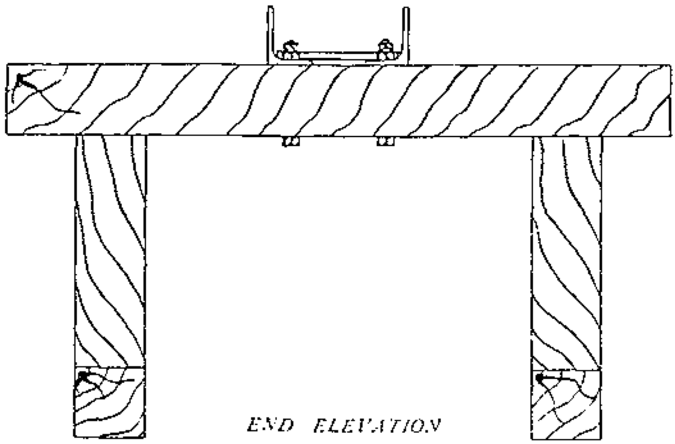
The boring table (*Fig.* 1) should be noted. This is fitted with a removable "auger board," cut from ⅜″ boiler plate. This auger board is fitted with dowel pins so that it is held rigidly in position. It guides the rods and also takes the weight of the dogs, when raising and lowering the rods. The method of operating will now be detailed.

The crew for boring consists of one N.C.O. and two sappers. The N.C.O. directs operations, looks after the engine, and works the fall

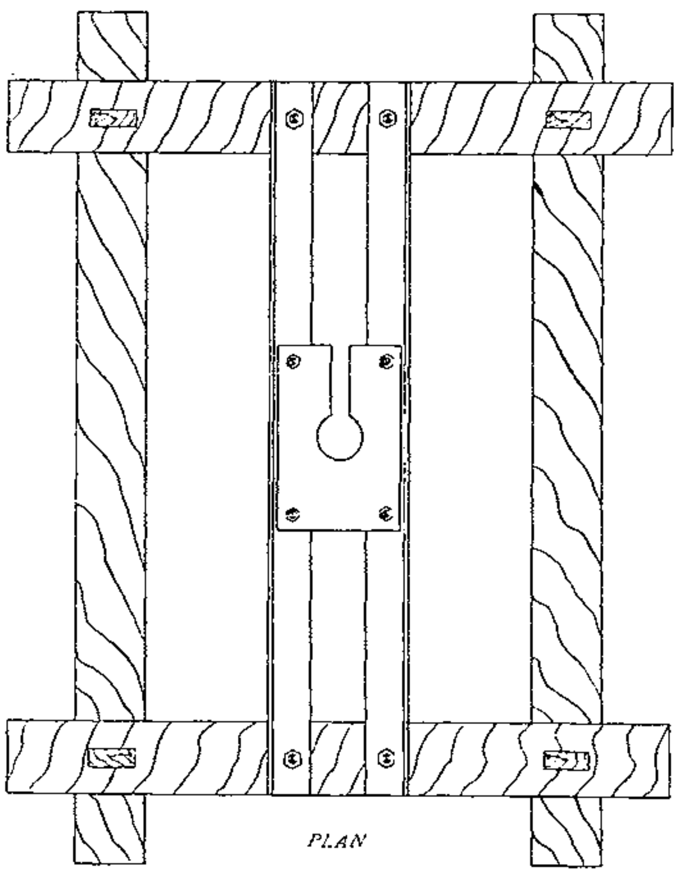
BORING TABLE

WITH REMOVABLE AUGER BOARD.

Scale—¾ Inch to 1 Foot.



END ELEVATION



PLAN

FIG. 1.

of the rope at the crab. The two sappers stand by the boring table to manipulate the rods and boring tools.

The rods and tools are all laid out in order side by side so that they can be easily selected as required. The male ends of the rods and tools towards the bore hole are supported clear of the ground to facilitate picking them up quickly.

It must be borne in mind that the rate of boring is largely dependent on the speed of manipulating the rods and tools, and also on the peripheral speed of the drum of the crab. In this connection it may be remarked that at first the crab drum was driven at a peripheral speed of about 35′ a minute, but when the crew had gained experience different pulleys were substituted, making the speed some 65′ a minute which seemed a fair average rate.

The rods should always be kept in the same order so that the same male and female ends come together. Interchange of the screwed ends causes undue wear.

To detail the actual operation of boring, let us suppose the hole is 40′ down, and has just been cleaned out. The strata encountered is hard. Sappers A. and B. are manipulating the tools while Corpl. C. drives the crab. Sapper A. takes a lifting dog and drops it over the swelled end of the T chisel (or any other tool which may be selected), and places the chisel down the hole until the dog rests on the auger board. Note that all tools and rods should invariably be handled by means of the lifting dogs when boring or clearing operations are in progress. If this precaution is neglected a tool may be dropped down the bore hole. Having thus got the tool in position, Sapper A. hands the spring hook, with another lifting dog attached, to Sapper B., who places it round the shoulder of the lowest rod which always comes at the bottom above the tool. Sapper A. then signals to Corpl. C. to hoist, which rears up the rod to a vertical position and brings the end over the tool. Sapper A. then screws down the rod on to the tool, using the hand wrench for the purpose, signals for the crab to hoist and removes No. 1 lifting dog which permits the tool to be lowered until No. 2 dog comes in contact with the auger board. No. 1 dog is next used again to lift another length of boring rod in position, and so on until the bottom of the bore hole is reached. The swivel-topped rod is then put on and the tillers for turning the rods fixed. The tool is jumped up and down in the bore, by surging on the drum of the crab. The tillers are kept turning round in order that the hole may be truly circular. When the tool has dropped a foot it is withdrawn and the *débris* removed with the shell.

In soft soils, sand or gravel, it is necessary to line the hole, to prevent the sides falling in. The best form of lining is undoubtedly the socketed type, with sockets levelled at each end. The blow of the monkey then drives on the ends of the pipe and not on the threads, as is the case if swelled end pipes are used. The lining should be in convenient lengths; 6′ lengths were used in this case. A driving cap should be used in order to prevent the monkey damaging the threads of the pipe. The lining is driven as the boring proceeds, using the monkey attached to the spring hook.

When water is struck the supply is tested by lowering a deep well pump down the bore by means of the delivery pipe, which in this case was ordinary 2″ galvanized iron in 10′ lengths. The pump rod was ½″ galvanized iron also in 10′ lengths working inside the delivery pipe and lowered at the same time. An old barrack pump with crank and fly wheel was used to couple to the ½″ rod, and arranged with a pulley to be driven by the engine. The supply obtained with the 3¼ bore hole was 200 gallons per hour continuously during the six hours' trial in one hole, but with the other no water was obtained after 90′ of boring, and the strata did not seem to point to success and the hole was abandoned.

THE TORSION BALANCE OF BARON EÖTVÖS.

By MAJOR E. H. HILLS, C.M.G., F.R.S., LATE R.E.*

THE torsion balance, developed as a practical field instrument by Baron Eötvös, is likely to prove of great importance in the higher branches of survey work and may fairly be said to place a new power in the hands of the geodesist. The function of the instrument is the determination of the local variation of gravity on the earth's surface.

Hitherto there have been two methods available for this research; one by pendulum observations whereby the value of *g* is found at any place and the other by a comparison, at a large number of stations, between geodetic and astronomical positions, thus finding the deviation of the plumb line, or the angular quantity by which the apparent vertical differs from the true normal to the spheroid. The direction and amount of the resultant horizontal component of the force of gravity at each station is thus deduced. The torsion balance is now available for checking and supplementing the information given by the older methods.

It arrives at the same results by a different route. Its function is not the direct evaluation either of *g* or of the variation of the level but, in place of these, it serves to determine the differential co-efficient of the force of gravity, *i.e.* its rate of change along any selected horizontal axis.

Thus suppose the value of *g* has been found at any two stations by the use of the pendulum; if now we determine the rate of change of *g* by the Eötvös balance along a series of intermediate points we shall have two values, of independent origin, for the difference in the force of gravity at the two original stations. A similar research would give us an independent value for the difference in the deflection of the plumb line at the two places.

Of these three methods now available for the investigation of anomalies in the distribution of rock masses in the earth's crust the advantages will lie with one or the other according to the particular character of the anomalous distribution and their mutual comparison will lead in every case to the best determination of the positions of the perturbing masses. The torsion balance is working

* Expanded from a "Note on Points connected with the Progress of Astronomy"; Monthly Notices, Royal Astronomical Society, LXXI., 4. February, 1911.

under the most favourable conditions when the masses are nearest the surface and it is not inconceivable that in addition to its use by the geodetic surveyor it may in the future find employment, of a severely practical nature, for the location of ore deposits. A somewhat analogous research has actually already been undertaken in the shape of a comparison between the perturbations due to gravity and those due to magnetic attraction, thus elucidating the distribution of magnetic masses and of those of high density but non-magnetic. The presence of masses of iron can thus be deduced.

The theory of the instrument is readily expressed in analytical form but the following considerations will enable the reader to understand its general principles without recourse to symbols. Imagine a torsion balance of the ordinary form, such as used in the "Cavendish" experiment, *i.e.* a light rod with equal weights at each end hung horizontally by a fine thread attached at its middle point, the upper end of the thread being fastened to a "torsion head" capable of being turned horizontally through any measured angle. Imagine further that the apparatus is placed at a station where there is no local attraction.

The thread will hang vertically downward in the direction of the resultant force of gravitation and, the distribution of the earth masses in the neighbourhood of the instrument being symmetrical or, in other words, the field of force round the instrument being uniform, the beam is under no constraint towards any particular azimuth, so that, suppose the beam to have come to rest in any position, if the torsion head, carrying the thread, be turned through any angle, the beam will turn through the same angle.

If, now, the symmetrical distribution of gravity is disturbed, say by the presence of an attracting mass of rock, giving rise to a horizontal component in the force of gravity, the thread will still hang vertically, but this "vertical" will be inclined to the original direction at a small angle, called the deviation of the plumb line. The beam can no longer assume any azimuth with equal facility. There are now two directions, one when the beam is in the line joining the instrument with the centre of action of the horizontal force, and the other when it is at right angles to this line, where the beam can come to rest with the thread untwisted. In any other azimuth there will be a residual twisting of the thread, so that if the torsion head be now turned through any angle the beam will not in general follow it through the same angle.

By turning the torsion head through successive angles of 45°, 90°, 135°, etc., and by noting the corresponding positions at which the beam comes to rest, we can map out the rates of change of the gravitational forces along any selected horizontal axis, and determine the direction of the resultant horizontal component.

Instead of noting the rest positions of the beam we can take advantage of the fact that the change in the horizontal force will affect the time of swing of the beam in the same manner as the time of vibration of an ordinary vertical pendulum is changed with a change in the value of g, so that we can derive the required information by noting the vibration period in different azimuths. As however to give the requisite sensitiveness this period must be large, in the case of Eötvös instruments it is not less than 10 minutes, this alternative method would be too slow for field use.

It will thus be seen that the essential features of the method involve no new principle. The great achievement of the inventor lies in the transformation of an instrument of an ultra-sensitive nature, only capable of use in a laboratory with every possible shielding from external disturbance, into a portable instrument adapted for use in the field.

The extreme minuteness of the quantities revealed by the torsion balance can best be realized when we remember that we are, in effect, measuring the torsional couple due to the difference in the attraction of the horizontal component of gravity upon the weights at the two ends of the beam respectively. The horizontal component is already itself very small, except in altogether abnormal places, so that, without going into figures, it is sufficiently obvious that this difference is near the limit of instrumental observation. The close accord of the results actually obtained by Eötvös in the field, both among themselves and in comparison with those arrived at in other ways, shows that the measurement lies well within the power of the instrument as designed by him.

In the actual instrument the beam is a thin brass tube, 40 centimetres long with platinum weights at each end, hung by a fine platinum-iridium wire, the whole contained in a double-walled brass case. The angular deviation or rest position of the beam is read off by a minor reflecting a spot of light. It has not yet been found possible to use the instrument except at night, in the daytime the temperature disturbances are too great.

It is interesting and important to note that sensitive as the instrument has proved to be its present form by no means marks the limit of sensitiveness. This could be largely increased by a diminution in size, accompanied by a change in the means of suspension from platinum wire to a quartz fibre, transforming the instrument in the same sense as the original Cavendish instrument was transformed by Prof. C. V. Boys in his classical determination of the mean density of the earth (*v. Encyl. Brit.*, article "Gravitation"). It is understood that Baron Eötvös is himself experimenting with a new instrument upon these lines.

A special investigation, to which the apparatus has been applied by its inventor, is to answer the question as to within what limits the constant of gravitation is the same for all bodies. If it is not, the direction of the apparent vertical will vary with the material of the plumb-bob, since the observed weight of any body is the resultant of two forces, the attraction which for two different bodies would have the same direction, but, on this assumption, a different intensity, and the centrifugal force which would have the same direction and the same intensity for every body.

Previous observations with the pendulum had shown that there was no difference greater than 1/60,000; with the torsion balance Eötvös has shown that any difference cannot exceed 1/200,000,000. Laplace investigated this question astronomically by comparing the Sun's attraction upon the Earth and Moon respectively, and found that any difference was smaller than 1/1,000,000. His calculations remade with the data now available give 1/50,000,000.

DECAY OF BUILDING MATERIALS IN EGYPT.

By CAPT. D. M. F. HOYSTED, R.E.

WHEN investigating the decay of buildings which is so noticeable in Egypt, two points are specially striking, firstly that the action is generally confined to a band extending to about 5′ above the ground line, or is greatest at or near that level, and secondly that it is often accompanied by a white crystalline deposit or efflorescence.

Further it is noticeable that the disintegration is brought about by the chemical deposits forming just below the superficial layers of stone which force them away from the mass.

A very extreme case of this kind has been seen by the writer in one of the barracks situated on the seashore at Alexandria. In the local Mineral Water Factory carbonic acid gas is used for aerating the waters, and is generated in a leaden vessel from carbonate of soda and sulphuric acid. The walls in the factory are about 2½′ thick and consist of native soft stone and mortar in rubble masonry faced with ¼″ of plaster. It was noticed lately that the plaster in the vicinity of the generator was beginning to bulge and flake off, dropping from the wall in large sheets. The surface of the stone below was covered with a crystalline growth resembling white hairs pointing stiffly at right angles from the face of the wall. The surface was thoroughly scraped and left under observation.

In about five days, fresh crops of the white hairs had formed, and in 10 days' time they were an inch in length and in places the fine needles stood almost as closely together as the pile of a carpet.

A chemical examination proved them to consist almost entirely of sodium sulphate with a slight admixture of sodium chloride. The old native walls are nearly always built of sand from the neighbouring seashore and contain therefore a large amount of sodium chloride. It appears that the quite unnoticeable acid fumes, from the generation of the gas for aeration, have a very active effect upon the salt in the masonry, forming crystals of sodium sulphate just below the surface.

This is borne out by some experiments made by Mr. A. Lucas, F.C.S., in 1902, from which he concluded that, in the case of building materials in Egypt, in addition to the disintegration caused by changes of temperature, the oxidizing action of the atmosphere and the corrosive action of acids present in the air or rain, there is also considerable detritus, most frequently near the ground level brought about by :—

(1). The presence of moisture.
(2). The degree of porosity of the stone.
(3). The presence of salts readily soluble in water, either in the stone or the neighbouring ground.
(4). The opportunity for the salts to crystallize out by evaporation of the water holding them in solution.

His opinion was that this special kind of disintegration is largely physical, and that the essential conditions consist of the presence of water, soluble salts and a porous stone.

In all native walls in Egypt the typical scaling of the outer surface is noticeable within a year of completion, and, if uncorrected, it will eat completely through the wall in time just above the ground level. The local stone is very soft and porous and readily absorbs moisture from the rain or mist, and is therefore invariably covered with a plaster for protection. This plaster, must, however, be renewed as it falls away.

I venture to bring this report forward, though, of course, the special case quoted at the beginning is quite of an exceptionable nature, being undoubtedly caused by the acid fumes, as the walls in the same room but at a distance from the generator, are unaffected.

I should be glad to know, if a petrifying liquid has ever been tried as a preventive in such case.

TRANSCRIPTS.

FRENCH REPORT OF THE COMMISSION ON THE PROPOSED BUDGET FOR 1911—WAR DEPARTMENT.

This transcript deals only with the parts of the above report which refer to the engineer troops of the French Republic.

(1). Pay of the Engineers.

Sum voted for 1910	4,168,783 fr.	+229,803 fr.
Sum asked for by the Government for 1911	4,398,586 ,,	
Sum proposed by the Commission	4,398,586 ,,	

(i.). *Details of Increases.*

New billets for N.C.O.'s in aircraft and telegraphy and the detachment of electricians and mechanics	15,971 fr.
Increases of pay and allowances for extra cost of living	7,370 ,,
Increase of subalterns' pay	144,456 ,,
Increases for extended men	53,518 ,,
Increase of captains' pay	20,000 ,,
Allowances to N.C.O.'s in charge of wireless stations	5,490 ,,
Increase of the number of pupils of the "Ecole des Ponts et Chaussées" doing their second year there as second lieutenants of the reserve ...	33,661 ,,
Increase of the establishment of reservists and territorial troops to be called out in 1911 ...	11,209 ,,
Calling up of the military telegraphy sections ...	3,000 ,,
Increase of various previous grants	8,917 ,,
Transfer to this vote of the sums allotted for the military instruction of the pupils of the "Ecole des Ponts et Chaussées"	585 ,,
Total increases...	304,177 fr.

(ii.). *Diminutions.*

Variations in the establishment and pay of officers paid under this vote...	42,509 fr.
Decrease in the establishment of rank and file ...	4,865 „
Variations in the establishment and rank of the reserve and territorial officers to be called out in 1911	5,563 „
Transfer to another vote of officers' horse allowance	9,937 „
Transfer to another vote of the cost of first outfit granted to pupils of the "Ecole des Ponts et Chaussées" on first appointment as second lieutenants	11,500 „
Total decrease	74,374 fr.
Net total increase	229,803 fr.

a. New Billets for N.C.O.'s in Aircraft, Telegraphy and the Detachment of Electricians and Mechanics.

	Sergeants.	Junior N.C.O.'s.
Aircraft	12	—
Wireless telegraphy	19	7
Electricians and mechanics	20	18
Total	51	25

These increases are justified in the aircraft department by the fact that the French have 4 dirigibles and 2 cruisers, each with two crews of 2 sergeant mechanics and in the wireless by the strength of the detachment 75 men.

b. N.C.O.'s in Charge of Wireless Stations.

These are N.C.O.'s who have extended their service to whom the following daily allowances are granted :—

1st Class stations (6 in all)	3 fr.	(Yearly billet).
2nd Class (6 in all)	2 fr. 50	For 3 months in the year.
3rd Class (8 in all)	2 fr.	

c. Special Allowances to Aviators.

These are as follows :—

(*a*). Soldiers on duty, when going up in balloons, dirigibles, or aeroplanes, will receive in addition to the ordinary travelling allowances, special allowances at the following rates :—

Rank.	Time in the Air.	Allowance.		
		Balloon.	Dirigible.	Aeroplane.
Officer, Q.M.S. or attached civilian	½ to 2 hrs.	3 fr.	5 fr.	5 fr.
	2 to 6 „	5 „	10 „	15 „
	Over 6 „	10 „	20 „	25 „

Sergeants, junior N.C.O.'s or men :—Half of the above amounts.

This allowance is not really intended to compensate the men for the risk they run, but rather as an increase of travelling allowance.

The length of the flight is certified by the senior officer. The time of the flight is the total of the times spent in the air on the day of the flight. No grant is allowed for flights of less than 5 kilometres, but for a single flight of 5 kilometres, officers, etc., receive 5 fr. and sergeants, etc., 2 fr. 50.

(*b*). Air pay will be granted at the following rates to :—

(1). Extended or attached officers or N.C.O.'s serving with the air troops or undergoing courses of instruction.

(2). Officers or N.C.O.'s serving beyond their legal time of service as pilots or learners :—

Rank.	Daily Rate.
Field officers or attached civilians	2 fr. 50
Subaltern officers or attached civilians	1 fr. 50
Government civilian employés, Q.M.S.'s	0 fr. 75
Other N.C.O.'s	0 fr. 40

(2). Engineer Establishments (Personnel).

Sum voted for 1910	1,189,775 fr.	—22,000 fr.
Sum asked for by the Government for 1911	1,167,775 „	
Sum proposed by the Commission ...	1,167,775 „	

Details of Increases.

Increase of the pay of technical engineer R. & F. ...	2,400 fr.
Range warden at the camp of Coetquidan	1,500 „
Allowances to one barrack warden	50 „
Transfer from another vote of the pay of Q.M.S.'s in charge of motors at wireless stations and of military pigeons	1,500 „
Increase of pension to workmen	1,750 „
Total	7,200 fr.

Details of Diminutions.

Transfer to another vote of the extra pay of engineer Q.M.S. clerks	29,200 fr.
i.e. Total net diminution	22,000 ,,

The only item requiring explanation is the creation of the post of range warden at the camp of Coetquidan. This range is in the charge of a Q.M.S. acting as D.O. Lands, and is so far from his house, that he is unable to devote that constant care to it which it requires, a range warden has therefore been instituted to keep tramps from the Government buildings on the range and camping ground.

(3). ENGINEER ESTABLISHMENTS (MATÉRIEL).

Sum voted for 1910	13,797,970 fr.	+ 202,710 fr.
Sum asked for by the Government for 1911	14,000,680 ,,	
Sum proposed by the Commission	13,964,680 ,,	− 36,000 ,,

Details of Increases.

Increase in the first cost of materials and labour ...	5,000 fr.
Dismantling of the fortress of La Rochelle	36,000 ,,
Maintenance of certain buildings used as barracks...	45,000 ,,
Increase of the aircraft and telegraphic services ...	62,560 ,,
Instruction of officers of all arms attached to the air troops	31,250 ,,
Addition training grant for engineer troops... ...	6,400 ,,
Additional for maintenance of *matériel* and tools ...	18,000 ,,
Total increase	204,210 fr.

Details of Diminutions.

Transfer to another vote of the allowances of Q.M.S.'s in charge of motor at wireless stations and of military pigeons	1,500 fr.
Remaining increase ...	202,710 fr.
Reduction effected by the Commission	36,000 fr.

(*a*). The dismantling of the fortress of La Rochelle consists in the removal of old works on plots of ground allotted for the training of troops. The dismantling of the fortifications on those plots of ground given to the town is carried out at its expense not at that of the War Department. The buildings used as barracks which have to be maintained are mainly seminaries. The sum allotted for this purpose is 1% to 2% of their value.

(*b*). Of the 62,560 fr. for the increase of the telegraphic and aircraft service 42,360 fr. are allotted to aircraft and the remainder to telegraphy, chiefly to cover the expenses of the new field wireless stations and telephone material of the infantry.

(*c*). The 31,250 fr. for the training of officers of all arms in aeronautics enables:—

(1). Twenty officers to undergo a course of instruction in ballooning for four months.

(2). Eight officers to undergo later a course of one month in ballooning, consisting chiefly of free runs. These officers must have passed the first course.

(3). Five officers with the necessary qualifications to undergo a seven months' course as dirigible pilots.

(*d*). The 18,000 fr. for the maintenance of *matériel* and tools is to pay for the supply of mobilization materials necessary for field and fortress engineer units, which is to be increased, and to upkeep the additional tools issued to the infantry and the light bridging equipment issued to cavalry regiments.

(4). Technical Engineer Staffs.

The chief items under this heading are the increase of 12 engineer captains and 3 Q.M.S. foremen of works. The pay of the Q.M.S.'s has also been increased.

(5). Barracks.

Sum voted for 1910	7,000,000 fr.	+ 2,000,000 fr.
Sum asked for by the Government for 1911	9,000,000 ,,	
Sum proposed by the Commission	9,000,000 ,,	

The 2,000,000 fr. is to be allotted to the construction of barracks for the new artillery units created by the law of the 25th July, 1909, together with a proportion of the old 7,000,000 fr.

(6). Fortifications.

Sum voted in 1910	12,042,000 fr.	– 1,000,000 fr.
Sum asked for by the Government for 1911	11,042,000 ,,	
Sum proposed by the Commission	11,042,000 ,,	

This money is to carry on the fortification of the places on the N. and N.E. frontier, in the Alpine districts and along the coasts.

(7). War Matériel of the Engineers.

Sum voted in 1910...	3,970,000 fr.	+ 3,600,000 fr.
Sum asked for by the Government in 1911	7,570,000 ,,	
Sum proposed by the Commission	7,570,000 ,,	

The increase is entirely due to the aircraft service, *i.e.* the building of new dirigibles and the provision of material for all branches of aviation.

(8). USE OF AEROPLANES AND DIRIGIBLES ON MANŒUVRES.

An increase of 50,000 fr. has been granted to carry out the above.

(9). INCREASE OF THE NUMBER OF ASPIRANT OFFICERS AT THE MILITARY SCHOOL OF THE ARTILLERY AND ENGINEERS.

There will be an increase of one aspirant officer for the engineers allowed for this school.

NOTE.—All through this paper the English rank Q.M.S. has been used to interpret the French rank "Adjutant" for which no adequate translation exists.

A. H. SCOTT.

AIRSHIPS: EXPERIMENTS WITH BEACON LIGHTS, Etc.

(From the *Hamburger Nachrichten*, 20th December, 1910).

We are informed that experiments are about to be carried out, by the Airship Battalion, with certain beacon lights intended to facilitate the steering of airships, by night. Two beacons or lighthouses have been constructed experimentally at the Spandau Railway Station. One is electric-automatic, while the other is an intermittent light.

The electric light consists of a wooden ring, 5 metres in diameter, which is mounted on the roof of a building. The 30 watertight 50-candle-power carbon filament lamps, carried on the ring, stand up vertically towards the sky. The device is controlled by a triple pole main switch, and a current of 220 volts is used.

The intermittent light, which is similar to that of an ordinary lighthouse, is of special interest. The system of vertical lines (planes) is used, which—by means of refraction and reflection—concentrate the rays and emit them parallel. In the case of lighthouses for aerial navigation, it is necessary that the beams of light should be visible from the horizon to the zenith and all round the horizon. For this reason a dome-shaped *Fresnel* lense with a focal distance of 187·5-m.m. (7·38″) has been used, such as are used with light buoys at sea. The lenses revolve so as to send a bright light in all directions such as will be visible as an intermittent fan-shaped beam to an airship at any elevation. In order to utilize rays of light falling below the horizontal plane, prisms placed below that plane deflect the light upwards. Various forms of gas (coal, acetylene, etc.) are utilized as illuminants.

The range, over which the light can be seen, is, in round figures, 12 miles. The employment of electric arc lights with *Fresnel* lenses of 300 m.m. (11·8″) focal length would increase the range to double that distance.

H. H. Dowding.

REVIEW.

FOR REMEMBRANCE AND IN HONOUR OF THOSE WHO LOST THEIR LIVES IN THE SOUTH AFRICAN WAR, 1899—1902.

By Colonel Sir James Gildea, K.C.V.O., C.B., 4th Royal Warwickshire Regiment, Chairman and Treasurer of the Soldiers' and Sailors' Families Association.—(Price £2 2s.).

This is a handsome volume in which Sir James Gildea has compiled a short description of 900 Memorials, with illustrations in most cases, erected to the memory of those who lost their lives in the above-named war. It is a work which must have given the Editor a vast amount of trouble, and although not claiming to be a complete record, is very comprehensive. Practically the whole of the illustrations are reproduced from photographs printed on excellent paper and thus giving a good idea of the appearance of the various subjects chosen to perpetuate the memory of those who fell in the War. Sir James Gildea has not included in his book those monuments which have been erected to chronicle the part individuals of certain districts took in the campaign.

The profits on the sale of the book will be devoted to the Royal Homes for Officers' Widows and Daughters at Wimbledon, in connection with the Officers' Branch of the Soldiers' and Sailors' Families Association.

NOTICES OF MAGAZINES.

Revue Militaire des Armées Étrangères.

September, 1910.

Foreign News of Divers Countries.—*Austria.*—By a decision of the 10th August, 1910, the engineer section of the Military Technical Academy has been divided into two parts, the pioneer class, and the class for the communication troops. From 1913, no cadet from the Pioneer Cadet School will be posted to the telegraph or railway units of the engineers, the officers of which will be only drawn from the communication troops class of the above-mentioned Academy.

Italy.—The reorganization of the army, as effected by the law of the 13th August, 1910, will be as follows:—

(1). General Staff, including:—The chief of the general staff; four general officers who in war will command armies; twelve army corps, 25 divisional and 3 cavalry divisional commanders; all other general officers.

Two commissions have also been created by this law:—The Army Council, and the Superior Defence Committee.

(2). The Staff.

(3). Infantry, including:—An inspector of mountain troops, with his staff; forty-eight infantry brigade headquarters; three Alpine brigade headquarters; two grenadier regiments; ninety-four line regiments twelve regiments of Bersaglieri; eight Alpine regiments. The recruiting officers of territorial districts are drawn from the auxiliary forces.

(4). Cavalry, including:—An inspector-general of the cavalry, with his staff; three cavalry divisional headquarters; eight cavalry brigade headquarters; twenty-nine cavalry regiments; remount depôts and stud farms.

(5). Artillery, including:—An inspector-general of artillery and staff; an inspector of artillery *matériel*; nine field artillery headquarters; four fortress artillery headquarters; thirteen artillery staffs; thirty-six field artillery regiments; one horse artillery regiment; two mountain artillery regiments; two heavy artillery regiments; ten fortress artillery regiments; one experimental staff; artillery material factories; remount depôts.

(6). Engineers, including:—An inspector-general of engineers and staff; two engineer headquarters; five territorial engineer headquarters; six engineer regiments (24 battalions, 69 companies, 6 depôts); one specialist battalion of 5 companies; 10 transport companies; 12 engineer staffs, 14 sub-staffs, and fortification committees as required (not yet formed); engineer *matériel* factories.

(7). The existing commissariat and pay departments are to be abolished and replaced by :—(*a*) A new commissariat corps, consisting of an inspector of transport and supplies and his staff; twelve staffs; commissariat offices; supply officers; twelve supply companies; (*b*) an administrative corps.

October, 1910.

THE SERVICE FOR TWO YEARS IN ITALY.—On the 11th February, 1910, a Bill suggesting the service of two years was brought up before the Italian Parliament, and it became law on the 30th June of the same year.

The question of reducing the time of service from three years (four in the cavalry) had already been under consideration for some time, and had actually been tried in 1909, when the "1887 class" had been dismissed after two years, as the supply of recruits was sufficient to keep the army up to peace strength, and the non-dismissal of this class would have involved an increase of establishments.

According to the old Recruiting Act of 1888 the Italian Army consisted of three classes of men :—(1). Those who served their whole time. (2). Those who served from two to six months and served to keep the units up to peace strength. (3). Those who were exempted from all service.

In 1907, the third category was almost entirely done away with and the numbers of the first greatly reduced by increasing those of the second; the peace establishments of the units remaining the same.

The way was thus slowly prepared for the reform which was to follow.

Consequent on the reduction of the time of service certain reforms were considered necessary. These were :—(1). That the training would have to be more arduous. As the Italian soldier is very quick, both mentally and physically, this was considered to offer no difficulty. (2). The army would have to give up the police duties it had hitherto undertaken. An increase of three battalions of carabinieri will, it is hoped, make up for this deficiency. The length of service in the "carabinieri" remains five years, and that of the customs troops, three. (3). The soldier servants granted to certain classes of officers are to be done away with, and these officers granted an allowance in lieu. Further, the cavalry soldiers will in future only be used as bâtmen to the officers by their own regiment. (4). Garrison battalions (battiglioni presidiari) are to be formed for permanent works.

Cavalry.—The length of service in this arm is to be two years only, but the men are to be specially chosen and not to be sent to this arm by chance drawing.

On certain questions which arose, the following rulings were given :—

(1). The peace strength of the cavalry was not to be increased from 13,000 to 15,000 men, as the North of Italy is not suited to the employment of large masses of cavalry.

(2). The training of all recruits by a special staff, and not in their squadrons, was also disapproved of as tending to destroy the personal influence of the captain on his men, and this influence is considered as one of the most essential elements of military education.

(3). About 2,400 remounts are annually required by the cavalry, and 700—800 by the artillery. These are sent from the State stud farms, and in view of the reluctance of Italian soldiers to re-engage after their time of service is over, it was decided to re-enlist the *personnel* of these stud farms from old troopers and gunners, and not to attempt to induce men to re-engage. The number of men required for this purpose is 1,200.

Cadres of N.C.O.'s.—This very important question is not yet entirely settled. At present it is suggested to increase the strength of mounted units by two N.C.O.'s; to promote to the rank of corporal, in the dismounted units, those men who enlist three months before they are due.

One-Year Volunteers.—The system of one-year volunteers has not been abolished.

General Remarks on the Innovation.—The peace strength of the army will be 250,000 men. It is expected that this reform will better the moral and physical conditions of the rank and file. The age of the army in general will be reduced, the oldest reservists being 28 years old.

MILITARY NEWS OF DIVERS COUNTRIES.—*Germany.*—Officers of the three arms are in future to be attached to the railway and telegraph troops for one year as follows:—

Infantry, a lieutenant and a second lieutenant to each railway regiment, and two lieutenants and two second lieutenants to each telegraph battalion. *Cavalry and artillery*, three lieutenants and three second lieutenants to each telegraph battalion.

(2). An aviation section of the experimental section of the communication troops has been formed.

(3). Two large telegraph troop exercises were carried out last August. The first, for wireless troops, only lasted six days. The four battalions taking part practised the communications of several armies on the same theatre of operations. The second exercise was carried out by the ordinary telegraph units and lasted five days. It consisted of practising the internal communications of the larger units.

Italy.—The Alpine troops are to wear the grey-green uniforms at all times, whether in the field or in garrison.

A new law has been passed on the subject of emigration, the *résumé* of which is that Italians, living out of Europe and under 16 years of age, will, if still living abroad, be exempted from military service. If they return to Italy before the age of 32 they have to serve, if they are older they are exempted. Italians living in Europe must report to the nearest consulate or legation, to be medically inspected when the time comes for them to do their period of service. According to the result of this examination they will be obliged to serve or be kept back.

December, 1910.

(1). RECENT MODIFICATIONS IN THE RUSSIAN ARMY.—The most important of the reforms which have taken place in the Russian Army since the Russo-Japanese War, is, without doubt, the entire abolition of the infantry reserve and fortress formations, and their transformation into formations of the active army. This reform has just been made final by the distribution tables of the army dated 14th October, 1910.

The original existence of the reserve and fortress formations was fully justified by the bad communications and great extent of the Russian Empire. It was however found that, on mobilizing the army for the Russian-Japanese War, a large number of men were immobilized by bringing these formations up to war strength, and could thus be employed only as second line troops, though badly wanted in the front line. Their abolition was accordingly demanded from 1906 onwards by most military writers. The result of the reform for the infantry is as follows:—

	October, 1908.	October, 1910.
Active Battalions	1,086	1,260
Reserve Battalions...	176	*Nil.*
Fortress Battalions......	56	*Nil.*
Total	1,318	1,260

The diminution of 58 battalions on the total is made up for by the strengthening of establishments and cadres of the active formations.

As a natural result of the increase of the infantry, the field artillery had to be increased, and has now been raised to one brigade of field artillery (six 8-gun batteries) per division, and three 6-gun howitzer batteries per army corps of two divisions. An artillery group of three 8-gun batteries is attached to each brigade of skirmishers, and a group of two horse artillery batteries of six guns to each cavalry division. Seven heavy artillery groups have also been created. The mountain artillery groups are no longer independent, and are attached as extra artillery to various brigades. The mountain horse artillery groups alone conserve their autonomy. There still exists one horse artillery depôt, which is allotted on mobilization to the cavalry depôt, and, in Siberia, a few artillery parks. The total increase is 54 mobile batteries, and one fortress artillery battalion. The C.R.A.'s of divisions have been given the new title of inspectors of artillery.

Cavalry.—A new division has been formed.

Engineers.—The more technical troops, wireless telegraphy, air troops and railway troops have been increased, but the other field engineer units remain practically unchanged in number. The engineer parks have been abolished as a peace formation, and the number of engineer siege trains increased by one.

The total increase since 1908 of the active divisions of the army is:— Infantry.—(1908), 69; (1910), $78\frac{1}{2}$ = increase $9\frac{1}{2}$ divisions. Cavalry.— (1908), 27; (1910), 28 = increase 1 division.

MILITARY NEWS OF DIVERS COUNTRIES.—*Austria-Hungary.*—An increase in the estimates of 50,350 crowns has been granted to the aeronautical establishments, and one of 33,719 crowns to the telegraph school, with a view to creating a special radio-telegraphic section for experimental work.

Germany.—Courses of instruction in the care and preservation of arms and bicycles, and in the use of range-finders took place last winter in the military arsenals of Spandau, Dantzig and Erfurt. The number of officers attending these courses was 109 subalterns. Their duration was 20 working days.

Spain.—An experimental committee for engineer *matériel*, consisting of one colonel, one lieutenant-colonel, two majors, and three captains has just been instituted.

Italy.—Special grants to aviators and military aeronauts. The following scale of grants to officers, N.C.O.'s and men, or other workmen employed in any free flights or voyages in dirigibles has been approved of :—Officers.—20 francs per ascension. N.C.O.'s.—10 francs. Men.—5 francs. The same scale applies for flights in aeroplanes or kites.

(2). An aviation section has been formed and attached to the engineer balloon battalion. Its strength is as follows :—1 captain, or lieutenant, commanding; 3 company officers. An indeterminate number of attached officers, 15 N.C.O.'s, 50 men.

THE SWEDISH AUTUMN MANŒUVRES OF 1910.—A complete description of these manœuvres is given; the following are extracts from the comments on the operations:—(1). For the first time the systems for the supply of ammunition and food were seen at work. (2). The captive balloon—an elliptical German model—made numerous useful observations. (3). The bridging train carried out its work well. (4). During the last two nights the searchlight sections were employed. (5). The telegraph and telephone services worked very well. (6). The Swedish horses are very good. The tactical employment of the cavalry gave rise to some peculiar situations, this arm being used independently of the others. (7). The whole medical service was as for active service, and carried out its work very well. (8). The sanitary state of the troops was good; the weather cold and on one occasion rainy.

MILITARY NEWS OF DIVERS FOREIGN COUNTRIES.—*Austria.*—Ski courses, which last for about one week, are being arranged for officers of the General Staff, and also courses lasting 13 days for reservists of the infantry and rifles.

(2). The war ministry has decided to purchase three aeroplanes for the army, the desiderata being:—(1). That the machine shall make a flight of two hours at a speed of 70 kilometres per hour. (2). Make a similar flight with a passenger on board, the total weight carried not to be less than 210 kilograms. (3). The machine must be such that it can be taken to bits in one hour, and put together again in two hours, and further be transportable on an automobile.

(3). Two new dirigibles have been bought by the Austrian Government :—The Lebaudy-Juliot, 60 metres long and with a capacity of 3,700 cubic metres; and the Boehmer, 57.5 metres long and with a capacity of 2,750 cubic metres. The former is of the semi-rigid and the latter of the non-rigid type.

China.—An Admiralty has been created with Prince Tsai-Suen, the younger brother of the regent, as Lord High Admiral. He is assisted by an under-secretary of state, and the ministry will be divided into a head-quarters staff of nine sections:—(1). Centralization. (2). Administration. (3). Technical matters. (4). Legislative affairs. (5). Coast defence. (6). Sanitation. (7). Music. (8). Supplies. (9). Pay. The fleets are to be distributed as follows:—(1). Fleet of the north or Peiyang. (2). Fleet of the south or Kwangtung. (3). Fleet of the centre or Yang-Tse.

Germany.—There are 40 holders of aviators' certificates in the German Empire, of which 8 are officers of the active army. At the military school of flying at Doeberitz, there are 10 officers undergoing a course of flying. Their aerial education will not be considered as complete until they are fully qualified to act as pilots to the following machines:—Wright, Albatross (two types), Farman, Rumpler, Grade and probably Dorner. They will then be entrusted with the duty of acting as instructors to the rest of the army.

Spain.—The strength of the army is fixed, for 1911, at 115,432 men. The pay of majors and colonels has been slightly increased.

Italy.—Four offices, of the Generals designed in time of war to command an army, have been instituted, and will be at Rome, Florence, Milan and Naples. They will temporarily consist of:—1 lieutenant-colonel or major on the General Staff. 1 lieutenant attached (not seconded from his unit). 1 infantry or cavalry lieutenant or 2nd lieutenant (*galloper*, also not seconded).

Japan.—The following are extracts from the new organization of Korea, since its annexation:—(1). The Governor-General of Korea is placed at the head of the Government of Korea. (2). He is chosen directly by the Emperor and is an admiral or a general. (3). He is directly responsible to the Emperor for his command and for the defences and forces in Korea. He is also responsible for administrative matters. (4). He is assisted by a staff consisting of two generals or one field officer, and one A.D.C. These officers may belong either to the army or to the navy. They are exclusively under his orders.

Russia.—The school of flying at Sebastopol was officially opened on the 24th November, 1910. It is commanded by a naval captain, and includes 5 instructors, and 12 officers as pupils, of whom 8 are soldiers and 4 sailors.

Turkey.—An Imperial Irade has sanctioned the reorganization of the light cavalry or Hamidieh. The object of this reorganization is to utilize the Kurdu tribes, which are to be organized into 65 regiments of light cavalry. The regiments will be formed of men of the same tribe, and will have a strength of 4 to 6 squadrons, each of 4 troops of 32 to 48 men. Each regiment will be commanded by a lieutenant-colonel of the regular army, assisted by the head of the tribe, a native major. If there are two tribes in any regiment, there will be a native major for each of them. The squadrons will be commanded by captains of the regular army, assisted by one lieutenant of the regular army, and three sub-lieutenants of the tribes. The length of service will be 27 years, from

18 to 45, the last twelve years will be passed in the redif, or reserve, of which each regiment has a formation. The regiments will be grouped into territorial inspections, each commanded by a colonel or brigadier assisted by three officers.

Rules on the marriage of officers:—Senior captains who have an increase on the ordinary captain's pay are authorized to marry without permission. Officers junior to this rank are not to do so unless they can prove that their own private means, those of their wife, or the allowance made to them by her parents are equal to the difference between their pay and that of the senior captains authorized to marry.

A. H. Scott.

Rivista di Artiglieria e Genio.

January, 1911.

La France Militaire of the 9th January, speaks of the good results that have been obtained from the first trial of a third dirigible, provided with the apparatus for wireless telegraphy, and having the following characteristics:—Length 68 m., with a diameter of 10·50 m., of the non-rigid type. The car, 18 m. in length, is formed with tubes of aluminium. There are two motors each of 75-H.P. made in the factories at Vienna. The envelope is of German pattern, but also constructed in the Vienna workshops.

The dirigible is provided with an arrangement for regulating the altitude, by projecting—by means of a pump—a water ballast towards the prow and the stem of the car. It is stated that this arrangement is imitated from Mod. III., and was provided in the dirigible *Erlesloh* which was destroyed in 1909 near Cologne. The new balloon is housed in the new hangar at Fischamend.

District Schools for Military Aviation.—*La Technique aéronautique* of 15th January states that General Roques has decided upon the formation of district schools for military aviation. Two of these will be established at Douai and Pau, and another will be formed at Biskra. Officers who have applied for this service will be selected by the commandants of the army corps for attendance at these schools.

After a month of instruction, a certificate as pilot will be granted to those who deserve it. From among the officers who gain this certificate a certain number will be appointed as official aviators, and will undergo a second course of instruction terminating with a trial of three aerial voyages of about 100 k.m., one of which will confer a superior brevet with a number of classification. The non-commissioned officers and men will be able to obtain the brevet of military aviator on the same conditions as the officers. The French marine service is also interesting itself in aviation, and it has been decided to construct aerodromes in the vicinity of the great maritime centres.

An aerodrome has been established at Sablettes, near Toulon, for experiments with a new apparatus that can alight in water, and the transport *Foudre* is provided with a large platform that will be used for the aviation trials.

February, 1911.

THE TRANSASIATIC RAILWAY FROM THE BALTIC TO THE GREAT OCEAN.—Lieut.-Colonel V. Traniello, Engineers.—The Transiberian railway may be divided generally into three parts: the *western* from Tcheliabinsk to Ob; the *central* from Ob to Irkutsk; and the *eastern* from Irkutsk to Vladivostok.

This last part, owing to modifications, has given place to the following sections:—Circumbaikaliana, Transbaikaliana, the Eastern Chinese and Transmanchuriana, and the extreme Russian section, or railway of Ussuri.

The western Transiberian railway—1,417 kilometres—follows along almost the whole of its course the 54th parallel, grazing the northern border of the Kirghiz steppe. It runs across a slightly undulating plain upon which are scattered forests composed chiefly of small birches. The soil is sedimentary and porous, black earth, and of recent formation.

The region is poor in minerals, and the stones and lime used on the railway works had to be transported from a distance. The wood was procured from enormous distances, and for its transport roads had to be made and large workshops built, the principal ones being on the banks of the river Irtish. Great difficulties were met with in procuring the stones and bricks. The stones for the bridge at Omsk had to be brought from a distance of 1,000 k.m.

The water of the lakes was quite un-usable owing to saltness. The Transiberian railway crosses four great rivers, the Tobol, the Isciur, the Irtish, and the Ob. It occupies an area of land of 16,770 hectares.

In the construction of this section, it was decided to abandon the plan of crossing the great rivers by ferry boats, and bridges were constructed; the four most notable metal bridges being built across the rivers mentioned above. The Tobol bridge is 469 m. in length with six spans, the four central ones being constructed with parabolic girders and the two end spans with rectilineal girders.

The Isciur bridge is 640 m. in length, with eight spans of which the six central ones are bridged with semiparabolic girders, and the end spans with rectilineal beams. The shoulders of the bridge are constructed of granite from Tcheliabinsk, laid in cement.

The Ob bridge, naturally the longest, is about 800 m.; it has nine spans, the seven central ones being on the cantilever principle. The piers are built on caissons sunk to a depth of from 1·73 m. to 7·25 m. below the lowest level of the water.

It is remarkable in Transiberia that the principal stations are the old fortresses erected during the successive phases of the gradual occupation of Siberia, and which have been transformed into villages and cities. Among these are Pietropavlosk, Omsk, etc. Omsk was constructed in 1765 with five bastions. It is of great strategical importance, being the crossing point of the road from Renburg and from Tobolsk, and was constructed by the Cossack general Springo. The scarcity of manual labour greatly increased the difficulties, an immense number of workmen being required. In 1895 the number amounted to 29,000, a great part of whom came from European Russia, although there was also a large proportion of exiles who came from the more distant centres. It is easier to imagine than to give the details of the enormous amount of provisions that had to be transported along an inhospitable and only partly known region.

The cost of the central Transiberian line was 298 millions of Italian lire or about 162,500 lire or £6,480 per k.m. The works were under the direction of the Engineer Mégéuinos. Commenced in 1893, the line was open between Ob and the station of Krasnoiarsk in January, 1898, and from this station to Irkutsk in January, 1899. In 1900 the two sections—western and central—were united into one.

In 1896, the year of the inauguration of the western section, 106,000 passengers, 169,000 emigrants, and 160,000 tons of merchandise were carried, and in 1898 this list increased respectively to 380,000, 195,000, and 480,000 tons of goods. And these amounts went on increasing, notwithstanding that the railway had not reached a port on the ocean. In 1902, between Tcheliabinsk and Strietensk, the number of passengers was 1,400,000. Between 1896 and 1898 it was found urgently necessary to construct 31 new bridges and to add to the rolling stock 30 locomotives and 600 wagons.

Omsk has lost none of its importance, and about the middle of the XIXth century was one of the best fortified places in Siberia. To-day it is one of the principal places of administration, commercially and politically, and a first-class military command; but the old classical fortress only remains as an archeological monument.

The works of the western Transiberian railway directed by the Engineer Michaelovsky, were commenced on the 19th July, 1892, and the whole was opened in October, 1896. The total cost of construction amounted to 46,125,000 roubles.

The *Central Transiberian line*—1,834 k.m.—from 55° parallel (Ob) runs to Marinsk, then following the 56° parallel to Kiansk; here it turns to the south-east and runs in a direction 51° 15′ to Irkutsk on the left bank of the Angara. At Crasnoiarsk it crosses the Fienissei by a bridge of 927 m. long with six metal arches, each 145 m., built on piers of granite with caissons. From Marinsk it follows the great Siberian postal line which it leaves near Kainsk.

These lines pass through immense forests, intersected at great distances by meadows, and occasionally by cultivated fields. The ground is rich with water courses, and is woody and mountainous, especially towards the east where the lines meet the Altaiche and Saianiche Mountains. In consequence, this section (differing from the western one) required enormous excavations averaging 19,000 cubic metres per k.m. with a maximum of 180,000 per k.m. The work was carried out under very difficult conditions, the thermometer in winter showing 50° centigrade below zero.

E. T. Thackeray.

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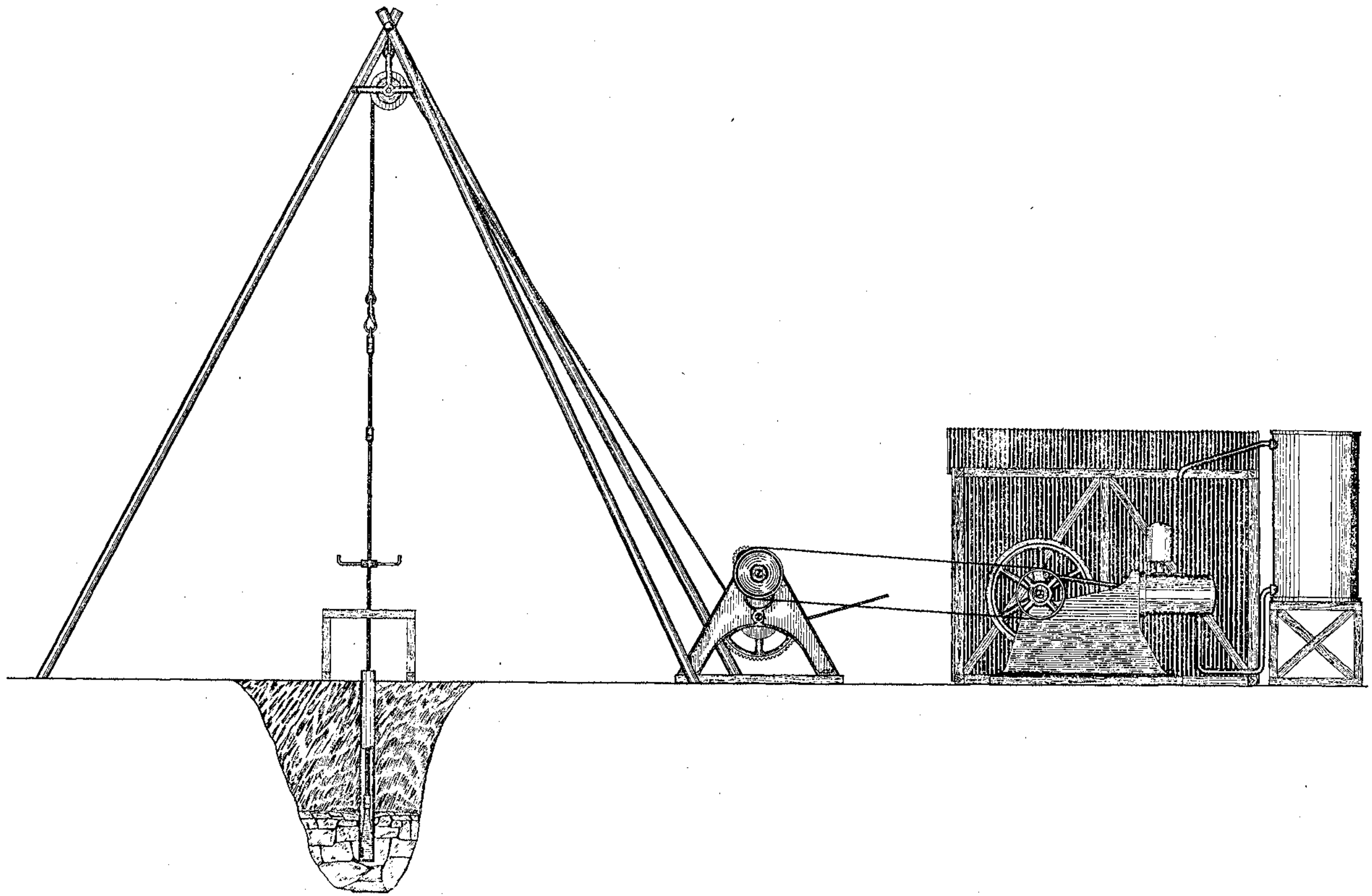

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