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

Photo 1. Electric grinding attachment on tool rub of lathe.

Photo 2.—Milling machine fitted with revolving head milling spur gear wheel.

Photo 4. Cutter grinder with cutter mounted between centres for grinding, and twist drill grinding attachment on the right.

Photo 5. Sensitive drill with casting table. Portable electric drill on the left.

WORKSHOP NOTES.

By I.R.E.M.

THE following notes may be of interest to officers who have to maintain machinery or workshops, and who have not had opportunities of seeing up-to-date shops. They are the result of actual experience in an existing R.E. shop, and are possibly therefore of more practical interest than a mere description of an up-to-date commercial shop where costly machinery is installed for repetition work, and is not justifiable in a repair shop.

In many cases repairs have to be carried out to high-speed enclosed engines, and to other new machinery which requires more accurate work than some R.E. shops are capable of executing. It will often be found that spare parts of engines purchased from the makers are not usable, as journals which have worn oval must be turned or ground true, and holes bored or reamered to make them round, and that consequently the spare parts will not be a good fit. It is therefore desirable, particularly abroad, to be able to accurately make all the simpler working parts of machinery and thus save much delay and expense in maintenance.

Modern practice also tends towards increased use of electrical machinery for all purposes, and a knowledge of electrical work is consequently becoming essential to machinery officers. In this connection two useful testing circuits are described.

Lathes.—Modern lathes are similar in principle to the lathe usually found in R.E. shops, and the most important improvement consists in the self-acting feeds being positively driven by variable spur gears, independent of leading screw and usual change wheels, which enables the work to be more rapidly machined and more accurately finished.

Many old lathes can, however, turn out accurate work if the headstock bearings are renewed and all end play eliminated.

The most important innovation of recent years is the use of high-speed tool steel, in place of the high-percentage carbon steel issued by the A.O.D. The work is not only turned out with much greater rapidity and time saved in grinding and tempering tools, but modern high-speed steel will machine metals that the high carbon steel will not cut at all. By the use of a suitable tool holder adapted to take

square or round section tools, no forging of tools is necessary, the tool being a piece of steel broken off the bar as purchased with just the cutting edge ground. The extra cost of the steel is more than compensated for by the extra work turned out. An electric grinding attachment fixed to the tool rest is often of great use in accurately grinding journals, bores of cylinders, etc. (see *Photo* I.), and can be purchased for about £15; this handy attachment when not in use on the lathe can be used as an ordinary tool grinder.

Milling Machines (see *Photos* II. and III.) are rapidly superseding shaping machines. The former can be purchased with a dividing head attachment and can then machine a great variety of work with great accuracy, and the following are a few of its most useful applications :—

Cutting spur gears from blanks.
Fluting taps and reamers.
Cutting keyways.
Cutting squares and hexagons on steel spindles.
Surfacing the butts of bearings.
Surfacing main bearings and general surfacing work.
Slitting metal.
Profiling.
Slotting.

The use of a milling machine necessitates provision of a cutter grinder both for regrinding worn cutters and grinding cutters true after being hardened.

A cutter grinder (see *Photo* IV.) can also be used for grinding case-hardened steel spindles true after quenching, and for grinding twist drills. The latter must be accurately ground in order to drill holes truly round, and at as great a speed as possible.

Sensitive Drill (see *Photo* V.).—Cheap, light sensitive feed drilling machines cost about £12. These machines have suitable tables for drilling work at any angle, and are much handier and quicker in operation than radial drills.

Furnace.—A muffle furnace heated by either gas or oil is essential for subjecting steel to the correct heat treatment. Messrs. Fletcher, Runnell & Co., of Warrington, specialize on these furnaces, which are largely used for case-hardening and carbonizing steel, hardening cutters, dies, taps and reamers. An electrical pyrometer is a useful accessory when used in conjunction with Brearley's "sentinels." The latter are fuzible salts which liquefy at a fixed temperature and immediately solidify again on the temperature falling below the melting point.

The sentinels are inexpensive and, by using several with different melting points, the heat of the furnace can be estimated and the desired temperature can be maintained. Small errors in the temperature will spoil steel or cutters under heat treatment. The usual method of hardening mild steel with prussiate of potash is not good enough for engine work, because the hard skin is extremely thin and is removed when grinding the object true after quenching. A low carbon mild steel, containing from 0·15 to 0·2 per cent. carbon, can be carbonized and hardened in a muffle furnace to give any desired thickness of glass hard surface, and reheated and treated to maintain a strong and fibrous core. This process is invaluable for motor gears, gudgeon pins, and all spindles and pins subject to excessive wear.

The undermentioned materials, which are not usually kept in Service workshops are of great use in engine work :—

(*a*). Mild steel 0·15 to 0·2 per cent. carbon for case hardening; this can be forged to the shape required, annealed, machined, hardened and finally ground to size.

(*b*). Chrome vanadium steel contains about ·25 per cent. C., 1·25 per cent. Ch. and 0·15 per cent. vanadium; this steel can be forged, annealed and machined. This is of great use for shafts and rods which are heavily stressed, and for such parts as cross-head pins of high-speed engines, which require great strength.

(*c*). A 3 per cent. nickel steel. This steel can be forged, annealed and then machined to make new valves for internal combustion engines.

(*d*). Cast phosphor bronze used for bushes and small bearings. This is cheaper to buy and easier to machine than the solid bar. The following small stores are of great use :—

(1). Portable electric drills to drill holes in mild steel up to $\frac{9}{16}$ in. fitted with change speed gear, as in Messrs. Wolf's drills; these drills save an immense amount of time compared with ratchet drills.

(2). Carborundum wheels of various grades suitable to several classes of work. Special attention must be paid to the grinding speed and to the makers' instructions.

(3). Centre drills for preparing ends of spindles, etc., to fit the poppet centres of lathes.

(4). Standard taper reamers.

(5). Standard taper pins for use with the reamers.

(6). Adjustable parallel blocks for use on the surface plate.

(7). Standard keys.

(8). Starrett's scribing blocks.

(9). Internal and external micrometers to read to ·001 in.

Electric Motors.—The use of electric motors for driving machine tools, drills, buffs, etc., is not only more convenient and economical than driving shafting from an engine, but it saves much time in starting and looking after the shop engine. Motors are particularly economical in the smith's shop for driving the fans for the forges and a power hammer, and under these conditions a smith's striker is rarely required and labour is economized.

Spring Hammers.—For small shops light spring hammers can be bought for about £28, capable of forging 2½-in. mild steel and with hammer head weighing some 56 lbs.

High-Pressure Testing Circuit (see *Fig.* 1).—The testing of insulation of electrical machines and instruments is quickly and efficiently done by applying a high-tension alternating current, at a pressure of 1,000 to 2,500 volts as desired, between the windings and frame of the machine. A circuit diagram is added showing a simple circuit designed to give a visible indication of whether the insulation will withstand the test, and to allow sufficient current to flow through a fault to indicate, by sparking or burning of the insulation, the position of the fault, without allowing any excessive current to pass. The high-tension circuit has a bank of carbon filament incandescent lamps in circuit, so that when the wandering leads make contact to complete the circuit, each lamp has its designed voltage applied. For instance a bank of ten 200-volt 50-watt lamps in series on a 2,000-volt circuit provides for a difference of potential of 200 volts at each lamp, and ensures that only the amount of current required to fully light each lamp can flow in the circuit, which in this case is 0·25 ampères.

The test of insulation is simple in the extreme, and consists in placing one lead on the winding of the machine under test, the other lead on the frame, and watching to see if the lamps glow. The current will jump a considerable air gap should the insulation break down. The insulation resistance of machines, as measured by instruments, varies very largely with the amount of moisture present, and is not always a reliable guide as to the efficiency of the machine in service—but a high-pressure test is of a much more searching nature.

If a supply of alternating current is not available, one can generally be obtained by adding two slip rings to the armature of any direct current generator or motor, and by connecting them to two coils 180 degrees apart electrically.

The combined cost of pressure-testing transformer, lamps and leads should not exceed £12. The instrument transformer and one voltmeter can be added, but are not essential.

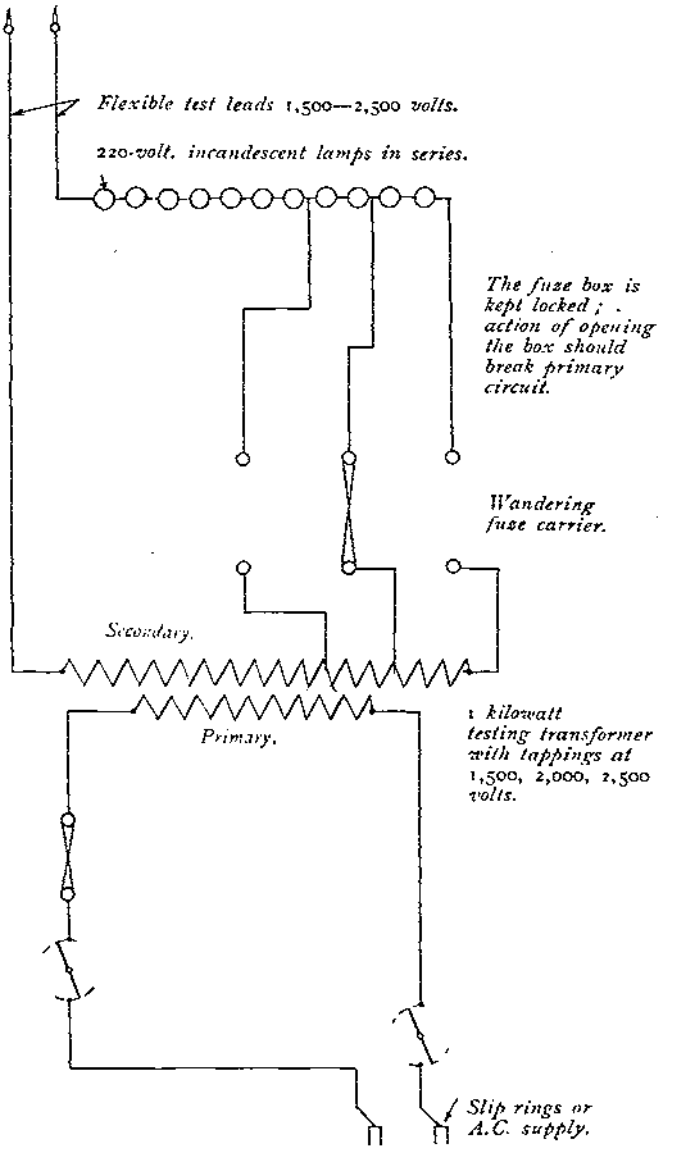
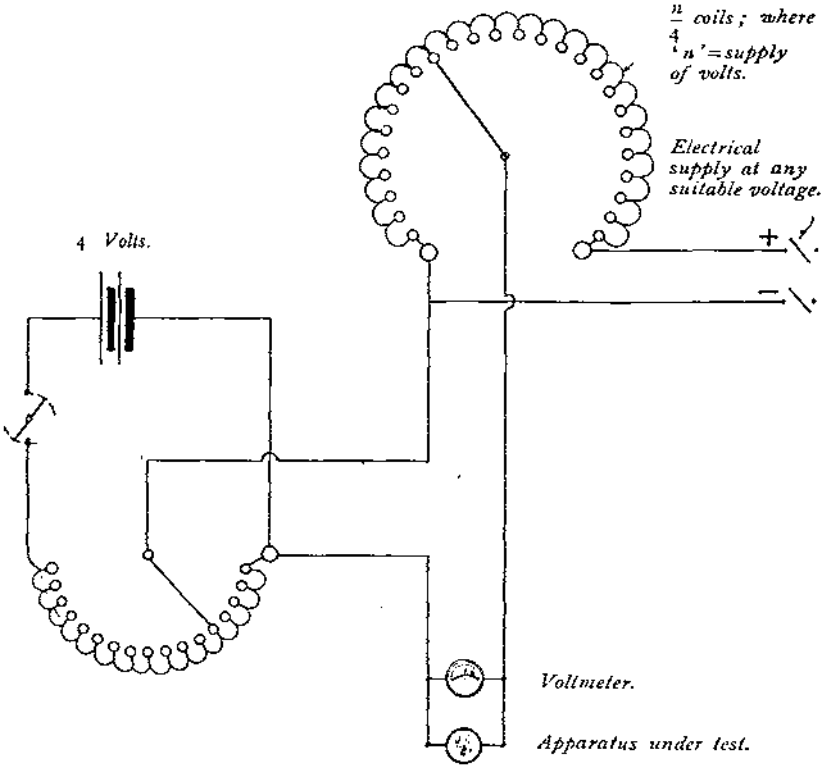


FIG. 1.—*Circuit Diagram of High-Pressure Electric-Testing Set.*

For Variable Voltage Circuit (see *Fig.* 2).—A circuit diagram of a circuit to give any voltage in steps of 0·1 volt at a time is added and is self-explanatory. This circuit is of great assistance in calibrating voltmeters, adjusting instruments and other tests.



A supply of any suitable voltage can be obtained by using suitable resistances with suitable number of contacts.

FIG. 2.—*Variable Pressure Electrical Calibrating Circuit.*

POSSIBLE FUTURE DEVELOPMENTS IN AEROPLANE DESIGN.

By LIEUT. B. T. JAMES, R.E.

AEROPLANE design is now advancing with such swiftness that further progress, without some radical departure from present lines, seems impossible. Theory, however, suggests several methods by which improvements might be made, and it is with the object of investigating the possibilities of some of these improvements that the present article has been written.

The subject is an extremely interesting one from a scientific point of view, and for the benefit of those who may not have studied the subject I have endeavoured to explain all technical points as they occur. The science of aeronautics is founded as much upon experiment as upon pure science, and it will therefore be necessary to take certain things for granted. Where any assertion is made which is not supported by a definite proof, it may be assumed that it is sufficiently supported by experiment.

Briefly speaking the greatest limitation of a modern aeroplane is its limited speed range and the difficulty of landing a fast machine slowly. Machines can now be built to travel at speeds as high as 125 miles an hour, but their landing speed is so great that they cannot with safety be flown across any but the most ideal country, and as practical machines they are therefore useless. They require a field at least half a mile square and with a good surface, in order to land without damage.

The problem which designers have to face is the production of a machine with a greatly increased speed range, which can fly at high speeds, and whose speed can be reduced for landing to 45 miles an hour or thereabouts.

Theory tells us that there are two methods by which this result can be obtained, firstly by increasing or decreasing the wing surface while the machine is in the air, and secondly by increasing or decreasing the camber (*i.e.* the curve) of the wings. The "camber" is usually measured as a fraction of the "chord" or distance from front to rear of the wings. The reason for the first of these is fairly simple. The lift of a plane is expressed by the following equation :—

$$P = kSV^2$$

where P is the lift of the planes ;
S is the area of the planes ;
V is the velocity of the machine ;
k is a coefficient, which is determined by experiment for various angles of incidence of each particular wing shape.

In the case of any given machine P is constant and equal to the weight of the machine.

We have therefore

$$V^2 = \frac{P}{kS},$$

so that V^2 varies inversely as the surface. It is not quite so easy to see how the alteration of camber alters the speed of the machine, as the proof of this is due more to experiment than to theory, but it is due to the fact that wings of small camber are found to give generally smaller values of k than wings of larger camber, and hence it is necessary to fly at higher speeds in order to obtain the necessary lift from them.

We see then that two methods of increasing the speed range are possible, one by increasing or decreasing the wing surface, and the other by increasing or decreasing the camber. Of these two methods, the first can be dismissed without much comment as being beset with too many practical difficulties to be possible at any rate for some time, but this is by no means the case with the second method. The difficulties here being by no means insuperable. For instance, it should be quite possible to construct a machine having three main wing spars, instead of the conventional two, and to increase or decrease the camber of the wing by altering the relative positions of these spars. The same movement could probably be used at the same time for lateral control of the machine, if suitable arrangements were made.

Many practical difficulties exist in the design of such a machine, chief among which would probably be the design of the ribs. However I do not wish to discuss constructional problems. My object is, taking reasonable assumptions for the weight of machine, horse-power, body resistance, etc., to try, if possible, to find out what are the possibilities, and what are the limitations of a machine with wings of variable camber.

With this object, taking fairly practical assumptions, I have carefully worked out the probable speed and power curves which could be obtained in practice with a variable camber machine. The data which I have used are as follows:—Gross weight of machine, 1,300 lbs.; B.H.P. of engine, 110; propeller efficiency, 75 per cent. at the maximum speed of the machine (165 foot-seconds) decreasing to about 65 per cent. at 80 foot-seconds.

Lift coefficients and lift drift ratios are taken from wings tested by the National Physical Laboratory.

The resistance of body, under carriage, struts, wires, etc., is taken as $\cdot 01\, v^2$ (v being the flying speed in feet per second); this gives a slightly better value than the Royal Aircraft Factory's graphs of BE_2 aeroplanes which are very well borne out in practice.

Fig. 1 in the *Plate* shows graphs of the horse-power required to propel the machine at various speeds, with wings of various cambers. Curve 8 gives the effective B.H.P. of engine and propeller at various speeds.

The first thing that will be noticed is that the curves for wings with cambers greater than ·075 chord (shown dotted) all lie within the other three curves, and that none of them give as low a minimum speed as this wing. This is due to the fact that the efficiency of the wings falls off considerably when the camber is increased beyond this point, the ratio of lift to drift or head resistance not being nearly so large for these wings as for the wings of lesser camber.

From this we see that no useful object will be gained by increasing the camber beyond ·075 chord. It will be shown later that very little could also be gained by decreasing the camber beyond ·025 chord. The designer will therefore be able to obtain his maximum speed range by varying the camber between the limits of ·025 chord and ·075 chord. This is not a large amount, and the fact that this small movement is all that is necessary is a great point in the designer's favour.

The curves for the various wings are all very similar in shape; the maximum speed attainable is 112·5 miles per hour, with a camber of ·025 chord, and the slowest landing speed is about 44 miles per hour, with a camber of ·075 chord. I also plotted the H.P. curves for a flat plate, which should be the limiting case, but its shape was so irregular that I have omitted it, as nothing seemed to be gained by its inclusion.

The next point to be considered is the alteration of the characteristics of the machine when the camber is varied, and with the object of investigating this I have plotted in *Fig.* 2 these various characteristics as a function of the camber. These curves are all of a simple nature, and speak for themselves.

With regard to the maximum speed, this might possibly be increased by using a camber slightly less than ·025 chord, but probably only to a very small extent, as the power available for climbing and for emergencies (*vide* Curve No. 3) appears to decrease rapidly as the camber is diminished. The minimum speed (63 ft. per second) is obtained with a camber of about ·07 chord; the best climb (1,220 ft. per minute) is obtained with a camber of ·075 chord; and the best glide (1 in 7·65) with a camber of ·055 chord (approximately).

Briefly summing up, the following advantages would seem to be obtainable from a machine with wings of variable camber, viz.:—A very high maximum flying speed combined with a very low proportionate landing speed, and also a better climbing rate and a better gliding angle than could probably be obtained with wings of fixed camber; because—and here lies the root of the matter—the pilot of a variable camber machine can always adjust his wings to the

best possible camber for whatever he wants to do; if he wants to glide, he sets his wings to the best possible camber for gliding; if he wants to climb, he adjusts them to the best camber for climbing; and if he wants to fly fast, he opens his throttle and reduces his camber, and away he goes.

I should like to point out also that I have, if anything, rather underestimated the possibilities of the variable camber machine, which, in the light of what has recently been done by British designers with the fixed camber type of machine, should give even better results than I have indicated.

It might now be supposed that, having produced by means of variable camber a machine with a high-speed range, nothing further was necessary to enable the pilot of a high-speed machine to land in a small field. As will be shown later, however, this is by no means the case, and in order to completely solve the problem it is necessary to approach it from a different point of view. Having now dealt with the possibilities of variable camber, I wish to suggest another method which, used in conjunction with variable camber or by itself, should make the problem of landing a fast machine in a small field still easier.

At the present time, by far the greatest difficulty which a pilot has to contend with is the landing of a fast modern machine in a small field. The difficulties are enormously increased if the field is surrounded by high trees or other obstacles. The landing of a modern machine without damage when flying across country, when for some reason or other the engine has failed, requires the greatest skill and judgment on the part of the pilot. The solution of this problem is of special importance in England, where large areas of country exist which are composed almost entirely of small fields with high trees round them, in which the landing of a fast machine is a difficult and often dangerous proceeding. The country chosen for the manœuvre area last year provides some very typical examples of this type of country.

In attempting to solve this question, I will first try to show what happens when a pilot attempts to land in a small field. *Fig.* 3 represents a section of a small field surrounded by high trees. The only way in which it is possible to land a fast machine in such a field is by finishing the Volplané at as "flat" an angle as possible, so as to reduce the flying speed, and then to come in just over the tops of the trees (see AB, *Fig.* 3). This requires the most accurate judgment on the part of the pilot, and is not a safe manœuvre at any time, as there is always the risk of a wind gust dropping the machine into the trees at the near side of the field at the last moment. Moreover, a machine gliding at its slowest gliding speed is seldom properly under control.

If the machine comes into the field at a slightly steeper angle

(*vide* the dotted lines, *Fig.* 3), owing to the high efficiency of the machine (resistance of body, struts, wires, etc., being cut down to a minimum) the speed of the machine increases enormously, and the pilot finds, when he flattens out to land, that his machine is travelling at a speed far in excess of the speed at which he can safely do so. He must therefore glide on until his speed has dropped sufficiently to allow him to land. By this time he probably finds himself colliding with the hedge on the far side of the field.

The above difficulties, which are due chiefly to the small body resistance and high efficiency of the machine, occur to almost as large an extent with wings of large camber as with wings of small camber, so that it is evident that variable camber does not really solve the problem. It might be possible to land a variable camber machine slowly, but it would still be extremely difficult to land it in a small space.

The difficulties are almost entirely due to the high state of efficiency of the modern machine; when glided at any angle which is appreciably steeper than its normal gliding angle, it increases its speed at an alarming rate, and on flattening out, owing to its high efficiency, its momentum carries it an enormous distance before its speed falls off sufficiently to allow the pilot to land it. The faster and more efficient the machine, the harder it is to land it in a small field without damage.

The obvious remedy to these difficulties is to provide a brake of some sort. The various forms of brake which can be used can be classified broadly under two headings.

Firstly "land" brakes, consisting of some form of skid, which catches in the ground, or a brake applied to the under-carriage wheels. This form of brake relies entirely for its effect on friction with the ground.

Secondly "air" brakes, consisting of some arrangement of flaps or other suitable attachment whereby the air resistance of the machine is increased. An "air" brake should be so designed that it can be applied without danger when the machine is in the air, and at any height.

Of these two, the land brake has already been tried on several machines. This form of brake is of very little use and does not really solve the problem, as it cannot come properly into operation until a large proportion of the weight of the machine is resting on the ground. This does not happen till after the machine has landed and run some distance. Until the machine has already slowed up considerably after landing, a large proportion of the weight is taken by the wings, and is not therefore available for "braking" purposes. The fault of the "land" brake is that it does not come into operation till after the machine has landed, and it is while the machine is still in the air that the real difficulties occur. The "land" brake is therefore not of much use.

The " air " brake on the other hand does exactly what is required, for it increases the air resistance of the machine while it is still in the air, and thus makes the machine inefficient. It is obvious that this is exactly what is wanted. The air brake enables the pilot to bring his machine into the field at a much steeper angle and at a greater variation of angles without his speed becoming excessive, and when he flattens out, it checks the speed of the machine and enables him to land almost at once.

To obtain the best effect from the air brake it would often be necessary to apply it while the machine was in the air and at a considerable height. It has been suggested that an air brake used in this manner would upset the stability of the machine, and would for this reason be dangerous. Careful design and careful experiment are essential to secure safety. It might even be found necessary to use larger rudders and tail planes for this purpose. Given careful design however there seems to be no reason why it should not be safe to apply the air brake at any height.

With the object of finding out how far the gliding angles and speeds of a machine would probably be affected by an air brake, I have again taken an imaginary machine. The results are shown in *Fig.* 4, in which are plotted curves showing the gliding angles of the machine with the air brake applied, and without it. The assumptions are the same as before, the wing with a camber of ·05 chord being used for these calculations. An air brake has been assumed which when applied doubles the " body " resistance of the machine.

Approximate calculations, based on Eiffel's experiments, show that two flat plates each about 2 ft. 0 in. square, extended at right angles to the direction of motion of the machine, would be sufficient to have this braking effect. An air brake of this power would therefore be a practical proposition. From *Fig.* 4 it can be seen that the best gliding angle of 1 in 7·7 is reduced to approximately 1 in 5·6 by the application of the air brake. The speed that would be attained by a fairly steep Volplané of 1 in 4·5 is reduced from 95 miles per hour to about 65 miles per hour, while it would be possible to descend at an angle as great as 1 in 3 with the air brake on without exceeding 85 miles per hour.

I have attempted to show these results graphically in *Fig.* 3. Although up to the present no machine has yet appeared with wings of variable camber it is interesting to note that experiments are already being carried out with air brakes, and it will therefore not be long probably before at any rate one of the developments which I have endeavoured to discuss becomes an accomplished fact.

SIEGES AND THE DEFENCE OF FORTIFIED PLACES BY THE BRITISH AND INDIAN ARMIES IN THE XIXth CENTURY.

By COLONEL SIR EDWARD T. THACKERAY, V.C., K.C.B. (LATE R.E.).

THE following accounts of Sieges of the British and Indian Armies in the 19th century have been arranged and compiled in a comparatively abbreviated form. They commence with the Capture of the Fortress of Asseerghur in November, 1803, and will be continued in consecutive numbers of the *R.E. Journal*. Many histories and books on military subjects have been referred to, and the sources of information from which the accounts of the sieges are derived will, as far as is possible, be mentioned.

It is not proposed, or intended, that the descriptions of the various sieges should be given in very minute detail, and it would be impossible within the scope of a work of this kind to relate more than the salient points of the sieges. But it is hoped that the accounts —even in their abbreviated form—may be of interest to officers of the Corps, to officers of other branches of the Service, and to subscribers to the *R.E. Journal*.

In the present number the following sieges are dealt with :—

(1). The Capture of Asseerghur, November, 1803.
(2). Siege of Gawilghur, December, 1803.
(3). Siege of Asseerghur, March, 1819.
(4). Blockade of Cadiz, February, 1810.

In compiling the accounts of the above sieges the following works have been consulted :—*History of the Madras Engineers*, by Colonel H. M. Vibart, R.E. (by kind permission) ; *Wellington's Despatches ;* Napier's *History of the Peninsular Wars*.

E.T.T.

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(1).

CAPTURE OF ASSEERGHUR (*October*, 1803).

The first siege of Asseerghur took place during the first Mahratta War in 1803.

The British force under Wellesley having totally defeated at the Battle of Assye the enemy under Scindia and the Bhonsla in September, Colonel Stevenson, as reported in the following despatch,

advanced upon the Fortress of Asseerghur and captured it after a short siege.

The fort is situated 2 miles from the end of the great western ranges of the Satpoora Hills, and 16 miles north of Boorhanpore. It is placed in one of the principal passes from the Deccan into Hindustan, and the natural defence that it receives from a precipice of rock on almost every side has been increased by a thick and lofty rampart of masonry—which is built on the summit of the rock—and by large cavities with guns, which at the time of the capture of the fortress by Colonel Stevenson in the month of October, 1803, commanded the country in every direction.

The general height of the position above the plain is 750 ft., and the total circumference including the upper and lower forts is 4,600 yards, or considerably over $2\frac{1}{2}$ miles.

The third enclosure, which contains the lower fort, is called Malighur.

The following despatch from Major-General Wellesley to the Governor-General of India gives a detailed account of the capture of this fort :—

CAMP, *6th November*, 1803.

To the GOVERNOR-GENERAL.

"I now proceed to give your Excellency a detailed account of Colonel Stevenson's operations against Asseerghur.

On the 16th October he advanced to Asseerghur, and encamped 3 miles south of the fort. The remains of the enemy's infantry had fled towards the Nerbudda on the previous day, in the state which I reported them to be, in my letter of the 24th October ; and Colonel Stevenson determined to attack Asseerghur.

On the 18th he reconnoitred the fort, attended by a squadron of cavalry and the piquets of the Native infantry ; and having seen a favourable opportunity, attacked the pettah and carried it, and made a lodgment within 150 yards of the lower wall of the fort. In the evening he reinforced the troops by a battalion. On the 19th all the preparations were made for carrying on the siege ; and two batteries were ready to open at 2 o'clock in the afternoon of the 20th ; one to breach the upper wall, and another of four brass 12-pounders, to destroy the defences of the lower wall.

On the 18th Colonel Stevenson had sent a flag of truce to the killadar to summon him to surrender the fort, to which message he did not receive a decided answer. The communication was continued, but Colonel Stevenson did not relax his operations against the fort, as there was reason to believe that the negotiation was carried on only to give time to Dowlat Rao Scindiah to come to his relief. Before opening the batteries, Colonel Stevenson apprised the killadar of the terms on which he should surrender the fort ; which were that the garrison should march out with their private

POSSIBLE DEVELOPMENTS IN AEROPLANE DESIGN.

FIG. 1.

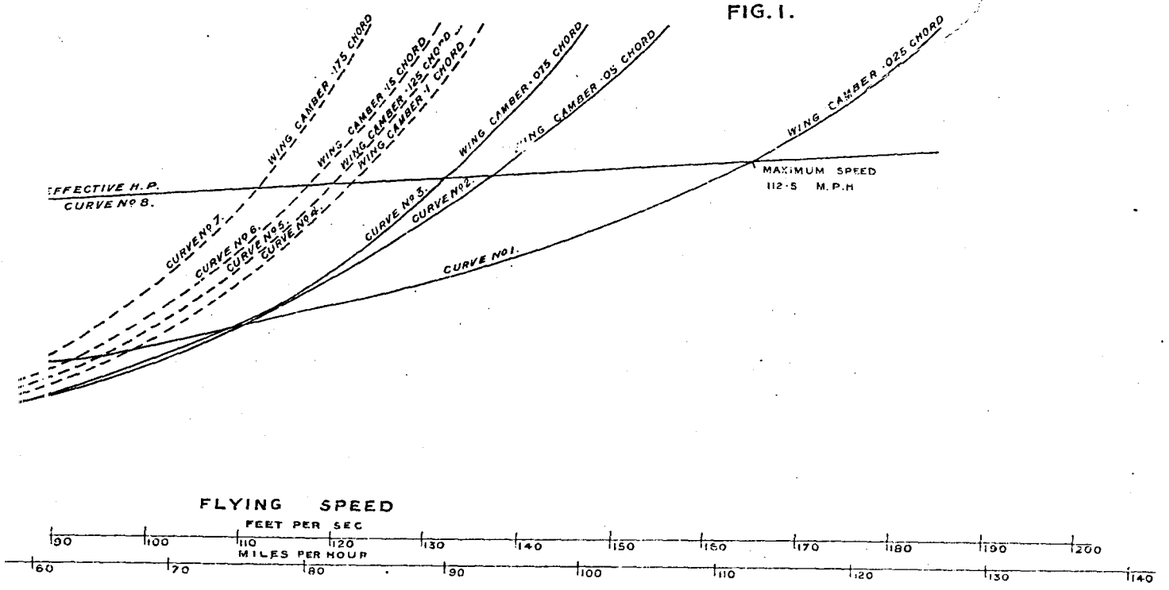


FIG. 2.

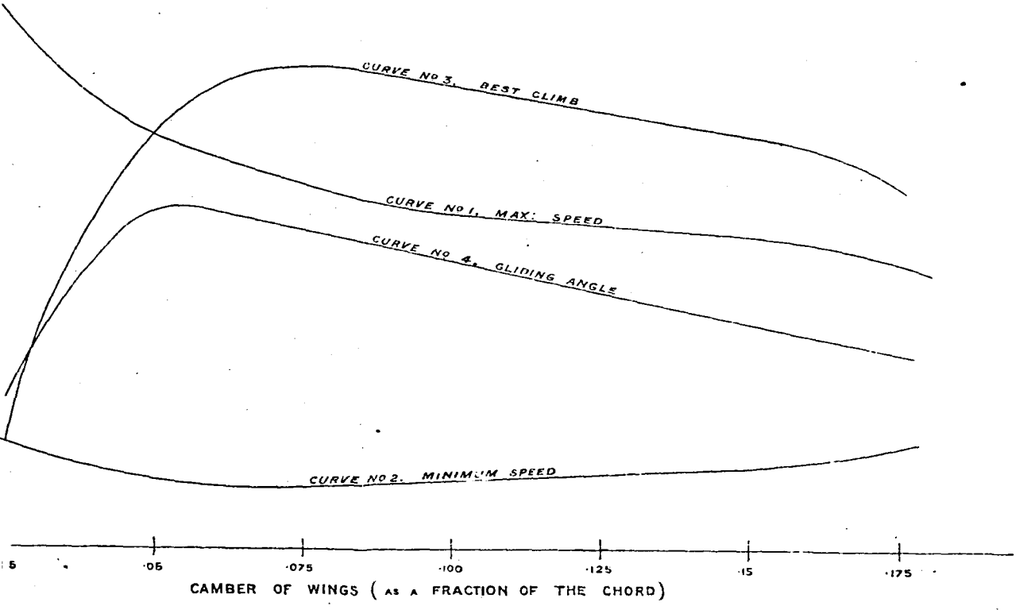


FIG. 3.

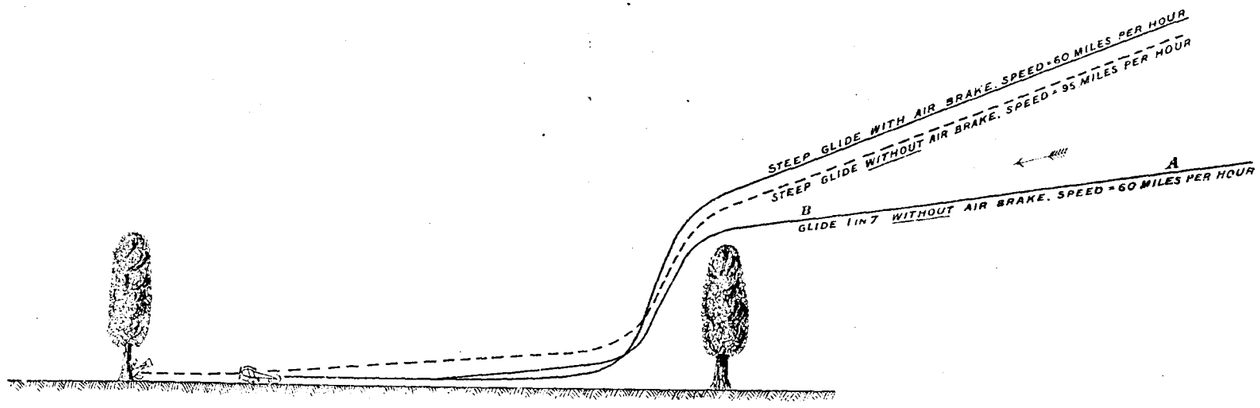
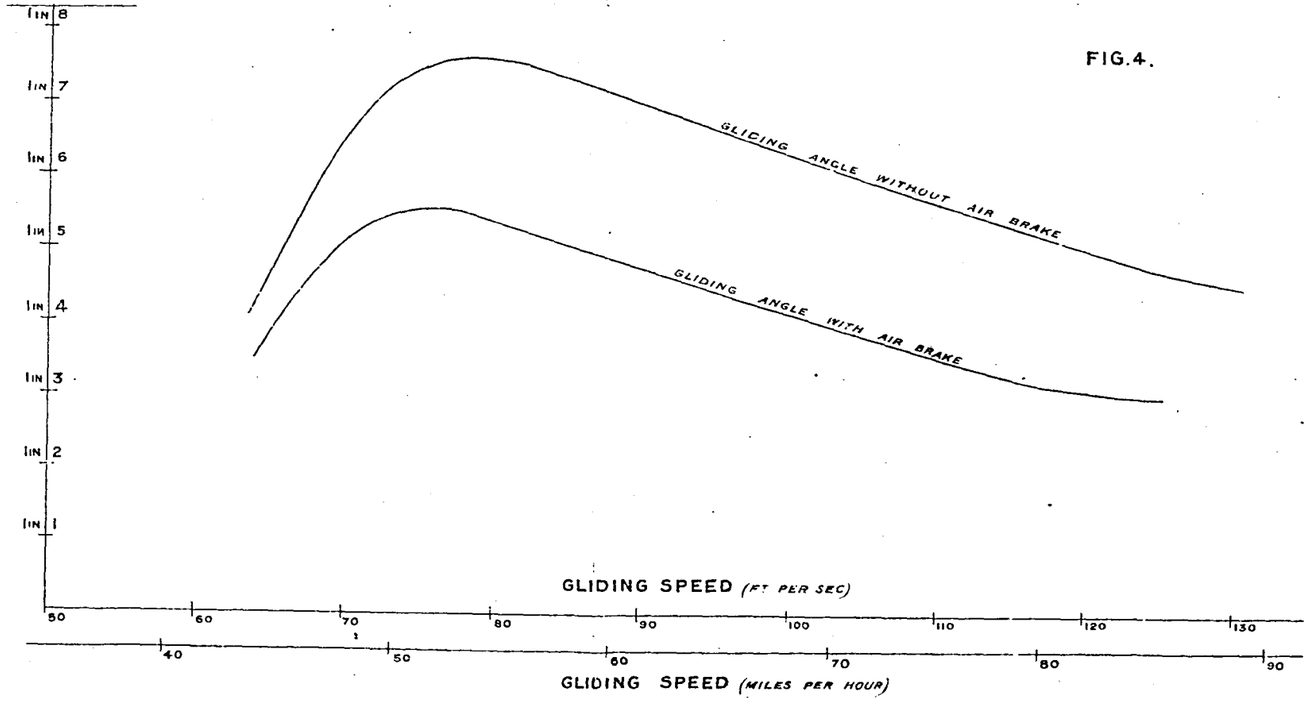


FIG. 4.



property, and be allowed to go where they might think proper, and that their arrears should be paid to the amount of 20,000 rupees.

After the batteries had opened about an hour, a white flag was shown from the walls of the fort, which was the signal that had been agreed upon in case the terms should be accepted; hostages were sent down, and an engagement made that the fort should be delivered up on the following morning. It was accordingly evacuated; the garrison carried off their property in security, and received the sum agreed to be paid to them.

Colonel Stevenson mentions in high terms the conduct of the officers and troops under his command; and I cannot omit to take the opportunity of expressing to your Excellency my sense of the merits of Colonel Stevenson and of the body of troops under his command. Upon every occasion I received from the Colonel the most cordial and zealous assistance; and the troops under his command are in the highest state of discipline and order, and fit for any service in which they can be employed.

On the 16th, 9 officers, 4 sergeants, and 1 matross, formerly in the service of Dowlat Rao Scindiah, delivered themselves up to Colonel Stevenson under your Excellency's proclamation of the 29th August.

I have the honour to enclose a return of the killed and wounded of the troops under the command of Colonel Stevenson, during the operations against Asseerghur. Hereafter I shall have the honour of transmitting return of the ordnance, stores, grain, and other property captured in that fort."

(2).

SIEGE OF GAWILGHUR (*December*, 1803).

The second siege dealt with is that of Gawilghur which took place during the same campaign. It was undertaken by Major-General Wellesley himself, and a full and detailed account of his operations is given in the following despatch to the Governor-General in India:—

CAMP AT DEOGAUM, 15*th December*, 1803.

To the GOVERNOR-GENERAL.

"After the Battle of Argaum I determined to lose no time in commencing the Siege of Gawilghur. I accordingly marched on and arrived at Ellichpoor on the 5th instant, and halted there the 6th; in order to establish a hospital there for the wounded in the Battle of Argaum.

The fort of Gawilghur is situated in a range of mountains between the sources of the rivers Pooma and Taptee. It stands on a lofty mountain in this range, and consists of one complete inner fort which fronts to the south, where the rock is most steep; and an outer fort, which covers the inner to the north-west and north. This

outer fort has a third wall, which covers the approach to it from the north by the village of Labada. All these walls are strongly built, and fortified by ramparts and towers.

The communications with the fort are through three gates; one to the south with the inner fort; one to the north-west with the outer fort and one to the north with the third wall. The ascent to the first is very long and steep, and is practicable only for men; that to the second is by a road used for the common communications of the garrison with the countries to the southward; but the road passes round the west side of the fort, and is exposed for a great distance to its fire; it is so narrow as to make it impracticable to approach regularly by it, and the rock is scarped on each side. This road also leads no further than to the gate. The communication from the northern gate is direct from the village of Labada, and here the ground is level with that of the fort; but the road to Labada leads through the mountains for about 30 miles from Ellichpoor; and it was obvious that the difficulty and labour of moving ammunition and stores to Labada would be very great.

However, after making inquiry at Ellichpoor it appeared both to Colonel Stevenson and me, that this point of attack was, upon the whole, the most advantageous, and we accordingly adopted it.

Colonel Stevenson had equipped his corps at Asseerghur for the Siege of Gawilghur, for which service it had long been destined; and I therefore determined that he should make the principal attack by Labada, while I should cover his operations with my own division and all the cavalry; and if possible assist them by other attacks to the southward and westward. On the 6th inst. the 1st Batt. 2nd Regiment, under Lieut.-Colonel Chalmers, and two companies of the 94th, and the 1st Batt. of the 6th, under Capt. Maitland, were detached; the former to drive the enemy from the ground which they occupied to the southward of the fort; and the latter to seize the fortified village of Damergaum, which covers the entrance of the mountains by the road by which Colonel Stevenson was to pass towards Labada, and to protect the parties sent forward to reconnoitre and repair the roads in the mountains. Both these detachments succeeded.

On the 7th both divisions marched from Ellichpoor; Colonel Stevenson into the mountains by Damergaum, and my division towards the southern face of the fort of Gawilghur. From that day till the 12th, on which Colonel Stevenson broke ground near Labada, the troops in his division went through a series of laborious services, such as I never before witnessed, with the utmost cheerfulness and perseverance. The heavy ordnance and stores were dragged by hand over mountains, and through ravines, for nearly the whole distance, by roads which it had been previously necessary for the troops to make for themselves.

On the 12th at night, Colonel Stevenson erected two batteries in front of the north face of the fort; one consisting of two iron 18-pounders, and three iron 12-pounders, to break the outer fort and third wall; and one consisting of two brass 12-pounders, and two 5-in. howitzers, to clear and destroy the defences on the point of attack.

On the same night the troops of my division constructed a battery for two iron and two brass 12-pounders on the mountain under the southern gate, with a view if possible to breach the wall near that gate; or at all events to draw the enemy's attention to that quarter. Unfortunately the iron guns could not be moved into the battery, notwithstanding the utmost exertions of the troops; and the fire of the brass guns produced but little effect.

The fire of all these batteries opened on the 13th in the morning; and on the 14th, at night, the breaches in the outer walls were practicable. All the arrangements were then made for storming on this day. Lieut.-Colonel Kenny, of the 11th Regiment, commanded the party for the storm, consisting of the flank companies of the 94th Regiment, and of the Native Corps in Colonel Stevenson's Division, supported by the 94th Regiment, and Lieut.-Colonel Haliburton's Brigade, with Lieut.-Colonel Maclean's Brigade in reserve. At the same time I made two attacks from the southward to draw the enemy's attention from that quarter; one, under Lieut.-Colonel Wallace, consisting of the 74th Regiment, 5 companies of the 78th and 1st Batt. 8th Regiment, on the southern gate; and one under Lieut.-Colonel Chalmers, consisting of 5 companies of the 78th and the 1st Batt. 10th Regiment, on the north-west gate. These last attacks could be of no service, except to draw the enemy's attention from that from the north; unless they should succeed in blowing open the gates; and till they should communicate with detachments from Colonel Stevenson's Corps, as they had no other means of entering the fort. All the troops advanced at about ten in the morning. The detachment under Lieut.-Colonel Chalmers arrived at the north-west gate at the moment when the enemy were endeavouring to escape through it, from the detachment of Colonel Stevenson's Corps, which had been sent to communicate with Colonel Chalmers; and he entered without difficulty.

The wall of the inner fort, in which no breach had been made, was then to be carried. After some attempts upon the gate of communication between the inner and the outer fort, a place was found at which it was possible to escalade the wall. Capt. Campbell, with the light infantry of the 9th Regiment, fixed the ladders against this place, escaladed the wall, opened the gate for the storming party, and the fort was shortly in our possession. The enemy's garrison was numerous. It consisted of Rajpoots, and a great part of Beny Singh's Regular Infantry, which had escaped from the

Battle of Argaum, commanded by Beny Singh, himself. They were all well armed with the Company's new muskets and bayonets. Vast numbers of them were killed, particularly at the different gates. This service has, I hope, been performed, with small loss on our side. No officer has been killed; and but few wounded, that I have heard of, excepting Lieut.-Colonel Kenny, of the 11th Regiment, and Lieut. Young, of the 2nd of the 11th. In the performance of this service all the good qualities of British troops have been conspicuous to a degree which I have seldom witnessed. In bringing on their ordnance and stores to the point of attack, the troops of Colonel Stevenson's Division performed the most laborious work with a zeal for the service, and patience and perseverance never surpassed; and when opposed to the enemy, their conduct showed the same gallant spirit that has carried the British troops through so many difficulties in the course of the war.

Although the most laborious and the most brilliant part of the service did not fall to the lot of the troops of my division, I have to apprise your Excellency that they performed the part allotted to them in a manner perfectly satisfactory to me; and Lieut.-Colonel Wallace, Lieut.-Colonel Chalmers, and Capt. Beauman, commanding the Artillery, have received my thanks for the manner in which the two former led their divisions to the attack, and the latter exerted himself, to forward the service of the department.

I shall hereafter have the honour of transmitting to your Excellency a list of the killed and wounded, and returns of the ordnance and property captured in the fort."

(3).

SIEGE OF ASSEERGHUR (*March*, 1819).

In 1819 it was again found necessary to capture Asseerghur, and a force for this purpose was assembled under Brigadier-General Doveton and consisted of:—

Three regiments of Native cavalry.

Three and a-half battalions of European infantry.

Seven battalions of Native infantry.

Also a division brought down from Malwa by Malcolm composed of 1 regiment of cavalry, 4 battalions of Native infantry, with horse artillery and trains of both forces. Besides this, a further train was on its way detached from Sangor under Brigadier-General Watson. There were altogether 28 guns, 15 mortars and 19 howitzers.

The pettah is situated to the west of the fort in a hollow intersected by numerous ravines, and is commanded by the lower fort. The pettah was carried by assault at daybreak on March 18th, 1819, by the columns under Brigadiers Sir John Malcolm and Doveton.

Doveton's Column, commanded by Colonel Fraser and led by H.M.'s Royal Scots, entered the pettah by the south-west gate at head of the Buttakerah Nullah; Malcolm's Column entered by the high road from Boorgaum, through a gap in the hills which covers the pettah on the north-east. The enemy were taken by surprise, made little opposition, and our troops soon established themselves under cover of the houses, with a trifling loss occasioned by fire from the lower fort.

The Engineer Department was established in a large bombproof pagoda in the centre of the pettah, and the troops occupied the street in advance, which runs parallel to the fort. On March 23rd the Engineers reconnoitred the east front of the fort to fire on ground for General Doveton's Encampment.

On March 27th the Ram Bagh under the north-east angle of the upper fort was occupied, and the Engineer Depôt stationed there.

On April 7th, the breaching batteries opened on the retaining walls, and with the assistance of a third breaching battery a practicable breach was nearly effected.

On April 8th the breaching batteries opened at daybreak. About 11 a.m. orders were received to cease fire, the killadar, Jeswant Rao Lar, having agreed to an unconditional surrender.

(4).

BLOCKADE OF CADIZ (*February*, 1810).

The fourth siege of the present series is that of Cadiz. In this instance the French were the besiegers whilst the British formed part of the defending force.

Before giving the details of this siege, it may be well to recall briefly the events which led up to it. It was in October, 1807, that Napoleon laid his first steps for the future conquest of Spain, by signing a secret convention with the Spanish minister for the partition of Portugal between France and Spain. For this purpose 28,000 French troops were to be sent into Spain for the ultimate occupation of Portugal, whilst an additional 40,000 were to be cantoned at Bayonne as a support to the first Corps. The natural result followed. Portugal was easily overrun by the Allies whilst the French reinforcements entered Spain and secured several of the Northern fortresses. Meanwhile the dissensions of the Spanish Royal Family provided Napoleon with a pretext for dethroning the Spanish Bourbons and for replacing them by his brother Joseph. This act was, however, immediately followed by a general uprising of the Spanish people, during which the people of Cadiz compelled the French warships there to surrender, and the levies of Andalusia forced General Dupont and 23,000 men to lay down their arms at Baylen. Sir Arthur Wellesley, also, landed with a British force and,

after the Battle of Vimiera, Junot—who was in command of the French—agreed to evacuate the country. Napoleon now seriously turned his attention to the subjugation of Spain. In January, 1809, the British force under Sir John Moore was compelled to retreat and re-embark at Corunna and, although in the following July, Sir A. Wellesley again defeated the French at Talavera, by the end of the year they were virtually masters of Spain. In January, 1810, they entered Seville, overran Andalusia and pushed on to capture Cadiz. The city was at the time utterly unprepared for attack and there were under 1,000 men in the Isle of Leon. Fortunately General Alburquerque, on his own initiative and contrary to the orders he had received, realized the vital importance of saving the town. Pushing on with the greatest rapidity and by forced marches, he outmanœuvred and outstripped the French, and on the 2nd of February, after a march of over 260 miles he entered the Isle of Leon with 8,000 men.

Defeated in his attempt to surprise Cadiz, Victor spread his troops round the margin of the bay and commenced works of contravallation, 25 miles in length. Although the towns, the islands, the castles, the harbours, and rivers thus enclosed are too numerous, and in their relative bearings too intricate for minute description, the leading features shall in due course be given.

The blockade comprised three grand divisions, separately entrenched, namely, Chiclana, Puerto Real, and Santa Maria. The first resting its left on the seacoast was carried across the Almanza and Chiclana Rivers to the Zuraque, being traced for 8 miles along a range of thickly wooded hills bordering a marsh from 1 to 3 miles broad: both the line and marsh were traversed by those rivers, and by many navigable water courses and creeks, all falling into the Santi Petri, a natural channel connecting the upper harbour of Cadiz with the open sea. This channel, 9 miles long, 200 or 300 yards wide, and of depth to float a seventy-four, was the first Spanish line of defence. In the centre, the bridge of Zanzo, by which the only road to Cadiz passes, was broken and was also defended by batteries on both sides. On the right hand the Caraccas, or Royal Arsenal, situated on an island in the harbour mouth of the channel, and on account of the marsh not open to attack save by water or by bombardment, was covered with strong batteries and served as an advanced post. On the left hand the Castle of Santi Petri, also built upon an island, defended the sea-mouth of the channel.

Beyond the Santi Petri was the Isla de Leon, a vast triangular salt marsh, but having one high strong ridge in the centre, about 4 miles long, on which the town of Isla stands; this ridge within cannon shot of the Santi Petri offered the second line of defence.

At the apex of the Isla stood the Torre Gardo, from whence a low narrow isthmus 5 miles long connected it with the rocks on which

Cadiz is built. Across the centre of the isthmus, a cut, called the Cortadura and defended by the large unfinished fort of Fernando, offered a third line of defence. The fourth and final line was the land front of Cadiz, regularly fortified.

On the Chiclana line, the hostile forces were only separated by the marsh. The Spaniards possessed the Santi Petri, but the French, having their chief depôts in the town of Chiclana, could always command the marsh, and might force the passage of the channel. For the Chiclana, Turaque and Almanza Creeks were navigable beyond the lines of contravallation, the thick woods behind furnished means of constructing an armed flotilla, and the Santi Petri itself, on both sides, could only be approached by water off the high road; or at best by narrow footpaths leading between the salt pans of the marsh.

The French centre, called the Puerto Real Division, extended from the Turaque on the right for a distance of 7 miles. This line ending at the town of Puerto Real was traced along a ridge skirting the marsh, so as to form with the position of Chiclana a half-circle. Puerto Real was entrenched; but a tongue of land 4 miles long projected from it perpendicularly towards the isthmus of Cadiz, being cloven in its whole length by the creek or canal of Trocadero. It separated the inner from the outer harbour, and at its extreme points stood the village of Trocadero, and the fort of Matagorda; opposed to which there was, on the isthmus of Cadiz, a powerful battery called the Puntales.

From Matagorda to Cadiz was above 4,000 yards; but from Puntales it was only 1,200, and was therefore the nearest point to Cadiz, and to the isthmus, and the most important post of defence. From thence the French could search the upper harbour with their fire, or throw shells into the Caraccas and the fort of Fernando; while their flotilla, safely moored in the Trocadero Creek, could quickly reach the isthmus and turn the Isla, with all the works between it and the city; nevertheless the Spaniards dismantled and abandoned Matagorda.

The Third or Santa Maria Division of blockade followed the sweep of the bay. Reckoning from the San Pedro on the left, to the Castle of Santa Catalina, the extreme point of the outer harbour on the right, was about 5 miles. The town of Santa Maria, built at the mouth of the Guadalete in the centre of this line, was entrenched, and the ground about Santa Catalina was extremely rugged.

Beyond these lines, which were connected by a covered way concealed by thick woods and finally armed with 300 guns, the towns of Rota and San Lucar de Barameda were occupied; the first, situated on a cape of land opposite to Cadiz, was the northern point of the great bay or roadstead; the second commanded the mouth of the Guadalquiver. Behind these lines of blockade, Latour

Maubourg occupied Medina Sidonia with a covering division, his left being upon the upper Guadalete, his advanced posts watching the passes of the Sierra di Ronda.

General William Stewart reached Cadiz with 2,000 men the 11th February; 1,000 more joined him from Gibraltar, and all were received with enthusiasm. The Portuguese troops were equally well received, and soon 4,000 Anglo-Portuguese, and 14,000 Spanish regulars were behind the Santi Petri.

The ships recovered at Ferrol had been transferred to Cadiz, and thus were in the bay 23 men-of-war, four of the line and three frigates being British. The *Euthalion* and *Undaunted* also arrived from Mexico, with six millions of dollars, and thus money, troops, and a fleet were suddenly collected at Cadiz. Yet to little purpose. Procrastination, jealousy, ostentation, and a thousand absurdities marred every useful measure, and there was so little enthusiasm among the people that no citizen was enrolled, or armed, or volunteered either to labour or to fight.

Stewart's first measure was to recover Matagorda. In the night of the 22nd a detachment consisting of 50 seamen and Marines, 25 artillerymen and 67 of the 94th Regiment, pushed across the channel during a storm, took possession of the dismantled fort and effected a solid lodgment: the French cannonaded the work with field artillery all the next day, yet the garrison supported by the fire of Puntales, was immovable, and the remainder of February passed without any event of importance. Early in March the city wanted provisions, especially fresh meat, and a tempest beating on the coast from the 7th to the 10th of March, drove three Spanish and one Portuguese sail of the line, a frigate and from 30 to 40 merchantmen on shore between San Lucar and St. Mary's. One ship of the line was taken, the others were burnt and part of the crews brought off by boats from the fleet; but many men, amongst others a part of the 4th English Regiment, fell into the hands of the enemy, together with an immense booty.

On the 15th the enemy's outposts at Santi Petri were driven in by Major Sullivan, of the 79th, to cover an attack meditated against the Trocadero, but the design was baffled by the surf in one quarter and the difficulty of crossing a shoal in another. In the same month Mr. H. Wellesley, Minister Plenipotentiary, arrived; and on the 24th General Graham, coming from England, assumed the chief command of the British troops and immediately caused an exact military survey of the Isle to be made. It then appeared that the force hitherto assigned for its defence was quite inadequate. Twenty thousand soldiers, with redoubts and batteries, requiring the labour of 4,000 men for three months, were absolutely necessary; the Spaniards had only worked beyond the Santi Petri, and there without judgment. Their batteries in the marsh were ill-placed, their

entrenchments at the sea-mouth were contemptible; the caraccas though armed with 150 guns was full of dry timber and could be easily burnt by carcasses. The interior defences of the Isla were quite neglected. Matagorda and the Trocadero had been abandoned, but the batteries beyond the Santi Petri had been pushed to the junction of the Chiclana road with the Royal causeway; that is to say 1½ miles beyond the bridge of Zanzo, and consequently exposed without support to flank attacks both by water and land.

It was in vain that the English engineers presented plans and offered to construct the works, the Spaniards would never consent to pull down a house or destroy a garden; their procrastination paralyzed their Allies, and would have lost the place had the French been prepared to press it vigorously.

Additional reinforcements reached Cadiz the 31st, and both sides continued to labour at their lines; but the Allies worked slowly and without harmony, the people's supplies were interrupted, scarcity prevailed, many persons were forced to quit the city and 2,000 Spanish troops were detached by sea to Ayamonte to collect provisions on the Guadina.

Matagorda was small, of a square form, without a ditch, without sufficient bombproofs, and having one angle projecting towards the land; it could only bring seven guns to bear, yet though frequently cannonaded it had been held 55 days, and now impeded the completion of the French works. A Spanish seventy-four supported with an armed flotilla moored on the flanks, and co-operated in the defence; but at daybreak on the 21st heavy batteries, hitherto masked by some houses on the Trocadero, sent a hissing shower of hot shot upon the ships and drove them for shelter to Cadiz. Then the fire of 48 guns and mortars of the largest size were concentrated on the little fort, and the feeble parapet disappeared in a moment before the crushing flight of metal. The naked rampart and the undaunted hearts of the garrison remained; yet the men fell fast, and the enemy shot so quick and close, that a staff bearing the Spanish flag was broken six times in an hour. The colours were then fastened on the angle of the work itself, to the discontent of both soldiers and sailors who besought their officers to hoist the British ensign, attributing their slaughter to their fighting under a foreign flag. Thirty hours this tempest lasted, and 64 men out of 140 had fallen, when General Graham, finding a diversion he had projected impracticable, sent boats to carry off the survivors. A bastion was then blown up under the superintendence of Major Lefebure, an engineer of great promise, but he also fell, the last man whose blood wetted the ruins thus abandoned.

Matagorda Point was soon covered with batteries by the French, but the war languished in front of Cadiz.

In May some French prisoners cut the cables of two hulks at Cadiz and drifted in a heavy gale to the French side; they beat off

two of the craft sent after them by throwing cold shot from the decks, and about 1,500 saved themselves, despite of the fire from the allied fleet, and from the batteries. Cadiz was now a scene of great disorder. The English General was hampered by the perverse spirit of the authorities, and the Spanish troops were daily getting more inefficient from neglect.

Blake was then called to command in the Isla, and his presence produced some amelioration in the condition and discipline of the troops; and at his instance the British Engineers commenced a regular system of redoubts for the defence of the Isla. English reinforcements continued to arrive, and 4,000 Spaniards joined the garrison now within the lines; but such was the state of the Spanish troops, such the difficulty of arranging plans, that hitherto the taking of Matagorda had been the only check given to the enemy's works.

In July the British force in Cadiz was increased to 8,500 men, and Sir Richard Keats took command of the fleet; the French, intent upon completing their lines and constructing flotillas, made no attacks. The preparations at Matagorda constantly and seriously menaced Cadiz, and a British division was necessarily kept there; for the English Generals were well assured that some fatal disaster would otherwise befall the Spaniards. Graham's Division might have been set free instead of being cooped up without any counterbalance in the number of French troops employed to blockade. The latter aided indirectly, and at times directly, in securing Andalusia, and if not at Chiclana, must have been covering Seville as long as there was an army in the Isla; but Graham merely defended Cadiz.

In November, 1810, while the Spaniards were entirely occupied with the debates in congress, the French works were finished: their chain of forts was completed, each fort having a ditch and palisades with a week's provisions. Soult came to San Lucar, and his flotilla there and at Santa Maria, Puerto Real, and Chiclana, being all ready for action he proceeded to concentrate. On the last night of October 30 pinnaces and gunboats, slipping out of the Guadalquiver, eluded the allied fleet, passed along the coast to Rota, and from thence, aided by shore batteries, fought their way to Santa Maria and the San Pedro River. But to avoid the danger of doubling Matagorda the vessels were transported overland on rollers, and 130 armed vessels and transports were thus safely assembled in the Trocadero Canal. At the Trocadero Point there were immense batteries, and some notable pieces of ordnance, invented by Colonel Villantwys, called cannon-mortars. These huge engines, one of which was afterwards placed in St. James's Park, were cast at Seville, and being placed in slings, threw projectiles over Cadiz, a distance of more than 5,000 yards. To obtain this flight the shells were partly filled with lead, and their charge was too small for an effective explosion, yet they alarmed the city and were troublesome to the shipping.

Soult's design was to ruin by superior fire the fort of the Puntales

then to pass the straits with his flotilla, and establish his army between the Isla and the city; nor was this plan chimerical, for on the side of the besieged there was neither conceit nor industry. New drafts made by Wellington had reduced Graham's force to 5,000 men, and in October the fever broke out; but as Soult's preparations became formidable, reinforcements were drawn from Gibraltar and Sicily, and at the end of the year, 7,000 British, Germans and Portuguese were still behind the Santi Petri. To insure naval superiority, Admiral Keats drew all the armed craft from Gibraltar. To secure the land defence, Graham urged the Regency to adopt certain plans, and he was warmly seconded by Sir Henry Wellesley; but neither their entreaties nor the inconvenience of the danger could overcome the apathy of the Spaniards; their troops were wanting in discipline, clothing and equipment and only 16,000 men of all arms were effective on a muster roll of 23,000. The labour of the British troops far from being assisted was impeded, and December ended before Graham, after many altercations, could even obtain leave to put the interior line of the Cortadura in a state of defence.

When in February, 1811,* Graham knew that Soult had gone to Estremadura he undertook to drive Victor from his lines. Troops sailing from Cadiz were to disembark in rear of the French and be joined by the garrison of Tarifa under Major Brown and by 3,000 Spaniards from San Rouque under General Beguines. Contrary winds delayed the expedition, and the despatch vessels carrying counter-orders to Brown and Beguines being likewise retarded, those officers advanced, the first to Medina, the second to Casa Vieja. Victor got notice of the design and kept close in his works, until he heard of this failure in the combinations, when he sent troops to retake Medina and the Casa. At the same time 12,000 men from the Northern Governments reached him and his whole force being 20,000, he had 15,000 in the lines; the remainder were at San Lucar, Medina, and other ports. This was known at Cadiz, but 10,000 infantry and 600 cavalry were again embarked, being this time to land at Tarifa, and march straight on Chiclana. General Layas was left in command of the Isla with orders to throw a bridge over the Santi Petri near the sea-mouth.

On the 22nd the British troops passed their port in a gale, and landed at Algesciras, marched to Tarifa the next day, and were joined by the 28th Regiment, and the flank companies of the 9th and 82nd Regiments. Thus more than 4,000 effective troops including 2 companies of the 20th Portuguese, and 180 German hussars were assembled under Graham; all good and hardy troops, and himself a daring old man and of a ready temper for battle. The Captain-General, La Peña, landed on the 27th with 7,000 Spaniards, and Graham to preserve unanimity ceded the command, although it was contrary to his instruction. Next day a march of 12 miles carried

* Official abstract of military reports MSS.

them over the ridges which separate the plains of San Roque from those of Medina and Chiclana, and being then within 4 leagues of the enemy's posts the troops were reorganized. The vanguard was given to Lardizabal, the centre to the Prince of Anglona; the reserve, composed of two Spanish regiments and the British troops, was confided to Graham: the cavalry of both nations, formed in one body, was under Colonel Whittingham, then in the Spanish service.

Before this Beguines and the partidas had driven the French into Casa Vieja and Medina; but General Cassaque being reinforced had retaken both places and entrenched Medina, acting as a covering force to the river. Victor manned his works at Rota, Santa Maria, Puerto Real and the Trocadero, with a mixed force of Juramentados and regular troops; but he assembled 11,000 good soldiers near Chiclana between the roads of Couil and the Medina, to await the unfolding of the Allies' project which was not delayed.

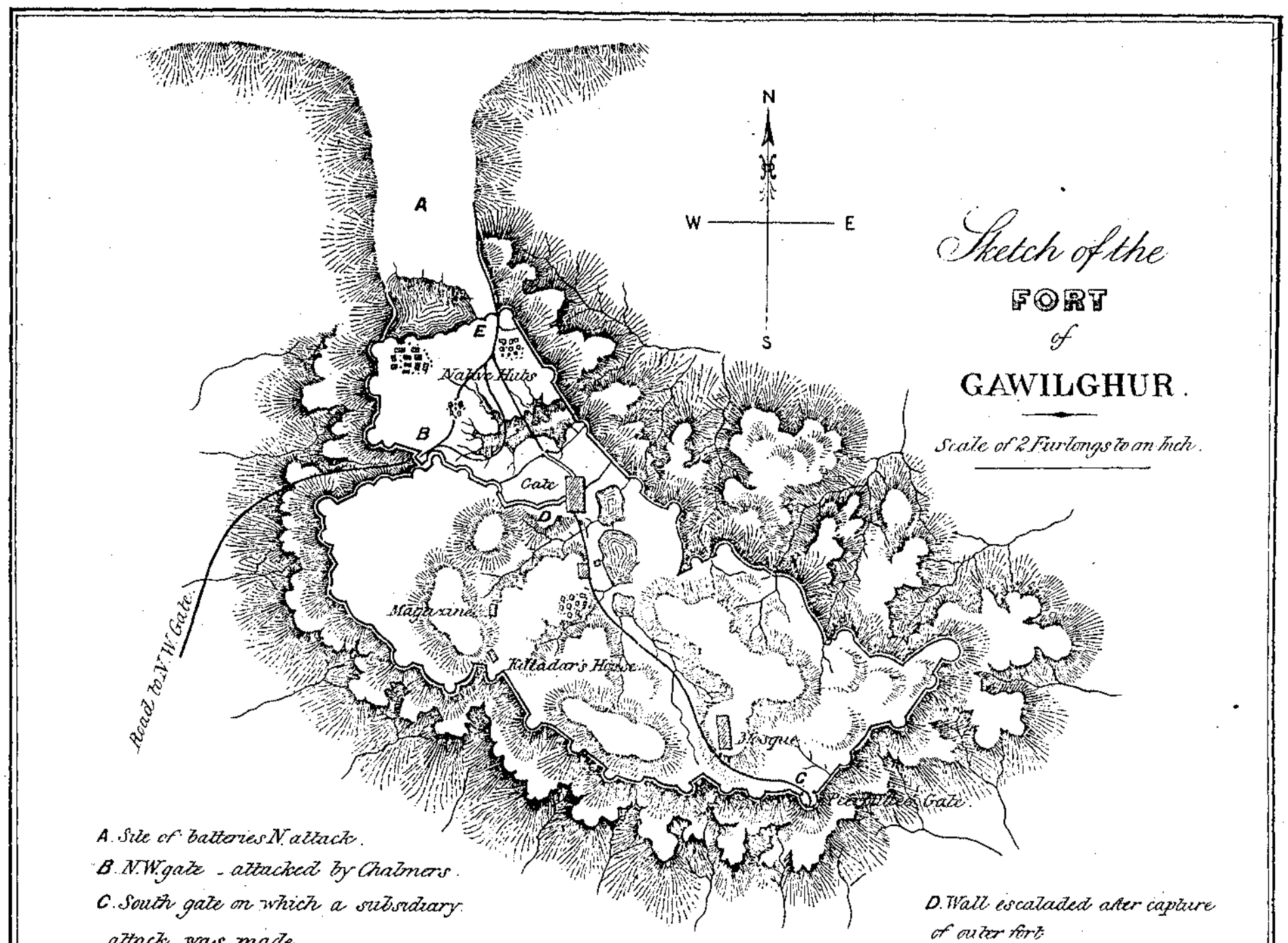
La Peña having 12,000 infantry, 800 horsemen and 24 guns turned towards the coast and drove the French from Vejer de la Frontiera. The following evening he continued his movement and on the morning of the 5th after a skirmish, in which his advanced guard of cavalry was routed by a French squadron, he reached the heights of Barosa being then 4 miles from the sea-mouth of the Santi Petri. Then followed the bloody Battle of Barosa which is fully described in the XIIth book of Napier's *Peninsular War*. The battle lasted only 1½ hours, but 50 officers, 60 sergeants, 1,100 British soldiers, and more than 2,000 French were killed and wounded: 6 guns and an eagle, 2 generals, both mortally wounded, together with 400 other prisoners fell into the hands of the victors.

All the passages in this extraordinary battle were broadly marked, and La Peña's contemptible weakness was surprisingly contrasted with the heroic vigour of Graham whose attack was rather an inspiration than a resolution, so wise, so sudden, was the decision, so conclusive the execution.

After the Battle of Barosa violent disputes arose in Cadiz. La Peña in an address to the Cortes claimed the victory for himself; he said that the arrangements previous to the battle were made with the knowledge and approbation of the English General, and the latter's retreat to the Isla was the real cause of failure.

Graham incensed at this proceeding wrote a letter to the British envoy in which he exposed La Peña's misconduct: he refused with disdain the title of Grandee of the First Class voted to him by the Cortes, and when Lascy used expressions relative to the action personally offensive he enforced an apology with his sword. Having thus shown himself superior to his opponents at all points, the gallant old man relinquished his command to General Cooke, and joined Lord Wellington's Army.

(*To be continued*).



Sketch of the FORT of GAWILGHUR.

Scale of 2 Furlongs to an Inch.

A. Site of batteries N. attack.

B. N.W. gate - attacked by Chalmers.

C. South gate on which a subsidiary attack was made

D. Wall escaladed after capture of outer fort

E. Breach.


Scale of Yards.
Plan of the Attack
of
ASSEER GHUR,
Which surrendered on the 9th of April 1810.
To the Combined Forces
under the Personal Command of
Brigadier General J. Doveton C.B.
Section thro' the Breach & Casemates on the E. Side of the FORT.
REFERENCES
A C Wall of the Fort
B Interior of Casemate
D E Retaining Wall partly Breached.
Scale of Feet.
Section thro' the Breach on the N. Side of the FORT.
REFERENCES
A Interior Wall
B Protruding Do.
C D Space between Walls filled with Rubbish
D Parapet of Fausse Wall Breached
D E Slope of Hill
REFERENCES
West Attack
A Howitzer Battery containing 5 Howitzers.
B Breaching Battery of the lower Fort containing 6 heavy Guns.
C Advance Post during the Day.
D Do. Do. Night.
E Mortar Battery containing 4 Mortars.
F Mortar Battery containing 4 Mortars & Howitzers.
G Breaching Battery of the lower Fort containing 4 heavy Guns.
H Breaching Battery of the second Fort containing 6 heavy Guns.
K Breaching Battery of the upper Fort containing 4.18 Pounders.
East Attack
L Battery containing 5.18 Prs. to destroy the defences of the Left Flank.
M Battery containing 4.18 Prs. to destroy the defences of the Right Flank.
N O Breaching Batteries containing 4 heavy Guns each.
P Q R Mortar & Howitzer Batteries.
S Three 18 Pounders drawn out to destroy the N.E. Bastion.
T Two 12 Pounders to silence the Gun in the N.E. Bastion at the Commencement of operations.
1 Northern Tower.
2 North East Bastion.

THE RELATIVE CARRYING CAPACITY OF RAILWAYS FOR TRAFFIC OF THE MILITARY TYPE IN WAR CONVEYED OVER LONG DISTANCES.

Based on a Lecture delivered at the School of Military Engineering, Chatham, 20th November, 1913, by W. TETLEY STEPHENSON, ESQ., B.A.

WHEN considering the carrying capacity of railways for traffic of the type that a railway must deal with in time of war, it is well to bear in mind that the traffic which is typical of our home railways is not of that kind. A much nearer parallel is to be found in the traffic handled by the great American railways. There traffic is dealt with in great bulk; trains loaded with a single commodity like wheat compose a large proportion of the trains on many railroads. The distances to be traversed are great, and these single commodity trains frequently run 1,000 miles or more to the ports without any change in the composition of the trains. Whether the distances were 500 miles or 2,000 miles would not be very material—once the distances are considerable the principles of working remain the same.

In dealing with the capacity of a railway in war, one has always to look at it from two points of view. An instance of a short-time point of view is given by the last rush of trains to Ladysmith before its investment. At such a time a number of trains may be passed over a line in a few hours by methods of working which would be wholly unjustifiable in ordinary working. Then there is the long-time point of view, when the question is more likely to become one of working the greatest amount of traffic over the line in a period lasting over weeks—possibly months. The problem was presented in an extreme form on the Trans-Siberian Railway in the Russo-Japanese War, and, wonderful as was the work accomplished by the engineering staff, the organization of the traffic working is open to much criticism. The capacity of a railway from the long-time point of view is mainly dealt with in the pages that follow, and must not be confused with the capacity of the railway for a very short time.

The first question usually asked about a railway is:—"What is its gauge?" Is the distance between the rails 5 ft. 6 in. or 4 ft. 8½ in. (the Standard Gauge) or 3 ft. 6 in., or some other width? This information is of very limited value by itself. Its greatest value lies in giving some idea of the opportunities of obtaining more rolling stock, often a matter of the greatest importance in war time owing to the rapid expansion of traffic calling for a large expansion in the rolling stock.

In testing a railway's capacity the Loading Gauge is of really greater importance. Appended are some diagrams to show this. *Fig.* 1 relates to Standard Gauge line. The outer line defines

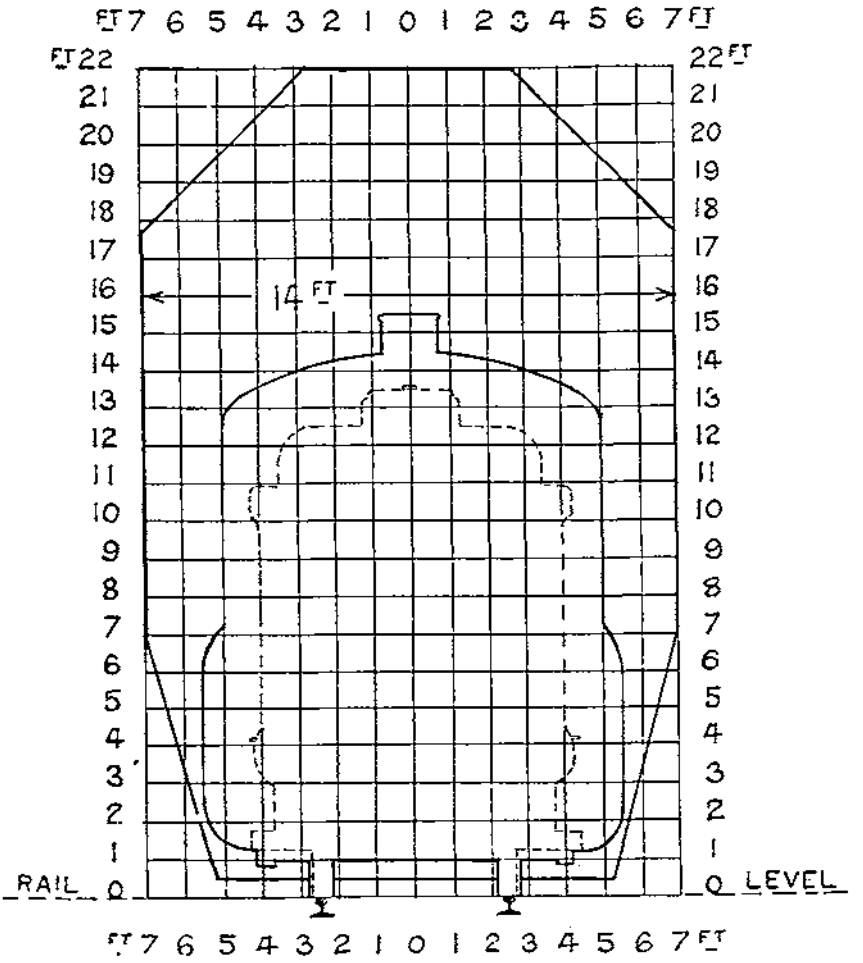


FIG. 1.—*Maximum Load Gauge, 4-ft. 8½-in. Line Gauge.*

the largest Loading Gauge to be found in the United States of America. It is exceptional even for that country, and full advantage of it is not taken. The Loading Gauges of large railways in this country vary somewhat, but a width of 9 ft. and a height of 13 ft. 6 in. at the centre above rail level may be taken as typical. The inner continuous line shows a cross-section of a typical large American locomotive, and its dimensions exceed in both width and height the English Loading Gauge dimensions. The broken line represents the biggest type of engine on the Great Northern Railway, and it is not only about as large as any in this country, but it is so

large that the margin between it and the Loading Gauge is in places only a matter of inches. The bigger Loading Gauge allows the Americans to have locomotives of about double the power we can build. Wagons can be worked that are 1 ft. 6 in. to 2 ft. wider, which means, with other dimensions unaltered, a gain of 20 to 25 per cent. in carrying capacity. But the gain in height means a further addition and a wagon of the same length would be able to take 30 to 50 per cent. more traffic, whilst if absolutely full advantage were taken of the possible dimensions, the load would be double. Even as it is the difference in the dimensions of the Loading Gauges allows many United States railways to build locomotives and wagons which make it possible to convey three times the traffic load which can be taken by a similar train in this country.

Fig. 2 shows the limits of Loading Gauge for a 3-ft. 6-in. railway. In every direction the dimensions are in excess of

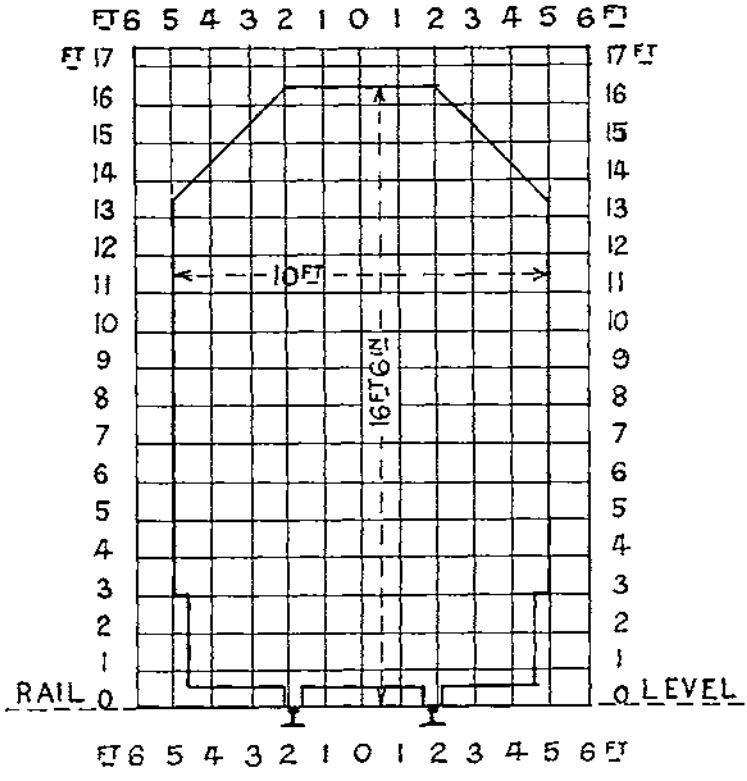


FIG. 2.—*Maximum Load Gauge, 3-ft. 6-in. Line Gauge.*

the Loading Gauge of our railways. Considerable advantage is taken of these limits. On the Rhodesian railways the width used is 10 ft. compared to our 9 ft., and the railways, not having platforms, the 10 ft. can be used as low as the wagon floor allows. It is not

until 11 ft. from rail level that this width has to be reduced, and then only to 9 ft. 4 in.; still in excess of every English railway except the Great Western Railway. The maximum height allowable is 13 ft. 3 in. from rail level, which is about the average in this country. The advantages of our wider rail gauge are small. It costs more to construct and maintain, using more material and more labour. In working freight traffic we gain absolutely nothing. Our sole advantage is in connection with high-speed passenger trains; we can run our trains faster with safety.

A reference to Russian railways may be of interest. The gauge of these is 5 ft. 0 in., whereas "Standard" Gauge is the rule in all the neighbouring European countries. Has Russia one single advantage in peace or war for this to set against the extra cost? The writer fails to find one. Russia dare not make use of a larger Loading Gauge than the railways of Prussia, Hungary, etc., in case, in war, it should require to work its rolling stock over those railways. Russia also recognizes the great difficulties of widening the line gauge, and so goes to the expense of equipping its wagons with a device which enables them to work either on Russian or Standard Gauge lines. It is expense all the way, and not an item on the other side of the balance sheet worth mentioning.

Turning to the railways of a line gauge of 2 ft. 6 in. (*Fig.* 3)

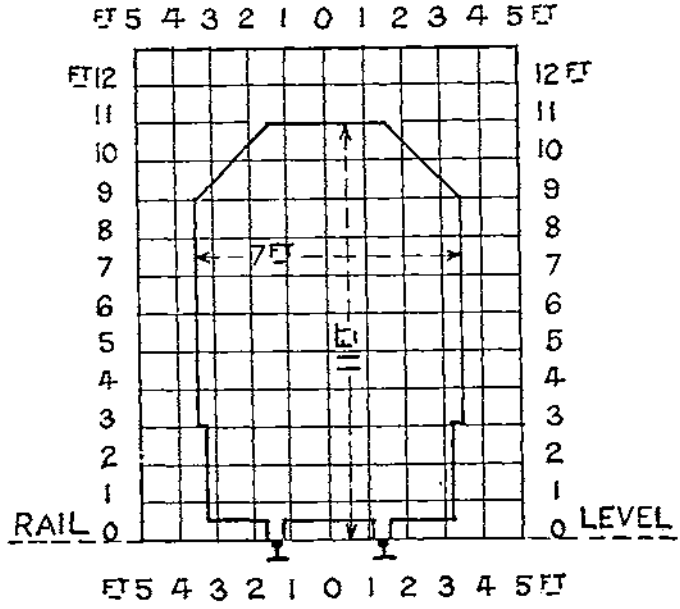


FIG. 3.—*Maximum Load Gauge, 2-ft. 6-in. Line Gauge.*

at last a gauge is reached which must have a smaller loading gauge than that used in this country. The position still, however, remains,

that no comparison of relative capacity can be arrived at without the loading gauge being known.

A very rough rule is, that with varying line gauges and proportionate loading gauges the power of the locomotives can vary as the squares of the line gauges. The ratio of the traffic loads of the trains would be very much greater; probably the increase would be upwards of 50 per cent.

In practice a simple set of relations like this is rarely met with. Usually the narrow gauge railways have a relative advantage in loading gauge, but lose that and often much more through being planned with more severe gradients and sharper curves. The outcome is that though the locomotive is relatively more powerful for the narrow gauge line, the train which can be hauled is relatively smaller.

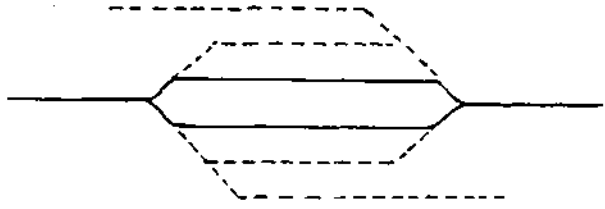
After the gauges, the next question is whether the line is double or single. The great mass of the world's railway is single line. In the United States, which alone possess more than one-third the railway mileage of the world, barely 10 per cent. of the mileage is double line.

Looking at single line first, the number of trains which can be worked over a line in each direction, provided rolling stock is adequate, depends upon the distance between the passing places and the way in which those passing places are laid out. In railway working all miles are not equal. One mile of railway is level and straight; another is on a steep up gradient; a third is on a falling gradient; another possesses curves of small radius. The result is that one mile will take two or three times as long for a train to run over it as another. Taking the Trans-Siberian Railway at the time of the Russo-Japanese War, a section measuring 7·6 miles on heavy up grade took the fastest train of the day 32 minutes. Whereas a section 8·9 miles, *i.e.* a $\frac{1}{8}$th longer, of undulating line took only 25 minutes. From a train-running point of view the first section was the longer. A little further on two sections, both $5\frac{1}{3}$ miles long occurred; one took 13 and the other 18 minutes to run. The distance between passing places requires to be measured by the time a train will take to run it rather than by the actual physical mileage. Moreover, if a single line is carrying the maximum number of trains, the capacity will be ruled by the section that takes the longest time, just as the strength of the chain is that of its weakest link.

Then as regards the accommodation at the passing places—this controls the size of the trains, and the number of trains which can be run. The Russians worked as large trains over the Trans-Siberian Railway as they could, but at some of the crossing places it was only just possible to get the trains inside by drawing the train forward until the brake van was clear inside, then fastening down the brakes on the rear wagons, and the engine shunting back

as to close up the couplings and get the wagons close together. This process occupied anything from 5 to 10 minutes, and was equivalent to lengthening the time the train took to run the section by that amount. Those crossing places not only limited the lengths of the trains, but reduced the number of trains it was possible to work over the line.

Then crossing places may only have accommodation for one train in each direction to pass at a time, or there may be additional sidings



or loops so that two or even three trains in each direction can pass one another. When sections are short such extra sidings are not of much value, but when sections are long they may be of great value as if trains are run in pairs a few minutes behind one another 60 per cent. more can frequently be run over the line in a given time. The Rhodesian Railway with crossing places 20 miles apart will serve as an instance. If trains were run at a speed of 20 m.p.h. including stops, it would be just possible to work 12 trains in each direction in 24 hours. But if two trains ran 10 minutes apart, and passed two others run in the same way, and if 5 minutes extra were occupied crossing the trains, two trains would be run in each direction every $2\frac{1}{2}$ hours, or something over 18 trains in the 24 hours. If night working has to be prohibited, the relative figures become perhaps 6 against 10, and those extra trains might be invaluable.

If once the trains, which can be worked over a single line, exceed one per hour in each direction and the trains are of the heavy type, which should be run as far as possible for military traffic, it will hardly ever be necessary to trouble about the capacity of the railway to carry the number of trains required. Almost invariably it will be found that either rolling stock is short and more trains cannot be run for this reason, or station accommodation is insufficient and more train loads can be worked than can be dealt with at the stations. This is well illustrated by the German single-line railways leading to the French frontier. Although the length of single line is comparatively short, and the stations have been specially equipped for dealing with military traffic, the authorities only count on them as capable of dealing with a maximum of 20 trains each way in the 20 hours per day they would be worked. The lines ought to be able to carry at least 50 per cent. more trains in the time. The limiting

factor is not really the train capacity of the lines, but the capacity of the stations.

With double line working the cases in which the train capacity of the lines is a limiting factor must be very rare. So long as the trains are run at a uniform speed and the line capacity is not wasted through running a few high-speed trains intermixed with trains of moderate and slow speeds, it will be possible as a rule to run trains at about 10-minute intervals. If there are long difficult gradients, 15-minute intervals might be necessary, but these are unusual. Generally 5 or 6 trains an hour should be reckoned on, and this means a number of trains which will tax the supply of rolling stock if distances are considerable, and even more will be likely to overtax the stations. To see the truth of this, it is only necessary to calculate the amount of rolling stock necessary if the journey takes 3 days out, 3 days back for the empty stock, and only a $\frac{1}{2}$ day each end for loading and unloading. Let the trains be no more than 40 wagon trains. Each day 4,800 wagons will be used, and in 7 days, *i.e.* up to the moment the first returned wagon might be expected back, 33,600 wagons would have been used. This is a number greater by 4,000 than the total wagon stock of a great railway like the Union Pacific R.R., U.S.A.—the total length of which is about 7,200 miles. It would hardly be surprising if rolling stock ran short. Even more is the difficulty likely to be found at stations. The whole tendency is for military traffic to concentrate on some particular spot, just as in peace time traffic will concentrate on an exporting port. The difference is that whilst in the latter case the accommodation has been laid out to meet the estimated traffic, in the former there is only a short time for preparation. Even as it is, in the former case the capacity of double-line railway is so great that it would be easy to work into a place like Southampton Docks more traffic than the sidings could possibly provide for, and that undesirable condition of congestion could be reached before the conclusion of the first day. Again, it can be seen how the Germans interpret these conditions into numbers. In spite of special preparations, preparations which involve the provision of accommodation far in excess of commercial requirements, they count 60 military trains in 20 hours the maximum number for any double line, and the trains allotted to the frontier double lines vary from 40 to 50.

Over many double lines in peace time a far larger number of trains is run. But no comparison can be made between the ordinary trains which drop part of their load here, and part of their load elsewhere, or between the conditions which permit of a complete separation between freight and passenger traffic, and military trains in war time. Guns must accompany artillery; horses must go with cavalry; road vehicles must travel on the same trains as the men of the Army Service Corps. In this way freight and passenger

traffic are combined, and the individual train requires a time at the terminal stations which is comparable to the freight train rather than the passenger train.

In ordinary peace-time working a double-line railway should be capable of dealing with four or five times the number of trains that a single-line railway can take; but when it comes to military traffic under war conditions, the double-line number drops to two or three times the single-line number. This ignores the capacity of the trains. How taking into account of train capacity alters the position may be illustrated by a comparison between the Southern Pacific Railroad of U.S.A. and our heaviest railways here. A few years ago, when the former was wholly single line, it was handling a freight traffic greater in density than the freight traffic of any of the lines here—all our main line is double track and much of it four-track road. The secret lay in the Southern Pacific's train load being at least five times the train load in this country. The difference in loading gauge and method of working were just balancing the difference between single line and double line.

Turning to other considerations, a few points of special interest only can be noted. First, I will pick out a couple of points in connection with locomotive working—the supply of fuel and water. For one large railway in this country, the freight engines burn on the average 85 lbs. of coal per train mile; so each ton carries a train only 26½ miles. When these engines are being worked with two shifts of men, they commonly burn about 6 tons in the two shifts. A hundred such engines are burning a train load, consisting of 60 wagons, each wagon carrying 10 tons. If a considerable length of line is being dealt with, and as many trains as possible are being worked, several train loads of coal for locomotive use may have to be worked daily. In this country it is not a very important matter because there are coalfields all up and down the country, and where there are not coalfields there are ports near to which coal can be brought for shipment. But in a country like South Africa, coal is found in Rhodesia and in Natal, and the Cape Colony ports, Cape Town and Port Elizabeth, are more than 1,000 miles away. Thus leads of 500 miles and upwards for locomotive fuel are quite usual. The locomotives required for the trains necessary for this work could ill be spared in war time. The occupation of the lines would mean an interference with military traffic, which would be undesirable. Every additional train which has to carry the fuel may mean one less military train. It is necessary to treat locomotive fuel as rather precious, and not to be lightly tampered with.

If fuel is of moment, water is of even greater importance. An engine commonly consumes an amount of water seven or eight times the weight of the coal burnt. If it burns 6 tons of coal, it will require 40 to 50 tons of water. So the carriage of water is a much more

serious matter than the carriage of coal. On most railways it will be found that the supply of water for locomotives varies enormously. At some places it is superabundant, and under no conceivable circumstances is it likely to run short. At others the supply will be just sufficient for ordinary uses, and usually no more. Any draft on the latter places means a shortage which will bring engines to a standstill unless water is hauled. The shortage may be the more serious because all water is not suitable for locomotive purposes. For instance waters which produce a hard scale in the boiler are bad, and not only cause trouble on the road but increase the time engines must be laid off for cleaning and repairs. Then the military traffic may cause a big increase of traffic just where the margin of water is least, and, as the Russian railways found in the Russo-Turkish War of 1877–78, a shortage of water may actually limit the number of trains which can be worked. It is never safe to reckon on the trains which a line can carry until it has been ascertained that there will be a sufficient supply of water for the locomotives to run those trains.

Then earlier a reference was made to the likelihood of rolling stock running short and becoming the controlling factor. Even if it does not run short for military purposes it may make such trouble for the civilian population as to become a serious factor. In the Russo-Japanese War the amount of rolling stock drawn from European-Russia was responsible for famine, and at the same time grain lay rotting at other stations for lack of rolling stock to carry it. Organized control of the movement and use of the rolling stock is most important, and that control should concern itself with the empty vehicles as much as with the loaded. It is one thing to have plenty of empty wagons on a railway, and quite another to have those same wagons where they are wanted at the time they are wanted. It is important to realize to what a large extent wagons must be moved about empty to reach places where there are loads for them. On very well-regulated railways, with a well-distributed traffic, some 30 miles have to be worked empty out of every 100 miles worked loaded and empty when general merchandise is the traffic. When the traffic consists of minerals the proportion is 47 or 48 empty out of every 100 miles worked. Now what applies to mineral traffic in this country applies generally to traffic worked in large quantities over long distances. In war time military traffic flows almost wholly in one direction. If then empty wagons are not returned promptly a shortage is most likely to occur.

But organized control is necessary from every point of view. A very old practice was to paint a permanent instruction on the sides of many vehicles "When empty return to Station A." In the absence of adequate organized control this was very necessary, but it was very wasteful. A wagon would be 10 miles from a station

needing one of the kind, but being marked for a station 100 miles away it would duly go away empty, whilst the station in need waited for the return of another wagon from an equally long distance. Waste of time to the traffic, waste of wagon time, waste haulage. In France to this day many wagons are still marked in this way, and in the case of a mobilization loss of valuable time might ensue in carrying out the work of getting the labelled wagons to their home stations. An organized system of control, under which a few district controllers, under a head controller, have daily full particulars of the positions of all wagons available for loading, does away with this waste, and experience has proved such control may result in 10 per cent. more use being got out of a given stock of wagons.

A few only of the many considerations which have to be taken into account have been noticed. Others fall into various groups. There are engineering matters, like the strength of the permanent way: there are matters of organization, like the prompt loading and unloading of wagons. These and many similar matters have a great influence on the rapidity with which a mobilization or concentration of forces can be carried out. It is only after each and all have received their due share of attention that the capacity of a railway for military traffic in war time can be gauged.

A NEW METHOD OF MEASURING IMPACT.

By MAJOR D. BRADY, R.E.

A PAPER of great interest by Major B. Hopkinson, Cambridge University O.T.C., R.E. (T.), better known as Professor Hopkinson, F.R.S., on "A Method of Measuring the Pressure produced in the Detonation of High Explosives or by the Impact of Bullets," is published in the *Transactions of the Royal Society*. Its reference number is A. 506, 31st January, 1914.

The author explains how a blow on one end of a bar is transmitted to the other end as a ripple of pressure, and returns as a ripple of tension. The whole momentum due to the blow lies in the part of the bar under the ripple. The length of the ripple is a measure of the duration of the blow, and its shape—supposing it is plotted—indicates the character of the blow.

Suppose the ripple is 10 in. long—which in steel represents a duration of about $\frac{1}{20000}$ second—and suppose there is a butt joint unable to resist tension not more than 5 in. from the end of the bar. While the ripple is being reflected, all the pressures pass forward through the joint, and all the tensions pass back through it. There must come an instant when some tension going back through the joint just equals some pressure going forward. The piece then flies off carrying with it whatever momentum is included in the central part of the ripple between equal ordinates of stress. If the piece is, say, 4 in. long, the equal ordinates are 8 in. apart; if the piece is 5 in. long it carries off the whole momentum due to the blow.

By repeating the experiment with different lengths in front of the joint, the momentum of each corresponding length of the ripple is found, and a great deal about the ripple, and therefore about the blow, is disclosed. The only thing not disclosed is whether the ripple leans forward like a wave about to break, or leans back, or leans neither way. If that information is worth getting, it might be possible to get it by repeating the experiments after arranging that the joint shall break at a definite tension, instead of being unable to resist any tension.* The parts of the ripple measured would then lie between ordinates having a definite difference, and a comparison of the two sets of experiments would give the missing information.

*[The author makes no mention of this, and it would probably be very difficult to do.—D.B.].

The author's apparatus is very simple. A steel bar about 4 ft. long is slung horizontally. Different thicknesses were used, but most of the rifle shots were fired at a bar 1 in. in diameter. One end of the bar receives the blow, at the other end, against a carefully scraped surface, pieces of different lengths can be fitted. As the pieces are shot off they are received by a ballistic pendulum. The bar acts as its own pendulum to register the momentum left behind by the detached piece. To hold the pieces in close contact with no unnecessary force a solenoid was used to magnetize the bar and piece.

Professor Hopkinson made a great number of experiments with the old ·303 Service bullet, and made some experiments with a 1-oz. primer of gun-cotton. He was compelled to keep the gun-cotton $\frac{3}{4}$ in. clear of the bar, as the steel would not stand a closer blow. The Service bullet gave a pressure of about 19 tons as a maximum, and the whole impact lasted about $\frac{1}{17000}$ second. This duration is, as it should be, approximately equal to the time taken by the bullet to travel its own length at 2,000 ft. a second. The pressure $\frac{3}{4}$ in. away from a 1-oz. gun-cotton primer averaged about 30 tons a square inch for $\frac{1}{100000}$ second, and probably reached a maximum of about 40 tons. Within about $\frac{1}{50000}$ second the pressure falls to less than one-fifth to that. The way gun-cotton breaks steel before there can be much deformation is clearly shown by some examples, one of which shows quite a lot of deformation that must have happened *after* the break.

The discussion of the method and its possible errors is of great interest.

BAIRD SMITH PAPERS DURING THE INDIAN MUTINY.

AMONG the many interesting Corps documents which have found their way into the R.E. Museum during the last two years, there are few of greater historical interest than those of the late Colonel Baird Smith which have recently been presented to the Corps by his two daughters. These include not only several personal diaries, reports, etc., but also the original Engineer diary of the Siege of Delhi, a rough tracing of the City that was issued to Brig.-General John Nicholson on the eve of the assault and which shows the routes to be taken by the assaulting columns; the letters and memos sent by Major-General Archdale Wilson to Colonel Baird Smith during the siege, and the final despatch submitted by the C.E. to the General after the capture of the City.

In the present *Journal* it is proposed to print a most interesting letter written by Colonel Baird Smith to Mr. C. E. Norton, giving an account of the mutiny of the Sappers at Roorkee: also Colonel Baird Smith's official account of the steps taken at Roorkee for the protection of the European community there.

From the letter it will be seen that the original mutiny of the Sappers at Meerut was apparently due to a misunderstanding, and that although their action led to the mutiny of the remaining companies at Roorkee, the latter was attended with no violence, and the officers and other Europeans were treated with courtesy and consideration by the men of the Corps.

(1).

Letter from Colonel Baird Smith to C. E. Norton, Esq., of Cambridge, Massachusetts, U.S.A.

ROORKEE, *30th May*, 1857.

MY DEAR CHARLES,

I write to you in the midst of all the turmoil of a state of war at our own doors and it is among the possibilities, tho' please God not among the probabilities of the future, that I may never write to you again. A fortnight ago no community in the world could have been living in greater security of life and property. Clouds there were that indicated to the thoughtful minds a coming storm and that, in the most dangerous quarter, but the actual outbreak was the matter of an hour, and has fallen upon us like a judgment from Heaven, sudden, irresistible as yet, terrible in its effects, and still spreading from place to place. I daresay you may have observed among the Indian news of late months that here and there throughout the country mutinies of Native Regiments have been taking place.

They had, however, been isolated cases and the Government thought it did enough to check the spirit of disaffection by disbanding the Corps involved. The failure of the remedy was, however, complete, and instead of having to deal now with mutinies of separate Regiments we stand face to face with a general mutiny of the Sepoy Army of Bengal, and to those who have thought most deeply of the perils of the English Empire in India this has always seemed the monster one. It was thought to have been guarded against by the strong ties of mercenary interest that bound the Army to the State and there was probably but one class of feelings that would have led to these being too weak to have this effect—the feelings of religious sympathies or prejudices. The overt ground of the general mutiny is offence to caste feelings shown by the introduction into the Army of certain cartridges said to have been prepared with hog's lard or cow's fat. The men must bite off the ends of the cartridges so the Mohammedans are defiled by the unclean animal and the Hindoos by the contact with the dead cow. Of course the cartridges are *not* prepared as stated and they form the mere handle for designing men to work with. They are I believe equally innocent of lard and fat, but that a great deal of dread of being Christianized has by some means or other been created is without doubt, tho' there is still much which is mysterious in the process by which it has been instilled into the Sepoy mind and I need not trouble you with mere rumours of explanations as I question if the Governor has any accurate information on the subject.

It was on the 10th of the present month that the outbreak of the mutinous spirit took place in our neighbourhood. The locality was Meerut. The immediate cause the punishment of 85 troopers of the 3rd Light Cavalry who had refused to use the noxious cartridges and had been sentenced by a Native Court-Martial to 10 years' imprisonment. On Saturday the 9th the men were put in irons in the presence of their comrades and marched off to jail. On Sunday the 10th, just at the time of Evening Service, the mutiny broke out. Three Regiments left their lines, fell upon every European, man, woman or child, they met or could find, murdered them all, burnt half the houses in the station, and after working such a night of mischief and horror as devils might have delighted in, marched off to Delhi *en masse* where three other Regiments ripe for mutiny were stationed, and on the junction of the two Brigades, the horrors of Meerut were repeated in the Imperial City and every European who could be found was murdered with revolting barbarity. In fact the spirit was that of a servile war. Annihilation of the ruling race was felt to be the only chance of success and impunity, so no one of the race was spared. Many however effected their escape and after all sorts of perils and sufferings succeeded in reaching military stations having European troops. Many of my own officers I am thankful to say

were of this number. Young Thomason, a son of the late Lieut.-Governor and in this department, got safely to Kurnaul after a week's wanderings on foot—he was engaged to be married to a Miss Jennings, the daughter of the Chaplain of Delhi. Father and daughter are among the murdered and Thomason's dream of life has a heavy darkness over it. Stewart Rigby (?) Parker, Anderson Marshall, all canal men, had some to flee, some to fight for their lives, and are all safe. The works generally are cruelly damaged, but we shall soon put them to rights.

It was on the 12th at daybreak that I received the first intimation of the Meerut Mutiny and Massacre. When I went to the porch of my house to mount my horse for my morning ride I found Medlicott, our geological professor, sitting there looking oppressed with some painful intelligence, and on my asking what the matter was he then told me that about an hour before Fraser, the Commandant of the Sappers and Miners, had received an express from the General at Meerut ordering him to proceed with the Regiment by forced marches to that place, as the Native Regiments were in open revolt, and had left Cantonments with their arms. Not a word was told but even the bald statement was alarming enough. I immediately suggested the Ganges Canal route instead of forced marches, which would have fatigued the men much and made them unfit for service, and as Fraser at once agreed I had boats equal to the transport of 1,000 men ready within 6 hours and the Corps 713 strong, started the same afternoon and got to Meerut 60 miles off in about 24 hours. Just as they were starting another express came to say that two companies were to be left for the protection of Roorkee, so that finally about 500 men moved. I sent off the same morning an express to the Commandant of the little Ghoorkas at Deyrah to tell him I thought his Corps would be ordered down too, and begging him to march on Roorkee where I would have another fleet ready for him in a day or two. He came with his almond-eyed Tartars in due course, and off they went too. Then came the news of the Delhi massacre, and it became necessary for me to provide for the security of our little community here. I had indeed begun to do so from the day the Sappers left, and had determined that the Workshops were to be our Citadel. Here I had got the Superintendent quietly to begin equipping 3 cannons, and had planned the defensive works that would have to be executed. I had also organized an Intelligence and Commissariat Department, so that when the time came to occupy the place all preliminary arrangements had been made. This we did on the 16th when the women and children, then exceeding 100 in number, were moved into the workshop rooms and all decently accommodated there. The males were about the same number but chiefly clerks and the like, so unaccustomed to arms. We had however about 30 trained soldiers and 8 or 10 good

officers, and on them my main reliance was. However such as the force was, it was organized into guards, placed under Commandants and formed into a manageable body. Our two companies of Sappers proved an embarrassment rather than a source of strength. They were all Natives and we had reason to know that the prevailing spirit of disaffection had in some measure tainted them, and although I personally believed that the main body was entirely worthy of trust, still there was much uneasiness about them. I put them however under the command of two officers well known to them, spoke to the best men among them myself, gave over to their charge all the College Buildings and could do no more. Thus matters continued until the 18th on the afternoon of which day it was reported to me that extreme excitement prevailed among the men of the Sappers and that some Sepoys of the Corps had come in from Meerut and reported that the Regiment had mutinied there, killed poor Fraser and been immediately attacked by the Europeans and destroyed by grape from the guns. One company had marched the night before with the Engineer Park to join the Commander-in-Chief and the detachment with us was reduced to about 190 to 200 men. I believed the report to be a device of the enemy having had letters from Meerut on the 16th (the day of the reported catastrophe); these I sent to the Cantonments and begged the officers to explain them to the men and to keep them quiet. The day however was one of intense anxiety as a struggle between 20 or 40, and even 200 trained and educated soldiers like the Sappers was rather a serious contingency to anticipate. All sorts of wild rumours were flying about . . . In the evening it was reported to me that the company which had marched the previous day had been overtaken by the men from Meerut, had mutinied on the spot, refused to move forward and insisted on returning to Roorkee to rejoin their comrades. The report added of course that they were resolved to attack us, burn Roorkee and kill every European in it. Of this however I had comforting doubts when I learnt that the men were accompanied by their European officers, not one of whom had been injured or insulted. I sent out a party to observe the movements of the Company, and I had settled in my own mind that if it meant mischief, it would march on to Roorkee Bazaar, if not, by a road that leads to their own lines, and you can scarcely fancy the relief it was to me to hear from my scouts that the Column was moving by the latter. It was a small straw that gave me some light as to how the wind blew, and for the moment I felt certain no collision with us was in contemplation. I was of course on foot the whole night, the garrison was kept to its arms, guns loaded with grape and everything ready for a stiff struggle, if struggle there was to be. At midnight the officers of the Roorkee Sapper Detachment came in to tell us that their men refused to obey them any longer, but had

sent them away not only with courtesy and kindly personal feelings, escorting them out of Cantonments and protecting them against the few bad characters who were disposed to injure them. About 1 a.m. the officers of the returned company also reported themselves to me, and it then became evident that our Mutiny was to be distinguished honorably from those which had preceded it by the absence of all atrocity towards Europeans, as the whole body consisting of 6 officers, 6 sergeants, 6 women and 5 children were now safe within the Workshop walls. Then came the question—What next? I had all along felt satisfied that the main body of the men were mutinous from fright and distrust, not from disaffection to the State, and I was not unprepared to hear as I did about 3 a.m. that they were in mortal terror of my attacking them at daybreak with the guns and were running away in confusion as fast as they could. The moment the light did break I sent a strong body of Europeans under Maclagan to clear the lines, and when they reached them they found them tenanted by about 40 Sepoys only out of 300, and these declared that they had no other wish than to serve the Government faithfully. The rest were clean gone, some across the Ganges, others to Delhi, but near us they have come no more. And so this, the darkest cloud we had over us, burst and passed away without one flash of forked lightning. My heart never beat more lightly than when a report came back from the Cantonment that the Mutineers were then 10 *miles off*. In the course of the 19th authentic intelligence was received of the dispersion of the Corps at Meerut, of poor Fraser's death, and of the safety of the other officers of the Corps. So far as I can offer an opinion want of judgment on Fraser's part brought on the catastrophe. He had promised the men that they should keep their own magazine, and meant of course that they should do so, but he wanted for better security to put it in a bombproof building and ordered its removal without having the object fully explained to the men. They suspected treachery and stopped the carts—he abused the men who did so—an Afghan sentry then shot him in the back—another shot the Native N.C.O. with him, some others fired at Maunsell, the Adjutant, but missed him. Then the guns opened on the Corps and scattered it, and the Carabineers charged the fugitives and killed about 50 or 60 of them and the Corps of Sappers and Miners ceased to exist.

From this crisis our local anxieties have lessened. But the country around is in utter confusion—bands of robbers are murdering and plundering defenceless people—Civil Government has practically ceased from the land. I have not heard *one word* from the Lieut.-Governor since this disastrous time began. A full month will elapse before the Mutineers are checked by any organized resistance. A force is or is supposed to be marching on Delhi but the outbreak occurred on the 10th of May and this day is the 1st of June and

Delhi has seen no British Colors and heard no British guns as yet. I am sick to death of a military system so feeble as ours and against it at any rate am mutinous to the core. As to the Empire it will be all the stronger after this storm, and I have never had a moment's fear for it. It is not 5,000 or 6,000 mercenaries or ten times that number that will change the destiny of England in India, and tho' we small fragments of the great machine may fall at our posts, there is that vitality in the English people will rebound from misfortunes and build up the damaged fabric anew.

At this place we are all in high spirits. We are respected and somewhat feared. Plunderers avoid us because they know they will be attacked. We have confidence growing round us daily and our Bazaar is full and the people contented.

Yours, etc.,
R.B.S.

To C. E. NORTON, ESQRE.,
Cambridge, Massachusetts, U.S.A.

(2).

Report of Proceedings at Roorkee during the Disturbances of 1857 *and* 1858.

By LIEUT.-COLONEL R. BAIRD SMITH, C B.

THE following Narrative is prepared in conformity with the orders of the Right Hon'ble the Governor-General as given in Circular No. 212, dated 30th April, 1858.

The state of feeling in the Native Army out of which the mutinies grew was first brought directly under my personal notice at the instance of certain enterprising merchants of Meerut and Delhi who, availing themselves of the facilities for transit supplied by the Ganges Canal, had entered into large speculations in grain for the supply of the Military Bazaars at Futtygurh, Cawnpore, Mynpoorce, etc. The grain was ground into flour at the Canal Mills and transported in boats to the points nearest to the stations mentioned. Under date the 24th April, 1857, the Native Agent of the Navigation Department at Cawnpore forwarded to Mr. James Finn, the Superintendent, a report stating that provision had been made for the transport of 1,000 maunds of flour to Cawnpore, of which 200 maunds had arrived and been offered for sale, that evil-disposed people had however spread a report among the Sepoys that in grinding the grain at the Canal Mills the bone dust of cows and swine had been mixed with the flour by order of Government, and with the object of defiling Hindoo and Mahomedan alike, that much excitement had been created and none of the flour sold, he therefore requested instructions how he was to act. He was informed in reply, that the Canal Officers had no concern either with the mills or the grain

ground in them, that they were entirely in the hands of native contractors with whom the proprietors of the grain made their own arrangements, and that the report of any interference of Government with the purity of the flour was false, that he might give this assurance to all requiring information, but no further steps need be taken in the matter.

On the same date that the above circumstances were reported to me, I sent details of them to the late Mr. Colvin, who concurred with me in thinking that any further official interference would not be expedient. I certainly did not attach much significance to the occurrence at the moment, and as it was known to me that the merchants had themselves superintended the grinding of the corn, I considered them to be the best agents to trust to for the removal of the prejudice against it. It was all disposed of ultimately, but not to the Sepoys.

As the merchants engaged in these transactions had meant to carry grain to all the important cantonments in the Dooab, and had actually made considerable purchases for the purpose, I think it is a fair inference that they were entirely ignorant of any organized or extensive conspiracy against the Government. Considering the ordinary caution of native traders, it seems incredible that they would have staked eight or ten thousand rupees in speculations of which the failure was inevitable in the event of such a conspiracy breaking out. Although therefore these men may have been conscious of the general feeling of distrust and alienation between the Government and the European Community on the one hand, and the Native Army on the other, yet it has always been my impression that the actual outburst of the Mutiny took them and their class almost as much by surprise as it did ourselves.

In relation to the same point, I may mention here that almost up to the date of the outbreak, village communities along the line of the Ganges Canal were spontaneously entering into contracts for water to extend over three years and taking upon themselves considerable pecuniary obligations connected therewith. After much enquiry among Native Officials whose subsequent conduct has placed their fidelity to Government beyond all question, I have been wholly unable to discover any satisfactory proof that the agricultural class with which this Department is so intimately connected had any knowledge that so terrible a convulsion as the Mutiny was impending.

So far therefore as the conduct of the Commercial or Agricultural classes came under my own observation, or was open to my enquiries, it has led me to believe that as great classes they had no share in the machinations out of which the outbreak arose but to the day of its occurrence were occupied with their own interests and work.

It was before daybreak of the 12th of May, 1857, that the first

intelligence of the Mutiny of the 10th at Meerut, and its disastrous results reached this station. It came in the form of an express message from Major Waterfield, Assistant Adjutant-General, to Captain E. Fraser, Commandant, Sappers and Miners, directing the latter officer to proceed with his regiment by forced marches to Meerut as the whole of the native troops were in open mutiny and were then supposed to have marched to Delhi with their arms. The message was communicated to me at day break, and I then suggested to Captain Fraser that instead of proceeding to Meerut by forced marches and thus arriving with officers and men fatigued, it would be both quicker and better to drop down the Ganges Canal. This being agreed to, measures were at once concerted with Mr. James Finn, the Superintendent of Navigation for collecting the boats required, and by this officer's indefatigable exertions the whole number necessary for the regiment was equipped by noon.

Meanwhile, a second message had arrived from Major Waterfield conveying Major-General Hewitt's orders for two Companies to be left in the cantonments at Roorkee, which was accordingly done, and at 2 p.m. of the 12th, the Head-Quarters, and six Companies embarked with all their baggage and reached their destination in due course.

After seeing the preparations for the Sappers fairly in progress, I wrote to Major Charles Reid commanding at Deyrah to give him the intelligence of the mutiny and to say that as I thought it probable his corps would also be ordered into Meerut, I would have boats, sufficient for the transport of 1,000 men with their baggage ready within 48 hours, and begged him if so directed to march on Roorkee and proceed from thence by water carriage to Meerut. This letter, sent express, gave the first intelligence of the mutiny at Deyrah, and Major Reid at once agreed to the arrangements proposed should the Sirmoor Battalion receive orders to march.

Having thus disposed of matters connected with the movement of the only two regiments in this neighbourhood, it was necessary next to consider the position of the European community at Roorkee and the best means of providing for its security. Though far from anticipating at that moment the universality of the revolt, it was impossible to consider the successful mutiny of three Regiments, the march of the mutineers upon Delhi with its probable results, and the events of the preceding three months at almost every large military station in this part of the Country, without feeling the gravest apprehension for the issues that might follow. It seemed to me therefore prudent and right that the worst should be anticipated and provided for though possibly enough it might never happen.

The condition of the community here at the time of the Mutiny was certainly as defenceless as it well could have been ;—numbering in all about 200 souls, of whom about 90 were males fit to bear arms, and the remainder females and children, it did not include more

than about 30 trained soldiers of whom not one-fifth had ever seen any service. The rest of the men were assistants and clerks in the Civil offices at the Station or connected with the Thomason College; all lived in houses scattered over a large area forming the Military Cantonment and Civil Station, and the only arms and ammunition available at the moment were 30 stand with 30 rounds for each which had been supplied to Captain Maclagan by Captain Fraser for the use of the soldier students of the Thomason College on the departure of the Sappers and Miners for Meerut.

Considering the circumstances above described it seemed that the safety of the community would be best secured by providing a defensible post sufficiently large to contain the whole; by arming and strengthening the same, in such ways as were possible; by supplying it with provisions; by organizing a good system of intelligence, and having the different roads of approach to the station watched; and by obtaining a reserve supply of arms and ammunition sufficient for the whole of the male inhabitants at the place.

In the workshops at Roorkee we possessed a place with considerable capability for defence against Infantry, or against any *Coup de Main*. They were quite untenable against Artillery, as the enclosing walls were too weak and thin to stand the fire of even the lightest Field Guns, but it was hoped that Artillery would not be brought against them, and on the whole they formed a far better post than any other large building at our disposal. I determined therefore at once to prepare them for the reception of the community.

* * * * *

From a desire to avoid any unnecessary or premature alarm, I gave my instructions confidentially to Lieutenant Baillie, Superintendent of the Workshops, and Mr. James Finn, Superintendent of Materials, to whom the charge of the Commissariat and Intelligence Departments was entrusted; and most admirably were they carried out by both these gentlemen.

Among the materials for the use of the foundry in the shops were some old Sikh guns, the spoils of the Punjab Campaign, much the worse for wear but still not unserviceable. Three of these were selected and Lieutenant Baillie proceeded at once to construct carriages for them. They were of old French pattern and just too small for six-pounder balls, but this difficulty was got over in the first instance by preparing only grape and canister, and afterwards by casting balls specially for them.

By night fall of the 12th all needful arrangements had been decided on, and a beginning made in carrying them into effect. The 13th passed quietly over without our receiving any further intelligence from any quarter of the progress of the Mutiny, and with no signs of disturbance or bad feeling among the sepoys in cantonments.

But about 1 A.M. on the 14th I was roused from my bed to receive a report that one of the barracks for the soldier-students of the College was on fire, and I proceeded at once to the spot. By the time I arrived the roof was burning fiercely. Happily there was little or no wind and the light gusts that occasionally rose came from the East and carried the flames and sparks away from the mass of buildings, all thatched, forming the barrack-square. It was doubtless to this circumstance that the escape of the other buildings was due. The fire engines were in full work when I arrived, the Sappers had been brought down from their lines and were working the engines apparently with good will and zeal. All efforts to extinguish the fire were however useless and the main object was to prevent its spreading. This was effected and the damage done was limited to one barrack.

On considering the circumstances connected with this fire so far as they could be ascertained, it was quite clear to me that it was not accidental, and the painful conviction was felt that we had among us the same destructive and mutinous spirit that had shown itself in like forms at other stations. All sense of security for property was at an end, and it only remained for us to take instantly such precautionary measures as were in our power. In the course of the 14th, therefore, the soldier-students of the College were armed and formed into a guard having its head quarters at the Model Room in the Workshops. A party of officers undertook mounted patrol duties, and from that time forward the Station was traversed at uncertain hours of the night by guards of horse or foot. No further attempts at arson were ever made, and the single barrack destroyed represents the whole loss to Government from the mutiny at this Station.

On the 15th I received orders from the Commander-in-Chief to assume Military Command of the place and to detach at once to join his camp one of the two Companies of Sappers left here, forwarding with them a considerable convoy of Engineer Stores. Measures were at once taken to give effect to these orders.

It had now become necessary to obtain, by some means or other, arms and ammunition for the main body of the community who were found to be almost entirely destitute of them. If our guns were to be of any use to us, powder for them, of which we had not a grain, must also be obtained. In the magazine of the Sappers about 200 stand of spare arms, considerable quantities of spare musket ammunition, and about 211 barrels of Ordnance powder used for mining practice were stored, and of these I determined to take possession. But before doing so, and with reference to the conviction which the recent case of arson had created regarding the state of feeling among the men, it seemed to me expedient first to attach some officers to the detachments, on whose firmness, dis-

cretion, and personal influence I could rely. With this view I appointed Captain Drummond, Superintendent, Northern Division Ganges Canal, who formerly had charge of one of the companies and knew all the older soldiers in it, to command the detachment, and Lieutenant Bingham, Head Master of the Thomason College, who had been for 20 years in the corps and was universally respected by the native officers and soldiers, to act as Adjutant. Both officers moved into the Lines and resided there permanently.

Orders were then sent to Mr. Conductor Smith in charge of the Magazine to send down the arms, ammunition and ordnance powder to the workshops, and Lieutenant Baillie was instructed to despatch carriage at once for them. The first set of carts were loaded and despatched without the slightest difficulty. The men seemed at first to consider the matter as one with which they had no concern, and a fair supply for the Garrison was securely lodged in a temporary Magazine that had been prepared in the shops.

On the second set of carts being loaded however a change had come over the feelings of the men. They turned out tumultuously, and refused to allow any more arms or ammunition to leave their magazine. As night had fallen I directed the carts to be left at the quarter guard, and next morning I rode up to the lines unarmed and accompanied only by Captain Drummond, and sending for the Native officer who came, and accompanied by a considerable body of Sepoys, we sat down in the quarter guard and explained the objects for which I wanted the arms and powder. By this time rumors of large gatherings of Goojurs and other marauding tribes of which this neighborhood is a principal seat, had become very rife and I placed my desire to have arms for the Europeans chiefly on the ground of necessity for being prepared against such attacks. The men were all perfectly civil and respectful and the conversation ended in their withdrawing all opposition to the removal of the carts, which accordingly reached the workshops in the course of the morning, and all anxiety regarding a sufficient provision of arms and ammunition was at an end.

Satisfactory progress had by this date been made in preparing the workshops for occupation, arrangements for supplies of provisions had been completed, and every road leading to the station was well watched.

On the 16th the intelligence of the occupation of Delhi by the Meerut mutineers and its terrible consequences was received here, and it seemed quite clear that the proper time had arrived for taking the only step that remained for us by moving the whole community into the workshops.

In considering the details of this move it was suggested to me by Captain Maclagan that it would be a good plan to place the whole of the College Buildings under charge of the sepoys on the withdrawal

of the Europeans from them, and as this seemed to me an excellent idea, orders were at once issued for giving effect to it. The Sepoys were informed that it had now become necessary to arrange for the defence of the station, and that relying on their conduct and loyalty I placed the cantonments and college under their charge and directed them to protect the same from all injury. Circular instructions were at the same time sent to all the inhabitants of the station directing them to move into the workshops in the course of the day taking with them such articles only as were indispensably necessary for them and their families.

Much excitement and alarm naturally prevailed but the movement into the shops was effected with wonderfully little confusion and by about 8 p.m. the whole European Community, with the exception of the officers attached to the Sappers who remained with their men, had been collected within the walls, and quarters moderately comfortable and perfectly safe were occupied by the women and children.

A strong sepoy guard under Lieutenant Fulford of the Engineers occupied the hall of the Thomason College. The men were obedient but their excitability was shown on the first rounds of the European night patrol, on hearing which approaching they suddenly flew to their arms, began loading, and seemed to think they were about to be attacked. Finding however that the patrol was friendly the excitement soon subsided and was not again shown.

The collection of stores to accompany the detachment under orders to join the Commander-in-Chief's camp having been completed, the company marched on the morning of the 18th to Secunderpore, it being intended that it should proceed *viâ* Saharunpore and Juggadrie. There were no difficulties made by the men about marching and they seemed all quite content to proceed to Delhi. The day passed quickly over, and the garrison of the workshops was organized and distributed at its different posts. Entrenchments in front of the gate-way were completed and a gun was mounted on the roof of the sheds near the gate, whereby the main street of the Native Town of Roorkee was completely commanded and could if necessary be swept with grape. The bridge also was secured by the same means. The carriages for the two other guns were completed so that by the 18th our force consisted of about 90 Europeans armed with carbines, and three guns. The men were of course wholly undisciplined but they were all in excellent heart and quite prepared, if need were, to defend themselves and their families as vigorously as Englishmen usually do.

The 18th was a day of intense anxiety and great risk. About noon a messenger arrived from Meerut in the Lines, and his arrival was followed by an outburst of weeping and wailing among the women of the regiment, and of excitement and agitation among

the men, the effects of which were soon perceived by the European officers. About 3 p.m. Captain Drummond and Lieutenant Bingham reported to me that a rumour was current in the Lines of the whole corps at Meerut having been destroyed by grape, and that so great was the excitement in consequence that they conceived an outbreak possible at any moment. I stated that rumours of this kind were among the most likely means of agitation to be used by ill-disposed men among them, that I had myself a letter of the 16th from the Adjutant in which no allusion whatever was made to any catastrophe on that date, the letter was given to Captain Drummond and he carried it to the Lines with him and explained its contents to the men. His personal influence and that of Lieutenant Bingham were sufficient to prevent any disturbance at the moment but matters were so evidently near a crisis that I quietly warned the officers of the Garrison, and had all needful arrangements made to meet any sudden attack.

All was still however till about 10 p.m. when a sowar arrived from Secunderpore, and reported to me that the detachment there was in open mutiny, had insisted on returning to Roorkee to rejoin their comrades there. They were now about four or five miles distant. With this detachment there were two officers, Lieutenants Pemberton and Jeffreys of Engineers, one warrant officer and two European non-commissioned officers. The sowar informed me that he had seen the whole of the Europeans marching back with the men. The town of Roorkee was greatly agitated, many of the inhabitants were flying, and general alarm prevailed among the natives. I immediately sent men out on the road by which the detachment was approaching to watch its movements. About half a mile from Roorkee a side road diverges from the main line and, leading to the Guneshpore Bridge across the Ganges Canal, gives a direct communication with the cantonment without passing through the town of Roorkee. That the mutinous detachment should have left all its European officers unharmed and should be returning with them and the whole of the Public Stores under their charge seemed to indicate but little virulence of spirit and I concluded that probably no attempt would be made that night, at any rate, to disturb the peace of the place. It seemed farther probable that if the men were thus disposed they would avoid the workshops and take the direct road to their Lines. The videttes sent out to watch the detachment were instructed to forward instant intelligence of the line the company should take, and meanwhile the garrison was held in readiness for service according to circumstances.

About midnight information was brought to me from the advanced posts that the detachment had turned off from the main road and was marching direct to cantonments so that all immediate risk of a collision was postponed.

On this I returned from the gate guard to the Esplanade of the workshops, and found there Captain Drummond, Lieutenant Bingham, and all the Europeans from cantonments. Shortly afterwards Lieutenant Pemberton with his party reported themselves to me, and somewhat later Lieutenant Jeffreys arrived in garrison. From these gentlemen I received statements of the progress of events outside the garrison during the night of the 18th.

Captain Drummond and Lieutenant Bingham slept in the quarter guard. Before midnight they were visited by the native officers and a party of the men who told them that they were certain of the destruction of the corps at Meerut, and that they were determined generally no longer to serve Government, but that many among them, and the party then present in particular, were anxious to save the European officers from harm, and had come to entreat them to leave the Lines at once, that all remonstrance was a waste of time and added greatly to the risks of mishap, as there were bad men among them who were then doing all in their power to provoke a collision in which the Europeans might be destroyed, but that they were prepared to conduct them in safety to the workshops. After some conversation it became quite evident to Captain Drummond and Lieutenant Bingham that their longer presence was merely provocative of evil, and they accordingly stated their readiness to leave. Collecting from the barracks all the Europeans there, the small party, consisting of 10 or 12 in all, was escorted by the native officers and men, who were observed to form a complete circle round them, beyond the college grounds and there they separated, the Sepoys returning to their Lines. Throughout, the bearing of the men was described as more than respectful, and no doubt was entertained by the officers that if they had been attacked the men with them would have protected them at the risk of their own lives. The party of Europeans as already mentioned reached the workshops in safety about midnight.

From Lieutenant Pemberton I learned the course of events with the detachment that had marched back from Secunderpore. The same messenger that had brought tidings of the collision at Meerut to Roorkee continued his progress to Secunderpore and communicated the intelligence to the detachment there. On receiving it the men seem to have taken their decision at once to return to Roorkee, having probably been requested to do so by their comrades there. The native officers communicated this decision to Lieutenant Pemberton, and, in reply to his remonstrances, only said that the detachment had determined to return and would obey no orders to the contrary. The men immediately commenced to get the store carts ready for the march. They maintained a perfectly inoffensive manner towards the Europeans and between 6 and 7 p.m. commenced their retrograde march. On reaching the lines about midnight the

native officers requested Lieutenant Pemberton and the other Europeans to leave at once, which they accordingly did and joined us in the workshops, beyond the walls of which no European now remained.

I had a watch kept on the movements of the men in the Lines throughout the night, and just before daybreak one of the scouts brought me intelligence that a good deal of firing had been heard, that he thought some disturbance had broken out among the men themselves and that some were running away. I at once took measures for organizing as strong a party as could safely be spared from the Garrison, about 40 men, and attaching one gun to it, placed it under command of Captain Maclagan and sent it at daylight to clear the Lines and drive out any men who might be found there. On reaching the Lines Captain Maclagan found that the main body of the mutineers had fled before daylight towards the Ganges, that about 50, including several native officers, had remained in the Lines, and it was their determination to remain, and the collision this gave rise to, that had caused the confusion reported to me by the scout. The mutineers had seriously maltreated them, had fired into them, slightly wounded the old Subadar whose property to the value of Rs.2,000 they had plundered, tearing his gold necklace from his neck and his many medals from his breast. The other officers had only been less harshly used, the magazine had been broken open, some camp equipage destroyed, but the barracks were untouched. Strange to say the sentry at the quarter guard maintained his post throughout the collision, and was found upon it when the Garrison detachment occupied the Lines. The man was promoted to the rank of Havildar by the order of the Commander-in-Chief on the matter being reported to him.

Thus passed what I have ever considered as the real crisis of the mutiny for the station. Three hundred trained soldiers like the Sappers might have been very dangerous foes to a body of about 90 men hampered by the charge of upwards of a hundred helpless women and children. They would never have taken the workshops, I believe, but so much cover existed outside the walls for them that they would doubtless have caused many deplorable casualties. The station of Roorkee with all its public and private property outside the workshop walls was also temporarily at their mercy. Happily however they were considerably more afraid of us than we of them.

The men who were left informed me that they fully expected us to attack them on the morning of the 19th, and knowing we had three guns with abundance of "grape," their hearts failed them and they fled.

During the progress of the mutiny I had been in frequent communication with the residents of Saharunpore who were watching events here with deep and natural anxiety and was glad to be able

to send intelligence early on the 19th that for the moment at least our position was perfectly secure.

The mutinous sepoys having been traced across the Ganges and found to be making apparently for Oude, there seemed little probability of their giving us any farther trouble, and attention could be given to the condition of the district around us which we had hitherto been compelled to neglect. Almost simultaneously with the arrival here of the news of the mutiny at Meerut, there arrived rumours of risings of the Goojurs and other marauding tribes. Their old instinct of plunder sprung up strong and active the moment it was conceived that our repressive influence had passed away, and several instances of petty attacks on Canal posts had been reported. On the 15th an attempt was made to sack the large town of Munglour, and constant rumours of designs against Roorkee were brought in. The object in all these attacks seemed to be merely plunder; they were in no way specially directed against Europeans or against the Government, but every large town having property or wealth was threatened. It was quite impracticable to take any active measures against the marauders while our small force was paralyzed by the presence of the mutinous Sapper sepoys. So soon however as they were disposed of, means were at once taken to re-establish order in the neighbourhood. The plan adopted, and followed throughout the period of the disturbances, was immediately to follow up any rumour of gatherings of marauders at particular places by a visit of part of the Garrison to such places. Collisions were very rare and, the plunderers having been made to feel the effects of such as took place as severely as possible, it was not long before we enjoyed comparative immunity from even the reports of their rumored descents. The system was commenced on the 19th the same day that relieved us from the presence of the Sappers, and scarcely a day passed during the ensuing month that some part of the district was not visited by our patrols. In some instances the towns-people themselves beat off the marauders, as on the 21st at Kunkull when eleven of the assailants were reported to have been killed, and on the 26th at Jowallapore, both considerable towns near Hurdwar. About the same time a strong body of Dacoits attacked the Ganges Canal Regulators at Myapore, with the evident object of possessing themselves of the wood and iron work to make weapons. They were very gallantly repulsed and a few of them killed by a party of Canal Beldars led by the Head Mistree of the section, Moollah by name, and were effectually prevented from doing any mischief. Had they succeeded in their attempt, we must have lost all command over the floods of the Ganges and it is scarcely possible to exaggerate the disastrous results that would have followed the unrestricted entrance of such vast volumes of water into the canal channel. I have always

considered this feat of Moollah and his party to have been one of the most valuable that could have been performed, as it obviated the risk of the gravest damage being done to works which had cost Government very nearly a million sterling, and of deplorable consequences to life and private property besides.

On the 23rd, communication was opened with Saharunpore by a party from the Garrison riding over to that station. The road, usually covered with travellers of different classes, was found utterly deserted. On the 27th, a party of 8 or 10 officers and volunteers, with some armed Canal Beldars and a few mounted followers, accompanied me on a patrol to the neighborhood of Hurdwar. This was the first visit made by Europeans to those localities since the outbreak of the mutiny, and the reception given to the party by the inhabitants of Jowallapore, Kunkull, and Hurdwar, was to all outward appearance enthusiastic, and their professions of loyalty to the Government were earnest and profuse. I have never seen any reason since to question their perfect sincerity, and to the best of my knowledge and belief they have always behaved well. Our visit had an excellent effect in re-assuring the population, and satisfying them that the machinery of Government was not wholly out of gear among them.

It being considered very desirable to visit the southern portion of the district, and if possible to communicate with the isolated station of Mozuffernugger, where it was known that two or three officers were maintaining a most precarious position, a patrol left Roorkee on the 1st June, and proceeded down the Ganges Canal to Jowlee about 30 miles. For about 6 miles north of this point the villagers had been actively destructive, and had done considerable injury to the Canal works, chiefly however by carrying off all the iron and wood they could, doubtless as in other instances to provide themselves with weapons. Two villages had made themselves conspicuous in this plundering, and various articles of Government property having been found in them both were burned. The immediate effect was to lead to very large quantities of iron, that had been plundered by other villages from a fleet of canal boats, being brought back secretly during the night and deposited close to the Canal station house. The party proceeded from Jowlee to Mozuffernugger, and returned to Roorkee on the 4th, having made a circuit through the Saharunpore and Mozuffernugger Districts of about 70 miles without meeting the slightest obstruction, though being forced to observe that in the latter district the people gave them no welcome but showed so far as they dared that their feelings were hostile and bad.

Some anxiety was felt during the Eed, which was celebrated at this place on the 27th of May. A foolish or malignant report had been circulated in the town that when the Mahomedans had all assembled at prayer it was my intention to open the guns on them and destroy

them. And a counter report was current among the European community that the Mahomedans meant to rise that day. The first report I took means to have summarily contradicted and personally assured some of the most influential Mahomedans in the place that, if they conducted themselves loyally and quietly as they had hitherto done, they need have no fear of any bad treatment from the Garrison; while to satisfy them that we were able to protect ourselves against any rising, advantage was taken of the Queen's Birthday to show them the guns and Garrison in action by firing a royal salute and a *feu de joie*. The Eed passed over with more than usual quietude.

On the 6th of June, intelligence was received here of three Europeans, Mr. Sub-Conductor Stephens, his wife, and Corporal Bruce, attached to the Forest Department, having made their escape from the Patlee Dhoon, and being then in the hands of the Newab of Nujeebabad who was represented as treating them with much kindness and hospitality. As Bijnore was at the time believed to be occupied by the Civil authorities no immediate anxiety regarding the safety of the party was entertained. But on the 11th, the whole of the Europeans from Bijnore having arrived in Roorkee, the position of Mr. Stephens and his companions become very isolated and dangerous, and it was determined to make an effort to relieve them from it. This duty was undertaken by Captain A. C. Robertson, H.M. 8th Regiment, and Mr. H. B. Medlicott, professor of Geology, in the Thomason College. The 13th of June was fixed for their departure, and they were to have been escorted as far as Hurdwar by a party of Rohilkhund horse about 30 strong which had accompanied Messrs. Shakespeare and Palmer, C. S., from Bijnore. On the afternoon of 13th, however, Mr. Palmer reported to me that, on warning the men for the expedition, the native officer in command informed him that they refused to move without an advance of two months' pay! As they had very recently before received pay and were only required to proceed to a place a single march off, Mr. Palmer who intended to accompany them very naturally concluded that an unreasonable demand of this kind indicated the prevalent spirit of mutiny among the men and sought my instructions. A number of ladies occupying my house at the time and the party being at dinner, I did not disturb them, but despatched a note to Lieutenant Baillie in command of the Artillery requesting him to get a gun ready for service, and to warn the Garrison day guard with such other Europeans as might be in the workshops, for duty. Allowing sufficient time for preparation, I then joined the detachment with Messrs. Shakespeare and Palmer, marched into the sowar's camp, disarmed them all and made them prisoners. No disturbance was created and the station generally was not aware of the event till it had passed, so all alarm was avoided. The matter

was subsequently investigated, and some blame was attached by the Court-Martial to Mr. Palmer for prematurely reporting the men in mutiny. I thought however that Mr. Palmer had acted very properly and had quite sufficient grounds for his belief that the men were just trying how far they could go. It was no time to trifle with any symptoms of a mutinous spirit and I thought it right to order the whole of the men out of the station within 24 hours.

The defection of the expected escort was not allowed however to interfere with the expedition of Captain Robertson and Mr. Medlicott, who started the same evening for Hurdwar provided with letters for Mr. Stephens and a vernacular demand from myself addressed to the Nawab requiring him to deliver the Europeans to the officers sent to them.

The party crossed the Ganges on the afternoon of the 14th. Some armed Canal Beldars were posted at the Ghat on the left bank of the river, and a stronger body of the same occupied a point in the forest about 10 or 11 miles in advance where a bivouac was established on the night of the 14th till the moon rose. Then pushing forward with a personal escort of 12 Canal sowars, Captain Robertson and Mr. Medlicott reached the vicinity of Nujeebabad about 8 A.M. I had instructed them to halt about two miles from the town and to send forward a couple of sowars with the letters. This they did and the demand was instantly complied with by the Nawab. At 2 P.M. Mr. Stephens and his companions joined Captain Robertson on an elephant provided by the Nawab, and the whole party retraced their steps towards Roorkee which they safely reached on the 17th. Up to the last the Nawab had behaved with uniform kindness, and on their entire route the party had received all possible help from the villagers and such native officials as they came in contact with.

The whole expedition was admirably conducted by Captain Robertson and Mr. Medlicott. Their movements were so rapid that no time was left to the ill-affected party among the Nawab's advisers to raise any obstacles to the delivery of the prisoners and it was most satisfactory to have had them rescued in this way.

From very nearly the commencement of the disturbances it became necessary to rely on our own exertions for the collection of money from the district for the support of the Garrison and the maintenance of the works. I was very anxious that the latter should not be wholly stopped as bodies of men would then have been thrown loose on the country without any legitimate means of subsistence, and providing them with at least partial employment promised to be the best means of keeping them in order and also of giving to the people generally the impression that the machinery of Government was still maintained among them. This end was attained in all the public establishments at this place, none of which ever wholly suspended work. Captain Maclagan carried on the duties of the

College, Captain Drummond those of the Canal, the workshops under Lieut. Baillie and Mr. J. Watson gave employment to considerable numbers of mechanics; and, though in all the amount of work done was necessarily contracted, it was still found to be sufficient for the object in view. No measures more rigorous than occasional visits to defaulting villages were found necessary for the collection of the Revenue, and the sums so collected with the occasional assistance of remittances from the Collector, Mr. Spankie, sufficed for all our wants.

The defences of the workshops had been steadily extended and increased as time and means permitted. A new entrenchment was made in front of the main Guard, and in it were mounted on Garrison carriages three old 18-pounders and an 8-inch mortar. The defect of flanking fire in the long walls of the shops was supplied by projecting musket-proof platforms. Loopholed walls were built where required, and palisades closed all open points. Shot and shells were cast for the guns and mortars, and for field purposes two brass and two iron mountain train guns with two 12-pounder howitzers were very successfully cast and bored in the workshops. The iron guns were I believe the first of the kind cast in India. A small body of sowars, 40 in number, were raised among the well-disposed villages, and was very useful in escort and patrol duties. The Beldars of the Ganges Canal having shown an excellent spirit throughout, a company 100 strong was formed of selected men from among them, drilled, and armed with carbines. About as many more were armed with spears and formed into cantonment and city guards for ordinary police purposes. The garrison guards were regularly organized and permanent posts allotted to each. Such interior arrangements as the comfort and health of the community required were made and maintained. Finding the most usual and pernicious causes of alarm among the garrison were unfounded reports of attacks from without and groundless apprehensions of treachery within, it appeared to me that if information as accurate as circumstances would permit were circulated to all a sedative effect would be produced. It was at first intended to do this merely in manuscript but as means and labor were both available from the College Press, and at the time unemployed, they were made use of. Out of these circumstances arose the little paper called "The Roorkee Garrison Gazette" designed solely for the limited object above referred to and of which only 60 copies were printed. The general management was placed in Captain Maclagan's hands, but the proofs were invariably read, and the local articles almost as invariably written, by myself so long as I remained at Roorkee. I was made aware of but one indiscretion in the management, the giving of certain information relative to the actual strength of the force before Delhi which should not have appeared, otherwise

I believe the information circulated was not only inoffensive but useful and certainly the local object contemplated was well served by it, as when people knew regularly what was going on about them we were singularly free from every thing like panics or extravagant alarms. I have thought it right to allude briefly to this matter as I had of course no authority for the act of establishing a paper of the kind, and if there was any impropriety in it the responsibility must be exclusively mine.

Between June and October but little occurred to vary the ordinary tenor of garrison life. On the 22nd June a party of about 200 Goojurs gathered at Munglour to plunder that town. Captain Robertson, H.M.'s 8th, and Lieutenant Pemberton of Engineers were sent with a small detachment of Sappers to disperse them. The marauders began to retire the moment they heard of the approach of the detachment, but Captain Robertson and Lieutenant Pemberton pushing on with only four Canal sowars as escort, dashed in among them, slew three, and captured eight. The Goojurs were rudely armed with old matchlocks, spears and the like, but the whole body fled in confusion then as they ever did before even the smallest of our parties. The eight prisoners were tried and hanged. On the 26th I received orders to proceed to Delhi, and left on the 27th with a large convoy of stores for the Engineer park, and 600 Beldars to serve as Pioneers. The command of the Garrison devolved on the next senior Officer, Captain H. E. Read, 50th Native Infantry.

No active movements of any importance were made until the 14th July, when a party of officers and volunteers with a detachment of Sappers, a gun, and some Sikh Horse proceeded under command of Captain Maclagan of Engineers to Futooah, a village in an island between the Bangunga and Ganges, where a large body of marauding Binjarris and others had concentrated, and from whence they issued to plunder the villages of the Ganges, Khadir carrying off cattle and grain, and driving the inhabitants away from their homes. The detachment was entirely successful, dispersed the plunderers, recovering large stores of grain, and about 300 head of cattle, with a number of prisoners, the ringleaders among whom were executed.

The party returned on the 18th, and next day another detachment under Captain Read with two guns proceeded to the relief of the town of Deobund, which had been kept for some time previous in a state of siege by hordes of Goojurs and was in great danger. A detachment of the Nusseeree Battalion from Saharunpore reinforced the Roorkee party and a combined attack ended in the utter dispersion of the plunderers. With this affair terminated the necessity for active operations on the eastern side of the District. The country continued perfectly quiet, revenue was paid in freely and, on my return to Roorkee on the 29th September, I saw no necessity for continuing longer the organization of the Garrison. It was accordingly broken up on the 1st October, its members resumed their

ordinary duties and the station was fully re-occupied. Precautions however were taken to keep all defensive arrangements in efficient order in case of farther disturbances. The Europeans retained their arms. A month's supply of provisions was kept within the workshops and the ordnance was carefully kept in condition for immediate service. It was thus possible at any moment if need should be to resume our defensive position.

The conduct of the whole garrison was throughout self-reliant, cool, resolute, and most exemplary. Officers and men were alike ever ready for active work; and, weak though their numbers were, the maintenance of the peace throughout a large section of this district, the salvation of public property considerably above a Million Sterling in value, of private property of material amount both in the station itself and in the Native towns around it, and the support of the authority of the Government, were among the results of their activity, courage, and devotion.

In compliance with the instructions contained in para. 7 of Circular No. 212, I have the pleasure to submit the names of the following officers for active and meritorious service during the period of disturbances at this place:—

Captain H. E. Read; 50th Native Infantry.
Captain R. Maclagan; Engineers.
Captain H. Drummond; Engineers.
The late Captain F. Spring; H.M.'s 24th Regiment.
*Captain A. C. Robertson; H.M.'s 8th Regiment.
Lieutenant G. Baillie; Artillery.
Lieutenant E. L. Earle; Artillery.
The late Lieutenant T. E. Dickens; Artillery.
Lieutenant R. C. B. Pemberton; Engineers.
Lieutenant H. W. Jeffreys; Engineers.
Lieutenant R. F. Angelo; 41st Native Infantry.
Lieutenant H. Bimgham; Head Master, Thomason College.
Mr. H. B. Medlicott, Professor of Geology, ,,
Mr. H. Martin; Assistant Superintendent-General of Irrigation, N.W.P.
Mr. Conductor J. Finn; Superintendent of Navigation.
Mr. James Watson; Practical Engineer, Roorkee Workshop.

I may also be allowed to express here in a few words my grateful sense of the constant, cordial and most effective assistance given to the community of this station by the Magistrate and Collector of the District, Mr. Robert Spankie, during the whole period of the Mutinies.

I have, etc.,

R. BAIRD SMITH.

* Capt. Robertson was at the time Deputy Superintendent of the Ganges Canal Northern Division.

Nominal Roll of Officers of all Grades attached to the Irrigation Department, North Western Provinces, the Thomason College of Civil Engineering, and the Forest Agency in May, 1857, with Notices of their Services during the Mutinies.

Divisions.	Names of Officers.	Appointments.	Head-Quarter Stations.	Notes of Services.
I. Irrigation Department N.W.P. (General).	Lieutenant-Colonel R. Baird Smith.	Superintendent General of Irrigation, N.W.P., and Visitor, Thomason College.	Roorkee.	Commanded at Roorkee from 12th May to 27th June, 1857; proceeded to Delhi as Chief Engineer of the Force there; returned to Roorkee 30th September, 1857, and placed in command of the Troops in the Saharunpore and Mozuffernugger Districts.
Do.	Mr. H. Martin.	Assistant do. do.	Roorkee.	Mounted Patrol, employed on District service, proceeded to Delhi 27th June, and served there throughout the siege.
Ganges Canal, Northern Division.	Capt. H. Drummond.	Superintendent.	Roorkee.	Commanded Detachment of Sappers and Miners at Roorkee between 13th and 18th May, 1857; brought to notice of His Excellency the Commander-in-Chief for courage and conduct during the mutiny of the detachment; constantly employed on Field Service in Saharunpore District between May and September; maintained complete order in his Division. Served as Commanding Field Engineer with General Jone's Column in Rohilkhund.
Do.	Captain A. C. Robertson, H.M.'s 8th Regt.	Deputy Superintendent.	Roorkee.	Commanded Reserve Guard till 27th June, 1857. Constantly employed on Field service in Saharunpore District; conducted successful expedition in June; for rescue of 3 Europeans from Nujeebabad; attacked and dispersed marauders at Munglour; proceeded to Delhi to rejoin his Regiment 27th June and actively employed there, and at Lucknow.
	Mr. W. Phillips.	Supervisor.	Roorkee.	Mounted Patrol; field service in the District.

DIVISIONS.	NAMES OF OFFICERS.	APPOINTMENTS.	HEAD-QUARTER STATIONS.	NOTES OF SERVICES.
Navigation and Material Department.	Mr. Thomas Martin.	Asst. Supervisor.	Roorkee.	Main Guard.
	Mr. James Finn.	Superintendent.	Do.	Commanded west guard; in charge of Commissariat and Intelligence Departments; rendered services of the highest merit.
	Sergeant Ogle.	Overseer.	Cawnpore.	Killed there with his family.
Workshops.	Lieut. G. Baillie, Artillery.	Officiating Superintendent.	Roorkee.	Commanded Artillery; equipped the Guns for service. Superintended all interior work in the workshops, constantly employed in district field service, proceeded to Delhi 18th June, served there and in the Districts of Saharunpore and Mozuffernugger up to present date.
	Mr. J. Watson.	Do.	Roorkee.	West Guard. Officiating Superintendent after Lieutenant Baillie's departure to Delhi; Superintended casting of Guns, shot, and shell; equipped 3 18-Pounders, 2·8 Mortars and 4 Mountain Train Guns for service; was indefatigable in his exertions.
	Mr. J. McArthur.	Assistant Supervisor.	Roorkee.	Attached to Artillery and Store keeper.
	Sergeant Wilson.	Overseer.	Roorkee.	Gate Guard.
	Sergeant Ainsworth.	Overseer.	Roorkee.	Gate Guard.
	Trooper Cummings.	Assistant Overseer.	Roorkee.	Main Guard.
Upper and Lower Central Divisions.	Mr. James Parker.	Superintendent.	Boulandshahur.	Employed constantly on active service in the Meerut and Boulandshahur Districts, and engaged repeatedly with marauders; restored order in his Divisions with much energy, and throughout did excellent service.

Divisions.	Names of Officers.	Appointments.	Head-Quarter Stations.	Notes of Services.
Upper and Lower Central Divisions.	Mr. C. Anderson.	Depty. Superintendent.	Futtehgurh Branch.	In camp alone when the mutiny broke out, and escaped to Meerut with great risk of life; actively employed in maintaining order; proceeded to Delhi in August, and served there as Local Ensign with the Punjab Sappers; wounded.
	Mr. H. Nuthall.	Depty. Superintendent.	Camp.	Actively employed in Meerut District; proceeded to Delhi in August, and served there as Local Ensign with the Punjab Sappers; continued service in the Doab, at Lucknow, and in Rohilkhund to present date.
	Mr. W. B. Macrone.	Depty. Superintendent.	Alleegurh.	Actively employed in district service.
	Munnoo Lall.	Assistant Superintendent and Depty. Magistrate.	Boloundshahur.	Actively loyal and energetic throughout the whole period of the mutinies; recovered large quantities of public property, and materially aided in restoring order and confidence in his charge.
Cawnpore Terml. Division.	Lieutenant G. Price.	Superintendent.	Cawnpore.	Proceeded to Calcutta, 4th June.
	Lieutenant F. Angelo.	Officiating Superintendent.	Do.	Killed in Entrenchment.
	Captain Tonnochy.	Depty. Superintendent.	Mynpooree.	On Separate duty.
	Petumber Sing.	Asst. Superintendent and Deputy Magistrate.	Secundra Rao.	Actively loyal throughout the mutinies.
	Madhoo Ram.	Do. do.	Cawnpore.	
	Sergeant Swan.	Asst. Overseer.	Camp.	Escaped to Agra, and did duty in the Fort there.
	Sergeant Burton.	Do.	Do.	Killed, or died naturally under circumstances unknown.
	Sergeant Fullerton.	Do.	Do.	Killed or died naturally under circumstances unknown.

DIVISIONS.	NAMES OF OFFICERS.	APPOINTMENTS.	HEAD-QUARTER STATIONS.	NOTES OF SERVICES.
Etawah Terml. Division.	Captain F. Whiting.	Superintendent.	Mynpooree.	Escaped towards Agra. Killed on or about the 27th June, 1857.
	Lieutenant O. Span.	Depty. Superintendent.	Camp.	Escaped to Agra, Died in the Fort there.
	Sergeant R. Kelly.	Overseer.	Do.	Killed under circumstances unknown.
	Sergeant Mitchell.	Do.	Do.	Escaped to Agra, and did duty in the Fort there.
	Sergeant Scott.	Do.	Do.	Do. do. do.
	Mudsoodeen.	Assistant Supervisor.	Do.	Actively loyal throughout the mutinies.
Eastern Jumna Canal.	Lieutenant H. A. Brownlow.	Superintendent.	Saharunpore.	Actively employed in maintaining order at Saharunpore; proceeded to Delhi, and served throughout the operations; dangerously wounded; served in Rohilkhund with General Jone's Force; restored order in his division with energy and tact.
	Lieutenant R. Home.	Depty. Superintendent.	Do.	Employed in District service.
	Mr. W. Willcock.	Do.	Surrowlee.	In hands of Goojurs with his wife and family for some time; treated by them with much kindness, and brought to Saharunpore; actively employed in District service; proceeded to Delhi and served there as Adjutant of Pioneers.
	Sergeant Brown.	Assistant Overseer.	Camp.	Also in hands of Goojurs. Employed in district service.
Western Jumna Canals.	Lieutenant Stewart.	Superintendent.	Delhi.	In Camp at time of Mutiny at Delhi; escaped to Kurnal; joined Delhi Field Forces and served throughout the siege. Active and energetic in the restoration of order in his Division.
	Lieutenant Thomason.	Depty. Superintendent.	Do.	Escaped from Delhi on 11th May; and, after much suffering, reached Kurnal; served at Delhi throughout the siege.

Divisions.	Names of Officers.	Appointments.	Head-Quarter Stations.	Notes of Services.
Western Jumna Canals.	Mr. H. Rigby.	Depty. Superintendent.	Camp.	Served at Delhi as Local Ensign with Punjab Sappers; died of fever.
	Mr. Fitzpatrick.	Assistant Supervisor.	Hansee.	Killed there.
	Sergeant Duncan.	Do.	Dadoopore.	Maintained his post throughout the whole period of the mutinies, and showed great gallantry and judgment in doing so.
	Sergeant J. Martin.	Assistant Overseer.	Do.	Aided Sergeant Duncan and did excellent service.
	Sergeant Corcoran.	Do.	Kurnal.	Served with Artillery at Delhi during the siege; wounded.
	Sergeant Dennis.	Do.	Delhi.	Killed there on 11th May.
Deyra Doon Canals.	Lieutenant E. Walker.	Superintendent.	Deyrah.	Left Deyrah 15th May with Simoor Battalion; District service in Bolundshuhar district; present in the actions on the Hindon; joined at Delhi, and was severely wounded there; died of Cholera in July, 1857.
	Mr. R. Forrest.	Depty. Superintendent.	Do.	In charge of works; occasional district service
Rohilkhund Canals.	Captain Maxwell.	Superintendent.	Barrielly.	Employed on active service at Nynee Tall; repeatedly engaged with the mutineers from Barrielly.
	Mr. Aspinal.	Assistant Superintendent.	Do.	Killed with his family at Barrielly.
	Mr. Bremner.	Do.	Pilibheet.	Prisoner from May to February when he escaped to Nynee Tall.
Bundelkhund Works.	Lieutenant J. Powys.	Superintendent.	Nowgong.	Killed with his family at Jhansee.
	Sergeant Kirchhoff.	Overseer.	Mahoba.	Escaped after great danger and suffering to Cawnpore with his wife; died there of Cholera.
Agra and Delhi District Works.	Mr. E. Battie.	Superintendent.	Agra.	Did duty in Fort and district.

DIVISIONS.	NAMES OF OFFICERS.	APPOINTMENTS.	HEAD-QUARTER STATIONS.	NOTES OF SERVICES.
II. Thomason College.	Captain R. Maclagan.	Principal.	Roorkee.	Staff Officer of the Garrison; constantly employed in field service in the District; commanded successful detachment against a strong body of marauders at Futooah, and aided in all measures of internal defence at the station.
	Lieutenant G. T. Chesney.	Assistant Principal.	Roorkee.	At Umballah when the mutiny broke out; proceeded with Commander-in-Chief's Force to Delhi, and served there as Brigade Major of Engineers throughout the whole of the operations. Severely wounded.
	Lieutenant E. L. Earle.	Professor of Surveying.	Roorkee.	Commanded Gate Guard and attached to Artillery. Employed in District service; proceeded to Delhi 19th June, and served throughout the siege.
	Mr. H. B. Medlicott.	Professor of Geology.	Roorkee.	Mounted Patrol, constantly employed in field service in the District; accompanied Captain Robertson to Nujeebabad for rescue of Europeans there; engaged with insurgents at Deobund.
	Lieutenant H. Bingham.	Head Master.	Roorkee.	Acting Adjutant of Detachment Sappers and Miners; brought to notice of His Excellency the Commander-in-Chief for courage and conduct during the mutiny; proceeded to Delhi and served throughout the operations there as Commandant of Pioneers; also in the Doab, at Lucknow, and in Rohilkhund.
	Captain F. Spring, H.M. 24th Regiment.	Senior Department.	Roorkee.	Commanded Main guard; of the greatest assistance in organizing the Garrison, and distinguished by his zeal and professional intelligence on all occasions. Proceeded to join his Regiment 29th June, 1857, and killed at Jhelam by the mutineers of the 14th Native Infantry.

Divisions.	Names of Officers.	Appointments.	Head-Quarter Stations.	Notes of Services.
II. Thomason College.	Lieutenant R. F. Angelo.	Senior Department.	Roorkee.	Commanded East guard; employed in district service.
	Mr. W. Scotland.	Drawing Master.	Roorkee.	Gate Guard; service in the district.
	Sergt. Gilchrist.	Assistant Master.	Roorkee.	Acting Sergeant-Major; rendered most useful service.
				The Students of all Departments of the College were embodied for Military service.
III. Forest Agency.	Captain H. E. Read.	Superintendent.	Roorkee.	Commanded at Roorkee from 27th June; constantly employed in the districts; commanded successful expedition for the relief of Deobund, and defeated a large body of insurgents there. Most active and energetic throughout the whole period when service was required.
	Mr. Sub-Conductor P. Stephens.	Forest Overseer.	Patter Dhoon.	Prisoner at Nujeebabad; rescued with his wife 17th June; commanded Garrison Artillery, after all the Artillery officers left for Delhi.
	Sergeant H. Bruce.	In charge of Saw Mills.	Do.	Prisoner at Nujeebabad; rescued as above; attached to Garrison; employed in District; in charge of Engineers Park with General Jone's Force in Rohilkhund.

R. Baird Smith, *Lieutenant-Colonel,*
Superintendent, General Irrigation, N.W.P.

TRANSCRIPT.

ON AN INDIAN CANAL.

By MAJOR-GENERAL G. K. SCOTT-MONCRIEFF, C.B., C.I.E.

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(*Continued*).

II.

THE province of India above all others which, from its natural configuration, is especially adapted to irrigation works on a large scale, is the Punjab. The work there of late years has been carried out under difficulties unknown to the engineers of the earlier days in the Ganges valley and elsewhere, because of the barren and uninhabited nature of the country; but it is an even greater boon to the people there, and it is more than in any other place remunerative to the State. The rainfall in the country watered by the Ganges and Jumna Canals is about 30 in. or more on an average in the year, whereas in the Central Punjab it is about 10 to 16 in., and in some years falls as low as 4 or 5 in. The State is the owner of huge tracts of waste land which can be cultivated if only water can be brought to it, and the whole province is divided into clearly defined sections bounded by the Indus and its five great tributaries. So we have in this province plenty of culturable land, but needing water for cultivation, plenty of water rolling down the great rivers, and a strong and hardy race of agricultural people willing to take up the work. The problem has been to bring them all together. Curiously enough, nearly the entire province is a great plain of alluvial and excellent soil overlying a water-bearing stratum. If a well be sunk anywhere on this plain, it will tap the water-level at no very great depth sooner or later. Indeed, if one travels by rail from the mouth of the Indus at Karachi to Lahore, and thence by Umballa and Allahabad to Calcutta at the mouth of the Ganges, one passes over this great alluvial plain from end to end. The railway does not pass through a single tunnel the whole way (about 2,000 miles), and, except for a short distance in Bengal, does not even pass through a cutting deep enough to obstruct the view from the railway carriage. If the traveller is journeying in the months of June or July, he will not desire to see the view, and there will be little for him to see but a shimmering plain with a blinding glare. His one desire will be to darken his carriage as much as possible, and provide himself with iced drinks and refreshing literature. But if the journey is taken in April, there will be a sea of ripe golden wheat traversed for hundreds of miles, or in September the still more picturesque crops

of maize, millet, or sugar-cane gladden the eye. These are largely due to the influence of irrigation, either from the great canals or from village wells.

These last are a most important feature in the Punjab. There are some 300,000 of them. Where the rainfall is from 15 to 20 in., and in places where the water-level is not more than 40 ft. below the surface, these wells are found in every village, and the water from them is raised by Persian wheels, whose not unpleasant drone is a familiar sound to every one who has been in North India. In the hot dry months of April and May the wheels are worked day and night, the water brought up in the tiny buckets falling into wooden shoots, and thence led through small channels to the thirsty ground. This goes on till the anxiously expected rain gives the tired bullocks or buffaloes a rest, and the farmer can wait till his harvest comes.

But as the ground rises gently away from the valleys of the rivers, the level of the water in the wells gets farther and farther from the surface, cultivation then ceases, and what is called the "Bar," or waste land, begins. The soil is smooth and shining, bare of grass, and dotted all over with shrubs of three different kinds, two of which are rough thorn bushes, while the third (called various names, *jâl* and *pilu* and *van*) resembles in leaf the mistletoe, and has a white wood, which, as well as the leaves, has a peculiarly disagreeable odour. These shrubs, like the gazelle and the camel, can live with impunity in long droughts. The people who inhabit these tracts are pastoral, owning large herds of cattle, buffaloes, and camels. The last-mentioned animal can live upon, and seems to enjoy, the thorn bushes and the malodorous *jâl*; but the cattle must have grass, and therefore the owners move about from place to place, like the patriarchs of old, according to the state of the country. The human inhabitants are a fine sturdy race, living almost entirely on milk and curds, with very little clothing either in summer or winter. They are men of simple tastes and habits. They know little of civilization and not much of agriculture; but if you should chance to lose any of your baggage-camels, or lose your way (which is a very possible contingency in such a trackless country), you will find that these peasants have a knowledge which you do not possess and which is exceedingly useful. The other denizens of the Bar region are snakes and lizards, kites and vultures, occasionally an antelope or gazelle, a few partridges and blue rock-pigeons.

There have been for many years, in the neighbourhood of the great rivers, canals dug in such a way as to fill when the rivers are in flood—*i.e.*, during the summer months, when the snows of the mountains are melting, but empty during the cold weather, when the rivers are low. These inundation canals, as they are called, are very useful adjuncts to the prosperity of the country, and they pay the State a very respectable return on the capital invested in their construction. They have, however, many drawbacks. The rivers constantly change their course, so that the position which has been suitable as a head for the canal one year may in the following year be far away from the water; while, on the contrary, the river may take a turn the other way and sweep away any small works devised to regulate the flow at a canal head. Then

the water may fail, by the river falling, just at the very time the farmer wants it most; or it may come with a mighty rush at a time when he does *not* want it, and it cannot be turned away. The inundation canal, therefore, is far from being an ideal one.

It requires no expert knowledge to see that there must be some means of utilizing the water when the river is low, and of getting rid of superfluous waters when rain has fallen or the need for irrigation has ceased. A canal devised to supply these wants is called a " perennial " canal.

The first requirement is met by a weir across the main stream. The construction of a weir is a task for a Titan, and yet when it is all accomplished there is little to indicate above the surface the mighty work that has been carried to completion. People sometimes visit the head works of a canal expecting to see something that will attract the eye like the Forth Bridge, or the great Vyrnwy Dam that has created in Wales an artificial lake to supply Liverpool with water. They are disappointed that, having come out to the wilderness to see a work that has taken several years to build, there is only a very low bank of masonry over which the water is placidly flowing, or furiously tossing, according to the season. But to the man who has built it, a weir is almost part of himself, a child of his brain that has cost much travail and care, a mighty proof of mind and a sign of victory. Day after day, month after month, ay, year after year, it has been uppermost in his thoughts. It has involved a warfare against a crafty and vigilant foe, a grappling with a wild and untamed monster, who has not yielded without inflicting at times heart-breaking loss, and who has developed unexpected powers of resistance at times when all precedent pointed to capitulation. To supply the food of the assailant, too, what gigantic efforts have been necessary. One, two, even three, train loads of stone every day are swallowed up in this conflict, and other materials in like proportion. The army of invasion has to be organized, managed, directed by day and night, in cold and heat. The work has to be subjected to the severest tests while it is yet fresh from the masons' trowels, and, while the materials must always be of the best, reliance must be placed rather on design than on workmanship, on strategy rather than tactics.

A weir is, in short, a broad and deep bar of stone and concrete across the shifting bed of a river. There are miles of training works which radiate from the ends and prevent the river outflanking it altogether, and the foundations are laid so deep and so continuously that the water cannot undermine it. The river is, in fact, compelled to obey man's behests. The water must either pass over the weir or into the canal, the head of which is situated on one bank just above the weir. The river, too, must excavate a deep pool just at the canal head, so that the entrance to the canal may never be choked by silt. This is done by means of under sluices through the weir at the end close to the canal head, arranged so that the water is, so to speak, attracted to pass through them when it can escape nowhere else, and thus its current scours out a pool just at the place where such is needed.

When the country is dry and the river low, the weir prevents any water from passing over it at all, if such be the will of the canal engineers. Shutters along the top of the weir are raised, the under

sluices are closed, the entire volume of the stream pours through the arched gates of the canal into the great artificial bed prepared for it. In the Chenab and Sirhind Canals nearly every cold weather the whole current of the rivers, Chenab and Sutlej, is thus utilized. But when rain has fallen, and when the farmer does not need the water, the shutters along the weir are dropped, the gates at the canal head are closed, and the river careers in foaming torrent over the weir down its ancient channel.

Superfluous waters in a canal are disposed of by "escapes"—*i.e.*, sluice-gates opening into some natural or artificial water course down which the water can be allowed to flow away.

In the case of the older canals, the water was brought to the villages which existed prior to the canal. But in the case of the Bar reclamations there were no villages worth mentioning, and so these had to be brought to the water. In other words, new villages were planned to be peopled by colonists from congested districts, and built in positions most favourable for agriculture.

The basis of the whole scheme was a square of about 27 acres in area, a suitable size for a peasant farmer. On paper the whole thing was delightfully simple. You have your tract of waste land, say, 100 miles long by about 30 broad, all of which has been proved, from the preliminary surveys, to be capable of irrigation, and which has formed the subject of many reports, and finally of the Secretary of State's sanction. You draw a straight line down the middle as a sort of backbone, and you draw other lines at right angles to this and parallel to it, until the whole area is divided up into a vast number of 27-acre squares.

Now go out and mark it on the ground. It is not quite so easy. To lay out an *absolutely* straight line on the ground for 100 miles may be possible, but to lay out hundreds of squares depending on this centre line with anything like scientific accuracy is hopeless. As one gets farther and farther away from the backbone, the squares become more and more lozenge-shaped, diamond-shaped, and otherwise distorted. However, the Punjabi peasant is not very particular, and the actual area of the plot is not far out one way or the other. Every corner peg of each square has to be accurately levelled,—*i.e.*, to have its level accurately recorded to the hundredth part of a foot,—so that long before the detailed design for the works even can begin, a host of workers, European and Native, must be busy each cold season, from dawn till dark, living in tents, and moving from place to place as the work develops.

By the month of April tents become unbearable, and the shimmering haze on the ground makes accurate levelling impossible. Looking through the telescope of your instrument, you will see the levelling staff, a very rigid piece of wood and brass, so distorted by the haze that it is apparently wriggling like a snake, or rather performing a feat no snake ever succeeded in accomplishing—viz., standing on its tail and dancing.

Now the accuracy of levels is a matter of vital importance where the flow of water in open channels is concerned. It is important, of course, in other branches of engineering, such as railway work, but if you do chance to make a slight mistake there (and I have heard of a case where

a mistake of 10 ft. was not discovered till two ends of a cutting were found to meet at a difference of that level), it is possible to make the gradient differ a little one way or other. But with water this is impossible; hence when the weather makes the levelling staves wriggle, it is time to stop work for the season and begin the paper work.

A long and arduous task is this: first the planning of the distribution system,—whether the gigantic leaf will be like that of the oak, with a central main channel and a series of distributaries branching right and left; or whether it will resemble the plane or the vine, with a bifurcation at the end of the stalk and a series of branches proceeding thence, each with its own system. In any case, these have to be settled according to the conditions of the ground, not forgetting, too, that where there is irrigation there must also be drainage, or the land will be waterlogged and the inhabitants unhealthy.

Then comes the settling of village sites and the channels leading thereto. The design of the falls, the regulators, the escapes, the bridges, the diversion of roads, the positions of inspection-houses, and probably the planning, or at least the selection, of the site for a new town to act as a headquarters of the new district, have all to be taken up, designed, and estimated—a stupendous task, and one which will be most carefully scrutinized by superior authority in its most minute details.

For it has always been a tradition in this department that no detail is too insignificant to be slurred over. Financial control is not understood merely to mean the authority to spend money on a given work in any way you please, and then to examine the accounts. Examination certainly does take place with scrupulous exactness, but it is not there that economy comes in. It is recognized that economy must begin with the early stages of the work—scrupulous care in connection with the scientific planning, and the materials specified. This does not mean that these are inferior—on the contrary, no better workmanship is to be found in the country; but it must be so controlled in every detail that no useless expense is allowed anywhere. This means often long delay before a work is actually begun, but it is time well spent.

Here the reader will perhaps pardon me if I digress for a moment to give a personal testimony. I served for about three years, at various periods, in a varied career now of some 34 years, in the Irrigation Department, and was three times summoned away by telegram to go on active service from a canal. I found the experience I had gained there of infinite value to me in war, in the practice gained in organizing masses of men and planning for supplies of all sorts. But I learned also, in a way that has proved of incalculable value, the lesson of practical economy on a large scale. I have served in every other branch of the Public Works Department in India, have carried out works under Government in various other parts of the world, and have a very fair knowledge of what is done in civil life at home on railways, harbour works, and water-supply schemes, but I have never come across in any place any large works so thoroughly and efficiently managed as those of the Punjab Irrigation Branch.

There are two results of this. One is, that one never hears of a large contractor making a fortune out of the canal works, as one does in

connection with other engineering schemes; the other is, that partly due to this economy, and partly to the natural configuration of the Punjab, the canals pay an enormous profit to the State.

As regards the last point a few facts may be quoted. The immortal Mr. Gradgrind, we may remember, was above all things desirous to obtain facts. Well, there is a report annually published by the Punjab Government, called the Administration Report of the Irrigation Branch, full of the hardest facts that the mind of man could ever be called to digest, and purchasable at a cheap price from any Government publisher. It contains the exact area of every crop grown on watered land. The names of some of these crops will be new and strange facts to Mr. Gradgrind, but this is a matter of detail. The lengths of all the channels, main and subsidiary, the cost of every canal, the maximum amount of water which it is capable of discharging, and the maximum that it did discharge at any second of the year, are all recorded in a manner so interwoven that one is reminded of the accounts of a Mess, where it is said that in order to arrive at a balance sheet the secretary multiplied the butter by the potatoes, and divided the product by the honorary members.

From this mass of facts we learn that the Chenab Canal, the largest of the Punjab canals, so far, but still only one among several, has cost Rs.28,227,748, that the gross receipts in 1906 were Rs.8,762,061, the working expenses Rs.1,961,473, leaving a net revenue of Rs.6,800,588, or a percentage on capital outlay of 24·09. The interest charges on the capital, however, amount to Rs.1,093,926, which, deducted from the net revenue, leaves a surplus of Rs.5,706,662, or a net percentage of 20·22. The area irrigated is approximately two million acres, and the value of the crops raised in *one year* (from land which a few years ago was entirely waste) is given at Rs.38,565,915,—*considerably in excess of the total capital cost.*

The canal discharges at a maximum 10,730 cubic ft. a second. Its main line is 40 miles long, its branches 387 miles, and its distributary channels 2,308 miles. This takes no account of minor village channels.

To grasp these huge figures, let us take for comparison the water supply of London with its seven million inhabitants. For municipal, trade, and domestic purposes 30 gallons per head per diem of the population are considered necessary, or 210 million gallons in 24 hours, for the entire city and suburbs. Now if all this quantity were obtained, not, as it is now, from several different sources, but in one large stream, it would be equal to a discharge of 400 cubic ft. a second. Hence the Chenab Canal is designed to discharge water enough to supply 26 cities as large as London, with a population of 182 millions, or the entire domestic, industrial, and municipal needs of the British Isles, France, Germany, and Austria combined!

This is the largest of the great perennial canals, but there are four others (the Bari Doab, the Western Jumna, the Sirhind, and the Jhelum) which discharge each more than 4,000 cubic ft. per second. Setting aside the Western Jumna Canal, which is the reconstruction of an old native work, one may say that in this province of India the engineers of the Victorian era have devised and carried out a system

of water distribution more than is needed for all requirements in respect of water supply by the entire population of Europe.

Then as regards revenue, the direct returns only are put to the credit of the canals; but this means only the enhanced land revenue paid by the people over and above the ordinary rent paid for unirrigated land. Even in lands watered by wells, where the farmer himself supplies the labour for raising the water, a higher land revenue is paid than would be paid for land which had to depend on rainfall only for its moisture. It is therefore in accordance with the fundamental principle of land assessment—viz., that a percentage of the value of the crop is paid to the State—that canal-watered land should pay the highest revenue. The credit to the canal department is useful enough, 20 per cent. being considered by anybody a very satisfactory return, but after all it only represents a part of the benefit conferred by irrigation on the people. The crops, which in one year exceed in value the entire capital outlay, would never have grown at all on the Bar land but for canal water; and the millions of acres now under cultivation are no longer populated by snakes and lizards, but by a thriving class of vigorous peasants, in whose welfare is the real strength of the nation.

It is not the least part of the skill with which these works have been devised, that from first to last they are designed to be carried out by native labour and materials. It is safe to say that of the capital expenditure at least 90 per cent. has found its way into the pockets of the people of the country. The excavation of the hundreds of miles of irrigation channels, large and small, has been effected by swarms of humble labourers, with their rude mattocks and baskets. Entire families are employed, the men doing the digging, the women carrying the stuff to the spoil heap, the children, according to their age and strength, carrying out some part of the work, either helping to lift the baskets or break up the clods in the spoil. So remunerative, indeed, is this simple labour that one tribe, who were originally employed on the Ganges Canal works some sixty years ago, have now abandoned agriculture, and go about the country from one canal work under construction to another. These people, who are locally called Odes, are skilful navvies and earn excellent wages, but they have become arrogant and troublesome, presuming on their superior skill. Hence they have been somewhat humorously described as "Odi profanum vulgus."

No doubt a modern digging machine, with its huge steel jaws taking at one bite as much earth as a whole family of Odes would do in a day, would carry out the work as cheaply, and probably more expeditiously, than the swarm of human ants above described. But such an application of modern machinery is unnecessary, because there are many other works on a canal to be constructed as well as the actual digging, and these always take most time. Besides, the rulers of the land are as much opposed to free trade in labour as any British workman can be, and the capital cost and the working expenses of such labour-saving machinery would not benefit the people of the land. Their comfort and advantage are studied everywhere, as indeed is only right. The bridges, falls, regulators, and other masonry works which occur so frequently over the canal system, are all designed so as to be made of materials

either quarried or manufactured by native labour and built by native artisans.

In this, irrigation works contrast favourably with other public works. In railways, for instance, much of the capital expenditure goes to rolling stock, permanent-way materials, and signalling instruments, all of which are of European manufacture. The working expenses on railways involve the employment of many Europeans, not only in the superior ranks, but also as guards, engine-drivers, foremen, etc. On canals nearly the whole of the establishment employed is native, with the exception of the few European officers. There is a whole army of *patwàris*, gauge readers, patrols, as well as clerks, secretaries, and other functionaries exclusively employed in office work.

But, unfortunately, there is one dark shade across a very bright picture. The service of the Irrigation Department, lofty in its scientific aims and splendid in its results, is a most unpopular one among European engineers. The life, as we have pointed out, is lonely and exposed. A man, not unnaturally, desires some social or domestic relaxation from official cares, and in no branch of the Public Works Department does he get so little of these. There is practically no corresponding compensation in the matter of emolument. However skilful or scientific, the Indian civil engineer cannot command the price for his brain work that his compeer in practice in England can: I am speaking, of course, of those who are at the top of their profession in both countries. Nor is there any chance of the Indian civil engineer nowadays obtaining any of the rich administrative appointments open to the covenanted Civil Service. It was different in the case of the military engineers who were the early pioneers of this work. Sir Henry Durand, for example, rose to be Lieutenant-Governor of the Punjab, and Lord Napier of Magdala became Commander-in-Chief in India, and subsequently Governor of Gibraltar. With these and other celebrated military engineers the case was somewhat different from that to-day of the civil engineers by whose skill these great canals have for the most part been built. They have practically no other career before them. A turn in fortune's wheel might take a soldier engineer away from his canal to a campaign where honour and advancement await him, but the civilian comrade with whom he has been working has to stay on at his steady work, with very little prospect before him, except that he knows he must retire at an age when his experience is most mature and his knowledge of the country most extensive. He knows also that, with the exception of Egypt and America, his skill and experience will not find a market in other parts of the world, and though he may be listened to with the utmost respect at the headquarters of the Institution of Civil Engineers at Westminster, he will find no scope in England for actual practice. Little wonder, therefore, that he endeavours to obtain a transfer from work so unremunerative, and to follow his compeers at Cooper's Hill or Roorkee into railways or some other less specialized branch of their profession.

There is also the feeling that the work is not appreciated,—that the very art which has concealed the art of scientific canal design has been so effectual that the lay mind has come to think there is no art at all.

This feeling of bitterness may be unfair, but it unquestionably exists; and it must be admitted that there have been certain incidents which have given grounds for it. When a colossal work like the Chenab Canal was opened, one might have thought that the occasion was one for a little *éclat*, and possibly the bestowal of some marks of honour by the representative of the Sovereign. When the Glasgow Waterworks were opened in 1859, Queen Victoria, at some personal inconvenience to herself, graced the occasion with her presence, and gave proofs of her appreciation to those principally concerned. But no Viceroy of India went near the Chenab Canal for some six years after its opening. When at last one did visit the place, and there was a good deal of high falutin about the desert blossoming—which was true, if not very original,—the next Honours Gazette contained no reward whatever for any engineer. There was a decoration given, but it was to the colonization officer who had arranged for the transplanting of families from the congested districts to the new area. Very probably this officer had done his work, and deserved his honour, most thoroughly. But to reward him only was, as the principal Lahore newspaper severely said, as though, in opening a large public building by the Sovereign, the architect had been ignored and only the lawyer who drew up the deed of occupancy had been noticed. It is needless to say that the private comments on this occasion were forcible and caustic.

That the rulers of the Punjab fully appreciate the loyal and conscientious service of the canal engineers is evinced by many public utterances of successive Lieutenant-Governors. It is understood that quite recently improvements in pay, etc., have been made, which will alleviate the bitterness above alluded to. No doubt the Government has carefully considered how best to put the matter on a more satisfactory footing, and that being the case, it would be impertinent for an onlooker, however cognizant of the facts from within, and however sympathetic, to suggest a remedy. But no account of canal work in the Punjab, however fragmentary, would be true without some allusion to this subject. In a work so interwoven with the welfare of the people, and involving such large sums of money, dissatisfaction among the workers is a serious national question. There are to-day in progress further schemes still vaster than any which have hitherto been accomplished, and to leave the working out of these in any but the best hands would be a national calamity.

(*To be concluded*).

NOTICES OF MAGAZINES.

Engineering News.

1st January, 1914.

Bituminous Surface Treatment of Macadam Roads.

During the year 1913 the Bureau of Highways of Philadelphia treated 415,000 sq. yards of water-bound macadam roads with bituminous materials with satisfactory results. Preparation of the road has an important bearing on the success of the treatment. Dust and dirt were removed by machine sweepers, scrapers and hand brooms. The surface dressing used was clean sharp sand or rock chippings passing a $\frac{3}{4}$-in. screen. The average amount used was 25 lbs. per sq. yard.

The bituminous material used consisted of 65 per cent. asphalt and 35 per cent. commercial naphtha, 53—55 Baume. This was applied cold, about $\frac{1}{3}$ to $\frac{1}{2}$ U.S. gallon being used per sq. yard. The naphtha assisted penetration, which was usually about $\frac{3}{4}$ in. if the weather was not too cold. Whenever possible the treated surface was allowed to stand 24 hours before the application of the top dressing, but where traffic conditions did not allow this to be done the top dressing was applied before stopping work for the day. The surface dressing was afterwards ignited to burn out the naphtha, which caused immediate setting of the asphalt. Very little penetration can be secured in cold weather, so that all work of this nature should be done in the summer. Care should be taken that surplus bituminous material is not left on the surface after maximum penetration has been secured, as this forms a plastic pad which creeps and forms pits.

8th January, 1914.

The Hell Gate Steel Arch Bridge.

This bridge is of special interest on account of its size, its massive structure and its large capacity. It is a double-chord parabolic arch, 40 ft. deep at the crown and 140 ft. deep over the abutments. The span is 977 ft. 6 in. and the rise of the lower chord is 220 ft. The arch is divided vertically into 23 panels of equal length. The roadway is partly suspended, the 17 centre panels being below the lower chord. The bracing is very complete. Each chord has its own system of cross-bracing and the two trusses are cross-braced vertically at the panel points. The roadway is separately braced for wind load and traction and breaking stresses.

The bridge carries four lines of standard-gauge railway track. The dead load of the bridge averages 53,000 lbs. per foot-run. Impact is

allowed for in accordance with Lindenthal's impact formula (*Engineering News*, August 1st, 1912), which is

$$I=\frac{L^2}{L+D}\times\frac{8Q+qa}{4Q+4qa}$$

where I = stress equivalent of the impact.
L = live load stress.
D = dead load stress.
Q = weight of locomotives and tenders.
q = weight of train behind tender.

This bridge is now being constructed in the shops and will be erected during the coming summer.

VALUATION OF THE SEWERS OF MANHATTAN BOROUGH, NEW YORK CITY.

The report on this work shows that the average life of a brick sewer is 64 years, *i.e.*, after this period it is uneconomical to continue repairs, and replacement is necessary. Most of the failures, as tabulated, appear to be due to insufficient lateral support. This points to the advisability, in design, of considering the top of the sewer as an arch and the bottom as the abutments thereto. In pipe sewers there was no wear due to length of service. The principal causes of failure were depressed joints, and breakage of the pipe, which latter, however, only occurred at and above the centre, due, probably, to the super-imposed load.

15th January, 1914.

SAFE OPERATION OF REDUCED SPEED SECTIONS OF RAILWAYS.

A paper by a German Engineer in the *Bulletin of the International Railway Congress* discusses the requirements for permanent and temporary speed reduction points on railways. These may be summarized as follows (many of the comments were suggested by reading the article) :—

1. There should be as few reduced speed places as possible. The necessity for this is shown by the large number of permanent speed reduction places published in the instructions issued to railway employees (over 1,000 on L.N.W.R.).

2. There should be as few varieties of reduced speed as possible This can be realized on curves by providing the proper super-elevation, and at switches by restricting the frogs used to as few varieties as possible.

3. Reduced speed places should be properly marked ; the permanent ones by a notice board, illuminated at night if necessary, on which is plainly shown the speed allowed ; temporary ones, in addition, by specia signals, day and night, placed at each end of the section referred to One method of doing this is to use a temporary distant signal fixed at danger at the beginning of the section, and a temporary stop signal in the " off " position at the end of the section. Temporary reductions should be eliminated at night as far as possible, if the nature of the work will admit. Care should be taken that the locomotive men are kept informed of the temporary reduced speed places.

4. The schedule should allow extra time for reduction of speed and no blame should attach to the driver if he is compelled to lose time in consequence of speed reduction places.

5. All locomotives should be fitted with direct-reading recording-speed indicators, which, in conjunction with occasional tests by officials, would ensure that instructions are obeyed.

6. If the number of speed reductions on any line is excessive it indicates that the schedule is too high or that the line requires to be reconstructed.

W. G. TYRRELL.

REVUE MILITAIRE.

August, 1913.

THE NEW GERMAN ARMY LAW OF 2ND JULY, 1913.

The additional engineer details to be provided are:—

Three new battalions (2 fortress).

Nine fortress regiments formed, one from the 2 Bavarian battalions, 8 from 8 battalions and 8 headquarters of existing corps engineers.

Nine searchlight detachments attached to the above regiments.

One siege unit.

Two Bavarian companies to complete establishment.

25 battalions of field engineers to be increased by 3 N.C.O.'s and 30 men each.

26 searchlight squads to be converted into detachments.

The field and fortress units will henceforth be separated, and the latter will be composed of the above-mentioned 9 regiments each with its siege train and searchlight detachment stationed probably at Königsberg, Grandenz, Posen, Cologne, Coblenz, Mayence, Metz, Strasburg, and Ingolstadt. Each of the 2 battalions per regiment will have 3 companies. Since the existing battalions have 4, only 2 remain to be provided. It is noticeable that the searchlights with an Army Corps are doubled, and that the Germans lay great stress on their use. There are increases in telegraph, telephone, and wireless telegraphy units. Three battalions and 3 odd companies are to be added to the flying corps which will now consist of 6 battalions (17 companies). With the exception of 2 battalions, they are to be allotted to dirigibles and stationed at Düsseldorf, Cologne, Mannheim, Darmstadt, Lohr, and Friedrichshafen on the western frontier; Königsberg, Grandenz and Schneidemühl on the eastern frontier, and Hanover, Dresden and Munich in the interior; at each of these places there will be a double rotating shed, providing in all for 30 dirigibles. The aeroplane companies will be redistributed between the following stations:—Döberitz (2), Zeetham, Posen, Grandenz, Königsberg, Cologne, Hanover, Darmstadt, Metz, Strasburg, and Fribourg with 2 in Bavaria.

The organization of the Norwegian Army is described.

FOREIGN INTELLIGENCE.

Belgium.—In accordance with the new army law the strength of the army will be raised from 251,000 (the maximum foreseen by the old law) to 340,000 of which 150,000 will form the field army, the remainder being part detailed to the fortresses of Antwerp, Liège and Namur (130,000), and part reserve and auxiliary units.

E.R.

CORRESPONDENCE.

THE SIPHON AS AN AID TO WATER SUPPLY

DEAR SIR,

With reference to H.K.'s letter, which I have only just noticed in the February *R.E. Journal*, on the above subject, I am very grateful to him for pointing out an error in *Plate* I. accompanying my article in the January number.

The stopcock at the junction C in sectional elevation AC should be called No. 3, as it is in sectional elevation BC. Stopcock No. 2 is at the head of Siphon B.

It would no doubt be possible, with a good pump, to start a siphonage action in the 2-in. pipe at Sierra Leone by the arrangement he suggests; but it would be quite impossible to extract all the air from the pipe by this method with such a difference in levels; and since air in the siphon reduces its output, and gradually stops it, I do not think it would continue to run for long.

It is one of the first essentials for efficient working of a siphon that it should be free from air, and the airlock was devised as the easiest means of starting and keeping it as far as possible in this condition with the plant and materials available.

H.K.'s arrangement makes no provision for preventing air accumulating at the head of the siphon, or for extracting it while the siphon is working. His $\frac{3}{4}$-in. pipe required restarting after some hours of working; I am afraid the 2-in. pipe at Sierra Leone (which contains 30 times as much as his) would, with his method, require almost constant attention, and this it was my chief aim to avoid, if the siphon was to justify its existence.

The expense of some extra 2-in. stopcocks is I think more than compensated by the saving in labour.

Yours truly,
E. W. S. MAHON.

23rd February, 1914.

The Editor, *R.E. Journal.*