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CONTENTS.

# CONTENTS.



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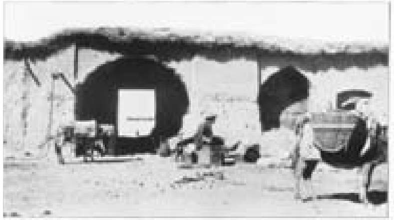
1.—A Posting-House on the Teheran-Isfahan Road.



2.—A Caravanserai on the Bakhtiari Road.

3.—A Stream on the Bakhtiari Road.

4.—On the Bakhtiari Road—the beginning of Trees.

5.—A Bakhtiari Family.

6.—Kaleh Tol and my Escort.

A Journey Across Persia

# *SOME IMPRESSIONS OF A JOURNEY ACROSS PERSIA.*

*By* Lieut. J. F. Gray, R.E.

I happened to be in Russia in October, and had intended to return to India at the end of my leave *viâ* Constantinople and Port Said, but the Fates and Turkish quarantine, which those who have experienced it say is an ordeal to be avoided, combined to induce me to change my plans at the last moment and to try a short cut through Persia. As I had not thought of this route until a week before leaving Russia, I was very vague as to how precisely I should arrive. Hence possibly a short account of the trip, and a little information as to ways and means of travel in Persia may be of interest to others.

Passing through the country from north to south, the general impression it produces is desert—dry, sandy wastes of camel-coloured desert, intensely hot when it is hot, and very cold at nights in the cold season. And the road just wanders straight on for hundreds of miles in an apparently aimless fashion, with a small village or perhaps only a caravanserai every 15 to 20 miles—wherever a little water is obtainable. Passing continually up and down the road are caravans of all sorts and sizes, camels, mules, ponies, donkeys and even cows, accompanied by Afghans, Arabs, Curds, Tartars and Persians, the latter with their women in long black "burqas" covering them from head to foot, with a white veil in front and a narrow strip of openwork over the eyes, sitting huddled up in wooden panniers, two to a mule, and the men, some walking, but mostly perched on top of a piled-up load on a mule. In the early morning—and they always like to start just before it gets light—the nature of a caravan is recognizable long before it can be seen by the sound of its bells; the tinkling bells of a poor man's few donkeys, the short-distance caravans with one or two deeper-toned bells, then the fuller notes of a big long-distance caravan, and lastly the deep boom of the big camel bells on a string of 200 or 300 of these out-at-knees-and-elbows looking beasts, silently padding along, each in the track of the one in front. It is a delightfully leisurely life, with nothing ever worth hurrying about, for, in Persia, time is still the servant and not the master of man; in the evening at a caravanserai the men sit round a fire smoking the Kalian or Persian water-pipe, whose steady gurgle mingles peacefully with a monotonous jingle of bells from the feeding animals.

They are however very cruel to their animals, and it is the exception for a beast of burden to die in its stable; for if an animal is old or ill, why not make sure of one's money's worth before it dies? The result is that the roadside, especially in the hills near the tops of passes, is strewn with skeletons.

The towns through which one passes produce a rather sad impression of a country whose day is over, of former splendour and present decay. There are houses empty and tumbledown, bazars whose shops are only partially tenanted, some fine old buildings with wonderful old Persian tiles—but half the tiles are missing, broken or stolen—and, in the courtyards, gardens now uncared for and the characteristic strip of artificial water in a masonry tank whose sides are crumbling away.

To a casual observer the Government in Persia appears to be very incompetent, partly perhaps through lack of money, which is almost an essential of good government, and possibly the new *régime* has so far scarcely had time to prove itself definitely a success or a failure, but it seems that its Ministers spend most of their time in intriguing against one another, which can hardly be conducive to efficiency.

In common with other Oriental races the Persians have very little idea of the value of time. One might almost take as the motto of the Persian people "Farda Insha-Allah" (to-morrow if God will) which is the usual Persian reply to the question "When?", and of which a very free translation would be "Never do anything to-day which you can possibly put off till to-morrow." They are apt to be boastful as to past events and full of big talk concerning future events, but when it comes to the point, the actuality is usually very different and they are generally cowardly. I believe a saying is recorded of a famous Persian general some centuries ago "What fine soldiers we Persians would be if war were not a matter of dying."

I left Europe at Baku, whence I crossed the southern end of the Caspian Sea in a wretched little tub of a paddle-boat—rather dirty and crowded with passengers of all nationalities—to Enzeli, the principal Persian port on the Caspian. Enzeli is a collection of a few ramshackle houses on a narrow strip of land cut in two by the narrow entrance to a big shallow lagoon, known as the Murd-Ab (or Dead Water), about 7 miles across. This we crossed in a largish flat-bottomed boat with six rowers and a helmsman, helped by a sail and a light breeze, and were then towed up a small stream, almost in flood from recent heavy rains, between marshy banks covered with thick undergrowth and trees, all delightfully green, with flights of duck from time to time passing over our heads, to Pir-i-Bazar, which is a village consisting of a few wooden huts on a slimy mud bank. From there we drove in a two-horse victoria to Resht, a distance of about 6 miles. At Resht, where we had to wait two days to get a carriage, there is nothing of great interest; just an ordinary Oriental town, with narrow streets, none too clean, between mud houses, and in the middle of the town a big open space, the Sabz-i-Meidan, where there is a badly-kept public garden.

As the best hotel, the Hotel d'Europe, was full, I stayed at a hotel kept by a Russianized Persian, which was quite clean, and the local manager of the Imperial Bank of Persia was kind enough to give me most of my meals. He was shortly starting for home on leave and had a Goanese cook, who rejoiced in the name of Pascoes Joas Carvalho, whom he wanted to send back to India. This suited both of us, so I took him along with me and he proved most useful, as a man who can cook is a necessity after Isfahan, unless one is prepared to do one's own cooking.

Having procured a carriage, which I shared with another Englishman who was on his way to Teheran, we travelled straight through day and night for 57 hours to Teheran, only stopping at the various stages to change horses.

The first part of the road is pretty and very hilly—hills green and tree-clad at first and becoming gradually more rugged and bare as one climbs higher and further away from the rainy zone round the Caspian. It is a Russian road, wide and fairly well built, and the carriages are drawn by four ponies abreast. The ponies are underfed and overworked, but they contrive to pick their way up and down the steep hills at a fair pace, even in the dark.

Near Kasvin, where the Russians had then a garrison of some 1,200 Cossacks (I have since seen it reported in the newspapers that this number has now been increased by 600, though for no ostensible reason as Northern Persia appears to be absolutely quiet) after crossing the Elburz range at a height of about 7,500′, one arrives at the beginning of the true Persian plateau, which lies at a height of between 3,000′ and 5,000′ above sea level. The rest of the road to Teheran is dull and monotonous, over dry bare plain with low rocky hills, the only relief to the monotony of the scenery being the view from near Teheran of the snowy cone of Mount Damavend, which appeared a glorious pink over low blue hills in the light of the setting sun. Another not-to-be-forgotten feature of the road is that Kasvin contains a comfortable hotel kept by an Italian and his wife who cheered us on our way with a warm greeting and a good dinner.

We arrived at Teheran just after dark and so had to satisfy the police at the outer gate of the city as to our business and destination, before we were allowed to enter.

Teheran is a modern Persian town, fairly busy and for an Oriental town very clean, with some wide open streets with avenues of trees and a horse-tram running down one of them. I stayed at the English hotel, as the new Hotel de Parc—said to be better, and managed by a Belgian, ex-valet to a Belgian ex-Minister—was full. The next morning, hearing a band playing, I walked in its direction and found a small review of Persian troops in progress. The troops consisted of cavalry and infantry who did not march badly but looked a weedy lot compared with Indian troops, and the cavalry were mounted on small though wiry-looking ponies. It appears that recently their training has been carried out under a German military instructor and that there has been a great improvement in their drill at any rate, but they suffer from a lack of officers worthy of the name, and from pay that is apparently apt to be precarious. This review was taking place on the Meidan-i-Mashk, a big open space in the city used as a drill ground and surrounded by barracks. Not far from this is the principal square, the Meidan-i-Tup-Khaneh, *i.e.* Artillery Square, in the middle of which are some muzzle-loading guns surrounded by an iron fence, and on one side of which is a fine building occupied by the Imperial Bank of Persia (a British concern), and on another the office of the Indo-European Telegraph Department. Leading from this square, through large arched gateways, are some of the principal streets, in one of which, a wide avenue, most of the foreign legations are situated. Of these the most imposing is probably the British Legation, where, inside a wooded enclosure surrounded by a high wall, are the residences of the British Minister, Military Attaché, and other attachés. Owing to the very limited amount of leave left to me, I could only spend 24 hours in Teheran and then, having obtained a big and very ancient landau from the carriage contractor, drove straight through for three days and nights to Isfahan, a distance of about 360 miles. It is possible to sleep very comfortably in these carriages by filling up the well and spreading blankets on top, but it means getting up at each stage to worry the driver into bringing out the fresh horses quickly, otherwise the sleepy traveller is left to slumber peacefully in his carriage till daylight.

The road lies across the desert, for part of the way along the shores of a big salt lake, and for many miles the water is brackish. It is a dull monotonous road, hot and dusty, the posting houses and the few trees round them appear in the distance to float on a sea of heat haze, and in places the sand is so deep that the ponies can hardly drag the carriage beyond a walking pace.

I stopped for a few hours at Qum, a place of pilgrimage and sanctuary, where there is a fine mosque of great sanctity, containing the tomb of Fatima, with gilded domes and walls covered with blue tiles outside—the inside has never been seen by a European except in disguise—and a big bazar of narrow streets entirely covered in with vaulted roofs, through which there was only just room for my big landau without the two outer ponies to push its way through the crowds of people and donkeys. To add to the jostle there was also a religious procession carrying a gilded hand, a sacred emblem of the prophet Ali.

Then I stopped for a couple of hours at Kashan, formerly the chief centre of the Kashikari or Persian tile industry, famous too for a peculiarly malignant breed of scorpions, and where, four days before, there had been a fight of considerable severity—that is to say severe according to the standard of Persian fighting, which usually proves on investigation to be less bloodthirsty than reports make out. An extremely sporting freebooter of the name of Naib Hussein, who with a couple of hundred followers had been looting caravans right and left, had been besieged there by over a thousand Bakhtiari troops in the employ of the Persian Government, had kept them in check for several days, and then one night had quietly walked off with 500 mule loads of loot. The only damage inflicted by the Persian troops in their bombardment was to set fire to a workshop and kill a few non-combatants in the town.

At Isfahan I stayed with the British Consul-General, who was most hospitable. He was repaying a formal call on the Sadr-i-Ashja, one of the big Bakhtiari chiefs through whose country I had to pass, so I went with him. A Persian call is full of formalities and elaborate politeness, each person calling himself a humble slave and the other "Your Excellency." "How is the health of your August Highness?" "Thanks be to God by the kindness of your Excellency this slave's health is good." And so on for about 10 minutes after which it is possible in a leisurely fashion to get to business. We sat on three chairs for an hour or so, with a mirza (scribe) squatting on the floor with a roll of paper, pens, and ink, while a servant brought round small cups of tea and spiced coffee, and cigarettes for us, and a Kalian for the Sadr-i-Ashja. He made his mirza write letters to other Bakhtiari chiefs to look after me, and provide me with escorts for the road which was then considerably troubled by robbers who loot caravans whenever they get the chance.

Isfahan or Ispahan was the old capital of Persia, and in those days must have been a very splendid Oriental city—certainly the early travellers of the 17th century seem to have been very much impressed by its magnificence. Now it is but a memory of the past. The population is very much smaller than formerly, so that many houses in the outskirts of the city are empty and in ruins and there is a general feeling of decay.

The Chehel-i-Sutoun (*i.e.* House of Forty Pillars) contains some old Persian pictures on its walls, painted in the time of the great Shah Abbas, representing scenes of battle and court life, and a later picture depicting Nadir Shah in one of his battles. It was then the Hall of Audience and part of the Royal Palace, but was until recently used by the Governor of Isfahan as a storeroom, and is now very dilapidated and the garden a wilderness.

In the centre of the town there is a very large square, or rather oblong, about 500 yards by 200, the Meidan-i-Shah, with the remains of stone pillars which were used as goal posts, when, in more vigorous days, the Shah and his court used to play polo there; at one end stands the Masjid-i-Shah and another fine mosque at one side.

There is also the Madrisseh-i-Shah Hussein (Madrisseh meaning school) which consists of a large courtyard with a strip of water and some trees, surrounded by high walls and archways with domed roofs and two minarets, all covered with blue tiles. But that too is dilapidated though still used, and there are great blank patches where there used to be tiles.

Julfa, a suburb of Isfahan, contains a large Armenian population and an old Armenian cathedral, originally built about 250 years ago. The walls inside are entirely covered with paintings representing scenes of Biblical history from the Creation to the Last Judgment. Some of it slightly grotesque, but on the whole very effective.

The Consul has an escort of 20 sowars and a native officer from an Indian cavalry regiment; they had recently had to escort a British Consul from Shiraz to Isfahan and in doing so lost two of their number who were shot by brigands; they had however been able to follow them up and kill the two men who had fired the shots and their rifles, saddles and bridles now adorn the hall of the Consulate at Isfahan.

Having made a contract with a muleteer to supply me with five mules, three for my baggage and one each for my servant and self, to take me down to Ahwaz (260 miles across the hills) in 10 days, which is about the shortest possible time, I spent the next nine days on a mule's back, with intervals of walking. I was marching usually from just before sunrise to sunset, sleeping at night sometimes under an archway of a caravanserai, when it was not too dirty, and at other times in a small tent kindly lent me by the Consul at Isfahan. And it was thoroughly enjoyable, as the weather was almost ideal, though sometimes a trifle too cold at nights. I was escorted all the way by two Bakhtiari horsemen, each with a rifle slung over his shoulder and a bandolier full of cartridges, riding on highly ornamented but most uncomfortable little saddles with high peaks studded with brass nails, and on ponies that were not much to look at but very surefooted over the stony Bakhtiari hills. They amused themselves from time to time by firing at rocks from horseback at a gallop, and nothing seemed to please them so much as loosing off ammunition at anything. It is a country where everyone who can afford it carries a rifle, and one sees all sorts of weapons, long Arab guns with a barrel like a piece of gas pipe worn very thin and ornamented with brass and silver bands, old Martini black powder carbines, a few fairly modern cordite rifles of French or German manufacture, and some Mauser pistols. I was carrying a Colt automatic pistol, chiefly in order to have something to show to people, as they always ask to see one's weapons and are delighted to show their own in return.

My first day's march consisted of 27 miles of flat plain between rocky hills with a certain amount of cultivation and groves of fruit trees, as water is fairly plentiful, and I arrived after dark and slept in a comparatively clean room in a caravanserai. All the next day, and it was a long march of 35 miles, the country was gradually getting more hilly, but bare and treeless. Halfway, at Ghavarukh, I had to get fresh sowars from the local Bakhtiari chief and while I was waiting was entertained by him with tea and fruits—grapes, melons and pomegranates—in a large room, bare except for Persian rugs, with the two principal Bakhtiaris and myself sitting on cushions on the floor, and all round a number of Bakhtiaris squatting on the floor with their rifles in front of them and a mirza to write letters, including some on my behalf to various Khans on the road. The result was that I did not reach my camp till 9 p.m., and then slept the sleep of the weary till 4 a.m. when I found it too cold for sleep. The next day the country became more interesting, hilly with a good many small streams, and a steep ascent and descent over a pass to a pleasantly shady grove by a village where I had tiffin. Then a stiff pull up and near the top trees to delight the eye—true they were not very large or very many, but still trees and a change from barren plains and bare hills. Then a steep zigzagging descent down a white chalk cliff, the Pass of the White Breast, and a glorious view of mountains with a silver stream cut deep into the rock several thousand feet below, hillsides covered with trees and numbers of hill partridge that made me wish I had a gun with me.

The fourth day was much the same with two stiff passes and a bad road along a dry ravine, with frequent ups and downs to avoid perpendicular cliffs, to a caravanserai at Shalil.

On the morning of the fifth day, after crossing a new iron suspension bridge over a narrow rocky gorge, there was a stiff climb to the top of a pass where things were really lively, two big caravans from each direction meeting at the top and through the middle of it all we were hustling our small caravan, while a little way down the slope was a group of Bakhtiaris firing shots at some thing or person on the opposite hillside. About sunset we came down to the swift Karun River, turquoise blue between low brown hills with a background of distant blue mountains, and from my open archway that night in the Godar caravanserai, I looked straight up a magnificent deep rocky gorge through which flows the Karun River, lighted up in the clear atmosphere by a nearly full moon.

On the sixth day, after crossing a small pass, we reached the real Bakhtiari plateau, fairly well watered, with a certain amount of cultivation and the rest camel-thorn. These Bakhtiaris are a hardy, vigorous race of highlanders, mostly very poor and uneducated and fond of fighting when there is a chance of loot and not too much danger. They wear a high egg-shaped felt hat without a brim and long locks that curl up from under the edge of the hat, loose nondescript clothes covered by a long-skirted coat, usually a knife in their belts and nearly always a rifle slung on their shoulder. Near each village there is a cemetery, and over the graves of tribesmen a stone crudely carved to represent a lion as a sign of valour. They are divided into clans, each directly under their own Khans, who are responsible to the various Bakhtiari chiefs, one of whom is the paramount authority. One of the chiefs represents them at Teheran, but they have very little respect for the wishes of the Persian Government, unless, as is the case at present, it happens to suit their own policy.

On the seventh day I made my midday halt at Kaleh Tul, a big fort with high mud walls flanked by towers, built on a mound with groves of pomegranates, and a village below it. There I had again to change my sowars and was given tea and pomegranates while I sat in a tent on the ground with the Khan and other Bakhtiaris, with my feet crossed under me—a position that is most tiring when one is not used to it—and endeavoured to make conversation in bad Persian.

The eighth day's march was over salt plain, with pools of brackish water and streams said to be undrinkable, to Jaru. From there next morning I crossed the last range of hills and dropped down to the flat, sandy plains of Arabistan. The inhabitants are Arabs, quite different to the Bakhtiaris in appearance, tall, lean men with hooked noses, who talk guttural Arabic and wear long flowing robes covered by a loose "aba" or cloak, and on their heads two rings of plaited camel's hair over a piece of cotton stuff, the ends of which they tie round their necks. They are horse breeders and nomads, living in black tents made of woven goat's hair, moving about with large flocks of sheep and goats, and owing allegiance to the Sheikh of Mohamerah and so indirectly to Persia. At one of their encampments an Arab pony and two mounted Arabs as escort, sent out by the British Consul at Ahwaz, were waiting for me. So I rode straight through the 43 miles to Ahwaz, covering 60 miles that day all together. My mules arrived the next afternoon, and I sent on my baggage and servant by "belam" or native sailing boat to Mohamerah, a port on the Shat-ul-Arab (the confluent of the Tigris and Euphrates).

Ahwaz is a small settlement, of Europeans mostly, adjoining the larger native town of Nasireh, on the river Karun, which is navigable, though shallow and full of shifting sandbanks, from Shuster, a little distance above, to Mohamerah. It contains a British Consul (at present a subaltern in the Indian Army), a Dutchman who is the Russian consular agent, a couple of Englishmen belonging to the firm of Lynch Brothers, some more Englishmen in the employ of the Anglo-Persian Oil Company—one of whom had lived for three years in a Curdish family as a Persian mirza without being discovered—a few white houses and some palm trees.

That was the end of my journey in Persia, except for an exciting motor drive of 60 miles across country, through deep sand, over thorn bushes 2′ or 3′ high, over patches of dried-up marsh, all at a speed of about 30 miles an hour, losing one nonskid band, breaking a mudguard and nearly upsetting by getting two wheels deeply imbedded in the pipe-line trench and having to push the car out backwards. We were driven by the pipe-line engineer of the Oil Company, with another man and myself in the back of the car hanging on like grim death, and in spite of that bouncing off our seats till our heads hit the cape hood above the car. Then 12 miles by river, partly in a native boat and partly in a petrol launch, to Mohamerah, where I dined with the British Consul and then went on board the British India mail steamer bound for Muscat and Karachi.

A project for a railway to connect Europe to India through Persia has recently been discussed in the newspapers. It appears that the route proposed is from Baku, skirting the southern shore of the Caspian Sea to Resht, thence through Kasvin to Teheran and on *viâ* Isfahan, Yezd, and Kirman, thence probably through Beluchistan south of Seistan to join the Indian railway system at Nushki, 100 miles S.E. of Quetta. The total length of line to be constructed is about 1,500 miles and it does not present any very great engineering difficulties, except the rise from sea level to roughly 7,500′ between Resht and Kasvin, and the difficulties owing to lack of water and scanty population in the desert region between Kirman and Nushki, where both labour and water would have to be transported over several hundred miles. It is proposed that the railway should be financed by combined Russian and British capital, the two countries having control of the line within their respective spheres of influence. As regards British interests, this railway, if constructed, should very materially assist trade from India, which is at present considerably hampered by the insecurity of the trade routes from the ports of the Persian Gulf.

It has been asserted that by this means Bombay could be reached in a week from London, but this seems difficult to reconcile with the fact that it is at present a 70 hours journey from London to Moscow, 64 hours thence to Baku, and 65 hours from Quetta to Bombay, or just over eight days, without allowing for 1,600 miles of single line from Baku to Quetta. Taking this at an average rate of 40 miles an hour (or 40 hours), and an accelerated through service *viâ* Vienna, it would probably mean rather under seven days to Quetta and nine days to Bombay.

## DETAILS OF JOURNEY.

| | Conveyance. | Cost. | Time. | Remarks. |
|---|---|---|---|---|
| *Baku* | | | | British Consul.<br>Hotel d'Europe. |
| to | Steamer Baku to Enseli. (Bi-weekly). | 12 Roubles (£1 6s. 0d.) | 36 hrs. | Fare includes 1 meal only. |
| *Enzeli* to | Carriage whole distance or | 8 Tumans (£1 12s. 0d.). | 4 hrs. | Carriages and boats must be bargained for.<br>Toll of 1 Tuman near Resht. |
| | Boat to Pir-i-Bazar and thence carriage. | 3 Ts. } 2 Ts. } 5 Ts | 6 hrs. | |
| *Resht* | | | | Hotel d'Europe.<br>Imperial Bank of Persia.<br>British Consul (an Italian). |
| to Kasvin and | Carriage. | Carr. 61 Ts.<br>Toll 6 Ts.<br>Tot. 67 Ts. (£12 15s. 0d.) | 36 hrs.<br>18 hrs.<br>Total 54 hrs. | Rooms at post-houses on road.<br>European Hotel at Kasvin.<br>Tip to drivers 2 krans per stage. |
| *Teheran* | | | | Hotels de Parc and d'Europe.<br>British Legation.<br>Imperial Bank of Persia.<br>H.Q. Indo-European Telegraphs.<br>Head Office of Lynch Bros. |
| to Qum, Kashan and | Carriage. | 122 Tumans<br>1 T. (toll)<br>123 Tumans (£23). | 18 hrs.<br>18 hrs.<br>34 hrs.<br>Total 70 hrs. | Rooms at Telegraph Offices at Qum and Kashan.<br>Tip to drivers 2 krs. per stage. |
| *Isfahan* | | | | British Consul-General.<br>Imperial Bank of Persia.<br>Indo-European Telegraph.<br>Agent for Lynch Bros. |
| by Bakhtiari Road to | Mule Caravan. | 10 to 15 Ts. per mule. | 10 to 18 days. | Price of mules varies, being more expensive for a quick journey, and must be bargained for. Toll of 5 krans per laden mule.<br>Ordinary rewards to escort 3 krans per man per diem, allowing for return journey. Servant and tent necessary. |
| *Ahwaz.* | | | | British Consul.<br>Imperial Bank of Persia.<br>Office of Lynch Bros. |
| | Steamer (sailings uncertain) or Native boat. | Not known.<br>5 to 7 Ts. | 48 hrs. | |
| *Mohamerah* | | | | British Consul.<br>Imperial Bank of Persia. |

N.B.—Rate of exchange varies, but roughly £1 = Roubles 9.50 = Krans 53, and 10 Krans = 1 Tuman.

# *THE USE OF MATHEMATICS TO A SOLDIER.*

*By* Lieut.-Colonel C. F. Close, c.m.g., R.E.

This paper is intended as a contribution to a discussion of the value of a mathematical training, at school and at the military colleges, as affecting the efficiency of an officer in his career in the Service. It is not proposed to take the high deductive line, or to begin by asserting broad principles, such as the alleged antagonism between the practical and theoretical types of mind, or the supposed superiority of the classics to the mathematics as mental training, or *vice versâ*, or the breadth of view which is, or is not, engendered by a literary training, or the clearness of thought which does, or does not, result from a study of science.

It is the humbler task of this brief paper to attempt an examination of two practical points bearing on the main question: First, what is the use of mathematics in war, or in preparation for war? And secondly, is there any common term in the upbringing of the famous commanders of modern times which will throw any light on the value of a mathematical training?

## Peace-Time Studies which require Mathematics.

It is not necessary to deal at any length with the various uses which officers of the Army find for mathematics in peace time. The chief opportunities occur in the domains of artillery construction and gunnery, engineering, electricity, and geography; all very necessary studies, but studies not confined to soldiers. There are some specialist studies, which, though not without a certain importance, might be left entirely in civilian hands. However, apart from narrow issues, it will be generally agreed that a knowledge of the principles of mechanics is, for example, essential to the engineer. The amount of mathematics he uses in his engineering will generally depend on his ability, but he must use some. The more he knows the greater his competence to deal with unusual problems. He cannot thoroughly understand what he is doing if he has not a bowing acquaintance with the calculus, although some engineers think they get on very well without.

There is no need to labour the point. It is recognized that a mathematical training is a desirable preliminary to the study of constructional engineering. In the allied domain of geography it is no less desirable. The mapping of the land surface of the globe is, with one notable exception, in the hands of the armies. Our own officers scattered throughout the world take a principal part in the systematic exploring and mapping of our enormous Empire.

As regards artillery construction and gunnery the necessity for a mathematical treatment of the problems dealt with will not be disputed, nor can there be any doubt that practical experience and mathematical theory must in this matter go hand in hand.

We shall not go far wrong, therefore, if we say that it is reasonable that there should always be available a number of officers whose mathematical training should fit them for the conduct and prosecution of certain ancillary duties and studies, duties and studies which are necessary as a part of the peace preparation for war.

## THE USE OF MATHEMATICS IN WAR.

In war itself the direct value of mathematics, except mathematics of a very elementary character, nearly disappears. It may be as well, however, to note the sort of thing which may be wanted. There is, of course, for engineers the building of bridges, with the elementary calculations which this involves.

In *Forty-One Years in India* Lord Roberts gives an account of an officer who was ordered to make a bridge and busied himself so much with the calculations therefor, that in the meanwhile another officer had been ordered to build the bridge, and had finished it before the first man was ready to start.

There is another story, told of a certain siege. The C.R.E., being puzzled what to do with a junior officer, said, "He is a useless fellow, tell him to make a map of the place." So he was told to make a map. Time passed and the fortress was captured and somebody remembered the aforesaid officer, and he was asked what had happened to his map. His reply was to the effect that he had not yet cleared up a discrepancy in his base measurements.

The moral of these stories is obvious. Officers who do these things are totally lacking in a sense of proportion. One may also suppose that the individuals quoted were not very familiar with the work required. But both stories belong to a past generation. There is now an admirable examination which ensures that Engineer officers who are promoted to the rank of captain use the formulæ required in field engineering with perfect discretion.

Another class of calculation which may sometimes be required is that for the number of transport animals necessary for the supply of a force of a given size at a given number of marches distant from the base. There is, of course, no difficulty in stating the problem in symbols, making provision for the drivers' rations, mules' forage, and for spare mules. But for those who dislike symbols there is always the rhetorical method, which, however, for any considerable number of marches, is very laborious.

There is at least one instance of the use in war of the method of taking differences. This method is well known in experimental work as a useful means of detecting errors and of ascertaining the probable existence of any simple law. Now, at Kimberley, at the outbreak of the South African War, the armament consisted of 7-pr. R.M.L. guns. These little guns were sighted up to a comparatively short range, too short to be of material value in keeping back the advanced positions of the enemy. It therefore became necessary to extend the range table. This was done by putting down the known elevations in minutes corresponding to known ranges in yards, and extending the table for a few hundred yards by taking successive differences. Of course there is no magic in the use of differences, but they must be used with discrimination.

Another practical use of mathematics in the rough business of war will be found in the application of the mathematical theory of trajectories to the problem of hitting aeroplanes and airships. Contrary to common belief there is no simple rule which gives the relation between height, distance, and elevation.

We may now sum up this portion of the enquiry by saying, that all the mathematics required, or likely to be useful, in war, is of a very elementary description. Obviously no aptitude at analysis is wanted. The higher flights of mathematics are, as a fact, of no value to the soldier in the field. In peace time they are blameless as a relaxation.

## The Effect of a Mathematical Training.

We now come to the second part of this investigation which attempts to deal with a question of far greater importance than that discussed above, and this second question is, "What is the indirect value to a soldier of an aptitude for mathematics, and what is the indirect effect of a mathematical training on his habits of thought?"

As a means of finding an answer to this question it is proposed to examine the education and special aptitudes of the great commanders born in the 18th and 19th centuries. These are, Frederick, Washington, Napoleon, Wellington, Moltke, Lee and Jackson.

*Frederick*, 1712—1786.—Frederick was brought up rigorously; the system of education devised by his father being directed to making him a hardy soldier. At the age of 9 years every hour of his day was allotted to some definite occupation. He never learnt English, and was forbidden by his father to learn Latin. "Encouraged by his mother and under the influence of his governess and of his first tutor, Duhan, a French refugee, he acquired an excellent knowledge of French and a taste for literature and music." * His father, in his instructions for his education, laid down, "Die

* *Encyclopædia Britannica.*

Rechenkunst, die Mathematik, Artillerie und Oeconomie muss er aus den Fundamente erlernen."*

Although he had a good grounding in elementary mathematics there is no reason to suppose that he had any special liking for the subject. His tastes lay in the direction of philosophy, history, poetry and music, precisely those things hated by Frederick William. He played really skilfully on the flute and amidst the cares of State retained his fondness for music. It is not surprising that, as a result of the system of education enforced by his father, Frederick should have had a particular affection for those studies and pursuits which were forbidden to him.

One of his latest biographers says that he showed himself "blind to the latent possibilities of natural science and mathematics." "Is it not true," he demanded of d'Alembert, "that electricity . . . has only served to excite our curiosity? . . . Is it not true that all the operations of chemistry are in the same case?"†

*Washington*, 1732—1799.—Whatever impartial historians, if there be such people, may think of the rights and wrongs of the quarrel between the American Colonies and the Home Government, there can be no question that the eight years' struggle between France and the Colonies on the one hand and Great Britain on the other produced only one soldier of eminence,—Washington. The Washingtons were of pure English stock, as is indicated by the name. Washington's great-grandfather settled in Virginia about 1657, and in Washington's time the family was amongst the foremost in the Colony. They were large landowners, and theirs were all the advantages of a cultivated Colonial society.

As regards his education it is reported that "at 13 years of age he had become quite a proficient in arithmetic, and entered upon the study of geometry."‡ About this time his half-brother Lawrence formed the project of putting him into the Royal Navy as a midshipman, but owing to the strong opposition of his mother nothing came of this scheme.

It was then decided to educate him as a land surveyor, and with this end in view he studied geometry and trigonometry for which he showed great aptitude. His calculations, books, drawings, and accounts are particularly noted for their accuracy and method. Up to the age of 16 much of his time was spent "in the study of mathematics to which he had become strongly attached, and in amusing himself by practically applying it in surveys and admeasurements" of the territory surrounding Mount Vernon.

When he was a little over 16 he was entrusted by Lord Fairfax

* *Friedrich der Grosse*. Halm. 1855.

† *Frederick the Great*. W. F. Reddaway. 1904. G. P. Putnam's Sons.

‡ *Life of Washington*. Upham. 1852.

with the survey of the great Fairfax estates, and for the next three years was almost continuously employed upon surveying and exploring expeditions. Some of his own accounts of these adventurous journeys are still in existence. His biographers lay stress on the value of this training to him in his after career, as accustoming him to a hard life, giving him an intimate acquaintance with the frontier regions and their inhabitants, and giving him what is vaguely called an eye for country, *i.e.* enabling him to carry in his head true notions of the frontier geography.

At the age of 19 he was appointed by the Governor, adjutant-general of his district with the rank of major; his duties were to inspect the Militia and generally prepare for the struggle with the French which was seen to be impending. This appointment was no doubt due partly to family influence, and partly to his own force of character and fondness for soldiering and adventures. In 1754, when he was 22 years old, he was given the rank of lieutenant-colonel and appointed second in command of the military forces of Virginia.

He does not appear to have received in early life any instruction in modern languages. For, at the age of 22, in the affair of Fort Necessity, he was unable to read the French proposals and was obliged to rely upon an interpreter. He knew no Greek but it may be presumed that as a boy he was taught Latin. But, so far as we know, the only educational subject for which he had a special liking was mathematics.

*Napoleon*, 1769—1821.—Napoleon's academical career and aptitudes are extremely well known and have been often described. He entered the Military School at Brienne in 1779, when he was 10 years old, and remained at this school for more than five years, passing in September, 1784, as a *cadet-gentilhomme* into the Military School at Paris.

At Brienne his abilities do not seem to have attracted much attention, but he was studious and did well in mathematics. He had neither liking nor aptitude for grammatical studies. On leaving the school he was described as having "always distinguished himself by his application to mathematics."

He spent one year at the Military School at Paris and on leaving was thus reported on :—"Retiring and diligent, he prefers study to amusements of any kind, and delights in the reading of good authors; he is devoted to abstract sciences, with little leaning to others, is well versed in mathematics and geography; is taciturn, loves solitude, is obstinate, proud, and exceptionally inclined to egotism; speaks little, is energetic in his answers, ready and severe in his refutations; possesses much love of self, is ambitious and hardworking. This young man deserves to be pushed on."*

* *Napoleon as a General.* Yorck v. Wartenburg.

A couple of his sayings of later life may here be quoted :—

" Military science consists in carefully weighing all possible eventualities, and then, almost mathematically, eliminating chance. It is here that no error must be made, for a decimal more or less may change everything. But this discrimination between skill and chance can only be exercised by a real genius."

" There is no mystery in arithmetic or in geometry. Of all sciences these most stimulate the mind."*

His latest biographer says :—

" Strangely, it may seem, both of them [Napoleon and Wellington] showed a marked taste for topography and for figures. Both gave much attention to exploration of ground and to map study ; both had the gift of numbers. Wellington told the Rev. R. Gleig that his special talent was rapid and correct calculation, while Napoleon was a mathematician and seemed to think in figures."†

*Wellington*, 1769—1852.—All that we know about the tastes and aptitudes and studies of Wellington may be very briefly told. After spending a few years at Eton he was removed by his mother when he was 15 and sent to school at Brussels. After a year or two at Brussels he was sent to a military school at Angers where he spent one year. According to the *Dictionary of National Biography*, he had no turn for scholarship. It is certain that he was fond of music and played well on the fiddle. It may here be noted that his father, Lord Mornington, was a musician of some distinction.

He gave up playing the fiddle when in India on the ground that it was not a very soldierly accomplishment.‡ The only evidence of any other special aptitude is that of Gleig, who heard him say more than once that his special talent was rapid and correct calculation and that " if circumstances had not made him a soldier he probably would have become distinguished in public life as a financier."§

*Moltke*, 1800—1891.—Let us now turn to the study of Moltke's life and note what instruction he had when young and what were his special aptitudes.

Moltke went to the Royal Danish Academy when he was 11 years old and remained a cadet at that academy until he was 18. The course of instruction included higher mathematics, applied mathematics, fortification, chemistry, tactics, strategy, surveying, military geography and statistics, French, German, philosophy, drawing, and sketching. The subject in which he did best was mathematics.

At the age of 22 he entered the Prussian service and from the age of 23 to 26 he was at the War Academy in Berlin. In the report for

* *Maximes et Pensées*. 1820 ed., p. 40.

† *The Growth of Napoleon*, p. 350. Norwood Young. John Murray. London, 1910.

‡ *The Croker Papers*, I., p. 337.

§ Maxwell's *Life of Wellington*, I., p. 5.

the first year the only subject in which his work was not described as "very good" or "excellent" is French. The subjects marked "excellent" were, mathematics, statistics, theory of surveying, and surveying. In the second year he studied spherical trigonometry, the elements of mechanics, the calculus, geography, fortification, German literature, tactics and strategy, surveying, French, and natural science. In the third year, the course consisted of military history, attack and defence of fortifications, general literature, General Staff business, and surveying. In the general report on his work it is stated that "He has written good essays on the practical military subjects given. The result of his scientific studies has been very good."

Writing in 1866, of his studies in the War Academy, Moltke says: "I was sent exceptionally early to the War Academy in Berlin, where the lectures of Major v. Canitz on the history of war, of Professor Ritter on geography, and Professor Irman on physics, interested me much."

In reading his biography one's attention is necessarily attracted to his liking for drawing. He was a skilful draughtsman, and his skill was not limited to landscape drawing. He drew admirable portraits. He was an exceptionally good topographer. For three years he served in the topographical division of the General Staff, working in Silesia and Posen. During his three years in Turkey he carried out surveys of the Dardanelles, Constantinople, the Bosphorus, and made maps of Varna, Schumla, Silistria and greatly increased the existing knowledge of Asia Minor by his exploratory surveys based on astronomical positions. When in Rome in 1849 he made the first accurate topographical map of the neighbourhood. Writing during the siege of Rome in 1849 he says: "I cannot help mentioning with great regret a magnificent pine tree (one of my best trigonometrical points) which grew close behind St. Peter's, but has been felled by the barbarian defenders, without any conceivable advantage." *

Briefly then, Moltke received a very sound and thorough general and military education between the ages of 11 and 25. In this education mathematics played no small part and he did very well in the subject. He was a good draughtsman and a keen geographer, and had a great fondness for music.

*Lee*, 1807—1870.—In General Long's biography† of Lee the first note as to his education is that he was taught to practice the strictest economy in all financial concerns. Early in life Lee had made up his mind to enter the Army and, with a view of going to West Point, at the age of 17 he entered a school in Alexandria to study mathematics. He did very well at this school and it is particularly noted that his diagrams to illustrate problems in conic sections were

* *Moltke: His Life and Character.* Osgood, McIlvaine & Co. 1892.
† *Memoirs of Robert E. Lee*, by A. L. Long. 1886.

remarkable for accuracy and neatness. He spent four years at West Point, passing out second on the list, and was commissioned as a second lieutenant of engineers in 1829.

For the next five years Lee was employed on the construction of the fortifications for the defence of Hampton Roads. In 1835 he was appointed assistant astronomer on the commission for marking out the boundary between Ohio and Michigan, in 1836 he was promoted first lieutenant.

We find him next employed in making surveys, plans and estimates for the improvement of the navigation of the Mississippi. The river was "triangulated and sounded from the mouth of the Missouri to some distance below St. Louis."* For some years after this he superintended the execution of the navigation works. Then follow some miscellaneous appointments, and in 1846, when he was 39 years old he took part in his first campaign, the Mexican War.

Thus his early education was largely mathematical, it is known that mathematics entered considerably into the four years' course at West Point, and it will be noted that after leaving West Point he was for 17 years employed on engineering duties necessitating the use of mathematics.

*Stonewall Jackson*, 1824—1863.—All readers of Henderson's life of Stonewall Jackson will remember that Jackson had little or no schooling as a boy. In early life he is said not to have been clever, but persistent and painstaking, qualities which showed themselves in a remarkable degree when he was at West Point. He joined at West Point in 1842 when he was 18 years old, and, on account of previous lack of education, had a very uphill task. "'We were studying,' writes a classmate, 'algebra and geometry that winter, and Jackson was very low in his class. Just before the signal "lights out" he would pile up his grate with anthracite coal, and lying prone before it on the floor, would work away at his lessons by the glare of the fire. . . . If he could not master the portion of the textbook assigned for the day, he would not pass it over, but continued to work at it till he understood it.'"†

The course at West Point then included mathematics, engineering, chemistry, logic, French, history, drawing, topography and fortification. The length of the course was four years and during this period there was a continual elimination of cadets who failed to reach a satisfactory standard. As for Jackson, the longer he stayed at West Point the higher he moved up in his class. The original strength of the class was 72 and Jackson passed out seventeenth, but it was commonly said by his contemporaries that in another year he would have been first. His determination to master and understand the problems

* *Memoirs of Robert E. Lee*, by A. L. Long. 1886.
† *Stonewall Jackson*, Henderson, I., p. 15.

presented to him in mathematics, logic, and engineering, is noteworthy. He did not take things for granted or learn formulæ by heart. There can be no doubt that it was the determination to understand these subjects which shaped and strengthened his mind.

A contemporary says: "This immense application of mind was naturally strengthened by constant exercise, and month by month, and year by year, his faculties of perception developed rapidly, until he grasped with enerring quickness the inceptive points of all ethical and mathematical problems."*

In 1847 he took part in the campaign in Mexico. In 1851 he was appointed Professor of Artillery Tactics and Natural Philosophy at the Virginia Military Institute at Lexington. He remained in this post for no less than 10 years, *i.e.* until the outbreak of the American Civil War.

The subjects for which he was specially responsible were optics, mechanics, and astronomy. He was not a very successful instructor in these subjects or in mathematics. Although "a thorough master of his subject he lacked altogether the power of aiding others to master it, . . ." writes Henderson. "To the brighter intellects in his class he communicated accurate scholarship; and although the majority lagged far behind, the thoroughness of his mental drill was most useful, to himself perhaps even more than to the cadets."*

During the Civil War this thoroughness was seen in the completeness with which he studied each situation. He left nothing to chance. He dealt in fact with a situation as with a problem and intended his mind upon the various possible solutions.

In any summary of the conditions which formed and developed Jackson's mind it is impossible to avoid laying stress on his struggles and studies for four years at West Point and his ten years' professorship at Lexington in which mathematics had so large a part.

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We have now examined the acquirements and temperaments of the most eminent commanders of modern times. It is evident that the further back we go in history the less influence will science be found to have, and, in fact, in the middle and dark ages organized knowledge hardly existed. We should find a closer parallel to modern conditions in classical times, and perhaps something might be gathered from the career of Cæsar, who certainly had scientific inclinations; but it is more reasonable to confine the enquiry to modern men and modern conditions.

What then may be fairly deduced from a consideration of the lives of these seven great men, Frederick, Washington, Napoleon, Wellington, Moltke, Lee, and Jackson?

* *Stonewall Jackson*, Henderson, I., p. 15.

First, one conclusion stands out clearly. Not one of these commanders had the least inclination or aptitude for classical or grammatical studies.

Next we find that a pronounced taste for modern literature was the endowment of Frederick but of none of the others. Then it may be noted that a fondness for music was the characteristic of Frederick, Wellington and Moltke.

But the most impressive positive fact is that Washington, Napoleon, Moltke, Lee, and Jackson, and to a small degree Wellington, were all men who evinced, to a greater or less extent, an aptitude for mathematical studies and calculations. We have indeed arrived at a somewhat similar conclusion to that expressed in celebrated words three hundred years ago :—

"*As tennis is a game of no use in itself, but of great use in respect it maketh a quick eye, and a body ready to put itself into all postures ; so in the mathematics, that use which is collateral and intervenient is no less worthy than that which is principal and intended.*"*

* Bacon. *Advancement of Learning.*

# RECENT DEVELOPMENTS IN TELEGRAPHY AND TELEPHONY.

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

ABOUT 12 months ago I was privileged to visit the United States and Canada, to study recent developments in engineering practice in telegraph and telephone matters on behalf of the British Post Office, and an account of the most up-to-date systems inspected, together with a brief summary of the conclusions I formed, may be of assistance to brother officers responsible in one way or another for the safe and expeditious transmission of verbal and written communications.

## TELEGRAPHS.

The use of the Morse code for commercial telegraphy is gradually being supplemented and even superseded by typewriting systems, and, since the elimination of the human factor tends to promote accuracy, those responsible for the introduction of typewriting systems in the field will wish to be kept informed of the development and possibilities of such systems.

It has not been our practice in the past to look to America for guidance in telegraph methods, but in connection with my other investigations I examined carefully the methods of handling traffic and the organization of the Western Union Telegraph Company and the Postal Cable Telegraph Company. Most of the circuits of these companies are equipped with sounders, and current is usually supplied direct from the lighting mains or from motor generators run from these mains. I was informed that the Edison Lighting Company has organized the supply so thoroughly that a breakdown is practically impossible; in the event of one service of supply failing another service is available, the mains to the office traversing an alternative route. As a result, the telegraph companies named have not provided installations of accumulators, and the use of batteries for telegraph purposes is rapidly declining. Typewriters are largely used for typing messages direct from the Morse sounder, and although up to the present the results obtained by this method have not been encouraging in this country, I cannot help thinking that we must look in this direction for any improvement in the handling of telegraph traffic.

An ingenious device is the spool on which punched and received tape is wound to facilitate handling. Punched tape is wound on a spool as it is punched up, and then unwound by being passed through the transmitters, and received tape is wound on a spool attached to the receiver and is unwound in the process of typewriting or transcribing the messages for delivery.

Telegraph recording apparatus is extensively used in America, primarily, no doubt, on account of the penalty attached to the commission of errors in the transmission of messages, but there is only a small field for its use in this country.

There are many types of printing telegraph machines in use in the States but there are few which have not already been examined by British Post Office Engineers. Among the systems I inspected I may mention the Rowland, Barclay, Telepost and Ashley.

The Rowland system (Appendix I.) appeared to be making some headway in the American telegraph world at the commencement of my visit, but I found later that the Postal Telegraph Company considered the system was not sufficiently reliable, and after a trial of 2½ years they discontinued its use. This company is now experimenting with the Wright system, and although it is in an experimental stage I understand that satisfactory results are being obtained on a circuit between New York and Washington.

The Western Union Telegraph Company employ the Barclay system to a large extent (Appendix II. and *Fig.* 1) and so far as I could ascertain a satisfactory service was being afforded. Mr. Barclay was, until quite recently, Assistant General Manager of the Western Union Telegraph Company and he informed me that a test had been made on a New York-Chicago circuit 1,000 miles in length, when, by means of duplex working, 1,919 messages were sent from New York to Chicago during a period of 9 hours 15 minutes, and 814 messages were sent at the same time from Chicago to New York during a period of 8 hours 25 minutes. The test was made under ordinary working conditions, the messages were of average length, and the staff at each end of the duplex circuit consisted of one printer clerk, one transmitter clerk, and two punchers. The system is complicated as all machine telegraph apparatus must be, but no claim is made that it is a high speed system, and it certainly appears to be well adapted for dealing with domestic and business messages under ordinary working conditions.

I endeavoured to obtain reliable information concerning the Dean system, but without success. Inspection of the typed characters produced by this apparatus did not create a very favourable impression in my mind as to the suitability of the system for public messages in this country.

The Telepost system is very similar to the Wheatstone so far as the transmitting apparatus is concerned, and the receiving apparatus is on the principle of the Bain chemical recorder. It is claimed that higher speeds can be attained with the Telepost than with the Wheatstone on underground circuits.

I also inspected the Ashley fast speed system which is in process of development, but it was necessary for me to give an undertaking not to describe the apparatus as it had not been patented. It is divulging no secret to say that the system is very simple, the received signals being recorded on chemically prepared tape as in the case of the Telepost.

## Radio-Telegraphy and Radio-Telephony.

My efforts to obtain information of new developments in radio-telegraphy were largely unavailing. I met Professor Fessenden in New York and visited his station at Brant Rock, but unfortunately owing to the Nicaraguan imbroglio all the operators had been withdrawn from the station. I was however afforded an opportunity of judging the possibilities of radio-telephony in a telephone conversation over a distance equivalent to 10 miles in the neighbourhood of Brant Rock, at the time the circuit was not altogether clear of disturbance and I understand that "atmospherics" constitute the chief difficulty in the progress of the art. Professor Fessenden claims to be able to eliminate the interference due to atmospherics, but responsible engineers have grave doubts as to the efficacy, under severe conditions, of the arrangement Professor Fessenden has designed. I met one engineer who informed me that he has frequently listened to a radio-telephonic conversation between Brant Rock and New York, a distance of 400 miles, but he stated that at times the atmospheric conditions rendered speech by this means quite out the question.

## TELEPHONES.

The telephone situation has been rapidly developing in late years and is being complicated by the advent of automanual and automatic systems, which, as in the case of the telegraphs, are designed to dispense with skilled human agency as much as possible. As the names imply, the difference between the systems lies in the degree in which it is possible to eliminate the operator, and although the merits and demerits of the systems will be discussed later, I may state at once that, in the present state of development, the automanual system is to be preferred to the full automatic in all important commercial and industrial centres where a number of large local telephone exchanges are required to provide the public requirements.

Apart from the development of the automatic system, there are few features in the telephone situation of interest to readers of this *Journal*. During my visit I discussed very fully questions relating to the loading of aerial and underground lines, repeaters, and the location of trunk exchanges, but perhaps the most interesting development in manual telephony is the ancillary jack which provides for calls appearing at two or more positions on the switchboard, instead of at one position only as hitherto, thus facilitating team working.

The American engineers fully realize that, in connection with the long-distance service, it is not only the quality of the telephone service from the point of view of distinctness of speech which is an important consideration with the public, but also its availability at the moment it is required. The second of these requirements can certainly be met by the provision of a sufficient number of circuits in every case, but commercial considerations demand that the whole of the plant installed shall provide an adequate revenue to pay all expenses and to earn a profit. This clearly points to the necessity of effecting some compromise between an instantaneous service, and a service involving unreasonable delays in providing the use of lines. The subject appears to have been approached in a very commendable spirit by both the telephone companies and the public. The provision of trunk circuits is based on the assumption that the public will tolerate a longer delay in connection with places very distant from one another, than in the case of places close together, whilst, on the other hand, it is admitted that in certain cases an almost instantaneous service may justly be demanded. In order to guide the administration in the provision of additional circuits between important centres, schedules have been prepared laying down the F.S. (file and start) time for the various circuits. In other words the F.S. time is the maximum delay which it is expected that the public will, as a rule, submit to, or, in scientific terms, it is the "modulus of elasticity of the patience of the public." Should delays habitually exceed the scheduled times, the question of the provision of additional circuits is at once taken in hand by the engineers. A study of this nature led to the provision of an underground cable between New York and Philadelphia, and the number of circuits provided is such that an almost instantaneous service between these centres is now being given.

The financial considerations involved in the loading of aerial and underground lines are so great, as to call for the most thorough investigation of the results obtained in America, and the methods adopted in that country. In 1908 the British Post Office conducted an exhaustive series of experiments on underground loading, and it may be useful at this stage to recall the principal conclusions arrived at in order to clear the ground for the consideration of the further points embodied in American practice.

The conclusions were :—

(1). That in the best conditions the loading of underground circuits permits the range of speech on a given cable being increased 3·7 times, that is to say, if speech could be conducted on a given cable for 100 miles at present, then, by judicious loading, the same cable could be utilized for speaking over a length of 370 miles.

(2). That the cost of providing and fixing the coils is very much less than the expense of providing a cable of such an increased gauge as would improve speech to the same extent as loading coils.

(3). That the loaded circuits require less duct space as a smaller gauge of wire suffices.

(4). That there is every prospect of satisfactorily maintaining loaded circuits if the best iron core coils are used.

The additional information now furnished as to American practice, and the results obtained in that country may be briefly classified under the following heads :—

(i.). Information as to the transmission efficiency of overhead loaded circuits in America, as compared with aerial unloaded circuits of the same gauge.

(ii.). The use of terminal transformers to reduce terminal losses, and the method of signalling on various types of junction circuits in which terminal transformers are used.

(iii.). Detailed information as to fitting loading coils, and the lightning protectors necessary for their protection upon poles.

(iv.). The method of fixing loading coil cases in underground manholes.

The conclusions to be drawn from a study of American practice are :—

(i.). The increase in transmission efficiency obtained by loading overhead lines is not relatively as great as in the case of loading underground circuits.

(ii.). The advantages of aerial line loading, as indicated by American experience, are so great (resulting in a saving of $2\frac{3}{4}$ cwts. per mile per wire) *i.e.* increasing the efficiency of 100 lbs. copper to that of 260 lbs. copper, that trial of this type of loading is very desirable. The only element of doubt as to success in this country is the humidity of the climate. It is stated that an insulation of 2 or 3 megohms per mile is necessary for the proper working of aerial loaded circuits, but it is believed that experience has shown that this can be obtained in England. It would appear that the best results can be obtained by the loading of wires of the smaller gauges, with the available type of loading coil. It is further very important that a lightning protector should be placed upon the poles for the protection of every loading coil. Difficulty has been experienced in America in obtaining a satisfactory protector, but it is stated that one has now been designed.

(iii.). The use of terminal transformers, although beneficial when very short terminal circuits are connected to loaded circuits, is not necessary when these circuits are of a moderate length, and as great complexity is entailed by the use of the transformers, the conclusion in this country is that they can with advantage be dispensed with.

(iv.). The advantage of placing heavy coil cases at the top of poles is attended by such obvious disadvantages that I consider it should only be resorted to when the advantages gained as regards efficiency are considerable. An examination of the problem however, shows that for a 100-lb. circuit loaded for 600 miles the loss need not exceed 1 mile of standard cable, and it is thought that this loss is preferable to the placing of the coils upon the poles.

The telephone repeater is still largely in an experimental stage, but it is used to a considerable extent on some of the longer lines in America. Owing to its inherent physical characteristics the repeater has, at present, very decided limitations. It cannot be used on loaded lines; it introduces a certain amount of distortion, and it is particularly susceptible to conditions of line balance. A sample repeater under test was found to give such unreliable results and to involve such difficulty in eliminating "singing," that it is clear considerable additional work has to be done before it can be installed to general specification for commercial use.

## Automatic Telephones.

I devoted considerable attention to the study of the automatic telephone situation in America, and inspected five different types of switch equipment designed to provide automatic and semi-automatic telephone service. Three of these equipments were seen in actual operation, a fourth as an exhibit, and the fifth in process of construction. I visited one of the pioneer installations of the "Strowger" equipment at Grand Rapids, and the latest types of this system at Omaha, Columbus (Ohio), San Francisco, Los Angeles, and elsewhere. The Lorimer system I saw in operation at Peterborough and Brantford; and the North Automanual type in operation at Ashtabula (Ohio). The American Automatic Company had an exhibit of their equipment at Chicago, on the occasion of the annual convention of the Independent Companies, which I was enabled to visit, and the Western Electric Company very kindly afforded me facilities for inspecting the switchboard, which is being built in order that the company may fully study the technical and economic aspects of semi-automatic switchboards for use in multi-office areas.

The desire to operate telephone exchanges by means of automatic equipment dates back almost to the first days of intercommunicating telephone circuits. The growth in recent times has been due largely to the enterprise of a manufacturing company—the Automatic Electric Company of Chicago—which has succeeded in capturing the Independent Companies, and there seems to be little doubt that the aspect of novelty has been seized upon as a means of competition with the older forms of switching equipment.

### Advantages and Disadvantages of Automatic System.

The advantages claimed for the automatic system may be summed up as follows :—

(*a*). The elimination of human agency in switching.
(*b*). The certainty of connection within a given time.
(*c*). The rapidity of disconnection when the calling subscriber replaces his receiver, thus releasing costly junctions and enabling those circuits to carry a heavier load.
(*d*). Uninterrupted all night service without additional expense.
(*e*). Saving in operator's wages, buildings, conduits and cables.

On the other hand opponents of the system point out that the following are amongst the more serious disadvantages of the automatic type of plant :—

(*a*). Complexity of apparatus.
(*b*). Heavy capital expenditure in exchange plant.
(*c*). Increased maintenance charges.
(*d*). Inadequate means of registering the number and class of calls and limitation to a uniform rate of charge.
(*e*). Impracticability of working arrangements for a series of junction circuits exceeding two in number.
(*f*). The failure of a single unit may cut off 100 subscribers.
(*g*). It is possible for a mischievous person to send a false call and "engage" the line of some subscriber against whom he bears malice or whose interests clash with his.
(*h*). The calling device cannot be operated in the dark.

It is claimed that in the manual system the operator exercises continual supervision of the lines under her control, and that this supervision is not obtainable in the automatic system ; but this statement is hardly correct, as the switch attendants are continually patrolling the exchange, and if they notice (as they are able to do) that a particular line is engaged for an inordinate length of time, it is their duty to investigate the matter. I think that automatic exchanges will work best in communities where the interests involved are not of a keen competitive order ; requirements of a special nature are difficult to provide on an automatic switch, and for all preferential services and trunk working operators will continue to be necessary. No means have yet been devised for dealing with calls for which a different rate of payment is demanded, and this is a serious defect in the case of large areas in which a differential rate at present prevails.

The abuse of the system by swindlers and evil-disposed persons is, I understand, mitigated by the employment of detectives by the companies, and it is claimed that little or no trouble of this kind is now experienced. One other disadvantage of the automatic system, which is not however very serious, is that if a subscriber accidentally depresses the receiver hook during his conversation he is immediately "cut off" from his correspondent.

There are many features common to the three full automatic systems which may be eliminated in comparing them with each other, such as for example the advantages and disadvantages of automatic and manual in all its aspects, which I have already dealt with. The general features of the exchanges are such as now appear to be applied by all automatic telephone companies, that is to say, all the systems give full common battery facilities, the exchange apparatus works on the step-by-step principle, and the various switches are designed on a percentage basis for connecting simultaneously a predetermined percentage of subscribers at one and the same time. At the subscribers' stations the principal features of full automatic systems are also similar. The calling subscriber must always select the called subscriber and either rotate a handle and dial (American Automatic system), turn a dial (Strowger), or move fixed levers and wind up his apparatus (Lorimer) in order to put the automatic selective apparatus into motion. There is still some doubt in the minds of the engineers responsible for the installation of the Strowger equipment, as to whether the so-called three-wire system—*i.e.* one using "earth" in connection with the calling device—or the so-called two-wire system in which no such "earth" connection is used, is the more satisfactory one in actual practice. Another feature which divides the automatic equipments into two groups is that the Strowger and American Automatic systems are wholly operated from the sub-stations, but in the case of the Lorimer the calls are set up by the positive action of the selecting devices at the exchanges, on the arrival of a preliminary signalling current; the number required having been first completely set up at the subscriber's instrument.

The Lorimer subscribers' apparatus presents the most convenient arrangement for calling, inasmuch as the completed subscribers' number is continually on view until the next number is set up; this is not the case in the other two systems. The apparatus at the exchange is of a very robust construction, and the contacts are made by the positive action of a machine which is power driven. The parts of the mechanism are therefore more durable and the life of the plant should be longer. Any sparking at electrical contacts is arranged in this system to take place at the exchange and not in the subscribers' apparatus, and the motion of the machine parts consists in the uniform rotation of brushes over cylinders—there is no stepping up vertically and horizontally. The disadvantages of the system include the cost of power to drive the mechanical parts, which must be kept continuously rotating, but the advantage gained by the solidity of the parts will no doubt materially reduce the depreciation factor. The step-by-step movements appear to be more numerous than those in other systems, and the continuously rotating machinery would necessitate much more attendance at district exchanges than would be required in the absence of it. Technical details of the system are given in Appendix III.

The Strowger system (Appendix IV.) has been more extensively used than any other, and there is the advantage that greater experience has been gained of the operation of the system, which has led to a more fully developed method of working junction, party, lines, and message rate circuits, etc., than in any other system. No power machinery is required at the exchange to drive the selective machinery as is the case with the Lorimer, and the equipment appears to require less space than the Lorimer apparatus. The disadvantages are that in order that the electric parts in the exchange may be driven with sufficient speed by impulses over the subscribers' lines, they are comparatively light and not so durable as compared with the Lorimer system, but the first cost should consequently be low. The motions of the selector switches involve vertical and horizontal movements which do not appear to be so simple as the simple rotary movements in other systems, and it is thought that some sparking takes place in the subscribers' apparatus. The rotation of the disc on the subscribers' apparatus is not so convenient as the arrangement in the Lorimer system, since the completed number of the called subscribers is never on view. The system is so delicate from the electrical point of view that great care must be exercised to prevent any but very slight variations in the line voltages.

In the American Automatic Company's system (Appendix V.) the various switches and selectors appear to be of simple uniform design, the wipers or brushes only moving over a semicircle in each case, without vertical movement. There is no continuously rotating machinery at the exchange for selective purposes, and the apparatus appears to be compact. In this equipment the relays and other parts liable to derangement, have been mounted on plates which can be readily removed and replaced by others. From the maintenance point of view such an arrangement presents very considerable advantages. The disadvantages associated with the system are that the movements on the dial of the subscribers' apparatus are not so convenient as the device in connection with the Lorimer system, for the reason that the completed number of the called subscriber is never on view, but there is one feature in the dial which appears to make it more convenient than the Strowger dial, *i.e.*, one operation of the dial is alone necessary to call numbers up to 50, and four digit numbers can be set up by two motions only of the dial where numbers under 5,000 have to be dealt with. From a mechanical point of view this type of equipment has an advantage over the Strowger, since only a rotary movement is necessary in the selectors, and, in consequence, the moving parts are more substantial and will probably prove to have a longer life.

### AUTOMANUAL *versus* AUTOMATIC SYSTEMS.

There is no doubt there are considerable advantages attached to a system in which the subscribers' apparatus can be made as simple as possible, and in which the operations to be effected at the sub-station require the minimum amount of intelligence. In the automanual system (Appendix VI.) the subscriber is relieved of the manipulation of the selective device upon his telephone ; all the automatic apparatus is concentrated in the exchange and its maintenance simplified in consequence. Further, the elimination of the subscriber's circuit from the automatic arrangement will tend to the better working of the automatic machinery, as impulses have not to be transmitted over the lines, and any leakage faults upon them would not have such serious consequences. As calls are automatically distributed to the disengaged operators and manipulated at the exchange, there will be possibilities of utilizing the operators to the fullest advantage, and this will give more elasticity to the service as regards the operation of junction circuits, trunk circuits, party lines, metered services, etc., than would be possible in a full manual system. The operators, also, being continually employed in the manipulation of the numbers, will become expert and a rapid service will result. The expertness of the operators as compared with that of the subscribers cannot fail to reduce very appreciably the liability to errors in operating the automatic selective devices, and the conditions prevailing at the exchange allow of the most suitable devices being designed for operating the switches. The subscribers' apparatus will be cheaper and simpler to maintain when the automatic selective device is removed to the exchange, and the absence of complexity at the sub-station office will be an inducement to all to become subscribers whose time is of value, and who do not care to be troubled with a selective arrangement.

The disadvantages include the increase in the cost of operating and of exchange buildings as compared with an automatic system. The latter is due to the increased space required by operators' positions, retiring rooms, etc. The rapidity of the service will be dependent upon the speed of answering of the operator, and to those subscribers who find the elimination of the operator an advantage, the system will be open to objection.

In brief, an automanual system will be more efficient, more rapid, and more elastic, particularly in urban districts, than an automatic system, but it will be more costly in operating expenses.

### Keith Line Switch.

In any telephone system the cost of the wire, cable, and conduit, is always the largest factor, and it not infrequently represents two-thirds of the entire first cost of the system, depending of course not only upon the number of lines, but the density of the plant as determined by the location of the business centre, the nature of the soil, and the obstructions encountered. In the manual system if the number of subscribers in an outlying district is insufficient to justify the erection of a small exchange and the provision of staff and superintendence, the district can only be served by running lines from the main exchange. The automatic companies in an endeavour to overcome this difficulty have provided small sub-stations, located so that every subscriber will be within reasonable distance of one of them. Junctions are run from the sub-stations to the exchange. It is claimed that these sub-stations or Keith units (*Fig. 2*) can be located in cellars, or outbuildings, or even in manholes in the street, and can be run without staff. Maintenance visits by the linemen would, of course, be necessary, but at infrequent intervals. I doubt, however, if any substantial economy is effected if we take into consideration the cost of housing the plant (however small this may prove to be), and of the time occupied in maintenance visits. The "units" are to some extent the weak parts of the system, and as they must be located some distance from the exchange the time occupied in maintenance visits cannot be inappreciable.

### Conclusion.

The greatest care has been taken by the automatic telephone companies in selecting and training men for the maintenance of the equipment, and I am of opinion that much of the success of the system is due to this fact. The chief engineer of one company informed me that it takes from three to four years to train a switch attendant, and even then the man must be fairly intelligent before the training commences. The automatic equipments inspected were all working very smoothly, the standard of maintenance being excellent, and I cannot lay too much stress on the necessity for the employment of highly-trained "troublemen," or linemen, in connection with the maintenance of the automatic system. Military requirements necessarily differ from commercial requirements, but if the automatic systems can be made thoroughly reliable the advantages accruing from the elimination of the operator without any increase in the transport required for the engineering plant should form an inducement to the authorities to adopt the system for military purposes.

It is necessary to emphasize the point that the mechanics required to look after the automanual and automatic switch equipments must be very highly-trained men, but the number of mechanics need be no greater than is at present employed on the maintenance of magneto exchanges.

## *APPENDIX I.*

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## THE ROWLAND TELEGRAPH SYSTEM.

The Rowland is a duplex multiplex printing system, and is based on the principle that the carrying capacity of a wire is far in excess of the operator's ability to send. Messages are transmitted in both directions over a single wire by synchronizing the apparatus at each end and giving to each of four operators the use of the wire for a short period. The dominating feature of the Rowland System is that a current is always on the line and the signals are made by reversal of certain impulses. Thus it is essentially different from those systems in which no current passes along the wire except at the instant when the message is to be signalled. The system can be duplexed so as to provide four channels in each direction, or eight in all. At the sending end a transmitter, similar to the keyboard of a typewriter, is fitted on each channel. The actual signalling depends on special combinations of the typewriting keys, each of which has 11 contacts, so that it is possible to form 35 different signals The depression of a key reverses two of the 11 impulses sent out by the alternator, and this reversal of current causes the relays at the distant end to operate the printing receiver which is under the absolute control of the sending operator. A record of the signals is also made at the sending end on a tape printer.

At the receiving end the type wheel of the printing mechanism is kept revolving in synchronism with the incoming reversal, a bank of distributing relays being utilized to select the required letter according to the signals received. The printing of the messages is done automatically in ordinary type in page or any desired form.

In order to secure perfect synchronous movement between the transmitting and receiving apparatus, the speed of the latter is varied by means of a rheostat until a musical sound of a definite pitch is obtained in the telephone used as a synchronizing detector. The inherent defect of the P.O. Multiplex System is thereby avoided.

It is claimed for this system that a speed of 35 words per minute per operator can be obtained, so that with duplex arrangements a speed of 280 words is possible, with the advantage that the messages are printed ready for delivery.

Viewed from the economic aspect, the merits of the Rowland over existing types of Morse systems used in the British Post Office are :—

1. No time occupied in writing up messages.
2. Employment of typists instead of expert telegraphists.
3. Increased output of work.

On the other hand, the Rowland apparatus is very complicated, and its use would probably be limited to busy centres.

## APPENDIX II.

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## THE BARCLAY PRINTING TELEGRAPH SYSTEM.

The Barclay Telegraph System is essentially a Wheatstone Automatic Duplex System with the addition of a printing apparatus in the local circuit. This apparatus consists of:—

1. A keyboard perforator, so arranged that the depression of a key brings into play various combinations of levers to form a particular letter. The action is purely mechanical, except that a 110-volt. D.C. motor is employed to expedite the mechanical operations.
2. The transmitter differs from the P.O. Wheatstone transmitter in one or two details, chiefly the use of dynamos for sending the currents to line; arrangements are also made to keep the driving mechanism in constant motion during certain prescribed hours of the day, a ·110-volt motor being employed for the purpose. The operation of "winding up" which detracts from the value of the Wheatstone System is entirely eliminated.
3. A polarized relay is also used at each end of the line and is identical with the P.O. standard relay with the exception that the permanent magnet is replaced by a third coil of 100 ohms resistance through which a local current of 50 milliampères is always flowing to increase the sensitiveness of the relay.
4. The printer is really an electrically controlled typewriting machine adapted to telegraphic purposes. In place of the usual finger keys, a series of electro-magnets are utilized to manipulate the mechanism by which the type wheel is rotated and brought into position ready for printing.

Messages for transmission are first treated by an operator at the keyboard perforator, producing a paper tape with perforations representing the message in the Barclay code. This tape is passed through the transmitter which sends to line the desired long and short currents. At the other end of the line the various letters are formed by different combinations of three positive and three negative currents. These currents actuate the polarized relay which in turn actuates a bank of distributing relays. The latter are utilized for the purpose of setting up certain predetermined combinations, which rotate the type wheel of the printer into any selected letter position, and at the same time bring it into contact with the message form upon which the letter is printed. After the selection and printing of a letter, the distributing relays are restored to their normal position by a local current.

The maximum speed of Barclay apparatus is 100 words per minute under simplex conditions.

Compared with the Wheatstone Automatic System, the Barclay has the following advantages:—

1. No time occupied in transcribing messages.
2. Any particular letter is formed on the keyboard perforator by a single depression of the key lever, compared with two to five depressions on the Wheatstone perforator.
3. Multiple copies of messages can be obtained.

On the other hand the keyboard perforator of the Barclay System is complicated and requires a heavy current (3·4 ampères at 105 volts = 357 watts).

## *APPENDIX III.*

## THE LORIMER SYSTEM OF AUTOMATIC TELEPHONY.

In this system the subscribers in the main exchange are divided into entirely separate groups of 100, and this permits of future extensions with a minimum of complexity.

The apparatus is designed to affect the switching operations for a percentage only of the subscribers in the same way that pegs and cords provide for putting through only a percentage of the circuits connected in an ordinary exchange.

The apparatus for each 100 subscribers is divided into two parts (1) a sectional division and (2) as many percentage divisions as there would be pairs of pegs and cords in a manual exchange.

The apparatus consists generally of cylindrical switches with tags inside, and brushes revolve inside these cylinders and make contact with the tags as required. In one case (the Decimal Indicator Apparatus) the brushes are stationary and the other part revolves.

One hundred subscribers are connected to the decimal indicator of the sectional division, each circuit being terminated on separate contacts but one indicator sufficing for the whole. The percentage division has five separate cylindrical switches with auxiliary ones for advancing the switching operations step by step. The subscribers' apparatus contains a disc divided into four quadrants with contacts corresponding to units, tens, hundreds, and thousands and with contact brushes driven by clock-work.

To effect a call the brushes are placed on the number of the required subscriber; this closes a circuit to the exchanges, actuates an electro-magnet, and the revolving apparatus on the sectional division stops, a free percentage division is brought into use and the calling circuit by the same movement is connected to it. Then step by step the units and tens of the called subscriber are joined up by the switches and the inter-connector finds a free percentage division in whatever hundred the called subscriber may be found. The various switches are actuated by current impulses sent over the subscriber's circuit due to the brushes on the subscriber's apparatus being driven by clockwork over metallic contact points. These current impulses drive the exchange switches through the agency of electro-magnets. The number of impulses is determined by the position of the brush on the number of the called subscriber.

When the called subscriber's line is joined up the calling subscriber presses a button and rings him up. The clearing signal is given when the receiver is hung up.

The system is common battery for speaking and signalling. The moving brushes are actuated by machinery which must be in continuous rotation day and night. Heavy currents are required. The mechanism is more complex than others and the expense of maintenance would probably be high.

Spare apparatus would be necessary as the consequence of the stoppage of a sectional division with 100 subscribers would be serious.

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## *APPENDIX IV.*

## STROWGER SYSTEM OF AUTOMATIC TELEPHONY.

A typical Strowger Automatic System consists essentially of:—

(*a*). The subscriber's signalling apparatus.
(*b*). Step-by-step switching apparatus at the exchange for passing on the calls.

The subscriber operates the central exchange mechanism by the manipulation of a dial on the front of his telephone, the rotation of which actuates the switches at the central exchange by means of current impulses sent along the line and causes the switches to select automatically the telephone of the subscriber with whom the caller desires connection.

The exchange equipment is divided into units of 100 lines so that the exchange equipment can be augmented on the unit system. The number of selectors used, however, is governed by the size of the exchange.

The essential exchange apparatus consists of:—

(*a*). The line and master switch.
(*b*). First and second selectors.
(*c*). A connector.

Each subscriber's circuit terminates on a line switch in connection with a master switch (which controls a group of line switches). The master switch performs the function of an operator in transferring a call from the 100 group of lines in which it originates to a disengaged line in a group of 10 circuits which correspond to the pegs and cords of a manual exchange. The 10 circuits terminate on a "first selector." This piece of apparatus controls the group of "thousands" circuits. The selector switching apparatus consists of rows of tags—placed vertically one above another—and a wiper or contact brush which, by means of impulses sent over the subscriber's line and through the agency of an electro-magnet, step up the wiper on a vertical rod to the row in which the required thousand is found, the wiper then moves horizontally and automatically along the line of tags till a disengaged circuit is found. By this means the calling line springs are connected to a "second selector" which continues the connection to the hundreds group governed by impulses from the subscriber's line. The second selector is similar to the first and joins up the line to a further similar switch called "the connector," which finally completes the connection to the called subscriber's line. The subscriber hangs up his receiver on the completion of the call and earths both lines, thus causing the release of the clearing mechanism by means of relays acting on the various dog clutches. The subscriber can clear at any time by replacing the receiver.

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## *APPENDIX V.*

## AMERICAN AUTOMATIC TELEPHONE COMPANY'S EXCHANGE SYSTEM.

This is a common battery 2-wire system, and it consists essentially of:—

(*a*). A subscriber's signalling device.
(*b*). A finder
(*c*). First and second selectors } At the exchange.
(*d*). The connector

The subscribers' apparatus in addition to the ordinary C.B. speaking device, contains clockwork and a dial with letters and numbers around its circumference. Instead of merely a number, a combination of letters and numbers may be used, as, for example, "DC 12." The dial has 50 holes around its circumference, with letters and a number opposite each hole.

To call the subscriber DC 12, a handle, forming a radius of the dial, is turned until it stands opposite the letter D, and at this point the handle is pressed down, thereby pressing a pin into a hole. The dial is then turned round clockwise by the handle, and allowed to rotate back by its own spring tension. The operation just described is repeated for "C" and "12." Each of the rotations of the handle sends a number of impulses over the line, the number of these impulses being regulated by the letters and figures operate on the dial.

In the exchange the subscribers' circuits are divided into groups of 50 and, as is usual in automatic systems, the exchange can be built up in independent units without costly alterations to the multiple.

The 50 grouped subscribers terminate on "finder" switches. A finder switch has 50 subscribers' circuits terminating on tags arranged in a semicircle with a "wiper" or "brush" which forms a radius of the semicircle, and which is stepped round the contacts by a ratchet wheel actuated by the armature of an electro-magnet known as the motor magnet, this is in turn controlled by a line relay worked by impulses from the subscribers' circuits. Each group of 50 subscribers' circuits in a 5,000 exchange has the possibility of using any one of six finders, and these finders correspond to the pegs and cords in an ordinary exchange. It will be seen, therefore, that provision is made for the connection of 12 per cent. of the subscribers at the same time.

The wipers or brushes are each in connection with a "first selector" one such item being provided in connection with each finder, and it joins up the subscribers to the "thousands" group of circuits by impulses sent *viâ* the finder to the controlling magnet of the first selector which causes the wiper to step round by means of a ratchet wheel as in the case of the finder switch. If the wiper should rest on an engaged circuit contact for an instant, this contact will be found to have a potential upon it, and as a consequence a further series of impulses will be sent through the motor magnet which automatically causes the wiper to move forward until a disengaged circuit is found. The first selector through its contact springs joins the calling subscriber to a second selector which is a switch of the same construction as the finder and first selector switches, and the second selector in turn continues the connection by similar means to another switch of like construction, termed a connector, which finally joins the line to the called subscriber.

When it is desired to clear the circuit on completion of a conversation, the receiver is hung up and a relay operated which releases the various clutches and allows the different switches to fall back in their normal position in readiness for another call.

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## *APPENDIX VI.*

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## THE CLEMENT AUTOMANUAL SYSTEM.

An installation comprises :—

(*a*). Standard common battery apparatus at the subscribers' office.
(*b*). Operator's signalling table }
(*c*). Selector } At exchange
(*d*). Connector }

in addition to power plant, generators, fuse and protector frames, etc.

### Operation of the System.

(*a*). When the subscriber lifts his receiver, a lamp lights in front of the operator who depresses speaking key, repeats the figures to the subscriber and at the same time signals the number required.

(*b*). Each operator has sets of numbered keys, three lamp signals in connection with each set of keys, and a speaking key and a starting key common to the set. Each set of numbered keys is connected by a separate call wire to a switch which is actuated on the lifting of the subscriber's receiver. If one set of keys is engaged, the subscriber's line will be connected automatically to the next set. Three sets of keys are provided at Ashtabula.

When the starting key is depressed, the subscriber's line is connected to the switches which complete the circuit to the required line, and the operator's call wire junction to the number keys is free for the next call.

(*c*) and (*d*). These are similar in principle to the Strowger type, and perform the same functions. The spindle however moves first in a rotary, then in a vertical direction.

The contacts are made vertically and it is considered that this ensures greater freedom from dust troubles.

## CALL WIRES.

Two exchanges may be worked by operators at the main office. In this case, the call wire junctions to the keys for each operator are extended from the selective switch at the sub-office, to the keyboards at the main, and it is a matter of financial consideration whether it would be cheaper to extend the junction circuits and concentrate the operators, or save the cost of junction lines and provide separate staffs of operators.

The proportion of call wire junctions is low, as the time they are required for each call is very brief; the estimated proportion of call wires is less than 1 per cent. at the larger exchanges.

## JUNCTION LINES.

Separate junction circuits for the actual conversation between the subscribers are provided, and where there are several sub-exchanges the circuits may be taken by the most direct route, not necessarily through the main exchange.

# *EFFECTS OF A LIGHTNING STROKE ON AN ELECTRIC LIGHT INSTALLATION.*

*By* Capt. R. St. J. Gillespie, R.E.

The writer has lately had what he believes to be the somewhat uncommon experience of a flash of lightning directly striking the wires of the electric installation in his charge, and has thought it worth while to record the exact details of the effects, in the hope that the account may be of value or interest to other officers.

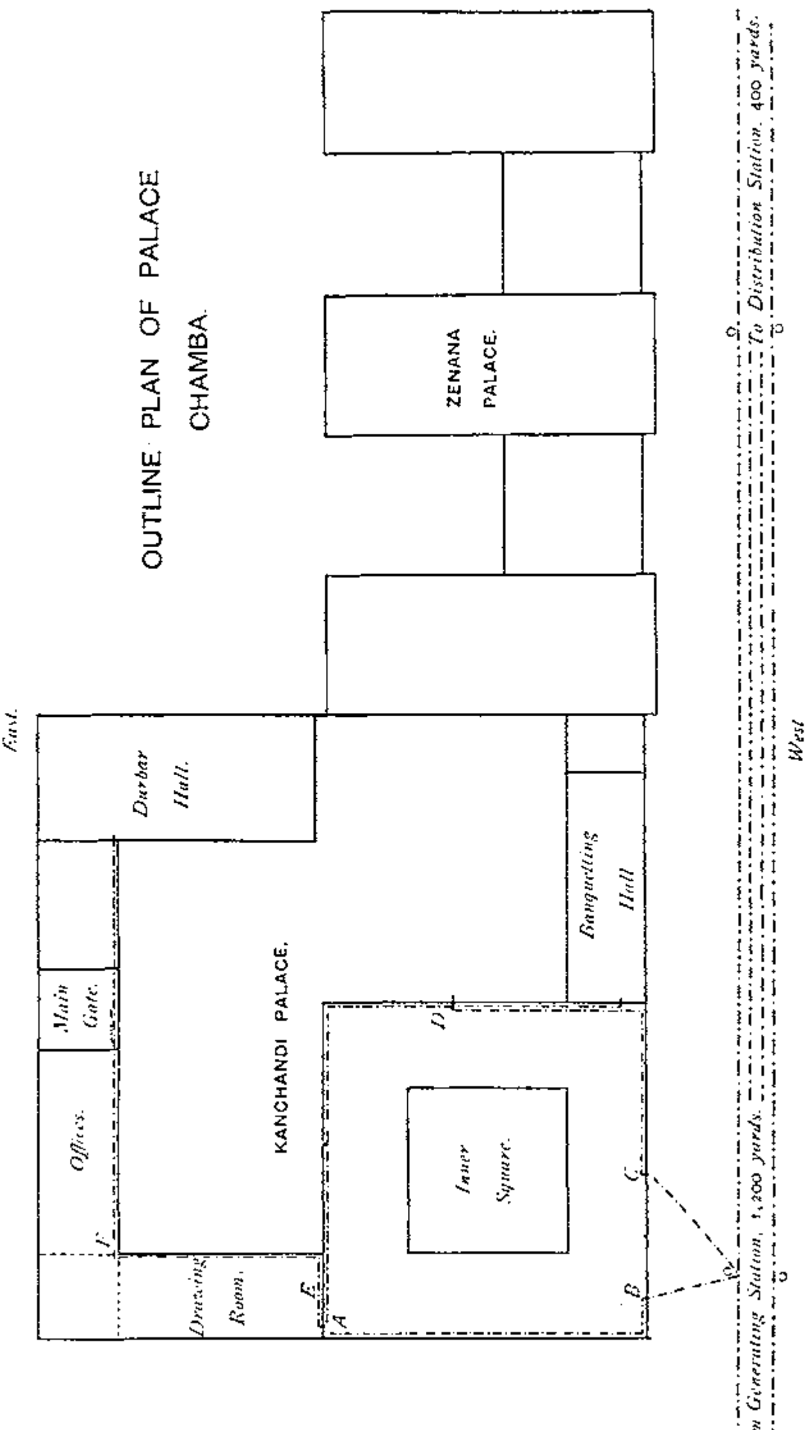
The conditions are, of course, somewhat abnormal, as it is unusual to find a large building, equipped with electric light, standing in an exposed position and yet not fitted with lightning conductors.

At the same time it may be noted that though thunderstorms are common in Chamba a stroke in the town has rarely been known, probably owing to the fact that the town is closely surrounded by high hills.

In this case, during a heavy and prolonged thunderstorm, the lightning struck the roof of the Palace, which consists of two main portions, the Khanchandi Palace and the Zenana Palace.

The Khanchandi is a two-storied edifice built in the form of a hollow square with a smaller square enclosed in one corner. It has a low pitched roof of slates, with a plank ridge covered with strips of galvanized iron. There are few chimneys and the roof has only two breaks in its continuity, viz. over the main gateway, where it is higher than the rest, and at point (E) on the accompanying plan, where there is a gable, the roof over the inner square and Banquetting Hall being a few feet lower than the rest. There are no lightning conductors on this part of the Palace, which is completely fitted with electric lights.

The Zenana Palace is a newer and much more lofty building, roofed with corrugated iron, and with several high gables. It has lightning conductors, but they have not been tested for many years though they appear to be mechanically intact. The ridges are ornamented with iron scroll work, well adapted for dissipating static charges of electricity. There is no electric light in this part of the Palace block. Nearly the whole of the upper story of the Khanchandi consists of long empty galleries with wooden ceilings, the




OUTLINE PLAN OF PALACE CHAMBA.

lower floor containing State reception rooms and offices. The only part used for habitation is the lower floor of the inner square.

The Durbar Hall roof is the same height as the rest, but the Hall itself is the full height of the building inside. The main transmission lines run along the west side of the Palace being of bare copper carried on Hamilton poles. The mains for the Khanchandi enter close under the eaves at (B), where a pair of Garton lightning arresters are fitted. Inside are a pair of "Reason" type main fuzes, and from these a pair of 19/16 leads runs to the main marble switchboard at (A). This has a double-pole main knife switch from which are taken the leads for the three main circuits.

A pair of 19/16 leads pass through two large china hand-grip type fuzes, and thence along the gallery walls to the Durbar Hall, where there is a wooden switchboard with another d.p. knife switch on the mains, and a number of distributing fuze boards and tumbler switches for the fans and lights in the Hall.

A pair of 7/18 leads pass through a d.p. tumbler switch and a pair of fuze boxes on the main board, and under the floor of the gallery over the drawing room and offices to supply the latter. Another pair of 7/18 leads pass through a similar switch and fuzes, and round the gallery of the inner square to the Banquetting Hall where there is another main switch and distribution switchboard.

The Durbar and Banquetting Hall mains are in wood casing along the top of the gallery walls.

At (C) another set of leads come in from outside, through a d.p. tumbler switch and a pair of "Reason" fuzes, and then round the gallery to (D), where they cross the Banquetting Hall leads and go out to join the armoured cables which feed the flaming arcs in the courtyard. The joints to the armoured cable are high up on the wall outside. There are Garton arresters at (C) outside.

All main leads are in wooden casing except those under the flooring.

A heavy thunderstorm accompanied by steady rain began on the evening of January 24th, and continued without intermission till the morning of the 26th. About 7.30 p.m. on the 26th there was a brilliant lightning flash simultaneously with a deafening peal of thunder, and all the electric light in the town went out at the same instant. After a few minutes the lights came on again, and the state of the 50-c.p. Osram lamps in the Club at once showed that the wires had been struck somewhere. These lamps burnt with the most intense brilliancy on account of their filaments being all twisted together and half short circuited. Needless to say the brilliancy was of short duration.

Next morning, investigations showed that the lightning had struck the Khanchandi Palace somewhere above the drawing room. A careful examination inside and out led to the discovery of a couple of small holes in the galvanized iron ridge 6′ from the gable at (E).

The holes are irregular oblongs about 1″ × ½″ and look as if they had been burnt out by an oxygen flame, and under one of them was a black charred mark on the planking. The writer is of opinion that this is the actual point where the flash struck.

A few inches away was the second hole which was found to be exactly over the head of an 8″ iron spike evidently meant to fasten the ridge plank to the truss beneath. The carpenter who drove the spike had made a bad shot, missing the truss by a couple of inches, leaving the spike projecting into the roof space beneath. The head of the spike showed clear signs of fusion and from its lower end a discharge had evidently taken place, the point having been melted and the truss close to it having a black charred mark as if of a flame.

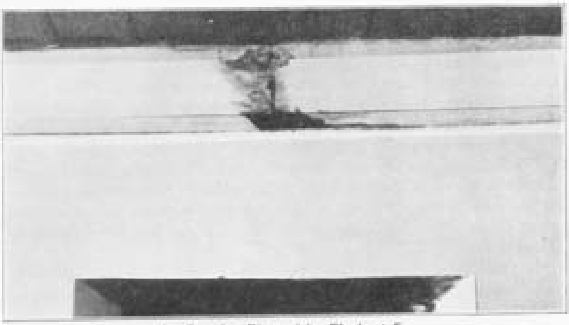
From the point of this spike the lightning evidently jumped a space of about 4′, taking the shortest and straightest path to the Durbar Hall leads just below the cornice of the gallery below. The cornice offered little resistance to the flash, being neatly cut through as can be seen from *Photo* 1.

A similar mark in the cornice was found at (F), and it would seem as if part of the flash had run right along the ridge, down the iron gutter, leaving a mark like that of a hammer, jumped an inch to an iron nail and thence through the cornice to the leads again. The lightning thus got clear on to the 17/18 Durbar Hall leads. The d.p. knife switch in the Hall was open, but all switches on the main board were closed.

The two large china fuzes were blown to atoms with such force as to completely wreck the marble switchboard, as may be seen from *Photo* 3.

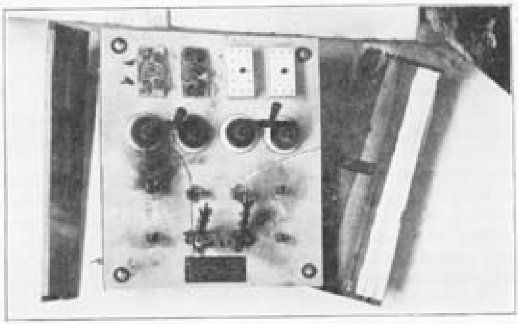
The easiest course from this point for the discharge to take was out through the main leads at (B) and apparently the greater part went this way. The main fuzes at (B) show only slight traces of the passage of the current, but one of the arresters outside was blown to pieces, the other being, strange to say, undamaged. The fuzes to the drawing-room circuit were not blown, but those to the Banquetting Hall had gone violently, smashing the china covers to bits.

Both these pairs of fuzes had No. 12 tin and lead fuze wire in them, while the large pair had thin copper wire, No. 18 gauge. The reason for the blowing of the Banquetting Hall fuzes was soon apparent, as it was found that the lightning had broken through the insulation of both pairs of leads at the objectionable cross at (D), and had gone to ground in both directions on the arc lamp leads. The d.p. tumbler switch at (C) was open, but this made no difference as the discharge jumped from one terminal to the other by way of the brass covers, punching holes in the latter. Both lightning arresters were badly



1.—Cornice Pierced by Flash at E.

2.—Cornice Pierced by Flash at F.



3.—Main Switchboard Wrecked by Flash.

**CORNICE PIERCED**

damaged. In the other direction the discharge had broken through the insulation at the joint to the armoured cable and had gone to earth on the armouring. The Palace guard appear to have been treated to a fine display of fireworks from the tops of the arc lamp standards from this part of the discharge.

The lightning arresters at (B) and (C) were evidently unable to get rid of the whole of the discharge, being taken in rear, and part got on to the main wires. Flashes of fire are said to have run along the wires in all directions, and a couple of insulators were certainly found broken.

In the Generating Station there was a fine discharge from the lightning arresters behind the switchboard, and both the overload and reverse current circuit breakers came down. The Sikh carpenter in charge was not dismayed but shut down his turbine promptly, and finding no damage done to his dynamo started up again and switched on to the mains again cautiously.

At the Distribution Station, about 400 yards from the Palace, no damage was done except to the lightning arresters, of which four or five suffered.

In the Palace itself the effects of the discharge are numerous and not easy to understand. Nearly every lamp in the drawing room had its filament broken and the wall paper below each group of switches was scratched and torn as if by mad cats. The leads to the switches in question are in iron conduit embedded in the wall, and it is presumed that the discharges took place from the ends of these conduits. The wall paper on the wall at the south-east corner of room shows similar marks though there are no switches here.

In the next room however there is a conduit in the wall behind the discharge marks though separated from them by a couple of feet of solid masonry.

The Durbar Hall has four 24-light electroliers, wired from the ceiling high above, and a lot of 3-light brass brackets on the walls, the wires to which are carried about 10' from the floor along the top of the panelled wooden dado.

Sixty per cent. of the lamps in the electroliers went up but a much greater proportion suffered in the brackets.

It should be noted that at that time no lamps were burning anywhere, and the main switches in both Durbar and Banquetting Halls were "off."

There are numerous marks of discharges on the walls of the Durbar Hall, but here they cannot be accounted for by conduits in the walls.

It rather looks as if every piece of metal in the Hall had been electrified and had discharged to earth, many of the marks leading up to iron curtain brackets, and some to the electric brackets, while others seem to have no apparent starting point. In the Banquetting

Hall the damage to the lamps was about the same as in the Durbar Hall, but no discharge marks were found on the walls which are covered with a heavy moulded red and gilt paper well varnished.

There are ceiling fans in all the large rooms but these were practically unaffected, one carbon brush being found broken and one wire being found out of its terminal.

After re-insulating the damaged portions of the main leads, insulation tests were taken. The Durbar Hall gave 2·5 megohms while the smaller circuits went up to 30 and 40. Altogether out of 290 lamps over 150 were spoilt.

The installation of the electric light in the bazaar and private houses has only just begun, but there are altogether eleven installations in the town besides the Palace. Four of these were fitted with Garton arresters, the remainder with home-made horn arresters of copper wire.

Of the former, two suffered no damage to lamps at all, the other two only losing one or two. A couple of arresters were damaged. Of the houses fitted with horn arresters, some lost many lamps, some a few, one lost none. It apparently depended on the condition of the horns. It was found that the monkeys, which are an unmitigated nuisance on an overhead electric supply, had knocked the horns into all sorts of shapes and the spark gaps varied from $\frac{1}{8}''$ to $2''$. The larger the gap, the greater was the damage. The conclusion arrived at is that horn arresters are just as good as the more expensive Garton type if only the monkeys can be kept off them.

It is difficult to arrive at any very definite conclusions from these effects.

According to theory, if the building had had lightning conductors it would probably have not been struck. It was struck at the most likely spot on the highest point of the most prominent and largest area of roof. A lightning conductor here would almost certainly have carried the discharge harmlessly to earth.

The electric light leads inside the building acted as an internal lightning conductor, an undesirable and expensive form, and prevented further damage to the structure, and injury to the people in the lower floor of the inner square who were quite unaffected.

Lamps were destroyed by induced currents in nearly all cases, as it made no difference if they were burning or not except in the case of the Club which is lit entirely by Osram lamps. Here no lamps were broken that were not switched on.

Distribution board fuzes were generally undamaged except in the case of those for the Durbar Hall brackets which all went. They are all of fine tin lead wire 5-ampere capacity.

The explosion of the hand-grip type fuzes on the main switchboard, while the main fuzes at the points of entry of the mains were not damaged, is curious.

It is possible that this may be due to the tortuous path offered to the discharge by the former as compared with the comparatively straight run through the others.

The writer offers the above conclusions with some diffidence as it is his first experience of this kind, but hopes that where he is wrong he may be corrected by the wider experience and knowledge of others.

# A SIMPLE FORMULA FOR CALCULATING THE STRENGTH OF REINFORCED CONCRETE.

## A REPLY TO CAPT. KELSALL'S ARTICLE.

*By* LIEUT.-COLONEL E. STOKES-ROBERTS, R.E.

IN the February number of the *R.E. Journal* Capt. T. E. Kelsall, R.E., points out that the values of X in the equation $bd^2 = \frac{WL}{X}$, as given by the writer in his *Application of Reinforced Concrete* (in India), are, in the case of percentages of reinforcement above 1 per cent., much higher than those given by the formulæ in Capt. Fleming's *Reinforced Concrete*; he also assumes that the writer's values of X were obtained by equating the maximum bending moment of a uniformly loaded beam supported at the ends, with the moment of resistance of the beam for each percentage of reinforcement.

As Capt. Kelsall invites a reply to his article, and as the above formulæ may have been used in places where no copy of the *Application of Reinforced Concrete* has been available, this opportunity is taken of explaining that the values of X, quoted by Capt. Kelsall, were derived (as is stated in the pamphlet in question) from experimental data collected by Mr. F. E. Kidder, and published by him in the 1905 edition of his *Architects' and Builders' Pocket Book*, from which the following quotations are taken :—

"It is obvious that with values for F obtained directly from experimental data, the results obtained by the formulæ will agree with actual tests, whether or not the entire tensional stress is resisted by the steel."

"At or near the breaking point this condition (that entire tensional stress is resisted by the reinforcement) probably exists, but when the load does not exceed one-third of the breaking load, a careful analysis of numerous tests would seem to indicate that the concrete does materially assist in resisting tensile stress."

"In connection with the values of F given in the preceding table, and the stresses assumed, the author recommends that a factor of safety of 3 be used for plain beams."

In the writer's pamphlet the values of X are one-third of the F referred to above, and are stated by Kidder to correspond with a safe stress in the steel of 16,000 lbs. per square inch for plain mild steel bars having an elastic limit of 48,000 lbs. per square inch.

In 1908 the Royal Institute of British Architects published their *Report on Reinforced Concrete*, and as this, which is probably at the present time the highest British authority on the design of reinforced concrete beams, differs considerably from Kidder in regard to the safe loads for reinforcements above 1 per cent., the writer may perhaps be excused for quoting the following extract from pages 42 and 43 of his *Some Practical Points in the Design and Construction of Military Buildings in India* (published in 1910), which attempts to explain the reason for this discrepancy :—

"10. In view of the interesting and important principle involved in the application of the factor of safety, as discussed below, it seems desirable to see how the formulæ compiled from experimental data and given in Kidder's pocket book (*vide* pp. 21 and 22 of the writer's notes on reinforced concrete) compare with the formulæ given in the R.I.B.A. Report. For this purpose a table has been prepared where item 6 represents the value of $M/bd^2$ as deduced from Kidder's formulæ, which were worked out from the actual results of a large number of beams tested to destruction.

"As Kidder takes *the working load as one-third of the breaking load*, the values of $M/bd^2$, as given in item 2 of the table, are one-third of those in item 6, and the corresponding values of $bd^2$ as given in the writer's Notes (*i.e.* those referred to by Capt. Kelsall) will be found in item 1.

"Items 3 and 4 give the corresponding theoretical stresses in the concrete and steel when the working load is imposed, and it will at once be observed that the stress in the concrete greatly increases as a larger percentage of reinforcement is employed, whilst the converse is the case with the steel; in other words although the factor of safety for the working load remains constant at 3 the factor of safety for the stress in the concrete becomes less as the percentage increases.

"11. The R.I.B. Architects however proceed on the principle usually adopted for ordinary materials of construction that a *given working stress in the concrete or steel shall not be exceeded* whatever the percentage of reinforcement may be, so that the factor of safety is constant for the stresses, and not for the working loads.

"Assuming an ultimate strength for the concrete of 2,700 lbs. per square inch and an elastic limit of 48,000 lbs. for the steel, we see from item 9 of the table (using the smaller values) that the theoretical *breaking load* is in every case greater than Kidder's average test loads in item 6.

"But when we compare the theoretical *working loads* in item 5 with Kidder's working loads in item 2, we find a close agreement in the case of $\frac{1}{2}$ and 1 per cent., whilst a larger working load is allowed by theory for $\frac{3}{4}$ per cent., and considerably smaller ones for $1\frac{1}{2}$ and 2 per cent., this divergence being due to the different method of applying the factor of safety.

"Now comparing items 3 and 7, and assuming that the concrete will rupture at a stress of 2,682 lbs. per square inch when 2 per cent. reinforcement is employed, we see that with Kidder's working loads the factor of safety for the concrete varies from $2682/473 = 5{\cdot}7$, for $\frac{1}{2}$ per cent.

reinforcement, down to 3 for 2 per cent., whereas the R.I.B.A. factor of safety remains constant at 2682/600 = 4·4.

"Finally comparing the *lowest* values in items 5 and 9, (since steel with a yield point of 48,000* lbs. per square inch could certainly not be counted upon under ordinary conditions in this country), we find that the ratio of the breaking to the working load varies from 2 in the case of ½ per cent. reinforcement to 4·0 for 2 per cent., thus differing from Kidder's constant factor of 3.

TABLE.

COMPARING KIDDER'S AND R.I.B.A.'S FORMULA FOR WORKING AND BREAKING LOADS.

| Item No. | WORKING LOADS. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Percentage of reinforcement | ½ | ¾ | 1 | 1½ | 2 |
| | Corresponding value of percentage in R.I.B.A.'s Report. | ·005 | ·0075 | ·01 | ·015 | ·02 |
| 1 | Value of $bd$ as given in writer's Notes, where W = safe dist. load in lbs. inclusive of weight of beam, and L = clear span in feet. | $\frac{WL}{45}$ | $\frac{WL}{57}$ | $\frac{WL}{73}$ | $\frac{WL}{100}$ | $\frac{WL}{130}$ |
| 2 | Corresponding values of $M/bd^2$, where M is the bending moment in inch-lbs. | 67·5 | 85·5 | 109·5 | 150 | 195 |
| 3 | Stress in concrete in lbs. per sq. in. calculated from R.I.B.A.'s formula $C = \frac{2M}{kbd(1-\frac{1}{3}k)}$. | 473 | 522 | 608 | 741 | 894 |
| 4 | Stress in steel in lbs. per sq. in. calculated from R.I.B.A.'s formula $t = \frac{M}{pbd(1-\frac{1}{3}k)}$. | 15100 | 13013 | 12717 | 11919 | 11847 |
| 5 | R.I.B.A. values of $M/bd^2$. When concrete stress = 600 | 85·55 | 98·29 | 107·97 | 121·57 | 131·10 |
| | When steel stress = 16000 .. | 71·5 | 105·1 | 137·7 | 201·3 | 263·3 |
| | " " = 17000 ... | 75·99 | 111·7 | 146·4 | 215·9 | 279·8 |
| | BREAKING LOADS. | ½ | ¾ | 1 | 1½ | 2 |
| 6 | Value of $M/bd^2$ at rupture as given in writer's Notes, *i.e.*, three times item 2 above. | 202·5 | 256·5 | 328·5 | 450 | 585 |
| 7 | Stress in concrete in lbs. per sq. in. from formula as in item 3. | 1419 | 1566 | 1824 | 2223 | 2682 |
| 8 | Stress in steel calculated as in item 4 ... ... | 45300 | 39039 | 38151 | 35757 | 35541 |
| 9 | R.I.B.A. values of $M/ba^2$ at rupture. When concrete stress = 2400 | 342·2 | 393·2 | 431·9 | 486·3 | 524·4 |
| | " " = 2700 | 375 | 442·3 | 485·8 | 547·1 | 589·9 |
| | When steel stress = 32000 | 143 | 210·2 | 275·4 | 402·6 | 526·6 |
| | " " = 48000 | 214·6 | 315·4 | 413·1 | 604·1 | 790·1 |

* The yield point of Cossipore mild steel bars is from 31,000 to 36,000 lbs. per square inch.

"12. It remains only to decide which method to adopt, and the experienced designer will have no difficulty in deciding any case on its merits, bearing in mind that in the present state of knowledge the R.I.B.A. formulæ are admittedly only approximate.

"For ordinary *moulded* reinforced concrete (1:2:4) work the writer will adhere to the formulæ in item 1 on account of their extreme simplicity, but will increase the devisor for $\frac{3}{4}$ per cent. from 57 to 60, as 57 really corresponds to a percentage of ·0071 and not ·0075. It may also be pointed out here that the whole weight of the beam should be included in the working load, and not one-third, as is incorrectly stated in Kidder's pocket book, and repeated in the writer's Notes.

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"14. Any percentage above $1\frac{1}{2}$ must be used with caution and then only when there is no probability of the working load being exceeded to any appreciable extent (as in the case of rafters and bressummers), for as will be seen from items 7 and 8 of the table, the concrete is severely stressed as a highly reinforced beam approaches rupture, whilst the steel is still well within its elastic limit, so that when failure does occur it will be owing to the crushing of the surface of the concrete under compression, and will consequently be sudden and with little or no previous warning. On the other hand with low percentages the failure will be due to the yield point of the steel being exceeded, and ample warning of coming rupture will be observable from wide cracks opening up in the lower surface of the concrete."

Now, as a very large number of moulded beams, rafters, etc., designed from Kidders' formulæ (in some cases with only one-third of the weight of the beam itself deducted from the working load) for the barracks at Jubbulpore and Ahmadnagar and probably elsewhere, with reinforcement as high as $1\frac{1}{2}$ per cent., have behaved admirably and give no cause for anxiety, the writer's remarks in para. 12 above appear to be justified, bearing in mind the caution given in para. 14, and that the moulded reinforced concrete rafters, etc., he refers to can only, from the nature of the case, be used in positions where the working load is not likely to be largely exceeded. It would be inadvisable to use the Kidder formulæ for beams containing a high percentage of steel and forming part of a floor or other portion of a building where the assumed working loads may on occasions be much exceeded.

It should also be pointed out that in moulded work it is necessary to place a certain amount of reinforcement in the upper (compressive) portion of the beam, to provide against improper handling before the beam is placed in position, and, although this extra steel is not taken account of in the Kidder formulæ, it adds materially to the strength.

The following table summarizes the differences between the R.I.B.A. and Kidder formulæ for *working loads* :—

| Percentage. | | $\frac{1}{2}$ | $\frac{3}{4}$ | 1 | $1\frac{1}{2}$ | 2 |
|---|---|---|---|---|---|---|
| Values of X in formula $bd^2 = \frac{WL}{X}$ | Kidder | 45 | 60 | 73 | 100 | 130 |
| | R.I.B.A. | 47·2 | 65·8 | 71·5 | 81 | 87 |
| Theoretical stress in concrete from R.I.B.A. formulæ. | Kidder | 473 | 550 | 608 | 741 | 894 |
| | R.I.B.A. | 495 | 600 | 600 | 600 | 600 |
| *Theoretical stress in steel* from R.I.B.A formulæ. | Kidder | 15,000 | 13,700 | 12,717 | 11,919 | 11,847 |
| | R.I.B.A. | 15,900 | 15,000 | 12,400 | 9,550 | 7,950 |

It will be seen from the above table that for reinforcement higher than 1 per cent. the stresses in the steel are very low in the case of the R.I.B.A. formulæ, and that, with the working load allowed by Kidder, the stress in the concrete rises to nearly 50 per cent. above the 600 lbs. per square inch permitted by theory.

As is well known the actual tensile stress in the lower flange of a cast-iron beam must be less than is indicated by theory, and by analogy it may perhaps be correctly argued that the real compressive stress in the concrete of the upper fibres of a reinforced beam is less than the theoretical one.

From this point of view the following quotations from Claxton Fidler's treatise on Bridge Construction may be of interest :—

"The lateral adhesion (between the fibres) does not alleviate the tensile stress in the outmost fibre in the manner erroneously supposed by some writers, for its action is evidently exerted in doing the opposite thing."

"The difference between the actual breaking weight of a beam and that which, theoretically, produces the ultimate tensile stress, may perhaps be partly explained by a certain shifting of the neutral axis . . . , but this can never account for more than a small part of the discrepancy which is observed in practice, and which has never been explained."

"In the meantime we can only determine the strength of a beam of any given material by direct experiments on cross breaking."

It must be admitted however that formulæ based on experimental data are rarely used, and that either the R.I.B.A. theory or a close approximation to it is adopted in general practice, but at the same time the present deficiency in theoretical knowledge is testified by the numerous tests and experiments now being carried out in almost every country by universities, institutes, etc.

Capt. Kelsall refers several times in his article to the "economical ratio" of tensile reinforcement, which, ordinarily speaking, is in the neighbourhood of $\frac{3}{4}$ per cent., since the concrete and steel will then be theoretically stressed at not far from the assumed working limits of

600 and 16,000 lbs. per squre inch respectively, but in practice there are often other considerations which render it desirable to employ an excess of steel in order to reduce dimensions, or to obtain greater strength with given dimensions. Where reinforced concrete is used in the form of rafters, etc., it is necessary to keep down the weight on account of ease in handling, so that the higher percentages may often be required.

Again it by no means follows that because the steel and concrete are working at or near their limiting stresses, the most economical design has necessarily been attained, and this point is discussed in Turneaure and Maurer's *Principles of Reinforced Concrete Construction*, where it is shown that the maximum economy of construction may sometimes be obtained by using less than the allowable working stresses in one or the other of the two materials.

The cost of a rectangular beam to support a given moment M, varies inversely as the depth, directly as the square root of the breadth, and directly with the cube root of the ratio of breadth to depth; but the depth may be limited in various ways, *e.g.* by the headroom required, or by the fact that a certain breadth is necessary to cover the steel properly, or to give a satisfactory proportion to the beam, or finally to give sufficient strength against shear. Again the breadth may be fixed as in floor slabs.

When the cost of steel per unit volume is 25·4 times that of concrete the most economical reinforcement will be as follows :—

*Depth fixed* ; 2 per cent. reinforcement at both the top and bottom of the beam.

*Breadth fixed* ; $\frac{3}{4}$ per cent. reinforcement at the bottom and one-fifth of this (0·15 per cent.) at the top of the beam.

*Ratio of breadth to depth fixed* ; 1 per cent. reinforcement at the bottom and 0·8 per cent. at the top of the beam.

When however the cost of the steel per unit volume is as high as 50·8 times that of the concrete, the economical reinforcement will be as given below :—

*Depth fixed* ; there is no difference in cost between (*a*) $\frac{3}{4}$ per cent. at the bottom with no steel at the top of the beam, and (*b*) 1 per cent. at the bottom and 0·4 per cent. at the top of the beam.

*Breadth fixed* ; in this case, also, the use of $\frac{3}{4}$ per cent. at the bottom with no steel at the top of the beam is the most economical arrangement.

*Ratio of breadth to depth fixed* ; here again $\frac{3}{4}$ per cent. will be best for the bottom with the addition of 0·3 per cent. in the top of the beam.

# *TRANSCRIPTS.*

## THE CAVALRY MARCH TO CAIRO.

*By* Colonel Sir C. M. Watson, K.C.M.G., C.B.

(Reprinted from *Blackwood's Magazine* by kind permission of the Proprietors).

Having had the good fortune to take part in the rapid advance of General Sir Drury Lowe with the cavalry after the defeat of the Egyptian Army at Tel-el-Kebir, and to command the small force which occupied the citadel of Cairo and turned out the Egyptian garrison, I think it may be of interest to give a short account of the operations. I was attached to the cavalry division as intelligence officer the day before the Battle of Tel-el-Kebir.

The cavalry division was ordered to take up a position on the extreme right of the British Army, quite clear of the right infantry division, so as to avoid any risk of confusion with the latter in the dark.

At 12.45 a.m. on September 13th General Lowe gave the order to march, the Bengal Lancers leading. A flagstaff had been fixed at some distance in the desert to mark the proper direction for the column; but, after this had been reached and passed, it was necessary to move by compass, aided by the stars which shone here and there through broken masses of cloud. In places the deep sand of the desert muffled the sound of the horses' hoofs, and viewed from a short distance the column looked like a spectral body of troops moving noiselessly through the darkness.

At 3 a.m., as the division had reached what appeared to be the correct position, the order was given to halt, there to wait until the infantry attack on the lines of Tel-el-Kebir had commenced. The men took what rest they could, holding their horses, and wishing for the day to break. Just as the first glimmer of light appeared in the east, the order was given to mount. Immediately afterwards the dull boom of a gun far away to the left, followed by the roll of musketry, and then the continuous crash of artillery and rifle fire combined, told us that the struggle had begun.

The cavalry advanced at a trot. When we came in sight of the entrenchments I noticed an Egyptian battery in action on the left flank of the works, but this was quickly silenced by the horse artillery, and the Egyptian gunners ran away. Not far from us, on the left, the infantry of General Graham's brigade were seen crossing the lines, and the cavalry passed the latter at a point near the Egyptian battery already mentioned. Here the entrenchment was very weak, being little more than a shallow ditch, which was practically no obstacle to horsemen or guns. After crossing the lines the cavalry wheeled to the left, and rode southwards inside the works, driving the flying Egyptians before them.

When the division had advanced some distance, the heavy brigade was halted, while the Indian cavalry pushed on to the line of railway near Tel-el-Kebir Station, pursuing the routed Egyptians, who were trying to escape into the country. Some trains which were standing in the vicinity of the station were filled with fugitives, and two of these succeeded in getting away, but the third was stopped. Arabi Pasha himself, having failed to escape by train, mounted his horse, and, with some of his staff, fled in the direction of Belbeis, about 18 miles distant, not giving much thought to the fate of his army.

General Lowe ordered General Wilkinson to continue the pursuit with the Indian cavalry brigade and the Mounted Infantry along the north bank of the freshwater canal, and I was directed to lead the column. Lowe himself waited at Tel-el-Kebir to meet Sir G. Wolseley, and then, as soon as the heavy brigade and the horse artillery came up, took them across the bridge and marched by the south bank. At Belbeis the two brigades were to unite for the march to Cairo.

I had a good general idea of the road to be followed, and knew that there would be no difficulty except at the point where the branch canal, coming from Zagazig, joined the main canal at El Abbasa, as there was no bridge there. But, fortunately, there was a footbridge at the lock, over which the cavalry were able to march in single file. It was well that there was no artillery, as it would have been a somewhat difficult matter to get the guns over.

After crossing, at the village of El Abbasa, the troops halted a short time to water the horses. The inhabitants came out to meet us, waving flags and asking for peace. They probably feared that the British soldiers would burn their houses and carry off their goods, but were soon reassured when they found that they received kind words instead of ill-treatment.

The Egyptian soldiers were flying before us in hundreds, and made no attempt at resistance. The action at Tel-el-Kebir had taken away any courage they may have possessed, and their sole thought was to get home as quickly as possible. They were ordered to throw down their rifles and ammunition, and to go where they liked; many of them stripped off their uniforms also, and, in the twinkling of an eye, were transformed into harmless peasants. The rifles were left on the ground, and years afterwards I came across some of these Remingtons in the hands of tribesmen in the Jordan Valley, and was told that after the British cavalry had passed many of the rifles were collected by the Beduin, who, later on, did a good trade by selling them to the Arabs in the Sinai Peninsula and elsewhere.

It was a warm September morning, and one looked with longing eyes at the shady groves of palm trees which were passed as we rode along. As the column approached Belbeis there was a slight attempt at resisting its advance, and a few shots fired from a group of palms on the right showed a feeling which it was necessary to check at once, so the Mounted Infantry opened fire, and the Indian cavalry formed line and advanced at a trot, upon which the Egyptians disappeared.

Then we saw some distance ahead a small body of mounted Egyptians making off as fast as they could, and, from information I obtained afterwards, it seems probable that this was Arabi and his party on their way to Cairo. He arrived at Belbeis only a short time before us, and finding a train coming from Cairo, had the engine detached, and, mounting on it, told the driver to go to Cairo "like the wind." He seems to have been the first person to bring the news of his own defeat at Tel-el-Kebir—rather a unique position for the general of an army.

Shortly before noon we saw the minarets of Belbeis standing out sharply against the clear sky. Soon afterwards the bridge over the canal was reached, and the first part of our march to Cairo was completed. General Wilkinson directed me to seize the railway station, the telegraph office, and the post office, and to bring him the Governor of the town. So I took a small escort and proceeded to the station, which was on the other side of the town and at a considerable distance from the canal.

It was probably many years since the bazaars of that quiet little place had been so excited, and it was quite a scene for an artist, as the inhabitants, dressed in every kind of eastern garb, swarmed round the British officers and their Indian escort, while the notables expressed the delight of the town at the arrival of the British Army. Perhaps what they said was true, as no doubt all they wanted was peace and quiet, but I am inclined to think that they would have said something of the same kind to Arabi's officers 24 hours earlier. On arriving at the station I went into the telegraph office to see what was going on. There were some interesting telegrams just received from Arabi, who had reached Enshas, the next station on the way to Cairo, where he had stopped to telegraph to the officer in command at Salahiyeh, ordering him to send his troops at once by train to Mansureh. In another telegram he asked for news as to the movements of the English, but as no reply was sent to his messages he probably assumed that Belbeis was captured, for he went on at once to Cairo.

Late in the afternoon General Lowe, Colonel Baker Russell, and Colonel H. Stewart arrived with the 4th Dragoon Guards, and we then heard that the heavy brigade and the horse artillery had been much hampered in their advance in consequence of having to cross a number of small canals. General Lowe decided to make an early start on the morning of September 14th, and we were all up and ready for the advance soon after 3 a.m. But there were still no sign of the missing brigade and the guns, so, after waiting an hour, he decided to proceed without them.

The column, about 1,200 strong, consisted of the 4th Dragoon Guards, the 2nd Bengal Cavalry, part of the 6th and 13th Bengal Cavalry, and the Mounted Infantry.

The sun had not yet risen, and the morning air was cool and refreshing, while the hard, gravelly surface of the desert made good going for the horses. There were no more Egyptian runaway soldiers to be seen, and the inhabitants of the villages which we passed seemed all to be peacefully disposed. Two Egyptian officers, Dhulier Bey, a Belgian, and Hussein Effendi Ramsi, who had been sent by the Khedive to Ismailiyeh, and were attached to General Lowe's staff, read out, every now and then, a proclamation to the villagers, assuring them of peace and security if they were faithful to the Khedive. To this the people replied with loud cries of "Aman," "Aman," "Peace," "Peace." Not a word of regret was to be heard for the defeat of Arabi, which had by that time become generally known.

As the morning wore on and the sun rose higher in the sky, the heat steadily increased until it was like that of a furnace, but no halt was made until a little after noon, when we reached the village of Es Siriakus, about 25 miles from Belbeis. Here some food for the men and forage for the horses were easily obtained, and an hour's rest under the shade of the palm trees was much appreciated.

When the column started again we left the canal, which had been followed from Belbeis, and went into the desert so as to avoid the low ground, broken up with little irrigation canals and not suitable for the movement of cavalry. We were now drawing near to Cairo, and naturally our conversation turned to the question as to what kind of reception we were likely to meet with, as it was known that there was a garrison of about 20,000 troops which had not fought at Tel-el-Kebir, and which might be prepared to resist our advance to the capital. I told the General and Herbert Stewart of what we had heard as to the probability of Cairo being burnt like Alexandria, and pointed out the great importance of putting British troops in the Citadel that evening. There is an old Egyptian saying, "He who holds Cairo holds Egypt, he who holds the Citadel holds Cairo," and it was almost certain that once the population knew that the Citadel was in the possession of the British, all resistance would collapse. But it was, of course, not possible to say how the Citadel was to be secured until it was known what the Cairo garrison would do, and whether Arabi would spur them on to fight, or would bow to fate and acknowledge that he was beaten at Tel-el-Kebir.

Soon we saw the line of the Mokattam Hills, which rise sharply over the city of Cairo, and then gradually we could make out the dome and minarets of the mosque of Mohamed Ali in the Citadel. An hour more brought us within sight of the great barracks of Abbasiyeh, situated in the desert, 2 miles north-east of the city, round which we could see thousands of Egyptian soldiers swarming, and looking just like ants whose ant-hill has been disturbed. General Lowe ordered his force to advance by echelon of squadrons from the left, making as great a show as possible with the small number he had under his command. Then he halted the cavalry and sent Colonel Stewart forward to reconnoitre and to see what was going to happen.

Stewart took an escort of 50 men, and, accompanied by Lieut.-Colonel H. M'Calmont, the Brigade Major, the two Egyptian officers, and myself, started on his mission of investigation. We rode on towards the barracks, and saw an Egyptian squadron of cavalry coming out to meet us, every man of whom had a white flag, or something that represented a white flag, tied to his carbine. The Abbasiyeh garrison had decided to surrender, and was determined to do it in good style!

It may be interesting to relate what happened in Cairo while the British cavalry were advancing from Tel-el-Kebir, and I will give the account as described to me afterwards by one of the members of the Egyptian Council of Defence. It was known in Cairo that the British Army had concentrated at Kassassin on September 12th, and that there might be a battle at any time, but when it would come off was of course uncertain. As I have already mentioned, Arabi Pasha, escaping from Tel-el-Kebir after the fight, had got to Belbeis and started from it by rail just before General Wilkinson's column arrived. When Arabi reached Cairo, he went to the Kasr-el-Nil Palace, where the Council of Defence were holding a meeting. He was tired out, and quite collapsed when he sat down; then raising his head after a time, he said, "It is all finished," and told the Council of the defeat of the Egyptian Army, and that the English would soon be in Cairo. Then there was a great discussion as to what was to be done. Some were for making further resistance, while others were for sending their submission to the Khedive. A little later news came in that the British had taken possession of Zagazig, which General Macpherson, with the Indian contingent, had occupied on the afternoon of September 13th.

General Macpherson, as soon as he reached Zagazig, telegraphed to Cairo to announce his arrival, and, late that evening, the Egyptian Council decided to send a deputation to the Khedive offering their submission to him, and they sent a telegram to Sir G. Wolseley informing him of the fact, and begging him to take no further action "until you receive orders from His Highness the Khedive." There can be no doubt that the Council wanted, as the Chinese say, "to save their face"; they wished it to be understood that they made their submission to the Khedive, *not* to the Commander-in-Chief of the British Army.

Nothing more, according to my informant, was done that night, but the next morning when they found that the British had not yet arrived the more warlike members got in the ascendant, and it was decided to take steps for defending Cairo in case the British Army advanced towards it. It was arranged that entrenchments should be thrown up in front of Abbasiyeh, and an engineer officer was sent to carry this out. The line was traced and the work of digging had actually begun when the small force of cavalry under General Drury Lowe was seen in the distance, and a messenger was sent in at once to the Council to inform them that "the whole English Army was arriving."

Then there was naturally the greatest excitement, and the members of the Council were at their wits' end what to do. I was never able to ascertain whether they came to any decision, nor whether they sent orders to the garrison of Abbasiyeh to surrender, but I am inclined to think that it was a case of every man for himself, and that the Commander of the troops at that place decided that it was the best policy to surrender, no matter what the Council might do. But, however that may be, there can be no doubt that when Colonel Herbert Stewart and his handful of men approached the Abbasiyeh Barracks, the Commanding Officer came out to meet him, and surrendered, unconditionally, with his force of cavalry, artillery, and infantry, about 10,000 in all.

It was quite a dramatic scene: in the centre was the little group of British and Egyptian officers discussing the terms of surrender, while on the one side were the British and Indian troopers, and on the other the squadron of Egyptian cavalry; behind, the white mass of the Abbasiyeh Barracks, about which we could see great numbers of Egyptian soldiers —some drawn up in column, and some wandering here and there like sheep without a shepherd. Then, as a background, Cairo in the distance, and beyond all the Eastern sky, bright with the red gleam of the setting sun.

The preliminaries were soon arranged, and then the British advance guard moved on to the barracks, while Stewart sent me back to General Lowe to tell him that all was well. As soon as the troops heard that Abbasiyeh had surrendered, they gave a ringing cheer, and were then ordered to close up and advance. The greater part of the cavalry, however, were kept out in the desert, and not brought into the barracks, as the General thought it wiser not to let it be seen what a small number of men he had with him.

Immediately after the surrender at Abbasiyeh, Colonel Stewart ordered the Commanding Officer to send to Cairo and summon the Governor, the Chief of Police, and the Commandant of the Citadel, and these gentlemen all came out in a short time and tendered their submission to General Lowe. The Chief of Police was asked for information about Arabi Pasha, and stated that he was in his own house; he was directed to return to Cairo and bring Arabi out to Abbasiyeh. The Governor and the Commandant were then informed that the Citadel must be surrendered that evening. The Governor begged General Lowe not to send any troops into Cairo that night, as he feared it might cause a disturbance; but the real danger was, of course, that if British troops did not occupy the Citadel at once, the evil-disposed people of the town would feel that there was no one in authority and would do mischief. After some discussion the Commandant agreed, though rather reluctantly, to surrender the Citadel, if required to do so.

After darkness had set in, Colonel Stewart informed me that he was to take a small force of cavalry and occupy the Citadel, and that I was to take possession of the fort on Mokattam heights, which commanded the Citadel, with another small force. This seemed a very satisfactory arrangement, as it was desirable that the Egyptians should be turned out of both these positions before the sun rose, and before the people realized what an insignificant British force had reached Cairo. The hour named for the start was 8 p.m., as it was important that we should not march until it was quite dark.

At that hour, when the troops were falling in, Colonel Stewart told me that the plan had been changed, and that he was to remain at Abbasiyeh with General Lowe, and that, as I knew Cairo, I was to take command of the force which was to occupy the Citadel and turn out the Egyptian garrison. He gave me no written orders, and said that I was to carry out the operation in whatever way I thought best. I asked him what was to be done about the fort on Mokattam, as it was impossible for me to go to both places at the same time, and he replied that I must use my own discretion with regard to it. Although it was a certain responsibility, it was, on the other hand, rather satisfactory not to be hampered by detailed orders, as I was thus able to make my own arrangements.

The force placed at my disposal by Colonel Stewart consisted of 5 officers and 84 non-commissioned officers and men of the 4th Dragoon Guards, under Capt. Darley; and 4 officers and 54 non-commissioned officers and men of the Mounted Infantry, under Capt. Lawrence. I also took with me Hussein Effendi Ramsi, who had come with us from Tel-el-Kebir, and three of Arabi's officers, one of whom, an engineer, had been employed on strengthening Abbasiyeh against us a few hours before. I made it clear to these officers that their future in life depended on doing exactly what I told them, but they fully realized the situation and were very helpful.

As it was important that we should not be seen by the inhabitants of Cairo until close to the Citadel, I decided not to enter the town by the Bab Husseiniyeh, the gate nearest to Abbasiyeh, but to follow the desert road leading by the Tombs of the Memluk Sultans, commonly called the Tombs of the Caliphs, and to enter by a small and little-used gate called the Bab el Wezir, which is just under the Citadel. It was very important that we should find this gate open, as if it was closed it would have been necessary to go round to another gate some distance off, and this would have lost considerable time. The engineer officer, who was thoroughly acquainted with the fortifications of Cairo, assured us that we would find the Bab el Wezir open, and as his own interests depended on his telling the truth, I decided to trust him.

As soon as the little force had fallen in I marched them off, and then rode to the head of the column, telling each file as I passed that they must never lose sight of the file in front of them: this was essential, as the night was pitch dark, and, with the dust raised by the horses, it was difficult to see more than a few yards ahead. Those who know the road in the daytime will understand that it is not an easy one to follow on a dark night, but my Egyptian guide knew it thoroughly, and I soon felt that he could be trusted to lead us right.

We first crossed the desert for about 2 miles, then passed through the great cemetery of Kait Bey and over mounds of rubbish, full of holes, which were hard to avoid in the dark; and we seemed to have ridden for an interminable time when at last the walls of Cairo rose before us. Then we drew near to the Bab el Wezir, and I became a little anxious lest it should be shut after all. But when we got close the door stood open, and I rode through the dark tunnel and found it quite clear to the far end; neither was there a sign of a sentry nor of anyone watching the gate, so I brought our party through and led them up the hill to the Citadel.

The street leading up from the gate was very narrow and very steep, and the houses on each side were in darkness, except for the little shops below, in which were collected a number of people who looked at the British soldiers with surprise, probably not unmixed with fear. At the end of this short street we turned to the left into the broad road, leading up to the main gate of the Citadel; and I halted the party at a little distance from the gate, and went on to the gate with the Egyptian officers to see how matters stood.

There was a strong guard on the gate, who evidently had not expected us, and it was soon clear that, notwithstanding the promise of the Commandant, no arrangements had been made for sending the Egyptian garrison out of the Citadel. I therefore ordered the officer in charge of the guard to go to the Commandant and tell him to come to me at once. This took a considerable time, and I am inclined to think that the good Commandant had gone to bed.

He came out at last, however, accompanied by a number of officers, and asked what I wanted him to do. I said that he must parade the whole garrison without any delay, and send them down to the Kasr-el-Nil Barracks, in the lower part of Cairo. I said that I had brought a British force to garrison the Citadel, and that the keys of all the gates were to be handed over to me at once. He seemed a little doubtful at first, but not having any idea how many men we had, he decided to comply, and sent for the keeper of the keys, who brought a number of very large keys in a beautiful bag, and handed them over. Then the Commandant sent officers to the different barracks, and soon bugles were heard all over the Citadel sounding the assembly, and the troops began to hurry out of their quarters and to fall in on the large open space between the mosque of Mohamed Ali and the mosque of Nasr ebn Kalaoun.

As I was anxious not to let the Egyptian troops pass our small party, I arranged to march them out by a different road to that by which we had come up. Those who know the Citadel will remember that there are two principal entrances, of which one, the Bab el Azab, or lower gate, is in the Place Rumeyleh, opposite the great mosque of Sultan Hassan. This was the old entrance, and from it a steep road, the scene of the massacre of the Memluks by Mohamed Ali in 1811, leads up to the Bab el Wastani, or middle gate. The present principal entrance, on the other hand, known as the Bab el Gedid, or main gate, which was built by Mohamed Ali when he reconstructed the Citadel, is much higher up the hill; the road passing through it joins the road leading up from the Bab el Azab, just outside the middle gate. This disposition of the gates was very convenient for my purpose, as I was able to place our men on the road leading from the main gate to the middle gate, while the Egyptian troops were marched out by the steep road, which went down to the Bab el Azab, and did not pass by our men. One of our officers and a couple of men were placed at the Bab el Azab, to hurry them out into the town.

I was considerably struck with the good discipline of the Egyptians, who fell in by companies and marched off as if they were quite accustomed to being roused up in the middle of the night and turned out by foreign troops. But, in addition to the regular soldiers, there were a great number of what appeared to be camp-followers—women, laden camels, donkeys, etc.—and these hurried out of the Citadel with the troops, much interfering with the regularity of the march of the latter. For more than two hours the stream of Egyptians came out through the middle gate, and it was past midnight before the last stragglers went down the hill. As already mentioned, I had ordered them to go to Kasr-el-Nil Barracks, but a considerable number never arrived there, as they took the opportunity, while marching through the streets of Cairo in the dark, of slipping away and going to their homes. This, however, was a good thing, as they were useful messengers to spread the news of how they had been turned out of the Citadel by the English Army.

While watching the strange procession at the gate, I thought over the question of the fort on Mokattam heights, and considered how the Egyptian troops were to be got out of it. It was clearly no use trying to do it with our troops, as none of our officers knew where it was, and the men and horses were too tired for another expedition. At last a happy thought struck me, and I hailed an intelligent-looking Egyptian officer on his way out of the Citadel, and said that I would be much obliged if he would go up to the fort, send the garrison to Kasr-el-Nil, lock the gate, and bring me the keys. He thought for a moment, then said, "Hadir, ya Sidi." "All right, sir," and went off at once. From his manner he gave me the idea that he would carry out his mission; and my confidence was justified, as he came back in two hours with the keys.

Before leaving Abbasiyeh, Colonel Stewart had instructed me that, after I had cleared out the Citadel, I was to leave the next senior officer in command for the night, then to examine into the condition of Cairo, and return to Abbasiyeh to report to General Lowe. As soon, therefore, as the garrison had evacuated the Citadel, I told Capt. Lawrence, the next senior and an excellent officer, that he was to take command when I left, and took him round to give him a general notion of the fortifications. I had been acquainted with the place some years before, and had a fairly good idea of the important points, but to one who saw it for the first time on a dark night it must have seemed a puzzling labyrinth. Hussein Ramsi and the engineer officer accompanied us, and sentries were posted on the different gates with orders to let no one in or out during the night.

The Citadel seemed quiet, and I thought our task was over, but as Capt. Lawrence and I were returning to the middle gate, we were rather startled by hearing a tremendous noise, shouting and clanking of chains, as if pandemonium had broken loose. We then found that the din was caused by the prisoners, of whom there were many hundreds, who had been roused by the sound of the departing garrison, and had opened the prison door and were trying to escape. We succeeded in driving them back, and then went into the prison, which smelt badly. Here were a great number of prisoners, closely packed together, some regular jail-birds, and others who looked as if they might be respectable members of society.

The latter crowded round us, and said that they had been put in prison because they would not support the rebels, and they asked me to investigate their cases immediately and release them. The idea of holding a court under the circumstances was rather humorous, and I told them that it was impossible to do anything for them that night, but that as the English had taken possession of Cairo their cases would be gone into as soon as possible, and justice would be done. The following day, when Colonel Sir Charles Wilson arrived in Cairo, I told him of the state of the prison in the Citadel, and he obtained authority to go into the matter, and to release all those persons who had been imprisoned without due cause.

Having quieted the prisoners as far as possible, we went out of the prison, the doors were locked, and sentries were posted with orders to shoot anyone who tried to escape. Notwithstanding this, I believe that a certain number did succeed in getting away after I left the Citadel, and I know that one man at least was shot. This was an inoffensive individual, coachman to one of the American officers in the Egyptian Service, who had been put in prison because he was supposed to be in favour of the Europeans. Fortunately he was not much hurt, and soon recovered.

After the episode with the prisoners had concluded satisfactorily, I went with the Commandant to his quarters to discuss the situation. Having been a supporter of Arabi, he was naturally anxious as to his prospects, and inquired whether I was satisfied with the way he had acted. I told him that he had behaved admirably so far, but that he must remain in the Citadel for the night and do all he could to assist Capt Lawrence, explaining to him at the same time that if anything disagreeable happened he would be held responsible. I then questioned him as to the composition and strength of the Egyptian garrison which had been in the Citadel, but rather curiously, neither he nor his officers could give a definite account of the number of men, and their estimates varied from 5,000 to 7,000. By a rough calculation I had made while they were marching out, there were about 6,000, and this number, or perhaps a little more, was probably nearly correct.

After again giving a word of caution to the Commandant, I bade him good-night, and went with Capt. Lawrence to the main gate. Here the Egyptian officer had just arrived who had carried out the evacuation of the fort on Mokattam heights, and I thanked him for having assisted me, and let him go home. Then, leaving Capt. Lawrence in charge of the Citadel, I started to carry out the second part of my instructions as regards the examination of the state of Cairo, taking with me Hussein Ramsi and the engineer officer.

We followed the main road down from the Citadel to the mosque of Sultan Hassan, and then proceeded along the Boulevard Mohamed Ali to the Esbekiyeh Gardens. Cairo was like a city of the dead: the news of the occupation of the Citadel by the English had become known, and the inhabitants wisely kept to their houses. The engineer asked if we might go round by his home to get his greatcoat, as the night was chilly. So we made a detour, and I found all the streets we rode through equally tranquil. It was rather a curious situation: here was I, an officer of the invading army, riding quietly through what had been supposed to be a hostile city, having as companion an officer of the enemy who, less than 12 hours before, had been preparing to put Abbasiyeh in a state of defence against us; and yet it seemed quite natural, and as if there had never been a war at all.

After passing the Esbekiyeh, we rode by the Coptic quarter of the town, which was also perfectly quiet, though, as I learned afterwards, the Copts had been in a great state of anxiety since the defeat of Arabi at Tel-el-Kebir, and were much relieved when they heard that Cairo was in the possession of the English, and that all danger was past. Then we went on to the Fagalla; and as by this time I had been through the city from one end to the other, I had seen sufficient to justify me in reporting to General Lowe that Cairo was peaceful. So we took the road to Abbasiyeh by the mosque of Zahir, and reached the barracks a little after 4 a.m., just 25 hours since we had prepared to start from Belbeis. It had been an interesting day, but I was not sorry it had come to an end at last.

On entering the barracks I went to find Colonel Stewart, who told me that during my absence in Cairo Arabi Pasha and Toulba Pasha had come out from the city and surrendered. The Egyptian military revolt was at an end. Stewart took me to General Lowe, to whom I reported that all had gone well at the Citadel, and that Cairo was perfectly quiet. He said, "Well done," and in a few minutes we were all asleep.

The next morning General Lowe ordered me to accompany a squadron to the railway station to meet Sir Garnet Wolseley, who was expected to arrive by train from Zagazig, where he had been delayed by a breakdown on the line; so he did not reach Cairo until 9.45 a.m. On returning from the station, I made a written report to General Lowe respecting the surrender of the Citadel, and strongly recommended the Commandant for favourable consideration. I am glad to say that, though he was a senior officer of the Egyptian Army, and a great supporter of Arabi, he received a free pardon from His Highness the Khedive.

The engineer officer was, of course, also pardoned, and a few months later, when I was employed under General Sir Evelyn Wood on the organization of the new Egyptian Army, he became one of my subordinates in the War Office. We often talked over the night of our first acquaintance, and he asked me once whether there was any chance of his getting the British war medal. I told him that, though I was greatly obliged to him for his assistance on the night of September 14th, it was not in accordance with English custom to give medals to officers of the enemy's forces. But there can be no doubt that but for the cordial way in which he and Hussein Effendi Ramsi assisted me, it would have been much more difficult to carry out General Lowe's instructions.

The cavalry march to Cairo affords an excellent instance of the importance of following up a beaten enemy without an instant's delay, and Sir Drury Lowe is worthy of the highest credit for the manner in which he carried it out. It is to be regretted that in the *Official History of the Campaign*, published by the War Office in 1887, neither Sir G. Wolseley's orders to General Lowe nor that officer's report upon the march is given. As regards the former, all that is stated is "that the cavalry were directed to continue their pursuit, and advance upon Cairo with all possible rapidity, to save it, if possible, from the destruction intended by Arabi Pasha." Apparently this meant that Lowe was to take the whole of the cavalry division to Cairo. If this is so, he took a considerable responsibility on himself in leaving the greater part of one brigade and the whole of the artillery behind when he started from Belbeis; but his action probably saved the situation, as, if he had waited for the heavy brigade and the guns, he would not have reached Cairo until September 15th.

What would have occurred in the interval it is, of course, not possible to say with certainty, but one of two things might have happened. Either the forward military party would have taken the lead, and an attempt would have been made to defend Cairo with its large garrison, or else the fanatical Mohamedans would have put Arabi and his colleagues on one side, and Cairo would have been treated like Alexandria. In either case the result would have been disastrous for the city.

In after years I often discussed the question with Egyptians who had lived in Cairo during the war, and met many who thought the latter event the more probable. The Coptic Patriarch, for example, used to say that he was sure there would have been a massacre of the Copts on the night of September 14th, had it not been for the arrival of the British cavalry on the afternoon of that day, and their taking possession of the city. The burning of Alexandria might without any doubt have been prevented, if British troops had landed *immediately* after the bombardment; but the unfortunate delay in that case led to the loss of many lives, and the destruction of property of the value of £4,000,000, which Egypt had to pay.

It is probable that the rapid advance of Sir Drury Lowe saved Cairo from a similar fate.

# METHODS OF COMMUNICATION IN THE ENGLISH ARMY.

Translation by Lieut. F. S. G. Piggott, R.E., of a lecture by Capt. Shintarō Koriyama of the Engineers.*

The scope of this lecture, from its mere title, "Methods of Communication in the Army," is very wide, but I only propose to give here an outline of the two principal methods, viz.: communication by means of electricity and communication by means of signalling.

In the English Army the methods of electrical communication adopted are the telegraph, the telephone, and wireless telegraphy. Of these, telegraphy and wireless telegraphy are in the hands of special troops, and the telephone is distributed also among all field units by whom it is very much used.

I will now give an outline of the telegraph units and telephone detachments. The kinds of telegraph units and their *personnel* are as follows:—

*The Divisional Telegraph Company.*—There is one company, attached to each division, whose duty is to keep up communication between the divisional headquarters and brigade headquarters, or artillery. It is capable of laying 30 miles (48 kilometres) of insulated wire and of establishing six telegraph stations. It is divided into three sections, each section having one cable cart (with 8 miles of insulated wire) and one light four-wheeled wagon, (with 2 miles of insulated wire, and instruments, boxes, etc.).

*The Cable Company.*—The object of this company is to keep connection with army headquarters and divisional headquarters, and it is capable of establishing 80 miles, (128 kilometres), of insulated wire, and 24 telegraph stations. It is divided into four sections, each section having two cable carts and one light four-wheeled wagon, exactly similar to those used by the divisional telegraph company. These cable carts consist of limber and wagon, and are drawn by four horses: on the limber are carried the instrument boxes and telegraph stations, and on the wagon four cable drums each with 2 miles of cable. The operators for unreeling the wire and laying it along the ground, ride on the carts: as the rate of laying the line can be increased up to the speed of a horse galloping, it is very suitable when rapidity is necessary.

*The Air-Line Company.*—This is used when changing the cable of an already-laid line to bare wire, and also for establishing communication between army headquarters and divisional headquarters when great speed is not essential. Each company has sufficient *personnel* and material to erect 60 miles of wire (96 kilometres) and 12 telegraph stations; also

* The various establishments, etc., are as given in the lecture and must not necessarily be taken as correct.

there are sufficient men to maintain 120 miles (192 kilometres) of line. It is divided into four sections, each having four 4-wheeled wagons with material for 5 miles of line: each wagon also has instrument boxes and the material for one telegraph station. Further, the company has a cart for spare stores, which include 8 miles of insulated wire.

*The Wireless Telegraph Company.*—Its *rôle* is to keep connection between army headquarters and the cavalry division. A company is capable of establishing four stations; the system at present in use is the Lodge-Muirhead, and communication can be kept up to a distance of about 25 miles, (40 kilometres). As the study of wireless telegraphy is going on continuously, it cannot be said that this system will be permanent.

*The Line of Communication Telegraph Company.*—This company consists of *personnel* sufficient to maintain 100 miles of line and 10 telegraph stations, but does not carry any stores. If there should be no line already laid ready for use, or in other special cases of necessity, the stores are usually sent up from the rear.

All the above is the duty of the Engineers. In addition there is also a telegraph company, formed by the War Office in collaboration with the department* of communications, whose principal work consists of the erection of permanent lines, and the training of telegraphists. I shall not deal with the organization, instruments, stores, etc., here.

*The Employment of the Telephone in all Branches.*—There is a squad of telephonists in an infantry brigade, an artillery brigade, and a battery of artillery. Details as follows:—

*In an Infantry Brigade* (4 battalions) there is a telephone section consisting of 2 N.C.O.'s and 15 men. The section has two horses, each carrying six drums containing ½ mile of light telephone wire on its back, whence it can be unreeled directly. There are in all 6 miles, and *personnel* for four stations (telephone).

In an *Artillery Brigade* there is a telephone squad of 13 men, who have one cable cart similar to those used by the telegraph companies. In a *Battery of Artillery* there are two mounted telephonists for keeping up internal communication: they each have one telephone, and carry two rolls of light telephone wire, and also requisite knives, stakes, and signalling flags.

From what I have already said, it will appear that there is a full provision of a network of electrical communications from the main army to the furthest advanced post. In addition to this, very much use is made of signalling. There is both *visual* and *oral* signalling, the former being the method principally used in the Army. I shall refer to it in this article simply as signalling.

There is no special unit in existence for the purpose of signalling communication. Every unit has a certain number of signallers, and there are also signallers attached to brigades and divisions. The approximate numbers in each branch are as follows:—An infantry company has two N.C.O.'s and three men, a cavalry squadron eight N.C.O.'s and men, a

* *i.e.* Post Office.

battery of artillery and a company of Engineers three N.C.O.'s and men each. There are also a certain number of signallers belonging to regiments and battalions.

There are two methods of signalling, the "Morse" and the "Semaphore." The "Morse" system is the one adopted in ordinary telegraph work and is used with flags only, with the heliograph, and with the signalling lamp. The "Semaphore" system consists of two wooden arms, which according to their position represent letters. Two similarly coloured flags can be used to signal with: and in certain cases one can communicate by using merely the arms. The speed is greater than when using flags in the "Morse" system, but the effective distance is much less. The reason for this is, that when using flags in the "Morse" system, in order to make the dots and dashes, the rapid fluttering of the flags makes them appear to the eye larger than they really are, and consequently they are able to be distinguished at a great distance. Our "Katakana" signalling is on the same principle as the "Semaphore" and therefore does not appear suitable for communicating over long distances.

I will here mention briefly the signalling apparatus used in the English Army. The flags used are of two colours, white and dark blue: the former is used in places with a dark background, and the latter in places with a light background, as on the highest point of rising ground where the flags can be seen against the sky. This is not definitely laid down, as white or blue flags may be used even when the background is of a similar shade; it depends on actual trial, on the presence or absence of the sun, and on the state of the atmosphere, etc. It is very important to choose the right flags to use on different occasions. In our country, when signalling in "Katakana," the system in vogue is to use at the same time both a white flag and a red flag. Should there be occasions when either of these colours are hard to distinguish, there is a fear that communication might not be established. I think that all these points are well worth our study.

The flags are also of two sizes, the larger being 3′ square, and the smaller 2′ square, both sizes are made in the above two colours. * * * In addition to them there is the heliograph and the signalling lamp. * * *

*The Method of Training the Signallers in the Various Units.*—In every unit, it is usual to hold a yearly signalling course, for the purpose of keeping up the establishment of signallers. For the purpose of training them as instructors and assistant instructors respectively, a certain number of officers and N.C.O.'s undergo the course of instruction at the Army Signalling School. As the method of training in units is closely in accordance with that of the Signalling School, it is ensured that the signalling in all units of every branch of the Service is absolutely uniform. The unit commander decides the length of the signalling course, it is usually from three to four months. When once the course is begun, no interruption is allowed, of course those doing the course are excused all duties. A very brief synopsis of the course is appended.

(*a*). The method of forming letters, numerals, and special signs, in both "Morse" and "Semaphore" codes.

(*b*). The construction, capacity, dissection, assembling, and means of maintenance of all the instruments and materials used in signalling.

(*c*). The duties of a signalling station.

(*d*). The establishment of a network of communication in the field, and signalling exercises.

As the "Morse" symbols must be absolutely committed to memory, during the training from four to eight letters a day is the limit taught, also they are not taught in sequence, but in order of simplicity. At the same time they instruct them with a practice transmitter and a sounder, and make them send and read the letters they have already learnt. From the beginning the speed is 30 words a minute, and at the same time they are taught how to manipulate the flags, how to hold them and how to make the dots and dashes. Special attention is paid to correcting the position of the body. The "Semaphore" is taught at the same time, all the exercises being carried out so as to mutually harmonize. Also the assistant instructors send correct messages either with the flags or the heliograph, and the men are accustomed in reading them. In this way they are enabled in about two weeks to send and receive messages over short distances. In these exercises those under instruction are divided into two parties each consisting of two men, they are placed facing each other and alternately send and receive. * * * Later the duties of signal stations are taught and also the methods of arranging for a connecting, or intermediate, station. Finally signalling manœuvres are carried out, and at the end of the course there is an examination. Those who qualify are designated "Signallers," wear a special badge, and receive additional pay.

Once every year the signallers of all units are inspected, this inspection being both individual and collective. In the individual inspection the ability of each man is determined and if he does not come up to the requisite standard he at once ceases to be a "Signaller." The standard is different according to the instrument used, but they must obtain at least 95 per cent. marks in both sending and receiving 40 words a minute. In the collective inspection, the instructors, assistant instructors, and signallers of the regiment or battalion are collected, and they are required to organize a network of communication according to some tactical scheme, this tests their practical efficiency.

*The Signalling School.*—The object of instructing officers and N.C.O.'s is to make them instructors and assistant instructors of signalling. As the system of army signalling is universal throughout the whole service, officers and N.C.O.'s are sent from all branches to form the classes. The period of instruction lasts about two months, and new classes are assembled about five times a year. The *personnel* of each class consists of about 30 officers and N.C.O.'s, chosen by their unit commander. Before entering the school they must already be able to signal at the rate of 30 words a minute, they are all men of ability and having a general knowledge of signalling. At the end of the course there is an examination, and a certificate is given to those who pass. During these two months the students are very much occupied with various exercises all day, and practise with the signalling lamp in the evenings. As there is practically no day of leisure, by the time they pass out their skill has reached a very high standard.

*Occasions for the Use of Signalling Communication.*—In fortress warfare, and of course in field fighting, the occasions when one can use signalling as a means of communication with advantage, are numerous. For instance, in all kinds of attack and defence, to establish connection between the commander and the various detachments, between the outpost line and the troops in rear, between troops on the march and the advanced, and flank, guard; and between the cavalry, the reconnoitring parties, and the main body. In the English Army, both at field exercises, and at manœuvres, very great practical use is made of signalling in addition to the telegraph and the telephone. From what one has heard from senior officers who have been in Europe, signalling is not used anywhere like it is in the English Army. The truth is that English officers realize the value of signalling as a means of communication, and the excellence of their method, and the ability and training of their signallers, makes them confident that they are (in this respect) superior to all other armies. For which reason the attention paid to signalling as a means of communication is very great.

*Conclusion.*—During a campaign, the leadership and co-operation of the armies depend on the service of communication, and it is unnecessary to insist that victories and defeats depend directly on the good or bad quality of this service. Of all means of communication adopted in the Army, electrical methods are the most important. The development of art, and the advance of technical manufactures, in recent times, has more and more tended to the ingenuity of the instruments; but in proportion to the fineness of their mechanism the slightest defect makes them very liable to lose their efficiency. Further, a hitch would be often likely to occur on the battlefield, or, owing to an accident happening at a critical time it is quite possible that a valuable opportunity might be lost. For which reason it is very essential that some alternative method should be studied. Also, there are naturally limits to the establishment of electrical communication, and one cannot hope to make use of it on every occasion and in every place. For these times, it is extremely advantageous to practise an alternative method, and, with the exception of signalling there is nothing that satisfies all the conditions. In our Army it has always been considered that the signalling—for example "Katakana" signalling with flags—has given very inaccurate results, the reasons being an inadequate study of the method and imperfections in the training. When excessive demands have been made on the system and the results have not come up to expectations, has one not lost confidence in it? For if the fault did not lay with the system, then it must have lain with those who were making use of the system. Signalling as a means of communication is certainly not such an inaccurate matter as that. The following true incident will show how far one may depend on it:—Once, from the Northern Frontier of India, a very important message consisting of about 1,500 words was despatched, and after passing through several signal stations manned by native soldiers, was telegraphed on and reached London in six hours with only two mistakes.

These native soldiers did not speak English, and had merely been instructed in the English signalling method. If one is able to achieve such a result as this, it follows that, if the method of instruction be good, the prestige of signalling as a means of communication would be greatly enhanced. Such a result would be impossible if the important points of signalling are merely explained; actual practice must be made of the first importance, or else good results cannot be expected.

Although I have only spoken in a general way about signalling as a means of communication, yet I think you will be able to appreciate its utility. But the development of electrical communications has been so remarkable, that one has been blinded by their glamour, and the present state of the case is that methods of communication like signalling have been almost discarded. Also it cannot be said that electrical communications are absolutely perfect and even for military purposes there are occasions when they cannot be depended upon. Therefore I believe that the comparatively simpler methods of signalling should never be discarded, and I also think that there is room for much further study, although unfortunately it is admitted here that signalling is treated almost as if it were an obsolete system. ° ° ° °

# *CORRESPONDENCE.*

## RESISTANCE AND "DRIFT" OF A BULLET.

SIR,

Will you allow a mere student to state some accepted facts as regards air resistance and drift.

Twenty-five formulæ, more or less of the type proposed by Colonel de Villamil for air resistance, are in existence. He gives reasons for claiming that his formula is not simply empirical. But he will admit (1) that his formula takes no account of the air carried with the bullet, (2) that whatever may be his meaning in saying that when the velocity of the bullet exceeds that of sound "the potential energy of the air is exhausted," the bullet still generates sound waves—only instead of the train of sound waves preceding the bullet they follow it.

As regards drift.

The greatest living authority on theoretical ballistics—an Englishman whose name is less known in England than in Germany, Russia, France, America or Japan—speaks of drift as "an obscure issue by gravity out of curvature of the trajectory."

There are four factors recognizable. (1), Precessional couple due to air resistance; (2), rolling of the shell on the cushion of compressed air in front of it; (3), excess of lateral thrust—due to the rotatory motion being with the air current on one side, against it on the other; (4), vibratory effects.

But the one thing that appears quite clear is that we want more light on the *facts*. For instance little is known even of the rate at which a shell loses "spin." Little is known of the true exact nature of the vibratory movements in the gun during firing.

It is generally regarded as an established fact that the nose of the shell is a little *above* the tangent to the trajectory. Has Colonel de Villamil any experimental evidence to refute this conclusion which is based on experiment?

Is it not possible that the cinematograph may throw light on these and other questions? (See *Cranz. Ballistik*, Vol. 4).

I am,

Yours faithfully,

R.M. Academy, Woolwich. C. S. JACKSON.

The Editor, *R.E. Journal*.

## THE "DRIFT" OF A BULLET.

DEAR SIR,

As there appears to be sufficient talent engaged already I do not propose to take part in the general discussion, although I must confess myself an uncompromising supporter of the text-book theory. I desire, however, to join issue with two of your correspondents on a matter of *fact*.

Capt. Carey says "As regards drift being caused by gyroscopic action. . . . The only drawback to it is that the bullet happens to drift in the wrong direction to suit this theory."

Lieut.-Colonel de Villamil says:—"Crabtree's explanation I cannot follow. He says referring to the hand gun (page 53):—

"(1). Spin of bullet is left handed.

"(2). Nose of bullet is above trajectory.

"(3). Wind pressure on the underside of the nose end *tends* to tilt the point upwards, but

"(4). Results instead, owing to gyroscopic action, in the bullet working over slightly *to the left*.

"An experiment with a small gyroscopic top suspended, as shown, should convince anyone that the result is *exactly the reverse*."

I have been acquainted for some years with the mathematical theory of the gyroscope and its application to the theory of the rifle bullet, but it never occurred to me before that the theory might not agree with experiment. I therefore borrowed a small gyroscope from Mr. L. Brennan (for whose kindness I tender my sincere thanks), and carried out the following experiment:—

Gyroscope rotated so as to represent bullet with left-handed twist (counter-clockwise viewed from behind). Upward pressure applied to the nose.

Result, nose deflected to the left.

I may add that a very clear and ingenious method of determining the direction of the precession is to be found in Mr. F. W. Lanchester's book on *Aerial Flight*, Part II., Aerodonetics, Appendix VII., and there is also a discussion of the rifle bullet in Appendix VIII*a*.

Yours faithfully,

K. E. EDGEWORTH,
*Capt., R.E.*

Chatham, 9th April.

THE EDITOR, *R.E. Journal*.

# RECENT DEVELOPMENTS IN TELEGRAPHY AND TELEPHONY.

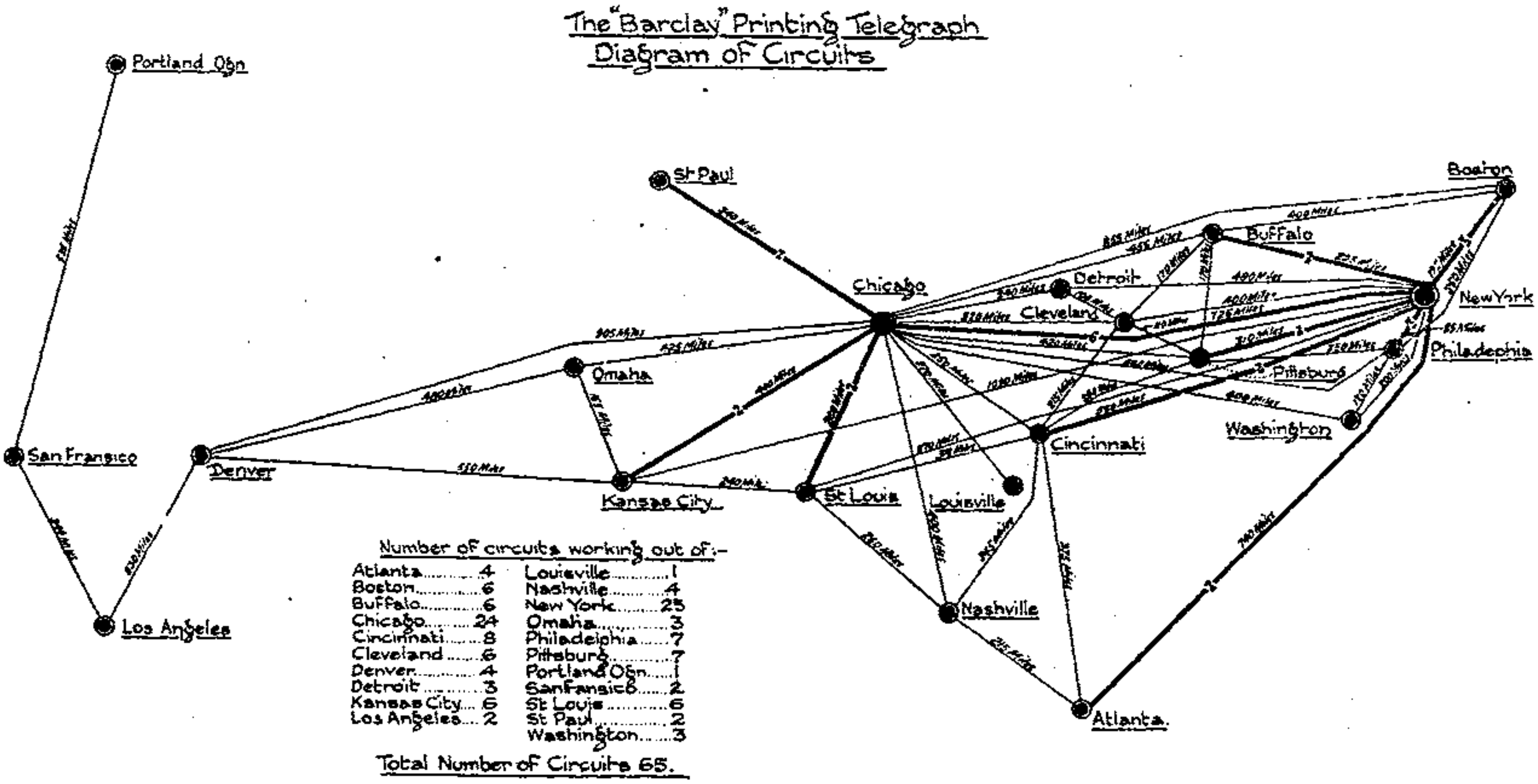


FIG. 1.

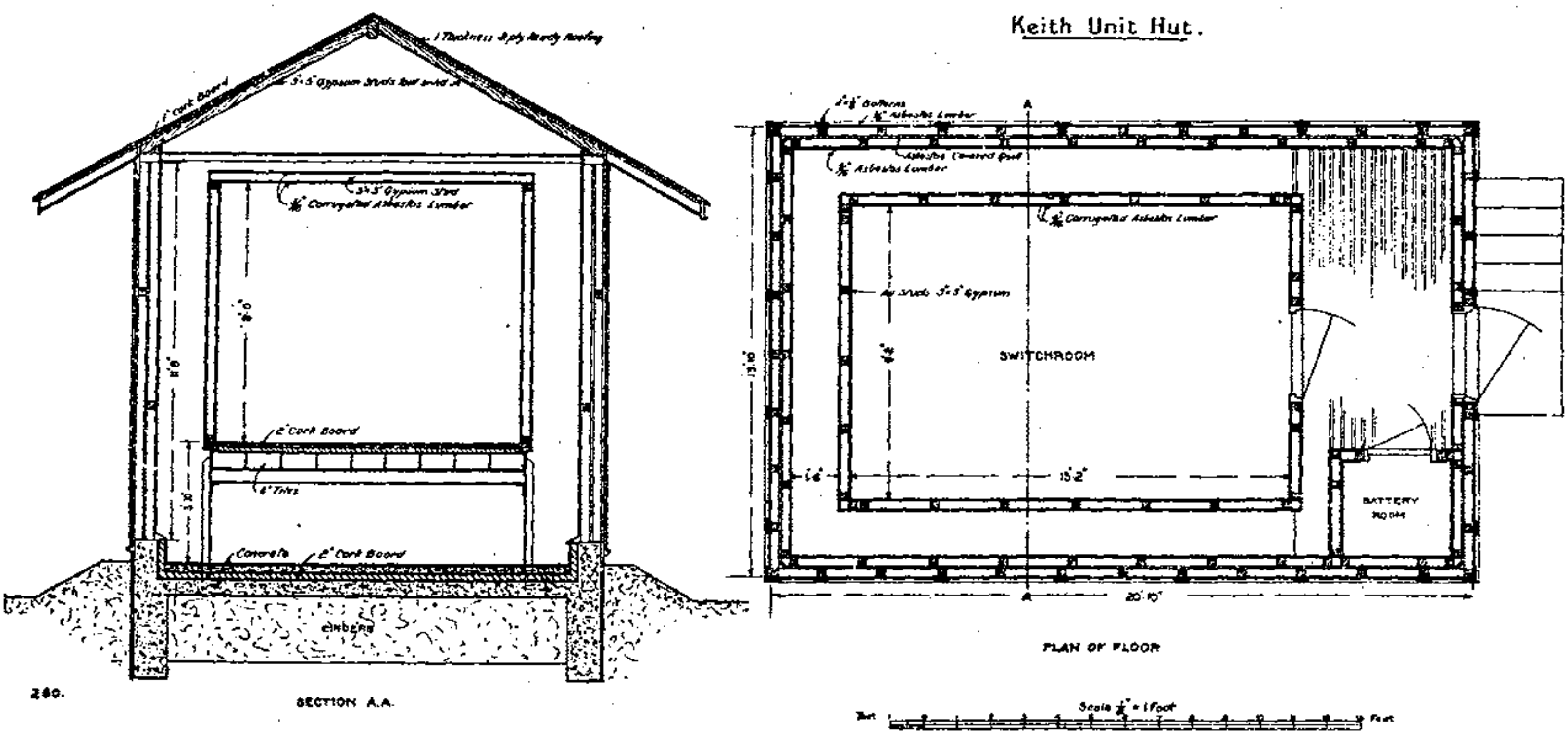


FIG. 2.

# LATEST PUBLICATIONS

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# King Edward VII's Hospital for Officers.

*Patron*—HIS MAJESTY THE KING.
*President*—HIS ROYAL HIGHNESS THE DUKE OF CONNAUGHT.



## REPORT.

**DURING 1910** 241 Officers received treatment. 174 Operations were performed.

**OFFICERS ADMITTED** :—Royal Navy and Royal Marines, 33; Royal Indian Marine, 3; Royal Artillery, 24; Royal Engineers, 20; Cavalry, 9; Foot Guards, 1; Infantry, 74; A.S.C., 1; R.A.M.C., 2; A.V.C., 4; A.P.D., 2. Indian Army—Indian Army 7, Cavalry 11, Infantry 46, I.M.S. 1—65.
Staff, Unemployed, etc., 3.

**TOTAL—241.**

### Dr. Balance Sheet, 31st December, 1910. Cr.

| Dr. | £ s. d. | £ s. d. | Cr. | £ s. d. |
|---|---|---|---|---|
| To Received in Advance in respect of Annual Contributions ... ... | | 202 12 0 | By Investments .. ... ... | 40,699 5 8 |
| ,, Balance—Viz., Excess of Donations over Initial Outlay and Current Expenditure to 31st December, 1909 ... ... ... | 43,099 12 0 | | ,, Cash at Bankers ... ... | 3,578 3 4 |
| ,, Excess of Current Income over Expenditure ... | 975 5 0 | 44,074 17 0 | | |
| | | £44,277 9 0 | | £44,277 9 0 |

### Dr. Income and Expenditure Account, Year ending 31st December, 1910. Cr.

| Dr. | £ s. d. | £ s. d. |
|---|---|---|
| To Rent, Rates, Taxes, Water and Insurance | | 708 1 2 |
| ,, Repairs and Alterations to Hospital ... | | 512 17 1 |
| ,, General Maintenance Expenses— | | |
| Salaries and Wages ... | 1,398 0 3 | |
| Washing ... ... ... | 272 10 5 | |
| Provisions and Household Stores ... ... | 2,040 18 3 | |
| Wines and Spirits ... | 67 16 3 | |
| Fuel and Light ... ... | 246 12 0 | |
| Clothing, House Repairs, Telephone, and other incidental expenses ... | 391 0 4 | 4,416 17 6 |
| ,, Surgical Dressings, Medicines, Pathological Reports, Massage, and Sundry Fees | | 950 1 7 |
| ,, Balance carried to Balance Sheet ... ... | | 975 5 0 |
| | | £7,563 2 4 |

| Cr. | £ s. d. | £ s. d. |
|---|---|---|
| By Subscriptions applicable to the Year, viz. :— | | |
| His late Majesty King Edward VII.... ... | 100 0 0 | |
| H.M. King George V.... | 100 0 0 | |
| Sir Walpole Greenwell, Bart. ... ... ... | 100 0 0 | |
| Sir E. Cassel, Bart. ... | 100 0 0 | |
| S. Neumann, Esq. ... | 100 0 0 | |
| J. Larnach, Esq. ... | 100 0 0 | |
| W. Burns, Esq. ... ... | 50 0 0 | |
| Lord Burnham ... ... | 100 0 0 | |
| S. E. Palmer, Esq. ... | 100 0 0 | |
| Sir H. Praed, Bart. ... | 10 10 0 | |
| Miss Keyser ... ... | 100 0 0 | |
| Sister Agnes ... ... | 100 0 0 | |
| Lord Rothschild .. ... | 100 0 0 | |
| Alfred Rothschild, Esq. | 100 0 0 | |
| Leopold Rothschild, Esq. | 100 0 0 | |
| C. E. Keyser, Esq. ... | 100 0 0 | |
| Mrs. Livingstone Bruce | 20 0 0 | |
| Margaret Lady Waterlow | 10 0 0 | |
| Mrs. Bischoffsheim ... | 50 0 0 | |
| Lord Strathcona... ... | 105 0 0 | |
| Sir Edward Sassoon, Bart. ... ... ... | 50 0 0 | |
| Arthur Sassoon, Esq., M.V.O. ... ... ... | 50 0 0 | |
| Viscount Iveagh... ... | 100 0 0 | |
| Sir E. Hambro, Bart. ... | 100 0 0 | |
| Baroness Eckardstein | 100 0 0 | |
| Lord Michelham... ... | 100 0 0 | |
| E. Gordon, Esq.... ... | 2 2 0 | |
| C. Gordon, Esq.... ... | 2 2 0 | |
| Mrs. G. Goddard ... | 1 1 0 | |
| S. Gordon, Esq.... ... | 2 2 0 | |
| Mrs. A. M. Corry ... | 20 0 0 | 2,172 17 0 |
| ,, Dividends on Investments ... ... ... | | 1,870 19 8 |
| ,, Subscriptions and Donations per Officers of the Navy and Army and Retired Officers | | 3,519 5 8 |
| | | £7,563 2 4 |

We have examined the above Statements of Accounts with the books and vouchers of the Hospital, and find the same to be correct.

*18th February*, 1911. PRICE WATERHOUSE & CO.