THE ROYAL ENGINEERS JOURNAL.

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CONTENTS.

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R.E. INSTITUTE.

It is notified that the title of the R.E. Institute has, with the sanction of His Majesty the King, Colonel-in-Chief, been changed to

THE INSTITUTION OF ROYAL ENGINEERS.

All communications for the Institution should in future be addressed to :—

The Secretary,
Institution of Royal Engineers,
R.E. Institute,
Chatham.

CONTENTS.

MONTGOMERIE PRIZE.

CONDITIONS.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded by the R.E. Institute Council in the manner considered best for the encouragement of contributions on professional subjects, by R.E. Officers, to the Corps publications. From the beginning of 1920 it has been decided that the Prize shall be confined to Officers on the Active List not above the rank of Substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions:—

(*a*). Descriptions of works actually carried out in peace or war.
(*b*). Inventions.
(*c*). Design (excluding works of defence).
(*d*). Labour organization on work.
(*e*). Scientific investigations generally.
(*f*). Accounts of exploration work and surveys.

THE R.E. KITCHENER SCHOLARSHIPS FUND.

THE original recommendation of the Education Sub-Committee of the General Committee of the R.E. War Memorial for the institution of this fund was stated in the following words:—

"They recommend that a sum of £2,000 shall be put aside from the "capital to form the nucleus of a permanent fund from the interest on "which Scholarships shall be given annually as a perpetual Memorial to "our Comrades who fell in the Great War, and of the part borne by the "R.E. in the War. It is hoped that this permanent Fund may be "increased by special gifts as time goes on."

This permanent Fund has now been established and subscriptions and donations to the R.E. Kitchener Scholarships Fund may be sent at any time to the Secretary, R.E. Institute, Chatham.

*HINDENBURG.

By COL. B. R. WARD, C.M.G.

ALTHOUGH this book bears the name of Hindenburg alone on the title-page, some fifty pages at the end of the work are devoted to a study of Ludendorff and to a comparison of the two great German leaders.

The portion of the book devoted to Hindenburg describes first his career, then his principal characteristics, his principles of war, and lastly his peculiarities.

The latter portion of the book is entitled "Hindenburg and Ludendorff," and contains first a description of the personality and characteristics of Ludendorff, next a comparison of the two men, pointing out their similarities and points of difference. This is followed by an essay as to the part played by each one in the conduct of the war, and a general conclusion as to the real nature of the two men.

In the Preface General Buat refers to a recent work of his on Ludendorff based on his written *My War Memories*, and expresses entire confidence that he will pursue his dream and that we shall see him in the future, in fact if not in appearance, playing a leading part among the numerous Pangermanists who are determined to act their play "Deutschland Uber Alles," which he freely translates "Germany at the head of the nations."

The publication of Hindenburg's *Life* has given our author an opportunity of making a study of the chief of a similar character to the one he has already made of his Chief Staff Officer.

A quotation from the writings of the famous naturalist Buffon occurs both in the Preface and at the close of the last chapter of the book.

The first quotation: "*Le style est l'homme même*," emphasizes the possibility of detecting the true nature of both Hindenburg and Ludendorff from their written memoirs. The last quotation is to the effect that "for every species there exists in nature a general prototype on which each individual of the species is modelled." This quotation is made use of to indicate that whereas Ludendorff reveals himself in his book as the Prussian prototype, full of pride if not of vanity, ambitious without any scruple, a conqueror without pity and even boasting of his inhumanity, spiteful without magnani-

*By General Buat. Librairie Chapelot, 136, Boulevard Saint-Germain, Paris. 1921.

mity, passionate almost to the point of insanity, rough in manner as in thought, Hindenburg on the other hand, though conforming no less to the Prussian prototype, represents a very different variety of the species. He is lacking in pride, is without ambition and without hate, a little inclined to be ashamed of the cruelties with which his armies are reproached, a moderate Pangermanist, by nature tolerant, kindly in his judgments, good-natured and easy of approach, while at the same time the slave of duty. In other words, the self-revelation of Hindenburg as effected by his book exhibits a far more sympathetic figure than that of his too-pushing Chief of Staff, who in spite of his undoubted military talents has succeeded in alienating all natural sympathy by means of his self-portraiture in his *Memories*.

It will be seen from the foregoing that General Buat's book is in its essence a psychological study, devoted in the main to Hindenburg, but at the same time comparing and contrasting him with his Chief of Staff. The fact that the book begins and ends with quotations from a writer on natural history emphasizes the scientific nature of General Buat's work. The question is not so much what Hindenburg has done as what his essential qualities are, how he should be classified as an individual specimen of humanity.

In the first place our author lays stress on the fact that he comes of an old Prussian family in which military service is a tradition even more than a duty. He was born at Posen—now in the Polish area—in 1847, and in becoming a cadet at the age of ten he did no more than accomplish the natural act for which he was destined. In 1866, as a Second Lieutenant in the 3rd Regiment of Infantry of the Prussian Guard, he distinguished himself at Rosberitz where he was wounded in the head. In 1870 he was at Saint-Privat, Sedan, and Paris,and was present at the proclamation at Versailles of the German Empire on the 18th January, 1871.

From 1873 to 1876 he was a student at the War Academy, and from 1876 to 1878 he served on the Great General Staff at Headquarters. In 1880 he served at Königsberg as a Captain on the staff of General Verdy du Vernois, an eminent chief, a distinguished military writer, and an educator of the first rank. In 1884, at the age of 37, after a period of fifteen months in command of a Company of the 58th Regiment—a regiment recruited in Polish Prussia—he was appointed to the Operations Branch of the Great General Staff, then under the direction of von Schlieffen. Here he assisted in drawing up a new edition of the Field Service Regulations, and followed this up by five years as an Instructor in Tactics at the War Academy. In 1890 he became Director of a Branch of the War Ministry, under his old chief Verdy du Vernois, at that time Minister of War. Here he drew up the Regulations for Pioneers on service, and for the employment of heavy artillery in the field.

At the age of 46, in 1893, he was promoted to the rank of Colonel, and was in command of the 91st Regiment of Infantry till 1896,

when he was gazetted Brigadier-General and became Chief of Staff of the 8th Corps at Coblentz.

In 1900, at the age of 53, he was given command of the 28th (Baden) Division. In January, 1903, at the age of 56, he was placed in command of the 4th Corps at Magdeburg. For nearly eight years he held this important command, until in 1910, at the age of 64, desirous of giving way, as he tells us, to younger men, and despairing of ever seeing active service again, he applied to be placed on the retired list. His application was granted, and for nearly four years he remained on the retired list. On the 22nd August, 1914, he was already beginning to fear that his sovereign had forgotten him when a telegram arrived from General Headquarters asking him if he was ready to accept a new post. In spite of his 68 years he replied laconically: "Am ready." Half an hour later a dispatch from General Ludendorff informs the retired General that he has been provided with a Chief of Staff, and that on the following day—23rd August—between three and four o'clock in the morning he will arrive at Hanover Station by special train destined to conduct them both to their destination. At about half-past seven that evening a second Imperial telegram informs Hindenburg that he is to command the 8th Army in East Prussia. The next morning early Hindenburg is at the station. The special, containing two coaches and some baggage trucks, steams in. An officer wearing the cross he has just gained for bravery at Liège steps on to the platform. This is the first meeting of the two men who are destined for the next four years to act in such close co-operation that to the world at large the two names Hindenburg and Ludendorff seem almost to represent one individual.

The most successful military operation connected with the names of the two men occurred within a week of their first meeting. The Battle of Tannenberg took place on the 27th to 29th August, 1914, and this was followed by the first Battle of the Mazurian Lakes on the 7th and 8th September. Within three weeks of their meeting at Hanover, East Prussia had been cleared of the Russian invaders, Hindenburg had been made Colonel-General and decorated with the first grade of the Iron Cross.

It is impossible to follow in detail their combined career except to mark the dates of outstanding events in their military history.

On the 29th August, 1916, Hindenburg was appointed Commander-in-Chief of the German Armies with Ludendorff as his Chief of Staff —First Quartermaster General. Roumania had just declared war, and the general situation was looking decidedly gloomy for the Central Powers.

The first task which confronted the new Chief was to assure unity of command among the four allied armies—German, Austrian, Bulgarian, and Turkish. The next was to carry out new schemes of

recruiting, organization, instruction, and other internal reforms. The third was to tackle the awkward military situation created by Roumania's entry into the war. In France the Battle of the Somme was in full swing after the failure of the German attack at Verdun which commenced in February, 1916. By the end of the year Roumania had been completely overrun by Mackensen's forces, and the German line had managed to hold on in France. This allowed breathing space to consider their plans for 1917.

Early in this year, acting on a report from the German Admiralty that England would be forced in a few months to sue for peace, Hindenburg and his Chief of Staff declared in favour of unrestricted submarine warfare. As a result America joined the Entente, but on the other hand the Russian Revolution paved the way for a settlement of affairs in the East, and allowed of a transfer of German Divisions to the Western Front for the "Kaiser Battle" of 1918.

The failure of this great offensive led to Ludendorff's resignation on the 26th October. Hindenburg still remained in command, and after the signature of the terms of the Armistice by the German delegates on the 11th November, Hindenburg, under the Kaiser's orders, carried out the terms and conducted the armies to the right bank of the Rhine. Having fully completed his task he went back quietly to retirement in Hanover, whence he had emerged so confidently on the 23rd August, 1914. The mere enumeration of the duties and responsibilities carried out by Hindenburg during those four years is sufficient to show that the old man—he was now over 71 years of age—was the possessor of an iron frame.

A powerful physical frame does not always accompany perfect health and vitality, but Hindenburg is reported to be able to sleep at any hour, no matter what mental strain he may have been subjected to beforehand. Nor is he over particular as to where he sleeps. A bed, sofa, or chair are all equally serviceable for him to sleep on. A clear indication, as General Buat puts it, of a tranquil disposition and an absence of nerves! This tranquility, however, is not an indication of sluggishness. He is naturally gay, is fond of youth, and never stands on his dignity. Here is one of his inspection reports on a regiment: "Discipline excellent, but the subalterns are too solemn."

At General Headquarters he keeps up the tradition of jokes and merriment which he used to encourage at the cadet school. He looks upon it "as a duty" to keep his collaborators cheerful and in good spirits.

With all this *bonhomie* and good nature it must not be imagined that Hindenburg is in any way lacking in firmness of character. As we shall see later in discussing his principles of war there is nothing he lays more stress upon than an indomitable will. From his childhood, he tells us, his parents set themselves to develop him into a

man possessing a powerful personality in a vigorous frame. If the personality of Ludendorff is overwhelming in its aggressive egotism, the more modest personality of Hindenburg overflows with life and good spirits. The motive power at the back of this vigorous personality may be described in three words. He is an aristocrat. He is a Prussian. He is an ultra-monarchist.

His full surname is "von Beneckendorff und von Hindenburg," and he is immensely proud of being a von Beneckendorff, a family that can trace its descent back to the year 1280. He is an intensely patriotic German, but Prussia is the surest and firmest support of the Empire, and in the reigning family Prussia finds her living expression. He always alludes to his sovereigns in semi-religious terms.

In 1859, when he was a cadet of 12, Prince Frederick William, the future Emperor Frederick, and his wife visited the school, and Hindenburg for the first time saw members of the Royal family at close quarters; never before did he "kick his legs so high at the march-past, or perform such perilous gymnastic exercises."

When in 1867, on his return from the Austrian campaign, King William at an inspection of his regiment inquired of him the circumstances under which he had gained the cross of the Red Eagle with swords, he felt thrilled with a sacred emotion.

On the 18th January, 1871, he was present at Versailles at the proclamation of the German Empire. His heart was thrilled with joy, but what moved him most, "as may be well imagined," was the apotheosis of his "august King and Lord."

A little later, the old Emperor appeared one day at the window of his palace in Berlin in response to the cheers of the people outside. Hindenburg, who was in the crowd with one of his sons, a boy of five, raised the child in his arms and said: "Never forget this moment, and you will always do your duty."

He never fails, at the slightest opportunity, to extol the qualities and the character of his Emperor. Can anyone say that William II. is anything but a man of simple tastes and careless of personal comfort considering that at Avesnes, during the spring offensive of 1918 he lived for several weeks in a train? Can his courage be doubted in view of the fact that he took no notice of the dangers he was incurring from hostile aviators?

Even the Crown Prince comes in for his praises. He is chivalrous, energetic, frank in manner, and his military judgment is sound. Finally when as a result of the treaty of Versailles, popular clamour demands that William II. shall be given up to the Allies in order that he may be brought to trial for the crimes for which he is nominally responsible, Hindenburg offers to take his place as the prisoner at the bar.

An aristocratic, Prussian, and monarchical tradition is thus seen

to be the driving force behind all his actions. What are the principles of war on which he lays most stress? In the first place strength of will, firmness of mind and character are in his opinion more valuable to a soldier than any refinement of intellect. Energy in action, the result of a decision once arrived at, is far more important than intellectual subtleties.

Calmness on critical occasions—a calmness which according to General Buat only failed him on two occasions, first after his defeat on the 8th August, 1918, and more especially after the Bulgarian collapse in the following month—is another quality on which he lays great stress.

Firmness of character implies a love of responsibility, but this does not mean the denial of responsibility to subordinates. As a Colonel he always endeavoured to give to his juniors "the right and the duty of acting with independence and initiative." This method of dealing with subordinates illustrates a striking characteristic, which Hindenburg displays in all his dealing with and comments on other people. He is eminently reasonable in his judgments and is very slow to condemn decisions honestly arrived at, merely because they did not eventuate in success.

Thus he even finds excuses for the politicians who were unable to prevent Roumania from declaring herself on the side of the Entente. "It is all very well for people who know nothing of the facts to judge them severely. People who criticize like that, generally base their criticisms on unsupported affirmations, and are like those writers ridiculed by Fichte in his *Message to the German Nation* who can never say what ought to be done until after the event has happened."

The Army Order issued by Hindenburg on the 12th November, 1918, illustrates this characteristic. While full of personal dignity, it makes full acknowledgment of the efforts put forth by the troops, the Government, and the Allies of Germany, in order to stave off the recent catastrophe.

For Hindenburg's intellectual qualities General Buat expresses respect but no particular enthusiasm, and if on the whole he finds much which Frenchmen can sympathise with in the character of the old Field Marshal he none the less points out the real weak spot of the Prussian tradition. Prussian loyalty and *esprit de corps* flourish especially amongst the corps of officers and Hindenburg defines this feeling as "a personal link uniting each officer to his King, as the vassal to his suzerain." "It is the same sentiment," says General Buat, "which animates the old monarchical and conservative families of Prussia. They have no understanding whatever of Humanity and can conceive of no system of order but a particularistic one based on the power of a State, solidly centralized and administered, the whole resting upon an army sufficiently powerful to conquer or to retain under all circumstances the place due to their country in the world."

THE ACTIVATED SLUDGE PROCESS OF SEWAGE PURIFICATION.

By CAPTAIN C. C. ADAMS, M.C., R.E.

IN the design of modern plants for sewage disposal, there has been a great tendency for engineers to break away from the anaerobic, or septic tank treatment, in favour of aerobic methods. Many systems for aerobic treatment have been devised during the last thirty years, the most modern being the activated sludge process, which has good claims to be considered the most satisfactory yet discovered.

The main objections to the septic tank system are due to the harmful and objectionable gases which are given off during the decomposition of the sewage, which prohibit the treatment being carried out in the neighbourhood of buildings. Further, the sludge produced by anaerobic action in the tank is of an offensive nature.

Many years ago, it was found that contact beds of clinker, designed to oxidize the septic tank effluent, are capable of treating raw sewage, provided the filling is of reasonably large material, in order to prevent clogging. After primary treatment in these "roughing beds," the effluent is given a further treatment in beds composed of smaller diameter filling, and so becomes completely stable and harmless. This system does not cater for any action by the anaerobic bacteria, and the objections to the septic tank are eliminated. Some solid matter or "humus" is carried off in the final effluent and a similar material is formed in the beds themselves, and in time chokes them up. This "humus" bears little resemblance to septic tank sludge; it is black, granular, easily dried, quite inoffensive and with a smell similar to that of vegetable mould. It is found to contain large numbers of aerobic bacteria.

After a contact bed has been emptied of sewage, it is necessary for it to rest empty for some hours, in order that interstices between the lumps of clinker may become filled with fresh air. This aeration is most important, and is essential for the efficient working of the bed, for without it, the aerobic bacteria cannot carry out their oxidizing action. It is found that a bed gives better results after it has been in use for some little time, the reason being that the "humus" which collects in the interstices contains, as has been stated above, aerobic bacteria in large numbers, and is, in fact, a bacterial culture.

A process which is identical in action takes place in Dibden's biological beds, the difference being that in these, the clinker is replaced by layers of slates or tiles.

For the efficient oxidization of sewage by this method it will be

seen that three essentials are necessary, the sewage, air, and an aerobic bacterial culture, and the more intimate the contact between these three, the more rapidly will the oxidization take place, and the more efficient will be the system.

In contact beds a high efficiency is not possible, owing to the fact that the "humus" forms in large lumps, and the area of contact between the sewage and the air is a comparatively small one.

The Activated Sludge process works on identical principles, but in this case a much higher efficiency is aimed at, and obtained, by intimately mixing the sewage with the bacterial culture by agitation. At the same time, minute bubbles of air are blown through the mixture, and a practically infinite surface of contact is thus produced.

A forced aeration process was tried early in 1912 at the Lawrence Experimental Station of the State Department of Health of Massachusetts. At the end of that year the work was shown to Dr. Gilbert Fowler, of Manchester, and with the aid of his colleagues, Dr. Ardern and Mr. Lockett, the process was brought to its present state of perfection.

The main action takes place in aerating tanks, in the bottom of which are "diffusers" of a special porous material, through which compressed air is passed and atomized, so that it rises in minute bubbles through the sewage. This aeration is continued until chemical tests show that all the ammonia in the sewage has been oxidized into nitrates. If the air is then turned off, the sludge will rapidly sink to the bottom, and the liquid can be decanted. This sludge is "activated sludge" and will be found essentially different to septic tank sludge, in that it is inoffensive and is an aerobic bacterial culture; in appearance, however, it resembles septic tank sludge rather than the "humus" from filter beds. If this sludge is left in the tank, and the latter is again filled up with sewage and the aeration continued, the nitrification of the second filling will take place rather more rapidly, owing to the presence of this "bacterial culture." This process can be repeated, and at each filling the oxidization will take place more rapidly, until when the tanks are about one-quarter full of activated sludge, complete nitrification occurs in a few hours. The plant is then ready for work. Actually it takes some weeks to build up the necessary quantity of activated sludge for the purification to take place in a minimum time. It is found that about 10 per cent. activated sludge can be obtained in 10–20 days; this is aerated continuously for a week, and the plant will then be in a fit state to work, but it will continue to improve in efficiency until it has been in action about three months. The tanks will then contain about 25 per cent. activated sludge. This period of building up can be reduced considerably if some previously activated sludge, or contact bed "humus" can be obtained from another plant.

It should be mentioned that the purification of the sewage appears to take place in two stages. The first is a rapid carbon oxidization process, in which the organic matter is broken down, and the carbon is converted into carbon dioxide. After this action, the liquid is found to be stable, but it is generally desirable to continue the aeration for a time, in order to allow the second oxidization to take place. In this, nitrates are formed in the liquid, and one can then be certain that the effluent will be highly purified and absolutely non-putrescible.

About 42 tons of wet sludge are obtained from one million gallons of sewage. It resembles septic tank sludge in appearance, but is very different in its properties. It contains large numbers of bacteria, as many as 22 millions having been found in 1 c.c., in addition to bacterial flora and protozoa. It is dark brown in colour with an earthy odour and contains 97-99 per cent. water; even after prolonged standing under water, this figure is only reduced to about 96 per cent. Up to the present time, no thoroughly satisfactory means of drying the sludge for commercial use has been found, as it is extremely flocculent, and microscopical examination shows it to be composed of immense numbers of minute "sausage skins" which contain water, and are not easily broken up. By lagooning and air drying, preferably on ash beds, the moisture content is reduced to 75-85 per cent. in about four days, and the sludge has then lost its colloidal nature, is granular in appearance, odourless and is spadeable. The moisture content can be still further reduced by pressing, and by heating it can be got as low as 10 per cent.; the sludge then appears to be quite dry and still retains its manurial value, although the latter is reduced if a high temperature has been used.

It is found that activated sludge will keep inoffensive under water for an indefinite time, provided it is aerated occasionally, but a process of auto-digestion sets in, and this has the effect of reducing the bacteria and quantity of organic matter present. It is extremely important that no particle of the sludge should be allowed to stagnate and become free from air. If this happens it will go black, become septic, and foul the effluent.

It will be seen from the following table, which gives the composition of the sludge, that it has a large nitrogen content, so that its value as a fertilizer is extremely high; it contains, in fact, three to four times as much nitrogen as the average septic tank sludge:—

Organic and volatile matter ...	64·7 —70·4 %
Minerals	35·3 —29·6 %
Nitrogen	3·75— 7·09 %
Phosphoric acid	2·1 — 4·2 %

Many experiments have been made to determine the manurial effect of activated sludge, and the results have been most satisfactory. With wheat, it has been found that activated sludge is a better manure than dried blood, nitrate of soda, sulphate of ammonia, or gluten meal. Similar results have been obtained with other crops and plants. Taken all round, it may safely be said that its manurial value is at least as good as any of those fertilizers mentioned above.

The effluent obtained from this process is remarkably pure; it is not only extremely stable, but is clear and free from colloids, owing probably to the presence of a clotting enzyme in the activated sludge. This clotting, or clarification, is the first action which occurs, and is a sign that the purification is taking place correctly; it also enables the sludge to separate rapidly from the liquid after the aeration is effected; in fact, complete separation will usually take place in less than one hour. The effluent without further treatment will pass any of the usual standards, including those recommended by the Royal Commission on Sewage Disposal. It possesses a low saline ammonia content and high nitrification; it gives a low figure for absorbed oxygen and contains much dissolved oxygen owing to the aeration which takes place in the process; further, the bacteria are found to be reduced by about 98 per cent. It does, in fact, compare more than favourably with that obtained from percolating filters.

The following table of analytical results taken at Withington gives figures for different populations, but with the same tanks in use, and clearly shows the nature of the effluent obtained by this process. The figures give "grains per gallon."

	Rate of operation in gallons per diem.							
	150,000		250,000		375,000		500,000	
	Sewage.	Effluent.	Sewage.	Effluent.	Sewage.	Effluent.	Sewage.	Effluent.
Oxygen absorbed in 4 hrs.	2·14	·44	1·66	·41	1·85	·42	1·97	·47
Free saline ammonia ...	1·75	·24	1·43	·28	1·52	·62	1·69	1·25
Albuminoid ammonia ...	·415	·07	·36	·07	·36	·07	·36	·08
Nitrites or nitrates ...		·93		·77		·46		·22
Dissolved oxygen absorbed		·36		·92		·88		·92
Suspended matter ...		less than 2		less than 2		2·0		2·18*

Reduction of bacteria in the effluent (all types) from 1 million to 20,000 per c.c. (98 %).

The details of the process can be seen from the plans of a typical plant which are reproduced. It is most important that all heavy grit

* An average of 30 determinations, varying from 1·1—3·7.

and large floating solids should be removed before the sewage enters the aerating tanks. Detritus pits are therefore essential when rain water from yards or roads enters the sewers (these are not shown on the plans, which were designed for purely domestic sewage containing no rain water). After the separation of the grit, the sewage passes through a coarse screen (2) to the circular Disintegration Tank (4). The purpose of this tank is to break up all solid matter into small particles, so that a large surface will be available for the subsequent treatment. This disintegration is effected by blowing minute bubbles of air through the sewage from porous stone diffusers fixed in the bottom of the tank, in narrow furrows placed radially. A fine emulsion of air and water is thus formed, which, having a low specific gravity rises to the top carrying with it the solids, which are thus broken up mechanically. The air is given off at the surface of the liquid and the solids then tend to sink, and in a properly designed tank, every particle of solid matter is constantly carried up to the surface and then down again. It should be noted that although some aeration takes place in this tank, oxidization of the sewage is not carried out to any appreciable extent, for the aerobic bacterial culture, or activated sludge, is not present. The function of the air at this stage is solely for disintegration.

After this action the sewage flows through the fine screen (5) into the grease-collecting chamber. It is drawn off from the bottom of this chamber, so that any grease will collect at the top of the liquid and be trapped in the cylinder. It can be skimmed off and removed from time to time. The sewage then passes to the mixing chamber (6) where it is joined by a percentage of previously re-aerated sludge from the channel (12) and this is intimately mixed with the incoming sewage, and aerated by means of the diffuser (6*a*). The volume of activated sludge added varies from 15 to 30 per cent. according to the character of effluent desired. The lower figure will give a clear and stable effluent, but if complete nitrification is required, the larger volume is necessary.

The mixture then passes along the aeration channel (7) where the actual purification takes place. This is a long channel (about 135 ft. on the plan here shown) and is, in this case, in three lengths (each about 45 ft. long), the inlet being at (5*b*) and the outlet at (8). The length of the channel and its cross-sectional area depend on the nature of the sewage; the time of aeration usually required is 6 to 8 hours, but it may be as short as 2 hours, or as long as 24 hours. There are diffusers all along the channel, and the three necessary constituents for purification (sewage, air and activated sludge) are in intimate contact throughout the length. In order to prevent short circuiting the aeration channel is divided into compartments by baffle walls (7*c*) in which there are small openings immediately over the diffusers near the floor. In this channel the sewage is com-

pletely purified, and the solids are "inoculated" and converted into activated sludge.

The air fulfils a threefold purpose in this work; it keeps the sewage in a constant state of agitation, it helps to coagulate the colloids, and supplies oxygen for the life of the aerobic bacteria, by means of which the purification takes place. For the latter part of the work, 2 c.f. of air per sq. ft. of tank area per hour are sufficient, but actually a much greater volume (6 to 9 c.f.*) is at present used. The air pressure depends on the depth of the tank, and need only be about $\frac{1}{4}$ lb. per sq. in. more than the pressure due to the liquid; usually 5 to 10 lbs. per sq. in. is sufficient. In the U.S.A. the compressed air is sometimes filtered to prevent it from clogging the pores in the diffusers.

After purification, the sewage passes through the orifice (8) down the feed-pipe (9*a*) to the Settlement Tank (9) which it enters by means of the Clifford Inlet. This consists of a vertical pipe discharging downwards into an eddy bucket (9*b*) which is supported inside a guard chamber (9*c*). The object of this is to break the force of the incoming sewage, so that the settlement of the sludge is not disturbed. Owing to the clarity of the effluent, the sludge is deposited very quickly, and in one hour, settlement is complete. The effluent is drawn off by the bell mouths (9*f*) and runs to a suitable outfall, no further treatment being necessary, except under exceptional circumstances.

The sludge is continuously being forced out through the outlet (9*k*) by the hydraulic pressure of the liquid above it, the rate of flow being regulated by the penstock (9*l*). It then enters the re-aeration channel (10), by means of which it returns to join the incoming sewage. The surplus increment of sludge due to treatment can be run off or pumped out of the channel at intervals, as found convenient. The sludge has a great avidity for oxygen and for this reason, that which is to be mixed with the incoming sewage should be re-aerated at this stage. There are diffusers along the length of the re-aeration channel for that purpose. After passing along this channel, the sludge is raised by two air-lift pumps (11 and 11*a*) to the level of the incoming sewage with which it then mixes.

If the sludge is left without aeration for a time, owing to cessation of the air supply, it will regain its useful properties after a period of aeration. Stoppages up to six weeks duration have occurred which have given no difficulty, and if the plant is occasionally shut down at night, or for one or two days, a few hours of aeration before admitting sewage will be quite sufficient.

* *Note.*—Actual volumes used per hour per sq. foot of tank surface are: Worcester=8 c.f.; Withington=9 c.f.; Tunstall=8 c.f.

The process lends itself very readily to the varying rates of flow occasioned by storms. During the peak flow in dry weather, and during the first hour's flush of torrential rainfall, the first particles of sewage to pass through the tanks are liable to be not thoroughly oxidized. But during the small flow of weak sewage at night in dry weather the sludge becomes fully activated ready for the peak flow next day, and by increasing the tankage in order to carry, say, 50 per cent. surplus sludge above that required for the average dry weather flow, any storm flow can be successfully treated. It must be remembered that after the first hour's flow in torrential rain, the increase over the average dry weather flow is merely dilution, and thus actually less work is then required from the bacteria carried by the returned activated sludge.

It is of course necessary to design the sedimentation tanks of a sufficient size to take the maximum storm flow plus the returned sludge to be settled, and for this a stay of one hour in these tanks should be arranged for.

Normally, the outlet from the aeration tanks is by way of the restricted orifice (8), so that even during the peak flow in dry weather, or a storm, only a small volume passes through the tanks, and consequently the level in them then rises. This enables the first sewage arriving at the works after a storm (which is particularly foul owing to the washing down of roofs and drains) to receive additional treatment in the aeration tanks. The level continues to rise until the sewage can pass over the overflow weir (*8a*) and the subsequent storm water, which is comparatively pure, will then pass through with a short period of aeration.

The activated sludge process has many great advantages which enables it to approach that perfection which is claimed for it by its inventors; the chief of these are as follows:—

1.—The purification is rapid and perfect and the effluent fully oxidized.

2.—Putrefaction stops at once, and the system is free from smells and flies.

3.—The plant can be installed close to buildings, so that long outfall sewers are often unnecessary.

4.—An inoffensive sludge which is a valuable manure is obtained.

5.—Only a small area of land is required.

6.—There is practically no loss of head (4 in. to 10 in.) and the sludge is raised automatically.

7.—Trade wastes which are alkaline, or of constant but low acidity, give no difficulty.

8.—A very small staff is needed, but it requires at least one skilled attendant.

9.—Capital costs are low owing to the simplicity of the plant, the small tank area needed (less than for sedimentation or septic tanks), and the absence of filter beds. Further, by installing the plant near a town, there may be a saving in the cost of outfall sewers.

10.—Maintenance costs are low owing to the revenue which may be obtained by the sale of manure.

Taken all round, the cost of installing and maintaining a plant is generally about two-thirds of the cost of septic tanks and filter beds. It should be mentioned that existing tanks can usually be converted, and in many places this has been done quite successfully at small cost.

The plants work well either with a large or small population, and would appear to be well suited for military stations. There are no real disadvantages in the system except possibly the production of compressed air, which is so essential for the working. In many places, compressed air is required for raising the sewage by means of ejectors, and no further compressing plant is needed. The expense of installing an air-compressor is not great.

The first large scale experiments in England, were carried out at Salford near Manchester in 1917. The results were extremely satisfactory, and the process is now becoming very well known in this country, and in the U.S.A. The Ministry of Health has recently sanctioned the erection of a plant at Reading to treat the whole of the town sewage amounting to 2,750,000 gallons per diem. The London County Council have just placed an order with Messrs. Activated Sludge, Ltd., for equipping a set of tanks at their Crosness Outfall Works to treat 110,000 gallons of sewage per diem, for the purpose of demonstrating the capability of the process to treat the sewage of London.

The entire patents for the process are held by Messrs. Activated Sludge, Ltd., of 14, Howick Place, Victoria Street, Westminster, to whom the writer is indebted, not only for much of the information given in this paper, but also for permission to reproduce the plans and photographs, by which it is illustrated.

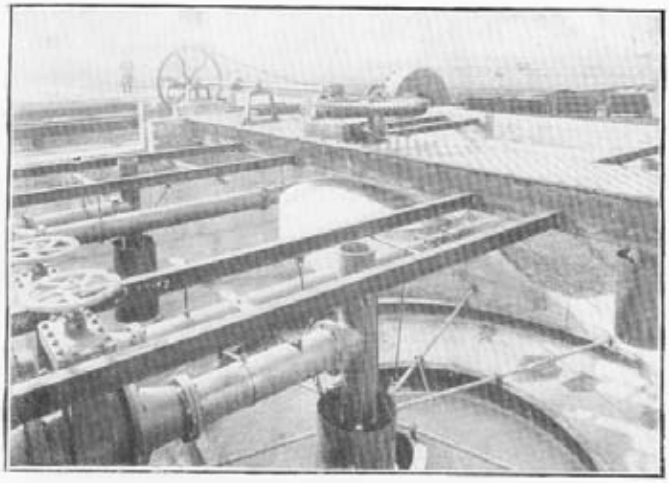
1.—National Filling Factory, Aintree.

This Government Installation for 2,000 workpeople has been in operation since 1916 and is still doing good service with reduced flow.

2.—Town of Tunstall, Stoke-on-Trent.

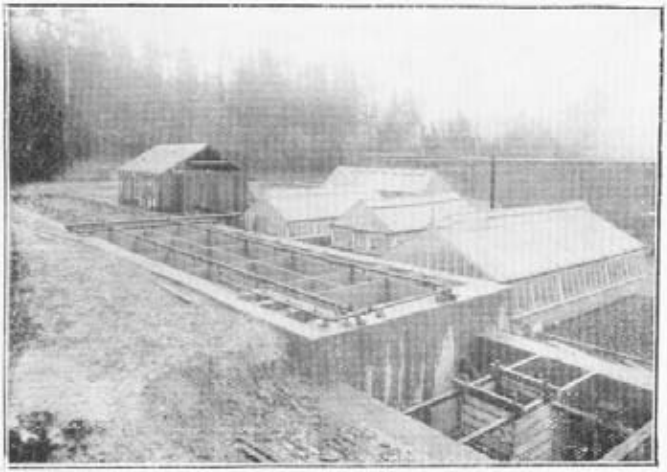
The Borough Sewage Engineer writes :—300,000 gallons per day is being treated efficiently and satisfactorily.

PICTURE 1 & 2



3.—Manchester Sewage Works at Davyhulme.

One of the Settlement Tanks before filling, showing patent inlet pipes and eddy buckets and helical scraper on dished bottom continuously rotated by water wheel operated by falling effluent.



4.—For American Red Cross Hospital, Southampton.

Population 2,000. A successful War Hospital scheme.

PICTURE 3 & 4

VERDUN AND METZ.

A Comparative Study of the Fortifications, taken from an Article in the "Revue du Génie Militaire" of January and February, 1921, by General Benoit, Chief Engineer of the Military Command of Metz.

By CAPT. C. LA T. TURNER JONES, D.S.O., M.C., R.E.

This study is subdivided into the following parts :—

I. The rôle allotted to Verdun and to Metz.
II. A historical summary of their fortifications.
III. The ideas prevailing in France and Germany on the organization of fortresses.
IV. The differences in the strength and construction of the works.
V. Constructional details of "Feste."
VI. The condition and cost to date of the fortresses of Verdun and Metz at the outbreak of war.
VII. Works carried out during the War.
VIII. The effect of bombardment on, and the part played by, these fortresses during the War.

I. THE RÔLE ALLOTTED TO VERDUN AND METZ.

Verdun and Metz on the Meuse and Moselle respectively, and some 60 miles apart as the crow flies, had somewhat similar rôles to play.

Verdun is a bridgehead on the Meuse and was the northern pivot, Toul being the southern, of the fortified region of the Heights of the Meuse, with a front of about 75 kilometres.

Metz is a bridgehead on the Moselle, a river quite as important as the Meuse, and with Thionville formed the fortified area of the Moselle, with a front of 45 kilometres.

The rôle assigned to Verdun and the Heights of the Meuse was :—

(1) To hold the approaches to the Meuse and to cover to a certain extent the concentration of the Field Army.

(2) To help any offensive action of the French Armies in the Woëvre and to safeguard their communications.

(3) In case of failure to guard the retreat of these Armies, to immobilize a portion of the enemy's forces and to threaten his communications.

The rôle assigned to the fortified area of the Moselle seems somewhat similar. It was :—

To cover the concentration of the German Forces in Lorraine

and to give Germany the command of the crossings over the Moselle between Luxemberg and the French frontier to the south.

This fortified area of the Moselle had a great advantage over the Heights of the Meuse in being much nearer the frontier, thereby rendering easier an invasion of the French territory commanded by its guns and on the other hand preventing any attempt at invasions made by the French in the direction of Metz.

The outer forts of Verdun being 40 kilometres from the frontier were not able to be of the same use.

II. HISTORICAL SUMMARY OF THE FORTIFICATIONS OF METZ AND VERDUN.

1st period: prior to 1870.—Before 1870 Metz being nearer the frontier than Verdun was better fortified; the latter had its citadel and its enceinte only, while the former had already some detached forts completed, namely:—Plappeville, Saint-Quentin, Queuleu and Saint-Julien—some under construction—Saint-Privat and Les Bordes; these forming a ring of forts round the enceinte and some three to four kilometres from the citadel.

2nd period: 1870–1886.—After the war of 1870 the Germans hastened the completion and development of these works. Between 1873 and 1880 they constructed Manstein (now Gérardin) and joined it to the existing fort of St-Quentin to form the "Feste" Frederick Charles. They also completed the ring of forts by adding Schwerin (now Decaen), Kameke (Déroulède) and Hindersin (Gambetta) and constructed earthen gun emplacements in the intervals between the forts. The development of Verdun was being carried out at the same time. Between 1874 and 1880 a ring of detached forts was begun two and half to six and a half kilometres from the citadel (Belleville, Saint-Miciel, Souville, Tavannes, Belrupt, Dugny, Regret, La Chaume and Marre) and also the fortifications of the Heights of the Meuse. About 1880 it was decided to occupy certain points further out from Verdun (five to eight kilometres) giving a good command over the approaches to the town. The foundation of this exterior ring was laid with the forts of Vaux, Moulainville, Rozellier, Haudainville, Landrecourt, Belle Epine and Douaumont.

3rd period: 1886–1899.—With the introduction of heavy howitzers the era of concrete began, and in 1888 the strengthening of the forts of the outer ring on the right bank of the Meuse was begun, and a few years later (1892–1897) that of those on the left bank. Earth works and earth battery emplacements were thrown up between the forts. Most of these works were provided only with simple masonry shelters, but it was intended to strengthen some later, viz., Froide-terre, Thiaumont, La Laufée, Charny. No armour was used before 1899 and ferro-concrete had not yet been introduced.

At Metz strengthening was also being done; the Germans, however, did not confine themselves to concrete but completed their defences by the addition of cupolas and armoured observation posts. They installed two 21-cm. howitzers in revolving cupolas at Saint-Quentin, two more west of the farm of Chêne, and two 15-cm. guns at Fort Kameke. In 1897 they were energetically pushing on with five armoured batteries, each of four 15-in. howitzers, in the intervals between the forts, two near Plappeville, another east of the farm of Chêne, another near Queuleu and the fifth at Sablon. By 1899 there was only a single ring of forts round Metz as compared to the two lines round Verdun, but the former was probably the stronger on account of its 28 pieces of artillery mounted in cupolas and its numerous concrete shelters.

4th period: 1899–1914.—In 1899 the construction of an outer ring of works was begun at Metz consisting of the "Feste" Lothringen, Kronprinz and Kaiserin on the left bank of the Moselle, Haeseler on the right bank and in addition Guentrange on the left bank near Thionville.

These works were barely finished in 1905 when the Germans began the completion of the ring by starting the works of Wolfsberg, Vermont and Leipzig on the left bank of the river, and on the right bank the "Feste" Wagner and Luitpold, the works of Chesny, Lauvallière and Mey, and the somewhat distant batteries of Sorbey, Mont, Silly and Sainte-Barbe. The "Feste" von der Goltz was begun in 1907. Illange and Koenigsmachern on the right bank of the river near Thionville were begun in 1905 and 1908 respectively. In 1911 the Germans began the fortification of Horimont and the Quarries of Amanvillers, and, later, (1912–13) the organization of the interval between the "Feste" Kaiserin and Kronprinz. This organization consisted of a continuous obstacle defended by a series of closed works provided with concrete shelters.

Neither these works nor the "Feste" von der Goltz were completed by 1914, and they were continued till the 1st April, 1916, when the labour and material were diverted to the Southern Front for the construction of a defensive line having one flank on the right bank of the Moselle and extending to Sorbey *viâ* Pomerieux and Chérisey.

In France the period 1899 to 1914 was a period of armour and reinforced concrete. A Commission on Forts was formed in 1899 and in 1900 laid down a vast programme for the strengthening of works. This included disappearing turrets, armoured O.Ps. and Bourges casemates in the forts themselves and concrete shelters and battery emplacements in the intervals between them. This programme was carried out between 1902 and 1910, 1902 seeing the first armoured turrets in the Forts of Verdun.

III. IDEAS PREVALENT SINCE 1899 IN FRANCE AND GERMANY WITH REGARD TO THE ORGANIZATION OF FORTS.

At Verdun.—The Forts at Verdun since 1900 were principally organized for their own defence and for that of the intervals between them. For their own defence they had machine guns, some in turrets and some not—also in some cases 75-mm. guns in turrets which were not to be used for the artillery duel but were to give a means of rapid fire to the works, and to ensure, in conjunction with the machine guns, the defence of the approaches to the work.

For flanking fire over the intervals the forts had guns placed either in concrete, *i.e.*, Bourges casemates, or under armour in disappearing turrets. The turrets primarily intended for flanking were not to be used until the last moment. In addition the forts usually being in the best fire position were sometimes provided with 155-mm. guns in disappearing turrets, each gun being allotted a specially important rôle. Nearly all these guns had shortened barrels. A few armoured O.P. were intended either for the artillery or for the Command. The garrisons of the forts were quartered in concrete barracks of some 3,600 beds, and were somewhat congested, there being only sleeping accommodation for two-thirds of the numbers detailed to the forts by the last "Instructions."

At Metz.—In 1899 the German conception of the rôle of forts was fundamentally different. They considered that long-range fire only was required and the essential feature of their works consisted of armoured batteries either built within the forts themselves, as at Saint-Blaise and Sommy (together forming the *feste* Haeseler), or else protected by infantry works surrounding the batteries and generally joined by a fire parapet. This is the system of fortification to which the Germans have given the name of "FESTE" (see *Fig.* 1) and which has been called "Offensive Fortification" in contra-distinction to the system used in France in which close-range fighting and the defence of intervals were chiefly considered.

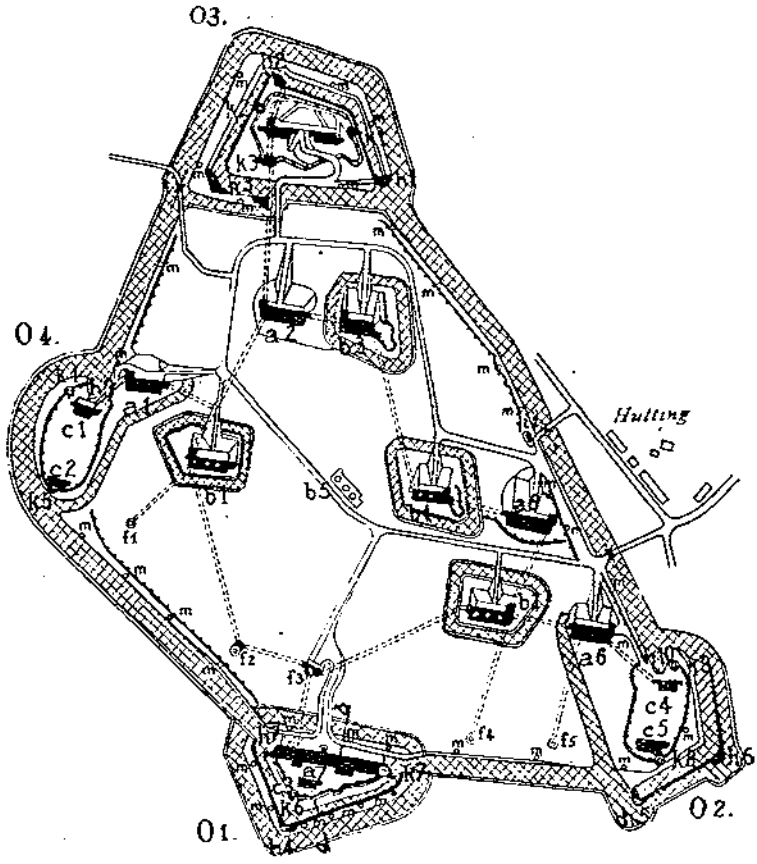
The armament of the large *feste* on the left bank of the river usually consisted of two batteries of three 15-cm. howitzers, 12 calibres long, with a range of 7·2 km., and two batteries of three 10-cm. turret guns, 35 calibres long, with a range of 10·8 km. All these guns were mounted in revolving cupolas. Each battery had in its immediate vicinity at least one armoured O.P., and concrete barrack for the artillery garrison.

The infantry works protecting these batteries enclosed numerous O.Ps., machine gun emplacements, etc., in addition to the concrete barracks for the garrison.

A wire obstacle surrounded each work and each battery, while another encircled the *feste*. Underground galleries joined together the different parts of the *feste*.

These *feste* covered considerable areas, *e.g.*, Kronprinz 355 acres,

Kaiserin 330, and Von der Goltz 506. For concealment the ground within the *feste* was kept as far as possible unaltered. Camouflage was much used and the planting of creepers, trees, etc., resorted to.



LEGENDE

a 1.7	Concrete barracks.
b 1.2	Armoured 10 cm gun batteries.
b 3.4	" 15 cm. how. "
b 5	Dummy battery.
c 1.5	Picket shelter.
f 1	Revolving armoured O.P.
f 2.5	Armoured O.P.
h 1.6	Chambers or caponiers for enfilading the ditches.
h 7.8 / h 9.10	Casemates for enfilading the obstacles.
i 1.2	Blockhouses for enfilading approaches.
k 1.9	Armoured Infantry O.Ps.
m	Look-out post.
.....	Underground communications.
O 1 4	Infantry works.
———	Trenches.

FIG. 1.—*Plan of a "Feste."* *Scale* $\frac{1}{10000}$.

1 c.m. = 10,000 cm. = 100 m.

The barrack "a 7" is about 150 metres in length.

Numerous dummy batteries and dummy observation posts were constructed. Ranging on the *feste* with ground observation alone would have been extremely difficult.

The defence of the intervals was not at first considered at all and no battery or even single gun was cast for the exclusive rôle of giving the flanking fire, considered so important in the case of the French forts. It was only later, 1909 onwards, that the idea of flanking fire appeared in Germany. The *feste* Wagner and Mey built in this year had casemates for flanking fire, as also had Luitpold and Von der Goltz built in 1911. At about the same time (1912–1913) the Germans constructed machine gun emplacements for the defence by flanking fire of the interval between the *feste* Kronprinz and Kaiserin; and in 1915 Marival, the most southern work in this interval, was given a casemate for a 77-mm. gun to flank the approaches of Kronprinz. During the war the number of concrete machine gun emplacements for flanking fire was considerably increased, especially in the intervals between the forts N. and E. of Metz.

In 1911, to increase the defensive power, the Germans began the construction of large flanked ditches on the north-western front of the fortified area, in front of the *feste* Lothringen. These were never completed, but were intended to form a most formidable obstacle on a front of 6 km. between Horimont and the Quarries of Amanvillers.

The same policy was responsible for the construction during the War of two well-flanked ditches round the principal works of the *feste* Kronprinz.

In the end the Germans were more and more considering the close battle and introduced into their new forts (*i.e.*, Mey, Von der Goltz, etc.) accommodation for mining personnel and shafts for countermining galleries, works which had been undertaken at Verdun as soon as the outer ring of forts were built.

At the same time they directed attention to the flanking of the obstacles round the *feste*, which flanking, except perhaps at Kaiserin, had originally been omitted altogether. For this purpose they constructed small concrete works without much command, which were reached either across the open or by underground galleries. In the case of Von der Goltz large concrete emplacements were built in 1914 which covered a considerable area and gave perfect flanking fire.

The forts were usually supplied with water from wells or springs outside them, and the pumps, etc., were liable to damage from a lucky shot. In the later works the wells were dug under the concrete barracks.

From the above it is clear that the German ideas, which in 1899 were almost entirely offensive, changed gradually to the defensive; this evolution can also be seen in the details of the works themselves. At first the buildings were not, as might be expected from the German character, proof against all shell; even ten to fifteen years after the introduction of high explosive shell the walls of barracks and batteries were still being built comparatively weak, and it was not till ten

years after their construction that steps were taken to strengthen them.

It was only shortly before the war, in 1911 and more particularly about 1913, that obstacles suitable for a really determined defence were considered desirable and that wide ditches or counterscarps of considerable thickness were constructed. It was about this time too that the thicknesses of walls and roofs were increased and use made of ferro-concrete.

This change is also noticeable in the armament of the *feste*, the number and power of the guns tended to decrease whilst the arrangements for close defence increased, *i.e.*, concrete emplacements for 57-mm. guns and for machine guns, bomb throwers, and concrete parapets provided with traverses and parados.

Everything thus tends to show a change in the conception of the rôle to be played; it seems that in the beginning the Germans did not fear any attack in force on Metz, and so developed only the offensive possibilities of the place; it was only latterly that they foresaw a possible defence against a serious attack, and made a tremendous effort, continued during the War, to make the place one extremely difficult to capture.

IV. The Difference in the Strength and Construction of the Works.

The Strengthening of the Old Works.—At Verdun the casemates were strengthened in 1886 by the addition of a layer, generally 2½ m. thick, of concrete, to the original masonry and separated from it by a layer of sand 1 m. thick. At Douaumont the eastern face was given only 1½ m. of concrete.

Similarly at Metz the strengthening consisted of the addition of a layer of sand 1 m. thick and then 1 to 2 m. of concrete.

Concrete and Ferro-Concrete.—In the works built at Verdun since 1900 ferro-concrete was much used, in thicknesses varying from 1·2 to 1·8 m. for floors and roofs, while walls were usually of special concrete.

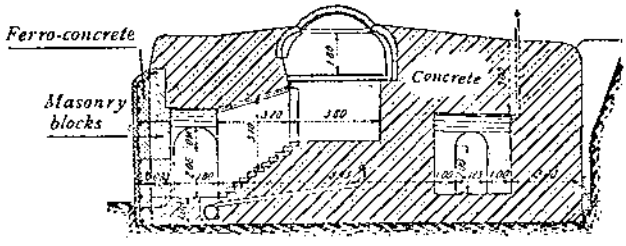
At Metz, up to about 1900, the new walls and roofs were made similar to the strengthened ones. In 1900 masonry and sand were dispensed with and special concrete 2½ to 3 m. thick was used. Still later ferro-concrete was used, an outer layer 1 m. thick and an inner one of 0·20 m. separated by 1 to 2 m. of special concrete. In the more recent works this inner layer was often replaced by metal troughing.

For the permanent works built since 1914 the inner layer of ferro-concrete was increased to 0·50 m. and the steel troughing retained in addition; iron bars of 20 mm. diameter connected the two layers

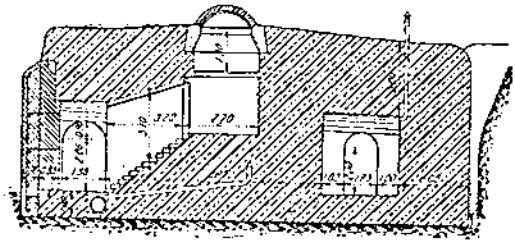
of ferro-concrete together. In some works 1 m. of ferro-concrete was added to the outside of the existing works giving a total thickness of 3½ m. This is the case at Guentrange. The outer walls of batteries and barracks were originally of masonry only, to these in many cases 1 m. of ferro-concrete was added; in the new works they were built of 1·5 m. of special concrete and 1 m. of ferro-concrete. About 1914 walls and floors of less than 2 m. thickness were made entirely in ferro-concrete.

Armour.—Armour has been much more frequently used in Germany than in France and armoured casemates were highly thought of in spite of their heavy cost and of the fact that they are barely stronger than concrete ones.

Armoured guns at Verdun were in disappearing turrets, whilst at Metz they were in revolving turrets. These turrets consist of a cupola and a shield built into a protecting block of concrete. The cupolas for 10-cm. guns or 15-cm. howitzers are of nickel steel 0·16 m. thick, lined with mild sheet-steel 0·04 m. thick. Those for 21-cm. howitzers are made of two metal plates, 0·13 m. and 0·075 m. thick respectively, separated by a layer of lead 0·020 m. thick and lined with sheet-steel 0·04 m. thick. These latter are older than the former



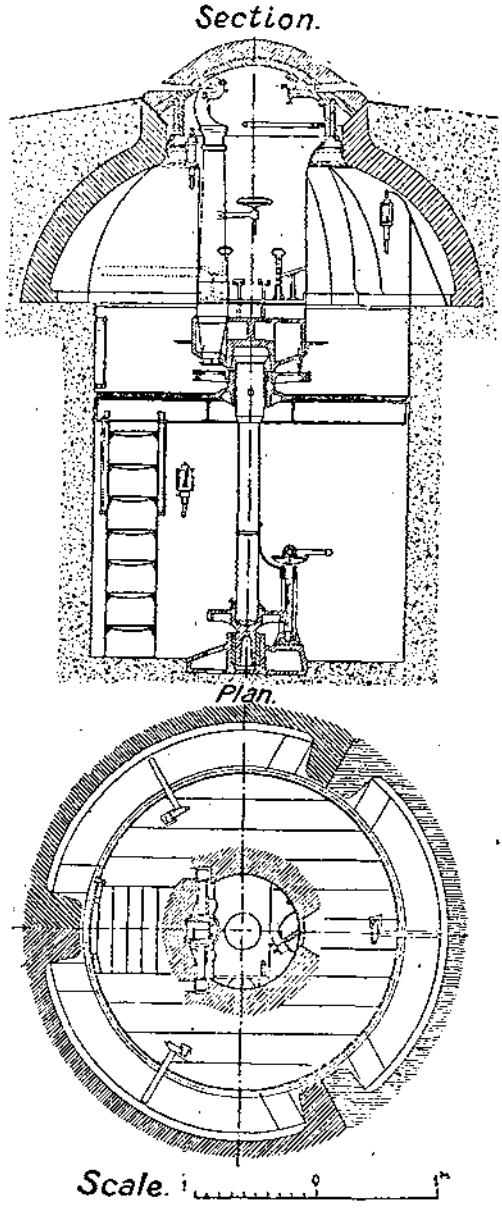
Section through a battery of 15-cm. howitzers.



Armoured Battery.

Legende.—1, Flanking casemate; 2, Stores; 3-4, Command posts; 5, Barracks; 6, Cleaning Cartridges; 7, Filling Cartridges; 8, Setting Fuzes; 9, Magazine; 10, Turrets; 11, Latrines.

and date, in fact, from before 1892. The interior diameter of the floor of the cupolas is 2·80 m. for the 10-cm. guns, 2 m. for the 15-cm. howitzers and 4 m. for the 21-cm. howitzers. The shields are composed (*a*) for the 10-cm. long and short guns of six segments of nickel



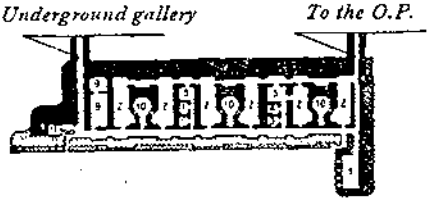
Revolving O.P.

steel 0·20 m. thick connected by riveted flanges, (*b*) for the 15-cm. and 21-cm. howitzers of four segments of cast-iron 0·605 m. thick at the top and 0·30 thick at the bottom. The cost of the armour for the 10-cm. guns was between 126,000 and 158,000 marks, and that for the 15-cm. howitzers about 63,800 marks.

Observation Posts.—Observation posts are either fixed or revolving. The former usually consist of a steel dome with 0·50 m. command over the surrounding concrete. The diameter of the O.Ps. is usually 1·15 m. to 1·30 m., and sometimes as much as 1·50 m.; 1 m. is not sufficient to use instruments with any comfort. The thickness of the steel is from 0·20 to 0·25 m. and the height varies from 1·70 to 2·25 m. Sometimes the O.P. consists of a rectangular chamber covered with concrete, or better with a special steel plate 0·20 to 0·30 m. thick. Revolving O.Ps. are 1·15 m. in diameter at the height of the table (see *Plan*). They are installed in pits of 2·60 m. diameter and 4·50 m. deep, made in a heavy mass of concrete and in communication with neighbouring works. The top of the pit is protected by a shield of nickel steel 0·20 m. thick and 1·50 m. high. The cupola of the observation post is made with a spherical roof of nickel steel 0·16 m. thick, lined with mild sheet-steel 0·04 m. thick. These posts can be actuated easily by the observers.

V. Constructional Details of the Feste.

Armoured Batteries.—All the batteries are of the same type and, having no command, are practically invisible to ground observation. The turrets are placed in one line about 20 m. apart and are merely revolving. Two, three or four make up a battery. Each battery has only one type of artillery, either 21-cm. howitzers (maximum range 9 km.), 15-cm. howitzers (12 calibres, range 9·700 km.) or 10-cm.



Section through a battery of 10-cm. guns.

guns (35 calibres, range 10·800 km.). Each turret contains one gun and one spare tube only. This armament was for the most part left *in situ* by the Germans, who, however, removed their 21-cm. mortars in 1916, as they were of bronze, and emptied and destroyed their ammunition.

The working of the guns is very easy; it is all done by hand, the cupola in its fire position being raised slightly above its shield and

when out of action resting on it. The shell are brought to the gun by a lift from magazines close at hand.

Each battery contains a small room for the men, a magazine, a command post with telephonic and aural apparatus, and a shell and cartridge store per gun. Most of the batteries have a concrete caponier at one end for the defence of the battery by rifle fire. The battery has its gorge closed by a defended railing and is surrounded by a wire obstacle defiladed by an advanced glacis. The battery is connected to its observation post by an underground gallery and by telephonic and aural communications. When the gallery is too long or too exposed, egress from the observation post to the open is arranged for by a ladder from the pit under the O.P.

Infantry Works.—Each infantry work was surrounded by a ditch, a covered way and a wire obstacle. At the top of the masonry or concrete counterscarp was a defended railing; the escarp was replaced by a gentle slope at the bottom of which was a defended railing. At the bottom of the ditch was a wire obstacle, sometimes extending over the lower portion of the escarp slope. The enfilading of the ditches was arranged for from concrete chambers which were provided with nearly horizontal railings to prevent any enemy throwing missiles into them after gaining access to the covered way. The chambers were joined together by a counterscarp gallery connected to the interior of the work by a single underground passage. The concrete barracks formed the gorge, and this was enfiladed by a caponier. The armament of the caponiers and chambers usually consisted of two 57-mm. guns, but there was a growing tendency to use machine guns

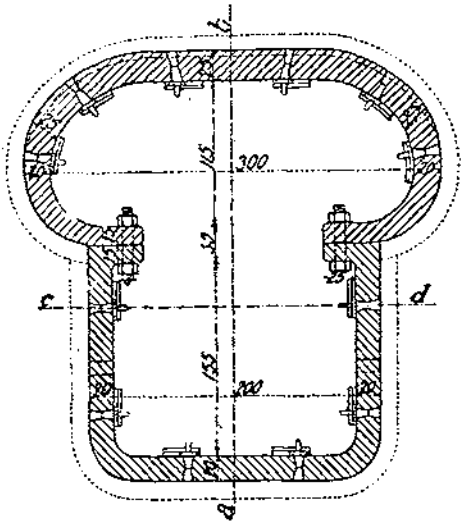
Covered Ways.—More importance in many works was attached to the covered way than in France. In the more recent works access to it was obtained either from one of the counterscarp chambers, or from the counterscarp gallery, by means of a ladder and a well.

It was enfiladed by concrete blockhouses placed either above these entrances or at the corners of the covered way.

Obstacles.—The obstacle can be observed from small observation posts of concrete or iron and is sometimes enfiladed from small concrete works. The depth varies, and is often 25 to 30 m. In the newer works the obstacle consists often of three strips of wire entanglement 10 m. deep separated by gaps of 10 m. The height of the pickets is never uniform, in order to make the obstacle more difficult to cross.

The Parapet.—The parapet of the infantry works was at first of earth, which was afterwards concreted in places. In the newer works the infantry position included a concrete parapet with splinter-proof shelters, traverses every 8 m. and a parados, the whole built of reinforced concrete 0·30 m. thick. It enclosed concrete machine gun and 57-mm. gun positions, look-out posts, and guard posts provided with an armoured infantry O.P. and so placed as to enfilade

PLAN.



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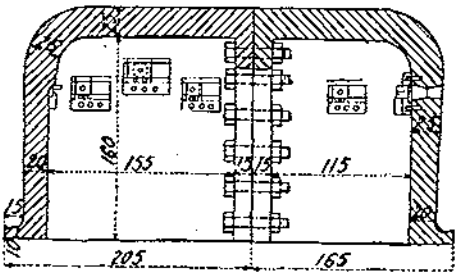

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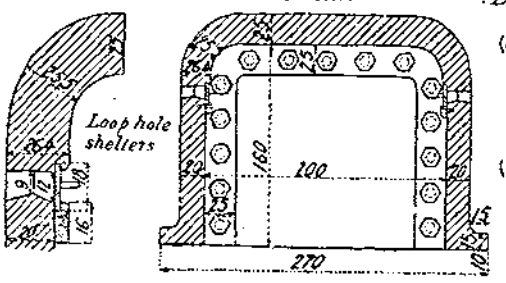


Dimensions of loop holes

(a) *Inside and outside*

(b) *In the middle*

Infantry Armoured Fighting Shelter.

the fire step. Close to the firing line there were many concrete shelters for piquets in communication with an armoured O.P. and able to fire into the work. These shelters were often connected underground to the sentry posts and always to the concrete barracks.

The Concrete Barracks.—The concrete barracks consisted usually of an upper storey, a ground floor, and often of a basement, each having one or two long corridors and at least one staircase at each end. The barracks usually included kitchens, bakery, hospital with bath rooms and operating theatre, dining rooms, magazines, reservoirs, central heating and 3 to 10 dynamos under ground level or on the ground floor. The upper floor usually contained barrack rooms with hammocks, a telephone exchange of 120 to 180 lines capacity, the various command posts and at one end (in the newer works) the casemates for giving enfilade fire on the gaps.

The various works defending the *feste* were joined by fire parapets with shelters of greater or less strength, and sometimes provided with O.Ps. and shelters for garrison troops.

(*To be continued*).

THE SIEGE OF MAUBEUGE.

THE German operations at the Siege of Maubeuge, August–September, 1914, have been described in detail by the officer in charge of them, General von Zwehl, in his book *Maubeuge—Aisne—Verdun*. An excellent summary of his account appears in French, in the *Revue Militaire Générale* for April, 1921. The story from the French side will be found in *La Verité sur le Siège de Maubeuge*, by Commandant Paul Casson, who was on General Fournier's staff. Will some officer of the Corps volunteer to prepare an account in English? The siege is of special interest to the Corps, as General Fournier is an officer of Engineers.

J.E.E.

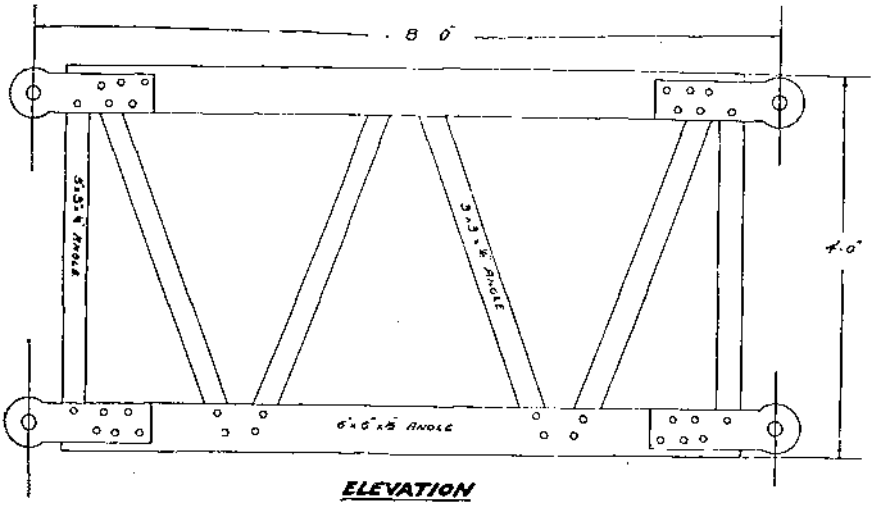
PROFESSIONAL NOTES.

NOTES ON BOX GIRDER BRIDGE.

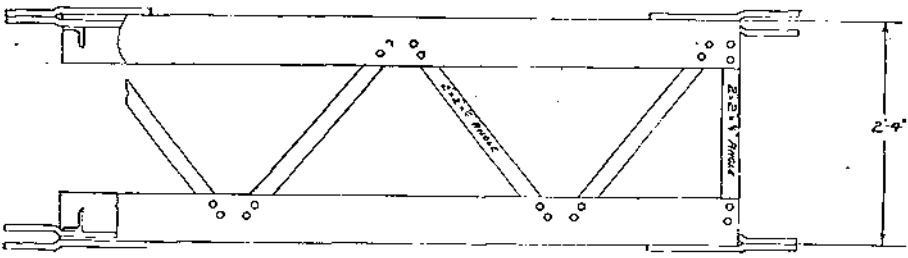
Designed by MAJOR G. LE Q. MARTEL, D.S.O., M.C., R.E.

[CONTRIBUTED BY R.E. BOARD.]

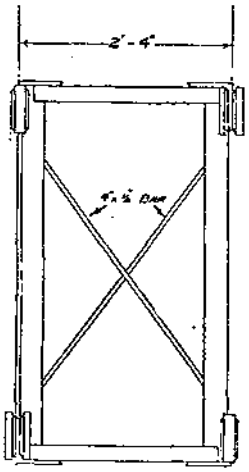
WITH the exception of the Inglis Pyramid Bridges, all the girder bridges which were produced during the War, were designed to carry the heaviest loads, including heavy tanks. Towards the end of the War, however, a demand for medium girder bridges became apparent. These bridges were required on side roads, which would only have to carry medium loads, and in the initial stages in an advance, when it was urgently necessary to provide a long bridge at certain points. Moreover, in Colonial warfare, the heaviest loads to accompany an army would often be medium loads, and both the total weight and time of erection for a medium bridge can be brought considerably lower than those required for a heavy bridge. At the end of the War, when a considerable number of different types of girder bridge was in existence, there was some doubt as to the advisability of introducing further types of medium girder bridge, and on considering the whole question it became clear that what we required, was one type which could be built up into a light, medium, or heavy girder bridge according to requirements, and with any desired length of span. With a view to fulfilling this requirement, Major Martel has designed a bridge known as the Box Girder Bridge. The bridge is of the deck type and the chesses rest directly on the girders, so that no transoms or road bearers are required. The girders are skeleton steel box girders, 4 ft. deep and 2 ft. 4 ins. wide. They are made up in sections, each section being 8 ft. long (*see* diagram); the girders can therefore be made up to any desired length. One section weighs 12½ cwt. and is quite capable of being man-handled. The sections are joined together by plain pin joints; no nuts or bolts are required. Either two, three, or four box girders are slung across the gap, according to the span and the load to be carried. The chesses are then laid on the girders, and kerbs and handrail complete the bridge. There are thus only two essential parts to the bridge—the sections of box girder and the chesses. It was thought at first, that a deck bridge would be unsuitable because of the restriction imposed on the waterway, but when it is remembered that the girders are only 4 ft. deep and that the roadways of the



ELEVATION



PLAN



END VIEW

ordinary through bridges are usually at least 2 ft. deep, it seems that a very small amount of ramping will enable the same waterway to be left with this type of box girder bridge as with a normal through bridge.

The following table shows the limiting spans for which the bridge will carry the various loads :—

No. of Box Girders used.	*Load.*	*Limiting Span in feet.*
2	Light loads	96
	Medium loads	72
	Heavy loads	48
3	Light loads	112
	Medium loads	88
	Heavy loads	64
	Heavy tanks	64
4	Light loads	120
	Medium loads	96
	Heavy loads	80
	Heavy tanks	80

There is a further advantage in this type of bridge, namely that any desired width of roadway can be constructed. To obtain a wider roadway it is merely necessary to add more box girders and use longer chesses, or a double row of chesses. By dispensing with the necessity of using transoms and road bearers, a considerable saving in weight has been effected. A comparison with existing types is as follows :—

Span.	*Type of Bridge.*	*Total Weight.*
60 ft.	Hopkins' 75-ft. Type	32 tons.
60 ft.	60-ft. Span Mark II.	32 tons.
60 ft.	Inglis Rectangular Mark II.	24 tons.
64 ft.	Box Girder Bridge using 3 girders	17.6 tons.

All these bridges will carry heavy tanks. A total of 48 sections of this bridge has been manufactured and is beginning to arrive at the Experimental Bridging Centre, Christchurch, and preliminary trial has shown that the sections can be coupled together very easily and rapidly. A single length of 96 ft. of Box Girder was built up and loaded until the steel was stressed slightly above 7·5 tons per square inch (the working stress at which the bridge is designed). After the initial stretch had been taken the girder was found to deflect 4¼ ins. under the full load. The top of each section is made a little longer than the bottom to provide a camber which was found to be 1-120th unloaded and this was reduced to about 1-240th when loaded. Although a 4-ft. girder is somewhat shallow for so long a span as 96 ft. the girder appeared to be comparatively

rigid and a deflection of 4¼ ins. is not excessive under full load for this span. It is hoped that this bridge may replace all the existing types of the shorter span girder bridges. It is proposed to launch the bridge by running out the girders over rollers, and using short shear legs and preventer tackle. As a 96-ft. length of girder only weighs 7½ tons, the launching should present very little difficulty. A further account of this bridge will appear in the Professional Notes when the bridge has been thoroughly tested.

CONSTITUTION OF R.E. BOARD.

THE R.E. Board has been constituted to carry out the duties formerly allocated to the R.E. Committee. Its duties and objects are briefly as under.

1. *Objects.*—The Board is appointed with a view to the prosecution and guidance of Scientific Research, and for experiment and design in connection with Engineering equipment and material required for the Royal Engineers and the Royal Corps of Signals, and to act as an intermediary between the War Office and the productive engineering resources of the community in carrying out the general line of policy laid down by the General Staff in regard to such material and equipment.

It is also responsible for studying the progress made by the above-mentioned branches of the Service in foreign Armies, and developments in engineering in foreign countries.

2. *Duties and responsibilities of the Board.*—

(*a*).—Research and Investigation.
(*b*).—Experiments.
(*c*).—Design of technical machinery, material and stores for Military Engineering and Signals.
(*d*).—Records and Intelligence.

3. *Constitution and Organization.*—The Board consists of a permanent central body composed of a President, three Members and a Secretariat, who have no other duties, together with certain *ex-officio* Members. With them are associated representatives of other Experimental and Educational Establishments, of the branches of the War Office concerned, selected Regimental Officers, and representatives of other Government Departments and Engineering Institutions.

The constitution of the Board and of its three main Committees is shown in the following tables:—

THE BOARD.

President.—Col. A. G. Stevenson, C.B., C.M.G., D.S.O., R.E.
Member (A).—Bt.-Col. R. A. Gillam, C.M.G., D.S.O., R.E.
Member (B).—Major A. D. Carden, D.S.O., R.E.
Member (C).—Major A. C. Fuller, R.C. of Sigs.

Associate Members.

Deputy Director of Staff Duties.—Bt. Lt.-Col. O. H. L. Nicholson, C.M.G., D.S.O., W. Yorks. Regt.
Assistant Director of Fortifications and Works (F.W. 9).—Lt.-Col. H. G. K. Wait, C.B.E., D.S.O., R.E.
Commandant, School of Military Engineering.—Maj.-Gen. H. F. Thuillier, C.B., C.M.G.
Commandant, Signal Training Centre.—*Col. Com. E. G. Godfrey-Faussett, C.B., C.M.G.
Chief Inspector of Royal Engineer Stores.—Bt. Lt.-Col. A. E. Davidson, D.S.O., R.E.

Ex-officio.

Representatives of
- Department of Scientific and Industrial Research.—Sir Joseph Petavel, K.B.E., F.R.S.
- Cambridge University, Engineering Faculty.—Prof. C. E. Inglis, O.B.E., M.A.
- Instn. of Civil Engineers.—Sir Brodie Henderson, K.C.M.G., C.B.
- Instn. of Mechanical Engineers, Sir John Dewrance, K.B.E.
- Instn. of Electrical Engineers.—Mr. C. H. Wordingham, C.B.E.
- Physical Society.—Mr. C. R. Darling, F.I.C., F.I.P.

Secretary.—Bt. Lt.-Col. J. G. Fleming, C.B.E., D.S.O., R.E.

(A) COMMITTEE.

Duties.

Bridging, Mining, Camouflage, Survey, and Field Service equipment for the Royal Engineers and the Royal Corps of Signals, other than that dealt with by Committees (B) and (C).

Members.

President.—Col. A. G. Stevenson, C.B., C.M.G., D.S.O., R.E.
Member (A).—Bt.-Col. R. A. Gillam, C.M.G., D.S.O., R.E.
Director of Military Intelligence (M.I. 4).—Lt.-Col. E. M. Jack, C.M.G., D.S.O., R.E.

Representatives of
- Director of Fortifications and Works.—Lt.-Col. H. G. K. Wait, C.B.E., D.S.O., R.E.
- Chief Inspector of Royal Engineer Stores.—Bt. Lt.-Col. A. E. Davidson, D.S.O., R.E.

Chief Instructor in Fortification, School of Military Engineering.—Major H. W. Herring, M.C., R.E.
Chief Instructor in Surveying, School of Military Engineering.—Major L. N. F. I. King, O.B.E., R.E.
Commanding Royal Engineer of a Division.—Bt. Lt.-Col. G. F. B. Goldney, C.M.G., D.S.O., R.E.

For Survey questions only.
- Chief Instructor, School of Artillery.—Major M. N. McLeod, D.S.O., M.C., R.E.
- Representative of the Ordnance Survey.—Bt. Lt.-Col. H. St. J. L. Winterbotham, C.M.G., D.S.O., R.E.

Associate Members.

Representatives of
- Quarter-Master-General.—Lt.-Col. D. Paul, C.B., C.M.G., C.B.E., M.I.M.E., R.A.O.C.
- Director of Staff Duties.
  - Bt. Lt.-Col. M. F. Day, M.C., K.O.Y.L.I.
  - Bt. Lt.-Col. O. H. L. Nicholson, C.M.G., D.S.O., W. Yorks Regt.
- Director of Artillery.—Bt. Lt.-Col. N. Eliot, C.B.E., R.A.

Superintendent of Research, Woolwich.—Comdr. H. C. Goolden, O.B.E., R.N.
Director of Inspection, Chemical (Woolwich).—Mr. W. L. Baillie.
Representative of Naval Mining School (Admiralty), for Mining.—

For Camouflage.
- Representative of Local Defence Division (Admiralty).—Major G. Rutledge, R.M.A.
- Representative of School of Army Co-operation (Air Ministry).—Wing-Comdr. E. L. Gossage, D.S.O., M.C., R.A.F.

Representative of Director of Research (Air Ministry).—Wing-Comdr. A. D. Warrington-Morris, C.M.G., O.B.E., R.A.F.
Assistant Secretary (A).—Lieut. E. N. Clifton, R.E.

Technical Establishments.

Experimental Bridging Company, R.E.—Bt.-Major A. V. T. Wakely, M.C., R.E.
Experimental Section, R.E.—
Camouflage Experimental Establishment.—Capt. C. le Breton Simmons, R.A.

(B) COMMITTEE.

Duties.

All Electrical and Mechanical services dealt with by the Royal Engineers and Royal Corps of Signals, including Searchlights and Sound Locating.

Members.

President.—Col. A. G. Stevenson, C.B., C.M.G., D.S.O., R.E.
Member (B).—Major A. D. Carden, D.S.O., R.E.

Representatives of
- Director of Fortifications and Works.—Lt.-Col. H. G. K. Wait, C.B.E., D.S.O., R.E.
- Chief Inspector of Royal Engineer Stores.—Bt. Lt.-Col. A. E. Davidson, D.S.O., R.E.

Chief Instructor in Electricity, School of Military Engineering.—Major G. Thorp, O.B.E., R.E.

Chief Instructor in Workshops, School of Military Engineering.—Bt.-Major H. H. Bateman, D.S.O., R.E.

Commandant, School of Electric Lighting.—Major P. S. Watkins, D.S.O., R.E.

Commandant, Anti-Aircraft Searchlight and Sound Locator School.—Capt. D. R. St. J. J. ffrench-Mullen, R.E.

Associate Members.

Representatives of
- Quarter-Master-General.—Lt.-Col. D. Paul, C.B., C.M.G., C.B.E., M.I.M.E., R.A.O.C.
- Director of Staff Duties.
  - Bt. Lt.-Col. B. L. Eddis, D.S.O., R.E.
  - Bt. Lt.-Col. R. K. A. Macaulay, D.S.O., R.E.
- Director of Military Operations.—Bt. Lt.-Col. M. St. L. Simon, C.B.E., R.E.
- Director of Artillery.—Bt. Lt.-Col. N. Eliot, C.B.E., R.A.
- Director of Inspection, Chemical (Woolwich).—Mr. W. L. Baillie.
- Director of Torpedoes and Mining (Admiralty).—Capt. A. P. Addison, C.M.G., R.N.
- H.M.S. "Vernon"—Lt.-Comdr. A. Willis, R.N.

(For Searchlights.)

Director of Naval Ordnance (Admiralty).—Comdr. Geoffrey Nicholson, R.N.

Director of Research (Admiralty).—Mr. F. E. Smith, O.B.E., F.R.S.

Representative of Director of Research (Air Ministry).—Wing-Comdr. A. D. Warrington-Morris, C.M.G., O.B.E., R.A.F.

Controller of Communications (Air Ministry).—Group Capt. L. F. Blandy, D.S.O., R.A.F.

Assistant Secretary (B).—Capt. M. T. Tudsbery, Genl. List.

(For Sound Location.)

Technical Establishments.

Searchlight Experimental Establishment.—Col. A. E. Le Rossignol, C.B., T.D., M.I.C.E., M.I.E.E., R.E. (T.).

Signals Experimental Establishment (for Sound Locating).—Lt.-Col. A. G. T. Cusins, C.M.G., R.C. of Sigs.

(C) COMMITTEE.

Duties.

Signals Equipment and Apparatus.

Members.

President.—Col. A. G. Stevenson, C.B., C.M.G., D.S.O., R.E.

Member (C).—Major A. C. Fuller, R.C. of Sigs.

Representatives of
- Director of Fortifications and Works.—Lt.-Col. H. G. K. Wait, C.B.E., D.S.O., R.E.
- Director of Staff Duties (S.D. 6).—Lt.-Col. H. C. Smith, D.S.O., R.C. of Sigs.
- Signal Training Centre.—Bt.-Major J. R. Pinsent, D.S.O., R.C. of Sigs.
- Chief Inspector of Royal Engineer Stores.—Major C. J. Aston, M.C., R.E.

Associate Members.

Representatives of
- Quarter-Master-General.—Lt.-Col. D. Paul, C.B., C.M.G., C.B.E., M.I.M.E., R.A.O.C.
- Director of Military Intelligence (M.I 1(b)).—Bt.-Major H. I. Allen, D.S.O., N. Stafford Regt.
- Director of Artillery.—Bt. Lt.-Col. N. Eliot, C.B.E., R.A.
- Engineer-in-Chief, Post Office.—Major T. F. Purves, O.B.E. (G.P.O.).

Assistant Secretary (C).—Capt. W. B. H. Carr, R.E.

Technical Establishments.

Signals Experimental Establishment.—Lt.-Col. A. G. T. Cusins, C.M.G., R.C. of Sigs.

4. *Procedure.*—The Board will meet as required to consider general questions; normally the work will be carried out by committees. The committees as at present arranged are—

(i.)	Bridging	Committee A.
(ii.)	Mining, Demolitions and Explosives	
(iii.)	Camouflage	
(iv.)	Survey and Photography	
(v.)	General Field	
(vi.)	Electric and Mechanical Equipment, Water Supply ..	Committee B.
(vii.)	Searchlights	
(viii.)	Sound Locators and Acoustics	
(ix.)	Signals, General	Committee C.
(x.)	Signals, Wireless	

The President will arrange for the attendance of such Members, Associate Members, etc., as may be concerned in the Agenda of each Meeting.

Representatives of the General Staff should be invited to attend all Meetings.

The dates of Meetings will be fixed by the President.

The President, if present, will preside at all Board and Committee Meetings. If the President is unable to attend, the Chair will be taken by the senior Member of the Board present.

The President will regulate the proceedings of the Board, and will, from time to time, lay down such regulations or bye laws as he sees fit for the distribution of work and the dispatch of business.

Any question of overlapping between the Committees will be dealt with at once by the President by referring any recommendation of a Committee to the Board, or otherwise, but unless he considers this necessary, the recommendation of the Committee will go forward as a recommendation of the Board.

5. *Attendance.*—Any *ex-officio* Member or Associate Member who is unable to attend a Meeting may depute an Officer to represent him.

Any *ex-officio* Member or Associate Member may, at the direction of the President, bring to a Meeting any assistant who is specially concerned with the business on the Agenda.

Representatives from the Experimental Establishments will attend as required by the President.

6. The Board should collect and index information (or references to where it can be obtained) on all development in engineering and mechanical and physical science that may affect their work. They should also take steps to obtain through Director of Military Intelligence, War Office, for questions outside the British Empire, information on technical subjects (*e.g.*, bridges, water supply, geology, local resources of engineering material, etc.) in all probable theatres of war.

7. Questions for investigation or opinion may be referred to the Board by any Director of the War Office direct. Such questions may also be referred by any other Government Departments having *liaison* Associate Members. The Board may communicate and report directly to the authority who made the reference, but a copy of the final report should be sent to the Director of Fortifications and Works.

8. *Inventions and Proposals from outside sources.*—The Secretary will inform all persons (other than those officially connected with the Board) communicating directly with the Board on the subject of new propositions and inventions, that their applications must, in the first instance, be addressed to the Secretary of the War Office. This applies also to designs submitted by outside inventors.

Before considering any inventions, designs, etc., emanating from outside inventors, the Secretary should see that the papers are referred to the Director of Artillery (A. 4) for record and the appropriate initial action.

All questions relating to the terms for the use of any inventions, patents, designs, etc., will be referred to the Director of Artillery (A. 4).

9. The Board may correspond direct with any branch of the War Office, Admiralty, Air Ministry, or any Establishment having a representative on the Board as Member or Associate Member. Should the Board desire to correspond with Scientific bodies, private manufacturing firms or private individuals in foreign countries upon any subject, the Director of Military Intelligence, War Office, must be consulted in order that the nature of the enquiry being made shall not clash with the policy of the General Staff in regard to the foreign country in which the addressee is situated.

10. *Attendance at Experiments and outside Meetings.*—Members and Associate Members will attend experiments or visit Experimental Establishments at the direction of the President.

They should be accompanied when possible by representatives of the branch of the General Staff concerned.

11. Members of the Board should take every opportunity of attending meetings of the Engineering Institutions and Scientific Societies dealing with the branches with which they are concerned, and should so far as possible be in personal touch with the leaders in the Civil Engineering and Scientific work.

12. *Reports, etc.*—The President will cause to be prepared and printed half-yearly extracts from the Board's proceedings showing the action taken in the various enquiries on which the Board has been engaged during the preceding six months. These should be circulated to all Chief Engineers, Commanding Royal Engineers, Educational Establishments, Government Departments and Branches interested. The circulation lists to be submitted to the Director of Fortifications and Works for approval.

Where work which is of value for commercial or scientific purposes has been carried out for the Board an account of such work should be published, provided it is not considered necessary in any case to keep the results confidential for reasons of State. Recommendations for the matter to be published and the manner of publication should be forwarded to the Director of Fortifications and Works. Copies of reports dealing with subjects concerning foreign countries should be passed to the Director of Military Intelligence as soon as possible, for any remarks he may care to make, before being circulated to Officers, Departments and Branches interested.

The President will forward monthly a brief summary of the progress for the information of the Director of Fortifications and Works.

A brief monthly summary of experiments will be circulated to all Chief Engineers and interested Government Departments for the early dissemination of results obtained.

13. *Experimental Establishments.*—The undermentioned Experimental Establishments will be under the direct control of the Board as regards all experimental work carried out by them—

(i.) Signals Experimental Establishment (Woolwich).
(ii.) Searchlight Experimental Establishment (London).
(iii.) Camouflage Experimental Establishment (Salisbury Plain).
(iv.) Experimental Bridging Company, R.E. (Christchurch).
(v.) Experimental Section, R.E. (School of Military Engineering).

14. *Additional or Expert Assistance.*—The Board is empowered to arrange for the attendance of Civilian Experts at any meeting, or to ask for their opinion on any matter before the Board. In such cases the payment of fees is authorized.

HUME REINFORCED CONCRETE PIPES.

THE process of manufacture of these pipes is the invention of Mr. W. R. Hume, of Adelaide, S. Australia.

The reinforcement consists of any suitable wire spirally wound on a revolving cylinder of the same diameter as the inside of the required pipe. The strength and amount of wire varies with the pressure that the pipe is required to withstand.

This wire reinforcement—removed from the cylinder—is placed inside another cylinder formed of 1/16-in. steel-plate which is supported horizontally in a casting-machine, on friction rollers. Flanges, with their centres drilled to correspond with the desired internal diameter of the pipe, are fitted to the end of this cylinder.

The mould thus formed, together with the reinforcement, is slowly revolved while the requisite quantity of wet concrete is introduced from one or both ends. The mixture is at the same time automatically distributed by centrifugal action evenly along the whole length of the mould, and completely embeds the reinforcement. No internal shuttering is required.

The velocity of rotation is then increased, causing the concrete

to spread itself outward under very great pressure. In a few minutes, excess of water in the mixture is expelled under this compression from the mass of concrete into the hollow of the pipe—from whence it drains when rotation ceases. The inner surface of the pipe so produced is polished, during subsequent rotation of the machine, by a round steel-rod resting on the inner circumference of the flanges. The time required for revolving the pipe ranges from 6 minutes for a pipe of 4-in. diameter, to 20 minutes for one of 48-in. diameter. At the end of this time the mould containing the pipe is rolled off the machine into a steaming-chamber where it lies for 24 hours. It is then opened, and the pipe is put to season for a month under cover, or in water tanks.

The flanges leave V-shaped circular depressions in the ends of the pipes which, when butted, are filled with plastic bituminous cement. The joints are covered by 6-in. reinforced concrete collars—made in the same manner as the pipes—held in position by cement backing.

The invention admits of manufacture of concrete pipes of perfect uniformity and density of structure. They can be produced at great speed and may be used with especial advantage for long lines in open country.

Since the aggregate is usually composed of local materials the cost of such pipe lines is very considerably less than for similar lines of cast-iron or steel.

They are stated to be impervious at high pressures. Excess of pressure is invariably accompanied by sweating and seepage, a fracture or burst is therefore unlikely to occur without warning.

The pipes are reported to have been subjected to pressure heads up to 900 ft., but no completed pipe line is as yet at work under a greater head than 400 ft. It is understood that tenders for pipes up to 8-ft. diameter have been submitted. At present the sizes manufactured range between 4 and 60 in., in 6 or 8 ft. lengths. They are constructed to meet working pressures up to 100 lbs. per sq. in. The pipes are said to be very largely used in water-supply and irrigation projects in Australia, and applications of the process to the production of telegraph poles, piles, columns, concrete blocks, and pipes of oviform section have given satisfactory results. It is stated that a cubic foot of two to one concrete packed centrifugally is some six pounds heavier than an equal quantity of the same aggregate mixed in the ordinary way.

A very full account (illustrated) of the process appeared in the current year's March–April number of the *Journal of Industries*, pp. 224–235.

The process is also described in the following Journals :—*Engineering News-Record*, Vol. 83, No. 15, pp. 707–708 ; *Journal of South African Institution of Engineers*, May, 1920, pp. 175–184, and Sept., 1920, pp. 28–29.

REVIEWS.

ENGINEERING CONSTRUCTION (2 Vols.).

By W. H. WARREN. (Published by Longmans & Co., 1921, price 66s.).

This treatise was first published in 1894 and dealt in a thorough manner with construction in iron, steel and timber, and has since been revised and enlarged several times. The edition under review is in two volumes, which can be bought separately, the first dealing with steel and timber structures and the second with masonry and concrete. Volume I. has been brought thoroughly up to date and now comprises in a comparatively small space a complete text book on modern practice in steel construction, together with several chapters on heavy timber structures. The physical properties and testing of the materials are very completely dealt with, and the principles and formulæ involved in their use are fully explained. Several of the simpler types of steel bridges are worked out in detail, and the methods involved in the design of large steel arches, swinging and suspension bridges are considered at length. Volume II. deals with all kinds of masonry from an engineering point of view, including a thorough treatment of reinforced concrete. The chapters on the properties, manufacture, and testing of the materials are very useful, and those on stress computation and design of dams, retaining walls, foundations, etc., are up to date.

Generally speaking the book comprises the most modern methods of treatment of engineering construction in all parts of the world, and, although necessarily somewhat condensed in parts, omits nothing of importance. To those wishing for an up-to-date work covering a very large field in a comparatively small space this book can be thoroughly recommended.

E.F.T.

A NOTE ON THE THEORY OF THE THERMIONIC TUBE.

By DR. J. A. FLEMING, D.SC., F.R.S.

Dr. J. A. Fleming, F.R.S., has kindly sent a copy of his note on the Theory of the Thermionic Tube, and the following extract may be of interest to those interested in Physics and Mathematics.

The case is considered of a hot wire cross-section radius (a) placed in the axis of a cylindrical anode radius R, which is at potential V_0.

V is potential at a distance (r) from centre of wire, ρ is density of space charge at that point and v is velocity of the electrons.

Then the thermionic current is given by

$$i = -2\pi r \rho v \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1).$$

From which it follows that

$$eV = \tfrac{1}{2} mv^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2).$$

Where e and m are the charge and mass of an electron provided it is assumed that

(*a*). The electrons are emitted from the cathode without initial velocity.

(*b*). The cathode is all at zero potential.

From (1) and (2) it follows

$$v = \sqrt{\frac{2e}{m}} \cdot \sqrt{V} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3).$$

Poissons Equation gives

$$\frac{d^2V}{dr^2} + \frac{1}{r}\frac{dV}{dr} = -4\pi\rho \ldots\ldots\ldots\ldots\ldots\ldots (4).$$

From which by application of equations (1) and (3) it follows that

$$r\frac{d^2V}{dr^2} + \frac{dV}{dr} = \frac{1}{\sqrt{V}} \times 2i\sqrt{\frac{m}{2e}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5).$$

Dr. Fleming shows that this equation can be solved by assuming that $V = r^n \phi(r)$ where $\phi(r)$ is some function of the form $\phi(r) = \beta^m K$ where K is a constant.

The solution given by Dr. Fleming is

$$i = \frac{2}{9}\sqrt{\frac{2e}{m}}\left(\frac{V^{\frac{3}{2}}}{r\beta^2}\right)$$

Where

$$\beta = \log\frac{r}{a} - \frac{2}{5}\left(\log\frac{r}{a}\right)^2 + \frac{11}{120}\left(\log\frac{r}{a}\right)^3 - \frac{47}{3300}\left(\log\frac{r}{a}\right)^4, \text{ etc.}$$

J. M. WADE, *Lieut.-Colonel.*

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 38.—*Official Announcements.*—Any soldiers, officials or workmen in army employment who were entitled to vote in the Upper Silesian plebiscite, were given an advance up to two weeks' wages, not exceeding 500 marks, towards their travelling expenses. Repayments to be made at 50 marks a month.

No. 39.—*A French View of Field-Marshal von Hindenburg.*—General von Kuhl, who was C.G.S. to von Kluck at the beginning of the war, reviews General Buat's book, and finds it, on the whole, very just. He replies to General Buat's criticism, that the Germans should not, in the spring of 1918, have tried for a decision before they had drawn all the hostile reserves, by saying that the Germans had insufficient resources to do this. They had to rely on the quality of their troops and the care with which their arrangements were made, to enable them to reach their objectives. General von Kuhl says that the fact that

these objectives were so nearly attained, is proof that their trust was not misplaced and that their calculations were very nearly correct. Buat's opinion of Ludendorff is much appreciated, but von Kuhl cannot agree that he did everything and that Hindenburg was only a figure-head.

A New Form of Taxation.—A proposal has been put up to the Hungarian parliament for the taxation of all who did not serve at the front during the war. According to the proposal any man, whether fit or not, born between 1868 and 1899, must show service, if not in the front line, at any rate in the front area, or else pay up to three times his income-tax and twenty times his property tax! If several members of a family avoided being sent to the front, the tax is to be increased fifty per cent. Employers, who succeeded in getting their employees exempted, are to pay up to 2,000 kroner for each man. The proceeds, which are expected to amount to 300 million kroner, are to be used to help war widows and orphans.

An Austrian Court-Martial.—The following verbatim account of an incident at an Austrian court-martial, held recently in Vienna, illustrates the soldiers' council régime.

The Accused:—I had only had three quarts of wine and about half a dozen pots of beer, up to mid-day.

The Court:—Did you know you were on duty that day?

Accused:—On pay day I never do any duty; I get drunk.

Court:—Take him away.

Escort:—We won't have our councillor taken away.

Court:—But why not? Since he behaves like a drunken swine. (To accused): Leave the room!

Escort:—None of that! We're all Christian-socialists here; besides, we've got our rifles. (Uproar, during which a number of soldiers appear at the windows and applaud the escort.)

No. 40.—*The 42nd French Division at the Battle of the Marne.*—General von Kuhl gives a clear account, from the German side, of this part of the Marne (1914). He says that General d'Esperey (5th Army) on the night of the 8-9th September relieved the 42nd Division, which was Foch's left division, in order to save a complete break through the 9th Army. On relief, the 42nd started on a ten-mile march to Linthelles, behind the right of the 9th Army, and should have arrived at 1 p.m. 9th. It was most urgently needed, but did not arrive till the evening and was then too exhausted to move. General Dubois, commanding the 9th French Corps, ordered a counter-attack to ease the pressure on the rest of the Army, and this counter-attack reached its objectives because, according to von Kuhl, the 3rd German Army had already retired in consequence of the withdrawal of the 2nd (von Bulow's) Army. The counter-attack consequently met with no opposition, according to the German account. On the other hand, the frontispiece of General Dubois' book gives a spirited picture of the "Assault on Mondement on the evening of Sept. 9th." (Whichever may be correct, it is well known now that the 42nd Division never made the attack which has been so widely attributed to it, though it is easy to see how such a story could arise.)

Tanks.—Lieut.-Colonel Scheunemann is very dubious about the future types of tanks, foreshadowed in a recent number of the *R.E. Journal.* He does not believe that a caterpillar track can stand the speeds indicated, or that a 12-*in.* mortar could be carried and fired successfully; still less does he believe in the 17-cm. armour plating of the heavy tank. However, he says the article merits careful attention, because it shows new lines of thought.

No. 41.—*The Break-through on the Macedonian Front.*—General von Scholtz, formerly army group commander on the Macedonian front, declares that the front could quite well have been held, if the Bulgarians had behaved reasonably well. There were plenty of reserves, but they would not fight, and the only part of the front which fought well was that commanded by Basov and Neresov, opposite the British. He says that G.H.Q. is blamed for two things; first for not attacking the allied right, on the Struma, when this had been stripped of all its reserves for the main attack, and secondly, for waiting too long before ordering the retreat of the western sector of the 11th Army. As regards the first, he says that the Bulgarian Army on the Struma front was not under him, but under the Bulgars; and besides, it was far too weak, morally and materially. The delay in withdrawing the western front was due to the fact that it formed the link with the Austrian troops in Albania. Even so, however, if Bulgaria had not capitulated these troops would probably have been able to effect their junction with the German and Austrian re-inforcements coming down from the north. General Scholtz declares that even after three years of consideration he cannot see that he could have done more than he did. If troops will not fight, no one can win battles with them. He notes that all the Germans, chiefly artillery, machine-gun and technical troops, did splendidly and showed none of the signs of disintegration which were, at that time, beginning to appear on the western front.

The Value of French and British Military Histories of the Great War.—The writer solemnly warns both French and British historians that, so long as they fail to lift up their voices in protest against the trial of war-criminals, so long German readers will refuse to believe what they write! Though our historians may perhaps fail to follow the argument, they will doubtless tremble at the threat.

No. 42.—*The Military and Political Situation in the World.*—The writer notes with satisfaction that the Reichswehr will, for the future, be beyond the reach of political influence. Exact limits have been laid down to define the unions and associations to which officers and men may or may not belong, and some of the hitherto best-known ones are now forbidden. The remainder of the article consists of the usual complaints about Upper Silesia, the indemnity, the size of the French Army and the hard heart of General Nollet, head of the inter-allied mission of control.

1914—*Near Paris.*—The writer describes his adventures on the 9th and 10th September, 1914. He was commanding a company in the 43rd Reserve Infantry Brigade, which was right flank guard of the 1st Army. The orders for the retreat failed to reach him and for some 24 hours he was completely surrounded by French cavalry. Eventually he got away, very tired, but proud of the fact that his was the unit

which reached furthest south. He says he saw the Eiffel Tower from the church of the village of Montagny St. Felicité.

No. 43.—*General von Prittwitz after the Battle of Gumbinnen on 20th August*, 1914.—General Reitzenstein contributes an article which, if correct, rather upsets the ideas hitherto held regarding the situation in East Prussia during the latter half of August, 1914. He says it is generally believed that General Prittwitz, who commanded the 8th Army, consisting of nine Divisions and the equivalent of four Landwehr Divisions, decided, on the evening of the 20th August, after the battle of Gumbinnen, to evacuate East and West Prussia and retire to the left bank of the Vistula. G.H.Q. apparently also believed this to be his intention, and did not agree with it. They accordingly relieved Prittwitz of his command, replacing him with Hindenburg, with Ludendorff as Chief of Staff, on 23rd August. (It may be noted that Prittwitz's alleged plan, to retire behind the Vistula, leaving Königsberg to hold out, was in agreement with the Schlieffen scheme. Hypotheses, though futile, are alluring. What would have been the result of the battle of the Marne, if G.H.Q. had decided to adhere to Schlieffen's plan and in consequence had not thought it necessary to withdraw two Corps from France, to reinforce East Prussia?) G.H.Q., on the evening of the 22nd, ordered the 8th Army to advance against the Russian Narew Army, under Samsonoff (10 Divisions). This involved leaving the Niemen army (24 Divisions) under Rennenkampf, practically unopposed. Von Prittwitz always asserted, verbally and in writing, that he had no intention of withdrawing to the Vistula, and intended, after the war, to publish his defence. Before he could do so he died, leaving to General Reitzenstein his papers, which include an autograph report to G.H.Q. written on the 21st August, copied during the night of 21st-22nd and despatched on 22nd, on the very day when he received his recall. The report, after describing the battle of Gumbinnen, says the situation is bad in the centre but good on each flank, and continues: "During the situation I have depicted which, in spite of the losses of the 17th Corps, was not unfavourable, an aeroplane report arrived, stating, with the greatest distinctness, that the enemy was advancing in three columns, from the Narew and from the direction of Warsaw. The heads of the two leading columns had reached the German frontier north-west of Mlawa. I had, then, to decide whether to renew the very promising fight, in which I had been hitherto engaged, or to content myself with the success already gained, block the defiles between the lakes and turn against this new enemy. I decided on the latter . . . because, although I could have given Rennenkampf a heavy blow, if he had stood, on the other hand the Narew Army would have gained an extremely valuable day. . . . To carry out my plan, it has been necessary to set the Army in motion towards its right flank, as quickly as possible. The 1st Corps has moved to Insterburg with a view to transport thence, by rail, to Gosslershausen and Bischofswerder. The transport begins on the 22nd. Detrainment should be finished on the 25th and the Corps be ready then to strike the enemy's left flank. 3rd Reserve Division and 6th Landwehr Brigade to detrain at Allenstein and come under 20th Corps. 1st Reserve Corps and 17th Corps reach Nordenburg and Astrawischken to-day (22. 8)

and move on *via* Gerdauen and Allenburg." So much for von Prittwitz's report. Whether it was right or wrong to leave Rennenkampf's (Niemen) Army and turn against Samsonoff, is not the question. What is clear, is that Prittwitz not only intended to attack Samsonoff, but also had actually started on 21st August the necessary movements to enable him to do so. Whether, without these preparations, the battle of Tannenberg could have been fought or not, cannot be definitely stated, but it seems clear that there was never any intention to withdraw behind the Vistula. The report does not even mention the name, and von Prittwitz could never understand how his intentions came to be so misrepresented. His staff knew all about them, for one of them wrote to him after Tannenberg and said, " It must be a great satisfaction to you that your plans, for operations against the Narew Army, have now had such brilliant success. Certainly they were carried out with remarkable energy, but victory could never have been attained unless the move of the 1st Corps had been begun in good time."

In German G.H.Q.—This is the title of a book by the head of the Austro-Hungarian Mission with the German forces. The author describes how the Austrian C.-in-C., Conrad von Hotzendorf, failed to appreciate the situation and blamed the German 8th Army, for not helping to relieve the pressure in Galicia in September, 1914. As the 8th Army not only occupied 12 Russian Corps and very large forces of cavalry, but also thoroughly defeated them, this blame seems rather unjustified, to say the least. When Italy's entry into the war became imminent, Germany begged Austria to ward it off, by conceding Italian demands. This Austria refused to do, apparently saying, " You hold Alsace-Lorraine; why should we not hold some Italian territory? " Perhaps the Austrians did not altogether trust their ally.

No. 44.—*Railway Transport at the Beginning of the War.*—General Baumgarten Crusius blames this somewhat severely in his book *German Leading in the Marne Campaign*, and now is taken to task by Major Kretzschmann. The latter states that on 24th August, 1914, the question of sending corps to Russia from France was first discussed, and the railways at once began their preparations. On 26th August, 1914, the move order was given and on 30th August, 1914, entrainment began. It is impossible without most careful examination to say whether this delay was avoidable or not. Kretzschmann says it was not.

No. 45.—*General von Prittwitz after the Battle of Gumbinnen.*—Lieut.-Colonel von Schäfer disagrees with General Reitzenstein (*vide* No. 43) about General von Prittwitz. He declares that on the 20th August it was von Prittwitz's intention to withdraw, but that in consequence of the communications he received from G.H.Q. and of the clearing up of the situation, by the time he wrote the report given by General Reitzenstein, his views had changed. On the 20th he apparently told Mackensen, on the telephone he was going back, and his intentions were so understood by the L. of C. authorities and others. When, on the 21st, Rennenkampf did not advance, he began to regain confidence, and worked on by G.H.Q., decided on a re-grouping of his army, so as to attack the left flank of the Narew Army.

Von Schäfer further states that on the evening of the 21st, before von Prittwitz wrote his report, he was speaking to von Stein and von Moltke on the telephone, and that he painted the situation in very gloomy colours and begged for reinforcements. General von Moltke replied that, if he really had to go back, he must at any rate hold the Vistula, at all costs; von Prittwitz said he was doubtful if the "handful of troops" at his disposal would allow him to do so. After this the Kaiser was advised to relieve him of his command.

No. 46.—*Railway Transport at the Beginning of the War.*—General Baumgarten-Crusius and Major Kretzschmann set about each other. General Baumgarten-Crusius declares that three days were lost in entraining the 11th and Guard Reserve Corps at the end of August, 1914; that the whole railway system in the east was bad, until a certain Major Tillmann took charge; and that the use of immature troops for the first Ypres battle was due to the technical railway difficulties which prevented more experienced formations being brought in. Major Kretzschmann says that the loss of three days, from 27th to 30th August, was not due to the railways, but simply to the fact that G.H.Q. did not order the troops to begin to arrive at entraining stations before the 30th; that the improvement in the Eastern railway systems was not due to any individual, but to the belated fulfilment of the demands long urged by the railway authorities, and that the use of young troops at Ypres was not attributable to the inability of the railways to bring up others, but to the loss of time which such a movement, however well carried out, must inevitably entail.

German Artillery in the Break-through Battles.—Colonel Bruchmuller, nicknamed Durchbruchmuller, was the authority most concerned with the organization of the artillery for all the great battles. He has now written a book with the above-mentioned title, which is very well received. He says that during the last 18 months of the war, almost all counter battery work was done with field guns.

The Bolivian Army.—General Hans Kundt has been nominated Chief of Staff to the Bolivian Army. About the year 1900 several German officers were brought in as instructors, but in 1906 a change of government led to their replacement by a French mission. In 1911 another change caused the recall of the Germans with Lieut.-Colonel Kundt at their head. The war caused another break, but he has now gone back, much to the delight, it is said, of the Bolivians.

L. CHENEVIX-TRENCH, *Major, R.E.*

REVUE MILITAIRE GÉNÉRALE.

November, 1920, *and January*, 1921.

The Revision of the Regulations, and our War Doctrines.—This interesting article, signed "Lucius," commences by pointing out how useful it would be, to those who will be entrusted with the revision of the military regulations, to have for reference a series of considered opinions on the events and lessons of the late war, and calls on every officer who

was engaged to contribute his impressions, however trivial they may seem to himself. The Minister for War has called for reports from technical commissions of each arm, but for many reasons it is desirable to supplement these by original contributions which would not suffer from the possibly cramping effects of official editing before publication.

The regulations need to be brought up to date for two reasons, one that they do not harmonize with the progress realized during the last six years, and confirmed by experience gained during the war. Many officers consider that the regulations have now no value at all, and ought to be replaced by entirely new ones, but this is only true of the manuals for the different arms; the more general regulations such as the Command of the Higher Formations (*Conduites des Grandes Unités*) and the Field Service Regulations are far from valueless. The second reason is that various instructions published during the war are now themselves out of date, having been based on considerations of the materiel available at the time they were issued, and this materiel has not ceased to improve in number and perfection since those dates. In addition to the work of the technical commissions referred to above, it falls to the High Command to revise the regulations applicable to all arms, which contain matters of principle, and the former can hardly produce useful work until the latter have formulated their doctrines. Again, the latter must be acquainted with the number and composition of the larger formations both in peace and war, which raises the questions of the reorganization of the army, the duration of military service, and general mobilization, considerations to be decided upon by the legislator, and not by the military authority, and outside the scope of this article.

The writer then investigates what he terms the French doctrine of war, without which no troops can be trained. To clear up this question he studies the doctrine prior to 1914, and the modifications suggested by the war. Sufficient indications to form a conception of the former can be gleaned from *La Conduites des Grandes Unités* of 28th October, 1913, from *Le Décret sur le Service des Armées en Campagne* of 2nd December, 1913, and from the Infantry Manœuvre Regulations of 20th April, 1914. Shortly put, the first named inculcates the annihilation of the organized forces of the enemy in as short a time as possible by a decisive battle pushed to the last extremity. The offensive alone leads to positive results, the defensive is vowed to certain defeat. Thus from the strategic point of view operations are conceived of as offensive. But speaking of the Army Corps, the tactical unit, the regulations foresee the case where the situation may necessitate the placing in a state of defence of all or part of the front, with the object of covering a concentration of force before proceeding to attack, or to contain the enemy with reduced effectives so that more troops may be devoted to attack elsewhere. In their turn the Infantry Manœuvre Regulations lay down rules for defence as well as offence. Here it must be noted that the strategic aim of the operations is not in question, with the Army Corps and smaller units the domain of tactics is entered, and the defensive, under the reserves above-named, is admissible. The doctrine therefore was the strategic offensive and the absolute exclusion of the defensive, and a

tactical offensive with defensive tactics in certain places to favour an offensive elsewhere.

As a practical result of this teaching on the mentality of the officers, in operations of every kind, whether on the map or in the field, there was never any question but of offence and attack. Certainly halts were provided for, as marches cannot be carried on day and night, and then outposts were studied. The delicate question of the retreat was hardly mentioned, was never made the subject of an exercise on the map, still less was it practised in the field. For covering troops only was the problem of defence considered, *i.e.*, the utilization of the ground with a view to holding with a small force an enemy superior in numbers. In consequence, sufficient regard was not paid to the effects of fire, formations were too dense, communications were neglected, and all to hasten the completion of the attack. For the one case in which the regulations permit of a defensive attitude rules are laid down. The Divisional Commander is so to organize his front that it can be held by the smallest possible number of troops, following a definite plan, and carrying it out as far as time admits. Centres of resistance are to be created, to each of which an infantry garrison is told off, artillery positions chosen to flank these centres and fire on the intervals and on possible enemy artillery positions. All troops available after these requirements are met to be held in readiness in rear. The infantry units charged with the defence receive orders as to the task they are to perform, the ground on which the defence is to be organized, the organization to be followed, the material resources placed at their disposal, the position of the command post of the next higher formation, and the communications to be opened with it, and with the neighbouring artillery units. So much for generalities; in regard to some of the details, the ground to be occupied must be reconnoitred, also that which the enemy must traverse, such as points forced on him for the passage of obstacles, hidden approaches, etc., facilities which the ground affords for counter-attack and for a resumption of the offensive. The preparation for the defence comprises organization of the posts to be held by troops, covered communications, telephones, and possibly the preparation of successive lines. The best works are the simplest, those which utilize the accidents of the ground and are difficult for the enemy to locate. Trenches should be deep and narrow, the parapets concealed from view, and dummy trenches should be provided to attract the enemy's fire to localities not occupied. A field of fire must be cleared, distances measured, and machine guns sited so as to flank important posts and to fire on such ground as the enemy may be forced to advance over. Searchlights are installed for night work. A strong and judicious organization permits of a reduction of the troops holding the front, and an augmentation of those held in hand for the counter-attack. In the defence the inviolable rule is to hold on to the end even if it entails complete sacrifice. Infantry act by fire, artillery can intervene by long range fire but must above all reserve the power of firing on the enemy's infantry. Counter-attack troops generally act on a preconceived plan independent of the fortunes of the battle, and resulting from the necessity for using the ground best suited to their action. Kept in hand under cover they attempt to act

by surprise, and advance resolutely, combining fire and movement. Whether ordered by local or superior command the support of the other arms must be assured to the infantry. Should the enemy obtain a foothold in the line a vigorous offensive return must be undertaken to dislodge him. This brief sketch allows of the statement that, if the principles inculcated were known and intelligently applied, the troops would very quickly adapt themselves to a war of position, but it must be allowed that the rules were not sufficiently widely understood, and in some cases were even ignored.

The instructions relating to the offensive are too long to analyse, and reference will only be made to (1) the importance of the effect of fire, (2) the support of infantry by artillery, (3) the necessity for good communications, and (4) the employment of field works. As to (1) all the regulations draw attention to the increased rapidity of fire, and low trajectory of rifle and gun, and lay down that formations must be flexible and adapted to the ground, that dense formations are too vulnerable, infantry must advance as a line of sharp-shooters, and at a methodical pace allowing of time for reconnaissance before the bulk of the force is engaged. As to (2) the Command of the Larger Formations prescribes the strict and constant co-operation of all arms, that artillery must aid the forward movement of infantry, and prior to the assault must concentrate on all the objectives of the attack. The F.S. Regulations state that until recently it had been agreed that the first duty of the artillery was to silence the enemy guns, and then to riddle with fire the objectives of the infantry attack. It is now recognized that the essential duty of artillery is to support the infantry by destroying whatever causes an obstacle to its progress, and that the only object of destroying the enemy artillery is to ensure the greatest possible vigour being employed against the objectives of the infantry. The preparation of the attack by artillery cannot be carried out independently of the infantry advance, since until the latter commences the enemy remains under cover. Again, the commander is to decide from time to time during the attack the targets for the artillery which will most efficiently aid the infantry advance. (3) The object of communications is to co-ordinate the efforts of all engaged in an operation, and should be established between the commander and his immediate subordinates, between commanders of adjoining sectors, and every subordinate should be in communication with his immediate superior. The command post of the G.O.C. is chosen with a view to rapidity of communication. Telephone and visual signalling are to be established whenever a halt admits of doing so, and with outposts. Stress is also laid on the necessity for close communication between infantry and artillery. All this refers to communication upwards; as to communication downwards, instructions are not so precise, but the Infantry Manœuvre Regulations state that the battalion commander must be in communication with his captains and with the colonel, and frequently with the artillery commander. Communication by aircraft was not foreseen when these regulations were issued. (4) Field fortification is not only foreseen but recommended, light work by infantry alone, and heavier with help from the engineers: 1st to facilitate the advance, 2nd to increase the

power of resistance of a force momentarily brought to a stand-still, and 3rd to allow a defensive line to utilize the ground to the best advantage. In the offensive ground must never be abandoned; the first troops strive to erect some slight protection, which is improved by successive occupants. If a halt is made by night these works are to be strengthened, and every strong point as it is occupied is to be organized to offer a serious resistance. Works in the defensive have been referred to already, the F.S. Regulations add that edges of localities and woods exposed to enemy artillery fire are to be avoided, but an unexposed edge is a strong point of support. Batteries must be protected by more or less important works, or be sunk entirely underground. Unfortunately field fortification was not made customary, it was urged that a man once under cover would only with difficulty be persuaded to advance again. Also manœuvre grounds could seldom be dug over, and if they could the trouble of refilling trenches was made the excuse for not excavating them. Thus a few exercises as a recruit were all the practice in fortification that a soldier was given.

The allegation that the reverses early in the war were due to faulty principles can now be discussed. There is no fault to find with the strategic principles, but the tactical teaching was perhaps imperfect. Rapidity of movement in the attack, due to a faulty estimate of the effect of fire, was too much insisted upon, hence attacks were at times undertaken with too little consideration, often disconnectedly, and sacrificing all to rapidity of execution. Formations were too dense, and artillery support insufficient, partly owing to want of effective inter-communication. There was a general inaptitude for, and repugnance to, the use of field fortification. Still the regulations distinctly foreshadow a delay amounting to days in completing an attack, and point out that a definite result may often be reached only by capturing several intermediate objectives. However, trench warfare was certainly not foreseen; it was forced on both sides by the peculiar circumstances of the moment. The initial reverses, therefore, cannot be ascribed to the strategic or tactical principles advocated, but to circumstances of which the violation of the neutrality of Belgium is the most important. Still the losses might have been lessened had a thorough grasp of the spirit of the regulations been more general. One excuse is that the Infantry Manœuvre Regulations were not issued until 20th April, 1914, and another is the perhaps excessive initiative to which the infantry had become habituated under the preceding regulations. This section of the article concludes with some words in praise of the training and general aptitude of the officers of the General Staff.

After five years of war against the most redoubtable of adversaries the French war doctrine can be based on the lessons of experience, and a rapid review of the principal events of the war enables the evolution of ideas, as new problems presented themselves, to be followed. To facilitate the study the operations are divided into 7 periods, (1) from August to 13th September, 1914, *Open warfare*, (2) 13th September to 16th November, 1914, *End of open and commencement of trench warfare*, (3) winter 1914–15 and year 1915, *The first attempts to penetrate the enemy's front*, (4) years 1916 and 1917 up to 16th April, *The German offensive at*

Verdun and the Allied offensives on the Somme, in Artois, and on the Aisne, (5) June to December, 1917, *Attacks with limited objectives*, (6) spring of 1918, *The great German offensive and re-appearance of open warfare*, (7) July to November, 1918, *The French counter-offensive and the general Allied offensive.*

In the first period events occurred as foreshadowed by the *Conduites des Grandes Unités*, which says that "the general engagement is the resultant of battles of armies more or less distinct from each other, but connected by one and the same aim." Thus the threat of envelopment by the Germans of the French left wing led to a retirement of the whole Allied force, and reciprocally a manœuvre of the same nature led to the retirement of the enemy at the Marne. Events in the first period also bring out, both from the strategic and tactical stand-points, the importance of certain recognized factors of success. From the strategical stand-point (1st) the value of suprise. The French anticipated only being opposed by 20 Army Corps and 8 divisions of cavalry, but contrary to expectation the Germans employed for the first shock 13 reserve Corps, thus being able to increase their right wing to 16 Corps instead of the anticipated 8. The movement through Belgium was foreseen, but was a surprise to the extent that it was not expected that the force on this flank would be so large and composed of the best troops at the enemy's disposition, nor that it would take the offensive before the French left was completely concentrated. One surprise for the Germans was the fact that the Russians were ready to take the field at the commencement of the war instead of two months later as had been expected, another was the entry of Great Britain into the war, a third the Allied stand on the Marne, and lastly Maunoury's attack on their right flank just as they were daring all to envelope the French left. (2nd) The general adoption of the enveloping movement. The German plan was to envelope both wings; their left was stopped by the frontier fortifications, their right almost succeeded. The victory on the Marne was due to a similar manœuvre, and so long as the fronts are not brought to an absolute standstill it is from an enveloping attack that each side will seek a decision. In none of these cases was the envelopment complete enough to lead to the annihiliation of the opponent, it only amounted to an outflanking movement, and envelopment was avoided in each case by the retreat of the wing attacked. For success, provided that the menaced force has not lost its *morale*, it must either be ignorant of its danger, or be so tightly held that it cannot withdraw in time, and the latter assumes a preponderating force on the side of the attacker. (3rd) The importance of *morale*. This is evidenced by the battle of the Marne, where, in spite of a retreat amounting to 300 kilometres on the extreme left of the Allies, the spirit of the troops was so maintained that when the time came for the promised advance all fatigue was forgotten, and faith in success and confidence in their leaders enabled the attack to be carried out with dash and ardour. (4th) The lack of co-ordination in the operations of the Allied armies, due to the absence of one controlling mind and unity of action.

A. R. REYNOLDS.

(To be continued).

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