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THE JUNCTION OF THE INDIAN AND RUSSIAN TRIANGULATION WORK IN THE PAMIRS.

In No. 1, Vol. XX., *R.E. Journal* (July, 1914), by the courtesy of the Surveyor-General of India, we were enabled to reproduce from the *Records of the Survey of India* an account of the Junction of the Indian and Russian Triangulation Work in the Pamirs.

We have recently received Vol. VI. of the *Records of the Survey of India*, which is completely filled with an account of the completion of the Link and we are again indebted to Colonel Sir S. G. Burrard, K.C.S.I., F.R.S., R.E., Surveyor-General of India, for the opportunity of placing before our readers some account of the wonderful work carried out. The volume which has been produced under the direction of the Surveyor General, is dedicated as under :—

To the
MEMORY
of
HENRY GORDON BELL
Lieutenant Royal Engineers
Assistant Superintendent Survey of India
Who lost his life on the Taghdumbash Pamir on June 25th 1912
THIS ACCOUNT
of the
COMPLETION OF THE TRIANGULATION
between
INDIA AND RUSSIA
with which his name will ever be associated
is
DEDICATED
by
THE AUTHORS.

An interesting Preface is written by Lieut.-Colonel G. P. Lenox Conyngham, R.E., and in the course of it he says :—

"This preface would not be complete if it failed to allude to the great loss that the Survey of India sustained in the death of Lieut. H. G. Bell, R.E., who died on the 25th of June, 1912, at Lup Gaz, close to the Mintaka Pass. He had made his way to the terminus of the Russian Triangulation and had met Colonel Tcheikine of the Russian Topographical Service and his detachment. Parting with them he began observations on his portion of the work, and had completed three stations when he was taken ill and died in a few days. He was an officer of high character and ability and his untimely death cut short a career which gave promise of distinction.

"The whole undertaking from its beginning, after the passing of the Resolution by the International Geodetic Conference of 1909, to its completion in the autumn of 1913 has been under the direction of Colonel Sir Sidney Burrard, K.C.S.I., F.R.S., R.E., and all who have taken part in it have to thank him for wise counsel, friendly interest, hearty encouragement and firm support."

The Introduction, a most interesting part of the work, is from the pen of Lieut. (now Captain) K. Mason, R.E., Assistant Superintendent, Survey of India. He writes—It is difficult to trace back the inception of any scheme that has taken more than a lifetime to accomplish, or to discover who first conceived the possibilities that may be the outcome of that scheme. If we look back into the early annals of the Survey of India, we find that it was Major William Lambton, of the 33rd Regiment, who first proposed the measurement of an arc of the meridian, by which geodesists would be able to determine the figure of the earth. With infinite trouble, Lambton collected from various sources the necessary instruments, and the measurement of the original base began on the 10th April, 1802, near Madras. Subsequently Colonel Lambton became first Surveyor-General of India, and died while on tour at the age of 70*. Colonel Sir George Everest succeeded him as Superintendent of the Great Trigonometrical Survey of India and Surveyor-General, and he conceived the great gridiron system of triangulation in India and carried it to the foot of the Himalaya. Sir Clements Markham, in *A Memoir of the Indian Surveys*, writes, "He had completed one of the most stupendous works in the whole history of science. No scientific man ever had a grander monument to his memory than the Great Meridional Arc of India. Everest's was a creative genius. The whole conception of the survey, as it now exists, was the creation of his brain." It would be very interesting if we could now know whether either Lambton or Everest ever contemplated the possibility of triangulation extending from the ninth parallel to the sixtieth. During the years that followed, work was commenced and carried on in the mountainous regions to the north, and we find Capt. Montgomerie commencing, in the spring of 1855, the triangulation of the mighty mass of mountains between the plains of India and the frontier of Tibet. He used a 14-in. Troughton and Simms theodolite, and carried this heavy and cumbersome instrument up many rocky peaks, some of which were 16,000 ft. in height. The location of his series was across Kashmir to Baltistan as the

* The Government Gazette of the time gave his age at 75.

regions to the west were not then under British control, and were inhabited by slave-dealing and robber tribes.

In the summer of 1888, Major Durand's Mission was sent to Gilgit, to enquire into the causes of an outbreak of hostilities between Kashmir and the tributary states of Hunza and Nagar; this resulted in the permanent establishment of a British Agency at Gilgit. In the winter of 1891, the Indian Government were forced by the intrigues of the rulers of Hunza and Nagar with our powerful neighbour across the border, to interfere, and the territories of these two mountain states became part of the Indian Empire.

During the year 1892, Sir Martin Conway led an exploration party in Nagar subsequently crossing into Baltistan, while smaller parties of officers on leave and duty have also increased our knowledge of the frontier in these parts. In 1896, the Pamir Boundary Commission commenced its labours, and settled the boundary between Russia on the north and the province of Wakhan in Afghanistan; but I do not think that the survey work accomplished in connection with this Commission was done with any view to linking up the great systems of Russia and India. The only connection between it and the Indian triangulation was by means of rays to very distant peaks, which had been intersected from the existing triangulation on the south; while an enormous gap separated it from any Russian work.

In 1909, Mr. James de Graaff Hunter, of the Survey of India, was deputed to commence a Principal Series* near Rawal Pindi emanating from the base Nerh-Khagriana of the North-West Himalaya Series and this triangulation had reached the neighbourhood of Shardi by the end of 1910. The work was of the highest order of accuracy. It was intended to complete this series to Gilgit and thence by following the Indus Valley to make a connection with Colonel Montgomerie's series in Baltistan.

At the same time, Colonel Tcheikine, of the Russian Survey, had begun a series from the base Ourtak-Tchoucour-Machali-Goudour (latitude 39° 33′, approximately), on the Trans-Alai Range, and had reached the neighbourhood of Pamirski Post.

During the International Geodetic Conference of 1909, which met in London, the possibility of a link of accurate triangulation between the Indian and Russian systems was discussed. It was suggested that the connection might be effected across the northern boundary ranges of India to the Chinese or Russian Pamirs, and a Resolution to this effect was proposed and passed. This appears to be the first occasion on which a connected and accurate system of triangulation from the south of India to the north of Russia was contemplated,

* The co-ordinates of the stations and intersected points of this series are included in Appendix A.

and the possibilities discussed. The complete series would be far the largest in the world, and it was anticipated that the results would yield matter of the greatest scientific interest. The Surveyor-General of India received this proposal in the early part of the year 1911.

Lieut. H. G. Bell, R.E., who succeeded Mr. Hunter, carried the Principal Series as far as Gilgit during the summer of 1911. Great difficulty was experienced owing to an early start after a late winter, as the snow lay as low as 8,000 ft. On one station the portable lightning conductor was struck, and the detachment was greatly delayed by inclement weather, while in the Indus Valley, a severe earthquake caused a cliff to be precipitated into the river, destroying the road and thus adding to the difficulties of the work.

Having reached Gilgit, Lieut. Bell and his assistant, Mr. Wainright, left that place on the 1st August, to reconnoitre the Darkot route and the Hunza Valley respectively with a view to finding the best means of effecting a junction with the Russian triangulation. Marching *viâ* Yasin, Bell reached the Darkot Pass and examined the peaks in the vicinity. He found the extensive glacier, rising on the pass, much intersected by crevasses, and only passable in the very early morning. The highest peak, about 19,370 ft., west of the pass, was found to be quite inaccessible for triangulation purposes, and the neighbouring peaks, though lower, were useless owing to high unclimbable peaks to the south and south-east. From Darkot, Bell visited the approaches of Garmush, 20,564 ft.; here also he found that the glaciers in the neighbourhood were extremely dangerous, and the slopes very liable to avalanches. The Darkot-Askuman Pass was crossed, and a peak ascended with a view to obtaining a more extensive reconnaissance of Garmush and the other peaks of the Sakiz Jarab Range, but the term "Glorified Matterhorns," which has been applied to the Karakoram Peaks further to the east, was found to be equally applicable here. In a letter, written from hereabouts, Bell mentioned that he doubted whether the peaks would be accessible for an experienced party of climbers, and that it was a physical impossibility to take an instrument up any one of them. A move was then made to the Karumbar Valley, in the hope of finding a possible connection by this route. But again the difficult nature of the obstacles encountered caused at any rate the temporary abandonment of this line.

Mr. Wainright meanwhile made a reconnaissance up the Hunza Valley towards the Kilik Pass. The settled condition of the country lightened his work to a great extent, and he reported that it would be practicable to run a series as far as the village of Misgar, but that from there it would be advisable to follow the general line of the Khūnjerab Valley and Kharchanai Pass. He also advised the use of a smaller instrument in place of the 12-in., which had been used as far as Gilgit. This latter advice was followed and a 6-in. micrometer theodolite was used for the subsequent triangulation.

During the summer of 1911, the Russian triangulation had been extended to the Russian frontier, and two stations in the neighbourhood of Beyik and Taghramansu, on the Russo-Chinese border, had been fixed. But, owing to the results of Bell's reconnaissance, the sites of these stations had to be slightly altered.

Lieut. Bell was again in charge of the detachment during the summer of 1912, and it seemed possible that the end of the season would see the completion of the link. The detachment arrived in Gilgit by the 31st May and commenced work soon afterwards. It had been decided to base the connection on a side of the Kashmir Principal Series, which had been completed the year before, in latitude 35° 55′ and longitude 74° 20′. Bell's plans were to go, accompanied by his assistant Mr. McInnes, *viâ* the Pamirs to the end of the Russian triangulation, arranging *en route* the work in the upper reaches of the Hunza Valley, and selecting the actual route north of Misgar. During this reconnaissance, he decided that the Khūnjerab Mountains would be impracticable for accurate work, and that the Kilik would probably afford the only suitable route.

In the meanwhile, a second detachment under Mr. Collins was to work up from the neighbourhood of Gilgit.

The year was a disastrous one for the Survey. From the very first, bad luck dogged the expedition. Early in June, the various detachments left Gilgit, but the weather was very unfavourable, and while on Yashochish Hill-Station, in the Great Himalaya Range, the camp of Mr. Abdul Hai was wrecked by lightning; his servant was killed, and his recorder was severely burnt, while he himself received a bad shock, which necessitated his return to Gilgit. This district is notoriously bad for electrical disturbances, and very different from the regions of the Karakoram, which, judging from the observations made by the Duke of the Abruzzi, are very free from storms. Collins carried the triangulation on from Gilgit towards Hunza, but on the 28th July, he had to take over charge of the detachment owing to Bell's death.

The latter, with McInnes, had crossed to the Taghdumbash Pamir McInnes was detailed to reconnoitre towards the Kilik Pass, and Bell proceeded to the Russian stations on either side of the Beyik Pass, on the Russo-Chinese frontier, meeting the Russian party under Colonel Tcheikine on the pass. On his return journey he completed the observations at three stations, and ascended a fourth, but here he found some difficulty in observing to one of his stations (Lup Gaz). He therefore decided to move his camp to this station, with a view to finding out if the stations were intervisible. He had not been very fit for the last few days, and had been over-exerting himself. On the 19th July, when in camp on Lup Gaz Hill-Station he awoke in very great pain, and becoming no better, he was carried down to his base camp in the Lup Gaz Jilga. He remained here a few days, and on the morning of the 24th, sent a note to McInnes asking him to come and take over the observations. McInnes received this note on the following morning at his camp near the Kilik Pass and at once proceeded to Lup Gaz. The same night Bell passed away. It is hardly necessary to add after what has been written above, that the ultimate success of the work, was to a large extent due to Harry Bell's untiring efforts. He never ceased to think of the link, and during his last interview with McInnes, he urged on him the importance of getting on with the work. On his death, I personally lost my dearest friend and I had known him intimately for many years; he was a daring mountaineer, and absolutely fearless, and his loss to the Service and to geography is greatly to be regretted.

This disaster delayed the work very considerably, and by the end of the season, a short late one for this part of the world, the triangulation from Gilgit had only been completed to a point some little way below Hunza. McInnes reconnoitred the Pamir work, but the reconnaissance in the Hunza Gorge showed that a departure would have to be made near Misgar, in order to obtain suitable figures. As the crow flies, there remained about 70 or 80 miles to be traversed with triangulation, but the actual length of the work would have to be half as much again. Of this about two-thirds was more or less reconnoitred.

During the winter of 1912-13, the question of this connection was again discussed at the International Geodetic Conference at Hamburg, and another Resolution was passed expressing the hope that the connection would be carried on again in 1913. On my return from three months' leave in Switzerland in February, I was given charge of the detachment to complete the work. Before going on leave, I had asked for the services of a member of the Indian Medical Service who would be able to assist in such subjects as Geology and Botany, and before leaving Dehra Dun, I had the pleasure of hearing that Lieut. R. W. G. Hingston, I.M.S., with whom I was acquainted, had been appointed. The results of his work are included in this report. Almost the entire collection of fauna was made by him, many of the rock specimens and plants from the Pamir itself were collected by him; the completeness with which the observations were taken to cirrus clouds for the Meteorological Survey of India, and the hæmatological investigation are entirely due to his energy. In addition to this work, he very largely assisted me with the photographic survey, both by taking photographs, and by helping with with the development in the evenings; and when my recorder went sick, Hingston undertook the work of recording. Since returning he has been engaged on the classification of his zoological collection, during his spare time.

The last week of February and the whole of March were spent in making preparations for the expedition, and in arranging the additional work to be done. The whole programme had to be thought out, and any difficulties that could be foreseen guarded against, for when once on the way, every day, almost every hour, was valuable, and we could afford to take no chances. The question of rations had to be carefully considered, as the country in which we were to work, produces no crops of any kind, nor does it contain any villages. Transport had to be prearranged, for the whole journey from Rawal Pindi to Gilgit, and a preliminary estimate worked out as to the number of coolies required. Instruments and kit had to be weighed and packed into loads not heavier than 60 lbs., suitable to the many and varied forms of transport. In connection with this, during the march up the road, there were a few loads that were somewhat heavier; in particular, the memorial stone to be erected in Gilgit to Harry Bell, which had come with me from England; but in every case where a coolie had the choice of carrying the excess load, plus a slightly increased wage, or of taking turns with a lightly laden coolie, he preferred the former. The three large cases of tea taken up for the coolies' consumption, came also under this category.

As regards our own rations, we did ourselves well. Cases were made self-contained, so that only one case was open at a time. The great thing to guard against was loss of appetite and consequent loss of energy, and it was hoped that a varied diet would contribute towards this end. The arrangement was as follows:—Boxes labelled A/1, A/2, B/1, B/2, etc., were for ordinary consumption; those marked C and D, for cooking and special occasions, respectively. All the "As" and "Bs" were in wooden cases, with the exception of A/1, which was packed in a padlocked yakdan. All the "As" were similar and all the "Bs," but the "As" differed slightly from the "Bs." The contents of both types were estimated to last three men for a fortnight, two men for three weeks, or one man for six weeks. When "A/1" was finished, "B/1" case was opened, and its contents turned into the yakdan; when this was again empty, or, more strictly speaking, on the regulation date, "A/2" was opened and its contents turned into the yakdan; and so on. This system worked excellently.

Each officer took a 40 or 80-lb. double-fly tent, and in addition, the Pamir detachment took two single-fly 16-lb. Whymper tents. These latter should be made of very fine material, a superior Willesden canvas, but the one made in Srinagar to the pattern used by the Duke of the Abruzzi, was not a success, and one is led to the conclusion that this special type of tent should only be purchased from the best makers at home. My own Whymper tent, which first saw service with the Duke of the Abruzzi in 1909, completed its fifth year of constant use in the hills on the Pamirs, and is still quite serviceable. In our high camps Hingston and I shared my 16-lb. Whymper tent and slept in sleeping bags on the ground; while the other was shared by the men. Khalassies and Gurkhas were supplied with 10-ft. by 8-ft. single-fly tents, generally four men to each. Coolies were given a tent, known as "the wigwam," 20 to 25 men in each. This consists of a light central umbrella-shaped structure, supporting a form of bell-tent. The height of the central part is about 4 ft.; I once, and only once, inspected one of these after a cold night, and ascertained that 25 Balti coolies find no difficulty in maintaining a good temperature. This tent is exactly the right type for coolies; it was, I believe, invented by an officer in the 5th Gurkhas.

Khalassies were clothed on the scale known in the Survey of India, as the "Arctic." It consists of

1 Balaclava cap.
1 warm coat.
1 pair warm *paijamas*.
1 woollen jersey.
1 warm puggrie.
1 pair puttees.
1 pair woollen gloves.
2 pair woollen socks.
4 thick blankets.
1 pair boots.

In addition, a waterproof sheet was issued with each tent. A point which I consider of great importance, is the personal fitting of the boots; and Hingston and I saw to this ourselves. Each man was given a pair of boots one size larger than his ordinary size, to allow him to wear two pairs of socks within each boot, so that his circulation would not be impeded. No cases of frostbite occurred amongst the men so booted. The whole of this warm clothing was purchased from the Supply Depôt, Rawal Pindi, and wore very well. As regards my own footgear, I found that the most comfortable for snow and rockwork was the ordinary ski-ing boot packed with at least two pairs of ski or goat-hair socks.

The date fixed for departure from Dehra Dun was the 10th April, and on this day everything was as ready as possible, and the detachment left by train for Rawal Pindi. Besides Hingston and myself, the detachment consisted of two assistants, Messrs. V. D. B. Collins and C. S. McInnes, who were each to have charge of sections of the work. Collins was to work up from the neighbourhood of Hunza, my own detachment was to work back from the Russian end, while McInnes was to reconnoitre the country in between, and observe there if he had time.

During the season the Link was completed, and now the triangulation, commenced over a century ago by the originator of the Survey of India, has reached and crossed the most northerly point of the Indian Empire. The Russian work in Asia has come down and joined on with this, and the whole series is practically complete from the ninth parallel on the south to the sixtieth parallel on the north.

I should like to take this opportunity of thanking all those who rendered assistance to the expedition. I am extremely indebted to Sir George Macartney, K.C.I.E., His Britannic Majesty's Consul-General at Kashgar, through whose kindness and personal influence any political difficulties on the Pamirs were avoided; to the Taotai of Kashgar and Amban of Tashkurghān who sent representatives to the Sarikōli Begs, instructing them to help us in every possible way; and to the latter for their invariable kindness and hospitality.

We met with the greatest assistance from the Hon. Stuart Fraser, C.S.I., C.I.E., Resident in Kashmir, and from Major A. D. Macpherson, Political Agent at Gilgit, who smoothed out our way to a large extent, and it will be impossible for us ever to forget the generous hospitality extended always to us at Gilgit—hospitality which has been recorded by every traveller in these parts, but which could never have surpassed that which we encountered.

It is here, too, that I must preface any account of the operations by a grateful reference to my fellow workers; to those indefatigable two Gurkhas of the 5th, Kulbir and Hastabir Rana; to Naik Bulnar Singh, 9th Gurkha Rifles, and his hard-working signallers; to my guide, Abdulla; and lastly to the long-suffering and much-maligned coolies, whose admirable qualities were never marred by those mutinous tendencies which may be expected from any followers if treated with a total lack of consideration and tact.

In connection with the writing of this report, Capt. Hingston and I are indebted to Mr. H. H. Hayden, C.I.E., Director of the Geological Survey of India, and to Mr. J. Coggin Brown, M.SC., of the same department, for their interest and for the classification of the rocks brought back by the expedition, which are now in their museum at Calcutta; to Dr. Gilbert Walker, C.S.I., F.R.S., Director-General of Observatories, and Mr. W. A. Harwood, M.SC., Assistant Director, Aerological Observatory, Agra; to Mr. M. S. Ramaswami, M.A., Royal Botanic Gardens, Sibpur, Calcutta, for his classification of the flora and to Mr. R. N. Parker, Imperial Forest Survey, for his arrangement of this section; * to Mr. N. D. Riley, of the Insect Department, British Museum, to Mr. W. M. Tattersall, of the Manchester Museum, and to Mr. N. B. Kinnear, of the Bombay Natural

* Since writing the above, and before the final publication of this report, Mr. Ramaswami has rearranged the whole of the chapter on the Pamir flora, and has written an introduction to his classification.

History Society, for assistance in classifying a few species of the fauna collected; and lastly to Major H. Wood, R.E., Survey of India, for many suggestions and corrections.

With reference to the triangulation, I would add my conviction that the final success of the British contribution to the link would never have been so fully attained but for the devotion of my friend Harry Bell. He it was who reduced the possibilities of the connection to the only feasible route across the mountains, and who devotedly gave his life when almost within sight of the completion of the link.

In a recent letter to me, Hingston wrote " I shall always look back on my experience on the Pamirs as one of the most fascinating of my life " ; to those of us who were permitted to take a share in the work, the memory of those days spent in the high camps of those vast empty spaces and the recollection of the gigantic scale to which nature has built the mighty barrier wall of this great Empire will always bring back the fascinating days and nights spent among the silent Lords of the Mist-Mountains.

Lieut. Mason follows with a chapter on " The Journey to the Pamirs," which we hope to print in the next number of the *Journal*.

ENGINEERING AND SCIENTIFIC RESEARCH.

By J. A. FLEMING, M.A., D.SC., F.R.S., M.INST.E.E., University Professor of Electrical Engineering in the University College, University of London.

THE following paper read on the 1st May is reproduced by the kind permission of the Society of Engineers (Incorporated), 17, Victoria Street, S.W. :—

There seems to be a very complete agreement that one result of the great war in which we are engaged will be to render absolutely necessary certain reforms in our national systems of education and especially in the attention given to pure and technical scientific knowledge. Hardly anyone disputes the propositions that scientific discovery and research must be brought to bear more fully on our national industries, and must be encouraged to a far greater extent than heretofore in this country; but the moment we go beyond these generalities we find great differences of opinion as to the best mode of giving effect to these desires.

Many scientific men have long and vehemently urged national attention to this matter, but the want of co-ordination between our various learned and technical societies and the strongly conservative element in our older Universities and public schools which resists a break with the past have prevented many useful changes being made.

The Board of Education Scheme.—An important step was, however, taken by the Government through the Board of Education last July in the establishment of a Committee of the Privy Council and the appointment of an Advisory Council to deal with the question of scientific and industrial research as described in a scheme outlined in a White Paper. As this Committee and Council have already come into existence we cannot regard the Scheme as merely a proposal to be discussed. We must accept it in a sense as an accomplished fact, but one in which the details may, we hope, be considered as open to modifications.

Since any such Government control over scientific research is bound to have a great influence in time on the direction of scientific work and its applications, it appears most desirable to gather views upon this scheme even after its inception, from those who are concerned with one of the most scientific of these industries, viz., engineering in all its branches

It is estimated that the capital invested in Great Britain at present in plant and materials in the two branches of mechanical and electrical engineering is probably not less than £1,000,000,000. When we bear in mind the manner in which a single perfected improvement or invention can revolutionize a whole industry it needs no further argument to prove the necessity for careful attention to the progress of scientific research in connection with it. Hence it seems extremely important that engineers should have the opportunity of discussing schemes proposed, or already launched for dealing with industrial and scientific research lest steps should be taken to give permanent form to proposals without sufficient consultation with those who will most be affected thereby.

It is a very widely held opinion that all that is required to effect reforms are Acts of Parliament, the formation of Committees, or the issue of regulations. Many instances could, however, be called to mind of legislation undertaken with all apparent care, the effect of which has been exactly the opposite of that intended. Electrical engineers will no doubt remember an Act of 1882, somewhat ironically termed "An Act to facilitate Electric Lighting," which was passed almost coincidently with the completed invention of the incandescent electric lamp, the immediate consequence of which was to throttle effectively this nascent industry in Great Britain for six years.

Necessary Improvements and Reforms.—In the particular matter under discussion we have been compelled to recognize the manner in which important industries have died out or never thriven in this country in consequence of our neglect of scientific education and research. It is equally important to realize that we cannot undo the effect of this neglect by a wave of the wand, but that reforms to be useful must be very deep and very thorough and begin at the top and at the bottom in our systems of national education. Whilst we cannot hope to reach anything like unanimity on a subject so complex as the means of imparting or creating knowledge, it is of the utmost moment that engineers should carefully consider the various proposals made for reforms, so as to bring to bear their practical experience on it and not permit schemes to advance too far which are the product merely of academic or political thought.

We have to consider then—

(i.). The improvements in the training of men who will become engineers.

(ii.). The best means by which scientific knowledge can be brought to bear on the problems of engineering.

(iii.). The scientific method in relation to the business side of engineering.

The enormous destruction during the War of the products of the engineer's shop and office will call for reconstruction, and offer a vast field for engineering work on its conclusion. We have to see to it that as much as possible of this work falls into the hands of the United Nations which form the British Empire.

This work will make a call for men trained both in the scientific and practical side of engineering and also for others proficient in the business aspects of it.

It is unquestionable that the success of the Germans in the commercial field is in part due to their system of national education, which prepares every man for some vocation and does it thoroughly. We are by no means desirous of copying it in its entirety as it possesses grave defects on its ethical side and in its extreme cultivation of materialism in its worst aspects. Nevertheless, we can usefully draw some lessons from it.

Our own educational systems from bottom to top are too bookish, too much devoted to the cultivation of memory and words, and not sufficiently leavened by a real knowledge of the facts of nature and power to draw true inferences from observations. The success of the Montessori system of training young children and of the Baden Powell Boy Scout movement in imparting self-directing power and vivid interest in learning about things, shows what can be done on right lines.

We have to bring the same principles to bear on all other departments of education. One barrier in the way of our industrial progress has been the imperfect scientific training of foremen, managers, and young heads of departments in many engineering works. The young men who are brought in to fill directing positions have generally received the usual public or middle-class school education with its entirely insufficient attention to scientific subjects. Even when this has been supplemented by a course at a technical college the time at the latter has been so much taken up with learning things which ought to have been learnt at school that the opportunity of acquiring advanced scientific knowledge or real power of independent investi gation has been very much curtailed. Hence when once immersed in business it has been impossible for them to keep up with scientific advances, and they can at most copy what they see others do. We have to produce more men who can do new things, and not merely know about old ones.

Until this state of affairs is remedied it is perfectly futile for Great Britain to hope to gain pre-eminence over Germany in scientific industries. The advantages which we have in greater originality of mind and better workmanship are neutralized to a large extent by the want of a sufficiently thorough and broad scientific education to enable us to see the practical value of, and work out exhaustively, and especially with reference to trade purposes, the openings given by scientific discoveries. It is the want of this sufficiently thorough scientific education which accounts for the limited faith of many employers and capitalists in scientific research and also for the inability of the practical worker to take advantage of, or see the meaning of facts which present themselves to him in his every-day work.

One of the educational reforms which seems most necessary is the compulsory attendance of lads after leaving the Board School at a technical continuation school. Assuming he leaves at 14 or 15 and is taken on at an engineering works it should not be optional whether he attends a continuation technical school. He should be compelled to do it until he is 17 or 18 years old, as in Germany. This continued education should not be merely a handicraft training but should be a careful instruction by practical men who are or have been engineers; in mechanical drawing, graphics, mechanics, physics, chemistry, metallurgy, electrotechnics and machine construction. The attendance should not be allowed to become irregular and the certificates of proficiency should have an immediate effect on the lad's prospects of advancement.

In the case of young men of higher social rank who have been to public schools I am very strongly of opinion that the practical experience in the shops and drawing office should not be deferred entirely until after the college course. The school education should have provided him with a thorough grounding in the elements of chemistry, physics and mathematics, pure and applied, and with a speaking acquaintance with at least one modern language. One year at a University or Technical College should then prepare him to take advantage of some shop experience and after that he should return to the College for a year or perhaps two for the Advanced Laboratory and Designs Work.

The Degree or Diploma Examinations should be made to depend more than they are at present on the results of practical laboratory and drawing office work. My experience is that students who come straight from school to college for three years without break are apt to spend much time in mere amusement and are less serious workers than those who have had some experience in an engineer's shop and then returned to the College.

In order to compress into this time the necessary training our methods and means of instruction must be much improved. It is essential now for every engineer to have a good working acquaintance with certain branches of mathematics. If he has no knowledge whatever of the Calculus or Trigonometry he finds it impossible to read many original papers in the technical journals. In teaching electrotechnics to young engineers I find I have to give much time to imparting elementary mathematical knowledge which ought to have been gained elsewhere. It should, however, be taught by engineers to engineers.

The great thing to guard against on the part of the student is premature specialization. He should broaden as much as possible his knowledge of the principles of chemistry, mechanics, physics, mathematics, and metallurgy, and he will then be able, later on, to build up on this foundation. Unless he does lay this foundation he will not be able to follow or assist in improvements. As an illustration of this we may take subjects such as telephony or wireless telegraphy. It is impossible now for anyone to make any really important addition to these subjects who has not a very competent knowledge of physics and some parts of mathematics. The easier problems are worked out and the design of telephonic systems or radiotelegraphic stations has become a matter in which advanced scientific knowledge is an important factor. Then again to make any advance in metallurgy requires a very intimate acquaintance with the chemistry of metals. A lucky accident might give a clue to an improvement, but an observer not sufficiently acquainted with modern chemical principles could not take advantage of it or follow it up.

In the third and fourth year the student will, of course, have given time to learning as much as possible of the methods of testing both mechanical and electrical—as are required in engineering work, the especial object of which is to enable him to deal with the kind of problems which will present themselves in practice.

It is of extreme importance that he should acquire sympathy with and confidence in scientific research to give the data for engineering work.

The Relation of Scientific Research to Engineering.—We turn then to the subject which it is our purpose more particularly to discuss, viz., the relation of scientific research to engineering practice. We may roughly divide this research work into three departments.

There are first the laboratory researches which aim at determining various physical constants of the materials used in engineering which are requisite to give data for design. This knowledge can never be made too accurate or too complete; but the moment one goes to any of the well-known pocket books or tables of engineering data it is astonishing to find the wide gaps in our knowledge. Hence we require abundant provision for re-determining these values for particular samples of new materials to be used in bulk for various purposes.

Then in the second place there are those researches which aid engineering by providing new methods of examination and test of materials or structures. As an instance of this, consider the invaluable aid rendered by what is now called Metallography or the study of the internal structure of metals and alloys by the aid of the microscope. The founder of this branch of investigation was Dr. Sorby of Sheffield, in 1864, who first began the microscopic examination of iron and steel. Every engineering student is now familiar with the processes applied and with the immensely important knowledge that has been gathered as to the composition of steels and other alloys by this method.

The great development of pyrometry and high temperature thermometry by the invention and improvement of the thermo-junction and radiation pyrometer and the electrical resistance thermometer, due to the scientific labours of Callendar, Le Chatelier, Holborn, Féry, and many others have provided the engineer with implements of great accuracy for the measurement of high temperatures and made it, in fact, an exact science.

The improvement in the means of testing the mechanical or elastic properties of engineering materials by testing machines is another instance of the same class of research. Of late years the applicances for testing the mechanical properties of materials under repeated stresses, vibrations or blows have become important in giving the dynamic as contrasted with the static stress properties. One of the latest additions to the resources of engineering testing is the very ingenious application of polarized light by Professor E. G. Coker to study the distribution and magnitude of stresses in celluloid models of beams, struts or rivetted plates used in engineering structures. To this class of research we may add such methods as those introduced by Froude for ship designing. Froude invented the method of predetermining the resistance to propulsion of a ship by dragging small scale models of ships' hulls made of paraffin wax through water in an experimental tank. The tractive force required is recorded graphically by a dynamometer. He discovered two very important laws, viz., the law of the "corresponding speeds" and that of the variation of resistance with the length of the ships when moving at corresponding speeds. These laws and methods are of the greatest use in ship design. Is it not possible that the same methods might be applied to determine the resistance of air to moving trains and motor cars, so that experiments with model vehicles would give data for design? It is being applied to the study of aeroplanes and of the problem of flight generally.

Then in the third place we have a type of research which calls for special aptitude and insight, viz., those which lead to the discovery of some new process, material or machine.

An excellent example of this is the discovery made simultaneously by C. M. Hall in America and P. Héroult in France when hardly more than students, which finally rendered the production of metallic aluminium in bulk a commercial success.

The process is founded on the fact that fuzed cryolite dissolves alumina and that if an electric current is passed through the fluid mass at a low voltage it not only keeps it fluid but electrolyzes the alumina without affecting the solvent; and since metallic aluminium has a slightly greater density than the electrolyte it falls to the bottom of the cell and is not re-oxidized but can be drawn off in the metallic state.

Further examples of the same important class of researches are given in the production of the various alloy steels, for example, tungsten, vanadium steels, and so on, with their extremely valuable properties. A certain nickel-chromium alloy called nichrome has been found to be of great service in electric heating by providing an inexpensive alloy which does not rapidly oxidize at a bright red heat.

Then we have additional illustrations in the galaxy of inventions which have made the internal combustion engine, aeroplane, steam turbine, wireless telegraphy, the polyphase alternator and asynchronous motor such epoch-making appliances. Whilst the initial ideas in these things were all the outcome of genius their development has required the steady application of the scientific method and the commercial ability to find the means of doing it.

The really important question is, what are the conditions under which we can stimulate this originative power? It is partly due to natural gifts; partly to effective training and partly to the possession of sufficient appliances and means.

Laboratories may, however, be built without number and chairs and scholarships endowed, but unless the right men occupy them very little results.

The true answer to the above question is, I believe, that originality stimulates originality. A really great investigator not only discovers himself but imparts something of his powers to his associates. No one can have worked under Lord Kelvin or studied under Clerk Maxwell without having caught from them some inspiration and some small fragment of their passion for the discovery of new truths and methods of doing it.

Hence we require to establish and strengthen those research institutions such as the Cavendish Laboratory, Cambridge, or the Royal Institution, London, where notable scientific investigators have established schools of research and imparted some of their great powers to students and colleagues. But the subject we are especially discussing is not scientific research in itself but research in relation to engineering.

The engineer requires scientific assistance first in the accurate determination of certain constants and data concerning materials and structures. Also certain very accurate gauges and measuring tools.

The work of furnishing these must be beyond suspicion in accuracy and authoritative in effect. Hence it can only be done in a national institution like the National Physical Laboratory.* The Engineering Standards Committee of the various engineering institutions has, however, rendered invaluable service by settling specifications for materials and sizes to be used in engineering and in securing for them general acceptance.

In providing a large mass of accurate scientific data for use in engineering: electrical, mechanical, hydraulic, and illuminating, the National Physical Laboratory has given most valuable service to engineering for the last twenty years. Nevertheless there are matters requiring assistance for which even its present resources are insufficient.

There are problems in connection with electrometallurgy and engineering which await solution for which our present appliances in private or University laboratories are insufficient.

We need in addition to the present resources of the Engineering Department of the National Physical Laboratory an increase in the facilities for metallurgical research work on a large scale, such as that conducted with valuable results in University College, Sheffield. Such a laboratory should be provided with full-size smelting and refining furnaces by coke, gas, and electric heating and with testing machines capable of dealing with test objects of commercial size even full-sized bridge members.

The engineering laboratories of some London colleges, such as University College, should have their accommodation and appliances largely increased. It would be of great advantage if these laboratories were so equipped as to specialize in certain lines of research and brought into closer contact with the problems requiring solution in connection with actual engineering work.

* The writer may, perhaps, be permitted to recall to mind that in November, 1885, he read a Paper to the *Society of Telegraph Engineers and Electricians* afterwards called *The Institution of Electrical Engineers* on "The Necessity for a National Standardizing Laboratory for Electrical Instruments." In the discussion on that paper about eighteen speakers were unanimous in approving the proposals in it. The Society appointed a Committee to further the suggestion, but want of funds prevented anything being done at the time. The writer spent much time in the next two years in working out the details of such a laboratory with the late Major P. Cardew, R.E. On June 19th, 1889, a deputation was received by the then President of the Board of Trade representing the Institute of Electrical Engineers and the London Chamber of Commerce urging the Establishment of a Board of Trade Standardizing Laboratory. This was done in the following year. In 1891 and 1892 Sir Oliver Lodge brought to the notice of the British Association the necessity for a National Physical Laboratory, and a year or two later the late Sir Douglas Galton described in a Presidential address the recently established *Reichsanstalt* in Berlin or State Physical Laboratory. Shortly afterwards our own National Physical Laboratory was established very much on the lines indicated in the writer's paper of 1885.

Much of the work carried out would then be of a highly confidential character, and might have to remain unpublished but be communicated privately to firms and corporations concerned with the subjects of the investigation.

Industrial Co-operative Research.—In Germany much of the technical research work is carried out privately by private associations of the trades concerned. In Great Britain manufacturers in the same trade are far too prone to regard one another as rivals, whereas in the future they will have to stand much more shoulder to shoulder against their common and German antagonists who will be united against them.

Hence in many matters it would pay British firms in the same business to promote scientific research in common on certain problems of manufacture, subscribing together the funds to undertake it either at a national technical laboratory or at some technical college or university which may be provided with the proper equipment. Such information when obtained would then only be communicated to the members of the association or union.

Then, again, the same principle of common action might be brought to bear upon the collection of information as to what is being done in certain branches of manufacture; the establishment in fact of an information bureau common to certain firms or manufacturers. There are, as everyone knows, already in operation many powerful and important trade associations, such as the British Electrical and Allied Manufacturers Association (B.E.A.M.A.), and many other kindred organizations which are doing and could extend this work with great effect.

It is certain that, as a rule, British technical firms do not expend anything like the same labour or money over their intelligence departments as German firms. The latter gather in from all countries every scrap of information which can assist them, both from scientific and technical papers and patent specifications. This is carefully digested and classified so that they are able to keep careful watch on progress in their own subject. The smallest valuable novelty is then carefully tested in practice.

The first direction in which our advances should be made is in improving the means for obtaining this early information on possible improvements and advances. In gathering in and bringing to early notice technical improvements greater assistance might, perhaps, be rendered by our technical papers and the proceedings of our technical institutions.

The field of knowledge is now so vast and technical literature so voluminous that it is becoming increasingly difficult for the busy engineer, whose day is occupied with settling contracts, specifications or routine work in an office or factory, to keep himself apprised of new departures in his own special work, even with the aid of all our ably conducted technical journals.

We need to improve in every way our means of classifying and notifying technical and scientific novelties and patent applications so that it may become more easy to keep abreast of progress. But when all this is done we may be as far as ever from making those discoveries and inventions which have value in commercial world.

If we look carefully at the history of successful invention we see that it always involves three things: first, a new idea or fortunate observation; secondly, the persistent following out of this idea to its logical issue by persevering work. The first step is always a stroke of genius, the second stage involves generally skilled assistance by persons of competent technical training. But there is a third stage, viz., the translation of the process or discovery into a commercial manufacture. This stage requires capital outlay and often large preliminary expenditure before any return can be obtained, but also it involves and necessitates high ability in applying the scientific method to the commercial problem. The public do not understand this. They mostly think that an invention leaps full grown from the head of an inventor like "Minerva from the head of Jove."

Everyone has known cases of scientific manufactures or industries which have been nearly brought to ruin under one management and rescued and reconstructed by another. Hence no amount of official organization of scientific research will necessarily produce successful results unless the men with right judgment and initiative are brought to the front.

The Position of the Engineering Institutions in Relation to Schemes for assisting Industrial Research.—The point which requires consideration is whether the scheme promoted by the Board of Education will meet these requirements of technology and manufacture and especially of engineering. For one thing it is much to be desired that the Advisory Council should have on it members who represent the constructive and manufacturing side of engineering in various branches. As at present constituted it is chiefly representative of eminence in pure scientific knowledge. It is satisfactory to find, from the latest report of its decisions and work that as regards assistance given to industrial research, its aid will be given through the intermediation of the established professional and technical institutions or societies because they embody in their membership the knowledge of the most necessary requirements in the way of such research.

A further reason for it is because many important problems which need attention are very large ones and will require the assistance of many experienced men. Such problems are the conservation and more economical use of our national coal supply; the universal adoption of gas or of electric heating in place of the wasteful combustion of raw coal in domestic fireplaces, the electrical transmission of power from coal fields to great cities, are examples. The coal question in its various aspects is especially important. Of all European coalfields, Germany has the largest known reserves, though of inferior quality. There are three great coal-bearing districts in Germany, viz., the lower Rhine and Westphalian basin, Silesia, and the Rhenish district near Saarbrücken and Aix-la-Chapelle. The life of these fields has been estimated at 2,000, 1,200, and 4,000 years respectively, whereas the figures given by the Royal Commission on Coal Supplies in Great Britain fixed the life of ours at about 200 years. We have, however, the advantage of superior quality of material. Nevertheless we must bring, at once, the highest scientific knowledge to bear upon the subject of our more scientific coal consumption and use. These are matters quite beyond any individual or small committees to deal with, they demand the conjoint consideration of many minds. Hence it is to be hoped that the principal engineering institutions will unite in a strong request to the Government, if they have not already done so, to place representative engineers upon the Advisory Council and also that in the disbursement of funds allocated to the assistance of industrial research, these institutions, as bodies, shall be to a considerable extent the avenues through which it is dispensed.

The present policy of the Government and of the Board of Education seems to be the creation of fresh committees and boards whilst setting on one side the existing learned and technical institutions. The latter are corporate bodies which include in their membership all those who have special knowledge and eminence in their various subjects.

Thus we are promised a plethora of new committees on various subjects which already fall within the scope of the operations of old-established and strong professional societies like the various engineering institutions of civil, mechanical and electrical engineers, and the Iron and Steel Institute, the Institute of Naval Architects and the Society of Engineers.

Mr. Runciman has, recently, appointed certain committees to report on measures to safeguard the commercial interests of iron, steel and engineering trades and on shipping and shipbuilding. The Advisory Council for Scientific and Industrial Research is also appointing standing committees to deal with mining and metallurgy, both non-metallic and metallic mining and non-ferrous and ferrous metallurgy. Also an engineering committee is promised as well. Furthermore, the Royal Society recently called a conference of about twenty-five of the chief scientific and technical societies and it was decided to form a board to advise the Government on any branch of scientific inquiry which may be brought before it.

The result of all this must be to diminish rather than increase the very organization and co-ordination required.

We are told that "in the multitude of counsellors there is safety," but it may seriously be doubted whether the same can be said of a multitude of committees unless very carefully organized and correlated. The existing scientific and professional societies if properly organized would supply all that is required. These engineering institutions and societies should take a leading part in guiding the fortunes of the industries they represent and not be reduced to the level of mere paper reading or discussion societies.

The head of the group concerned with pure scientific research should be the Royal Society acting not through a few, but all of its Fellows. At the head of the technical research an organized body selected from the professional and technical societies. At present, the Government prefer to ignore the existing societies and create fresh bodies of their own selection. The result will be to weaken these existing institutions and societies.

It is essential to guard against the bureaucratization of science, and the safest and most simple method of avoiding this would be to make the great technical and professional institutions the means of advising upon the most important steps to be taken in aiding technology. Suggestions have been put forward for the creation of a Ministry of Science. It is difficult to see how any such step will assist matters at present, whilst on the other hand it might be the beginning of a system of bureaucratic control which would involve a cumbersome and expensive machinery with much inertia and delay in giving assistance to genuine research.

We have first to create a great change in the attitude of the public mind towards scientific knowledge and research and develop the conviction that until it is regarded as a most serious pursuit we shall fail to make any firm advances towards victory in industrial war.

The Scientific Organization of the Business Side of Engineering.—Then we must glance in the last place at the applications of the scientific method to the commercial side of engineering.

No one who has studied, even casually, the German methods can fail to admit they have realized fully in commercial matters the truth that union is strength. Whilst British firms are regarding one another as competitors and greatly afraid to exchange information, their German rivals have adopted every possible means to weld together all portions of their commercial enterprise into one great machine. Our ideal has been largely individualism and competition, theirs has been organization and co-operation. The German commercial system is essentially militant in nature and organization. It is all part and parcel of the plan to achieve world conquest at any cost and by every means.

Our post-war policy cannot, therefore, be simply defensive. No tariff wall can be built so high, no boycott of German goods so thorough, as to defend our position in the absence of a positive and vigorous policy of attack.

Hence the first condition of success must be association and combination, and the second the scientific method in all things.

The first principle of scientific investigation is to collect the facts and to draw deductions only by the light of full knowledge.

The inference is that our information about foreign markets must be greatly increased. This means that our Consular Reports must be improved, that foreign agencies must be staffed with men who have the necessary linguistic and scientific accomplishments, and that the study of foreign markets and of the nature of the foreign demand for goods shall be made a scientific study.

In Germany, besides the assistance of their complete Consular Reports and the help of carefully devised legislation and low export rates on railways, there are special institutes founded in connection with the Universities for the scientific study of the problem of international commerce. Private firms also associate themselves into export societies. Thus manufacturers, shippers and financialists interested, say, in the Russian or South American trade, will club together to obtain information, support agents, and obtain facilities. Steps will probably be taken for a long time to come to prevent the re-establishment in Great Britain of that immense system of organized commercial espionage by Germans who took situations and appointments of all kinds here at reduced salaries, because they were partly supported by subsidies, to collect information and transmit it in weekly reports to their real employers in Germany.

In the main, however, we have to rely on bringing to bear scientific knowledge of all kinds upon the manufacture and distribution of goods and obtaining foreign markets for the same.

The subsidization of private or national scientific research by Government funds is, therefore, only a small part of the matter.

We need to bring the scientific method of collecting the facts and drawing inferences from them to bear upon all the commercial problems of obtaining the markets and securing custom for the manufactured article. In connection with this part of the subject reference should be made to the valuable series of addresses by Mr. T. C. Elder on behalf of the British Electrical and Allied Manufacturers' Association (see *Electrical Industries*, March 1st, 8th, and 29th), and also to a recent book by Mr. D. N. Dunlop on *British Destiny*, in which the principles of scientific co-operation without destruction of true individualism are well expounded. Some excellent pamphlets on the recapture and expansion of British trade are also published by the International Correspondence Schools, Ltd., of Kingsway, London.

The importance of a true education in science is that it leads to love of accuracy as to facts, loyalty to scientific truth, unwearying labour in obtaining it, and care in the inferences derived from it. We have to cut ourselves adrift from all the past, its easy, self-satisfied mediocrity, dislike of trouble, and contempt for knowledge.

The first steps in this seem to be large reforms in education, and the second reforms in our system of party government in which the true requirements of our national life are subordinated to the efforts to retain political power in the hands of individuals, clans or parties. The only desirable form of Government is an aristocratic Government in the true and proper meaning of the term, viz., government by the most efficient and the best. The nation will have that Government when it demands it in sufficient earnest.

COLONEL SIR CHARLES M WATSON KCMG CB MA

MEMOIR.

COLONEL SIR C. M. WATSON, K.C.M.G., C.B., M.A., ROYAL ENGINEERS.

CHARLES MOORE WATSON was the second son of William Watson, civil engineer (of whom there is a memoir in the *Proceedings of the Institution of Civil Engineers*, Vol. LXXV.), and of Sarah, daughter of the Rev. Moore Morgan, rector of Dunlavin, co. Wicklow. He was born in Dublin on 10th July, 1844, and was educated at Dr. Fleury's school in Lower Leeson Street. At the age of 17 he entered Trinity College, Dublin, and was placed in the first division. He obtained honours in the term examinations of 1862, but his undergraduate course was interrupted by his wish to be a soldier. In July, 1863, he passed for Woolwich at the head of his batch, and he was still at the head of it when he left the Academy in December, 1865, receiving the Pollock Medal. He then took his degree as B.A. at Dublin University, proceeding M.A. in June, 1869.

He was commissioned as lieutenant, R.E., on 17th April, 1866, and after spending two years at Chatham was sent to Cork Harbour, where he was placed in charge of the new defence works at Carlisle Fort. In October, 1871, he returned to Chatham, being posted to No. 4 Company, which was converted into a submarine-mining company. He took part in experiments in submarine mining and ballooning, and worked out details of equipment for the Ashantee Expedition. At the beginning of 1874 he was placed in charge of railways in Woolwich Arsenal and Dockyard, but was invited soon afterwards by Colonel C. G. Gordon to join him in the Southern Sudan for survey work. He went out in July, and was employed on the survey of the White Nile from Khartoum to Rageef along with Lieut. W. H. Chippindall, R.E.

Their traverse survey of the White Nile was printed in the *Journal of the Royal Geographical Society* for 1876, and was praised by Gordon. But the work was extremely trying to men not used to hot climates and both of them fell ill. In February, 1875, Watson was sent home, Gordon writing to the D.A.G., R.E. :—" I have every reason to be satisfied with Lieut. Watson ; he has been zealous and most painstaking in his surveys, and it is much to my regret he leaves me ; but, however much he may have wished to stay, I considered that it was not my duty to let him sacrifice his life in continuing here." For the remaining ten years of Gordon's life he kept up correspondence with Watson, and his letters were full and frank.

On his return to England Watson had six months' sick leave, and was then employed at the War Office in connection with the defence of London. In March, 1877, he was made Secretary of the Siege Operations Committee. He compiled an *English-Arabic Vocabulary for the Army and Navy*, which was issued officially in 1878. He was promoted captain on 25th December in that year. Two months before this he had become A.D.C. to the Inspector-General of Fortifications, Sir Lintorn Simmons. There had been talk of his rejoining Gordon, who was then at Khartoum as Governor-General of the Sudan, but Gordon regarded his own stay there as too uncertain. He wrote:—"I am somewhat relieved that you have taken the A.D.C., though it is a loss to me. This country is a pest house, the people have been dying like flies, and my belief is that Europeans cannot live here. You are sure to get on, and I feel certain you will have a fine career. These countries are not for such men as you are, they are more for the brigand class."

In the spring of 1880 Watson went to the India Office to assist in the reorganization of the India Store Department. On 11th May he was married at Montrose to Geneviève, daughter of the Rev. Russell S. Cook, and granddaughter of Dr. César H. A. Malan of Geneva. His wife was a true helpmate to him for the rest of his life, sharing his interests and labours. She was with him in Egypt and at Suakin, and accompanied him in his journeys, which extended, not only to all parts of Europe, but to Palestine, South Africa, and America. They spent on an average two months of the year abroad.

In December, 1880, he passed the final examination of the Staff College without going through the course at the College. In August, 1882, he was ordered to Egypt, for service in the Intelligence Department of the Expeditionary Force, being graded as D.A.Q.M.G. He was present at the actions at Tel-el-Mahuta and Kassassin, and at the Battle of Tel-el-Kebir. After the battle Sir Drury Lowe, who commanded the Cavalry Division, was told to advance upon Cairo with the utmost rapidity, "to save it if possible from the destruction intended by Arabi Pasha." Watson was Intelligence Officer of the division, and he was directed to guide the right column, consisting of Indian cavalry and mounted infantry. The column halted that night at Belbeis, 30 miles from Cairo, and was joined there by the 4th Dragoon Guards. Without waiting for the rest of the Heavy Brigade and the Horse Artillery, which had been delayed on the march, Sir Drury Lowe advanced early on 14th September with a force of 1,200 men. At the Abbasiyeh Barracks, 2 miles N.E. of Cairo, there was an Egyptian force of 10,000 men of all arms, which surrendered unconditionally.

The Governor of Cairo, the Chief of Police, and the Commandant of the Citadel were sent for, and were informed that the Citadel must be surrendered that evening. The Governor begged that

British troops should not be sent into the city lest there should be disturbance ; but there was greater risk of mischief by evil-disposed persons if the Citadel was not occupied at once. As Watson knew Cairo, it was eventually decided that he should be entrusted with this delicate task, which was at first assigned to Colonel Herbert Stewart. He was to enter the city after dark with 150 men, cavalry and mounted infantry, and to get possession of the Citadel and of the fort on Mokattam Heights which commanded it.

The story of the enterprise has been told by Watson himself in *Blackwood's Magazine* (March, 1911). He was accompanied by four Egyptian officers, one of whom was an Engineer who had been sent by Arabi to make arrangements for the defence of the Abbasiyeh Barracks. Guided by this Engineer, the British entered the city by a small gate just under the Citadel, and made their way to the main gate of the Citadel where there was a strong guard. Watson sent for the Commandant and called upon him to withdraw his troops and hand over the keys. After much delay and hesitation this was done. The Egyptian troops, to the number of some 6,000, "fell in by companies and marched off as if they were quite accustomed to being roused up in the middle of the night and turned out by foreign troops. . . . For more than two hours the stream of Egyptians came out through the middle gate, and it was midnight before the last stragglers went down the hill." Watson took care, while this was going on, to keep his own scanty numbers out of view. Picking out an officer who was leaving the Citadel, he sent him to the Mokattam Fort, and in two hours the officer brought back the keys of it, having turned out the garrison and locked the gate.

Handing over the command in the Citadel to the next senior officer, in accordance with his instructions, Watson returned to Abbasiyeh to make his report ; and on his way there he rode through the city from end to end, accompanied by two Egyptian officers, so that he was able to say that Cairo was peaceful. Lowe's rapid advance, followed by this bold stroke, had saved the city from the fate of Alexandria. Watson was given a brevet majority and the Order of the Medjidieh (4th Class), as well as the medal and bronze star.

He returned to England in October, but in January, 1883, he went back to Egypt at the invitation of Sir Evelyn Wood, to assist in the reorganization of the Egyptian Army. He was appointed Surveyor-General with the rank of colonel. In August, 1884, when Sir Evelyn Wood took charge of the lines of communication of the Nile Expedition, Watson was appointed Acting Sirdar and Chief of the Sudan Department. This kept him at Cairo, and though he was recommended for a brevet lieutenant-colonelcy he did not get it. In April, 1885, he received the Order of the Osmanieh (3rd Class), and in July he was made pasha in the Egyptian Army.

In the spring of 1886 he was appointed Governor-General of the Red Sea Littoral in succession to Sir Charles Warren. He took up his duties at Suakin on 3rd May. His younger brother, Capt. A. J. Watson, who was afterwards killed before Colesberg when commanding the 1st Suffolks, was his assistant Military Secretary. Osman Digna had left the neighbourhood of Suakin, and most of the tribes were tired of war. Watson did his best to conciliate them, and promised that markets should be opened for them as soon as the country was quiet. Tamai was the chief stronghold of the Mahdists, and a raid on that place made by friendly natives on 12th July met with some success. On 23rd August Watson called a meeting of sheikhs and notables to express their views on the pacification of the Eastern Sudan. Next day he left Suakin for Cairo, and did not return. He was succeeded as Governor-General by Colonel H. H. Kitchener. Tamai was stormed after he had left, but General Sir F. Stephenson reported that much credit was due to him for utilizing the friendly tribes and encouraging them in their friendly dispositions, and that the fights which took place while he was Governor materially assisted in undermining Osman Digna's power. He went home on leave, and in January, 1887, having completed four years' service with the Egyptian Army, he reverted to corps employment. He had been promoted major in the Corps on 17th April, 1886, and he was made C.M.G. for his services in Egypt.

For two years Watson was major of the Training Battalion at Chatham, and he was then put in charge of balloons. In September, 1889, he went to the War Office for duty in connection with the proposed Barrack Loan, and in the spring of 1890 he was sent to Germany to report on German barracks. On 13th May, 1891, he was appointed an Assistant I.G.F. for the work under the Barracks Act, and on 30th April, 1896, he succeeded Colonel H. Locock as Deputy I.G.F. for that work. He held that office till 20th March, 1902, when he was retired on account of age and was made C.B. for his services at the War Office. Thus he was continuously engaged on barrack construction for 12½ years.

In the third volume of the *History of the Corps*, published last year, Watson described very fully what was the work done under the Barracks Act and under the Military Works Acts which followed it. The Barracks Act was intended to make good defects in existing barracks, especially in the large camps; the Military Works Acts of 1897, 1899, and 1901, provided for new buildings made necessary by the increase of the Army and by changes in its distribution. The total expenditure with which Watson had to do was over six millions. In carrying out his duties he made visits of inspection, not only to home stations, but to Malta, Gibraltar, the West Indies, Halifax and the Cape. He might well say, as he did in his paper on *Barrack Policy* criticizing Mr. Arnold Forster's book (*R.E. Journal*, December, 1907), that the subject was one which he had had considerable opportunity of studying carefully. He was promoted lieutenant-colonel on 1st October, 1892, and colonel on 1st October, 1896.

In his case retirement from the Army did not mean unemployment. He was British delegate at the International Navigation Congress at Düsseldorf in July, 1902, and at similar congresses at Milan in 1905 and St. Petersburg in 1908. In April, 1903, he was appointed Secretary to the Royal Commission for the International Exhibition at St. Louis, and in August he was made British Commissioner-General. This duty took him three times to North America, and involved a continuous stay there of more than a year, in the course of which he visited the Western and Southern States and Canada. His office was no sinecure, but he enjoyed it. He was made K.C.M.G. on 30th June, 1905, in recognition of his services.

His activities were by no means confined to these official functions. He had become a Fellow of the Royal Geographical Society in 1875; he was elected a member of its Council in 1893 and again in 1912. At the meeting of the British Association at Winnipeg in 1909 he was a vice-president of the Engineering Section, and at its meeting at Dundee in 1912 he was president of the Geographical Section. He joined the Council of the London Topographical Society in 1914. In July, 1890, he became a member of the Executive Committee of the Palestine Exploration Fund; in November, 1905, he was elected chairman of it, and remained so till his death. Among his many interests this seems to have stood first, and he grudged no time and pains to it. He wrote many articles on archæological points in the *Quarterly Statement* of the Fund. In 1895 Walter Besant, then secretary of the Fund, wrote an account of the work done by it in the first 30 years of its existence. Last year Watson brought this account up to date, with large additions and alterations, under the title *Fifty Years' Work in the Holy Land: a Record and a Summary*. Three years before he had written *The Story of Jerusalem*, for the *Mediæval Towns* series, with illustrations by Lady Watson. Both of them were members of the Order of St. John, and he became a member of its council in 1906. In 1909 he was made vice-chairman of the Committee of the British Ophthalmic Hospital at Jerusalem, and three years afterwards he became chairman.

He took much interest in weights and measures, and was against the compulsory adoption of the Metric System. He gave a lecture to the Society of Arts on this subject in December, 1906, which won for him the silver medal of the Society. In 1910 he published a little book on *British Weights and Measures, as described in the Laws of England from Anglo-Saxon Times*. He was in request as a lecturer on this and other subjects, such as Egypt and Palestine, the Order of St. John, and old London. He was elected to the Athenæum in 1909, and was also a member of the Junior United Service Club.

He contributed articles on Jerusalem and the Holy Sepulchre to the last edition of the *Encyclopædia Britannica*, and also a memoir of General Gordon. He wrote the *Life of Major-General Sir Charles Wilson*, published in 1909. His intimate knowledge of Wilson and his surroundings made this a biography of exceptional value, and enabled him to do justice to a man who had been unfairly treated. Lord Cromer's book on *Modern Egypt* moved him to claim *Justice to General Gordon* in the *National Review* (June, 1908).

In 1894 he had attended the Swiss autumn manœuvres as British military representative, and was impressed with the suitability of the Swiss system for our home defence army. In 1909 he published a pamphlet on *Universal Service*, a singularly fair statement of the *pros* and *cons* of voluntary and compulsory enlistment with special reference to our own conditions. He was a member of the National Service League from its formation, but was not satisfied with its programme. Compromise on the score of political expediency was not at all to his taste.

With all his other interests he found time for the concerns of the Corps. He served for many years on the Council of the R.E. Institute, and took an active part in the business at Corps meetings. Quite lately he was elected a trustee of the Widows' Fund. He wrote many valuable articles in the *R.E. Journal*, and memoirs of Sir Lintorn Simmons, Sir John Ardagh, and others. He undertook the laborious task of bringing General Porter's *History of the Corps of Royal Engineers* up to date by a third volume which was published last year.

He was a man whom the Corps can ill spare. Few officers have had such diversified service; yet he always did well, for he was an all-round man adaptable to any job. He had ability, industry, and method, and—as he showed at Cairo—he had courage, coolness, and resource. The end came quickly and he was spared the pains of a long illness. He was occupied as usual up to Monday, the 13th March, when he was sufficiently unwell to see a doctor and go to bed. Bronchitis followed, and on Wednesday, the 15th, he passed away owing to heart failure. He was buried at Putney Vale Cemetery on the 18th, the first part of the service being held at St. Paul's, Knightsbridge (*v. Supplement to the R.E. Journal for April*).

The *Quarterly Statement* of the Palestine Exploration Fund speaks of his death as a calamity:—"During the last 10 years, his able guidance, his wide knowledge, and his personal charm have been invaluable to the Society, and endeared him to all those who in any way shared his work, or were brought into frequent contact with him." There was a good obituary notice of him in the *Times* of 16th March.

E. M. LLOYD.

REVIEW.

HISTORY OF UNDERGROUND WARFARE.

Being a Review of the book by A. GENEZ, Captain of Engineers, French Army.—(Librarie Militaire Berger Levrault, Paris, Rue Des Beaux-Arts 5–7, 1914. Price 5 francs).

MANY requests having been received that this Review which originally appeared in the *R.E. Journal*, commencing in September, 1914, should be re-published, the first instalment is herewith given.—[EDITOR, *R.E.J.*]

The small importance of the sieges undertaken during the Franco-German War, with the exception of that of Belfort, has had the effect of diverting attention from the use of military mines as an aid in siege warfare. Other causes, such as the advent of heavy shells with large charges, the addition of pontoon bridging to the duties of the Engineers, and the introduction of short service also tended to the neglect of the art of mining. The Siege of Port Arthur, however, has shown that this art is not out of date, and the time seems opportune for reviewing the past in order to recall the glories of underground warfare, to follow its evolution, and to compare the successive characteristics of mining in attack and defence.

This history is divided into four principal periods:—

First period—up to the year 1487 when gunpowder was first employed in mines at the Siege of Serezzanella, near Florence.

Second period—that of breaching by means of mines, from 1487 to the Siege of Candia (1667 to 1669) during which the miner determined to meet his adversary under the glacis, and employ explosives against him.

Third period—from the Siege of Candia to that of Schweidnitz in 1762 where the *globe of compression* of Belidor was first made use of.

Fourth period—from the Siege of Schweidnitz to the present day.

FIRST PERIOD.

The use of mines in the attack is of great antiquity. The Siege of Fidenæ by the Romans in 430 B.C. furnishes a typical example. At this time the only object was to gain a footing unobserved within the defended locality. The employment of mines in defence was probably subsequent to their use in attack, and an old Greek author, writing on the subject of countermines, recommended that when it had been observed that the enemy was driving a mine, a deep ditch should be dug outside the ramparts, having its sides supported by masonry. This was to be filled with dry wood, and when the assailants broke into it, the wood was to be set on fire and covered over with earth to force the smoke into the enemy's gallery. Another suggestion was that the introduction of swarms of bees into the mine would cause no little inconvenience to the assailants.

Again, he mentions the Siege of Barca by Amaris, King of Egypt. The defenders were convinced that a mine was being driven under the fortifications, but could not discover on which side. A tinsmith conceived the idea of using a bronze shield as a stethoscope. Applying it methodically to the ground in various places, he soon discovered where the miners were at work. A countermine was then sunk above the besiegers' gallery, and the defenders, having the advantage of the command, soon drove out their assailants.

Polybius gives an account of a breaching mine at the Siege of Pale. Philip III. of Macedonia caused galleries to be excavated up to the walls, with branches under the foundations. The walls were then supported on wooden staging for a length of two arpents (480 ft.). When all was ready the staging was set on fire, with the result that the walls collapsed, forming a practicable breach through which the besiegers rushed and captured the town. It is probable that holes from the galleries were made at intervals outside the walls to allow the smoke to escape and improve the draught.

Philip successfully employed the same system at the Siege of Thebes, but at Apollonia the defenders outwitted him. From inside the walls they drove galleries towards the front, and hung bronze vases in them. The vibration of one of the vases denoted the blows of a pick in a neighbouring mine, the position of which was carefully estimated. Above the supposed position of the mine, a countermine was [illegible]ted, in which were collected cauldrons of boiling water and pitch, m[illegible]il, and hot sand. During the night shafts were sunk to the mine and the materials thrown into it, killing all the workmen.

During the Milbridatic Wars at the Siege of Thermiscyra countermines were dug over the assailants' mines, and bears, and other wild beasts, also hives of bees, were lowered into them.

Many other instances occur in ancient times, and in the Middle Ages, of the use of mines both in attack and defence. One of the most striking of these is the Siege of Chateau Gaillard by Philip Augustus in 1204. The defenders excavated their countermines too close to the foundations of their wall, with the consequence that it soon fell under the blows of stones hurled from a ballista.

At the Siege of Acre, which fell in 1291, Greek fire was used to set fire to the works. The wooden towers on wheels which the Crusaders had constructed, were set on fire by this substance. Philip Augustus, who was present at that siege, succeeded later in destroying by Greek fire the English fleet which was blockading Dieppe. About the same time Gaubert of Mantes set fire under water to a double stockade which protected the Island of Andelys, after having had fireworks, enclosed in pots of earth, fixed to it by divers.

Cæsar (De Bello Gallico. Vol. VII.) relates that the Gauls at Bourges destroyed his works by mining under them, a labour to which they were accustomed owing to the number of iron mines in the country[1]

When the Romans excavated mines the Gauls broke into them, filled them with beams, sharpened, and hardened by fire, with pitch and heavy stones, and thus prevented the miners from approaching the walls.

Second Period.

Gunpowder produced a great improvement in weapons of war, but was not used in mines until two and a-half centuries after its invention. The first attempt at modern mining was made in 1487 when the Genoese were attacking the Florentine town of Serazzano. One of their engineers filled his mine with powder instead of with staging and faggots, but as he did not tamp the charge the explosion took effect outwards, and the fortifications were not damaged. A Spanish soldier in the Genoese service, Peter of Navarre, who was at Serazzano and afterwards rejoined the Army of his own country, tried in 1500 to blow down the walls of the Castle of St. George on the Island of Cephalonia. The attempt was not altogether a success, but the breaches which were made led to the surrender of the castle.

About this period, during the quarrels of Louis XII. and Ferdinand II. over the partition of the Kingdom of Naples, the French in the forts surrounding the city of Naples were besieged by the Spaniards. Here Navarre determined to repeat his experiment and blow up the Chateau Neuf. On this occasion he was successful in effecting a practicable breach. The Chateau de L'Œuf was next attacked. Situated on a rocky peninsula almost cut off by the sea and defended on the land side by a deep ditch, the castle could only be approached by sea. Navarre roofe[illegible] some boats, and from them opened a gallery which he drove str[illegible]t under the castle. In this he fired a mine by slow match, the rock was split, and a large portion of the wall of the castle fell. Many of the defenders were killed, the remainder were easily overpowered.

Navarre continued his brilliant career at the Siege of Bologna in 1512, and prepared a mine under the walls. The wall was blown vertically into the air for several feet, but fell again on to its foundations, hardly cracked. So high was it raised that the assailants actually saw beneath it the defending troops drawn up ready to repel their assault. From this failure Navarre learnt not to place his charge exactly under the centre of gravity of the mass to be shattered. That such an event is possible was exemplified in 1795 when the same phenomenon was repeated in blowing up a solidly constructed curtain during the demolition of Fontarabia.

Navarre had by this time achieved such a reputation that the Castle of Milan, which had already withstood several sieges and was considered impregnable, was surrendered with a strong garrison well supplied with food and munitions of war, by Duke Maximilian Sforza, as soon as it was known that Navarre was to conduct the siege.

Countermines were successfully employed at Marseilles in 1524, and at Naples in 1528, and the sieges were abandoned. In 1529 the Turks employed mines against Vienna. These were interrupted for the greater part by the countermines of the besieged, only a few could be fired and the assault was repulsed. The expedient of countermining therefore seems to have followed very quickly on Navarre's invention of powder mines

Probably the earliest instance of countermines prepared deliberately in advance occurred at Padua, which was besieged in 1509 by the Emperor Maximilian I. with a mixed army of Germans, Italians, Spaniards and French. This town then belonged to the Republic of Venice, and was exceedingly well organized to resist a siege. The garrison was large, provisions plentiful, and there were two lines of defence, in the interval between which countermines had been prepared. A few exterior works of small importance had been captured when a strong effort was made against one of the bastions. A breach was made by the artillery sufficiently wide for the advance of 1,000 men. Two assaults failed, the third was successful, but scarcely had the last Venetian left the bastion when the mines beneath it were fired. Many distinguished generals were killed, and the Imperial troops were so dismayed that they were rapidly driven from all the works they had already captured.

The moral effect of this event was so great that Maximilian found it impossible to induce any of his troops to hazard a further assault, although he proposed that it should be led by the cream of his troops, the gendarmery of France. Never was such a demand for priests to hear the confessions of those who might be detailed for the assault. The Chevalier Bayard expressed great indignation that noblemen should be expected to risk their lives fighting with bakers, shoemakers, and such riff-raff, and advised that, as there were plenty of German counts, seigneurs, and gentlemen, they should be directed to support the gendarmery, who would willingly show them the way. It is well known how the Chevalier, "sans peur et sans reproche," shuddered at the idea of a bullet, the only weapons worthy of him were spear and sword wielded by gentlemen.

In 1601 an army composed of Spaniards, Germans, Italians, and Belgians, under Marquis Spinola, laid siege to Ostend, which was held by a mixed garrison of Dutch, English, and French. This city had been fortified by William of Orange, who protected it by a girdle of bastions. The attack was directed almost entirely against the front facing Nieuport; on the attackers' left, near the sea, was the Sandhill Bastion, separated by a canal from the Hellemond Bastion, then the West Gate, South-West and Polder Bastions, and on the extreme right the South Bastion. Communication with the sea could not be interrupted, so that the defenders could by this means obtain supplies of all kinds. The Commandant was Colonel Vandernoot, an experienced and clever man.

Every attempt at a general assault failed, and in 1604 recourse was made to a step-by-step advance. To the Germans was entrusted the attack on the Sandhill, to the Spaniards that on the Hellemond, to the Belgians the West Bastion, and to the Italians the Polder and South Bastions.

A lunette called the Green Ravelin covering the Hellemond was first attacked in March, 1604. The earthwork of the salient was demolished by small mines, then called petards, and the salient captured. The work was cut in half by a palisade, to capture which mines had again to be employed. The besieged countermined, and combats took place in the galleries, but the besiegers managed to explode their mines, and the place was captured.

Meanwhile the Belgians mined the glacis of the West Bastion, and the explosion of "9 tons of powder" (about 900 lbs.) enabled them to obtain possession of a ravelin which protected the front of the bastion, and to capture its garrison on 18th April. The descent of the ditch was then undertaken, and by 27th May it was possible to reach the escarp. The ditch was fordable, and a hard bottom was made with fascines and hurdles. To save time it was decided not to mine under the ditch, and though a deserter said that the parapet was countermined, six officers and soldiers volunteered to cross the ditch, and make an opening in the escarp. They advanced under a fierce fire from both flanks, but in half an hour the survivors had dug themselves in. A covered way was then made across the ditch, and in eight days' time 40 ft. of mine gallery had been excavated under the parapet. The mine chamber was loaded with "30 tons" (3,000 lbs.) of powder.

Troops were drawn up for the assault, and a few men sent on to the parapet to draw the garrison out over the mine. The result of the discharge was to open a wide breach, but a great deal of the effect acted outwards, and killed or wounded numbers of the assailants. It also opened out the approach to the defenders' fire, and the assaulting troops lost heavily. A counter-attack by 400 men repulsed them to 60 paces from the ditch, their works in the crater were destroyed and their fascines burnt. A parapet 12 ft. high was then constructed to close the breach.

Several days were required by the assailants to regain the escarp, when the besieged themselves fired a mine, thereby disclosing a masked battery constructed behind the parapet, and which commanded the besiegers' approach. However a fresh mine was dug, and was about to be charged when the movements of the defenders seemed to indicate the preparation of a countermine. To make sure if this was the case or not the besiegers sent out a reconnaissance. The defenders thought this the prelude to an explosion, and themselves retired. The besiegers then waited for the discharge of the supposed countermine, and did not dare to return to their works until a spy had ascertained that no countermine existed. Eventually the mine was charged and fired at the end of June. Again the greater effect was produced outwards, and the assailants lost heavily. However the assault was delivered and half the bastion was taken, but another mine was necessary to capture the remainder.

On the besiegers' extreme right the Italians effected the passage of the ditch of the S.W. Bastion, and after several small explosions, each followed by a slight advance, managed to charge and fire a larger mine. The defenders countermined unsuccessfully, and the Italian mine formed a good crater from which they were able to make a further advance. At length the explosion of 2,000 lbs. of powder cleared the way for the final successful assault. But before this occurred the combatants often met below ground, where sanguinary encounters took place in the dark. Occasionally barrels of powder were accidentally fired, burying dead and living, or blowing up indiscriminately any combatants who might happen to be overhead.

The Spaniards advanced steadily towards the Hellemond, one of their mines uncovering a countermine which was just ready for firing. Another countermine was broken into, but a moment later a second close by was fired, and suffocated more than twenty of their workmen. An hour later the attack fired a mine which killed a number of the defenders, who had been enticed over it by the false alarm of an immediate assault. The capture of the Hellemond, which commanded and flanked the Sandhill, rendered possible the capture of the latter which it was almost impossible to mine as the sand fell in as quickly as it could be removed. It was taken on 13th September.

The besiegers now found themselves confronted by a second enciente. The defenders compared Ostend to ancient Troy, and called their first line New Troy, the second Little Troy. However batteries erected on the outer line soon reduced to silence the guns of the inner lines, which were on a low parapet, commanded by the former. The defenders were not yet discouraged, they fired mines in the space between the two lines and compelled the besiegers to advance with circumspection. When the second line had been captured yet a third appeared. The Germans from the Sandhill were able to penetrate a work defending the old town, which they carried after exploding a mine, and on their right the Spaniards captured a large demilune. The defenders had now lost the key of their position, their communications with the sea were threatened. They capitulated on 20th September, 1604, after three years of siege, and seven months of underground warfare.

Subterranean works thus had an important bearing on the results of this siege, but it is noteworthy that the defenders only used countermines to enable them to reach the attackers' galleries, to fight them there, and do what damage they could by hand. They do not appear to have made any systematic use of gunpowder to destroy at a distance the galleries and mines of their opponents. The explosions of the defence had as object to check the assaulting columns, and to spread panic in their ranks. The way in which they utilized mines to suddenly clear the foreground and unmask batteries trained on the attackers' approaches is also worthy of notice.

In 1654 Arras was besieged by the Spaniards, and affords a good example of the employment of a grand parallel covering the artillery. Approaches from it by zigzag or double sap brought the besiegers to the counterscarp. Fresh batteries were erected on the glacis, and mines carried from them towards the most advanced work, which was not revetted, but had steep slopes with palisades in front. The defence was stubborn, and the attack could only advance step by step. On 1st August two shafts were sunk, whence galleries were driven towards the salient. Efforts to reach these by countermining were unsuccessful, and on the night 7th August the mines were fired with good effect, and the craters occupied after a three hours' fight. No further advance could be made, and mining had again to be resorted to. This time the defenders were successful in countermining, and hindered the work considerably, only giving way on 18th August. On 24th the palisades of the covered way of the place itself were blown up, but attacks made on that and the following day failed, and Turenne's Army arrived in time to raise the siege. In this case the defenders advanced underground to meet the attackers as the ancients had done, and were undeterred by fear of explosions.

Military mines had now reached such importance that much controversy took place in regard to their construction and destruction. The ancients attacked the bases of the walls, but the advent of artillery led to the use of thick parapets of earth, which was obtained from a ditch, and galleries had to be inclined, or shafts sunk, to obtain the necessary depth. Wider and deeper ditches made the labour of driving galleries excessive. The failure of the first powder mines demonstrated the necessity of tamping the charge, and this led to placing the charge in returns, and not at the actual end of the gallery. Long vertical or stepped shafts with horizontal galleries from them were easier to construct than inclined galleries, but communication was more difficult.

Chevalier Antoine de Ville, an engineer born in Toulouse, now suggested sinking shafts in steps each the height of a man, from which it was more easy to remove the earth than from deep shafts. These shafts were sunk chequer-wise to facilitate tamping. Occasionally shafts were sunk in the ditch itself, or the ditch was crossed by blinded galleries. De Ville also indicated a method of defence by countermines; a shaft was sunk in the terreplein of the fortress whence a gallery was driven to beyond the counterscarp. At its extremity a transverse gallery was made embracing all ground likely to be threatened by the enemy's mines. From the transverse gallery shallow shafts were sunk, and branch galleries from these, which were in turn joined up by a second transverse gallery. De Ville unequivocally condemned the counterscarp galleries of the first French and Italian bastion systems, and to him therefore belongs the honour of having invented the system of modern countermining.

Candia, held by the Venetians, was besieged by the Turks from May, 1667, to September, 1669. The Turks could not isolate it from the sea, so that supplies were constantly pouring in. On the land side it was defended by a good seven-faced bastioned front, covered by exterior works which were countermined with a view to their destruction when they could no longer be held. Captain-General Morosini was in command, and this siege has made his name famous. The Turks opened parallels, and tried to make use of mines, but the defenders listening in their galleries always detected them, blew them up, or penetrating the galleries, damaged or carried off the powder. One of the outer works was captured by the Turks at the end of the fifth month of the siege, and after being recaptured, was finally abandoned and blown up with its Turkish occupants by a charge of 7,000 lbs. of powder. During the first six months 618 mines were fired, and the Turks acknowledged losing 12,000 men by that agency. A mine containing 18,000 lbs. powder is recorded, and during the year 1668 the defenders expended 3,000,000 lbs. of powder.

De Morosini had more faith in mines than in sorties, and the disastrous result of one sortie confirmed him in this opinion. In 1669 he determined to blow up the salient, which the Turks had captured, of one of his bastions. The explosion was of terrible effect, but the Turks returned to the attack, and on their part, succeeded in destroying the remainder of the bastion by a mine. This opened the place, and the end of its defence was at hand when a French division arrived as reinforcement. Morosini was unable to deter them from making a sortie, and they succeeded in driving the Turks from their trenches. Unfortunately at this moment a few barrels of powder left in a battery exploded. The French, who for the last two years had heard of nothing but the fatalities caused at Candia by mines, mistook this explosion for the bursting of a mine. Consternation seized commander and soldiers; the ranks broke and fled. The Turks pursued, but were checked by the fire of the garrison. It was, however, impossible to restore confidence, the remainder of the French troops departed by sea, the Germans followed, and Morosini, left to his own resources, was obliged to capitulate.

This deplorable event again draws attention to the moral effect of mines. Napier records that at the assault of Badajoz half a British regiment, which had escaladed the wall, fled in disorder at the sight of a lighted match on the ground, which had just been used to fire a gun. Prior to the assault of the Malakoff at Sebastopol, the Engineers fired several large mines on the glacis, which would certainly have destroyed any of the enemy's mines which had happened to be near, but were, in fact, only fired to inspire confidence in the attacking troops by showing them that their own troops were masters of the ground. Chevalier de Ville pointed out a means of locating the enemy's mines by the use of a boring tool. At Candia borers were used, and the miners placed small charges at the bottoms of the holes and fired them when they heard the enemy at work near by. This siege was therefore the first at which bored mines were used.

The French engineer Castellan, who was at Candia, returned to France after the siege, and was employed by Vauban to direct the mining operations at the Siege of Maestricht. He doubtless told Vauban how the Turks, against whom every inch of ground had been disputed, had multiplied their trenches and places of arms. Vauban had already published his *Première Instruction sur les Sièges*. At that time it was usual to open only one parallel, and in it, under the name of the Royal Battery, to place all the guns destined for the bombardment of the fortress. At Maestricht Vauban applied a new method of attack which he had deduced from the Siege of Candia, and opened several parallels.

A.R.R.

(*To be continued*).

NOTICE OF MAGAZINE.

REVUE MILITAIRE SUISSE.

No. 3.—March, 1916.

THE ITALIAN ARMY.

Impressions from the Front.

The article on the above subject begun in the number of the *Revue* for February of this year (*vide R.E. Journal* for May, 1916) is concluded in the March number of the *Revue*.

IX. *The Artillery.*—In a campaign which has assumed, to such a great extent, the features of siege warfare artillery necessarily plays a very prominent *rôle*. The Italians have employed mountain artillery, supported by naval guns of the smaller types, in the mountain regions in which they are operating with some success against the enemy's camps, masses of troops and transport columns; but the mountain artillery has not been found to be effective against the enemy's entrenchments.

The Italian field artillery has proved to be excellent; at the beginning of the War it was armed largely with guns of Krupp manufacture; a few only of the artillery regiments were armed with the French Deport gun—an improvement on the now famous "75" mm. gun. It is the Deport gun which is most largely in use to-day.

Fortunately, the Italians had, prior to the outbreak of the War, provided their field army with heavy artillery. The lessons of the early phases of the War have not been lost sight of and, in consequence, great efforts have been made largely to increase the number of heavy guns in the Italian Field Army; guns intended for the coast defences have in some cases been diverted to the use of the Italian Field Army.

On the whole, the artillery has been well handled by the Italians and the Austrians have on several occasions suffered heavily from artillery fire owing to the skilful management of the Italian guns.

X. *The Engineers.*—The Italian Engineers have had some exceedingly tough work to perform in this war. Since the Italians invaded enemy territory at the very beginning of the War one of the first tasks which fell to the lot of the Engineers was the restoration of the communications at points where railway and road bridges had been destroyed by the retiring Austrians; they have acquitted themselves right well. In the mountain regions, new roads practicable for artillery have been constructed in an incredibly short space of time by the Engineers.

Owing to the great extent of front along which the Italian Army is operating—amounting to 310 miles—it became necessary at the beginning of the War, to increase very largely the engineer arm; for this reason whole battalions of infantry have been converted into battalions of engineers.

XI. *The Cavalry.*—The present war has offered few opportunities for the cavalry to be employed on duties proper to that arm under normal conditions. Rather than wait idly for the day when conditions may again favour the employment of cavalry in its familiar *rôle*, officers, N.C.O.'s and men of the Italian Cavalry have sought transfer to other arms of the service, and, in consequence, large numbers of them have been transferred to the artillery, whilst others are now taking part in trench warfare as infantry.

XII. *The Officers.*—There are several military colleges for cadets in Italy, *e.g.*, at Pinerolo, Naples, Modena, Rome, Turin, Parma, etc., as well as schools for the technical branches of the Service and a War School at Turin. In Italy, as in other countries, candidates for staff employment are called upon to pass stiff examinations before their names can be placed on the approved list.

The courses of instruction in the military colleges and schools are based on the curricula which obtain in similar institutions in France and Germany.

XIII. *Discipline.*—The conditions which prevailed prior to the period when the several States, which now constitute United Italy, were welded into a single monarchy have left their trace on the Italian people; this consists in the marked individualistic tendencies shown by them. Nevertheless, in spite of this feature in the Italian temperament, thanks to the influence of the nationalistic policy which has been promoted by Italian statesmen, it has been possible to maintain a high state of discipline in the Army. A most excellent spirit obtains in the Italian Army and the relations existing between officers and men is all that could be desired, as is evidenced by the many deeds of self-sacrifice performed on the battlefield which have been recorded in connection with the lists of honours and rewards published from time to time.

XIV. *Conclusion.*—When the *Revue* article was written Italy had been at war for seven months; at that time vast reserves of *personnel* in the country had been left untouched and, except on the actual battle front, the civil population were carrying out their avocations almost in the same way as would have been the case under normal circumstances.

The present war has brought about that political union which the statesmen of Italy have been in search of during many decades past. Italians have flocked from all parts of the world to join the Italian armies operating on the Austrian frontiers with the object of realizing the ideals which the people of United Italy have been striving after, and for the first time in the history of this people is to be seen the spectacle of a national army sent forth to fight the battles of the country prepared beforehand in every way for the task assigned to it.

Belgium and Swiss Neutrality.

It is pointed out in an editorial note that the *Revue* article was written at a time when certain newspapers were calling attention to the fact that Belgium had not officially declared itself a party to the Pact of London, by which the Entente Powers had engaged themselves not to make peace separately with the Central European Powers; in consequence, it had been concluded that Belgium might possibly make a separate peace with Germany. The writer of the *Revue* article makes it clear that he personally did not consider the contingency of a separate peace on the part of Belgium probable; all doubts on the subject have now been set at rest by a recent declaration of Baron Beyens, the Belgian Foreign Minister, which amounts to an adhesion to the Pact of London. It is pointed out in the *Revue* article that Belgian honour has been too deeply wounded for the nation to accept lightly any peace offers which Germany may be willing to make; the government of Wilhelm II. has not yet been sufficiently humbled, it is thought, to induce it to offer anything more than the *statu quo ante* just now; at the same time it is recognized that the day may not be far distant when Germany will be glad enough to have one enemy the less and a frontier shorter by 90 miles to defend than that with which it is now concerned.

It is pointed out that it is not the probability of a separate peace between Belgium and the Central Powers which interests Switzerland most, but the effect such a peace is likely to have on Swiss neutrality and the independence of the Republic. The basis on which a separate peace might be concluded by Belgium is examined and for this purpose the history of this country is very briefly reviewed. It is pointed out that when the Belgian Provinces were under Austria in the XVII. and XVIII. centuries they constituted a more or less neutral buffer between Holland and France. After a short and troubled existence, from 1790 to 1795, as a Republic under the title of the United States of Belgium, this country—which then comprised more territory than it did in 1914—was annexed by France, in the year last mentioned. The next stage in its existence was as an integral part of Holland by virtue of the international agreement made at the Congress of Vienna. When the French sovereignty was put an end to a great part of Belgian territory, namely portions of the Departments of Luxemburg and the Lower Meuse, were acquired by Prussia and only what remained of Belgium thereafter was incorporated into Holland. The Belgian territory transferred to Prussia has for more than 100 years been in the nature of a Belgian "Alsace-Lorraine." The population of this territory is estimated at half a million and the majority of the inhabitants in this region, it is said, would welcome a return to Belgian rule. The surrender of this territory to Belgium would, it is thought, be pressed for by the Belgian Government in any peace negotiations with Germany. As Germany's military position would not be injuriously affected by acquiescing to such a demand, the reincorporation of this lost territory into a reconstituted Belgium may, it is suggested, well form a basis for peace negotiations. It is also pointed out that Belgium has never given up hope of some day re-acquiring the Grand Duchy of Luxemburg.

When the existence of Belgium as an independent kingdom was recognized by Austria, France, Great Britain, Prussia and Russia after the revolution of 1830, Holland obstinately refused to accept the situation, not only at that time but for some years after.

However, in 1839, on Belgium agreeing to allow Holland to retain, *inter alia*, Dutch Flanders, *i.e.*, the left bank of the Scheldt, west of Antwerp, the Grand Duchy of Luxemburg and the greater part of Limburg, including the fortress of Maestricht, Holland finally acquiesced in the independence of Belgium. Should Germany therefore desire to make peace with Belgium, it is expected that she might offer the latter the Grand Duchy of Luxemburg, since it now belongs to none of the European Powers, as well as the Rhenish territory formerly belonging to Belgium, since this forms but an infinitesimal part of German territory.

Although not strictly pertinent to the subject under discussion, the writer of the *Revue* article refers to the offer made by Belgium in 1863 to purchase from Holland the right to collect navigation tolls on the Scheldt, below Antwerp, for the sum of about $1\frac{1}{2}$ millions sterling; previously to this Belgium had attempted to reacquire, on suitable terms, Limburg, Luxemburg, and the territory on the south bank of the Scheldt below Antwerp. At that time Holland would not entertain the foregoing proposals, but the whole situation has altered since then.

The writer of the *Revue* article recognizes that the conclusion of a separate peace by Belgium with Germany might not be looked upon favourably by the Quadruple-Entente Powers. However, he argues that since Belgium sacrificed herself in 1914 to save France, it would ill-become the latter country to oppose, at the present time, any action Belgium might take to obtain advantageous peace terms from Germany. Sight is not lost in the *Revue* article of the fact that if peace should be restored in Belgium the future neutrality of this country must be provided for on a more secure basis than was the case under the Treaty of 1831; *inter alia*, Belgium will require a frontier better capable of defence than her frontiers of 1914, as also a larger army. Further, it is suggested that Belgium herself will demand to be placed in the same position so far as her new neutrality rights are concerned as that occupied by Switzerland at the present time, *i.e.*, she will claim the *right to remain neutral* instead of having *the obligation imposed on her to remain neutral*.

The writer of the *Revue* article concludes that it would not be *impossible* immediately to secure the neutrality of Belgium on a broad basis and with added territory beyond her former frontiers subject, of course, to the assent of the other belligerent powers. "What would," it is asked, "be the consequences of such an event on the neutrality of Switzerland?" At present Switzerland is far removed from the regions in which the struggle in the western theatre has been most intense. The elimination of Belgium as a theatre of operations would, it is suggested, materially alter the situation so far as Switzerland is concerned. The German Army Corps released from the portion of the western front situated in Flanders, in Artois and in the Champagne would be set free for operations in other theatres. "Would these troops," it is asked, "be transported to Bagdad, Erzeroum or Salonica when it is on the cards that immediate and decisive results could be obtained by one side or the other in the present struggle making use of Swiss territory as a means of getting at his adversary?" The writer of the *Revue* article answers the latter question in the following terms:—"It is hardly probable; rather is it necessary to expect the contrary." He is clearly of opinion that a separate peace between Belgium and the Central European Powers cannot be looked upon as something favouring Swiss interests. He recommends the Swiss Foreign Office further to study the military situation.

A HISTORICAL POINT.

A difference of opinion exists between the writer of the article entitled "Independence and Neutrality" (reviewed in *R.E. Journal* for September and December, 1915) and a critic of Swiss nationality with reference to the behaviour of the Armies of the Directory which invaded Switzerland in 1798. This difference of opinion has given rise to a controversy which is published in the March number of the *Revue* under the above heading. This controversy is of little military interest in this country.

SOME REFLECTIONS ON SWISS MILITARY EQUITATION.

The writer of the *Revue* article, who is a Swiss cavalry officer, states that instruction in riding and the breaking in of remounts are matters which, in his opinion, are not properly attended to in Switzerland; there is too much go-as-you-please in relation thereto. He urges, in consequence, that a school of equitation should be formed in Switzerland so that instruction in riding, breaking in of remounts, horse-mastership, and veterinary services may be centralized, and in order that uniformity of teaching and in practice may thus be gained.

HOW CAN THE GERMAN FRONT BE PIERCED?

The article on the above subject begun in the February number of the *Revue* (*vide R.E. Journal* for May, 1916) and is concluded in the number of the *Revue* under review.

The part of the article which appeared in the February number of the *Revue* concluded with a reference to the *rôle* played by the French artillery in preparing the way for the attack in an up-to-date battle. The part of the article under review opens with a reference to the *rôle* of infantry in carrying through an attack on the enemy's trenches. The important questions which arise in connection with the actual launching of the infantry for the attack are three in number:—

(*a*). How should the signal for the infantry to move forward for the attack be given?

(*b*). At what time should the signal be given?

(*c*). By whom should the signal be given?

As regards the first of these questions, it is suggested in the *Revue* article that it would be better for troops to act by the clock rather than that they should have to wait for a signal. In connection with the sieges of former times, the signal for the advance of the attacking troops at the opportune moment was, it is true, usually given either by the firing of an artillery salvo or of signal rockets. But in those days, the fronts held by the opposing sides were so narrow that the higher commanders could from personal observation form a more or less accurate opinion regarding the progress of events and decide whether or no the decisive moment had arrived for launching an attack. With the wide fronts held to-day it is impracticable, if not impossible, for the higher commanders to ascertain at first hand how matters may be shaping; under the circumstances, it is most difficult to give the signal for the attack at the psychological moment; it is as likely to be given too late or too early as at the decisive moment. It is recognized that serious consequences may follow in cases where the infantry is ordered to advance to the attack at a set time regardless of the actual situation. It is quite possible that the artillery bombardment may not have sufficiently paved the way to enable the infantry attack to be launched with any prospect of success; other circumstances, such for instance as fog, may intervene so as to prevent the infantry from moving. However, since the consequences likely to follow upon infantry being shelled by their own artillery must prove more disastrous than those to be anticipated in the case where columns of attack are late in making their forward move, it has become an established practice in the French Army to order the infantry attack to commence at a specified time.

Where the distance which must be covered by the attacking infantry to reach the enemy's trenches does not exceed 100 yards, the attack is delivered by successive "waves" of companies, the first of which is organized in two parts, thus:—

(1). A line of skirmishers at five paces interval, formed either by extending a complete section or by sending forward selected men from each of the sections of the company, in extended order.

(2). An "attacking line," 50 yards in rear of the skirmishers, consisting of a single rank of men, elbow to elbow, or at one pace interval.

It is unwise to count on surprising the enemy; and it would be equally foolish to assume that the attacking troops can be got to advance without replying to the fire with which they are likely to be met. The object of having a thin line of skirmishers, as above, is to afford some protection to the "attacking line," since the skirmishers can open fire on the enemy, whilst the closed rank in rear advances steadily forward without losing its alignment, and without firing until the enemy's trenches are carried.

Extracts are given in the *Revue* article from Capt. Laffargue's account of his experiences.

He states that at Neuville the first "wave" of the French infantry moved forward in the formation sketched out above; advancing at first at a steady marching pace, only when some 60 yards from the enemy's trenches did it break into a slow double. The "attacking line" maintained its alignment as if the men were on a peace parade. Considerable importance is attached by Capt. Laffargue to the maintenance of alignment on the part of attacking troops; he states that, in spite of the annihilating fire of machine guns, as he was leading the attack forward at Neuville, he could hear above the din of battle the "epic and splendid cry of supreme encouragement": "Alignez-vous! Alignez-vous!" which rang out along the rank behind him. He further states: "The advancing wall-like line proved irresistible."

Capt. Laffargue objects to the term "reinforcements" being applied to the second "wave," since the merging of the second "wave" into the first "wave" is in no way contemplated. On the contrary, it is expected that the first "wave" will, as a rule, have expended itself in the early phase of the infantry attack, and consequently fresh troops will have to be substituted for the men composing it. The second "wave" should, as far as possible, avoid the zones in which the enemy's fire has proved most destructive to the first "wave," and should be pushed into the attack along the portions of front in which the enemy's resistance has perceptibly weakened. When the second "wave" has succeeded in gaining a footing in the enemy's advance trenches, it should at once be re-formed and then pushed forward to the enemy's second line of trenches. The enemy, when driven eventually from portions of the second-line trenches assaulted, is generally able to continue in possession of the "centres of resistance" prepared in rear of the first line of trenches and thus can prevent the second "wave" from extending outwards.

It is suggested that in many cases the functions of the second "wave" have not been clearly understood by responsible commanders. Instead of looking upon it as a second line of attack, with a task similar to that of the first "wave," destined to replace it and to continue the action by advancing against definite objectives assigned to the second "wave," commanders have, too often, confined themselves to the utilization of the second "wave" for the purpose of reinforcing the first "wave" at points where it appeared to have been weakened and to need support. Another error made by commanders is that they have frequently lost sight of the fact that since the troops destined to form the second "wave" themselves come under the artillery and rifle fire directed against the first "wave" these troops should consist of specially picked men; by reason of this oversight, less reliable troops have often been employed in the second "wave" than in the first "wave," with the consequence that the attack has come to a dead stop before attaining its objective.

The above criticism may perhaps be correct; nevertheless the question arises whether after all the best troops should not be used to break a passage through the enemy's trenches for the troops which follow and also in order to set them an example to be imitated.

A short description is given in the *Revue* article of the preparations usually made in connection with the launching of the second "wave." It is stated that the troops to be employed in the second "wave" are pushed forward as near to the first-line trenches as possible and held in readiness in the sidings in the communication trenches. In cases where the opposing first-line trenches are very close together, the nearer the troops for the second "wave" are to the fire trenches the less are these troops likely to suffer from the enemy's artillery fire. As soon as the whole of the first "wave" has been launched, the troops for the second "wave" at once occupy the vacated first-line trenches. Although no long interval of time should be allowed to elapse between the launching of the first and second "waves," yet it is essential that the effort of each of these "waves" should be kept entirely distinct. The second "wave" should, therefore, be launched when the first "wave" is on the point of penetrating the first zone of the enemy's defences. The troops forming the second "wave," having deployed in the first-line trenches, are sent forward simultaneously against objectives which should be definitely assigned to them, *i.e.*, it should be clearly stated that—

(*a*). The zone between named points must be seized.

(*b*). The outlying parts of a definite "centre of resistance" must be seized.

Each company composing the second "wave" should advance in two parallel ranks, separated from one another by about 150 yards, the first rank being extended at three to four paces intervals. The company commander should place himself between the two ranks so as to exercise supervision over his command till the last moment.

Capt. Laffargue suggests two methods of delivering the infantry attack; namely, one method for the case where the elements of the first line brought to a halt are separated from the enemy's line of resistance by a distance of less than 200 yards, and the other where this distance is greater than 200 yards.

In the first of the above cases if the first line, when brought to a standstill, is able to hold on to the ground gained by it, the position reached by it becomes a sort of parallel from which the troops forming the second "wave" can be launched. In the case in which the distance to be covered to reach the enemy's trenches exceeds 200 yards, some suitable intermediate position, about 100 yards from the enemy's position, should be selected and occupied as a parallel with the deliberate object of launching the second "wave" of attack therefrom. If such a *parallèle de départ* exists naturally, well and good; if it does not exist, then one must be created, even if delay is caused thereby.

Other "waves" follow the second "wave"; whether these be the second, third or fourth "wave," each and all of them follow and conform to the movements of the first "wave." Thus it is that finally the end in view will be gained and the enemy's line pierced.

The writer of the *Revue* article suggests that Capt. Laffargue's reflections and advice may possess a greater literary than a military value; however, in this matter everyone can form his own opinions after reading what Capt. Laffargue has to say on the subject.

NOTES AND NEWS.

Switzerland.—In the previous issue of the *Revue* the French-Swiss view in relation to the Swiss General Staff Scandal was placed before the readers of this publication; in the current issue of the *Revue* is set out what is intended to be the German-Swiss view on the same subject.

The contributor of this *Revue* article begins by suggesting that an error was committed in high quarters. The competent authorities were inexplicably slow in taking action in the matter, and this has led to a weakening of confidence in the Government on the part of some people, though the majority of the Swiss nation have, it is stated, remained unmoved.

It is urged that the Commander-in-Chief of the Army and the Chief of Staff constitute, so far as soldiers are concerned, parts of the State organization in which the most implicit confidence must be placed, irrespective of any views which may prevail regarding either the personality of the holders of these offices or acts for which they may be responsible, since military discipline and loyalty to the flag impose an obligation on soldiers to follow them and to execute their orders without any reserve.

The "affair of the General Staff" is represented by the contributor of the *Revue* article to have been given a political colour by certain extremists who, although claiming to be patriots, are not really Swiss at heart. He considers that there is no justification for attributing German sympathies to the Swiss General Staff; it is claimed that, on the contrary, those holding the highest rank in the Swiss Army as well as those holding the lowest rank have, during the present war, as completely fulfilled their duties as Swiss citizens as any other part of the civil population.

It is suggested that public opinion is swayed by foreign influences, but the Army is unmoved by such influences which, if they could find a responsive chord therein, would end by completely destroying the strength of the nation. But the fact remains that the Swiss nation continues to live and Swiss troops still maintain the right spirit. The contributor of the *Revue* article concludes by stating that he has forgotten which point of view he had undertaken to defend, the French-Swiss or the German-Swiss; but this matters not, as his views are those of a Swiss soldier.

Portugal.—A special correspondent draws attention to the fact that two decrees of considerable importance to the Portuguese Army were promulgated in 1915; one of them dealt with the organization of a military mechanical transport service, and the other with regulations relating to the Military School of Aeronautics. A matter of general interest from the point of view of national defence is the bill dealing with the mobilization of industrial resources laid before the Portuguese legislature in December last.

The Minister for War has recently appointed a Committee on military mechanical transport (attached to the General Staff); further, two Schools of Instruction in Mechanical Transport have been created by him.

The Committee referred to consists of five members, one being a civilian, and is concerned with :—

(*a*). The preparation of designs for the construction of motor vehicles suitable for military purposes.

(*b*). The inspection of existing motor vehicles in the country and their classification with a view to employment for military purposes.

(*c*). The improving of the organization of the motor-vehicle service and the developing of mechanical transport in Portugal generally with a view to military needs.

The Schools of Instruction in Mechanical Transport are concerned with :—

(i.). The training of officers, N.C.O.'s and men in the driving of motor vehicles, and in the maintenance and execution of repairs thereto.

(ii.). The furnishing of *personnel* to the mechanical transport service, the custody and care of motor vehicles and the distribution of the same to the various formations of the Army.

Details are given of the courses of instruction at the Military School of Aeronautics.

The Portuguese Government, as a first step towards the mobilization of the industries of the country for war purposes, has taken over all chemical factories which were unable to procure the raw materials required to keep them going. These factories are now in charge of technical experts appointed by the Government and are producing materials necessary for the Army and also for agricultural purposes.

INFORMATION.

Switzerland.—Colonel Feyler contributes an article to the March number of the *Revue* on "the Swiss Crisis." He deals with the subject in two acts:—(i.) The trial of the two colonels of the General Staff before a Military Tribunal and (ii.) the session of the Federal Chamber.

The trial, he states, has helped to calm the public rather by reason of the manner in which it was conducted than by reason of the verdict and the judgment given. The Tribunal has found that a violation of neutrality was committed by the accused colonels brought before it.

The accused colonels were found to have acted under the orders of the Chief of the General Staff and, therefore, they were acting in good faith which mitigates their offence. It is pointed out that, nevertheless, their conduct does not tally with the policy laid down by the Federal Council and, therefore, must be condemned.

The conceptions of their obligation in relation to their military duty held by Colonel Sprecher, the Chief of the General Staff, and his subordinate, Colonel Egli—one of the accused—as disclosed by their evidence, largely account, it is said, for the unfortunate situation which has arisen.

Closely associated with the "Crisis" are the campaigns which preceded the reforms introduced by the Military Laws of 1907 and of 1911, campaigns which were really duels between Colonel Wille and Colonel Sprecher and therefore created a most unedifying situation. This situation has in no small measure contributed to bring about the crisis which has resulted in the two colonels of the General Staff being brought to trial.

In relation to the second act it is stated that the debates in the Chamber had not terminated at the time of going to press, but so far as they have gone:—

(*a*). It is evident that the views expressed in the debates are very different from those which prevailed in the Chamber a few months back.

(*b*). It is clear that the Swiss cannot be forced along paths which do not lead in the direction they wish to travel.

(*c*). By reason of the criticisms in the Chamber some diminution in the plenary powers conferred on the military authorities in the early days of the War has been brought about, and the control of the Legislature has been to some extent re-established.

It is said that order reigns once more in the Army and it is, therefore, now proposed to close the correspondence relating to the Espionage Scandal.

Indirect Fire from the Trenches.—A brief reference is made to a periscopic rifle sight which the Germans are said to have provided for the use of their infantry. It is claimed that a 20-fold magnification of the object aimed at is obtained by the use of these sights, which consist of a simple arrangement of a mirror: these sights are extremely light and portable.

W. A. J. O'MEARA.