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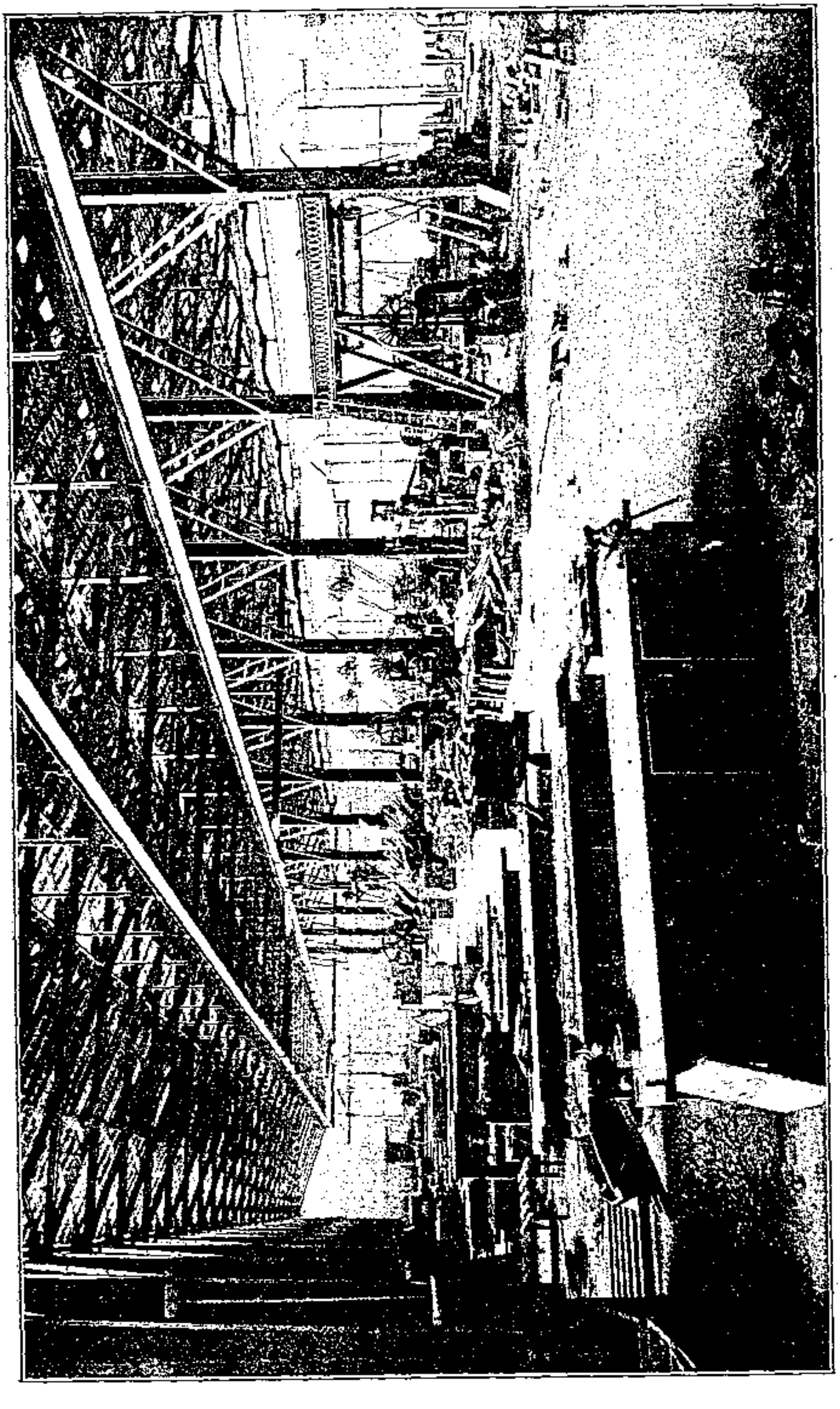
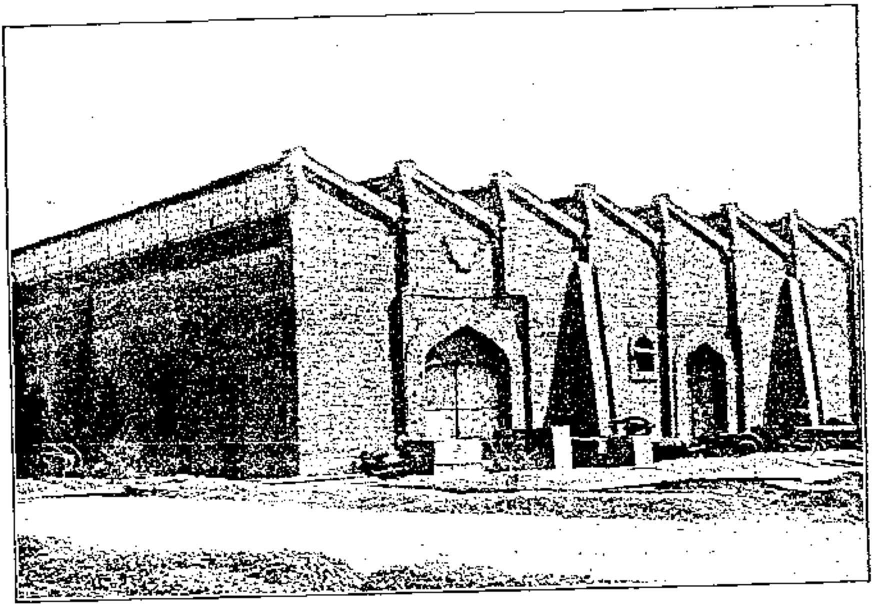
GUN CARRIAGE FACTORY AT JUBBULPORE.

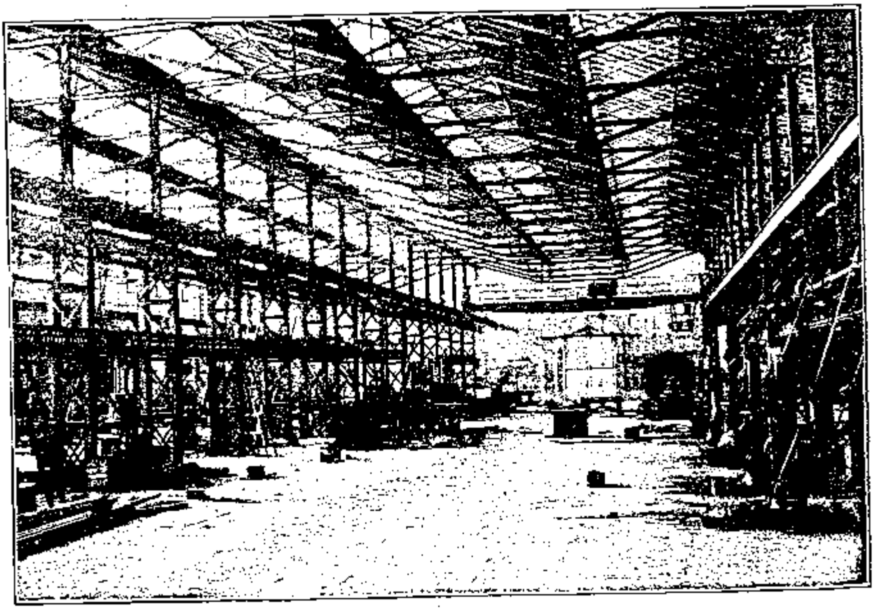


CARPENTER'S SHOP.—Interior—looking S.E.

GUN CARRIAGE FACTORY AT JUBBULPORE



MACHINE SHOP.—Exterior—from N.W.



MACHINE SHOP.—Interior—looking E.

DESIGN AND CONSTRUCTION OF LARGE WORKSHOPS AT THE GUN CARRIAGE FACTORY, JUBBULPORE.

As the design and construction of large shops for manufacturing or engineering works, contain some elements which are peculiar to themselves, and do not come as a rule within the purview of Royal Engineer officers employed on ordinary barrack construction and similar works, the D.G.M.W. in India has forwarded the following report by Major H. F. Thuillier, R.E., on some large shops recently constructed at the new Gun Carriage Factory at Jubbulpore, which may be both of general interest and instructive to those who have similar buildings to design in the future.

The buildings herein described are a machine shop for turning, fitting, and erecting, and a carpenters' shop. They are similar in general design, but differ in dimensions and in certain constructional details. To the carpenters' shop is attached an open shed designed as a sawmill. The machine shop will be first described, and then the points in which the carpenters' shop differs from it explained. The latter having been built after the former was completed, it was possible to remedy in its design certain defects which had shown themselves on the completion of the machine shop. These shops were designed in 1902–03 by Major E. A. Edgell, R.E., data and drawings showing the requirements having been supplied by the Ordnance Department.

Machine Shop.

Dimensions.—The internal dimensions of the machine shop are 270′ long by 250′ wide. The width is divided into five spans of 50′ each, separated by rows of compound steel pillars which carry the roof trusses, the travellers, and the shafting for machinery.

Roof Construction.—The roof over the 50′ spans is carried by truss girders 5′ 6″ deep. The upper boom of these girders is composed of double channel steel bars $6'' \times 2\frac{1}{2}'' \times \frac{3}{8}''$, the tie of flat $6'' \times \frac{7}{16}''$, the struts of double angles $2\frac{1}{2}'' \times 2\frac{1}{2}'' \times \frac{1}{4}''$, and the diagonals of flat $2\frac{1}{2}'' \times \frac{5}{16}''$. The truss girders are carried direct on the standards, which are spaced 15′ centre to centre. The outer ends of the girders in the outer spans are carried on the walls of the building. On these 50′ truss girders the tiled roof is carried in three subordinate spans, each with the north side vertical to give north lighting, and the south side at a slope of 1 in 2·38. The slope in the vertical north faces is governed by the height required to give sufficient light. (See below, *Lighting*).

These subordinate spans consist each of coupled principal rafters of Sal wood $7\frac{1}{2}'$ apart, butting against a $4'' \times 3''$ rolled steel purlin or bressummer resting on the main truss girders. The heads of the coupled rafters support a $4\frac{3}{4}'' \times 1\frac{3}{4}''$ rolled steel purlin, which in turn carries the Sal wood common rafters 2′ 6″ apart. The latter continued upwards rest on a $4\frac{3}{4}'' \times 1\frac{3}{4}''$ rolled steel purlin at the head of the north lights, and their lower end rests on the $4'' \times 3''$ bressummer. A short length of rafter framed on to the upper end of the common rafters forms the northern eaves at the head of the north lights. The vertical north face of each subordinate span is filled in with glazed steel windows, running continuously the whole length of the shop and 5′ high.

When the building was completed it was found that the rolled steel bressummers and purlins were too light in section and had slightly buckled sideways. They had been calculated according to the usual rules, but the pressures allowed for were the resultants, normal to the slope of the roof, of the weight of the roof covering, occasional loads, etc., and the resistance of the beam had been taken as that through the direction of its greatest dimension. This method of calculation, which is the usual one in roofs, and is shown in the *Military Works Handbook*, makes no allowance for the resultant parallel to the slope of the roof of the external loads. In ordinary roofs, where the feet of the common rafters butt against a wall or are spiked to a wall plate, this resultant is taken up by the wall. When, as in the present case, the feet of the rafters are secured to a bressummer supported at the two ends only, this resultant will bring a lateral strain on the bressummer and purlins and tend to cause them to deflect sideways. This tendency can be guarded against by calculating the bressummers and purlins to resist in the direction of their least dimension the resultant parallel to the roof slope. When this defect was discovered, horizontal iron tie rods were provided, fastening the bressummers to each other and to the outer walls of the building. These prevented further lateral deflection, but did not remove that which had already taken place. The method by which this difficulty was avoided in the carpenters' shop, which was built later, will be seen when that building is being described.

Roof Covering.—The roof covering is of a special patent hexagonal tile, manufactured in Jubbulpore by Messrs. Burn & Co. These tiles proved unsatisfactory from the difficulty of making them fit, and this gave rise to leaks; Messrs. Burn & Co. have now discontinued their manufacture. Other shops in the factory are roofed with tiles of the Mangalore pattern, also made by the same firm.

The main pillars have to carry not only the roof trusses but also a 5-ton overhead electric travelling crane on three of the main spans. Up to a height of 18′ above the floor, where the gantry way for the overhead crane is set, they are compound pillars consisting of two

13″ × 5″ rolled steel beams, set 2′ 6″ apart and braced to each other horizontally and diagonally. At the top of the compound pillar is a plate on which is vertically set a single 10″ × 5″ rolled steel joist as a pillar to carry the roof trusses. The compound roof pillars were calculated to bear not only the vertical stresses due to weight of the roof etc., the traveller, the crane and its load, but also the horizontal stresses, both along and across the building, due to the movement of quick travelling cranes liable to be suddenly braked. The latter was taken as 25 per cent. of the moving load in either direction.

Height of the Shop.—The height of the shop is governed by the space necessary to permit of the overhead cranes clearing the lowest member of these truss girders. That, in this case, is 25′ 6″, and the truss girder being 5′ 6″ deep, the height to the top of the upper boom is 31′.

Lighting.—The lighting of the machine shop was originally derived entirely from the north lights in the vertical sides of the fifteen subordinate spans. These lights are 5′ high and run the whole length of the shop. The sashes are of steel, and the two middle sashes in each bay are made to open on horizontal pivots. The proportion of glass area in the north lights to the cubic contents of the shop measured up to wall plate level, is 1 square foot to 100 cubic feet. The lighting, except in the northernmost span is found quite adequate even on cloudy days in the climate of Jubbulpore. For this span, as the bottom of the north light in the roof is nearly 33′ above floor level, the light does not reach the ground for a horizontal distance of about 30′ from the foot of the north wall. The result was that the north side of this span near the wall was too dark to permit of work being properly done on cloudy days and in the late afternoons. Six windows, 6′ wide by 7′ high, were therefore pierced in the north wall to give the required light near the floor of this span.

Roof Gutters.—The gutters along the junctions of the subordinate roof spans are of galvanized sheet iron, semicircular in form, 16″ in diameter. On the upper side a flashing of similar material is provided and carried up under the tiles. The gutters, which are horizontal throughout their length, are calculated to carry off a rainfall of 1″ in five minutes. At the ends of the building the gutters discharge into hopperheads and 6″ cast-iron down pipes. These gutters have proved unsatisfactory, and throughout the two monsoons succeeding their erection leaked incessantly. From various causes great difficulty was experienced in locating and ascertaining the direct cause of the leaks, and various measures were taken without success to stop them. It became evident that the flashing was responsible for part, at all events, of the leaks, and it was eventually concluded that the joints in the sheets composing it were at fault. These joints had an overlap of only $\frac{3}{4}$″ and the sheets were screwed down to the soling boards underneath.

The flashing has since been taken up and relaid with 3″ overlap at the joints, and the sheets riveted together instead of being screwed down. A considerable improvement was observed in the portion of the roof which had been treated in this way before the end of the past monsoon, but it is uncertain that it will not also be necessary to treat the gutters themselves in the same manner. (See also remarks under *Gutters* of carpenters' shop).

Overhead Cranes and Tramlines.—In the first and third spans (numbering from the north) 5-ton electric overhead cranes are fitted on travellers capable of being moved the whole length of the shop. In the second bay a similar crane and traveller can be erected when required. The gantry which carries the traveller consists of a 16″ × 6″ rolled steel joist, and is supported on the shoulder of the compound roof pillars at a height of 18′ above the ground. On the north side of the north span the traveller rail is carried on the wall of the building, where an offset to receive it is formed partly by corbelling out and partly by setting back the upper part of the wall, which is of less thickness than the lower.

In Nos. 4 and 5 spans there is a system of overhead tramlines carrying 1-ton travelling pulley blocks, which permits of loads up to this weight being delivered to all the machines in those bays. The tramlines consist of a single 10″ × 5″ rolled steel joist, the travelling pulleys, which are of a special pattern, running on wheels, on the lower flange of the joist. The junctions at points where lines diverge are of a special form, not requiring switches, and were obtained by the Ordnance Department from the makers of the pulleys. The tramline joists are carried on a system of cross girders of 14″ × 6″ rolled steel joists 10′ apart supported on the roof pillars and on an intermediate line of 12″ × 6″ rolled steel pillars down the middle of these spans. These pillars and joists also carry the electric motors and shafting for working the machines in these bays.

Offices.—The shop contains two offices, one 12′ × 11′ for the foremen turner, and one 15′ × 14′ for the foreman fitter and foreman erector. They are raised 8′ above floor level so as to enable the foremen to oversee their workpeople. The spaces underneath are utilized as tool stores. The offices as originally built were enclosed only with expanded metal on wood framing, but in consequence of the heat prevailing in the shops in the hot weather and of the noise of the machinery the expanded metal has lately been replaced by teak panelling and glazing. The offices are built against the end wall of the shop, and each has a small window through the latter, to which a khus-khus tattee can be fitted in the hot season.

Tramways.—The shop is connected with the 1′ 6″ gauge tramway system which is provided all over the factory. A line of tramway goes down the centre of Nos. 1 and 2 bays, and one transverse line enters at a door in the north wall and traverses all the bays, with turntables at the junctions with the longitudinal lines in Nos. 1 and 2 bays. In Nos. 3, 4, and 5 bays the tramways only extend a short distance into the shop at both ends.

Broad Gauge Railway.—A branch from the 5′ 6″ gauge railway which serves the factory is carried past the end of the machine shop and has a siding there, so that carriages for repair can be delivered at the doors of the shop and new vehicles removed by rail.

Floor.—The floor of the shop is of $1\frac{1}{2}''$ stone flags on 3″ lime concrete. A wood block floor was asked for by the Ordnance authorities when the building was designed, but this was negatived on account of its excessive cost. The stone floor has suffered—especially near the doors—from the moving in of the heavy machinery, but now that the latter is done it ought not to receive damage.

Doors.—The doors are galvanized corrugated iron sheeting on angle steel framing. They are 10′ wide and 14′ high, except two, which are 15′ wide to admit extra large machinery, etc. The doors are made to slide in two leaves and were originally hung from the top on rollers running on a rail attached to the wall. These doors have given a good deal of trouble. Owing to their weight they constantly jam, and can only be made to slide with great difficulty. The supporting rail was bolted in the middle through the relieving arch, which carries the soffit filling of the main archways. The weight and jar caused some of these arches to fail. The weight of the doors was then transferred to the bottom on rollers running on rail sunk in a reveal in the floor. This saved the arches, but jamming was no less frequent and the rollers often ran off the rail, owing principally to the fact that when the doors jammed the factory operatives attempted to lever them along with crowbars. On one occasion they levered a door off the top rail so that it fell down, fortunately without injuring anyone. Stops were then attached, rendering it impossible for the door to be lifted off the rails. The tendency to jam has not been overcome and probably cannot be so entirely. It is due to the great height and weight of the doors and to the fact that the force used in moving them is applied at a distance below the point of suspension. Leverage takes place, tending to lift the door and cause a jam. The trouble is accentuated by dirt and stones getting into the roller track in the floor. It is altogether an unsatisfactory type of door. In some other shops where similar doors have been provided, but only 7′ or 8′ high, no trouble at all has been experienced. Doors of this large size were specially asked for by the Ordnance Department, but the necessity for them is not apparent. No vehicles that will be made in this shop require openings 10′ wide by 14′ high. The entry of large machinery could have been arranged for by leaving one or two large openings, and when the machinery was got in, bricking up the openings and fixing ordinary-sized doorways therein. This is what was done at the engine house where the machinery erected was larger than anything in the machine shop. Smaller doors would have sufficed for ventilation, as ample ventilation can be got from the top lights if desired. Moreover in the hot weather all openings are kept shut to exclude hot winds, and at other times only one or two doors are left open, as it is found that the operatives slip out and evade their work.

The general appearance of this shop from the interior is very satisfactory. It is difficult, however, to get a photograph to show it, and the one that accompanies this article does not do it justice. Standing near the south wall and looking northwards at the roof lights, one gets a view of a very large and almost uninterrupted expanse of sky. The lighting is excellent, and the shop generally is very well adapted to the purposes for which it was designed.

Cost.—The cost of the machine shop up to date, including all alterations mentioned above, has been approximately Rs.2,69,500, which gives a plinth area rate of Rs.3/14/0 per superficial foot.

CARPENTERS' SHOP.

The carpenters' shop is 320′ × 150′, the width being in three spans of 50′. The general design of the roof, with three subordinate spans to each main span, and the arrangement of north lights, etc., is the same as in the machine shop. The roof pillars and main truss girders, however, are spaced only 10′ apart instead of 15′, as in the machine shop. The purlins, being on this account shorter, have not buckled sideways as they did in the other shop, and the general addition to the strength caused by the smaller spacing makes the roof of this shop a very satisfactory one.

Roof Pillars.—As there are no overhead travelling cranes in this shop, the roof pillars are simple 18″ × 7″ R.S. joists. Double angle steel struts are carried from a point 10′ below the top of the pillars, which are 24′ high to the centre of the bressummers. These serve to stiffen the pillars and to give support to the bressummers.

Height of the Shop.—The clear height from floor to underside of truss girders is 18′ 6″, and the latter are 6′ deep over all.

Lighting.—The proportion of glass area to cubic space, measured to top of truss girders, is the same as in the machine shop, *i.e.*, 1 square foot to 100 cubic feet. It has not been found necessary to provide windows in the north wall. This may be due to the fact that the building is less wide, and there is, therefore, more reflection off the south wall; also it is less high, so that the north lights are nearer the floor.

Roof Gutters.—The gutters are similar to those in the machine shop, but they and the flashing have been made to overlap at joints, and the lengths are riveted together. There has been no great leakage. It is probable that sheet-iron gutters of this great length will always leak to a certain extent owing to the joints opening from the expansion and contraction. One curious incident occurred in connection with these gutters. During the course of an exceptionally heavy rainstorm the rain water filled the gutters to the brim quicker than it could be discharged by the down pipes. It then overflowed along the whole length of every gutter into the shop. As the rainfall, as measured by a rain-gauge, was considerably less than the calculated capacity of the gutter, this could not have arisen from the diameter of the gutter being too small. The down pipes are 6″ diameter, and these also are big enough to carry off more than the amount of rain that fell. The only conclusion, therefore, was that the flow was restricted at the entrance to the down pipe. The arrangement was that the end of the semicircular gutter was projected beyond the wall of the building over the hopper head, and was closed at the outer end with a sheet-iron plate (see *Fig.* 1); a 6″ circular hole in the bottom of the gutter let the water through into the hopper head. Evidently the water could not get away quick enough through this hole. To remedy this the cast-iron hopper heads were removed, the projecting end of the gutters cut off, and large sheet hopper heads substituted (see *Fig.* 2). These were made so that on the inner side they fitted and were bolted to the semicircular gutter, and the remaining sides were up to the level of the top of the gutter. This allows an unrestricted flow of water into the down pipe.

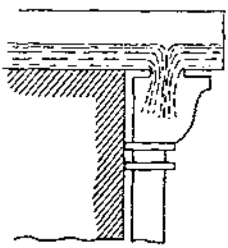


FIG. 1.

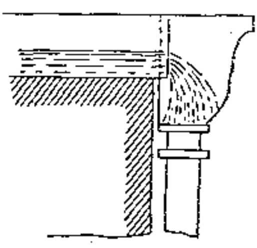


FIG. 2.

No storm of sufficient severity has since occurred to test the efficacy of this alteration, but it is unlikely that the gutters will overflow again. It may be noticed that the machine shop gutters did not overflow during the storm when this happened to the carpenters' shop gutters. This is probably due to the fact that the roof and gutters of the former are 70′ shorter than those of the latter.

Overhead Travellers, Tramways, etc.—There are no overhead cranes, but lines of overhead tramways for 1-ton pulley blocks similar to those in the machine shop exist in two out of the three spans. The joists which form the tramways are suspended from the main truss girders by flat steel hangers with angle clips. The trusses have been calculated to take the additional load of the tramways and their loads. On the floor lines of 1′ 6″ ordinary tramway enter the shop from the end nearest the timber stores, and pass through each bay and out the other end.

Other Details.—The floor, doors, and other details are the same as in the machine shop. There is also a small office for the foreman.

Basement.—In this shop the machinery is driven by motors situated in a basement under the floor. The floor of the basement is $8\frac{1}{2}'$ below that of the shop, and the latter is carried on brick pillars, rolled steel joists with curved corrugated-iron sheets resting on them, and lime concrete filling to the underside of the stone flags. The basement has only a rammed earth floor, and great difficulty has been experienced in making it dry. During the first monsoon after the completion of the shop the floor of the basement was under water. The subsoil water level in the vicinity of this shop, which is situated on ground that had been partially excavated out of side slope, is even in the dry season at about the same level as the basement floor, and during the monsoon is considerably above the latter. All efforts to pump out the water failed, as it came in as quickly as it was removed. The basement was therefore drained by a complete system of agricultural subsoil drains. The pipes used were glazed stoneware in short lengths, laid with open joints. Four lines of 6" pipes were given along the length of the basement, with 3" feeder lines 30' apart running into them diagonally. A brick inspection pit with stone cover was given at every junction. The drains were 1' 6" below the floor at their upper end, and laid at a fall of 1 in 400. At the lower end they were gathered into an 8" steel pipe, which was carried under the basement floor of the neighbouring saw mills, and thence into the factory main drain, which had to be lowered 3' to take it. This arrangement was very successful. Throughout the dry season the subsoil water was being drawn off through the outfall pipe, and during the next monsoon not a drop entered the basement. At the latter period the atmosphere in the basement smells somewhat damp, which is due probably to insufficient ventilation, and the earth floor feels at that time slightly damp to the hand. It has not been enough so far to affect the insulation of the motors or conductors.

Cost.—The cost of the carpenters' shop has been Rs.1,91,850, including the drainage of the basement. This works out to a plinth area rate of Rs.3/13/10 per superficial foot, which is a trifle less than that of the machine shop. The fact of its being 7' less in height than the machine shop is doubtless the cause of its cost being lower even though it has a basement beneath $\frac{2}{3}$ of its area.

REMINISCENCES OF THE SIEGE OF DELHI, 1857.

By MAJOR-GENERAL W. E. WARRAND, D.L., LATE R.E.

F.M. SIR EVELYN WOOD has lately given to the public, through the medium of *The Times*, a series of unconnected incidents of the great Indian Mutiny. There is, I think, a want of due proportion in his accounts of the various phases of the Revolt; some of the gallant actions in Central India are very fully described, whereas the operations of the Punjab Army, which held the Ridge before Delhi for three long summer months and eventually captured the fortress, are not given in any detail.

Little notice is taken by F.M. Sir Evelyn Wood of the difficulties which the Engineers had to contend with in the siege, and the bold and skilful way in which they were surmounted. The name of General Sir Alexander Taylor, G.C.B., is not even mentioned in his account of the capture of Delhi, although the heroic Brigadier-General John Nicholson wrote to Sir John Lawrence, the Governor of the Punjab, on 11th September: "General Wilson has made everything over to the Engineers, and they, and they alone, will deserve the credit of taking Delhi." And again, on the eve of the assault, he said, "If I survive to-morrow, I will let all the world know that Aleck Taylor took Delhi."

I have therefore thought it advisable to compile a brief account of the siege of Delhi, with especial notice of the work the Bengal Engineers had to undertake in the siege and capture of the fortress.

The defences of Delhi had been strengthened and improved a few years before the Mutiny by Lieut. Robert Napier (the late F.M. Lord Napier of Magdala). They were modernized forms of the ancient works; the bastions mounted from twelve to eighteen guns each, and were connected by long curtain walls built of solid masonry, 16 feet in height, 11 feet thick at top, and 15 feet at bottom. The circumference was about seven miles, the whole defended by a ditch and a glacis extending 50 yards from the counterscarp, and covering one-half of the walls from the besiegers' view.

On the 7th June General Barnard, advancing from the Punjab, found the Mutineers posted in an admirable position on both sides of the main road two miles from Delhi. To their right was a serai and a walled village protected by an impassable swamp. To their left, on rising ground, a sandbag battery for heavy guns had been constructed. On both sides the ground was swampy and intersected by watercuts. The fight began by a cannonade from the rebel artillery which caused us severe loss. No adequate reply could be made; our guns were too few and of too small calibre. The heroic gallantry of the 75th Foot in charging the guns, supported by the 1st Bengal Fusiliers, carried the day, and the rebels retreated hastily towards Delhi, leaving their guns on the ground; our men were much exhausted, but the General determined to push on and seize the Ridge before the rebels could rally or occupy another strong position.

The Ridge, on which the British force was to hold its own against vastly superior numbers for more than three months during the heat of summer and under the rain of the monsoon, rose about 60 feet above the city, and covered the main line of communication to the Punjab, upon the retention of which our very existence as a force depended. Its left rested on the unfordable Jumna; on the right a number of buildings and gardens afforded cover to the enemy, but at the same time impeded them in their attempts to organize an attack in force upon our flank or rear, the latter being well protected by a deep cut from the Najafgarh Jhil. The distance of the Ridge from the city walls, varied from 1,200 yards on our right to over two miles at the Jumna on our left.

Our troops being in position on the Ridge, the problem was, first, to hold our own against the repeated attacks of the enemy, and, secondly, how to take the fortified town in front of us. The first siege train comprised eight 18-pounders, four 8-inch and twelve 5½-inch mortars, with 150 European gunners, chiefly recruits—"a very trumpery affair with which to bombard and take a great city." Our resources in siege guns and ammunition were so limited, daily sorties, disease, and heat were making such ravages amongst our small force, and there was so little hope of receiving any considerable reinforcements, that General Barnard agreed to adopt a project worked out by three young officers of Engineers for taking Delhi by a *coup de main*. Orders were accordingly issued to the troops for an assault early on the morning of 13th June, but by a mistake on the part of the staff a delay occurred; day was breaking, rendering an unperceived advance to the walls impossible; a merciful dispensation of Providence which saved us from what would have been, almost certainly, a terrible disaster, when we think of the hard fighting encountered in the city by a much stronger force on its final capture.

For the next ten days, every day the alarm was sounded, attacks on our position being regularly made by the rebels, and though they were always driven back into the city with heavy loss, yet each attack cost us a number of valuable lives which could ill be spared, and we were practically besieged instead of being besiegers. The sun was the most deadly enemy; on the 23rd June, of ten officers in the 2nd Fusiliers, five were struck down by *coup de soleil* during a desperate attack for the first time on our left flank—as the rebels despaired from their numerous defeats in carrying our position on the right; they were driven back, but our troops advancing too far, suffered heavy loss from grape fired from the city walls. Thus ended our twenty-fourth actual engagement with the rebels since the 8th June.

On the 24th June Brigadier-General Neville Chamberlain arrived in camp, bringing with him Lieut. Alexander Taylor, of the Engineers, to act as Commanding Engineer, and it was he who introduced great and vital changes in our tactics. The whole Ridge had remained unconnected by any sort of breastwork; all communications between the batteries and picquets along the road which traversed the length of the Ridge had been effected at imminent peril; the relieving guards, the officers on duty, the orderlies, the native servants, all had to run the gauntlet of the enemy's fire between point to point. Now this evil was remedied, an almost unbroken line of breastwork was run up from the Flagstaff Tower on the left to our extreme batteries on the right. A large serai, with strong stone walls, was taken possession of and held as an advanced post on our right below the Ridge; sandbags were placed on the roof and it was properly prepared for defence, so as to be held by a moderate garrison. It was found to be very useful in preventing the use of the Delhi-Alipore road to the rebels if they tried to turn our right flank. Similarly, an old temple, called the "Sammy House," was occupied as an advanced post on our right centre, guarding against sudden attacks on our Ridge Battery. Experience had taught us the fatal policy of following up the retreating rebels, and orders were given that in future our position should, as far as possible, be purely defensive. When the rebels found that they could not lure a soldier beyond cover of his breastwork, they, too, changed their tactics, and instead of almost ceaseless harass days would now pass without any attack.

General Barnard died of cholera on 5th July, and was succeeded by General Wilson, of the Artillery.

Up to the 15th July the Chief Engineer had urged the General to attempt an assault on the city, but from this time forward, in consequence of our losses, all ideas of active operations against the place were abandoned.

The Engineers were busy in getting ready materials in their park for the construction of the magazines, platforms, etc., necessary for the final siege operations. Lieut. Aleck Taylor had been engaged in the siege of Mooltan in 1848, and this had given him some valuable experience; but all the other Engineers were subalterns, who had had but little or no training in fieldworks since they left Chatham; nearly all had been for several years engaged on roads and canals. Engineers could not be spared for military duty with the sappers, the companies being generally officered by infantrymen. Pasley's Siege Operations were at once studied, and practice in making field magazines, laying platforms, etc., was daily undertaken in the Engineer Park.

The labour available for the Engineer works consisted of—(1), about 120 of the trained Bengal Sappers who had not mutinied (the only remnant of the regular native army which was now in camp), and they behaved remarkably well; (2), of 800 Muzbees (or low-caste Sikhs), newly recruited as pioneers; and (3), a body of 1,000 common labourers on high pay, whose aid was invaluable from the first in relieving the fighting men from the digging and trenching in such fearful heat, and though without arms and untrained, rendered the most essential service during the siege, and, in spite of many casualties, worked cheerfully under fire. With the passive courage so common to natives, as man after man was knocked over, they would stop a moment, weep a little over their fallen friend, pop his body in a row along with the rest, and then work on as before.

That the siege operations should have been so successfully carried out with untrained men reflects great credit on the Engineers who directed the works, and especially on Lieut. Brownlow (now Major-General H. Brownlow), who, by his incessant activity in the Engineer Park, collected and made up the siege materials and carried out experiments in the best methods of arranging workmen, carrying materials, etc., etc.

On 1st August the actual force in camp may be set down in round numbers at 5,600 of all arms; of these some 3,500 were Europeans and about 2,100 natives; but, then, of the former 800, and of the latter 300, were in hospital, so that there remained fit for duty not more than 2,700 Europeans and 1,800 natives. On the 14th August General Nichōlson arrived with the Punjab movable column of 2,000 men. All felt that a great soldier had come among us, full-brained and lion-hearted, and one who would brook no delay in the siege. On the 4th September the siege train arrived. The excitement among all ranks now became intense; Delhi must now be taken within a few days at latest. Sir John Lawrence had despatched from the Punjab the last of his succours, and the city of the Mogul was doomed.

But some uneasily suspected that General Wilson would even now hold back. Anxiety had broken his health, and his nerves trembled as he thought of the magnitude of his task and the probability of failure. The truth was that he had written a few days before to Baird Smith, the Chief Engineer, explaining why it had been impossible to attempt an assault earlier, and saying that though he intended to begin more active operations on the arrival of the siege train, he could not hope to succeed until he was reinforced by the army from England. Baird Smith had insisted in reply that to deliver the assault as soon as possible would be the most prudent course, as the enemy would otherwise have time to learn our intentions and strengthen their defences.

The approach by parallels, that science has taught us how to make the siege of fortified places almost a certainty in the success of its results, was now of no service to us. Investment with our limited means was impossible. The attacking force was scarcely one-third of the numerical strength of the enemy, who had still possession of some important suburbs. It was necessary to select a front of attack on which all our available breaching power could be brought to bear. The front to be assailed contained the Mori, the Kashmir, and Water Bastions, with their connecting curtains. These works had, not many years before, been greatly strengthened by our own engineers, so that we well knew the force to be applied to their demolition. This front was selected, 1st, because our left flank would be protected by the river; 2nd, because the flanking fire from the city would be small, as only the Mori Bastion commanded the ground in front of it; 3rd, because there was excellent cover to within a short distance of the walls.

The general plan of attack was that which Baird Smith had projected before he joined the Delhi Army. It was the plan which had commended itself to all our Engineer officers from the first establishment of our army on the Ridge, and which Baird Smith, though wounded and ill, by his influence with the vacillating General, caused to be carried out.

Baird Smith, the Chief Engineer, was much enfeebled by sickness and distress of a painful wound, but when he ought to have been on the sick list he was busy in the works, never losing his high courage or his habitual cheerfulness. His second in command was Aleck Taylor, a man capable of any amount of work and ready for any enterprise. His energy was unbounded, and it was truly a fortunate circumstance that when Baird Smith was too ill to leave his tent, Taylor was ever ready to superintend all the engineering works. He was the heart and soul of every movement—always cheery, always active, never sparing himself, inspiring, aiding, animating all by his noble example. He had the sole executive direction of all the engineering department of the siege batteries which opened the way into the interior of Delhi; on the 7th the first heavy battery was traced 700 yards from the Mori Bastion. It was in two parts, the right of which was to batter the Mori Bastion, while the left was to hold in check the fire of the Kashmir Bastion; this deluded the enemy into the belief that the attack was to be delivered from the right only.

On the night of 7th September No. 1 Siege Battery was commenced; the moon rose on a busy scene, hundreds of camels, arriving, dropped their loads of gabions and fascines, etc., and by daybreak the battery for ten guns, with three magazines, was completed, but only one gun was mounted. The battery was built up to the sole of the embrasures entirely of fascines. We had little loss during the night, for though the noise of the camels, bullocks, etc., must have been great, the rebels probably thought it was one of our ordinary working parties cutting brushwood. With the first light, however, the enemy saw what we had been at. The Mori Bastion sent round after round of shot and grape, so that almost every man who ventured from the protection of the battery was knocked over. We had only one gun to reply to the storm, until Major Brind, R.A., dragged a howitzer well to the rear and fired over the parapet. In the meantime we had worked hard in the battery, and as each platform was finished, the artillery were able to open another gun on the enemy. Each shot told with tremendous effect at this range on the masonry, and the fire from the Mori Bastion became gradually feebler and feebler. By the afternoon it had ceased to fire, and was a heap of ruins. The enemy showed great pluck; they often managed to get a fresh gun into action and treat us to a few doses, till they were again silenced. Capt. Baird Smith wrote to Major Brind, R.A.:—"No. 1 Battery was unquestionably the key of the attack, and on its success depended the opening of Delhi to our assaulting columns. The progress of the other batteries depended upon its efficiency, and but for your moral courage, clear perception, and unwavering resolution in arming and working it, in spite of all obstacles, consequences would have followed causing the greatest embarrassment."

The cannonade continued with great effect on the 9th and 10th. Meanwhile the other batteries on the left were being constructed with but little interruption. No. 2, which was to batter down the Kashmir Bastion and breach the adjacent curtain, consisted, like No. 1, of two sections, the left immediately in front of a house known as Ludlow Castle, and the right a little to the right front of the same building; No. 3 was erected inside a ruined office of the Custom House, which the enemy had foolishly neglected to occupy. It was only 160 yards from the Water Bastion, against which its fire was to be directed. It was a happy stroke of genius to surprise the rebels by running up a battery 160 yards from an enemy, with his men lining the walls within easy musket shot. It was a task that required no ordinary nerve and skill to carry out. It was Lieut. Aleck Taylor's unaided idea; he had studied the ground well, and he had seized with quick soldierly eye upon the exact points at which it would be necessary to erect our batteries. He was one who thought nothing impossible, and all men worked under him with the heartiest goodwill. Those who were above him were equally impressed by his noble exertions. "If I survive to-morrow," said General John Nicholson, on the eve of the assault, "I will let all the world know that Aleck Taylor took Delhi." It must be remembered, however, that it was only by the influence of Colonel Baird Smith that the General allowed the siege operations to be commenced, and, when commenced, to be continued to the end.

General Wilson, in his letter of 20th August to Baird Smith, had pointed out that Delhi was seven miles in circumference, with an immense fanatical Mussulman population and a garrison of full 40,000 disciplined soldiers, with 114 heavy pieces of artillery mounted on the walls, with an unlimited supply of ammunition, besides 60 modern pieces of field artillery manned by trained gunners, and that it was evident to him the results of the proposed siege operations would be thrown on the hazard of a die; "but under the circumstances in which I am placed, I am willing to try this hazard, the more so as I cannot see any other plan to meet our difficulties. I cannot, however, help being of opinion that the chances of success, under such a heavy fire as the working parties will be exposed to, are anything but favourable. I yield, however, to the judgment of the Chief Engineer."

Baird Smith observed on the above:—"This, I think, everyone would allow, places on my shoulders the undivided responsibility for the results of the siege," and Baird Smith was not a man to shrink from the responsibility thrown upon him.

By the 12th September the fire from Nos. 2 and 3 had been most effective—the Water Bastion was a mass of ruins. The enemy, seeing the destruction of their defences, strove hard to make up for their past remissness. Round shot from enfilading guns on our right tore through the interior of the battery from end to end, while infantry, lining trenches fresh made in front of the walls, maintained a galling musketry fire. Yet the British gunners, unheeding their losses, regardless of the fearful heat, went on fighting their guns from hour to hour; never have guns been better served.

On the 13th Baird Smith and Nicholson arranged the plan of assault. Two Engineer officers—Medley and Lang—examined the main breach at 10 p.m., though the Sepoy skirmishers were firing away on their right some 30 yards from them. In five minutes they found themselves on the edge of the ditch, the dark mass of the Kashmir Bastion immediately in front. The counterscarp was 16 feet deep, and steep. Lang slid down first; Medley passed down a ladder and followed him. They saw that the breach was a good one, the slope easy of ascent, and that there were no guns in the flanks. They got back to camp safely, and reported the breach practicable. As the fateful moment drew near General Wilson's heart misgave him, and he wrote to tell Baird Smith that he feared it would be hopeless to assail the Water Bastion; but the Chief Engineer was firm, and promptly reassured him.

On the 14th the assault was delivered at four separate points. Two attacks on the left were directed against the breaches near the Kashmir and Water Bastions, while the 3rd column was to enter by the Kashmir Gate itself, which was to be blown open by an explosion party sent on ahead. This party consisted of Lieuts.

Home and Salkeld, of the Engineers, Serjts. Carmichael, Burgess, and Smith, of the Bengal Sappers, and eight native sappers to carry the bags of powder. Bugler Hawthorne, of H.M. 52nd Regiment, also accompanied the party to sound the advance when the gate was blown in.

There was an outer barrier gate, which was found open, and Lieut. Home then advanced over the broken drawbridge across the ditch with four men, each carrying a bag of 25 lbs. of powder which they deliberately laid at the foot of the gate. So utterly paralysed were the enemy at the audacity of this proceeding in open daylight that they only fired a few straggling shots, and closed the wicket with every appearance of alarm, so that Home, after laying his bags, jumped into the ditch unhurt. It was now Salkeld's turn. He also advanced with four other bags of powder, carried by sappers, and a lighted port fire; but the enemy had now recovered from their consternation, and had seen the smallness of the party and its object. Salkeld laid his bags, but was fired upon from the open wicket, not 10 feet distant, and was shot through the arm and leg. He fell back upon the bridge, handing the port fire to Sergt. Burgess, bidding him light the fuze. Burgess was instantly shot dead in the attempt. Sergt. Carmichael then advanced, took up the port fire and lighted the fuze, but immediately fell mortally wounded. Sergt. Smith, seeing him fall, advanced at a run, but finding that the fuze was already burning, threw himself down into the ditch, where the bugler had already conveyed poor Salkeld. In another moment a terrific explosion shattered the massive gate. The bugler sounded the advance, and with a loud cheer the 52nd Regiment sprang through the gateway.

Thus was accomplished one of the most daring acts on record. Salkeld, Home, Sergt. Smith, and Bugler Hawthorne received the Victoria Cross; but Salkeld, after lingering several days, died of his wounds. Rewards were also given to Havildar (Sergeant) Madhoo Rao and his eight native sappers who carried the powder bags, a faithful and heroic little band, whose comrades were mutineers fighting against them inside Delhi.

Towards evening General Wilson rode down to the city to see what progress had been made. The space between the Water Bastion and the Kabul Gate was in our hands. Lieut. Taylor, of the Engineers, had already taken every precaution for securing our position by loopholing, fortifying, and garrisoning the captured houses, etc., etc., but General Wilson was not satisfied. Owing to the failure of the right attack, that flank was still exposed, and even the first three columns had done little more than enter the city. Sixty-six officers and eleven hundred and four men had fallen during the day. The mutineers had lost heavily, but tens of thousands of them still remained. General Wilson spoke of withdrawing the troops to our old position on the

Ridge, but Baird Smith, to whom he turned for advice, insisted on his holding on. On the 15th no progress was made. On the 16th the magazine was taken; but the advance was dreadfully slow, our force was too weak for street fighting. On the 17th the Lahore Bastion was still in the hands of the enemy. The gallant Nicholson was *hors de combat*, and no advance had been made since he had fallen. The exposure of our few fighting men was by all means to be avoided. They had seen enough of it already. They courted no more; and if they consented, it was with manifest reluctance.

Happily, Alexander Taylor was alive, though severely wounded by a bullet in the chest on the morning of the assault. He returned to the city after two days' rest in camp, and suggested at headquarters that each brigade should be ordered to work under the guidance of Engineer officers attached to it, not along the open streets, but through the sheltered houses, during the advance, using them as means of communication. The project met with willing consent, and Taylor and his subalterns went about the work; but the progress was not rapid. On the evening of the 18th they were little further advanced than in the morning, for the Brigadiers did not fall in rapidly with the views of the young Engineers, or cheerfully recognize their temporary supremacy. So Taylor went to the General and drew from him an order to the Brigadier commanding at the Cabul Gate to place at his disposal 500 men to carry out the above-mentioned design, and early on the 19th the advance began in earnest. This was not one of the least of the great services of Aleck Taylor. Working onwards in this insidious but effective way by night we obtained possession of the Lahore Bastion, then the Burn Bastion, and on the 20th the King's Palace and the whole of the city were in our hands.

Thus fell Delhi just three months after the first arrival of the besieging force, and the lion's share of its capture can truly be said to be divided between two men—Baird Smith and Aleck Taylor—both Engineers.

To the former belongs not only the credit of evolving the daring plan of attack, but also the greater credit of taking the full responsibility of carrying out this plan with the small force at his disposal, and that at a time when defeat spelled ruin to the "British Raj" in India. Again, when the general, after the first assault, would fain have withdrawn his weary troops from their almost desperate position, it was due to Baird Smith's firm advice that they were left to cling with grim determination to the hardly-won outworks, from which they were eventually able to force their way into the city.

To Taylor belongs the credit of successfully carrying out the difficult details of Baird Smith's great plan. It was he who, by a stroke of genius, built his batteries right up against the massive walls of Delhi, and thus counterbalanced by its proximity the weakness of his ordnance. Finally, when the attack could be pushed no further, and was practically spent, it was his plan of advance which, in spite of the opposition of senior officers, ultimately enabled the sorely pressed columns to cut their way into the city and bring about its complete surrender by the final capture of the King's Palace.

And yet one of our leading generals, re-telling the story in *The Times* fifty years later, makes but a slight allusion to the work of Baird Smith and his Engineers, and omits entirely the name of Aleck Taylor ! !

It is true that this grave omission was rectified after attention had been called to it, but even so it is a curious commentary on the words of John Nicholson :—"The Engineers . . . alone will deserve the credit of taking Delhi," and "If I survive to-morrow, I will let all the world know that Aleck Taylor took Delhi."

RECENT IMPROVEMENTS IN INCANDESCENT LAMPS.

A Lecture delivered at the School of Military Engineering at Chatham, 7th November, 1907, by PROF. J. T. MORRIS, M.I E.E.

ALMOST exactly 100 years ago Sir Humphry Davy, working in the famous laboratories of the Royal Institution in London, produced for the first time the phenomenon, now familiar to us, of the electric arc. He produced it by connecting two pieces of charcoal to the terminals of a powerful electric battery, touching the charcoal rods together, and then drawing the carbons apart, when an "Arch of light," or "Arc light" as it is now called, was formed between the two carbons, giving out intense heat and light. This arrangement has since been greatly improved, and is at the present time the most efficient practical method we possess of converting electric energy into light. In passing, it is wonderful to note how varied are the accomplishments of the electric arc, for not only can it give out light, but, with special devices, it can be made to *sing* and *speak*, and, lastly, can be used to send wireless messages many hundreds of miles across space.

But it is not my object to give more than passing reference to this form of electric lighting. We must direct our attention now solely to the other common method of producing light by means of an electric current; that is, by the passage of an electric current through a *thin* solid conductor, which it heats by its passage to full incandescence.

Nernst Lamp.

Though not historically in order, I shall briefly describe, in the first place, the Nernst lamp. The light-giving rod in this lamp is made of the oxides of some of the rare metals, the materials not differing very greatly from those which are used in the familiar incandescent gas mantle. It is interesting here to note that Dr. Auer von Welsbach, in his experimental work on improving the electric incandescent lamp, found that it was more commercially possible to apply his researches to an improvement for use with gas instead of electricity, *i.e.*, in the well-known incandescent gas mantle! At a later date the Nernst lamp was developed. It consists essentially of the following parts:—(1), a light-giving rod as mentioned above; (2), a metallic resistance placed in series with the light-giving rod, and (3), a heating coil which can be automatically switched in and out of circuit. In the earliest form of Nernst lamp no heating coil was employed, and the lamp had to be lit by means of a match, thus entirely doing away with one of the distinct advantages electric light has over its rival, gas. Nowadays the heating coil is always employed, and together with it an automatic cut-out, which keeps the heating coil in circuit so long as the circuit is closed and the light-giving rod is not yet hot enough to give out light, but the moment this rod swells out into full brilliancy the automatic cut-out switches off the heating coil. As the light-giving rod in this lamp works in air, no vacuum is required, and the lamp has this further advantage—that it is essentially a high voltage lamp, that is, a lamp better suited for 220 volts than 110. But owing to the expense of the lamp and to the vagaries of the light-giving rod and the cut-out, it has not come into use as much as would have been expected, having regard to the fact that it gives nearly twice as much light for a given electric current as a carbon filament lamp.

Carbon Filament Lamp.

Turning now to lamps of the filament type, of course the most familiar example is the ordinary carbon filament lamp. As is well known, the essential features of this lamp are—(1), the filament is of carbon; (2), it must be wholly enclosed in a glass bulb; (3), the electric current must be capable of being led into and out from this bulb, and (4), the air inside the bulb must be almost completely removed. At the present day the mechanical processes utilized for attaining these objects are very highly developed. The exhaustion of the bulb is begun by mechanical pumps, and finished either by means of special mercury pumps or by chemical means. There is some hope that these methods may be improved by the use of the discovery that Sir James Dewar has made of the attraction of charcoal when cooled to a very low temperature for gases. If, for example, an electric lamp bulb which has only been exhausted by mechanical pumps be connected by means of a glass tube to a small bulb containing finely divided charcoal, and if this bulb containing charcoal be immersed in liquid air, the electric lamp bulb will in a short time be found to be almost completely exhausted of air.

Platinum wires have almost exclusively been used in the best class of lamp for leading the current into and out from the bulb, but of late a seal has come into use which consists of a copper wire of fine diameter, which has been rolled flat for a length of 10 mms., so that the thickness is reduced to ·075 of a millimètre. This extremely thin strip is coated with soft enamel glass and then sealed into the bulb in the usual manner, and, apparently owing to the extreme thinness of the copper, the difference of expansion between glass and copper is not sufficiently serious to cause the two materials to crack away from one another, and so spoil the vacuum.

Possible Materials for Filaments.

We must now turn our attention to the other materials which can be used for filaments, and for this purpose let us study the following table of melting points.

Melting Points of Elements (Degrees Centigrade).

Copper	... ...	1084
Platinum	... ...	1730
Tantalum	... ...	2150
„ Filament	... ...	2910 (not pure)
Osmium	... ...	2200
Titanium	... ...	2500
Tungsten	... ...	3080
Carbon	... ...	3500

From this table we see that if the highest melting point is to be a guide, carbon would unquestionably be the best material to use. Owing, however, to the fact that carbon, at a very much lower temperature than its melting point, throws off a large number of excessively tiny particles of carbon, if used at too high a temperature, the glass bulb in which the filament is would soon get seriously blackened, and so cut off a portion of the light which the filament is giving. The use of the large bulb in the high efficiency carbon lamp reduces this deleterious effect.

Platinum was used in some of the earliest experiments, but, unfortunately, besides its expense, it has the further disadvantage that its melting point is far too close to the temperature at which the filament must be run in order that it shall give a useful return of light for a given expenditure of energy. Hence, commercially, Platinum cannot be used. The next material on our list is Tantalum, and this metal has been used by Messrs. Siemens & Halske with great effect in the now well-known Tantalum lamp. Platinum. Tantalum.

Osmium was employed before Tantalum for a metallic filament lamp, but, partly owing to the fact that its price is even greater than that of Platinum, the cost of the lamp was excessive, and though this lamp may be considered the pioneer of the metallic filament lamps, it is practically obsolete now except for very low voltages. Osmium.

Tungsten (or Wolfram, its alternative name), a very heavy metal of density about 18, is very largely in use at the present time for the manufacture of metallic filament lamps, and silica is also being used with very efficient results in the Helion lamp. Tungsten. Silicon.

In the manufacture of these metallic filament lamps we have to contend with a difficulty which is not serious in the case of the carbon filament lamp, that is, the great length of filament required for a given voltage. If we compare these lamps we find that in a carbon filament lamp the length of the filament per 100 volts is from 4 to 9 inches, while in the Tantalum lamp it is about 26 inches, and in the Osram lamp some 20 inches. These great lengths necessitate special means of support for the filament. *Figs.* 1, 2, 3, and 4 show the various methods adopted for tackling this problem. The expansion of the filament has to be allowed for, and adjacent loops of the Arrangement of Filament.

filament must be prevented from touching one another. Some of these lamps, such as the Tantalum and the "Z" lamps, can be used in any position, whilst others can only be used with the filaments hanging downwards in a vertical position.

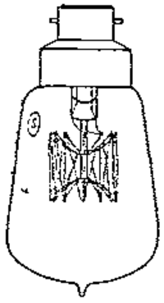


FIG. 1.—*Tantalum*, 110 *v.* 25 *c.p.*

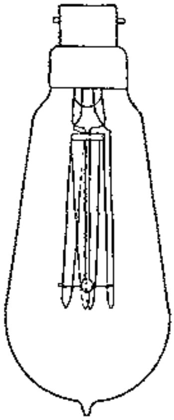


FIG. 2.—*Osram.*

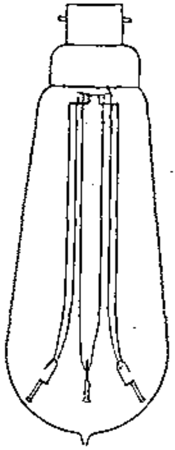


FIG. 3.—*Just-Wolfram*, 110 *v.* 40 *c.p.*

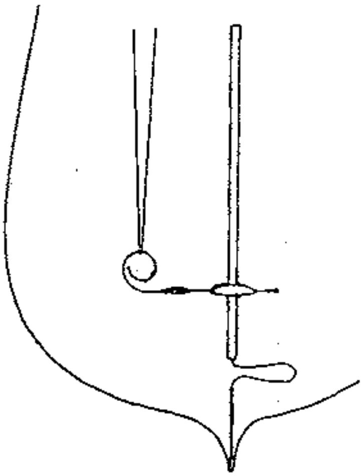


FIG. 4.—*Method of supporting Single Loop in "Z" Lamp.*

Variation of Resistance with Voltage.

We will now study the effect of variation of voltage on the resistance of these different types of lamps. *Fig.* 5 collects together the results. We see at once that carbon, when heated, decreases largely in resistance, whilst Tantalum, Osram, and other metallic filament lamps do exactly the reverse, that is, increase greatly in resistance as the voltage is raised. Quite recently the metallized carbon lamp (G.E.M.) has been introduced. It has an efficiency which is a considerable improvement on the ordinary carbon lamp; its voltage resistance curve is also plotted on this curve. This lamp has the characteristic feature of the metal filament, except at very low voltages, when it shows the characteristic of the carbon filaments. One result of these changes in resistance is that on switching a carbon filament lamp into circuit at constant voltage, the initial current is smaller than the final current, whilst with the metal filament lamp the initial current is many times greater than the final current (see Table II.).

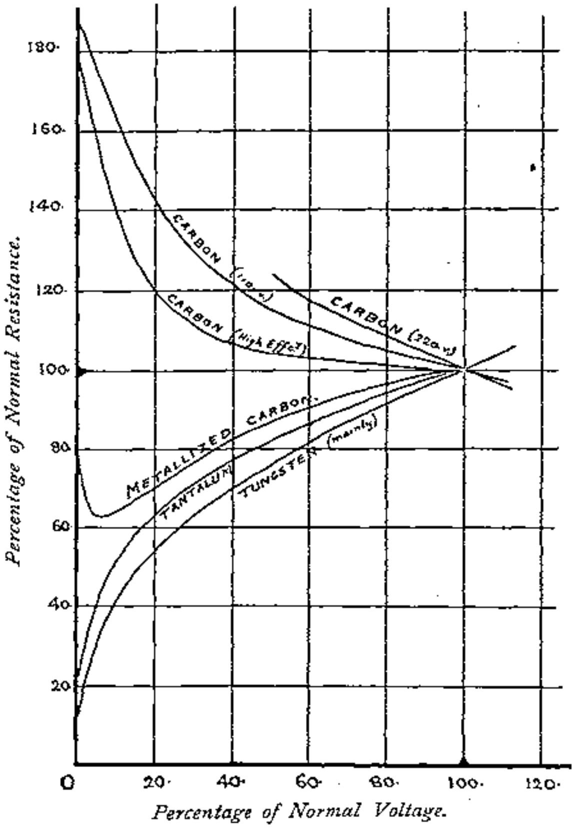


FIG. 5.—*Relation of Resistance to Voltage.*

TABLE II.

Lamp.	Initial Current. Ratio of Final Current.
Carbon	·55
Tantalum	6·0
Osram	8· to 12·
Just-Wolfram	about 12·

A consequence of this, which may be of practical importance, is that the metallic filament lamp lights much more quickly than the carbon filament lamp, and this may possibly be turned to useful account in some forms of signalling. Occasionally, signalling is carried out by means of switching on and off a carbon filament lamp. If in place of a carbon filament lamp a metallic filament lamp were used, the signals should be much more sharp, and hence a given number of signals by means of metallic filament lamps should be capable of being sent in a reduced time. The same result could be achieved by using a number of low candle-power carbon lamps in parallel.

Changes during Life of Lamp.

The next portion of our subject deals with the changes which occur in the filaments during the course of their life. The carbon filament, which initially has a bright metallic-looking surface, after running for some hundreds of hours, becomes more or less sooty in appearance, and is then not so useful in converting electric energy into light. The Tantalum filament, when used with direct currents, slowly changes its appearance from that of a smooth bright metallic wire to a wire having a pitted surface; occasionally, too, the wire gets slightly disjointed. When used, however, with alternating currents the Tantalum filament appears to break up into a number of very short lengths, and joins together again, but out of alignment. Some experimenters have even observed when these lamps are at work on an alternating circuit that a tremor goes through the filament lamp for no apparent reason. It has been suggested that the filament actually breaks while working, and the little arc at the contact welds the filament together again, but not exactly in line. However that may be, when a Tantalum filament has broken, it can very often be repaired merely by judiciously tapping the lamp when in circuit, so as to get the broken ends to touch again, when they appear to weld together, and make a really sound joint. These troublesome defects are said to have been considerably minimized in the more recent types of Tantalum lamps. As far as my experience goes, in all metallic filament lamps the material seems to get more brittle as the life of the lamp goes on, and it is not advisable to support these lamps in such a way that they will be subject to vibration during their later hours of life.

Relation between C.P. and Voltage.

Turning now to the effect of the variation of candle-power of these lamps when different voltages are applied to them, we have to accept the fact that all commercial electric supplies do not continuously give exactly the "declared pressure," but that the pressure is constantly fluctuating between certain limits, which on some circuits might well be narrower than they are. If these fluctuations of pressure are not to cause visible fluctuations in the light emitted by the lamp, then the increase in the candle-power produced by an increase in voltage must be small. Table III. gives the percentage change in candle-power produced by a ·1 per cent. change in volts.

TABLE III.

Type of Lamp.	C.P.
Ordinary carbon	6·5 per cent.
Metallized ,, ...	4·6 ,,
Tantalum	4·6 ,,
Osram	4·0 ,,
Just-Wolfram	3·9 ,,
Zircon	4·0 ,,

From this Table it is clear that the carbon filament lamp is the worst for use on a fluctuating pressure, whilst the Osram, Just-Wolfram, and Zircon are the best. If, however, an alternating current of constant effective value be supplied to any filament lamp, owing to the fact that the current flowing through the lamp passes through zero value twice in each cycle, the light emitted by the lamp must fluctuate also, even though the number of cycles per second be as high as fifty. The question then arises—Is this fluctuation serious? Experiments have been conducted to test this point in the following way:—A disc (see *Fig.* 6) was fitted on to the shaft of an alternator which supplied the alternating current, having as many radial slits in it as the alternator had poles. If a lamp fed by the

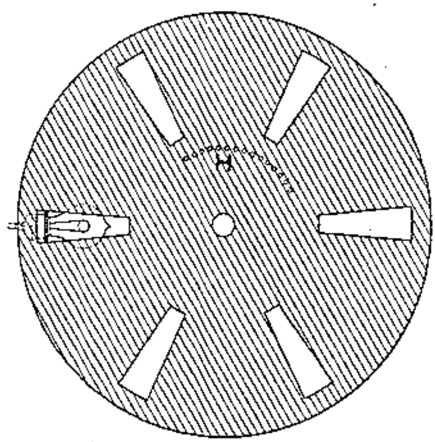


FIG. 6.—*Disc used in Experiments on Instantaneous Variation of Candle-Power.*

alternating current from this machine was examined through these slits while the alternator was running, the light emitted by the lamp which passed through the slit to the eye of the observer was the light corresponding always to the same instantaneous strength of the alternating current. Now if the disc was displaced through a given angle on the shaft of the alternator and the lamp again examined, the light emitted would now correspond to another instantaneous current strength. The results obtained by this mode of experimenting are given in *Fig.* 7. These curves show that though the flickering of the lamp is small at a frequency of 60 cycles per second, yet it is quite appreciable; and, of course, for lower frequencies the effect would be more marked.

I have collected in Table IV. the efficiencies of a number of these metallic filament lamps, and included some figures relating to arcs for purposes of comparison.

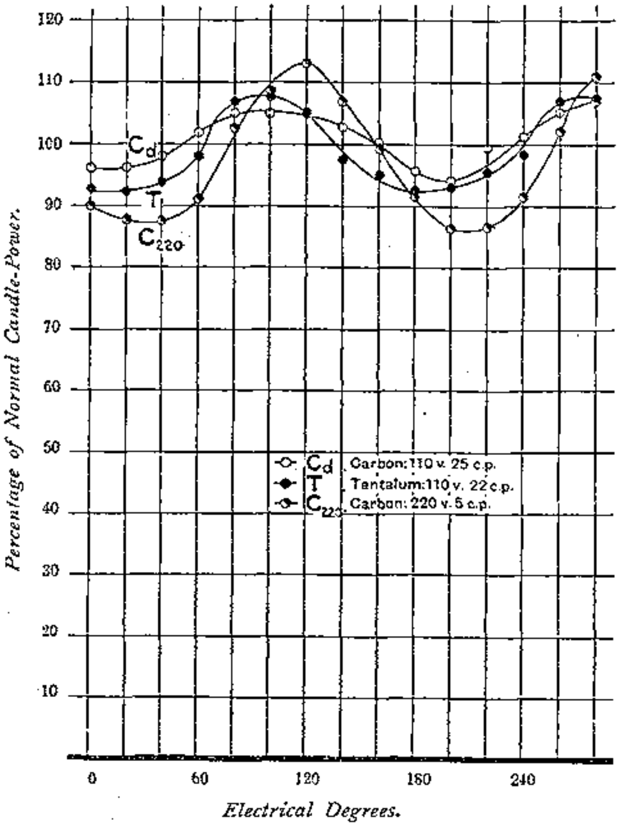


FIG. 7.—*Instantaneous Variation of Candle-Power at Frequency of* 60.

TABLE IV.—*Efficiency of Electric Lamps.*

	Watts per C. P.	C. P. per Watt.
Carbon	3·5	0·29
Metallized Carbon	2·7	0·37
Nernst	2·1	0·48
Tantalum	1·9	0·53
Tungsten	1·3	0·77
Helion	1·1	0·90
Arc (open)	1·0	1·0
Arc "Excello" (globe on)	0·4	2·5
Arc "Excello" (globe off)	0·26	3·8

The first column of figures in the table marked watts per candle gives what is commercially called the "efficiency" of the lamp, but really it should be called the *inefficiency* of the lamp. The last column gives the *real efficiency*, that is, the candle-power obtained per watt. From these figures it will be seen that one can reduce the amount paid for electric energy used in lamps to about one-third of that previously used for the same candle-power by the use of certain metallic filament lamps. And though the cost of the metal filament lamp is much greater than that of the carbon lamp, yet it is financially quite sound to pay from three to four times the price for a lamp, if by so doing, the current bill be reduced to a third, for in a carbon lamp about 13 to 15 times the cost of the lamp is paid for current used by the lamp during its lifetime.

In concluding, I will place before you (Table V.) some approximate figures relating to filament lamps, and would draw your attention to the present limitation of the voltage for which these metal filament lamps are made, *i.e.*, about 130 volts as a maximum, and also to the fact that the smallest candle-power obtainable is rather large.

TABLE V.—*Approximate Values.*

Name of Lamp.	Watts per C.P.	Useful Life in Hours.	Max. Voltage.	Min. C.P.	Price.
Ordinary Carbon ...	3·5	1000·	240·	5·	1s.
High Efficiency ..	3·0	500·	220·	25·	2s. 3d.
Metallized Carbon ...	2·7	1000·	130·	16·	1s. 9d.
Nernst	2·0	Uncertain	250·	25·	4s. to 16s.
Tantalum	1·9	1000·	130·	23·	2s. 9d.
Osram	1·3	1000·	120·	28·	3s. 3d.
"Z"	1·25	1000·	120·	28·	—
Helion	1·0	over 1000	110·	30·	—

NOTE.—Both Osram and "Z" lamps have been made experimentally for circuits of 200 volts, but as yet are not commercially obtainable.

An examination of these results leads us to the conclusion that although the efficiency obtainable nowadays is from three to four times that which could be obtained ten years ago, yet there is plenty of room for further scientific research in the laboratory, as well as for improvement of commercial processes.

Finally, let us hope that keenness of competition will cause us to persevere until a really good and healthy light may not be considered in any way a luxury, but may be within the reach of all.

ELECTRICITY SUPPLY.

By Capt. R. C. Hammond, R.E.

A short time ago, through the courtesy of the chief engineer of the Bournemouth and Poole Electricity Supply Company, I was afforded an excellent opportunity of visiting one of the largest electric supply works in the South of England. The following notes made at the time are intended to give a short description of the work I saw, and incomplete as they admittedly are I hope they may yet prove of use to officers interested in the subject.

The Bournemouth and Poole Electricity Supply Company supplies electric light for Poole, Branksome, Bournemouth, Boscombe, Southbourne, and Christchurch; also power for a considerable portion of the Bournemouth Electric Tram system.

The authorised area of supply is 54 square miles, with a population of 110,000, although the actual number of consumers is 3,500.

The annual output is 3,000,000 B.T. units.

Maximum load 2,000 k.w.

45 miles of high-tension mains.

120 „ „ distributing „

The main works are situated in the Bourne Valley about 2¼ miles from the centre of the town of Bournemouth. The Bourne, from which the town derives its name, is an insignificant stream by no means capable in itself of supplying the large amount of water required for the Company's works, and the additional sources of supply are therefore utilised.

Some of the feed water required for the boilers, is pumped from a well 269 ft. deep. The water is lifted by compressed air supplied by a quadruplex compressor driven by an electric motor; the pressure maintained being 42 lbs. per square inch and the rate of discharge about 4,000 gallons per hour. The diameter of the bore hole is 7 inches. The water is distributed to storage tanks by a centrifugal pump driven by an electric motor which is automatically started by a float switch.

Even then the combined supply of water thus obtainable from the Bourne and the well is insufficient for the normal requirements of the works. More water is certainly obtainable from the Water Company's mains, but it is so hard that it has to be softened before it is fit for use in the boilers, and the expense of using it in large quantities is almost prohibitive. It is therefore necessary on the score of economy to collect the condensed water from the engines and to purify it so that it may be again used in the boilers. This is done by treating it with a mixture of the following solutions; alumina ferric, carbonate of soda, hard water. This causes the oil to coagulate and be retained by the sand filters through which the mixture is passed, the purified water then passing through to feed tanks.

The Boiler House contains six boilers of the Babcock and Wilcox water-tube type capable of evaporating 120,000 lbs. water in the hour. Only small coal is used in the furnaces: it is conveyed by a bucket conveyor to overhead bunkers in the boiler house, the bunkers containing about 1,000 tons. The coal is drawn from the bunkers by automatic weighing shoots and miniature hoppers, and the furnaces are fed by moving chain grate automatic stokers. The cinders are removed by the conveyor as it passes back under the boiler house. The draught is effected by exhaust fans, so as to save building high chimneys. The flue gases are analysed in an automatic CO_2 recorder, a valuable aid to the economical control of the furnace, and these gases are afterwards utilised for heating the feed water.

The Engine Room.—To provide traction power for the tramways; a continuous current is employed at a pressure of 550 volts, capacity 400 k.w. For the electric light system and small power users, an alternating current is employed, potential 2,200 volts, total capacity 3,400 k.w.

The continuous current 'traction' set.—This has its own condenser, and the cooling water is either obtained from the Bourne brook or cooled by being pumped up on 'cooling towers.' The engine is a vertical fully-enclosed compound one, running at 400 revolutions per minute. The dynamo is 6 pole 550 volts, and can be run either as compound or shunt wound.

The alternating 'lighting' sets.—In the daytime, when the load is light, a self-contained set consisting of engine, alternator and exciter, all on one shaft, is sufficient.

For night work, with full load, five larger sets are brought into use, three of 400 k.w. each, and two of 1,000 k.w. each. These are separately excited from a small direct-current machine at low pressure. For each of the three smaller sets there are two vertical enclosed compound tandem engines running at 212 revolutions, whilst the two larger sets are driven by triple-expansion engines running at 250 revolutions. The alternators generate 2,000 volts at 100 periods per second. Steam is supplied to the engines at 150 lbs. pressure and heated to 450° F., *i.e.* about 100° super heat; this, it is found, increases economy and reduces leakages. The machines are perfectly balanced and run so smoothly that it is difficult for the onlooker to realise that each of these large dynamos represents a mass of 30 tons revolving 250 times in the minute. Needless to say, with this class of machinery, the most stringent precautions are taken to exclude anything in the nature of grit or dirt from the engine room.

The switch-boards are situated in a raised gallery running along one side of the engine room. The high-tension switch-boards are of cellular pattern, with all conductors behind glass screens. No unauthorised person is allowed in this part of the establishment. Underneath is a second gallery whence the cables radiate and which also contains appliances for regulating resistance. In connection with the 'traction' installation there is an automatic booster for regulating charge and discharge from a battery of accumulators. In accordance with Board of Trade regulations no precaution or device is neglected for ensuring the safety of employés, and the only fatal accident which has occurred was due to the victim having been guilty of a flagrant breach of orders.

The Distributing System.—With the exception of the two outlying sub-districts of Poole and Christchurch, the method of distribution is as follows:—The alternating current from Bourne Valley is conducted by five high-tension concentric feeders to the chief distributing centre situated in Bournemouth Central, and from there it is further distributed by high-tension cables to transformer chambers all over the district. This process of distribution necessitates the introduction of several high-tension inter-connecting chambers at various points between the distributing centre and the transformer chambers.

The pressures, in the different branches, are regulated at the distributing centre by means of booster transformers, these being static machines regulated by hand.

The transformer chamber is used for transforming the high-tension current into a low-tension current for delivery to consumers. The current passes to the transformer, thence to a maximum indicator, and thence to a distributing box, whence it is taken up by triple concentric distributing cables and delivered to consumers on the 3-wire system at a pressure of 100 or 200 volts. The pressure of supply is at 200 volts in all the more recently supplied areas, the lower pressure of 100 volts occurring only in the older parts of the system.

At the Head Offices of the Company may be seen a most interesting display of lamps, photometers, meters, etc., but as Lieut. Lloyd Owen has recently given the readers of the *R.E. Journal* a good description of the latest types of filament lamps I do not propose to describe them.

To ascertain the illuminating power of any lamp it is necessary to compare it with a standard lamp under the same voltage. This can be done by an instrument known as a photometer. The standard lamp is placed at a fixed distance from the photometer head; the new lamp is then approached to the photometer head from the opposite direction until the latter records that it is receiving an equal intensity of light from each lamp. The candle-power of the new lamp can then be read off on the graduated scale. The two principal types of photometer are the 'flicker' and the 'stationary' type. In the former, so long as the light received was not the same from each lamp, a 'flickering' was observable whilst watching an illuminated segment rotating in the centre of the instrument; whilst in the latter type one side of a wedge-shaped surface would appear less brilliantly illuminated than the other side. The process of comparison involved adjusting the distance of the unknown lamp until the flickering in the first case or the dividing line of shadow in the second were no longer observable. As regards the relative merits of these two types of photometer, it is found that when the lights to be compared are of different colour the flicker photometer is the most sensitive; but with lights of the same colour the flicker photometer is not so good as the best stationary photometer such as Bunsen's.

Lastly as regards meters; these are mostly on the motor principle, whereby the current in its passage rotates a disc connected to the recording mechanism. In other meters the current in passing through a liquid liberates gases, and their volume when measured forms a record of the amount of current which has passed. And, finally, there is the 'shilling-in-the-slot' meter. Any ordinary type of motor meter can have attached to it a mechanism by which a small switch is opened at a moment defined by the number of revolutions that the meter disc has made. The mechanism is set by the insertion of coins in a slot, and any number of coins up to 25 may be inserted at one time. The switch will then be open until current equivalent to the value of all these coins has been consumed.

In another type of 'shilling-in-the-slot' meter a copper ribbon is wound down into a chemical solution, a fixed amount for each shilling inserted. The passage of current through the copper and solution erodes the copper, so that, by the time current equivalent to the value of the coins inserted has passed, the submerged portion of copper strip is entirely consumed, and so the circuit is broken. This latter type can only be used on a continuous current supply and the amount of current thus obtainable for 1s. (some 1·7 units) is sufficient to light one ordinary carbon filament lamp of 8 c.p. for 56 hours.

THE SCHOOL OF ESTIMATING AND CONSTRUCTION AT THE S.M.E.

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

On the 15th September, 1825, an order of the Master-General and Board of Ordnance was published directing that a course of Practical Architecture should be instituted at the Royal Engineer Establishment at Chatham.

Lieut.-Colonel Pasley, as Director of the Establishment, shortly afterwards got out an *Outline of a Course of Practical Architecture, compiled for the Use of the Junior Officers of the Royal Engineers.*

This was one of the most valuable of Pasley's handbooks, and has had a longer life as a text-book than any other S.M.E. publication, having been subsequently reprinted in 1862.

The preface to the book is here reproduced :—

"His Grace the Duke of Wellington, Master-General of the Ordnance, having been pleased to direct that Practical Architecture should in future form part of the course of study of the junior officers of Engineers, and having approved of General Mann's proposition that it should be conducted at this Establishment, and that Mr. Robert Howe, Clerk of Works of the Establishment, whose mechanical skill and ingenuity, as well as his knowledge of the practical details of architecture, are well known to the Corps, should be employed to assist in carrying on this branch of duty as Professor of Practical Architecture, I have been induced, as Director of the Establishment, and responsible for the general execution of all the duties, to give my attention to this subject, and to endeavour, by the able assistance of Mr. Howe, to bring the proposed course of Practical Architecture to a system. I have, accordingly, commenced the following work, which I have entitled an *Outline*, etc., because it is not my intention to write a complete course, even if I were qualified for so doing. The most difficult branches of Practical Architecture have for some years past been treated of in this country by very able writers, amongst whom Mr. Peter Nicholson deserves the praise of having been the first to show so useful an example, which has since been followed by Mr. Tredgold and others. But there are several parts of this important subject which those writers have scarcely noticed, probably from the circumstance of their being generally known to all persons regularly brought up to the profession of architecture or to the mechanical trades connected therewith.

"My object has been to endeavour to fill up those deficiencies, an attempt which, if successful, may be useful to the junior officers of the Corps, who are often sent to the British Colonies soon after they enter His Majesty's Service, and are there required to perform duties analogous to those of architects or civil engineers, without having had any previous opportunity of acquiring a practical knowledge of the details of those duties; and where, although they will derive considerable assistance from a good collection of the books before alluded to, they will still find themselves at a loss in respect to many particulars of considerable importance, which are not sufficiently explained.

"In the course of this undertaking I have already derived considerable assistance from the liberal communications and information afforded me by some of the most eminent civil engineers and builders of this country and the persons in their employment, and I hope to derive equal benefit from the same source in the remainder of my work. A series of plates connected with it has been drawn by Mr. Howe, but, according to the custom adopted in my former elementary writings, I have generally preferred introducing figures extracted from those plates into the body of the work, opposite to those parts of the subject which they are intended to illustrate.

"Having, from circumstances, had less experience in those matters which form the subject of this work than most officers of the same standing in the Corps, if my brother officers will favour me with any remarks which they may consider useful I will be much obliged to them, as a few copies only have now been lithographed, under an expectation of improving the work in a second impression, after more information shall gradually have been collected.

"I have heard it remarked by some gentlemen in civil life that it seems almost too much to expect the same individuals to combine the habits and feelings of the military life with the laborious pursuits of men of business. In exacting both from the Corps of Royal Engineers the Government of this country appear, however, to have acted more wisely than if they had confined the Corps to military duties solely. The same kind of talent and knowledge that render an Engineer officer capable of forming the project of military works, and of arranging and directing great masses of workmen in a siege, or in fortifying the position of an army in time of war, by a very little more study will enable him to superintend the construction of public works of equal importance in time of peace; and if the Government did not find employment of that description, such as the superintendence of public buildings, barracks, etc., and the execution of other public works for the officers of the Corps of Royal Engineers and the soldiers under their orders, it would be necessary in time of peace either to employ them in the common routine of infantry duties or to disband them. There is no other alternative, for their being allowed to remain idle is out of the question.

"By combining science and industry with the activity, zeal, and spirit of the military character, and by considering none of the multifarious duties that he may be required to perform as a drudgery, since they are all equally useful to his country,* the young officer of Engineers has it in his power not only to establish a reputation for himself, but to contribute towards maintaining the fame of his Corps as one no less useful in peace than distinguished in war."

The last sentences of the foregoing preface, illuminated and framed, now hang in a place of honour in the Construction School, in order that Pasley's splendid ideal regarding the combination of science, industry, and the soldierly spirit may be placed before successive generations of R.E. officers while going through the course of Construction and Estimating.

The following is a complete list of the various officers who have held the appointment of Instructor or Assistant Instructor in this branch of study :—

INSTRUCTORS IN THE ARCHITECTURAL COURSE.

Mr. Robert Howe	1825-54
Mr. G. R. Brock	1854-66
Capt. T. B. Collinson	1861-66

INSTRUCTORS IN ESTIMATING AND CONSTRUCTION.

Capt. and Brevet Major H. Wray ...	1866-74
Major P. G. L. Smith	1874-79
" H. C. Seddon	1879-85
" A. J. C. Cunningham	1885-90
" E. C. S. Moore	1890-93
" G. K. Scott-Moncrieff	1893-98
" J. Winn	1898-04
" E. M. Paul	1904-

ASSISTANT INSTRUCTORS.

2nd Capt. H. C. Seddon	1867-72
Capt. W. R. Slacke	1872-75
" J. T. Marsh	1875-79
" A. G. Clayton	1879-84

* In respect to those details of duty alluded to, which are the most uninviting, such as the superintendence and measurement of barrack repairs, the receipt of materials, etc., the young officers of Engineers will do well to recollect that upon the strict and faithful execution of their orders when so employed the saving of thousands to the public may depend.

Capt.	C. L. Young	1884-88
"	W. H. Turton	1888-93
Lieut.	E. M. Paul	1893-98
"	J. Lang-Hyde	1895-00
"	J. B. MacGeorge	1898-02
"	S. G. Faber	1900-05
"	E. E. B. Wilson, D.S.O.	1902-06
"	G. J. P. Goodwin	1905-
"	P. O. G. Usborne	1905-07
Capt.	E. N. Stockley	1906-
"	A. M. Henniker	1906-
Lieut.	J. G. Fleming	1907-

Pasley's chief title to fame in connection with his work in the Architectural School is based on his discovery of the hydraulic properties of cement manufactured from chalk and Medway mud, now universally known as Portland cement. From a constructional point of view, the invention of Portland cement ranks probably, with Bessemer's improvements in steel manufacture, and the use of reinforced concrete, as one of the three most important inventions of the nineteenth century. To this day the greater part of the Portland cement made in England is manufactured on the banks of the Thames and the Medway.

The course, as originally framed by Colonel Pasley, although termed architectural, was confined for the most part to builder's work and timber structures. It was based on Tredgold's and other manuals of that time, and instruction in estimating and measuring up work was given in the office of the C.R.E.

Capt. Collinson,* 1861–1866, continued on much the same lines.

Major Wray, 1866–1874, introduced a more particular study of Applied Mechanics, and in general carried out the course on more scientific lines. He brought out a text-book entitled *Instruction in Construction* in 1872. In this book the subject was treated from a mathematical standpoint, and calculations for plate and lattice girders, iron roof trusses, masonry retaining walls, reservoir dams, etc., were introduced, in order to keep pace with the general advance in engineering science and the largely increased use of iron, due to improved manufacture. This book was successively revised by Majors Percy Smith, Seddon, and Cunningham, and was used as a handbook at the S.M.E. until 1893.

Major-General E. Renouard James, in an obituary notice of Lieut.-General H. Wray in the *R.E. Journal* of the 1st June, 1900, writes as follows of the work done in the Construction School at Chatham

* Capt. Collinson was one of the R.E. officers who was employed on the Great Exhibition of 1851 under Colonel Sir William Reid, K.C.B., R.E.

when Wray was appointed Instructor in Estimating and Construction on the 1st June, 1866 :—

"The newly-joined Engineer officer came to Chatham fairly grounded in mathematics and geometry; he could make some sort of a military survey of ground; draw and read plans; and (if ever so little artistic) sketch a landscape intelligently enough to illustrate a report; he had also learnt the elements of mechanics, mineralogy, and chemistry. His intellect, therefore, was in a properly receptive state to enable him to learn how to build a house, construct a bridge or a roof, or lay out a line of railway. Yet, the Chatham course in the arts of construction, as conceived by the authorities at the time under the advice of the estimable Mr. Brock, left the young officer exactly where he began—if, indeed, he did not forget much he had already learnt—and the average man left Chatham incapable of designing or superintending the erection of the simplest work. There were notable exceptions, of course, as, for instance, Wray himself, Fowke, H. Y. D. Scott, Seddon, Colin Scott-Moncrieff, and others, but the assertion is correct in the main. Our course consisted of little beyond colouring a series of outline plans, and the official idea seemed to be that this practice would have the effect of forcing the information these contained into our intellectual pores in some such manner as brine is absorbed in the pickling of pork. But, as the importance of neatness was much impressed on us, we learnt little more than the art of putting on flat washes of red and blue. No attempt was made to teach us how to apply statics and dynamics to the art of designing. We had no instruction as to the materials we should use in different countries; the estimating and taking out quantities for work ended by the mere copying of one page of figures. Can it be wondered at that many an one of us, finding the need of such knowledge in after life, had to grind it out for himself far away from libraries, with the humiliating feeling of dependence on clerks of works in carrying on works in his charge?

"Wray changed all this. On no account whatever should an officer be employed to copy plans! The proper use of an officer—in his view—was not this; and he merely required to be satisfied that sufficient technical knowledge of plans had been acquired at Woolwich, and in future all copying work ought to be done by subordinates. It should be the duty of the officer to supply the draft design, but it would be sufficient if this were made in pencil outline, provided that every essential dimension was figured. The stability of arches, the thicknesses of abutments, the scantlings of timber, the details of girders, the diameters of pipes, and, in fact, all matters involving calculations of strength, tension, compression, and so on, the officer must be personally responsible for. Directions should be given as to the materials to be used, and it would be sufficient at first for the officer to make an approximate estimate of cost. He should give rough sketches of the decorative details, artistic as far as he could make them so without loss of time. From the officer's notes the draughtsman and quantity clerk should make careful plots and a first estimate; and the officer, watching the working out of his ideas, should direct the necessary amendments as the work proceeded. It might become necessary to have the plans and estimates made more than once before elaborate drawings could be finished; but, even if this were the case, the pay of the draughtsman and quantity clerk would be well worth the saving in cost which would accrue by sparing the valuable time of the officer.

"Such were Wray's principles. They took concrete form in his well-known book on *The Theory and Practice of Construction*, the first edition of which was published in 1872. Sir J. Lintorn Simmons, Commandant of the School of Military Engineering, seconded Wray's efforts thoroughly, and in a letter dated December 27th, 1872, referred to the book 'as a lasting proof of the great benefit conferred, not only on the Corps, but on the public service.' By the examples given of the various constructional problems met with by Engineers, and by the clearness with which theory was reduced to practice in their solution, a long-felt want was supplied; and the book was at once accepted by the profession of civil engineers, as much as by our officers, as the best manual extant. The information it contained and the formulæ have been extended and applied to new inventions by Seddon and others; but the value of the original work remains undisputed, and it is acknowledged to be a pattern of what such a book should be.

"Wray remained at Chatham nearly eight years, during which period (as the Corps records show) nearly 300 second lieutenants benefited by his instruction. The principles he laid down are still in force, and (as it may be asserted that the great majority of our officers on the effective list have been trained on his system) their adoption has been of incalculable advantage to the entire Corps. Such a monument of the work of one man is the noblest which could be raised in his memory, and it might be said of him proudly:

'Si quœris monumentum, circumspice.'" *

A short obituary notice in the *R.E. Journal* of the 1st June, 1893, describes Major Percy Smith's work in the following words:—"He was a most painstaking, conscientious worker, always striving to do his very best, and, at the same time, unusually modest and retiring.

"The three volumes of *Notes on Building Construction* published anonymously by Messrs. Rivington for the use of the Science and Art Schools in connection with South Kensington are a lasting monument to his patient industry and capacity for mastering details. It is far

* *Corps Archæologia*, No. 3, pp. 122—125.

and away the best book of the kind which has ever been brought out, and many of his friends greatly regretted that the author's name should remain unknown to the thousands of teachers and students who have profited by it. A fourth volume on *Theory of Construction* was published in 1891."

In Major Seddon's time, 1879–1885, the practical part of the course was strengthened by his *Notes on the Building Trades and Building Construction*, first published in 1873, and by Slacke's *Notes on Drainage*, the first English text-book on the subject, published in 1875. Various useful pamphlets were also got out about this time by Capts. Marsh, Clayton, and Young, on doors, windows, stairs, roofs, etc.

Major Cunningham (1885–1890) brought with him Indian experience and great mathematical knowledge. At this period the principal schemes worked out by officers under instruction were designs for barracks and a plate girder, with some subsidiary schemes involving walls, roofs, stairs, etc.

Major E. C. S. Moore (1890-93) developed the study of sanitary engineering, and brought out a text-book entitled *Sanitary Engineering Notes*, and another entitled *Notes on Gas*. The former, under the title *Sanitary Engineering*, was enlarged by Colonel Moore, and re-published in 1898 by Batsford. It is recognized as a standard work on the subject.

Major Scott-Moncrieff (1893-98) introduced into the course a good deal of general engineering, including the study of railways, harbour works, and reservoirs. He wrote two text-books, *The Water Supply of Barracks and Cantonments* and *Principles of Structural Design*. He may be said to have given a practical trend to the course in the working out of schemes and engineering problems.

Major Winn (1898–1904) maintained the up-to-date character of the course, and introduced the study of reinforced concrete. His *Notes on Steel Concrete*, the first book on the subject published in English, is still in use.

The present policy of the Construction School is to keep in close touch with modern engineering practice, to familiarize officers with the application of the principles of applied mechanics and architecture by frequent practice in designing various structures in connection with military buildings, and in the preparation of schemes for the water supply and sanitation of cantonments both at home and abroad. Manuals dealing with various classes of structures are being revised and prepared to this end.

In the winter of 1905 an "Advanced Course" of three months' instruction was instituted in addition to the six months' S.M.E. course of instruction, hitherto authorized, but not always completed in the case of every officer.

This procedure still obtains, the object of the course being to give officers such professional information as will fully equip them for their duties as divisional officers at home and in the colonies.

The great advance of late years in engineering science has somewhat changed the character and scope of the course of "Estimating and Construction," so that some more comprehensive title, such as "Civil Engineering and Design," would better designate what is dealt with in the course as at present constituted.

The training of N.C.O.'s as Military Foremen of Works forms an important section of the School. Some twenty-two or so pass out annually, and after a probationary period obtain the rank of Staff Sergeant Military Foreman of Works. Their course lasts eleven months. This includes short furloughs and instruction in survey (one month), electric bell-fitting (fifteen days), the remainder of the time being devoted to instruction in building work, sanitation, water supply, estimating and R.E. services, and practical inspection of works in progress. Of recent years the educational qualifications have been increased so as to secure the best men, and raise the standard of technical attainments and knowledge.

N.C.O.'s, men, and buglers are also trained as architectural draughtsmen; this course lasts 150 days, and is a very comprehensive one.

Quite recently it has been decided that all N.C.O.'s proceeding to India shall receive a training as draughtsmen and in engineering subjects, which will fit them for their duties with the Corps of Indian Sappers and Miners, and Military Works Services. The course lasts about one and a-half months.

The best known, as well as the earliest established of the S.M.E. prizes, is given for proficiency in the Construction course. This is the Fowke Medal, which was instituted to effect a memorial to Capt. Francis Fowke, R.E., who died in London on 4th December, 1865, and who was undoubtedly the most distinguished architect that the Corps ever produced, and consequently a short *resumé* of his career may not be out of place in this article.

He obtained his first commission in 1842, but it was not until 1857, when he was appointed to the staff of the Science and Art Department as an Inspector, that he was given an opportunity of displaying his talents in this particular direction. At that time the offices of the Science and Art Department were located in Marlborough House. On the transfer of the Department to South Kensington, Fowke was charged with the superintendence of the buildings there. While engaged in this work he built picture galleries to receive the Sheepshank, Vernon, and Turner National collections. As architect and engineer of the Science and Art Department he designed the Museum of Science and Art at Edinburgh, and improved and enlarged the Dublin National Gallery. He planned the buildings for the International Exhibition of 1862, and the exact proportions of the picture galleries and the system of lighting were adopted afterwards in France at the Paris Exhibition of 1867.

In 1864 an open competition was held of designs for buildings to be erected on the site of the 1862 exhibition. Fowke, who did not make up his mind to compete until seven weeks before the drawings had to be sent in, was unanimously awarded the first premium.

At this time, and until his death in the following year, he was engaged in the erection of the present South Kensington Natural History Museum.

In the large entrance court—a quadrangle of about 100 feet span—he glazed over the entire roof without a single support, in order that the objects exhibited might not be interfered with by columns.

With the assistance of Mr. Godfrey Sykes, the decorative artist (*Dict. Nat. Biog.*, Vol. LV., p. 256), Fowke was working at the terra-cotta exterior decorations of the building, and at the highly-ornamented columns of the same material, at the time of his death, in December 1865.

Sir Henry Cole, one of Fowke's colleagues in the Science and Art Department, spoke thus of him at a meeting of the Society of Arts:—

"I firmly believe that the arts of construction in this country have sustained a great loss by Capt. Fowke's death. At this period, when art is so transitional, and science is making so many discoveries, and men's minds are seething with inventions, when the use of new materials is being constantly manifested, and the new adaptation of old materials is constantly entered upon, England has lost a man who felt the spirit of his age, and was daring enough to venture beyond the beaten path of conventionalism. Capt. Fowke, to my mind, was solving the problem of the decorative use of iron, and, by appreciating the spirit both of the Gothic and Renaissance architects, was on the threshold of introducing a novel style of architecture, when, alas! death, at the early age of 42 years, has cut short his promising career."*

The prize was instituted at a Corps Meeting in 1866. The Commandant of the S.M.E. submits annually to the Council of the R.E. Institute the names of one or more young officers who have lately passed through the School, and whom he considers to have specially distinguished themselves in the School of Construction, and a Silver Medal is duly awarded. A similar medal but in bronze is given annually to the non-commissioned officer who has most distinguished himself in the same subjects whilst under instruction in the Military Foremen of Works Class.

The following is a complete list of officers and N.C.O.'s who have gained the Fowke Medal since the institution of the medal in 1871:—

* *R.E. Professional Papers*, Vol. XV., 1866, p. 15.

OFFICERS.

Lieut. M. F. Ommanney	1872
„ C. H. P. Christie	1873
„ H. E. McCallum	1874
„ H. E. Rawson	1875
„ M. H. P. R. Sankey	1876
„ A. H. Mason	1877
„ J. H. Cowan	1878
„ A. G. Thomson	1879
„ J. A. Tanner	1880
„ E. H. Hemming	1882
„ W. A. J. O'Meara	1884
„ C. H. Enthoven	1886
„ P. B. Molesworth	1887
„ T. Fraser	1888
2nd Lieut. C. H. H. Nugent	1889
„ W. E. R. Dickson	1890
„ N. J. Hopkins	1891
„ A. G. Stevenson	1892
„ W. H. Jones	1893
„ C. F. Anderson	1894
„ A. A. Crookshank	1895
„ H. O. Mance	1896
„ H. de L. Pollard-Lowsley ...	1897
„ P. S. Greig	1898
„ C. M. Browne	1899
„ C. F. Birney	1900
„ E. W. C. Sandes	1901
„ E. de L. Young	1902
„ H. T. Morshead	1903
„ A. H. L. Mount	1904
„ L. V. Bond ... ... }	1905
„ C. E. Colbeck ... ... }	1905
„ L. E. Becher	1906
„ R. Hamilton	1907

NON-COMMISSIONED OFFICERS AND SAPPERS.

Sergt. T. Laman	1871
Corpl. J. Sutherland	1872
„ L. Boyce	1873
Sergt. J. Hussey	1874
2nd Corpl. W. Baker	1875
Corpl. G. Michie	1876
Sapper J. Fraser	1877
Corpl. A. Jones	1878

Sergt. F. Bowling 1879
Corpl. J. McLeod 1880
2nd Corpl. S. McKetterick 1881
Corpl. A. Cox 1882
2nd Corpl. C. Lloyd 1883
Corpl. W. Sherman 1884
,, G. Chimes 1885
Sergt. A. McIntyre 1886
Corpl. W. Dallas 1887
,, E. Cubbon 1888
2nd Corpl. J. Bullock 1889
,, T. Barnett 1890
Corpl. T. Smith 1891
,, F. Palmer 1892
,, R. Smith 1893
,, W. Cooper 1894
,, T. Welsh 1895
2nd Corpl. J. Harkness 1896
Corpl. G. Polkinghorne 1897
2nd Corpl. H. Lawford 1898
,, R. Gingell 1899
Corpl. B. Salter 1900
2nd Corpl. H. Peacock 1901
Corpl. A. Parsons 1902
,, H. Parke 1903
,, J. Boyd 1904
2nd Corpl. E. A. Wilmshurst 1905
,, A. W. Reynolds 1906
,, H. Osborn 1907

MEMOIR.

General Sir Edward Charles Sparshott Williams, K.C.I.E., Colonel Commandant, Royal (late Bengal) Engineers.

To the veterans of the Royal (late Bengal) Engineers, to the many officers of the Corps who went to serve in India soon after separate recruitment for the Indian Corps had ceased, and to all concerned with the Government of India from the days of Lord Lawrence and Lord Mayo to the present time, the name of General Sir Edward Williams will always be closely and honourably connected with the great State Railways of India. Indeed, to their creation and administration, in close and intimate association with his eminent chief, General Sir Richard Strachey, G.C.S.I., R.E., he devoted the more mature years of his service, both in India itself and subsequently at the India Office in London.

Proud of his Corps, proud of the great part it had played both in the field and in the development of Indian resources by the successive stages of roads, irrigation works, and railways, Williams in the early years of his service had a full share of the manifold duties which in those days, even more than now, fell in the way of and were the opportunities of the energetic young Sapper officer, and his brilliant abilities and remarkable capacity for orderly detail carried him successfully through a succession of new and difficult charges, from each of which he emerged with increased repute.

An interesting summary of Williams' services, which appeared in *The Times* on the 3rd October, 1907, is here reproduced in full.

"General Sir Edward Charles Sparshott Williams was one of the dwindling band of Indian veterans who were sufficiently experienced at the time of the Mutiny to hold positions of considerable importance and responsibility. Educated at the Royal Naval School, New Cross, and at Addiscombe, he was commissioned to the Bengal Engineers in 1848. When still scarcely out of his teens he was Adjutant of the Engineer Corps in Fort William, Calcutta, and concurrently was studying the machinery and equipment of the Calcutta Mint. For a short time he was extra Assistant Secretary to the Military Board—an authority which came into considerable conflict with Lord Dalhousie, and subsequently underwent substantial reform. It was in the capacity of Adjutant of Engineers that the young officer saw his first and only war service. This was in Pegu in 1852, when he was present at the bombardment and capture of Martaban and Rangoon (where he was slightly wounded), the capture of Prome, and the occupation of Meaday. He was mentioned in despatches for gallant conduct, and was awarded the medal with clasp. He remained in Burma to superintend the topographical survey of Pegu, and on returning to Calcutta was made Principal of the Civil Engineering College. During the Mutiny he was Under-Secretary to Government in the Public Works Department. In 1860 he left Calcutta to undertake the principalship of the Thomason Engineering College at Rurki, the chief institution of its kind in India. He returned to headquarters, however, in 1863 as Under-Secretary of the Public Works Department, and this position he held for six busy years, the department being then actively engaged in the development of railways and other communications which had been shown to be so desirable by the events of 1857. But Williams was a strenuous worker, and not only did he join the Bengal Sanitary Commission, but for twelve months held charge of the office of Inspector-General of Forests. Next came a transfer to Bombay as Mint Master and Commissioner of Paper Currency. He returned to headquarters in 1867 as Deputy-Secretary of the Railway Branch of the Public Works Department, a position he continued to hold till his retirement from India in 1880, save for three years' interval as Director of State Railways. His wide and varied experiences in the public service were naturally utilized by the Secretary of State, who appointed him in March, 1880, Deputy-Director of Indian Railway Companies. Twelve years later Lord Cross advanced him to the headship of this branch of the Public Works secretariat at the India Office, and a few months afterwards he was promoted from the Companionship of the Indian Empire, conferred upon him in 1878, to a Knight Commandership. Sir Edward Williams retired from the India Office in 1897, with the proud record of well nigh half a century of service of the Indian administration in manifold capacities, all in turn admirably filled. Sir Edward Williams was twice married, his first wife dying in 1857, and his second in 1872."

Of his early school days I am unable to add further particulars, but at Addiscombe Williams was head of his term, and on getting his commission in the Bengal Engineers in 1848 was the first recipient of the Pollock Medal then founded, and from that time the hall-mark of the most distinguished officer of his term. When Addiscombe was closed in 1861, the Pollock Medal was transferred to Woolwich, and in 1885 it was won by his only son, now Major H. B. Williams, D.S.O., R.E.

Shortly after his arrival in India in 1851 Williams was appointed Adjutant of the Corps in Calcutta, and on the despatch of the Burma Expedition in 1852 he accompanied it as Adjutant of Engineers in the Pegu Force.

A surviving brother officer,* himself the most modest of gallant soldiers, and honoured in later years by the Victoria Cross for subsequent services, has personally told me of Williams' gallantry in the stockade fighting of that expedition, and this same brother officer was the chief actor in the following episode, which an old friend, from whom I quote at greater length below, has cited to me as a remarkable evidence of Williams' intense love of fair play.

"During the first Burmese war young Williams, with several brother officers, who were always foremost in the fray, had rushed a stockade. Williams' sword having broken in the hand-to-hand conflict which ensued, he grappled with a powerful Burman, until a brother officer put an end to the struggle by passing his sword through the body of the Burman as the two wrestled together on the ground. Then Williams rose and indignantly protested against the interference, saying he ought to have been allowed to finish his fight fairly."

Williams was mentioned in despatches, and on the close of the war was appointed to superintend the survey of Pegu. In that capacity he prepared and published for the use of his assistants *Astronomical Memoranda for the Use of Surveyors*, and this is the only published work of his which I can trace, though the records of the Government of India are full of his masterly investigations of railway problems.

Soon after his return from Pegu to India he was appointed Under-Secretary to Government in the Public Works Department, a responsible appointment, which, to his great regret, he was not allowed to leave for active service during the Mutiny of 1857.

Throughout his service he looked forward to further employment on active service, but the early war service in Burma was all he was destined to see.

As will be seen by reference to the outline of his services, it was after a varied experience that Williams, then a major, entered upon the larger duties involved by the adoption in 1869 of a policy of State construction and administration of the railways needed to complete the great system projected by Lord Dalhousie.

Closely associated with General Richard Strachey during the inception of this policy, with which the names of Lord Lawrence and Lord Mayo are inseparably connected, Williams was responsible for the organization of the large department constituted to carry the new policy into effect. The results achieved are the best testimony to his success. A large mileage of railway has been constructed of excellent quality and at moderate cost, and the financial results are satisfactory. There were 5,000 miles of railway in 1870; there are now nearly 30,000.

* Major-General William Salusbury Trevor, V.C., R.E., the brother officer alluded to, died in London on 2nd November, 1907, just after this was written.

This memoir would be incomplete without a reference to the acute controversy which arose in India and in Parliament over the gauge of the Frontier Railways of the Punjab and Sind, but it will suffice here to say that Williams, who had an official part to fill in this controversy, lived to see with satisfaction the fuller protection of the North Western Frontier of India by a greatly extended system of standard gauge railways.

Of his personal administration of the great staff of Royal Engineers and Civil Engineers who were employed under him in surveying and constructing new railways in all parts of India and Burma, the testimony of one of his trusted lieutenants might be thought partial, and in this matter I am allowed to quote the following extract from a letter from my old and valued friend, Sir Guilford Molesworth, whose official association with the subject of this memoir began early in 1870, and was of the most intimate nature.

Sir Guilford Molesworth writes:—"Coming out as I did to an important appointment in the P.W. Department (Consulting Engineer to the Government of India for State Railways), at a time when the Department had only recently emerged from the condition of an almost 'Close Borough' of Royal Engineers, I naturally (as a Civil Engineer and an interloper) expected to experience some jealousy and friction, but, from first to last, Williams met me in the most cordial and friendly spirit, affording to me most valuable assistance in taking up the duties of my new office, and giving me every help and information in his power. I was greatly impressed with his wide and liberal views, his grasp of the subject, his power of organization, and his ability as an engineer. My official relations with him soon ripened into a warm personal friendship, which only ended with his death.

"It is to be regretted that he did not remain longer in India to assist in maintaining the Indian State Railway policy, which he so ably inaugurated and which was eminently successful, but which has unfortunately been in some measure abandoned, or modified, of late years.

"That which impressed me most in my official connection with him was his extreme conscientiousness, his rectitude, his aversion from anything underhand, his abhorrence of anything like a job, and his love of fair play. He was always most careful not to allow his *esprit de corps* to bias him when a choice had to be made between a Civil and a Royal Engineer."

A devoted public servant, careful of the interests and jealous of the honour of the Government he was proud to serve, dealing with large questions boldly, but critical almost to a fault of details, Sir Edward Williams, both as Director-General of Railways in India, and as Government Director of Railways at the India Office, devoted his great abilities to the expansion of the railways, which he held to be so essential to India's peace and progress. Fully alive to their commercial importance, he never forgot that it is by just and firm government, supported by the railway and the telegraph, that we sustain our military position in India, and he claimed, with acceptance by the best authority,* that it was due to the vigorous development of the railway system that "the total military force of India has been diminished rather than increased since 1857."

In his relations with his large staff he was a strong disciplinarian, but always ready to consider and adopt suggestions which stood the test of his keen powers of criticism. Appreciative of ability, he was a considerate and generous chief to all who gave the Government what he thought the best of their service. Himself thoroughly in earnest in all he undertook, he was intolerant of what he thought half-hearted service, and did not hesitate to let the shirker feel his hand.

In private life generous and hospitable, the soul of honour, no less earnest in his religious views than in his service to the State, General Sir Edward Williams, who became Colonel Commandant of the Corps in 1890, lived a full and active life to within a few days of his last illness, and died in London on the 2nd October, 1907, at the good old age of 76, leaving behind him a family of two daughters and the son above mentioned, and also a large circle of warm friends and admirers, who will, I trust, pardon the imperfections that must be found in this short memoir by the present writer, who is proud to have had his friendship.

W. S. S. BISSET.

* General Sir George Chesney, K.C.B., R.E., *Indian Polity*.

REVIEWS.

NAVIGATING THE AIR.

ESSAYS PUBLISHED BY THE AERO CLUB OF AMERICA.

THIS collection of essays, written by members of the club, will be found of great interest by those who wish to get some idea of the progress recently made in aeronautics.

The *Preface* gives a general account of the formation, objects, etc., of the club.

The *Introduction* describes the principal airships and flying machines from the time of "La France" up to the last efforts of Santos Dumont and Prof. Bell. It is a useful and well-illustrated summary, but does not of course go into much detail.

Chapters I. and II. discuss the machines constructed by the Messrs. Wright. Unfortunately very little information is given about the machines themselves, but the articles are of importance as they give statements by reliable persons which prove clearly that the Messrs. Wright really have performed the feats so frequently reported.

Chapter V. is interesting, as Mr. Ludlow describes his machine and his attempts at flight. There is a good photograph showing the aeroplane in actual flight under the guidance of the inventor.

Chapter VI., by Mr. J. P. Holland, the designer of the submarine boat which bears his name, is perhaps the best in the book. Commencing with some quite pardonable chaff of the various gentlemen who told him that submarines could never be got to work properly, and would be of no use if they did, the author goes on to describe some of his early schemes for flying machines. On page 63 he gives a design of a machine to be worked by muscular energy; but it must be confessed that the success of such an apparatus appears to be very doubtful, as it is not by any means clear that a man has sufficient power to maintain himself in the air. He next goes on to consider the flight of birds, taking the albatross as an example. His calculations for the lifting power do not, however, seem to be very convincing, as he makes out that the lift, when the bird is moving at the rate of 35 miles an hour, with a wing inclination of 6°, is 1·8 lbs. per square foot of wing area, or only about half the amount required. This is clearly incorrect. Any well-shaped surface of wing type, as, for instance, Lilienthal's Table IV. type, will carry nearly 2½ lbs. per square foot under the given conditions, and there is little doubt that the albatross type of wing is much more efficient than that designed by Lilienthal.

With regard to the question of rarefaction of the air over a bird's wing, it is very satisfactory to find that the author gives full credit to Mr. Phillips for the discovery of this important fact. He discusses the machine constructed by this gentleman in detail, and points out its effectiveness.

The chapter concludes with a description of a machine designed by Mr. Holland himself; it is very much of the Phillips type, with certain alterations, such as a movable aeroplane, etc.

Chapter XIV., "Critical Remarks on Progress," is of interest because Mr. Manley was for a long time associated with the late Prof. Langley, and helped him very considerably in his experiments. He gives a good deal of general information about these experiments which has not hitherto been published, and emphasizes (though that is hardly necessary) the great importance of Langley's work.

Space does not allow of a detailed discussion of the numerous other essays, many of which are of great interest; but the study of them can be recommended to those who wish to get a good general idea of recent aeronautical progress.

The illustrations are numerous and clear.

J. D. FULLERTON.

THE PROBLEM OF FLIGHT:
A TEXTBOOK OF AERIAL ENGINEERING.

By H. CHATLEY.

This work, which is a somewhat ambitious attempt to provide a textbook of aeronautics for members of the engineering profession, contains a fair amount of useful information. It is doubtful whether it will be found of much practical use, as its general arrangement is somewhat confused, and important aeronautical details, such as the shapes, dimensions, etc., of birds' wings, etc., have either been omitted altogether or only very briefly touched upon. No doubt this will be remedied in future editions, but the want of what may be called more purely aeronautical information is certainly a failing in the present one.

Considering the chapters in detail:—

Chapter I. describes briefly the reasons why the subject has been so much taken up lately, and enumerates the different classes of aerial vessels.

Chapter II. gives a very brief summary of certain general principles connected with flight, and ends with Mr. Chanute's list of points to be attended to when criticizing the design of an aerial vessel.

Chapter III., on "The Helix as a Lifting and Driving Appliance," follows conventional lines, discussing thrust, slip, efficiency, etc. The equations given for calculating the power of propellers, and so on, are useful enough, but some of them, for instance (6), page 18, do not appear to be of much value, while (1) and (4), page 9, are misleading, as the symbol c is apparently used in different senses.

There are some notes on the use of fans for jet propulsion, and various rules for the details of propeller blades are given. Some of these latter seem to be of doubtful utility, such, for instance, as (1), page 23, which would hardly apply in the form given to the curved blades used with aerial propellers.

The views of the author regarding the elasticity question will probably not meet with the approval of aeronauts, but possibly this matter affects the design of wings and supporting surfaces more than that of propeller blades.

In *Chapter IV.* the aeroplane and the pressure of air against surfaces and bodies moving through it is considered. The formulæ for lift and drift, etc., seem to be those used by Weisbach for windmills, and the results obtained differ considerably from those of other experimenters. The deduction that the best angle of inclination for a supporting surface is between a quarter and half a right angle will certainly not be approved of by aeronauts, who would not think of using such a large angle, except when starting from the ground.

Very little information regarding the resistance of bodies is given. Beaufoy's tables are of no practical use, as the bodies dealt with by him are not suitable for aerial work, while the results obtained by Hutton, Robins, etc., are quite unreliable, owing to the faulty apparatus used by them.

The lift and drift with curved surfaces is hardly touched upon, while the very important question of the movements of the centre of pressure at different angles of inclination is only dealt with in a general way.

In *Chapter V.* aviplanes, or machines of the bird type, are discussed, and notes on wing motion, balancing, etc., are given. As regards the ratio of weight to wing area, the results obtained by Mullenhoff are usually considered to be more accurate than those quoted. (See *Le Vol des Oiseaux*, p. 82.)

Chapter VI. deals with dirigible balloons, and goes into the general theory of the subject (see also Appendix F). The methods of making hydrogen are discussed, Renaud's and Pole's rule for power required are given, and various other details. It is to be hoped that the pig iron recommended for ballast will be used with that discretion advocated by the author, as the indiscriminate discharge of pig iron is hardly likely to render dirigible ballooning a popular form of locomotion.

In *Chapter VI.* the form and fittings of airships are discussed. Various rules, taken from marine practice, are given, but a good deal more information regarding the resistance and friction of the air is required before they can be applied practically. As regards "balancing," it is doubtful whether the views of the author will be approved of by aeronauts. The truth seems to be that good balancing does not depend so much upon the use of special apparatus for controlling the movements of an airship, but upon *the good design of the ship itself.* A well-designed airship is almost (if not quite) automatically stable, and does not require the special balancing devices so often advocated.

The chapter concludes with notes on various instruments required for navigating purposes, a discussion on dynamic stability, etc.

There are a few short appendices, the most important being Appendix H, which contains a brief account of the experiments made by Prof. Langley.

The work is well illustrated, the pictures of the Langley, Maxim, and Zeppelin machines being very clear.

J. D. FULLERTON.

NOTICES OF MAGAZINES.

ENGINEERING NEWS.

October 31st, 1907.

THE FORBES WATER STERILIZING APPARATUS.—The conditions in the Phillipines—where, it is stated, a very high proportion of the population harbour such parasites as obtain access to the human system through drinking water—has specially drawn attention to the need for a water-sterilizing apparatus. In the words of the article: "If the American or Englishman living in the tropics will drink sterilized water and protect himself from mosquitos, he can live in such countries almost as safely as at home."

The difficulty is to produce an apparatus both sufficiently portable, and at the same time sufficiently cheap in working, which will produce a water agreeable to the palate.

The apparatus under consideration involves the principle of applying heat to the water in a closed receptacle, so that the contained gas will not be driven off, it being so arranged that the stream of water leaving shall be able to impart its heat to that entering, and finally come out at a temperature not much above that at which it entered. The heating arrangement is so devised that the water, which reaches it at a considerable temperature, *boils over*, and then goes on to the part of the plant where it cools and exchanges its heat with the incoming water.

There are several types of apparatus, divisible into two classes—(1), *diaphragm*, in which the supply and discharge sections are separated by a partition; (2), *tubular*, in which the supply water rises through a jacket surrounding a set of tubes in which the discharge water is cooling. The supply is regulated by a float valve.

The U.S. Government has a water wagon on trial constructed on this principle. It is capable of delivering 400 gallons of water per hour, can start delivering water in 11 minutes from cold at a difference of 16° F. between supply and discharge. Weight of the outfit, 3,150 lbs. It consists essentially of a small water-tube boiler; 2″ × 3″ × 2″ Worthington duplex steam pump; double copper cell bone black filter; copper tank for filtered water, and one of 150 gallons capacity for sterilized water, both tin-lined; sterilizer; auxiliary hand pump; seven taps for issue; the whole mounted on a four-wheeled wagon.

It will be remembered that a water-sterilizing apparatus has now been for some time under trial in the British army.

November 7th, 1907.

STREET RAILWAY TRACK CONSTRUCTION.—Owing to the increase in speed and volume of traffic, the continued adoption of groove-headed rails for tramway or street railway lines has led to the introduction of sections of rail which, when one considers the small stresses brought upon the permanent way, are of enormous size as compared with those on steam railways. In addition to this the difficulties of making good joints and keeping the track in repair are everywhere very great. In fact, the groove-headed rail is almost necessarily less advantageously proportioned than the T-rail, such as is used on steam lines. But in paving it is difficult to ensure the same elasticity in the formation as in a ballasted road, although this is not touched on in the article.

The above considerations have led to the adoption of T-rails on a number of tramways or street railways in the U.S. On some of these, the line is laid on sleepers with a concrete covering to carry asphalte; on others, the rails are laid on concrete much in the customary manner. In either case the filling between the rails seems to consist of vitrified brick bevelled alongside the railhead to admit the wheel flange.

C. E. VICKERS.

MEMORIAL DE INGENIEROS.

June, 1907.

THE DAY OF SAN FERNANDO.—San Fernando was chosen patron of the Corps of Engineers on the 2nd May, 1805, and his feast is always celebrated with special honour.

THE ENGINEER MUSEUM AT ROME AND THE RESTORATION OF THE CASTLE OF SANT' ANGELO.—By Colonel D. Sixto Soto.—The museum was opened on the 13th February, 1906, by the King of Italy. It is installed in the Castle of Sant' Angelo, which has been restored under the direction of Lieut.-Colonel Borgatti, of the Italian Engineers. The exhibits are divided into six groups, dealing respectively with (1) the history of permanent fortification and with the attack and defence of fortresses; (2), works carried out by the Corps of Engineers for the Admiralty; (3), artillery, field fortification, machinery, field bakeries, pigeon lofts; (4), library and collection of drawings relating to fortification; (5), photography and telegraphy; and (6) optical telegraphy, bridging, railways, ballooning. The article contains an interesting account of the castle, and is illustrated by plans of the various floors.

INTERNATIONAL CONFERENCE ON RADIO-TELEGRAPHY.—An account of the Conference held in Berlin in October, 1906, of which full reports appeared in the English press.

THE MINISTRY OF WAR IN THE MADRID INDUSTRIAL EXHIBITION.—By Capt. D. S. Garcia de Pruneda and Lieut. D. F. González.—A second and final article on this subject appeared in the September number. The exhibition took place this summer on the Retiro at Madrid. Colonel Marvá, the distinguished chief of the Engineer Laboratory in Madrid, was the representative of the War Department, and under his direction a very fine pavilion, of which illustrations are given, was constructed to contain the exhibits of that department. The pavilion was divided into five sections, viz., General Staff, Engineers, Artillery, Medical Department, and Military Administration.

The General Staff exhibited a very interesting collection of maps both ancient and modern, the latter including fourteen sheets of a new map of Morocco, amongst which are to be found plans of Marrakesh, Mequinez, Larache, Tangier, and of various Riff Kabilas.

The Engineer exhibit was very complete, and was furnished by the museum, laboratory, and electro-technical centre.

The articles exhibited in the other sections were also of interest.

CONSTRUCTION OF THE PANAMA CANAL BY MILITARY ENGINEERS.—A translation of an article which appeared in the *Scientific American* of 9th March, 1907.

MILITARY REVIEW.—Great attention has been devoted in Germany in recent years to permanent fortification, and the expenditure under this head has increased from £150,000 in 1893 to £1,150,000 in the present year. The following conclusions are arrived at:—

1. The considerable development given to the German fortifications in recent years does not in any way imply a weakening of the offensive spirit which animates the empire.

2. Fortification is an arm like any other, and obtains all its value in co-operation with the field army, and aids the latter in the execution of offensive operations, tending to the destruction of the enemy's forces.

3. In a well-thought-out plan of campaign, such as the German, the *rôle* to be played by fortresses may be foreseen, or rather preconceived, like the operations themselves, and in which they may form an essential element.

Extracts taken from *A Staff Officer's Scrap-Book* are given from Sir Ian Hamilton's observations on the siege of Port Arthur and the value of its defences.

'M.'

NATURE.

October and November, 1907.

ALUMINIUM CABLES (*p.* 501) have been used in this country and largely in America, but not insulated. The difficulty of making sound joints has prevented a larger use of aluminium for commercial purposes. This difficulty has been overcome, and both mechanical and "sweated" joints can be made as desired. The makers claim that the electrical and mechanical properties of the joints are superior to those of the wire itself. The conductivity of aluminium is only 60 per cent. of that of copper, consequently the diameter of the aluminium cable is greater by 28 per cent., but a 50 per cent. saving in weight is claimed over copper conductors of the same capacity. The insulation used is vulcanized bitumen, as being lighter than paper for the same degree of insulation.

"CONCRETE-STEEL BUILDINGS."—By W. N. Twelvetrees (*p.* 576).—The author gives particulars of a number of typical pieces of work in ferro-concrete which have been carried out in the last few years. Engineers who consult this book will find full descriptions of buildings similar to any they may be called upon to design. Copious notes as to the methods of making the concrete, the nature of the reinforcing steel, and of the results of proof tests of the structures, are given. The last chapter contains a brief account of a few noteworthy collapses and of the probable causes of these failures. Much can be learned from inevitable failures.

SCIENCE IN THE EAST (*p.* 593).—A great magnetic survey has been in progress in India for some years. (1). Capt. R. H. Thomas, R.E., has made observations at 808 stations, and hopes in three more seasons to complete the field work. (2). Pendulum observations have also been made by Major G. P. Lenox-Conyngham and his assistants at ten stations, including nine nearly on a meridian passing through Darjeeling. The most northern station was at a height of 11,766 feet. The result of this work will, it is hoped, account for the observed large deflections of the plumb line and the deductions made as to the density of the material underlying the Himalayas. (3). Tidal observations and levelling operations are reported upon by Mr. J. P. Barker. He gives interesting information as to the accuracy of predicted times of high and low water. At the open coast stations the mean error in the predicted times was only nine minutes, and the mean error in the predicted heights was only 3 per cent. of the range. (4). Survey operations of a rapid kind with the Somaliland field force were made by Capts. Beazeley and C. G. Hunter, and successfully carried out under war conditions.

THE PLAGUE (*p.* 648).—Sir Lauder Brunton, in his address to the London School of Tropical Medicine, described the ravages of this disease in Europe in the fourteenth century, under the name of the "Black Death," and quoted from contemporary writers illustrating the terrible condition to which the countries attacked were reduced by the pestilence. In India, at the present moment, the ravages of plague, though not so great as those of the "Black Death" or of the Great Plague in London, are nevertheless dreadful. During the first six months of this year no less than 1,060,000 deaths from plague occurred in India, and out of these 632,000 took place in the Punjaub, which has only a population of 25 millions, that is to say one in every forty inhabitants in this district has died of plague between January and June. It has long been observed that great mortality in rats is apt to precede pestilence, and it has now been proved that the virus is transmitted by fleas, as 61 per cent. of white rats contracted plague from fleas which had been fed upon infected rats, but that they did not catch plague if they were protected from fleas by wire gauze, adhesive fly-paper, etc. Aerial infection did not take place if the rat was put into a wire cage two feet (that is more than a flea can jump) from the ground. The great difficulties in the way of preventive measures are ignorance, apathy, and superstition. There is great prejudice in some parts of India against taking life of any kind, but this is not universal, because in some parts goats are offered to Kali, the Goddess of Destruction. If the Brahmins could persuade the natives that the sacrifice of a rat as often as possible to Kali would avert pestilence, rats would soon be destroyed, and the plague would be at an end.

THE "MAURETANIA" (*p.* 663) is 800 feet long, nearly the length of the Houses of Parliament. The magnitude of the strains which she must experience in a heavy head sea is brought to mind by the provision which has been made for bending. The boat deck, together with the boathouses upon it, which contain the long suite of public rooms, is cut completely through in three places, so as to allow the ship to give longitudinally. The plates were rolled to a guaranteed thickness, enabling the builders to save 500 tons of dead weight, and the use of silicon steel in the boilers effected a further saving of 500 tons, making a total saving of 1,000 tons, which, reckoned as cargo, represent a gain to the Cunard Company of about £22,000 a year in the earning power of the vessel. Vibration, though moderate, is noticeable; it is at a maximum in the after part, and diminishes thence to the bows. The distribution is, however, erratic, regions of maximum vibration often being close to regions of minimum vibration. The cause of the vibration in turbine ships is not obvious, and at present there is no satisfactory hypothesis to explain it.

ANTARCTIC ANIMALS (*p.* 33) observed in the "National Antarctic Expedition, 1901—1904," are most interesting, and are well reported on by Dr. E. A. Wilson. On a particularly dark night the sea lions, following a boat, could be distinctly seen diving and twisting about beneath in the pitch-black water; each animal was ablaze with light; every stroke of their long powerful flappers was accurately visible in the pitchy darkness by the brilliance of the phosphorescence covering them. The Emperor penguin's egglaying is most curious. The bird chooses the darkest months of the winter in which to incubate its egg; it lays its one egg upon sea ice, with no pretence at nesting, but removes it at once to rest upon its feet, where it is held wedged between the legs, pressed to a patch of bare skin in the lower abdomen, and covered by a loose flap of skin and feathers. The incubation requires seven weeks, and as one bird cannot undertake this task, a dozen others stand patiently round waiting for a chance to assist. Every adult bird, both male and female, has a keen desire to "sit" on something. When the sitting bird feels hungry, it hands over its treasure to the nearest neighbour to undertake the duty of incubation.

THE PRESERVATION OF EGGS (*p.* 84).—In an absolutely sterile atmosphere, at a sufficiently low temperature and of a proper degree of humidity, eggs will preserve their "freshness" for very long periods of time, and all successful methods of keeping eggs imply a practical recognition of these principles. The eggs should be put in a cool place with their points down, so that the air can circulate freely round them. Nothing is gained by turning the eggs, or by packing them in salt, sawdust, charcoal, wood ashes, sand, etc. Some of these things taint the eggs, others are apt to set up the action of moulds. Good results are obtained by immersing them in a 10 per cent. solution of water glass, especially if the shells are smeared with fat or vaseline, whereby the slight taste of the alkali, which the eggs are otherwise apt to acquire, may be obviated.

W. E. WARRAND.

REVISTA DE ENGENHERIA MILITAR.

September, 1907.

PROPOSAL FOR THE CREATION OF A SUPREME COUNCIL OF NATIONAL DEFENCE.—By Capt. João d'Oliveira.—A Supreme Council of National Defence was constituted on the 24th December, 1906, under the presidency of the King, and has as its members the president of the council of ministers, the ministers of war and of marine, nine generals and five admirals. It is divided into two sections, one dealing with the army, the other with naval matters. Its object is to take the initiative in making all preparations for war, and to establish—

(*a*). The fundamental principles to which the organization and mobilization of the land, sea, and colonial forces should be subjected.
(*b*). The plans of military and naval operations.
(*c*). The plans for the defensive organization of the capital and the colonies.

The author welcomes the institution of this council, and then proceeds to point out some of the shortcomings of Portugal as regards defence, and the sudden and unexpected manner in which causes of quarrel arise between nations. He thinks it possible that at some future time Spain may endeavour to re-unite Portugal with her dominions, or that some foreign power may cast covetous glances on some of the Portuguese colonies such as Madeira or the Azores. Up to 1890 relations with England were most cordial, but in that year an incident occurred at Chire and Nyassa which showed that no reliance was to be placed on any guarantee given by that country, and it was not until the visit of King Edward VII. to Lisbon in 1903 that the friendly feeling between the two countries was restored.—(*To be continued*).

SOME CONSIDERATIONS ON THE FIELD BALLOON PARK BELONGING TO THE MINISTRY OF MARINE (*continued from the August number*).

SOME EXTRACTS FROM THE REPORT OF THE ENGINEER, REGO LIMA.—This portion of the report deals with the geological features of the Bundambungo district, and particularly with the veins of quartz met with there.

THE DEFENCE OF THE COASTS OF THE U.S.A.—A *précis* of articles which appeared in the July and August numbers of the *Rivista di Artiglieria e Genio*. The original project was drawn up in 1880, and was modified by a committee presided over by Mr. Taft, which commenced its sittings in 1906. At that date the following pieces of ordnance were mounted in coast defence works:—105 12-inch guns, 133 9·4-inch guns, 99 8-inch guns, 587 Q.F. guns of smaller calibre, and 376 12-inch mortars.

The Taft Committee made the following recommendations:—

1. Batteries for the defence of ports of primary importance should be armed with guns of a calibre not below 12 inches, with 12-inch howitzers, and with Q.F. anti-torpedo boat guns.
2. 10-inch guns are sufficient to defend the entrances of channels exposed only to cruiser attack.
3. 6-inch Q.F. guns should be employed for the protection of places liable to naval raids, and to command at long range areas from which torpedoes might be fired.
4. 3-inch guns should form the anti-torpedo boat armament at moderate ranges.

The committee considered that a submarine-mining defence was very necessary. In deep channels, or where the currents are too strong to admit of the employment of submarine mines, torpedoes should be used.

Great stress was laid on the electric-light defence, and it was considered that as a rule a central generating station for the current should be employed, but in order to minimize the effects of a lucky shot, subsidiary generating stations equipped with internal combustion engines should be established in each group of batteries. Special lights should be told off to the minefields. 3-ft. and 5-ft. projectors are recommended, as the former 2-ft. and 2-ft. 6-in. projectors are considered insufficient.

THE WAR BUDGET OF GERMANY FOR 1907.—The following are the more important items, referring to the engineer arm, which have been included in the budget:—

1. Creation of an additional battalion of pioneers, bringing the total number up to 27.

2. Engineer Committee; formation of a fourth section to deal with fortress warfare.

3. Establishment of a school at Strasburg for training clerks of works for duty with the Fortress Construction Corps.

4. Sale of lands and materials from certain disclassed fortifications at Posen, Strasburg, Diedenhofen, Graudenz, and Ulm.

5. Fortresses. (*a*). The following additions are made to the fortress staffs at Metz and Strasburg:—One field officer of the communications troops to be in charge of all the communications of the fortress; one mechanist to look after the motor cars, gas works, and wireless telegraphy apparatus; two warrant officers to take charge of the balloon, signalling and railway material.

(*b*). £15,000 are allotted for strengthening the fortifications of Germersheim; £150,000 for works at Maiz and Castel; £11,250 for Ulm; £300,00 for Cologne.

6. The sum allotted for the training of the pioneers is increased by £3,120, and that for the training of the communication troops by £8,800.

7. Formation of an additional telegraph battalion, and of a wireless detachment consisting of 1 captain, 6 lieutenants, 1 warrant officer, 13 sergeants, 92 men, 12 riding and 40 draught horses.

8. Formation of a mechanical transport detachment (1 captain, 4 lieutenants, 20 sergeants, and 150 men) attached to the experimental section of the communication troops.

9. Appointment of a major-general as inspector of telegraphs troops.

10. Large increase in the amount allotted for the purchase of telegraph material, and for aeronautical services.

'M.'

REVUE DU GÉNIE MILITAIRE.

October, 1907.

THE INFLUENCE OF THE FIGHTING ROUND PORT ARTHUR ON THE CONSTRUCTION OF FORTS.—This article is a digest of various articles which have been published by Lieut.-Colonels von Schwarz and Barmin, in the *Eenshenernee Zhoornal*. It is accompanied by an excellent map of the fortifications round Port Arthur, reproduced from the same magazine. The first portion of the article is devoted to a description of the works, their armament, and their field of fire. It points out that the general line of defence was too near the town and harbour, and very few of the works had been finished before the outbreak of hostilities. After the war had commenced, the following works were put in hand:—The completion of Fort No. 1, Kikwan North, and Ehrlong, and the construction of temporary works and trenches in the intervals between the forts and of temporary batteries. After the loss of Nanshan, the Russians commenced the construction of head cover, splinterproofs, and obstacles; among the latter was a bare electric wire carrying an alternating current of 3,000 volts, and extending from Kikwan North to Itsushan. Profiting by the respite given by the Japanese during May, the Russians constructed some advanced works.

The Kuropatkin and Temple Redoubts were commenced first, although the fortification of Takushan was of more importance. Differences of opinion among the senior officers led to the postponement of the more urgent work. During the middle of May the hills Plate (Akasaka), "de la Division" and Panlongshan were fortified. It was not till the middle of June that work was commenced on Siaokushan and Takushan. The soil was so rocky at these important points that progress was very slow, and the works had hardly been begun before the Japanese attacked them. The mistakes committed by the Russians clearly show that for each fortress a proper defence scheme should be drawn up in peace time, so that on the outbreak of war the various works may be taken in hand in the order of their importance. At Port Arthur there was no such scheme, and, as a consequence, the following points were overlooked. The communications were not screened from the enemy's view; the telephone lines were left exposed to the enemy's artillery; and the central enceinte was so exposed, owing to the omission of traverses and shelters, that it was useless. After describing in some detail the state of the various works on the 30th July, the author draws attention to the following points :—

1. On the right flank the permanent forts were too close in. It would have been better to advance the right flank to Takushan and Siaokushan, thus obtaining a shorter and stronger line.

2. Takushan and Siaokushan were badly fortified, and consequently very weak.

3. The line of forts was too close to the town, especially on the west front, where it was only one kilomètre away. It was thus possible for the enemy to bombard the town and harbour with guns of all calibres.

4. Out of six forts only one was finished.

5. There was much dead ground between the forts.

6. Some of the forts could neither see nor support their neighbours.

7. The intervals between the works were closed by old Chinese earthworks, or slight trenches, which had a very limited field of fire and could not resist an assault.

8. The forts had no arrangements for flanking fire, and the caponiers were badly designed.

9. On account of their unfinished condition there were dead angles in all the forts except Songshushan.

10. Krupp guns were mounted in all the works.

11. There were no shelters for the guns detailed to repulse assaults.

12. In some of the forts there were no guns to flank the ditches.

13. The roofs of the shelters had only 90 centimètres thickness of concrete.

14. The temporary batteries were built on the tops of the hills, and were visible from afar.

15. There was a deficiency of howitzers and an excess of old pattern guns.

16. Practically all the works and batteries were visible to the enemy.

17. The communications were not screened.

18. There was no trench tramway material available.

19. There were no observatories.

20. There were no protected look-out stations in the forts.

21. There was no special telephone circuit devoted to the artillery, and the general telephone service was bad.

22. All the telephones were operated by air lines only.

23. There were only 15 searchlights, of which 12 were fixed.

24. There was a wireless telegraphy installation, but it would not work.

25. There were no balloons.

26. The reserve of material was small, and had been drawn on already by the field armies.

The article will be continued.

J. E. E. CRASTER.