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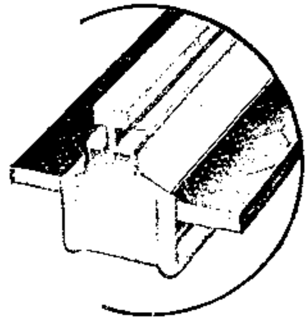

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A DESCRIPTION OF SOME SURVEY WORK IN JAMAICA, 1937–38–39.

By MAJOR J. C. T. WILLIS, R.E.

MOST people know, or at any rate few will admit to being ignorant of the fact, that the island of Jamaica, 130 miles long and between 25 and 50 miles wide, lies in the Caribbean Sea, Latitude 18°, and Longitude 77° 30′.

The island was originally inhabited by an Indian race called Arawaks, who have benefited to such an extent from the impact of western civilization that they are now entirely non-existent. The colonization of the island was originally in the hands of the Spaniards, who were driven out by the English in 1655. Jamaica soon became established as a valuable source of supply of sugar and rum; the large estates there being worked on behalf of their often absent landlords by West African slave labour.

Land was cheap and plentiful, the population was relatively small and the system of recording property ownership was haphazard. No adequate survey was put in hand and no reliable map of the island was ever attempted. The steady increase of the population, the advent of the banana, and the popularity of the island as a tourist resort emphasized the need of an accurate land registration system and of a reliable map, followed by the realization that no triangulation framework was in existence.

Prolonged negotiations, protracted to a great extent by the necessity firstly of explaining to a legislative council of predominantly African descent what triangulation was, and secondly, of convincing them of the need of it, led to the allotment of an adequate sum of money and the request that a survey party of the Royal Engineers should undertake the production of a primary triangulation: some twenty to twenty-five fixed points were mentioned as the probable extent of the framework necessary to cover the island.

A party consisting of one captain, one lieutenant and two lance-corporals was duly assembled and set sail at irregular intervals during October and November, 1937. The irregularity of the intervals was pre-arranged and important, as much preliminary work, calling on the local authorities and generally "drinking oneself in" had to be put in hand by the more senior members of the party before those more junior could be put in to bat on a reasonably well prepared wicket.

The Officer Commanding the party accordingly sailed first and was enthusiastically welcomed by the personnel of the local survey department, with the exception of the Surveyor General, who was unfortunately in jail at the time.

Arrangements had been made for the provision of transport for the section and this was duly taken over on arrival. The vehicles consisted of two Ford V Eight sedans (immediately exchanged for saloons) and two small open trucks on the same type of chassis, which were at once roofed in and made Jamaican-proof by X.P.M.

One week later the second officer of the section arrived, bringing with him the bulk of the stores. These had previously been assembled in England and their choice was governed by the standard of results aimed at, which was that of an average triangular error of 1 second. Hence the highest precision instruments available were necessary. Special emphasis was also laid on the need for extra precautions to ensure absolute permanence in the marking of each point, owing to the density of the population, its somewhat destructive habits and the consequent danger of malicious damage.

The required standard of angular accuracy was met by the provision of two Cooke Troughton and Simms Geodetic Tavistock Theodolites, supplemented by two small Tavistocks in case opportunity arose of fitting in some secondary triangulation in odd moments. The need for permanence of station marks was met by making concrete pillars of an exactly similar pattern to those in use for the major Triangulation of Great Britain by the Ordnance Survey. Indeed, this department provided all the stores for the estimated twenty pillars, together with collapsible shuttering and much valuable instruction and advice. Certainly every member of the section, and especially the Officer Commanding, owes a deep debt of gratitude to the Trigonometrical Division of the Ordnance Survey, to whose unfailing helpfulness and invaluable advice the "flying start" of the section was largely due.

As soon as the Governor, the Colonial Secretary and the heads of departments had been called upon and all the stores had been unpacked and sorted, it was possible to turn around and inspect the island and estimate the toughness of the nut which had to be cracked.

Shaped like a lozenge, and low-lying at the western end, the island is traversed by a main backbone of mountains, rising in height steadily as the chain runs eastwards until it culminates in the Blue Mountains (7,000 feet) at the eastern end. The broken nature of the ground and the precipitousness of the slopes defy verbal description. Columbus is said to have been unable to attempt it when questioned as to the nature of the countryside by his backers. Instead, he took a sheet of paper and crumpled it up in his hands. (An apt description. I often wish I'd thought of it first !) The serrated nature of the hills, which are largely composed of limestone formations rather like a petrified bath sponge, make climbing a real difficulty by day and, subsequently, an absolute nightmare in the darkness. In some areas, notably in the Cockpit country and in the John Crow mountains, progress through them by a lightly equipped party has been considerably under one mile per day.

Another feature of the island formation, which was noteworthy, and from the section's point of view extremely unpleasant, was the fact that the hills rarely seemed to run up to a single crest but rather to a series of summits, constituting a sort of rugged tableland throughout which each point visited was blocked by some nearby point of the same height. This made reconnaissance a lengthy and often infuriating business, but in every case, except one, some single point was ultimately found from which the requisite rays could be observed. The solitary exception however was the Blue Mountain summit itself, where two pillars within a short distance of each other had to be erected. It was doubly unfortunate in this case owing to the difficulty and expense of transporting materials. In fact the water for the concrete for these two pillars cost the section more, by the time it had been carried on woolly heads and mule-back to the summit, than draught Worthington.

Another factor affecting the progress of the reconnaissance was early discovered, and that was that every square yard of the island seemed to be private property belonging to someone, generally a negro smallholder, and almost all of it was under cultivation, either fruit, vegetables or trees whose value lay largely in the eye of the owner.

To the Officer Commanding the section, whose previous experience had been based on virgin forest where all obstruction was cleared away without reference to anyone, it was a shock to find that the survey was to be carried out in what appeared to be nothing but back gardens and allotments in the ownership of ill-instructed natives, who were either combative or rapacious and often both. Each square yard seemed at first to belong to a different and even more voluble owner than its predecessor and, as the party had no legal status or right of entry, endless difficulties were foreseen. At first an attempt was made to regularise the status of the section by adding a codicil to the Survey Laws, which would not only give members the legal right to move about the island in pursuance of their work but would also safeguard their primary pillars, which as the law then stood were fair game to anyone who wished to demolish them. This attempt was countered by an official letter suggesting a notice being put in the paper " requesting (*sic*) people not to interfere with the work " and ending somewhat naïvely with the " hope that this might have the desired effect." The suggestion was not tried, but the hope was doomed to disappointment at the outset owing to the fact that most of the smallholders were illiterate. Recourse was then had to a mixture of a sense of humour, a capacity for bluff and the nimble shilling adjusted in its proportions to suit each individual case and in most cases it worked admirably.

So much then for the technical difficulties, which were in the main due to the accidented and highly cultivated ground, the density of the population (in more than one sense !) and the difficulty of obtaining an authoritative warrant to enter private property.

Turning to the credit side of the account, perhaps the greatest asset from the survey point of view lay in the fact that the island is intersected by roads in all directions. Their quality is, with exceptions, extremely poor. Indeed, the conformation of the ground is such that it would be difficult for them to be otherwise, for they twist and turn almost beyond belief and it is no infrequent occurrence for a passenger, until he has become accustomed to the motion, to turn first pale and then green and then to vacate the car at speed. The fact remains, however, that bad though the roads may be, given a powerful car and an enterprising driver, transportation was possible to most places in the island.

The second favourable factor lay in the climate, which throughout the winter months is near perfection. In May, September, and October rains occur, accompanied in the latter two months by muggy heat which makes conditions very trying and visibility poor. There are no wild animals and no snakes and with reasonable precautions against mosquitoes and bad water there is little occasion for sickness.

So much for the credit side. Impossible to place definitely on either side of the ledger, but a very considerable factor in any case, is the question of the people themselves. By far the greater proportion of the islanders are of African descent. There is much interbreeding and only a small proportion of unmixed white parentage. In fact, a cynic has once said that there are only two pure white Jamaican families, namely that of the Lady who is talking and that of the Lady to whom she is talking. Be that as it may, there is a large proportion of the population with some coloured strain in their families, and although there is no colour bar whatever, the presence of this strain, real or suspected, brings a sense of latent inferiority which manifests itself, as so often, in marked self-assertiveness. Although the section was met by the most helpful kindness in every respect and relations were cordial, even where jealousy would have been most understandable, a constant watch lest words and actions should be misconstrued was essential. An abundance of tact, the patience of an archangel, and a continual readiness to be instructed in one's job by those to whom the very rudiments were a closed book, seemed to be a major part of the surveyor's equipment. No deliberate obstruction was encountered, and though much irritating delay took place at times, it was always traceable to a misconception of the conditions under which the party was working and of the capacity of its members to fill in forms in triplicate at all hours of the day.

On one occasion, however, delays in the transmission of imprest were such that funds ran out altogether and the Officer Commanding, desperate but determined not to close down the work, was forced to sell out personal capital in England in order to keep the wheels turning. The subsequent appearance of " brokerage " items in the section imprest produced such a storm, and subsequently such apologies, that that particular source of worry was entirely eliminated !

So much then for the conditions under which work was started. A first glance at the tortured and twisted gorges leading up to the Blue Mountains which tower over Kingston, the Capital, resulted in a decision to start operations at the other end of the island, leaving the eastern heights to be tackled when the section was riper in experience of the local conditions.

Accordingly accommodation was found at Mandeville, an inland village in the west centre of the island and some hectic days were spent in early reconnaissance while the two non-commissioned officers were receiving driving tuition in Kingston. In the course of these days it became clear that no attempt to enlist a regular labour force could be envisaged for the reason that no landowner would allow such men to traverse his land, or to do any work upon it. If work was to be done, the owner and his family were the men to do it or any rate to be paid for it. If the white man didn't like that, well he could go somewhere else. As ample labour, and unlimited spectators appeared to be available at any time and at almost any place, this situation presented no real difficulties. Indeed in many respects it was a blessing, as it obviated the necessity of maintaining a labour force inactive during bad weather.

Accordingly the section was augmented by four local Jamaicans only, each to act as chauffeur, guide and handyman to one of the party. These men were carefully picked, their qualifications vetted and as carefully trained. They responded readily to a good job under good employers—a situation all too uncommon in many parts of the island. In the outcome they became " more section than the section " with an *esprit de corps* and an enthusiasm which was outstanding, and ultimately ranked not only as chauffeurs, light keepers, morse coders, survey propagandists and loyal servants, but also as personal friends.

Thus, while the Non-Commissioned Officers were adjusting their ideas of driving to the habits of an island which has a left-hand rule of the road, coupled with left-hand steering in cars, making signals impossible and overtaking a grand adventure, the officers of the section, each in a separate area, were marking down likely hills and acquiring a bluff-and-charm technique which was to stand them in good stead throughout the tour.

Finally, three or four summits were found which could clearly be used as major points, whatever the ultimate design of the triangulation might turn out to be and the Non-Commissioned Officers were put to erect pillars upon them, while the reconnaissance was carried a stage further. These pillars, with three-quarters of a ton of concrete below ground level and three-quarters of a ton of tapered pillar above, took three days each in the building. This was irrespective of the time taken to break the stone, which was usually available on or near the site, to acquire the stores, to reduce the supplier of them and the transporters of them to common sense in the matter of finance, and to convince all the local worthies that we were working for King George VI and not for the Local Government. If the latter were suspected, opposition and hostility were at once encountered, for the native has it firmly embedded in his mind (and not without reason) that any attention from the Government, however beneficent in outward aspect, is ultimately linked with an attempt to increase his taxation. A further role allotted to the section by the more gullible, that of "Germans arranging to bomb Jamaica," resulted in an ugly scene in which one member was assaulted by a voluble and temperamental lady with a sugar cane, the situation being only alleviated by a mass meeting on the site, speeches by the Chief of Police, the local Parish Governor and the Officer Commanding the section and stern denunciations from the village pulpits on the following Sunday. This scotched the rumour, but did not kill it. It was always liable to crop up again, generally in company with a charge of attempting (and in one case successfully !) to make the mountains slide into the sea.

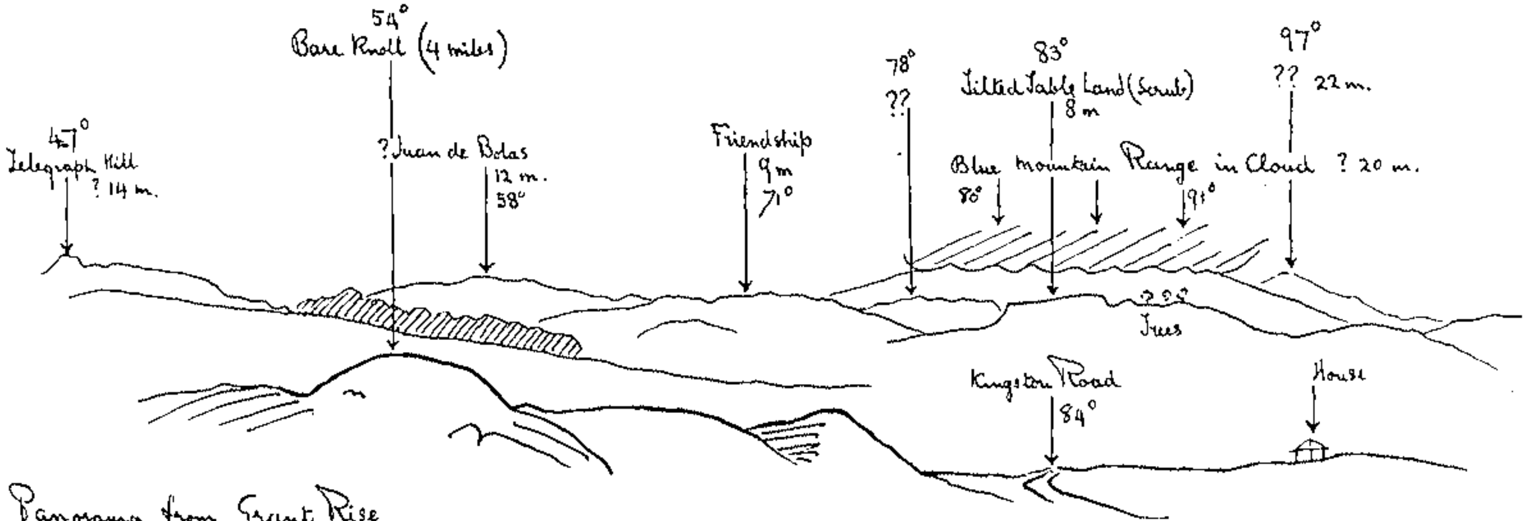
As soon as the Non-Commissioned Officers were safely embarked on their first few pillars, the two officers continued their reconnaissance outwards from Mandeville and gradually the scheme began to take shape ; not without its disappointments and seldom without its humour. On one hill, essential to the well-being of the entire framework, a fact of which the owner was kept not unnaturally in ignorance, the sum of £40 was demanded as compensation for the projected felling of a few worthless trees. After a renewed inspection of the trees a counter-offer of 15s. was made. Whereupon the owner, white with rage (a figure of speech only!), raised both his hands to heaven and cried " Fifteen shillings, FIFTEEN SHILLINGS "— then suddenly *pianissimo* " Couldn't you make it seventeen and six !! " He got the extra half crown !

And so gradually the western end of the triangulation began to take shape. The reconnaissance of the country and the selection, firstly, of suitable areas and secondly, of actual hills, was carried out by means of carefully drawn panoramas. These were constructed for every point visited and a good deal of care was expended upon them. Each feature and summit was marked with the correct compass bearing and an estimated distance, until finally, with increased knowledge of the island, the features became more familiar and could be named. In the making of these panoramas little or no skill at drawing is required and an " artistic finish " is definitely at a discount ! The proportions of the scene can be kept accurate by using squared paper and allotting a definite number of squares to a fixed angular compass measure, but after a little practice this precaution becomes unnecessary. A device called " compoculars " proved invaluable in producing these panoramas. It consists of a pair of service binoculars, with a liquid prismatic compass fitted to the side of one eye-piece. A section of the compass card is reflected by prisms into the field of view of the binoculars and the compass bearing can be read direct whilst the glasses are held up to the eyes, instead of the observer being involved in a sleight of hand with binoculars, compass, pencil, pad and paper.

A comparison of panoramas taken from various points enabled a rough idea of the relief of the country to be plotted on a board, on which alternative triangulation schemes could be considered, and a satisfactory system could be adopted. The golden rule in making panoramas is to omit nothing when carrying out the original drawing. All detail is likely to be valuable later on, if not actually at the moment.

The finding of an accessible point in the heart of the Cockpit country, which must be more impossible to transverse than almost any other part of the empire, was a stroke of great good luck well earned in perspiration and in energy by the junior reconnaissance party.

As regards the general design of the framework, it soon became clear that the original idea of having points along the north and south coast would need considerable modification. In the event, the design developed into a closely interlocked network, which, while it introduced computational problems into its subsequent adjustment, made it possible to omit rays from the observing programme if climatic conditions called for it, without endangering the stability of the whole. It must also be remembered that while this reconnaissance was in hand, no decision had yet been taken as to the best method of



Panorama from Grant Rise
22/4/38
Visibility good

(Diagrammatic only)

observing, although the section was equipped and prepared to undertake daylight observing either to opaque signals, or to helios or night observing to electric lamps.

At the end of three months' work in the field the reconnaissance and the construction of the pillars throughout the western half of the island had been completed and several stations had been selected and cleared in the south-eastern areas. Accordingly it was decided that a move might well be made to the northern coast, where the points were more accessible and experiments were put in hand to decide upon the best methods of observing.

Firstly, opaque vanes were constructed in the P.W.D. workshops in Kingston and were tested under varying conditions. It was found that these were quite satisfactory to intersect at dawn and dusk for a period of about half an hour, but that at all other times the heat flicker rendered them firstly unstable and secondly practically invisible. The periods during which they were easily observable were of insufficient duration, and the problem of securing vertical angles under these conditions seemed insoluble. In addition, these vanes had to be lifted in and out of the brass sockets in the pillars before and after the occupation of each station by an observing party. This implied at least four men, for they were by no means light or easy to handle, and some risk of internal damage both to the brass sockets and to the porters moving the vanes was incurred on windy days. Heliographs were next tried but were abandoned as a routine (as opposed to a supplementary) method of observing, because the sun is so apt to be obscured spasmodically thus rendering continuous rounds of angles, with the resultant simplification, impossible. In addition, it was felt that the difficulties in training the native personnel in their handling might prove insuperable. This was actually an error, for they picked it up with ease, in fact it was one of the joys of the day's work to hear " the subordinate staff " delivering itself of a lecture on survey in general and the uses and abuses of heliographs in particular to the wide-eyed and open-mouthed gatherings which assembled to watch them work on every possible occasion.

Finally, specially designed triangulation lamps were tried. They were made to screw into the socket of the pillar, as also were the helios and were thus automatically centred. These lamps, used by the Ordnance Survey and actually " advanced " by them until the Jamaican order had been filled, are designed to produce a beam as nearly parallel as possible. Each lamp is hand fitted to the optical axis of the reflecting mirror and the resultant light, from a 12-volt car battery, can be seen with ease over 35 miles on a clear night. These lamps, taken in conjunction with the fact that from eight o'clock in the evening to midnight tended to be the most consistently fine period of each twenty-four hours, solved the problem.

The chauffeurs, by now equipped with a uniform and a vast sense of importance, were promoted to " light keepers " and instructed in the care and maintenance of lamps and of public money. Thence by easy stages the elements of the morse code were instilled and a series of simple signals were evolved and practised. These, based once again on Ordnance Survey methods, consisted in the main of " G.B. " (Good-bye = Finished with that station, move on to the next to-morrow.) " G.N. " (Good night = Finished for the night, continue to light the same ray to-morrow night.) M.L. and L.L. (More Light and Less Light respectively) being employed as signals to indicate the need for removal or insertion of one or more of the " stopping down " discs which were added to the light keepers' equipment. Later the " O.K." was included in the repertoire and subsequently the need arose to forbid further unauthorized communications.

The school was a great success and for some days the ex-chauffeurs, now almost " assistant-surveyors," could be seen with knitted brows muttering " Darsh dart darsh dart dart " until finally they were adjudged " darsh-perfect." A system wherein each signal received was repeated by the recipient was also introduced to guard against misconception. In addition, they were taught and learnt readily the all-important maxim that Whatever Happens The Light Must Go Through. A short course on the prismatic compass, in order to pick up the leading light from the observing party, followed and the stage was set for the first bout of observing.

Although two Geodetic Tavistocks were available it was decided not to attempt more than one observing party. The island is too small for two parties to operate without continually falling over each other, with the consequent necessity of eccentric lights which would not always be aligned under European supervision and hence would always be suspect as a potential source of error. In addition, the transport available was barely sufficient for the movement of one set of light keepers and then often only with the most elaborate system of fetching and carrying.

The first programme was based on the occupation of eight stations in the west centre of the island, one observing party and six lighting parties being available. Two of the stations had more than six rays to be observed and consequently had to be tackled in two mouthfuls, with a move of light keepers in between.

The observations required to aim at an average triangular error of not greater than one second were decided upon as eight complete rounds (Face Left and Face Right) on as many different zeros making sixteen horizontal pointings in all, followed by four pointings on each light for vertical angles. The eight zeros from which observations were made were arranged symmetrically round the circumference of the circle, both the minutes and seconds being varied so as to bring

Theodolite on standard pillar.

"Catching the evening light."

Specially built pillar to clear obstructions and nearby houses.

Description of survey work in Jamaica, 1 - 4

PHOTO No. 5.—Demolition of Tie-Beam. The outer tie-bar has been bent out furthest; the roller saddle is undamaged.

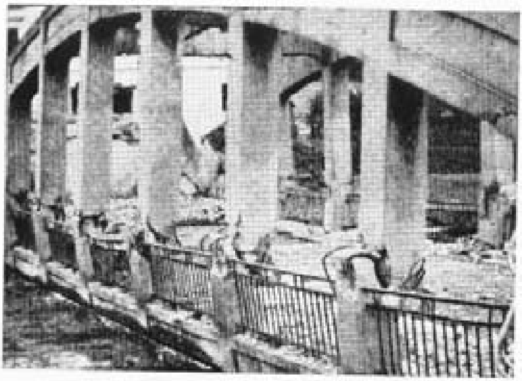


PHOTO No. 6.—Suspension members snapped across by the shock.

Description of survey work in Jamaica, 5 - 6

a different part of the micrometer circle under inspection at each change of zero.

The zeros actually used, again based on Ordnance Survey Practice, were :—

°	′	″
0	01	05
90	02	10
45	03	15
135	04	20
22	35	25
112	36	30
67	37	35
157	38	40

Rounds were observed in the order as given above, so that in the event of bad weather closing down observing after the sixth, or even after the fourth round, a fully balanced series would still have been obtained.

Each reading was made by optical micrometer, which was set and read three times for each pointing. Each set of three readings had to agree to within one second and others were added as necessary until this condition was fulfilled. By this means personal errors of setting the micrometer light gap were controlled. Errors of pointing were watched by comparing the Face Right reading with the Face Left on each zero and immediately repointing and re-reading if the departure from the average collimation error of the instrument was greater than three seconds. By adhering to these rules it was found that the range of the eight Face Left and Face Right pointings was seldom greater than five seconds and often as small as two. With these precautions, confidence was felt that the triangular error would be within the limits laid down.

Accordingly a start was made with the first eight stations, each light keeper being given elaborate instructions, covering not only his activities on the station but also the various and often complicated moves which had to be carried out between each completed night's work. The procedure at each observing station consisted of shining an observation lamp from the station in the direction of each point which was occupied by a light keeper. This beam served both as a means of communication and as a point upon which the light keeper could orient his own light. As soon as the light to be observed was satisfactory, the observers' light was put out and was not redirected on to a station again unless it was desired to transmit orders, such as G.B., on the completion of work, or L.L. if the light was becoming too bright. In this latter case, however, it was found more convenient to dim the light concerned by placing one or more thicknesses of butter muslin over the theodolite, which had the effect of eliminating all dazzle and halation and reducing the light as seen in the telescope to a hard nut or core.

At the outset the light keepers were instructed only to expect signals for five minutes before and after each even half-hour, in order to obviate the necessity of their maintaining a steady watch on the observing point for prolonged periods. In practice, however, it was found possible to call up a light keeper at almost any hour of the night and obtain a response within thirty seconds. This was due to the assistance of the crowd of unpaid but enthusiastic helpers who assembled on each station with the light keeper and who were temperamentally well fitted to staring out into the darkness for prolonged periods on the off chance of seeing the observers' light. On some occasions a cigarette was offered as the prize for being the first to spot the light, in which case the competition became very acute and was apt to cause strong recriminations if the result was in the nature of a "dead-heat."

The weather remained perfect, the lights shone brightly and, to the utter amazement of at least one member of the observing party, the first ten nights' observing was completed in ten actual nights' work with no hitch and no breakdown. The satisfaction of the observers at the completion of the first eight stations and the justification in practice of all the plans and preparations which had been made was tempered by considerable exhaustion at the end of the ten days. The fact that work is being done at night in no wise diminishes the many administrative duties, accounts, transport, moves of quarters, letters of officialdom and so forth which stalk abroad in the noonday.

During the earlier reconnaissances it soon became apparent that the selection of a suitable area for the base measurement would be a task of some difficulty, as most of the island is extremely precipitous and covered in vegetation. In addition, having had on some occasions to deal with no less than fourteen separate owners (inclusive of two, deceased but legally represented) in order to secure permission to clear less than an acre of valueless woodland, the imagination boggled at the prospect of attempting to clear a pathway, fifteen yards wide, in a straight line for a distance of some three to four miles, and endless difficulties of a non-survey nature seemed to loom in the way. However, a search was made in the plains of Savannah-la-Mar at the extreme western end of the island and the greatest good fortune attended these efforts. The West Indies Sugar Company had just cleared some two miles of straight and nearly level track for a light railway and readily gave permission for the base to be measured along it. Clearing at the eastern end was continued for another one and a half miles, and a fine base line of nearly three and a half miles with an excellent extension system of braced quadrilaterals, was obtained. The end terminals were marked with blocks consisting of about three-quarter tons of concrete. It was only later on, when the face of the island was more familiar, that the full extent of this piece of good luck was realized, for nowhere else could anything approaching so satisfactory a base have been obtained and certainly not in the property of a single individual. This latter consideration being perhaps the most important.

The angular observations of the base extension system were next undertaken and proceeded without a hitch, resulting in an average triangular error of ·8 seconds. By this time the section's activities were beginning to excite considerable interest amongst the local inhabitants and large crowds turned up to watch the light keeper at work and, as is the custom of the island, to advise him in the performance of his duties of which they were, of course, totally ignorant. These crowds were, however, completely surpassed by those which greeted the observing party, the record being held at 132, several dogs and a peanut stand. The effect of this congestion, up wind and on a hot night, was generally to ensure that the sandwich supper ration remained untasted throughout the evening!

These crowds became quite a feature of the work and their tactful handling a real necessity, especially later in the year when discontent and rioting was rife and a false move might have had undesirable results. They were, however, in the main much interested and short instructional lectures were laid on in the intervals of waiting for missing lights to appear. These lectures later expanded their scope and included talks on the British Empire, the history of the Corps and kindred subjects and upon occasion a sing-song. These methods, childish though they may seem, had a real effect on the inhabitants and contributed not a little to the fact that throughout the rioting period not one single day's work was missed owing to the disturbed state of the countryside. A comment by one of the observers is, however, worthy of quotation, "I don't mind doing trig -observations, but I hate having to do them in running shorts and spikes!"

In any case there are now many inhabitants of Jamaica who are experts in a small way on Corps History, the more so as every primary and secondary pillar had cast into it the R.E. Grenade, moulded from a cast supplied for the purpose by the Chatham workshops.

By such means the angular observing was continued well into the summer, until the arrival of the rainy weather in May rendered it advisable to switch from observing to a further bout of reconnaissance in the eastern end of the island. At this juncture the outbreak of disturbances and riots throughout the island added considerably to the anxiety but was not allowed to affect the progress of the work. At the end of July the section was withdrawn to England, after completing eight and a half months' continuous survey, in order to avoid the heavy rains of the late summer, which it was anticipated would bring outdoor work to a standstill.

After a spell of leave over the period of the Munich Crisis, which caused the island of Jamaica to recede very far into the background of the mind of the surveyor, the party returned to take up their duties again early in November. Attention was immediately paid to the problem of the measurement of the base, the site of which had been selected and cleared some nine months previously.

The new measurement apparatus which it was hoped to use was unfortunately not available and so the Ordnance Survey second set which had last been in use over twenty years before was sent out. This apparatus produced many misgivings. Several of the tripod heads, on the rigidity of which the accuracy of the measure depended, were warped and split, and new heads had to be whittled out on the site by the light keepers. Similarly, the engraved marks on the measuring head bosses were obscured and damaged and some had to be re-cut. Five invar tapes were available, two standard tapes and three field tapes. The former had been sent previously for standardization to the N.P.L. where it was considered advisable not to attempt to iron out the many kinks, but to leave them in their existing state. This caused some anxiety lest any of the kinks should tend to straighten out when the comparisons with the field tapes were being made. There is, however, little evidence that this did in fact occur.

It was decided to standardize the field tapes over a 100-foot bay between measuring head tripods, which were set up some distance away from the base. The reason for this was that anxiety was felt lest the standard tapes should be damaged if used in the neighbourhood of the base line itself. The line was in a populous part of the island, and was the scene of the original outbreak of rioting earlier in the year, and the actions of the disgruntled Jamaican negro when on "a mental spree" are completely incalculable. For the same reason the base was measured with two field tapes only, the third being kept in reserve elsewhere. Fortunately these precautions proved unnecessary.

Standardization of the field tapes was carried out before the first measure, half-way through the first measure, at the close of the first measure, at the commencement of the second measure and at the conclusion of the second measure.

The results were as below :—

December	8th	Tape 1—100·00210	Tape 2—100·00260
,,	17th	·00203	·00287
,,	23rd	·00202	·00289
,,	30th	·00217	·00277

The base line itself was about three and a half miles long and consisted of cleared scrub and sugar cane for about half of its length, the remainder being composed of the embankments and cuttings of

Observing.

Intersection vane.

Loading theodolite for Blue Mountain summit.

Intersection vane.

Description of survey work in Jamaica, 9 -12

Sugar Loaf from Blue Mountain.

Base measurement.

Home-made tape holder.

Base measurement.

Description of survey work in Jamaica, 13, 14, 15, 16 a light railway, which had materialized since the base line had been selected. This railway had been constructed during the absence of the section in England and it was something of a shock to find that the measure would as a result have to be carried out over slopes which were in some cases too steep for a man to stand upon with convenience and which in many cases required an extension to be lashed to the leg of the trestle or tripod before stability could be ensured.

After several days additional clearing and of training the staff, the measurement was commenced on December 8th. One serjeant was in charge of the setting-out party, his wire consisting of a 100-foot length of inner Bowden cable, which remained remarkably constant once the initial stretch had been taken out. The measuring party, consisting of two officers, followed and was followed in its turn by the remaining serjeant in charge of the levelling party. The Jamaican staff, supplemented by locally recruited labour as caddies, worked admirably. Once the need for extreme precision and team work was explained, they were second to none in their enthusiasm. The procedure adopted followed very closely that used in Africa by Major Hotine, R.E., to whose able descriptions in the *Field Survey Review* the Section is deeply indebted. No attempt was made to achieve record-breaking speeds, an average of 36 bays per day being maintained. Considering the heat this was felt to be satisfactory.

Little or no difficulty was encountered except from the steepness of the embankment slopes and the terrific heat. The former, however, had a compensating advantage in that the structural work on the railway had so smoothed the paths that though many of the " set-ups " were extremely awkward, in no case (except to close on the end terminal) did a short bay have to be inserted. The heat, however, had no compensating advantage. Hemmed in in full sunlight in an airless lane between high sugar cane, the work was very trying. Measuring heads became too hot to touch, observation was hampered by sweat continually running into the eyes and it was found that a party which started off first thing in the morning was pretty well " used-up " by one o'clock. There is a real danger in working on too long, as tiredness is very apt to produce inaccuracies. Fortunately, unskilled labour was plentiful and on the spot (it could generally be collected from the spectators " in the ring-side seats " at any moment !) and consequently all loads, stores, etc., could be carried by specially hired personnel. It was subsequently computed that this base was measured at the rate of about 500 yards to the gallon ! The greatest assistance was accorded to the Section by the officials of the West Indies Sugar Company, over whose land the measure was made and who contributed largely to the success of the whole operation.

The completed results gave the greatest satisfaction to all concerned and were considered by the local staff to be due to supernatural causes! The corrected measures were as follows:

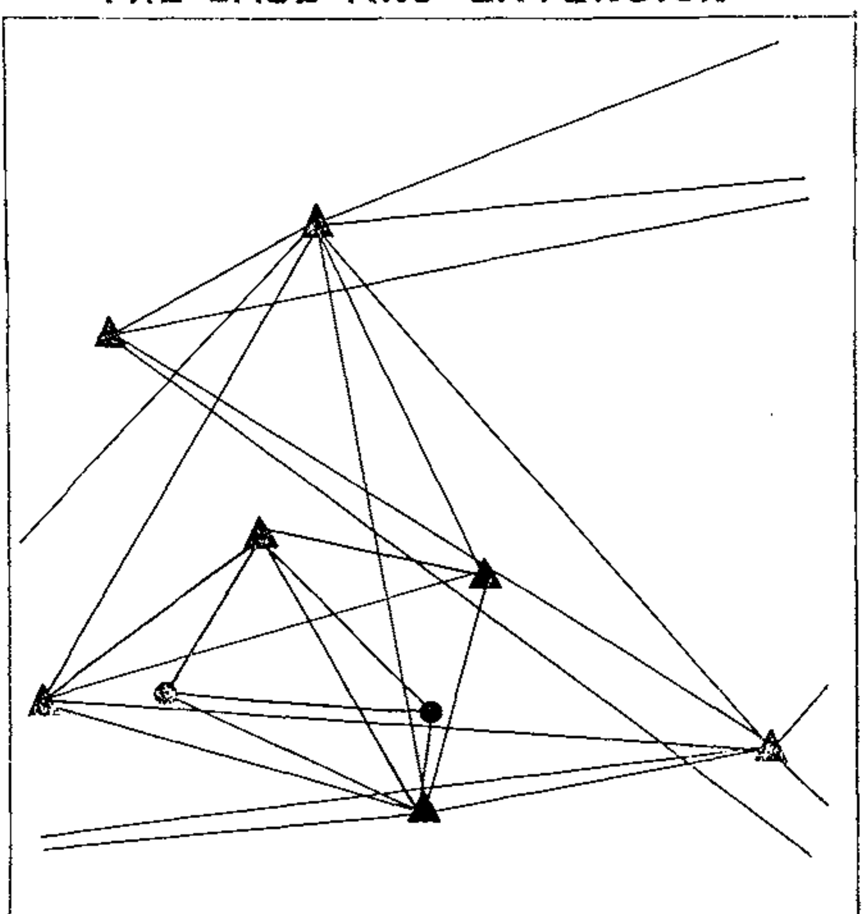
		Outwards	*Homewards*	*Diff.*
Section	I	2999·40204	2999·40333	—·00129
„	II	3899·94933	3899·95813	—·00880
„	III	3498·60336	3498·60779	—·00443
„	IV	4400·03662	4400·03521	+·00141
„	V	3003·64695	3003·65027	—·00332

Giving a total measure of:—Outwards 17801·63830 feet. Homewards 17801·65473 feet.

A difference of ·01643 in 17801 or 1 in 1,080,000.

With this result the Section felt they had all good reason to be satisfied and that Fortune had indeed smiled upon their efforts.

THE BASE AND EXTENSION



On the completion of the base measurement it was felt that the back of the job had been broken. The reconnaissance of the island was finished ; thirty-eight primary pillars and a considerable number of secondaries had been built ; approximately one-third of the primary observations had been satisfactorily completed and a system for carrying them out had been adopted, so that it appeared likely that no serious hitch would occur in the observation of the remainder. In addition, the Jamaican Government as a result of many interviews had decided to continue the work with a secondary triangulation and finally with a topographical map, both of which undertakings they desired to be carried out by the Corps. And lastly, the members of the Legislative Council voted the money for the secondary triangulation with scarcely a dissentient voice, a very different picture from the many years of explanation, discussion and cajolement which were the forerunners of the primary.

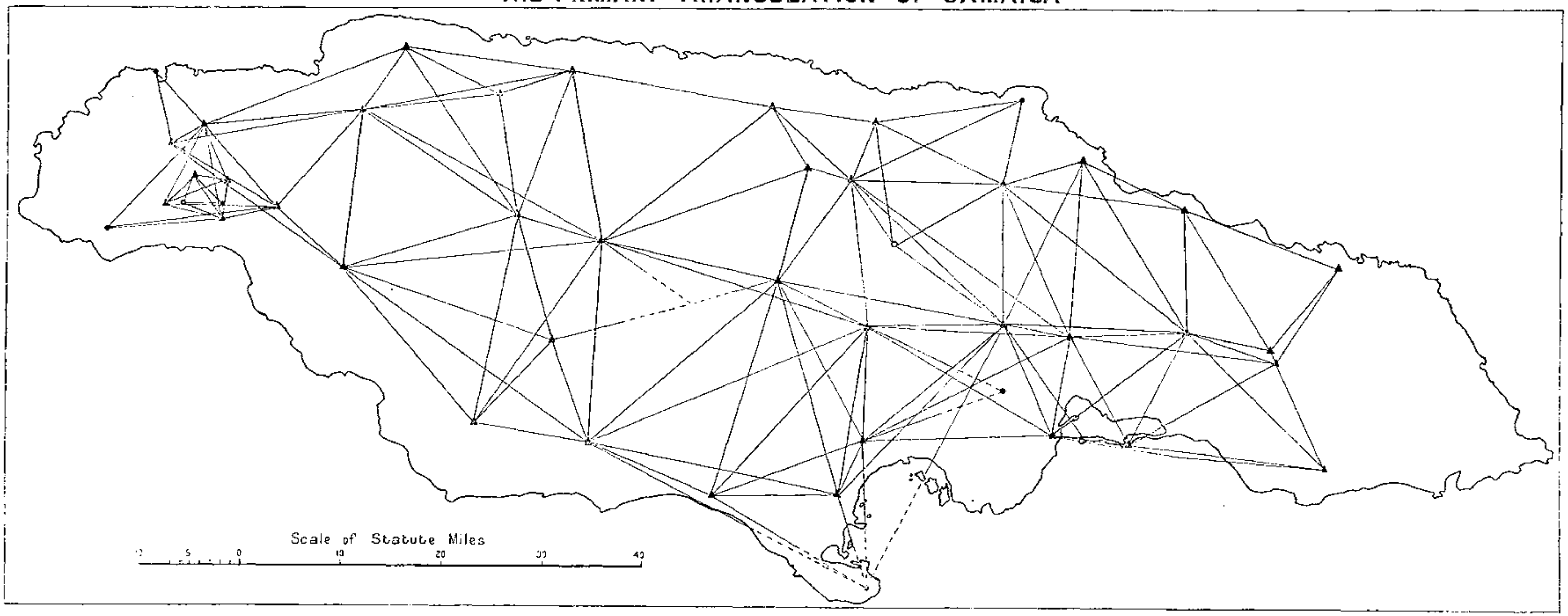
At this stage it was decided to recall the O.C. Section, who was required for other duty in England, and replace him with a junior officer and that the second in command, Captain L. J. Harris, R.E., should take over the reins. Only a very short time was left before the break up of the original partnership and it was decided that the time should be spent in tackling the observations from the two pillars on the summits of Blue Mountain peak, which were by far the toughest nut on the observing programme. The summits lie at well over 7,000 feet and are accessible only by mule or donkey. The main difficulty, however, lies in the fact that it is only very rarely that they are clear of cloud and when this does occur, it is still more probable that the points below and to north are covered, for these areas have a rainfall of over 140 inches per year, and the clouds bank up against the northern slopes of the Blue Mountain chain almost continually ; nor do these conditions vary much throughout the year.

Time, however, was short, the observing party was in good fighting trim and it was decided to tackle the job straight away instead of letting it take its proper place later on in the programme. The light keepers, late "assistant base measurers," were dispersed to their points over the eastern end of the island with orders to light from sunset to sunrise and the observing party, "wearing two of everything," set out on mules and donkeys for the summit. Once again the luck held. The more easterly of the two points was occupied first. Visibility was excellent to the south, fitful to the north and deteriorating. No time was lost and towards midnight the complete observations were "in the bag." A move was then made in total darkness, with all the instruments, over the mile or so of ill-defined forest track to the second (western) pillar. This was achieved without incident, though the recollection of stumbling in the darkness literally into the midst of four alarmed and temperamental mules will remain permanently engraved in the mind of at least one member of the party !

On arrival at the second point, the visibility had become a great deal worse. There was much low-lying cloud below and many wreaths drifting across the summit itself. It was, in addition, bitterly cold though the observer was almost rigid with extra clothing and had almost to be " wheeled into position " alongside the instrument. Gaps in the clouds appeared at intervals and every now and then lights appeared and would be intersected at once, until finally it seemed possible that the job would be finished that night after all. One by one observations on each light were completed ; the light keepers were summoned by signal and " sent to bed " until finally a break of a few minutes at sunrise enabled the last light to be seen satisfactorily and to good effect. The party had the joy of completing both stations after nearly thirteen hours at the instrument. Remained but the packing up, the four hours on a mule to the jumping-off place and the job was done. After that the summit disappeared in cloud and was not seen again for several weeks. So once again luck was with the party.

At this stage it was time for the writer to move to pastures new and he left, with the utmost regret, just one more of the interesting jobs that fall to the lot of the Corps.

THE PRIMARY TRIANGULATION OF JAMAICA



THE MILITARY BRIDGE OVER THE RIVER THAMES AT GRAVESEND.

By H. J. DEANE, B.E., M.INST.C.E.

BEFORE dealing in detail with the design of the military bridge at Gravesend, it would be of value to briefly describe the local conditions of the regime of the river and the considerations of traffic, which necessarily influenced many of the points which had to receive careful consideration. The river at this place is just under half a mile wide and Gravesend Reach itself is particularly subject to the influence of strong winds from the east as well as the west. The total range of tide, that is the height from the lowest recorded low water to the highest recorded high water, amounts to as much as 28 ft., though the rise and fall of a good spring tide is only about 20 ft. During the normal spring tides the current runs as much as 3 knots and the necessity for providing adequate moorings for any craft lying at anchor in the reach must therefore be apparent. In addition, the depths of water in the main channel, as shown by the charts, go down to about 50 ft. below low water of ordinary spring tides.

Furthermore, owing to the configuration of the river channels above and below Gravesend, the tidal currents are liable to set slightly across the river in one direction during the flood tide and in the opposite direction during the ebb. It is, therefore, necessary to allow for this action, emphasised by wind, in the mooring of craft head and stern up and downstream.

All traffic entering and leaving port has to pass Gravesend and, in addition, account must be taken of the fact that most, if not all, ocean-going vessels have to stop here to change pilots or for customs purposes. In this connection the south side of the river is reserved as an anchorage, both for large as well as for smaller craft.

The muddy foreshores on both sides of the river are exposed at low water and any craft which may lie afloat alongside the river banks at high tide must of necessity take the mud at low tide. On the south side, on which Gravesend is situated, the land is well above water level, but on the Tilbury side the low lying land is protected from inundation by an ancient system of river walls formed of clay, with stone or other protection on the river face against the erosive action of waves caused either by wind or passing river traffic. On the south side the protection is by wharves built up of timber-work or other suitable construction.

Consideration of the siting of the bridge had to take into account the route of the Tilbury-Gravesend vehicular ferry, the entrance to the Tilbury Docks and the large deep water wharves almost immediately opposite to the latter, as well as the suitability of the access by road, particularly on the Gravesend side. On the opposite side, being mainly free from obstructions, no limitations of importance were imposed. The site chosen, therefore, was between the Town Pier (to which the above ferry plied) and the Terrace Pier, extending across the river roughly at right angles to the main channel, commencing at the foot of Royal Pier Road, where there is a small open space used as a park, and terminating in front of the old Tilbury Fort. From this point a new road led to an accommodation road connected with the L.M.S. riverside station and Fort Road, crossing on its way the old moat by which the fort was surrounded. (Fig. 1, opposite p. 356.)*

The amount of river traffic required the provision of an ample opening to allow ships to pass in both directions without undue obstruction, whilst at the same time the possibility of having to still further restrict such opening, if required, had to be kept in mind. The kind and size of craft available, in view of the very rough weather conditions which sometimes prevailed, had to be carefully considered, and it was eventually decided to adopt the normal type of Thames Barge of about 80 tons register. The approximate average dimensions of these barges may be taken as 70 to 100 ft. in length over-all. Width or beam 18 to 20 ft. and depth 9 to 10 ft. These measurements vary slightly with different designs for the same tonnage. Whilst it was desirable to employ as few of such barges as possible, the span from centre to centre of the normal construction, combined with the loads to be carried by the bridge and the class of construction to be adopted for the spans between the barges, fixed the barge centres at about 40 ft. The loads for which the bridge was designed were as follows :—

A four-wheel lorry with 5 tons on each axle at 12 ft. 4 in. centres and a distributed load of 108 lb. per sq. ft.

At the removable units which formed the navigation opening, this span was maintained but with this difference ; some form of bascule had to be provided, to connect these units with the normal sections of the bridge, which could be easily operated by manual power and in these cases the distances between the centres of the barges carrying the bascules were reduced to 22 ft.

For the carriage ways on the bridge, two tracks had to be provided, so that, if necessary, vehicular traffic could be maintained in opposite directions, and, in order to simplify construction and to allow a considerable amount of gyratory movement in the barges, two

* Further descriptive matter relating to the drawings and photographs will be found in the Appendix.

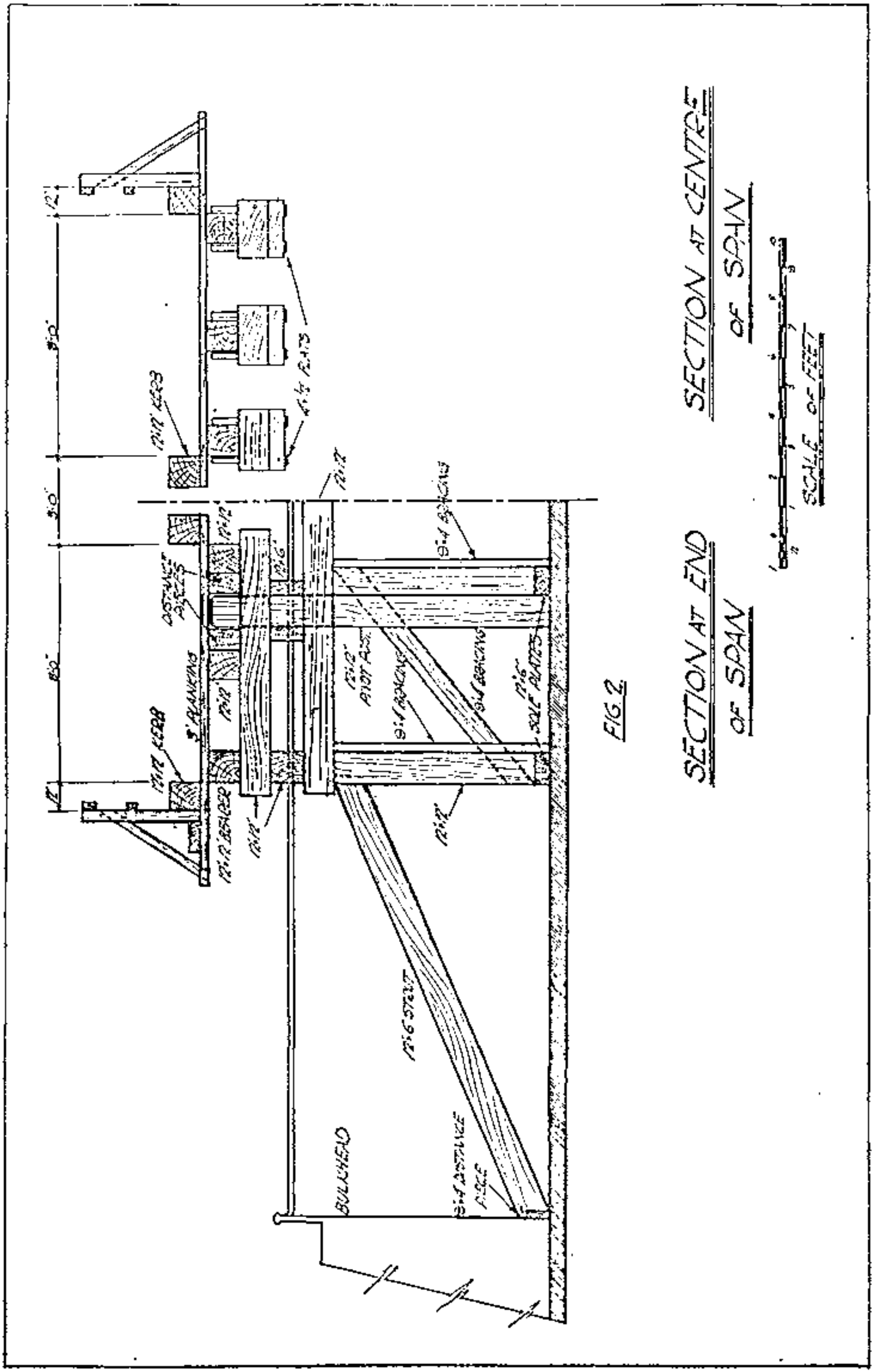

SECTION AT CENTRE OF SPAN
SECTION AT END OF SPAN
SCALE OF FEET
8'0"
3'0"
8'0"
DISTANCE PIECES
PLANKING
KERB
BEARER
BRACING
PIVOT POST
SOLE PLATES
STRUT
BULKHEAD
DISTANCE PIECE

FIG 2.

independent tracks were adopted with a 12 in. clearance in between. (Fig. 2). As horse traffic was to be expected, this space had to be filled in, so that any horse getting its hoof outside the curb would not readily slip into the gap. The method of obviating this difficulty will be described later. Each track was supported on a span composed of three trussed timber beams, made up of 12 in. square baulks with steel trussing bars and angles carried over pieces of the same section timber 18 in. deep. (Figs. 3 and 4.) One truss was placed under the centre of the track and the other two to take the wheel

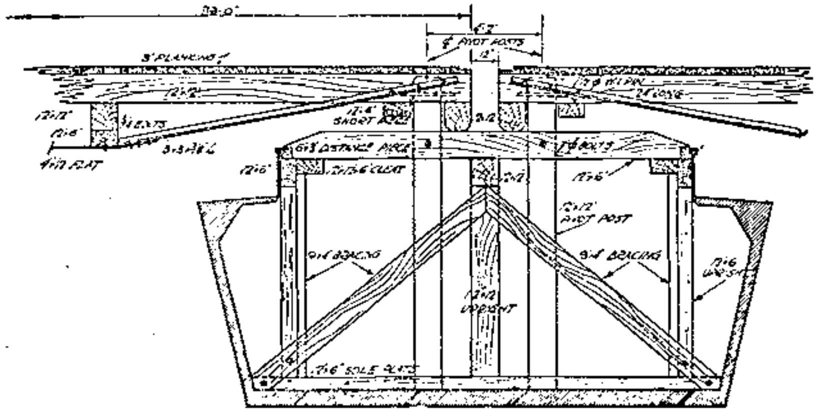


FIG 3.

CROSS SECTION ON ℄ OF BARGE

loads. Over and transversely across the trusses were timber decking, 3 in. thick and about 10 ft. long, projecting beyond the outer trusses so as to take the 12 in. timbers which constituted the curbs, the clear width between curbs, therefore, being 8 ft. (Fig. 2.) The outer or river side of each track was protected by substantial timber railings to prevent animals or men falling into the river. The space between the two tracks was filled with planks about 3 in. thick, to the underside of which were attached cranked steel brackets projecting far enough on each side to find ample support on the curb timbers. (Fig. 5.) These brackets were not secured to the curbs, so that relative movement of the adjacent curbs was possible when the barges happened to swing slightly.

The means of attachment of the span to the barges involved the provision of a pivot-like connection, whilst arrangements had to be made to take up any rocking motion in the barges themselves. At the same time it was essential to keep the weight from the spans as near the centres of the barges as possible, in order to reduce the rocking of the barges to a *minimum* when traffic was passing over the bridge, and also to keep down to a minimum the relative longitudinal movement of the spans when the barges were inclined to get out of square. (Fig. 6.) Under the ends of each span there was a 12 in. square timber, the bottom edge of which was rounded-off to

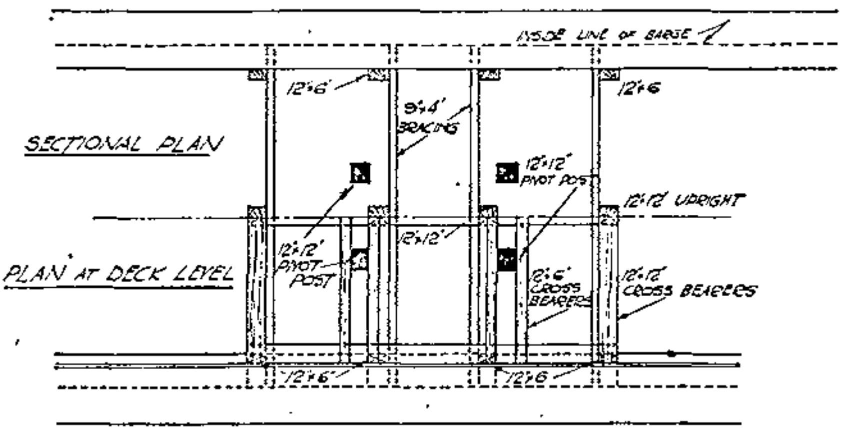


FIG 7.

PLAN OF FRAMING IN BARGE

SCALE OF FEET

allow for the rocking motion, whilst a second timber 12 in. × 6 in. in section was secured to the span, parallel with the former but about 14 in. clear away to fit over a 12 in. post set up in the barge itself (Figs. 3 and 7). There were four of such pintles or posts in each barge to take the ends of the four spans and they projected upwards, so as to come just inside the inside truss of each span and they too were rounded-off, so as to allow of the barges getting out of square without binding. The rounded bearing timbers under the ends rested on timber framework firmly secured in each barge and carried down and supported on the barge's floor beams. A steel ribbed cover-plate, attached to one unit only and loose on the other, spanned the

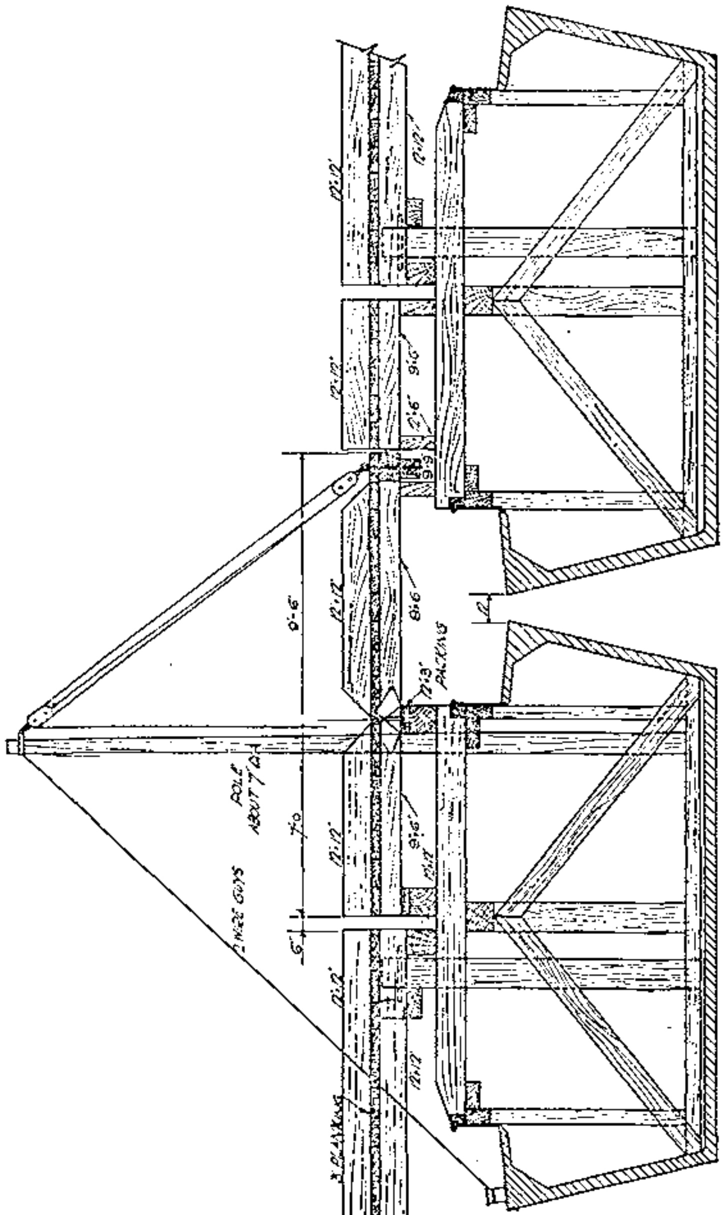


FIG 8

SECTION THRO LIFTING SPAN

SCALE OF FEET

short gap between the ends of the units and gave the necessary uniformity in the track itself.

The short bascules (Fig. 8.) referred to previously were pin-hinged and were raised by means of simple blocks and tackle, attached to a substantial post high enough to clear the blocks when the bascules were raised, the ropes being secured to cleats on the posts. There were three barges in each of the opening units, with two bascules at one end and two normal spans between the centre and the two outer barges and in operating these units no trouble was experienced in keeping the barges together. Similarly, these attachments proved quite satisfactory in the case of the standing portion of the bridge, though for safety, the ends of the barges were secured together by chains.

As it could not be foreseen precisely how the adopted dimensions of the spans and the closing units would work out in practice and in order to take up the variation in length of the tracks on the bridge due to the rise and fall of the tide, a sliding connecting piece of decking for the two tracks was provided and installed between two barges at the northern end of the bridge in place of the standard spans. (Figs. 10 and 11.) This was found in practice to work very well and allowed the bridge to be completed and the navigation opening to be properly closed.

With regard to the mooring of the barges (Fig. 1) this was effected by screwing standard cast-iron mooring screws into the river bed both upstream and downstream, normally about 600 ft. from the centre line of the bridge, and attaching a sufficient length of chain thereto so that, when lifted up at low tide, the end of the chain was available for the attachment of the wire ropes with which the barges were secured, thus enabling the ropes to be renewed whenever necessary. The size of these ropes was 3 in. circumference and there was one rope to each end of each barge and every third barge was moored to two screws. Thus, on the average, there were 3 barges to each screw. Four ropes to each screw secured two opening units at the up and downstream ends and, when it was necessary to release these ropes for the bridge to be opened for river traffic, the ropes, which were labelled, were passed across and roughly secured to the standing portions of the bridge ready for use next time without getting mixed up.

From the shore to the first barge on each side of the river the normal spans were used, the shore ends of which were kept at such a height that the maximum inclination of the track was approximately equal at high and low tide.

There were 8 opening units in the bridge which, under river traffic conditions, were moored above and below the bridge clear of the fairway on the north side and the manœuvring of these units into place was done by a couple of tugs, which were kept constantly

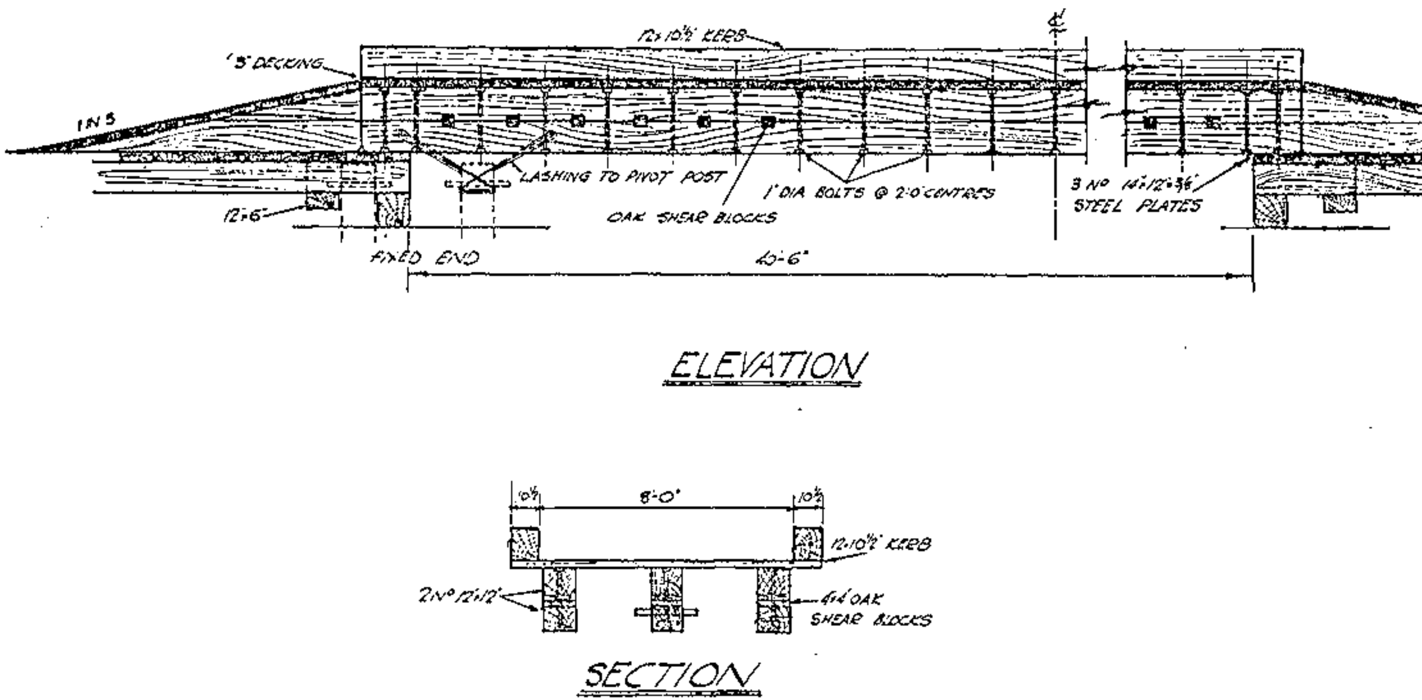


FIG 10

SLIDING SPAN

SCALE OF FEET

in attendance during the early part of the war. The maximum width of navigation opening amounted to about 800 ft. In case of damage to any of the barges forming the bridge itself, six spare barges provided with 2 spans each were prepared and moored in a suitable position on the south side of the river immediately upstream of the bridge. One of these was also fitted with a pair of bascules, in case damage occurred to a closing unit. The total number of barges employed were made up as follows :—

On the south side of the navigation opening ..	31	barges
In the navigation opening	24	,,
On the north side of the navigation opening ..	12	,,
Spare barges fully equipped	6	,,
Total number of barges	73	,,

An interesting piece of work occurred in the crossing of the old moat, where it was found that a considerable thickness of mud lay in the bottom which would not only have been very costly to remove, but would have incurred considerable delays in completion. This difficulty was overcome by the use of close-paled chestnut fencing, which can be obtained in rolls of a maximum height of 6 ft. or so. Several rolls were obtained and placed on the moat banks side by side and the end of each roll securely pegged into the ground, each roll being secured by stout wires to its neighbour. The fencing was then unrolled over the water until the other side was reached. Furnace ashes were tipped on to this "raft" from one side of the moat and the process continued until the moat had been crossed and the ashes brought up to the desired level. On top of the ashes were then laid cross timbers spiked to longitudinal bearers and arranged to break joint and finished off with a 12 in. timber curb at each side of the roadway thus formed. (Fig. 12.) Under test, very little settlement took place and subsequently, when the official test took place, the road proved the efficacy of the method adopted.

As time was the most essential element on the job, it was necessary to design the work in every detail so as to spread the making-up of the various component parts as much as possible, and employ as much labour as could be accommodated. Anything in the nature of forging work had to be cut down to a minimum. The steel components of the trusses were, therefore, not made of single plates and heated and twisted to shape but were made up of two 3 in. × 3 in. × $\frac{3}{8}$ in. angles at each end, and two 4 in. × $\frac{1}{2}$ in. flats in the centre, so that one leg of the angle would rest flat on each side of the timber baulk whilst the other leg provided for the attachment of the centre lengths of flat steel plate. Each flat was attached to the angles by three $\frac{3}{4}$ in. bolts and the angles were secured through the 12 in. baulks by three 1 in. bolts. Most of the preparatory work was carried out in the Surrey Commercial Docks, where there were ample facilities for fitting up the barges, for the preparation of the trusses, and the establishment of a temporary saw mill and shops in which to produce the various standardised parts. As on the average each barge supported two spans, the barges after being fitted up with the interior timberwork, were loaded up with two spans and other lots of various materials and parts, towed down to the site and assembled in position after being securely moored. While the work was going on at the docks, the screwing of the moorings and the attachment of the chains and other work at the site was proceeding.

As the barges and their equipment arrived, they were swung into place and secured to their respective moorings, working from the north and south shores at the same time. The spans were lifted off by one of the Port of London Authority's wreck-raising lighters (Fig. 4) and placed over their respective pintles or posts, and the remainder of the work of fixing the steel ribbed cover-plates and all other minor incidental work put in hand by the shore gang. The navigation opening was not filled up until the bridge was brought into use on the occasion of the first official test, but the units for filling the opening were assembled at the site and moored out of the way in readiness for use. The time allowed in which the bridge had to be ready for the official trial was laid down as one month; this had to include the preliminary consideration of the design and the organisation for its construction, the collection of barges and materials and for the construction of the bridge itself. The work was satisfactorily completed within that time.

Perhaps the most intricate part of the whole work was the arranging of the organisation for completing the bridge for traffic and closing the river to navigation; and a brief description of this organisation may therefore be of interest.

Traffic on the River Thames may be taken as being divided into two categories. During the flood tide there is very little traffic outwardbound, but most incoming craft take advantage of the rising tide and the upriver currents to make their way up to the docks and wharves. During the ebb tide the reverse process takes place. Most vessels leaving the docks and wharves leave their berths round about high water and navigate downstream on the falling tide, aided by the river currents. It was essential, therefore, that ample warning that the bridge was about to be closed to navigation should be communicated to the docks as well as to any craft already on the move in the river, in whatever direction they happened to be going. At the same time, as soon as word was received to complete the bridge, the bridge hands had to be immediately summoned for duty in order that the closing

FIG. 4.

FIG. 5.

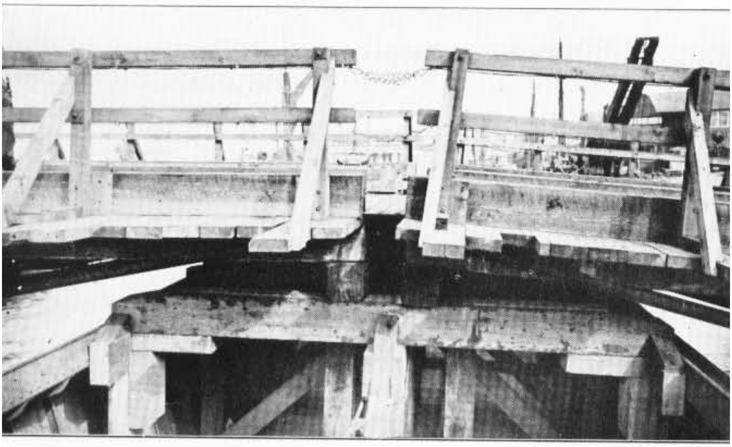


FIG. 6.

Military bridge over the Thames at Gravesend 4, 5 & 6

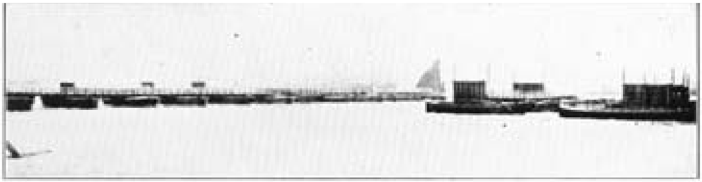


FIG. 9.

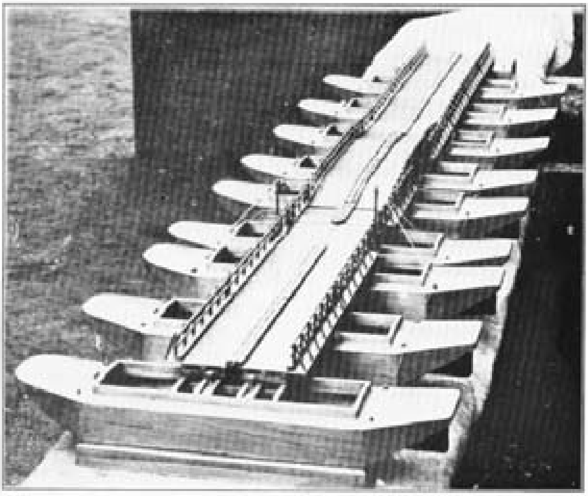


FIG. 11.

FIG. 12.

Military bridge over the Thames at Gravesend 9, 11 & 12

operations could be completed within the time allowed, viz. four hours after receiving notice from the War Office. On receipt of such notice, which was in code (and confirmed later by telegram), in order to prevent an unauthorised instruction being acted upon, an independent and separate telephone confirmation was sent back from the bridge office to the War Office. Everything being in order, two or three men were sent off immediately on bicycles to call up others, who in turn went off on bicycles to call the rest of the gang. At the same time, the watchmen at the bridge ends were instructed by telephone and they advised the "floating" gang to get on with the closing, whilst two river launches proceeded from the bridge up and downstream to warn vessels on the move that the bridge was being closed and that they should, therefore, drop their anchors. Also, telephone advice was transmitted to the various harbour masters' and dock masters' offices through a fan-shaped organisation. The former then sent their own harbour service launches to similarly warn vessels on the move and the latter prevented any vessels from leaving dock if they were intending to proceed downstream past Gravesend. On the bridge ends, navigation signals and lights were exhibited showing whether navigation was open or closed, so that craft manœuvring in the immediate vicinity were properly advised. It will be noticed in Fig. 1 that the closing units were equally distributed on each side of the bridge: this was arranged so that, whether the tide was flowing or ebbing, only half the units had to be towed against the tide and on completion of the closing operations the two tugs used for this purpose were left one on each side, so that on re-opening to navigation the most suitable unit could be taken out first according to the tidal conditions prevailing, thus making a passageway for the second tug to pass through and assist in the operations.

Each individual concerned was furnished with full typewritten instructions of his part in this procedure, so that the possibility of mistakes or forgotten verbal instructions was eliminated and everyone whether on or off duty knew precisely what his obligations were.

The whole of the construction and subsequent operations and maintenance of the bridge was carried out by the Engineering Department of the Port of London Authority. The date and time of the first test was kept secret from the Bridge Staff; the Author, however, happened [*sic*] to be at Gravesend on that day and about that time and was able, therefore, to satisfy himself that everything was operating according to schedule and had the gratification of seeing the closing of the bridge to navigation carried out in well under the specified time (viz.: 3 hours 19 minutes) and of viewing detachments of His Majesty's troops with guns and mechanical transport, etc., pass safely across to the Essex side without an untoward incident of any kind. It might be observed that the canting of the barges when the spans on one side only were loaded was negligible and that all allowances made in the design for movement in all directions had been amply justified. The restoration of the navigation opening occupied only 2 hours 8 minutes.

The Author would like to express his appreciation of the great honour conferred on him by the Institution of Royal Engineers in asking him to prepare this paper and his thanks to the Port of London Authority for permission to refer to their copies of the original drawings of the work, from which much of the information given herein was verified.

APPENDIX

FIG. 1.—Opening units marked A to H inclusive, moored to screws marked 11 to 14 inclusive. The L.M.S. River Side Station at Tilbury is about 500 yards to the west of the north end of the bridge. The sliding connection was between barges Nos. 57 and 58.

FIG. 2.—The two outer trusses had the major loads to support but the centre truss was made to the same design, for convenience in construction. No account was taken in the design of any additional strengthening due to the 12 in. curbs. The figure should be read in conjunction with Fig. 3.

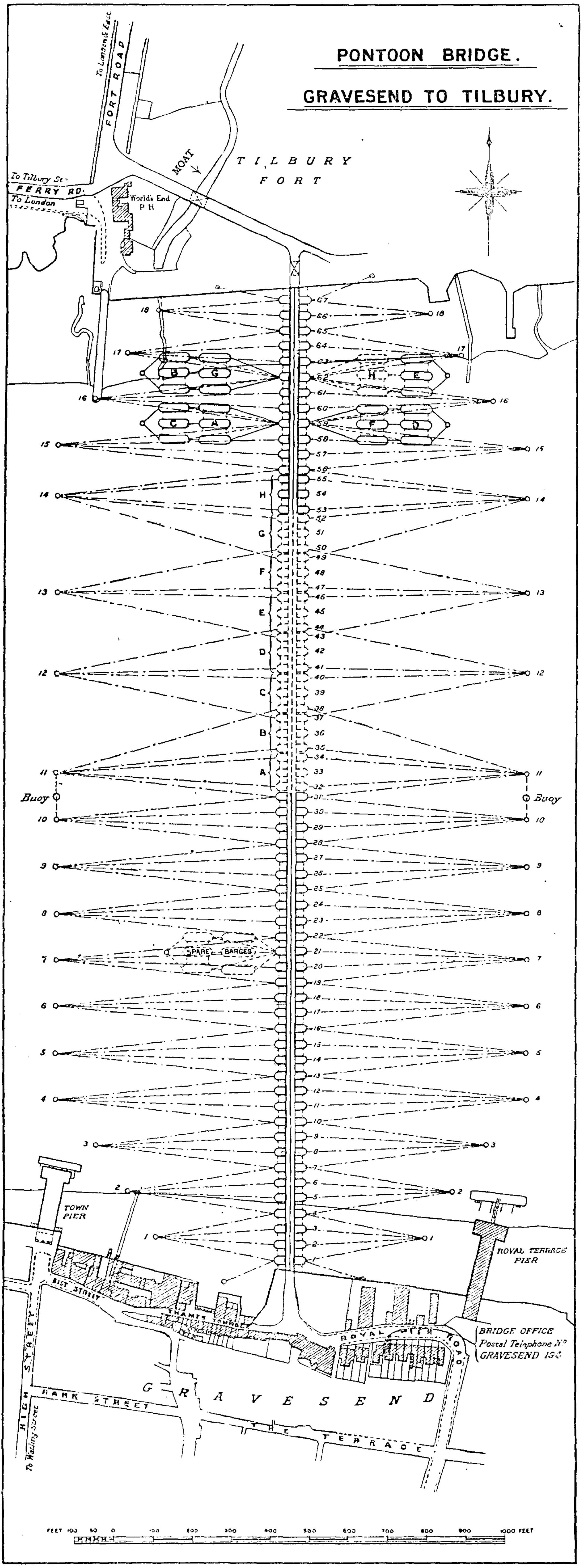
FIG. 3.—The "checking" in the end planks of the two adjacent trusses was for the reception of the steel plates used to cover the space between. The whole length of the spans is not shown but the overall dimension of 39 ft. gives the necessary particulars from which a drawing of the beam could be made.

The $1\frac{1}{2}$ in. diameter pin, shown through the top of each pivot post, was put in to prevent the remote possibility of the spans coming off their correct seating. This figure should be read in conjunction with Fig. 7.

FIG. 4.—One of the P.L.A. wreck-raising lighters with a special cathead fitted to facilitate the handling of the spans, one of which is seen suspended therefrom. The trussing bands are slack due to the points of suspension not being at the ends.

FIG. 5.—Shows how good the general line of the bridge was. It is especially intended to illustrate the arrangement of a plank, on iron brackets between the two inner curbs, to prevent horses or men dropping between the spans. It also shows the steel cover-plates at the junctions of the spans. The view is taken looking towards Gravesend.

FIG. 6.—This was evidently taken at about high tide when the span on the right had an inclination down towards the shore. The photograph shows the framework in the barge and the rocking timbers supporting the spans. It will be seen that the handrails were used for attachment of electric wires, etc.



PONTOON BRIDGE.
GRAVESEND TO TILBURY.
TILBURY FORT
MOAT
World's End P H
FORT ROAD
FERRY RD.
To Tilbury Stn
To London
SPARE BARGES
Buoy
TOWN PIER
ROYAL TERRACE PIER
BRIDGE OFFICE
Postal Telephone No
GRAVESEND
THAMES TERRACE
ROYAL PIER ROAD
HIGH STREET
HARK STREET
THE TERRACE
To Watling Street
GRAVESEND
FEET 100 50 0 100 200 300 400 500 600 700 800 900 1000 FEET

FIG. 1

FIG. 7.—This figure is to show the relative position of the 12 in. × 12 in. pivot posts and framework in the barges.

FIG. 8.—From this figure it will be seen that the worst conditions of eccentric loading of the barges in the closing units would occur when the wheels were immediately over the bascule pivot or at the point where the pulley block is attached to the end of the bascule. As the rocking caused by these loads was not excessive, the original intention of putting a stop block on the opposite gunwale of the barge was not carried into effect. This stop block would have come into contact with the underside of the trusses and so helped to keep the barge on an even keel.

FIG. 9.—Shows the northern end of the bridge. The barges to the right are the closing units on which can be seen the raised bascules. Similar raised bascules can be seen on the closing units moored on the opposite side of the bridge. The sliding span is in a direct line with the stern of the steamer about to pass through the bridge navigation opening.

FIG. 10.—The sliding span was bolted through the two 12 in. timbers with 1 in. bolts, which were sufficient to take up the vertical shear in the beam, whilst the oak shear blocks were put in to take care of the horizontal shear. The fitting of these blocks had to be done very accurately so as to ensure effective contact against the vertical sides.

One end only of the span was secured to the barge as shown, the other being free to slide over the adjacent deck.

No account was taken of the additional strength afforded by the attachment of the curb timbers.

The bolts in the centre of the sliding span are only placed there to keep the two timbers together, since the shear is negligible at this point.

FIG. 11.—Is of a model of the principle of the make-up of the bridge. The nearest three barges constitute one of the closing units with the bascule spanning between the third and fourth barges. Next comes the sliding span and, lastly, four normal spans with the barges under. This model was prepared for the War Department.

FIG. 12.—Shows the road crossing over the Tilbury Fort Moat and illustrates the satisfactory surface which was obtained by the method of construction adopted.

THE TRAINING OF THE R.E. OFFICER.

(Two lectures to the Senior R.E. Majors Course, S.M.E., 1939, by the Commandant, S.M.E.)

LECTURE I.—METHODS OF TRAINING.

GENTLEMEN,

I experience a certain diffidence in speaking to regular officers to-day on the subject of the training of R.E. officers, for two reasons :

firstly—because the regular R.E. officer is nowadays a rare bird, and not often to be found in sizeable coveys : certainly not at home.

and secondly—because, when you find him he is so busy with his job as a Works officer, or as an Adjutant of a T.A. unit, or as one of the two officers with a field company, that he really cannot find the time to spend whole days on training.

But you must remember that there are many R.E. officers other than regulars in this country who are in urgent need of training, and that there are abroad considerable collections of R.E. officers, in Sappers and Miners for example and at defended ports. Moreover I refuse to admit that even where two or three only can be gathered together training cannot be effectively carried out. That excuse is often given, but I feel sure that it is an excuse and not a reason for not training.

Is not the real trouble that we do not regard the training of ourselves for war as the primary duty of all R.E. officers, whatever the nature of their job? There ought to be very little doubt on that point at the present date, when war is constantly threatened.

Or is it that we do not realize that we are in need of training? Believe me, we are very much in need of training. More to-day than ever we were : since not only are so many officers employed on duties, such as A.A., which are not now of any value to their future in the Corps, but the strategical and tactical value of the engineer arm is greater now than it has ever been since the days of siege warfare, to meet the requirements of which this School was started by Charles Pasley. Moreover, you will have noticed the recent realization by all arms of the importance of field engineering, the appointment of battalion fieldworks officers, the creation of infantry pioneer platoons, the special training in fieldworks of certain selected infantry battalions, and the greatly increased responsibilities in regard to fieldworks which have been placed on all arms. We have not only to train ourselves in the tactical employment of our new organization and with our new equipment, since on this training depends the mobility and the safety of the Army: but we have also to pass our knowledge on to others who look to us for help.

At the same time the rush of everyday life, the constant change of employment, the attraction of staff appointments, the use of standard equipment and other factors seem to me to have caused a great falling off in our experience and knowledge as field engineers.

Or is the trouble that the field of activity of the R.E. is so wide that it seems almost hopeless to cover it in our training? I admit that the training of the other arms is simple compared with the training of the R.E. officer: but is that not a reason to train the R.E. officers young and to keep the idea of training always before our minds in all we do?

Or is the real trouble that we, as senior officers, find difficulty in preparing our training exercises and in making them realistic? And if we cannot achieve realism, we cannot learn the true lessons of experience. We shall, indeed, achieve nothing but boredom.

Our problem is, therefore :—

(*a*) How to find time for training.

(*b*) How to make our training realistic.

We must, however, first clearly visualize our objectives.

I think that we shall agree that the first objective must be :—

> to make ourselves and those for whose training we are responsible good field engineers, that is to say fully competent to fulfil our role as field company section officers, field company commanders, Div. and Corps C.R.E's.

Our second objective is :—

> to be good civil, that is to say base and L. of C., engineers and works officers.

Let us take first the "training in field duties" in the Div. and Corps.

How to find time for this?

The answer is that, if we cannot find days for it, we must, and I believe always can, find hours.

We have lately been organizing our winter training at Chatham largely in short one-hour, or one- and a half-hour, periods, and we find that where we can get one officer for a whole day we can get three or four for frequent short periods.

We can during those short periods have either :—

(i) Short exercises on the map or cloth model, or

(ii) "Happy half-hours" in the form of a technical question, or questions and answers on administrative matters or discussions on a selected text or sections of Engineer Training.

We shall illustrate these methods to you here during the course, but I should like to say something about the first, namely the preparation of short exercises.

There are three difficulties here.

(i) How is the busy C.R.E. or T.A. Adjutant to find the time required to prepare the exercise.

(ii) How is he to think of a realistic situation and a realistic solution.

(iii) How are we to save the time so often wasted in getting the class into the picture.

The answer to the first question is that no senior officer should try to conduct all the exercises himself. One learns far more from setting and conducting an exercise than from being one of the students. Therefore, farm them out. Set the subject, but let others, even the most junior, set and conduct exercises and happy half-hours. It gives the good lad a chance to show what he can do, and is excellent practice for everyone. And remember that, to take a low view of the matter, we must now all be prepared to train our subordinates for (*a*), (*c*) and *f* (i) examinations in which engineer tactics find a large place, or to sit on examination boards.

As regards the second and third questions—realism and the saving of time.

I know that some officers are deficient in imagination (but remember that excess of imagination is often a dangerous defect in war). Such officers find it very hard to invent a war or warlike situation which is realistic. The answer, as I suggested in an article in *The R.E. Journal* for September, 1936, is :—

To base *all* exercises for one season on one operation.

This year for example at Chatham we took the operations of the 1st Division on the Aisne on 12th to the 14th September, 1914. That operation admits of innumerable problems which will suggest themselves at once when one comes to examine it in detail.

You will remember that on the 12th the 1st Corps crossed the Vesle and should at least have reached the Aisne but did not do so. On the 13th it crossed the Aisne and formed a bridgehead. And on the 14th it failed to seize the Chemin Des Dames ridge and had to consolidate.

There are, as I say, innumerable problems here. For example: on the 12th evening:—

(*a*) Administrative problems—billeting and parking, duties of liaison officers, feeding. Inspection of men and vehicles, casualties among personnel and vehicles, replacement of losses, defaulters and prisoners of war, P.A.D., duties of R.S.M. and C.S.M., maintenance and replacement of bridging materials in bridge on the Vesle and so on.

(*b*) Operational problems—duties in connection with outposts (you will remember that the 1 Div. was very nervous about being attacked that night), orders regarding the next day's operations, preparation for repair of roads and for an opposed river crossing, C.R.E.'s operation orders, Coy. Comdr.'s orders, duties of subalterns, etc., organization of reconnaissances.

I maintain that once you begin to make a detailed picture of the action and situation of the Div. Engrs., these problems bubble up in the mind, like the bubbles in a glass of champagne.

Now take the German side—you realize of course that we must always use present-day British war establishments. Imagine a field company under command of the Landwehr (*i.e.*, Territorial Army) Inf. Bde. opposing the British 1 Div. on the evening of the 12th.

You have innumerable problems regarding demolition of the roads leading down the steep valleys to the Aisne, of the bridges on the canal and river, etc.

Some of these problems are, even in war, solved on paper, some must be solved on the ground. As regards those on paper, be sure to use the French maps such as we might get in war. As regards exercises on the ground, you may say " we can't go to the Aisne." The answer is, transfer the scene to a place near barracks—at Chatham to the slopes of the Medway, at Aldershot to the Chobham and Blackdown ridges running down to the Basingstoke Canal, at Bulford to the valley of the Avon or the Bourne.

For real bridge demolitions any good road or railway bridge can be assumed to cross the Aisne or the Aisne-Oise canal.

Turning back to the British 1 Div. on the 13th, we can similarly transfer the picture to English ground. It is easy to say of the Bourne or the Blackwater—this stream is 250 feet wide and unfordable. It is the banks and approaches which present the " special case "—the water surface can easily be imagined. We must not hesitate to invent or alter the historical example; it will remain realistic provided that the basic story is true to life.

I hope that the method is clear. If you like to take, instead of an historical episode, a Command or Divisional exercise and to break it down in the same way, do so. But I advise you to take the operations on not more than a Divisional front with perhaps an open flank, and to base all your exercises for the season on the one operation.

The reason is that it not only gets you yourself right into the picture, but the class also. They have the whole thing in their minds ; they know the map and ground, they have not got to search for Northland, Southland, Wessex and Anglia and all the paraphernalia of which, as an army, we are so fond. Within five minutes of getting the problem they are down to business.

The method has the further advantage that it makes it easy to lay down for one of your subordinates what operation he is to take for his own scheme : and at the same time ensures that his scheme will not be fantastic.

The method will also, you will find, give you plenty of material for "happy half-hours," but we will discuss these on another occasion.

To C.R.E's I say,—try to get your "G" staff to help—this is especially important in T.A. divisions, where the R.E. Adjutant is not always up to the highest standard as a trainer of officers.

So much for the training of officers in engineer tactics.

Young officers must also be given training in the type of technical problem represented by the *f* (ii) project. I admit that these are a dreadful labour, but we might get Y.O's. to set problems for each other and to correct them. The results of *f* (ii) projects are, in my experience, depressing—not because officers lack theoretical knowledge, but because they fail in seeing a true picture, in practical detail, and especially in organizing labour. Young officers evidently lack experienced guidance in their preparation for such examinations. Such problems, on the ground, as E.E.W.T's. must include the actual giving of verbal orders to subordinates. This prevents the woolly answer which evades difficulties. And remember that in war all action by commanders takes the form of orders first, and then seeing that they are carried out.

So much for the making of the field engineer. We have not much time to consider the civil engineer training of officers. There has recently been much writing in *The R.E. Journal* about the value of "Works" as training. Works experience of the best kind (*e.g.*, N.W. Frontier works and much work in the Far East and Palestine and even at home) is admirable training and experience. But even the dullest work can be good training, not only in co-operation with the other arms, but technically. I am, alas, no works officer myself, and learned I fear very little on the technical side from what small works experience I have had. But I remember some most interesting and instructive hours with the "Technical

Examiner" when he visited my charge. He invariably found fifty matters for criticism at every "stance" as we went round new construction. And I feel that, if senior officers (or S. of W's) could give young officers similar instruction they would learn much—both the seniors and the juniors. The trouble with works officers is that they are usually overwhelmed with routine—and in this India is the greatest sinner. The ideal is, of course, as we all know, work by direct labour—but I fear that the prejudices of "financial control" will never permit of our getting this, although it is the only real preparation for works in war.

By the same token I hope that all officers will take full advantage of the facilities for attending lectures, discussions and technical visits which the local branches of the Institution of Civil Engineers are now so generously extending to us.

One could talk on this subject of training for hours—but I go back to my first question.

Are we really convinced that preparation for war is our primary duty, towards both ourselves and our subordinates? If we are—and only if we are—we shall find the time and the means.

May, 1939.

LECTURE 2.—"HAPPY HALF-HOURS."

GENTLEMEN,

In my lecture on the subject of methods of training the R.E. officer, I mentioned what I called "Happy Half-Hours" as a way of utilizing the short periods which are all that the busy officer can sometimes give to training.

And you may remember that I suggested for these "half-hours," either :—

(*a*) A short exercise on the map, based on the historical or other "narrative" which should form the foundation of the whole of our season's training, or

(*b*) A catechism by question and answer on, for example, administrative problems arising from the same "narrative," or

(*c*) A "scripture reading" on the text of a section or paragraph of Engineer Training, or

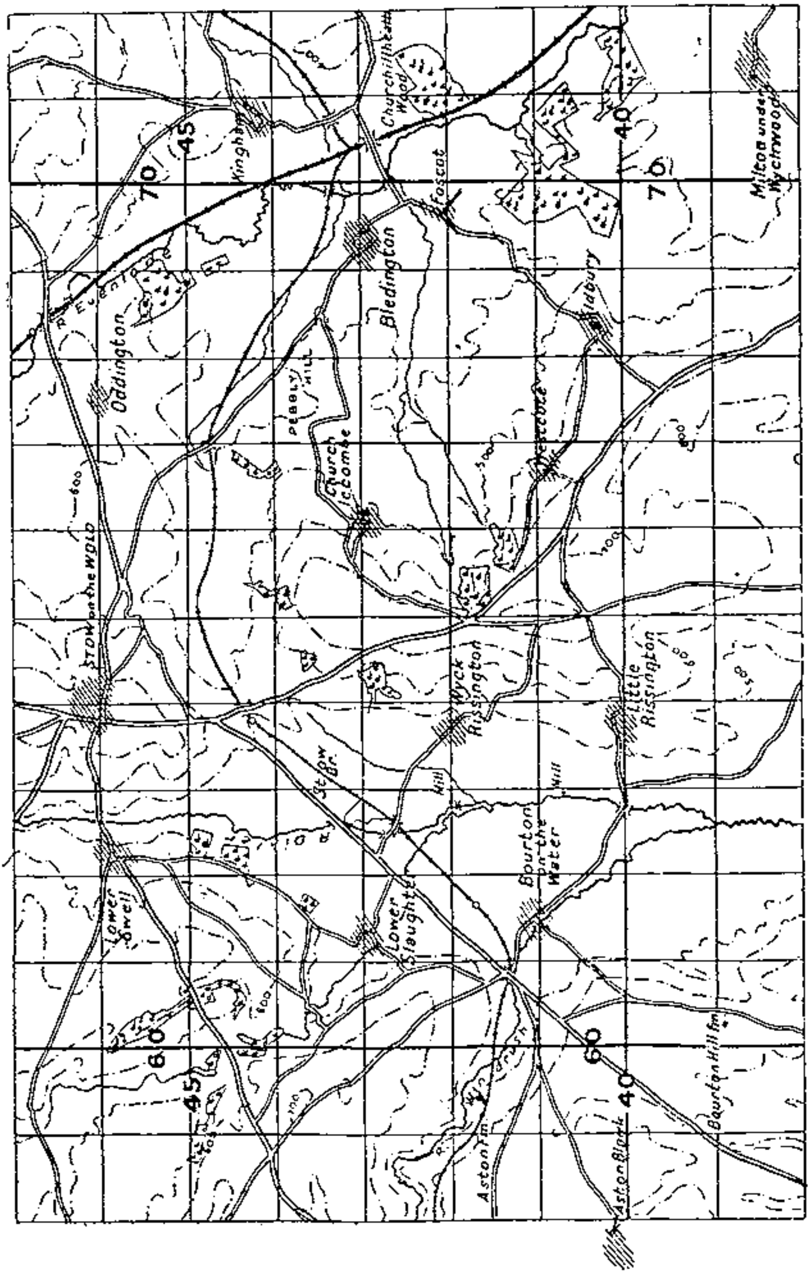
(*d*) A small technical exercise on the blackboard or model.

I propose during to-day's talk to give you examples of what I mean. I have already given out the narrative on which these "Happy Half-Hours" will be based* : so that you may be at once in the picture. In your unit or formation I should expect officers

*See "Historical Basis for the Lecture." p.365.

Plate I.

PORTION OF 1" ORDNANCE SHEET 93.



to be well in the picture from having done frequent exercises on the same theme "narrative"—or that you would have issued a special narrative overnight.

We are dealing as you will see with the operations of the 1 Div. on the Aisne on the 12th and 13th of September, 1914, and according to the rule which I recommended to you, we ought to be using the French map for the sake of practice. But in this case I have "transferred" the situation to a portion of the 1-inch Ordnance sheet 93 "Stow-on-the-Wold" (which we shall be using later in connection with a cloth model) merely to show you how easy it is to transfer such historical situations to accessible ground.

A.—Example of a Short Exercise on the Map.

Narrative.

You are the Adjt. 1 Div. R.E. at Div. H.Q. at Kingham Stn. (7042) on the evening of the 12th September.

At 1900 hrs., when you have just organized the office in your billet, the C.R.E.—who has been out with the Div. Comdr.—comes in and says:—

"We have just been warned to be ready to advance to-morrow before dawn to force the crossing over the Canal (R. Dikler) and the Aisne (R. Windrush) and to seize the high ground S.E. of Bourton-on-the-Water.

Historical Basis for the Lecture.

(*Ref. 1-inch Ordnance Sheet* 93.)

1. On the 12th September, 1914, 1 Corps of the B.E.F., following up the German First Army, crossed the R. Vesle, 1 Div. on the right, 2 Div. on the left, after overcoming slight opposition from a Landwehr Bde. During the night of the 12th/13th the Div. was in contact with the Landwehr Bde., 3 or 4 miles north of the R. Vesle. On the 13th September the B.E.F. continued its advance and the 1 Corps crossed the double obstacle of the Aisne canal and the R. Aisne and established itself on the hills north of that river.

2. For the purpose of this exercise the situation is transferred to 1-inch Ordnance Sheet 93, to the country in the large square 60/40 in the centre of which lies Stow-on-the-Wold.

3. In this case the B.E.F. is advancing from east to west, axis of advance of 1 Div. Bledington (6942)—Bourton-on-the-Water (6141). The R. Evenlode represents the Vesle, the R. Dikler is the Aisne canal, the R. Windrush is the Aisne, the high ground south and west of which represents the Chemin-Des-Dames ridge.

It is the late afternoon of the 12th September. The situation on 1 Div. front is:—

1 Gds. Bde. (one Sec. 12 Fd. Coy. under command)—Pebbly Hill (6743) area in touch with Mob. Div.

3 Inf. Bde. (one Sec. 23 Fd. Coy. under command)—Idbury (6840) area in touch with 2 Div.

with outposts in contact with the enemy east of Church Iccomb (or Icomb) (6643)—Westcote (6643).

2 Inf. Bde. and Div. Tps. Bledington (6942)—Foscot (6943)—Kingham (7144).

It has been raining heavily during the afternoon and is still raining. The Div. R.E. has had to place two Class 18 S.B.G. Bridges over the Evenlode.

4. The Aisne canal (R. Dikler) is 100 ft. wide and 9 ft. deep. Tow paths on both banks raised 3 ft. above water level and 4 to 8 ft. above general level of valley: 12-ft. drainage cuts easily fordable on both sides of canal.

The R. Aisne (R. Windrush) is 170–200 ft. wide and unfordable, current 1 m.p.h., banks generally 4 to 6 ft. above water, the level of which varies greatly with the season.

Div. right boundary (with Mob. Div.) :—

(Incl. to 1 Div.) Church Icomb (6643)—Stow Br. (6243).—Lower Slaughter—Aston Farm (5941).—Aston Blank (5740).

Div. left boundary (with 2 Div.) :—

(Incl. to 1 Div.) Idbury (6840)—Little Rissington (6340).—Bourton Hill Farm (5938).

"The Div. Commander thinks that the enemy are on the run, but that he is sure to carry out some demolitions. He wants two heavy routes in the divisional sector, if he can get sufficient bridging material and extra R.E. units, if necessary, out of Corps.

"I am afraid he may prove optimistic, and we must be prepared for resistance and extensive demolitions.

"I have to go with the Div. Comdr. to Corps at 1930 hrs. and I must have some food first. Let me know in 20 minutes' time what equipment and if necessary extra Sappers we should ask for."

Problem :—As Adjt. R.E. 1 Div. prepare your answer.

I do not propose to make you give that answer now. I give you the setting as an example of a short exercise—which is true to life since it would, even in war, have to be solved from the map.

This setting will in turn provide the basis for other short exercises or half-hours.

B.—Example of an Administrative "Catechism."

Let us take the same opening narrative ; the situation on the evening of 12th September.

You will remember that 23rd Fd. Coy. had a section under command of 3 Inf. Bde. at Idbury. The remainder of the Company (less ½ section on bridge maintenance at 699428) has been in billets in Foscot (6942) since 1800 hrs. They have not done much work during the day, except to build the S.B.G. bridge, but they have been on the move for fourteen hours, have been attacked from air, have lost 2 killed and 4 wounded and are tired and wet.

Here are a few administrative questions :—

(1) You are a section subaltern in Foscot. What are your duties when your section arrives in its billeting area ?

(2) You are the Company Captain :—

(*a*) What is the ration situation ?

(*b*) How will the following be fed :—

The Company in Foscot ?
The Section at Idbury ?
The bridge maintenance party ?

(c) The O.C. Section at Idbury reports by D.R.
Two men very ill, he thinks from exhaust fumes. One personnel lorry has run a big-end and has been towed into Idbury.
He asks what he is to do?

(d) The C.S.M. reports two German prisoners found in the billets. They are waiting outside under escort. How to dispose of them?

(e) The Transport Serjeant reports transport has only an average of 20 miles of petrol left. How is it refuelled?

(f) What reports and returns has the Company to send in to-night?

Etc., etc.

If you will picture the Company arriving in billets and settling down and the kind of incidents and casualties which might arise, you will, I think, find it easy to propound a vast number of such simple and practical questions, the answers to which we should all know.

The preparations for the following day's advance will supply another packet of conundrums.

C.—Example of a "Reading" from Engineer Training.

Still keeping in mind the same general narrative let us apply E.T. Sec. 110.5 to the forcing of the crossing of the Canal (R. Dikler) by the 1 Gds. Bde. between (inclusive) Stow Br. and Mill in 6241.

Let us assume that the Bde. only reached the canal bank 1700 hrs. on the 13th and has to force the crossing—with assault boats—during the night.

(This is a falsification of past history but not of future history, which is what really matters. It is permissible provided that the general setting is realistic.)

The 12th Fd. Coy. in support is to establish a F.B.E. bridge: a pontoon bridge being built later by another company.

Sec. 110.5 which deals with the organization of the forward movement of the bridging equipment to the off-loading points or bridge sites begins by saying:—

> "To minimize the risk of a hitch . . . special care must be given to the selection of the following points and of the routes forward from them" (which of course includes routes up to them).

Without looking at our books let us see if we are quite clear as to the meaning of these "points," *i.e.*,

Rendezvous (110.5 (i)).
Parking area (110.5 (i)).
Off-loading points (110.5 (ii)).
Assembly positions (110.5 (iii)).
Forming-up places (110.5 (iv)).
Bridge forming points (110.5 (iv)).

(NOTE.—This was done by question and answer.)

Now let us consider the application of this to our special case. Take first the "assault boats." How many are there available for the 1 Gds. Bde.? Where are they carried and how? Who is responsible for operating them, the infantry or the R.E.? What are the R.E. responsibilities regarding them?

At the rendezvous who will take them over, the infantry or 12th Fd. Coy.? I think 12th Fd. Coy. for two reasons—firstly because the boats will probably come up with the F.B.E. lorries—to avoid the extra risk of error which every additional detachment causes—and secondly, because the Fd. Coy. takes charge of all R.E. equipment and material for the Inf. Bde. to which it is in support or under command. See page 162, last para. of 110.7.

There will, therefore, be one rendezvous for the assault boats and F.B.E. coming up to 12th Fd. Coy. Who selects the rendezvous? The C.R.E. or the Fd. Coy.? See 95.6, second para., "the Staff will fix the rendezvous and times at which engineer officers of forward formations will meet the mobile bridge equipment." That is to say, the C.R.E. will do it and get Staff to issue the orders to the brigade, of which he sends a copy to Fd. Pk. Coy.

How is this rendezvous chosen?

E.T. 110.5 (i) only gives "parking space available for re-assembling lorries," but I think that you can suggest other factors, *e.g.*—

Easy access.

Ease of recognition in the dark.

Cover for waiting vehicles against ground and air observation.

Not a target for shelling (remember that it is a primary duty of the R.E. officer to know where shells usually fall. Heavy losses can be avoided by Company Commanders who pay attention to this).

Space to allow lorries to clear the road.

A point from which there are alternative forward routes.

Who is responsible for reconnoitring the rendezvous and the route to it? The Field Park Company. Where would you suggest a rendezvous from the map, the Fd. Pk. Coy. being in Churchill Heath Wood (7142)? Possibly the road fork and orchard in 6843.

Who meets the vehicles at the rendezvous? An officer of 12th Fd. Coy. and a party of Sappers.

What are the duties of the officer? See Sec. 95.6, the "officer will check the allotment made to his formation and guide it to the destination ordered."

What ought this officer to do before coming to the rendezvous? Reconnoitre the route to this destination, *i.e.*, the parking place and the destination itself to see that it complies with the requirements of a parking place, into which we shall go later. The company is also responsible for :—

Improvement, marking and screening of the forward routes (110.10 (ii)).

The possibility of the blocking of the approach by enemy harassing fire should be foreseen and provided against. (110.10 (ii)).

Why does a party accompany the officer? Sec. 95.6. "Where the delay in the arrival of the equipment will have serious results . . . it is desirable to detail a party to accompany each detachment to remove obstacles and to repack the vehicles in case of accident." One reason for putting the rendezvous well back; or even for fixing the Fd. Pk. Coy. lorry park as the rendezvous, since the Fd. Pk. Coy. has no men available.

And so we go on—I think, however, I have given you enough to show what I mean by a "scripture lesson."

To be effective I feel sure that such a lesson should be based on a concrete situation. If you have such a situation, you will have no difficulty in finding appropriate illustrations for almost any para. of E.T. dealing with "engineer tactics and duties in the field."

D.—Example of a Technical Exercise.

Strictly speaking, this example of a technical exercise should be based on our basic narrative, to give it a realistic character. But in this lecture I propose to illustrate a small disconnected exercise which would be suitable for young T.A. Officers and N.C.O's.

Imagine then that you are a T.A. subaltern taking a cadre class of N.C.O's. You have told them to design a small splinter-proof shelter for Company H.Q. to be constructed off a communication trench, and to put up a working drawing. One of the results is shown on the blackboard (see Plate 2). Criticize it.

This exercise can be run on the lines of a "drawing room competition," the competitor with the largest number of correct criticisms winning the prize.

(Note.—This was done, with the exception that no prize was offered. Altogether fourteen criticisms were accepted, without exhausting the list.)

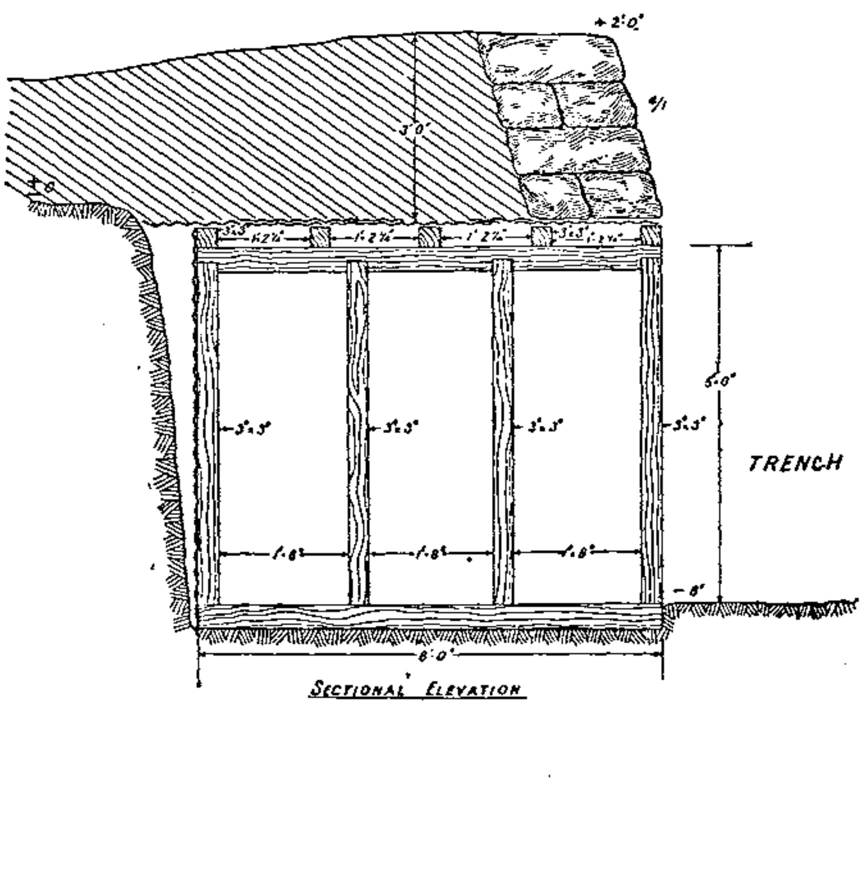
That, gentlemen, completes my illustrations of "Happy Half-Hours." I hope that I have convinced you that such short periods of training can be made profitable and not, I trust, uninteresting.

I need hardly say that when you are lucky in the situation of your barracks or drill hall, similar short exercises can be given on the ground. And do not be too ready to say that "there is no suitable ground." In war we cannot always choose our ground, but have to fight where we find ourselves.

L.V.B.

SPLINTER PROOF SHELTER

Plate 2.



SECTIONAL ELEVATION

ALEXANDRA COLD STORAGE AND BAKERY, SINGAPORE.

By CAPTAIN A. E. M. WALTER, R.E.

IT is not often that the opportunity occurs to construct a Cold Storage and Bakery in the course of service on Works. As a result the information available to assist the design staff, those responsible for the preparation of the specifications for building and Electrical and Mechanical work and those responsible for the supervision of the contracts, is limited. However well the lay-out is designed and however carefully the specifications are written, there will always be details of design and construction in the finished work " which might have been better." A close study of the " as designed " and " that which might have been improved " will result in progressive improvement and it is the object of this article to make this study in the case of a combined Cold Store and Bakery.

The subject is divided under the following heads.

A. Lay-out.
B. Operation of Bakery.
C. Insulation of Cold Chambers and Plant.
D. Operation of Refrigerating Plant and Air Conditioning Plant.
E. Electricity supply and distribution within the building.
F. Electric Motors and Control Gear.
G. Erection and Personnel Details.

It is emphasized that, though the majority of the information given is applicable to any Cold Storage and Bakery in the tropics, certain details (such as the operation of the Bakery) are affected by the tropical climate peculiar to Singapore. As the author was partially responsible for the preparation of the lay-out, the writing of certain of the specifications and supervised the E. and M. work on the site, any criticisms made come home to a large extent and are only made in the hope that they will provide useful information for the next job.

A. LAY-OUT.

1. *Building.*—The building lay-out is shown on Drawing No. 1. Rail (F.M.S.R. Standard metre-gauge) and road access are provided to loading platforms on both sides of the building. The working temperatures of the various cold chambers are shown on Drawing No. 1.

2. *Receipt of Supplies.*—In general, all supplies are delivered by rail direct from the docks. All supplies except flour are delivered in insulated wagons.

All supplies except flour, if received by rail, are weighed in the air lock on W.1; if received by road, these supplies are weighed outside the air lock at W.3. Supplies, other than flour, destined for the first floor, after being weighed at W.1 or W.3 are sent up in goods lifts 1 and 2.

All flour received is weighed at W.2 and the bags (140 lb.) or sacks (280 lb.) are lifted to the flour store on the first floor by an electric hoist fixed above the loading bay and projecting over the rail platform.

3. *Issue of Supplies.*—Meat, bacon, cheese and margarine are weighed in bulk on W.3 before going to the cutting-up room. The portable weighing machine W.4 is taken to the cutting-up room to assist the division of the bulk supplies. Rations are issued from the loading platform outside the cutting-up room to lorries backed on to this platform. Bread, after cooling, is also issued from this platform.

4. *Plant.*—Certain plant such as lifts, hoists and weighing machines may be regarded as part of the building, since their location and capacities assist the smooth flow of supplies to and from the building. General details of the sizes of this plant taken in conjunction with their location will be of interest.

(*a*) *Goods Lifts.*—There are two lifts, each 15 cwt. capacity at a speed of 120 ft. per minute. Neither lift can be operated by a passenger in the lift but can only be operated externally from controls on the ground or first floor outside the cages. Timber wheel guides are fitted to the floors of each cage, in such a way that the wheels of the meat trucks are always guided to a central position in each cage.

(*b*) *Flour Hoist.*—This is a motor-driven friction hoist, operating on a runway projecting over the rail loading platforms and capable of lifting ½ ton. The bags or sacks of flour are placed on a special galvanized iron tray fitted with S.W. rope slings. This tray is lifted by the hoist until the tray is just above first floor level. The hoist is then drawn inwards until the tray is opposite the air lock of the flour store. The tray is then lowered on to a three-wheel jack truck, similar to those used in any large railway station to move large quantities of baggage. The truck with the tray is then pulled into the flour store. Three of these empty trays are shown loaded on to a truck in the centre of Plate 1.

(*c*) *Weighing Machines.*—The fixed weighing machines W.1, W.2 and W.3 will each weigh loads up to 1 ton. Each machine has a dial graduated to read up to 15 cwt. in 4-lb. stages and also a steelyard which will weigh up to 5 cwt. All the meat trucks (used also for bacon, margarine and cheese) are carefully tared, so that they all have the same tare. This tare is set on the steelyard of each of the fixed weighing machines. Each empty truck when pushed on to the weighing machine brings the dial to zero. The weight of any foodstuff in a truck is then automatically registered on the dial without having to deduct the tare of the truck each time.

The portable weighing machine W.4 has a dial graduated to read up to 5 cwt. in 1-lb. stages.

(*d*) *Meat Trucks.*—The meat trucks are made with U-shaped bodies with open ends and have solid wheels, ball-bearing mounted. Fortunately, steel flooring, not provided in the original specifications, was suggested and used in the passages and dough room during construction. I say fortunately, because the steel wheels of the trucks have proved too hard wearing for the floors where the latter are grano-finished. Steel flooring stands up to these solid wheels very well but the noise made by these trucks on steel flooring is very excessive. Rubber-tyred wheels and grano floors would have given a better and cheaper result.

5. *Errors in Design of Lay-out.*—Although it is easy to be wise after the event, experience gained by the operation of the plant and the building has shown a few faults in the lay-out as follows :—

(*a*) *Ground Floor—Bread Cooling Room.*—Opening D should have been located at D.1 (Drawing No. 2). Plate 2 shows the two draw-plate ovens and the opening D. It will be seen that when the draw-plates of the left oven are drawn out, they draw out opposite the opening D (one draw-plate of the right oven is shown drawn out). In this position the heat of the draw-plates is radiated into the bread-cooling room (which is kept cool by exhaust fans). The passage between the draw-plates and the opening D becomes very narrow and the movement of the bread trucks is slightly impeded.

(*b*) *Position of Condensers in Compressor Room.*—Although the condensers are neatly tucked away in the alcove provided (Drawing No. 1), no window was provided on the external wall of this alcove. The alcove is a veritable trap for the ammonia fumes which are so often present in any compressor room. In addition, artificial light has to be used at all times when working in this alcove. As a consequence of this lack of window with its attendant ventilation, it has been necessary to provide a small 12-inch exhaust fan at F.1 (see Drawing No. 1).

(c) *Exit to First Floor Air Lock.*—The only exit for ammonia fumes (should a leak occur in the pipework on the first floor) and for the stale air which accumulates in the passages is down the stairs and the lift well. The air in the first floor air lock gets stale in three to four days and, owing to there being only one exit, no through draught could be obtained. It has been necessary to provide a 12-inch exhaust fan at F.2. This fan is on the external surface of the wall and the insulation of this wall is maintained by a detachable timber-lined cork plug fitted behind the fan. This plug is removed every fourth day, the fan is run and the air sweetened.

(d) *Ventilation of Compressor Room.*—There is no through draught and the windows are too small in the compressor room (Drawing No. 1). The working temperature varies between 94°F. and 96°F., too hot even for an Asiatic staff working for an eight- to ten-hour day.

As a consequence, it has been necessary to fit three 16-inch wall-mounted oscillating fans to create a movement of air inside the compressor room towards the exhaust fan fitted at F.1.

B. OPERATION OF BAKERY.

1. *Storage of Flour.*—The method of loading the flour store has been described in para. A (2) above. Daily shade temperature and humidity in Malaya average 84°F. and 83 per cent. Since flour should be stored as nearly as possible under the same conditions of temperature and humidity at which the wheat ripens, particularly humidity, the flour store is maintained at a temperature of 70°F., and a humidity of 50 per cent by an air-conditioning plant located in the position shown on Drawing No. 2.

In addition, in order to provide a circulation of air all round each stack of flour, the flour is stacked on a painted steel open flooring raised nine inches above floor level and assembled in removable sections. A surface channel runs along the two long sides of the flour store and the floor is graded from the centre down to these channels. The steel floor can be removed in sections and the concrete floor washed thoroughly when required.

Plate 1 shows a portion of the steel flooring and railing against which the bags are stacked. The suction air duct, through which air is drawn back to the air-conditioning plant, is shown in the top right of Plate 1 under the ceiling.

2. *Dough Making*—Drawing No. 2 shows the lay-out of the dough making machinery in the dough room and the flow of material (flour) is shown by the dotted lines. It will be seen that the lay-out is such that there is a steady flow forward and is so arranged that the men engaged in each operation do not get in each other's way.

The process of dough making is as follows. The bags or sacks of flour are brought out of the flour store on the trucks described in para. A(4) (*b*). Each sack in turn is emptied into the chute of the flour plant, in which a steel spiral feeds the flour forward to a spiral brush sifter. The spiral brush working against a semi-circular sieve thoroughly sifts the flour and passes it on to a small paddle elevator, from which the sifted flour pours down into the dough-kneading pans which are cast iron with heavily tinned interiors. The empty flour sacks are thrown into the sack-beater room where a man feeds each sack in turn into the sack-beater. Each sack is thoroughly cleaned by special brushes and the flour and fine dust drawn off and separated by a suction fan. The cleaned sack is discharged through a chute in the floor to the sack store on the ground floor.

Each pan is then pushed to one of the two dough kneaders. (Plate 3.) The pan is locked to the base of the dough kneader. The correct amount of water at a temperature of 70°F. is added to the flour from the water-mixing tank. Yeast, salt, etc., are added by hand and the whole thoroughly kneaded by the double action of the revolving pan and the swan-neck arm of the kneader. Kneading takes about 15 minutes.

After kneading, each pan is pushed to the pan park, where it remains for a period varying from four to six hours while the dough ferments. When the fermentation is complete, the pan is pushed to the dough divider (Plate 4). The dough is scooped out of the pan by hand and dropped into the hopper of the dough divider which divides the dough into pieces, each piece being the correct weight to give the finished weight of loaf. The dough pieces drop out of the dough divider into an hopper and roll down a chute to the tin-bread moulder on the floor below.

The dough pieces are further stretched and rolled in the tin-bread moulder and at the same time are moulded to a shape which will fit the baking tin easily. As the dough pieces are discharged from the moulder they are hand fed into the baking tins. The tins are loaded on to trucks with special detachable trays. The trucks are pushed to the ovens and dough pieces are loaded on to the oven draw-plates ready for baking.

3. *Baking.*—The ovens are oil-fired double deck circulating tube draw-plate ovens. Weldless solid-drawn steel tubes filled with a proper proportion of distilled water are heated by oil-fired furnaces. The tubes are arranged above and under the draw-plates so that the top and bottom heat can be adjusted exactly to suit requirements.

After baking (this takes 50 to 60 minutes) the bread in its tins is removed from the draw-plate to bread-cooling trucks which are parked in the bread cooling-room. It is proposed to feed the bread to a bread-wrapping machine after it has been cooled but the wrapping machine is still on its way out. After wrapping, the bread is kept in the bread store until issued.

4. *Errors in Design.*—The lay-out of the plant has proved very satisfactory but mistakes have been made in the types of machinery ordered. The process of making bread varies in certain details, according to the climate in which the bread is made and the types of flour and yeast used. Unfortunately, sufficient data was not available as to the process of making bread under local conditions at the time that the plant specifications were prepared. Three items of the original plant have since been found to be quite unsuitable for the process. It is hoped that a description of the errors made will emphasize that accurate data must be provided by the R.A.S.C. as to the exact process by which the bread will be made, if the correct plant is to be specified and relatively costly mistakes avoided.

(*a*) *Water Heater.*—(Drawing No. 2-H, also Plate 3.) It was proposed to add water at a temperature of 90°F. to the flour before the kneading process (see B (2) Dough Making). A 9 k.w. 3 Phase storage heater was therefore provided so that hot water and cold water (local cold water temperature is about 80°F.) could be mixed in the mixing or tempering tank T to give water at 90°F. It has since been found that water at 70°F. is essential to the success of the dough. The local cold water has therefore to be cooled, not heated. A storage tank with brine-cooling coils should therefore have been specified —not a storage heater of the size provided. Pieces of ice have now to be added to the tempering tank until the temperature of the water therein is reduced to 70°F. The heater is trying to justify its existence by providing hot water for sluicing the pans and machines. (Later Note.—Water at 80°F. (local cold water) is now being used, so there is hope that water at 90°F. will one day be used !)

(*b*) *Prover and Conical Moulder.*—Originally it was intended to make Coburg loaves, *i.e.*, loaves of the shape of the well-known Home ration loaf. To do this a Prover (an endless belt with pockets for the dough pieces) was purchased. The dough pieces from the divider fell into the Prover, which gave 10 minutes' proof or setting of the dough piece, and were discharged from the Prover into a conical moulder in which the dough pieces were further stretched and shaped to the Coburg shape.

Experimental operation locally revealed, however, that the crust of the Coburg loaf fell in while cooling after baking, in a manner similar to the unsuccessful home-made cake which fails to rise. This meant that a different dough had to be made and that the loaf required the support of a tin while cooling to prevent the crust falling in. As a consequence, a tin bread-moulder had to be substituted for the conical moulder and, since the new dough required one hour's proof, the 10 minutes proof given by the Prover was useless. Thus both the conical moulder and the Prover were redundant right from the start. In addition, the tin-bread moulder had to be purchased, altogether a costly mistake which might have been avoided so easily.

5. *Final Process in Production of Bread.*—As the designed process of making bread and the errors have been enumerated above, it might be as well to summarize briefly the final process adopted in the production of bread. This process is as follows :—

(*a*) Sifting of flour and filling of dough pans.
(*b*) Kneading with the addition of salt, yeast, etc.
(*c*) Fermentation in pans.
(*d*) Dividing of dough into dough pieces and discharge to
(*e*) Tin-bread moulder—moulding and stretching.
(*f*) Final proof of dough piece in baking tin.
(*g*) Baking—about 50 minutes.
(*h*) Cooling and wrapping.

C. Insulation of Cold Storage.

1. *Insulation of Chambers.*—Drawing No. 1 shows the working temperatures in the various cold chambers and the flour store and the thickness of cork insulation in each chamber. The cork arrived in cardboard cartons containing slabs measuring 3 feet by 2 feet, and in varying thicknesses, 3 inches, 4 inches and 6 inches.

2. *Insulation of Chambers in a Ferro-Concrete Building.*—The normal method of insulating the chambers of a ferro-concrete building is to use the cork slabs as shuttering for the construction of the walls and ceilings. The first layer of cork on the walls and ceilings is thus fixed very securely to the walls and ceilings and, in addition, the cost of timber shuttering is saved. Owing to the

revolution in Spain the first loads of cork for the Alexandra Cold Storage were destroyed. To avoid delay, construction proceeded with timber shuttering and the cork, when it arrived, was fixed to walls and ceilings by a method more normal to brick buildings.

3. *Method of Fixing Cork Insulation Employed at Alexandra Cold Storage.*

(*a*) *Walls* (1).—Timber studding (4 inches by 3 inches) was securely fixed to wood plugs in the walls. This studding ran from floor to ceiling and was spaced at eight-foot centres. Single horizontal studding was also fixed midway between floor and ceiling. Cork slabs with their edges stuck together with hot bitumen were then erected to a height of about 3 feet above floor level and at a distance of ¾ inch from the walls. This cork "shuttering" was held in place by light timbering. A cement grout was then poured in between the cork and the walls and carefully tamped. The cork slabs were given a coat of bitumen on the grouting face before erection into "shuttering" to seal the cork and make it water-tight. Erection of the cork proceeded in this way up to within 15 inches of the ceiling to enable the grout to be poured behind the cork.

(*b*) *Ceilings.*—The ceilings were also timber studded between the beams at 6 feet centres in both directions. The cork, first dipped in hot bitumen, was then stuck to the ceilings and wood skewers were driven at an angle through the edges of the cork into the timber studding thus giving an added support to the cork slabs. This was very necessary because this first layer of cork carried the weight of subsequent layers of cork. Subsequent layers of cork were stuck to the layer above with hot bitumen and given added support by more skewers driven this time through cork into cork.

(*c*) *Walls* (2).—After completion of the ceilings, the concrete walls, where exposed between wall cork and ceiling cork, were rendered and the first layer of wall cork was floated on in the same way that tiles are floated. Subsequent layers of wall work were stuck on to the layer underneath with hot bitumen and skewered.

(*d*) *Floors.*—The floors were rendered and the cork slabs were floated on and subsequent layers were stuck on and skewered. The rendering was necessary on the floors because they were very uneven, and the rendering would not have been necessary had the floors been well laid in the first place.

PLATE 1.

PLATE 2.

PLATE 3.

Alexandra cold storage & bakery 1 - 3

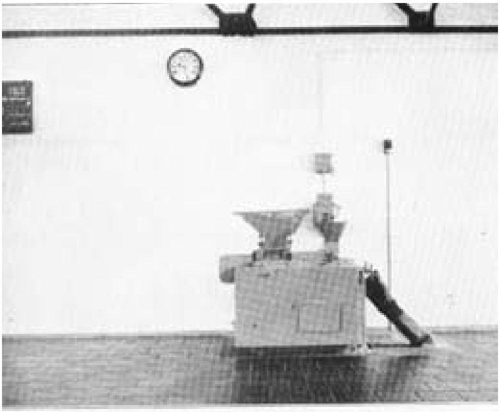
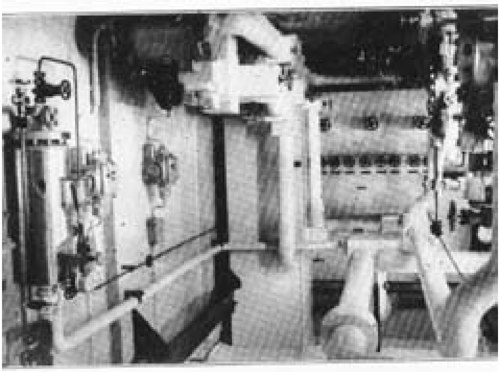


PLATE 4

PLATE 5.



Alexandra cold storage & bakery 4-6

(*e*) *Finish of Floors, Walls and Ceiling Insulation.*

(1) *Floors.*—After the cork had been laid, it was thoroughly sealed at the edges with hot bitumen and tarred roof felting was carefully laid and fixed to the cork. Although not originally specified, this felting was considered a wise precaution to prevent the ingress of moisture into the floor cork in the event of cracks developing in the grano floor above.

(2) *Walls and Ceilings.*—Rabbit netting of about 1-inch mesh was carefully pegged to the top layer of cork with wire staples. Walls and ceilings were then rendered with two coats of plaster (1 cement, 2 sand) total ½-inch thick and finished with a white plaster (1 white cement, 2 sand) ¼-inch thick. This white cement, though possibly a bit extravagant, gives a pleasing white and clean-looking finish and considerably assists in obtaining an even distribution of the electric lighting. (See Plate 5.)

4. *Fixing of Dunnage Battens.*—Though not a part of the actual cork insulation, it should be noted at this stage that two extra runs of horizontal studding were fixed in the cork insulation at suitable heights above floor level, to enable the vertical dunnage battens to be securely screwed to the walls at one foot centres.

5. *Fixing of Cooling Coils.*

(*a*) *Ceilings.*—(See Drawing No. 3, Fig. 3.) To fix the ceiling coils, timber studding was fixed on top of the cork with heavy galvanized coach screws screwed through the cork and into the ground work studding. After placing in position, the coils were retained in position by angle irons bolted on special iron studs fixed in the timber studding. The angle irons should not be bolted up too tightly, so as to permit movement of the coils when expanding and contracting due to temperature changes after defrosting a chamber.

(*b*) *Walls.*—(See Drawing No. 3, Fig. 2.) As in 5(*a*) above, timber studding was securely fixed on top of the cork (see Plate 5). This studding, however, had half circles cut in it to house the coils. The coils were then positioned, and timber retaining pieces (with half circles cut in them) were bolted over the coils. Protective battens were then screwed to the studding over the coils.

ALEXANDRA COLD STORAGE

FIXING CORK TO WALLS AND FLOORS

8" WALL INSULATION.

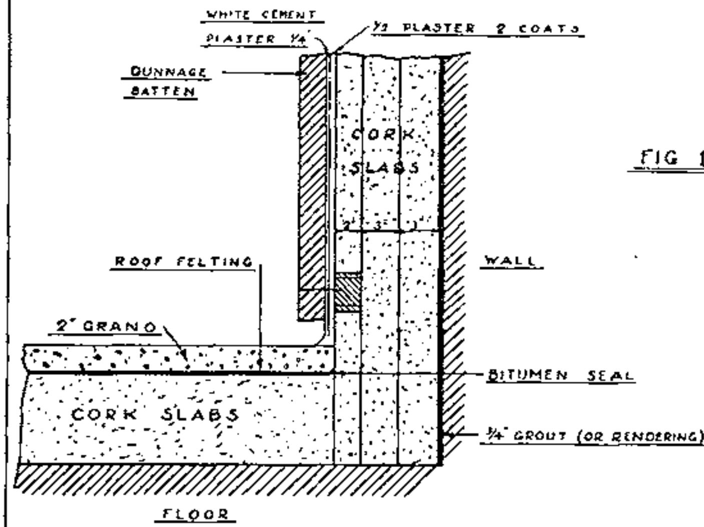


FIG 1

SECTION BETWEEN VERTICAL STUDDING

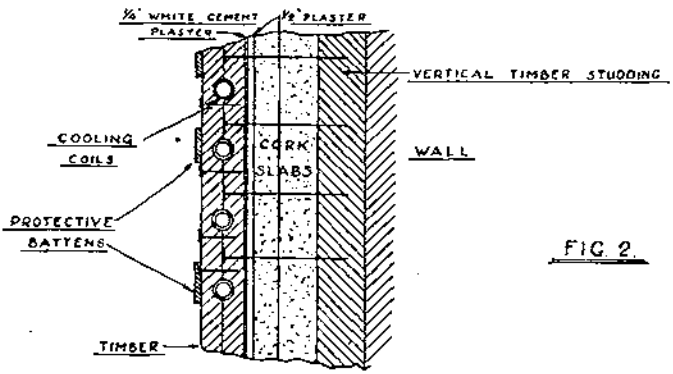
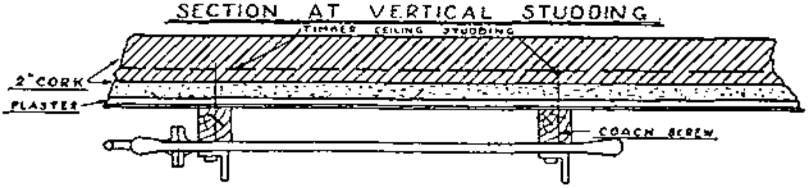


FIG. 2.

FIXING COOLING COILS TO WALLS.

SECTION AT VERTICAL STUDDING.



FIXING CEILING COILS (SEE PLATE 7)

FIG 3

DRG. Nº 3.

6. *General.*—The chief difficulties in fixing cork insulation are physical difficulties. All work has to be done by artificial light and during the early stages of construction at which the cork insulation is fixed, this lighting is not good. Large sections of the outer concrete wall of the passages outside the cold chambers were left out during construction to try and get as much daylight in as possible.

The bitumen used to stick the cork slabs has to be kept hot continuously and this is done by heating in open pans over charcoal fires. The fumes from the hot bitumen and the charcoal fires soon render the atmosphere thick and rather like a medium London fog, except that the temperature is about 100°F. As many electric fans as possible were kept going but really with little effect. As a consequence, the contractor had to rest his men one whole day in four days.

Uneven concrete walls, due to bulging of the shuttering boards at the joints, and uneven floors made the fixing of the first layers of cork by the artificial light a difficult task for Asiatic labour. It was due to the poor finish of walls and floors that the fixing of the first layers of cork had to be done by grouting behind and rendering underneath. The advantages of using the cork as shuttering for the walls and ceilings when casting the concrete became very obvious.

7. *Insulation of Plant.*

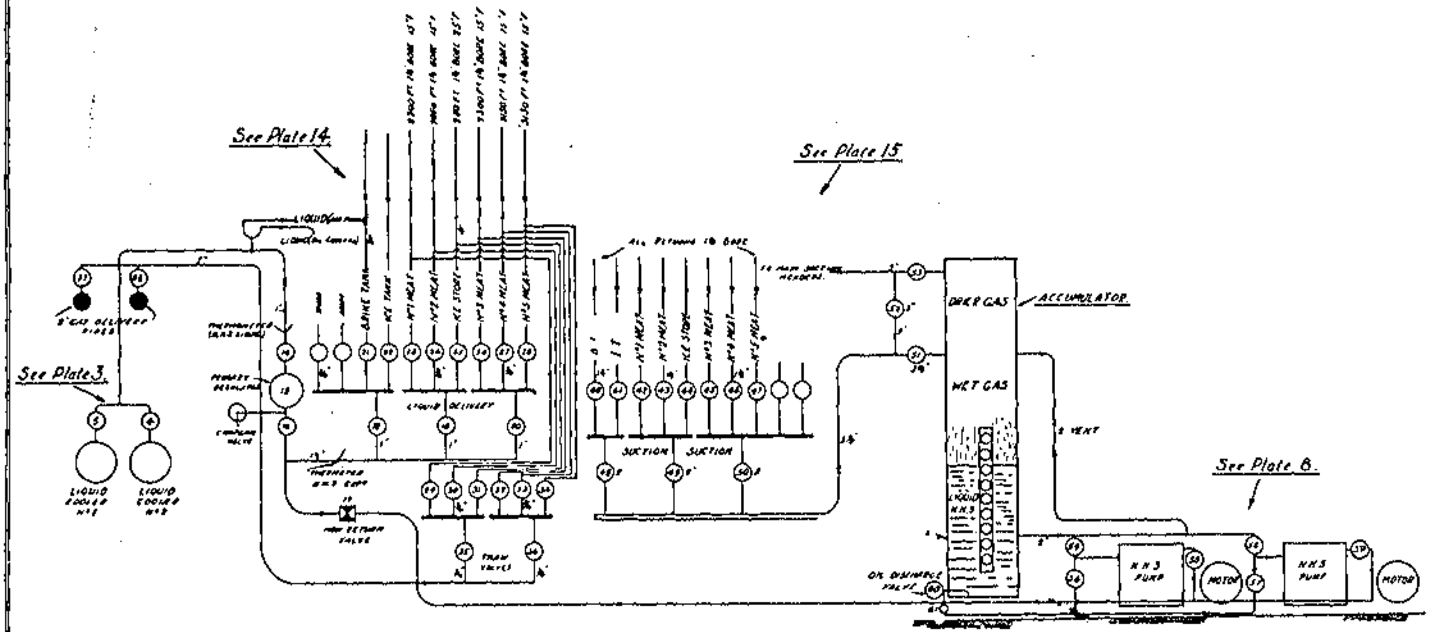
(*a*) *Pipework.*—For straight runs of pipework and over flanges and bends, special shaped sectional compressed cork (like the two halves of a bearing) to suit pipe sizes was stuck to the pipes with bitumen. Rabbit netting was bound round the cork and the ends of each length of sectional cork was secured firmly by a copper wire binding. The rabbit netting was pegged down with staples and two coats of plaster were trowelled on. A finishing coat of white cement plaster carefully and very cunningly smoothed with single palm leaf finished the insulation. Two coats of white paint gave the pleasing finishing touches shown on Plate 6. Great care was taken to see that the insulation really was sealed because any cracks in the covering cement let moisture in, which ultimately freezes, expands and causes further cracks. It is not a good policy to paint the cork with bitumen before putting on the plaster because the plaster never beds as firmly as it does into the porous cork untreated with bitumen and cracking of the plaster starts more easily as a consequence.

(*b*) *Valves, pipe headers.*—The valves and pipe work of the direct expansion regulating station and of the brine-cooling regulating station before insulation are shown on Plates 7 and 8. The same after insulation are shown on Plates 9 and 10. In each case a timber framework of 1½-inch by 1½-inch timber was constructed round the valves and pipe headers, this framework being securely screwed to plugs in the concrete wall or grouted into holes in the walls. The framework was then gradually covered with ½-inch T.G. boarding. As the covering proceeded, granulated cork was poured in all round the valves, etc., and carefully tamped. Both Plates 9 and 10 show that the work calls for careful planning and good joinery. Reference Plate 9, it should be noted that small boxes are constructed over each valve flange and that the tightening nut of each valve gland is not covered. This is important, because it enables each valve flange to be exposed at a later date with the minimum of disturbance to the rest of the insulation and also enables each valve gland to be tightened without any disturbance to the insulation. The regulating valves (top row left side Plate 7) have white metal seats and it is essential that the gland nut be easily accessible for tightening as wear takes place. Zinc drip trays (not shown in Plates 9 and 10) were fixed under the valves and led off to a collecting can. The exposed gland nuts are covered with ice during operation and weep water as a consequence and these drip trays carry away the water and prevent untidy pools.

D. Operation of Refrigerating Plant and Air Conditioning Plant.

1. *Direct Expansion System.*—The direct expansion of liquid ammonia is used to cool all meat chambers and to cool brine for ice making and brine cooling.

Ref. Drawing No. 4 *and Plates* 7 *and* 8.—Briefly and non-technically the system operates with flooded coils and dry compression. Ammonia gas is compressed and the hot gases are cooled and liquefied in multi-pass water-cooled condensers. The liquid ammonia is cooled in the liquid coolers and retained in liquid receivers. Primary expansion takes place at the Primary Regulator 15 at which the pressure on the liquid is reduced. This reduction in pressure causes a portion of the liquid to boil and vapourize. A mixture of liquid and gas (primarily liquid at reduced pressure) passes on *via* valves 18, 19 and 20, to the secondary regulating



Drg: No 4.

ALEXANDRA COLD STORAGE. CONTROL STATION. DELIVERY & SUCTION VALVES.

valves 21 to 28. From valves 21 to 28, pipes run to the cooling coils in the various chambers as labelled on Drawing No. 4. Return pipes from the chamber coils are connected to valves 40 to 47. Thus the cooling coil in each chamber is controlled by a secondary regulating valve at the delivery end (valves 21 to 28), and by a stop valve at the return end (valves 40 to 47). Each circuit is quite independent of its neighbours. The quantity of liquid and gas admitted to each circuit is controlled independently at its secondary regulating valve. Liquid ammonia is therefore flowing round the cooling coils in each chamber and boiling as it flows. The heat required for this evaporation or "boiling" is extracted from the heat in each chamber, the chamber thereby being cooled. Liquid and wet gas return by gravity *via* the collection valves 48, 49, 50 and 51 to the accumulator where they collect.

Gas is sucked off the top of the accumulator through valve 53 back to the compressor where it is compressed and the cycle starts again.

Liquid is drawn from the bottom of the accumulator by gear type liquid ammonia pumps. These pumps deliver the liquid ammonia *via* the non-return valve 17 and valves 18, 19 and 20 back into the cooling coils where, due to the pressure gradient existing between the secondary regulating valves and return valves 40 to 47, further evaporation takes place and more work in cooling is done.

2. *Technical Operation Data.*—Condenser cooling water and compressor jacket water are circulated over a wood slat cooling tower outside the cold store, make-up being added from the mains. The water from the tower is drawn up by centrifugal pumps and delivered first to the liquid coolers (with a branch to the compressor jackets) and then to the condensers from whence it returns to the cooling tower.

Normal Operation Data.

(*a*) Cooling water inlet temperature 84°F.
(*b*) Liquid NH_3 temperature 84°F. (measured before valve 14).
(*c*) Cooling water outlet temperature 92°F. (*i.e.*, after cooling condensers).
(*d*) Condenser gauge temperature 106°F. (*i.e.*, approx. C+10°F.)
(*e*) Evaporator gauge temperature —4°F. (measured at top of accumulator).
(*f*) Suction temperature on compressor 4°F. (f—e gives degree of super heat imparted to wet gas between accumulator and compressor).
(*g*) Compressor delivery gas temperature 282°F.
(*h*) Brine delivery temperature—3°F. (brine used to cool brine cooled chambers) see below.
(*i*) Brine temperature in ice tank 3·5°F.

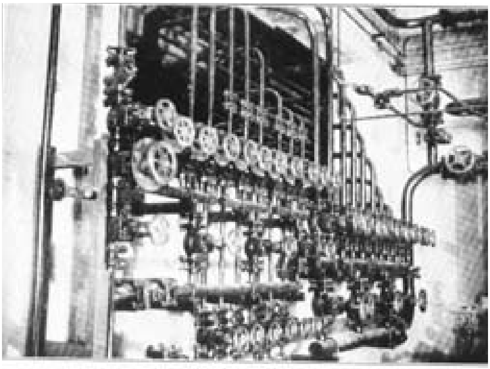


PLATE 7.

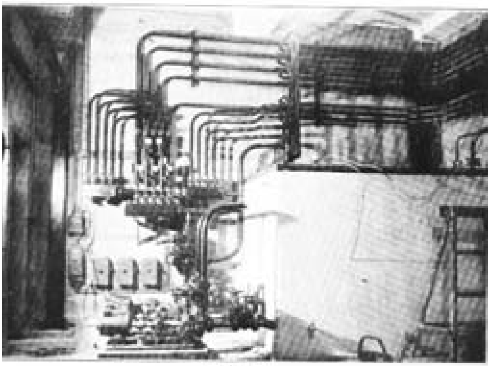


PLATE 8.

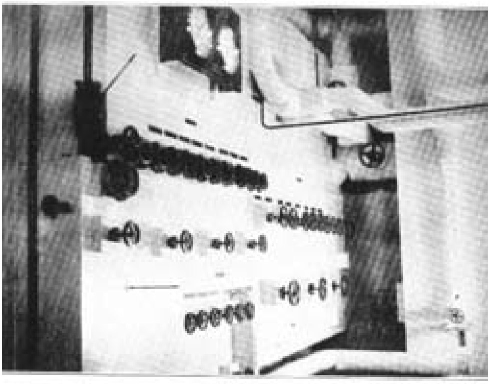


PLATE 9.

Alexandra cold storage & bakery 7-9

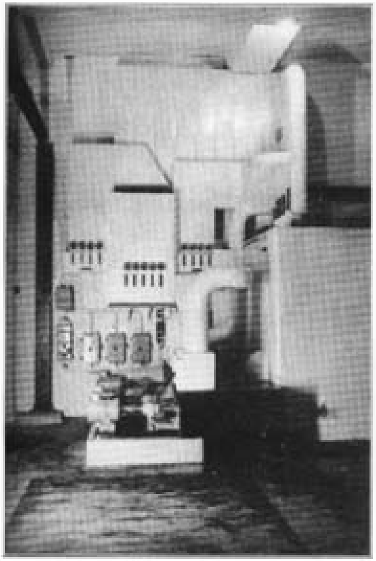


Plate 10.

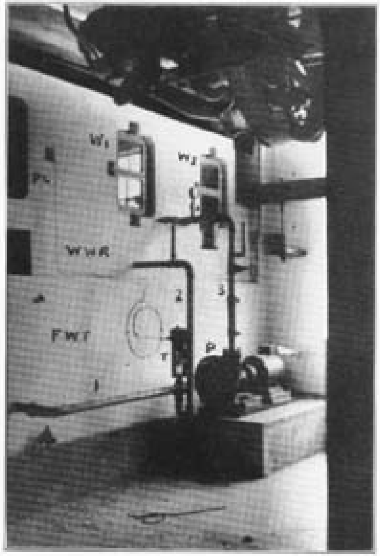


Plate 11.

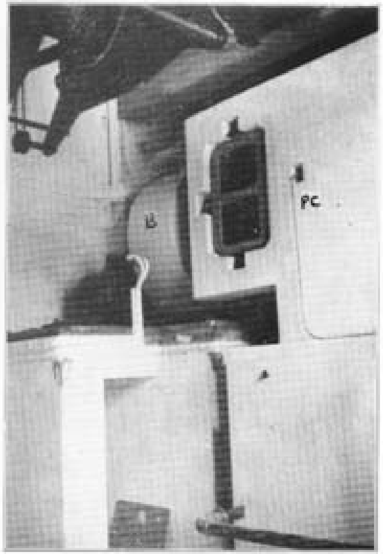


Plate 12.

Alexandra cold storage & bakery 10 - 12

The above data is taken from a typical day's log sheet in the middle of the day's working. The necessity to operate at such a low evaporator temperature as —4°F. is explained later. The high compressor delivery temperature is due to the high cooling water temperatures at which such plants operate in Malaya. This gives rise to considerable carbonization of the lubricating oil in the compressor and consequent valve troubles.

3. *Control of Cooling Circuits.*—Meat chambers 1 and 2 are on the ground floor, with ceiling cooling coils at a slightly higher level than the accumulator. Meat chambers 3, 4 and 5 are on the first floor and their cooling coils are at a very much higher level than the accumulator.

Complete regulation of the cooling coils should take the place at the valves 21 to 28. Equal openings of valves controlling the five meat chambers results in :—

(*a*) Rapid cooling of chambers 3, 4 and 5 on the first floor. Audibly there is good " boiling " through these circuits.

(*b*) Slow cooling of chambers 1 and 2 on the ground floor. Audibly there is poor " boiling " through these circuits.

The liquid ammonia pumps deliver their liquid at the same pressure as that of the liquid on the low pressure side of the primary regulating valve. The inference from (*a*) and (*b*) above is that circuits 1 and 2 get flooded with liquid because they are on the ground floor and the " head " is low. This results in reduced cooling effect in these chambers. The first floor circuits, 3, 4 and 5 get less liquid due to the increased head. This results in increased evaporation and greater cooling effect. As a consequence, it is found that circuits 1 and 2 have to be heavily throttled at their delivery valves 23 and 24 to get the same cooling effect as that obtained in circuits 3, 4 and 5.

In addition, due to difference of level between first and ground floor circuits relative to the accumulator, the liquid from first floor circuits tends to run back more quickly to the accumulator. To keep the liquid a longer time in the first floor circuits, the return valves 45, 46 and 47 have to be throttled. On the other hand, to get the more sluggish liquid back from the ground floor circuits 1 and 2, their return valves 42 and 43 have to be opened up fully.

These facts add to the complication of operation of the plant when trying to adjust delivery and return valves to get even lowering of temperature in all chambers. The moral from this is that if possible when designing a cold store, try and keep the direct expansion chambers all on the same floor level. Also, since the glands of the liquid ammonia pumps are a source of trouble and the cost of their operation is an additional charge on the running expenses of the cold store, it is far better to site the accumulator on the roof of the building or at any rate at a higher level than the highest cooling coil and so return the liquid by gravity to cooling coils. This eliminates the use of liquid ammonia pumps and gives far simpler operation of the plant.

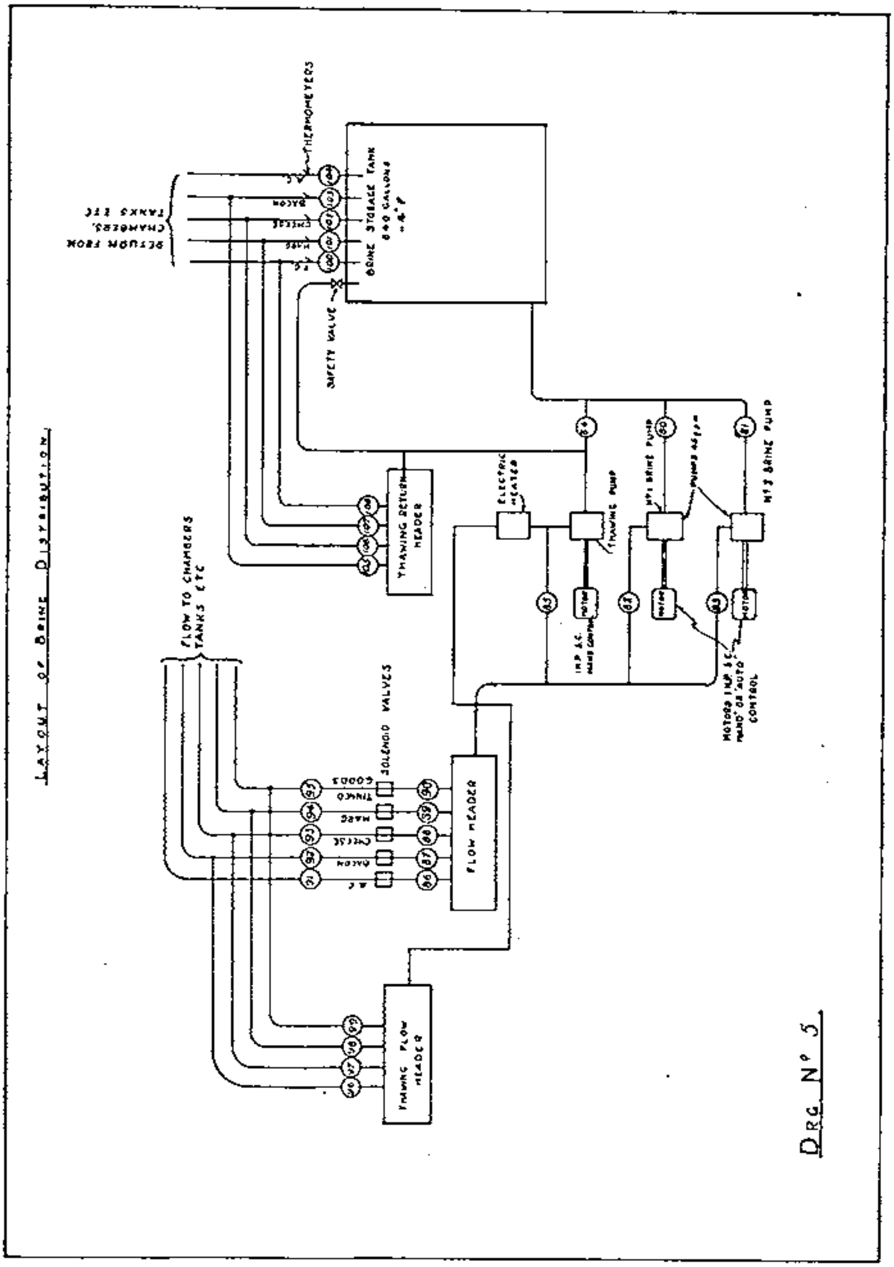
4. *Brine-Cooling System.*—Coils through which cold brine is circulated are used to cool the bacon, cheese and margarine rooms, and to cool the washing water for the air-conditioning plant.

(a) *Brine-Cooling, Storage and Circulation. See Drawing No.* 5.—Direct expansion coils controlled by valves 21 (delivery) and 40 (return), (see Drawing No. 4) cool the brine in the 840 gallons brine storage tank. Assuming No. 1 Brine Pump Operating, cold brine is drawn through valve 80 by the pump and delivered through valve 82 to the flow header. From this header the brine is delivered to the various brine-cooled chambers through valves 91 to 95. After circulation round the chambers the brine returns through valves 100 to 104 to the brine storage tank.

(b) *Thawing of Brine circuits in Bacon, Cheese, Margarine and Tinned Goods Stores. See Drawing No.* 5.—By closing valves 80, 81, 84 and 85 and closing valves 91 to 95 and 100 to 103 and by opening valves 96 to 99 and 105 to 108, brine is drawn back from the chamber cooling drums through the thawing return header by the thawing pump. This pump pumps the brine through the electric heater to the thawing flow header. Warm brine is thereby circulated through the chambers, and the cooling drums are de-frosted.

(c) *Cooling of Bacon, Cheese and Margarine Rooms.*—Cold brine is circulated as shown in (a) above through 9-inch diameter galvanized steel drums fixed to the ceilings of these chambers. In addition, air is circulated by a fan over brine-cooled coils and blown through timber ducting fixed at junction of wall and ceiling. These ducts run down two sides of each chamber, cool air being delivered from one side and sucked back from the other side. The air in these chambers is thus kept circulated and the overpowering smells of cheese and bacon are reduced. Operating temperatures for these chambers are shown on Drawing No. 1.

(d) *Cooling Tinned Goods Store.*—The tinned goods store is cooled by brine drums alone and circulation of cool air is not necessary for this commodity.


LAYOUT OF BRINE DISTRIBUTION
BRINE STORAGE TANK
THERMOMETERS
SAFETY VALVE
RETURN FROM CHAMBERS, TANKS ETC
THAWING RETURN HEADER
ELECTRIC HEATER
THAWING PUMP
Nº 1 BRINE PUMP
Nº 2 BRINE PUMP
FLOW TO CHAMBERS TANKS ETC
SOLENOID VALVES
FLOW HEADER
THAWING FLOW HEADER
MOTORS
DRG Nº 5

It has since been found that it is not necessary to keep tinned goods cooled. It is quite sufficient and is the local civilian practice to keep tinned goods in dry, well ventilated stores at atmospheric temperature, 84°F. At the best, exhaust fans are all that are necessary for tinned goods stores. In fact, an interesting case arose in which a quantity of tinned milk which had been stored previously at atmospheric temperature went bad when stored in the tinned goods store at 40°F. It is thought that the contraction caused by the reduction of temperature affected the solder with which the tins were made (and which at the best of times tends to be porous) and permitted the ingress of air which turned the milk bad.

5. *Air-Conditioning Plant.* (*See Plates* 1, 11 *and* 12.) The plant is designed to keep the flour store at a dry bulb temperature of 70°F. and the humidity at 50 per cent. (Atmospheric temperature 84°F, humidity 83 per cent.) Plate 1 shows the suction air trunking in the flour store. There is similar delivery air trunking on the opposite side of the flour store.

Air is drawn out of the store through the trunking and sprayed with fresh water cooled by a brine cooling coil. Reference Plate 11, this fresh water is retained in the fresh water tank F.W.T., and cooled by brine coils. The flow and return brine coils are shown on the right of Plate 1 before insulation. The motor-driven pump P (Plate 11) draws this fresh cold water through pipe 1 and delivers it through pipe 3 to the sprays. These sprays are located behind the windows W.1 and W.2. After washing and cooling the air, the spray drops to the warm water receptacle W.W.R. Fresh water make-up at local cold water temperature of 80°F. to 83°F. is supplied to W.W.R. through a ball valve. The spray water collected in W.W.R. after spraying is drawn off through pipe 2 to the pump P through the dew point thermostat valve T. The primary object of the cold water sprays is to reduce the temperature of the air drawn out of the flour store to dew point. A proportion of the moisture in the air is thus condensed out and when the temperature of the air is subsequently raised, the humidity has been reduced to the desired figure of 50 per cent. Since the water collected in W.W.R. is relatively warm compared with the cold water in F.W.T. (kept at 40°F. by thermostatically controlled brine-cooling coils), the function of valve T is to mix warm water collected in pipe 2 with cold water collected in pipe 1 to such a degree that the resulting temperature of the spray water delivered by the pump is such that the correct amount of moisture will be condensed out of the air.

After being sprayed the air, which is incidentally cleaned by washing as well as being cooled, is drawn through the plenum chamber P.C. This plenum chamber contains a number of acute-angled baffles, which make the air change direction rapidly and often and so fling off any additional suspended spray or moisture which has got carried over. In fact, this chamber operates in the same way as a steam separator.

Cooled dry saturated air is thus drawn from the plenum chamber to the blower B (Plate 12). The blower delivers the air through three single-phase electric heaters (cables to heater at C, Plate 12), which raise the temperature of the air to nearly 70°F., and in so doing reduces its humidity to the desired figure. Final heating of the air takes place in the air trunking leading to and in the flour store. The electric heater is switched on, phase by phase, by a thermostat placed inside the flour store. The temperature to which the dry saturated air should be raised should obviously be controlled by the existing temperature in the flour store. This temperature is registered in the thermostat in the store, the thermostat then controls the amount of heat required from the electric heater by switching on the phase banks of heaters.

Pump P and Blower B are hand-started but after that the operation is entirely automatically controlled by the dewpoint thermostat and the thermostat in the store. The plant is run daily until the desired temperature and humidity are obtained.

In measuring humidity, unreliable results are obtained by reading stationary wet and dry bulb thermometers and obtaining the answer either from tables or graphs. The simplest method of measuring the humidity is by means of a reliable type of hygrometer. If, however, only the normal type of W and D bulb type of thermometer is available, it must be fixed to the end of a short rope and swung rapidly, like a weight on the end of a sling to make at least twelve revolutions, and then readings taken rapidly if results which are at all reliable are to be made.

E. Electricity Supply and Distribution Within the Building.

1. *Supply.*—Electricity is supplied at 400/230 volts A.C.

2. *Main Switchboard.*—This is of the medium voltage, flat back Sindanyo panel type. Oil circuit breakers are used to control the two incoming feeders and to control the two outgoing feeders to the main compressor motors. These oil breakers are fitted with series overload trip coils with dash-pot time lags and mechanical " on " and " off " indicators. Their panels carry watt-hour meters, phase ammeters and red and green indicating lights. There is one voltmeter for the whole switchboard.

The outgoing feeders to the various auxiliary motors and power and lighting distribution fuzeboards are controlled by triple and double pole knife switches mounted on Sindanyo panels. Each feeder is protected by single pole cut-outs on each pole.

3. *Power Distribution.*—Power distribution, from the main switchboard to the power fuzeboards located at various load centres in the building, is carried out with C.M.A. 660 volt V.I.R. lead-covered cable mounted on teak battens.

4. *Lighting Distribution.*—Lighting distribution, from the main switchboard to the lighting fuzeboards located at various load centres in the building, is carried out with C.M.A. 250 volt V.I.R. lead-covered cable mounted on teak battens.

5. *Lighting Sub-circuits.*—All lighting sub-circuits are carried out with C.M.A. 250 volt single core T.R.S. cable mounted on teak battens. Wiring in conduit cannot be used in this climate owing to condensation inside the conduit. This condensation causes V.I.R. and T.R.S. covered cables to perish rapidly in conduit. T.R.S. cables on teak battens have a very satisfactory life in cold chambers.

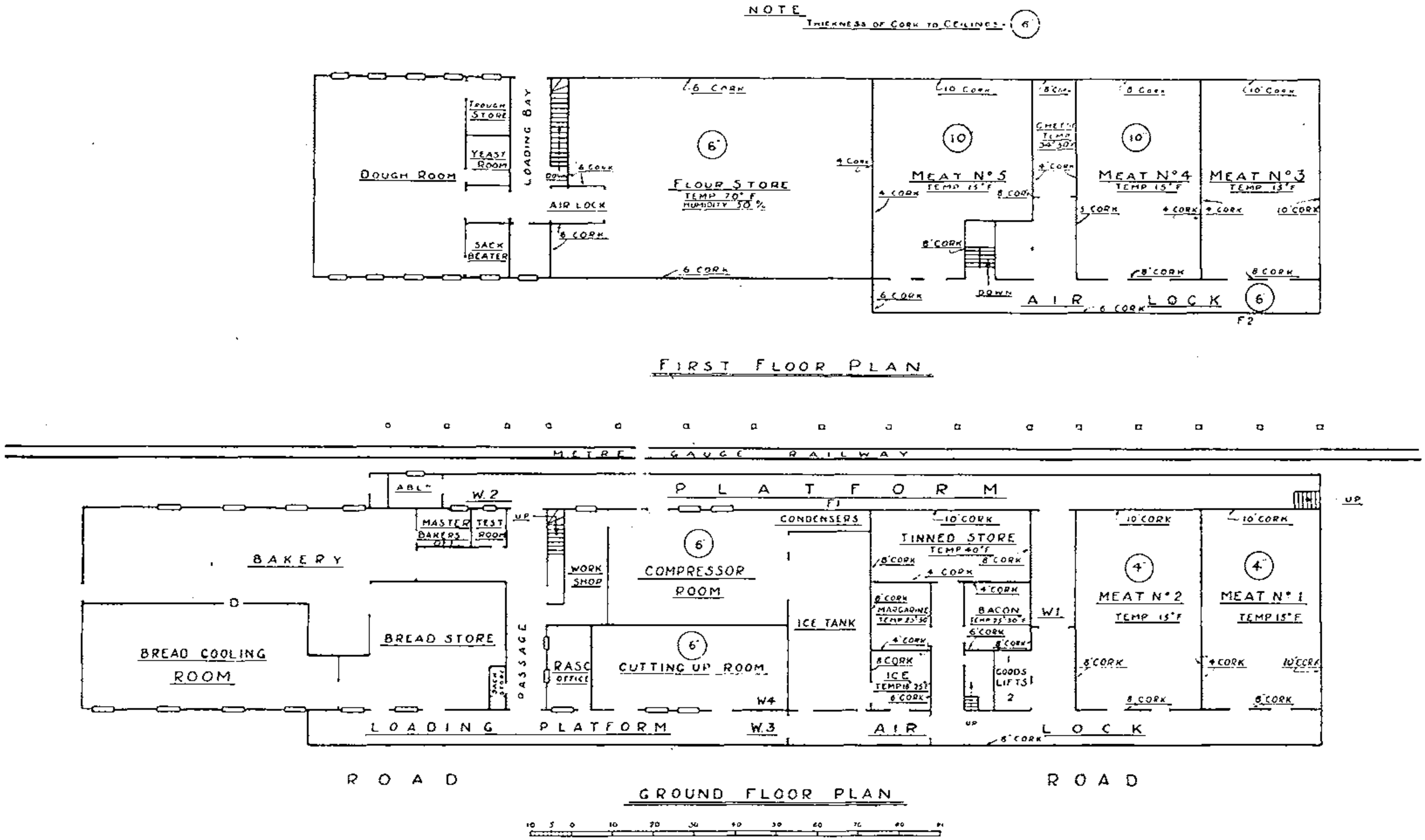
6. *Lighting Fittings in Cold Chambers.*—Wall mounted well-glass watertight galvanized fittings are used in cold chambers and passages. Sealed T.R.S. cable glands are used for cable entries and have proved very satisfactory.

7. *General—Temporary Switchboard.*—Electricity is always required for both light and power, right from the start of construction on works of this nature. Owing to delays in delivery of the main switchboard a temporary switchboard had to be improvised. The main incoming feeder was terminated and controlled by a 200 amp. ironclad switch fuze. Copper bars mounted on porcelain insulators, mounted in turn on a teak board, provided the distribution. The originators of I.E.E. Regulations (any edition) would not have approved, but it served its purpose and all cables including the main feeder cable were generously cut back before terminating on the final switchboard.

8. *Errors of Design.*—The only real fault in the electrical installation lies in the main switchboard. Exposed triple-pole knife switches on the working face of a flat back switchboard are bad practice, particularly in an engine room operated by Asiatics. Medium voltage exposed like this is not at all safe and a far better result would have been achieved by the use of ironclad totally enclosed oil and air break circuit breakers built up on the unit system.

F. Electric Motors and Control Gear.

1. *Main Compressor Motors and Control Gear.*—The main compressor motors are of the hypo-synchronous type running at 418 r.p.m. Each motor consists of a slip ring induction motor with a "V" belt driven Heyland Exciter mounted on the casing of the induction motor.



DRG No. 1.

SINGAPORE ALEXANDRA COLD STORAGE & BAKERY

The slip ring motor is started through an oil-immersed resistance and when it has run up to speed the Heyland Exciter is switched in. By rocking the brushes of the exciter the power factor of the motor can be raised or lowered.

Each motor is 90 b.h.p. with a full load efficiency of 90·5 per cent, approximately 74 k.w., at unity power factor. These main compressor motors are the largest single load on the electricity distribution system. Electricity is generated at a W.D. Diesel generating station. Other than workshop motors, the main day load of such a station in the tropics is the fan load and the station operated at an average Lagging Power Factor of 0·7 during daylight before the advent of the hypo-synchronous compressor motors. The compressor motors are run at 0·97 P.F. Lagging and have raised the overall Power Factor of the generating station to an average of ·95 Lagging.

In industrial concerns in civil life, power factor correction plant is continually being applied either to the whole system at the main intakes or to the largest motors in the plant. This latter method is adopted on the Alexandra Distribution System by running the main compressor motors at 0·97 P.F. Lagging.

2. *Bakery Motors and Control Gear.*—The kneaders, the tin-bread moulder and the sack beater each require 3 b.h.p. slip ring motors controlled by Stator-Rotor starters.

The flour plant and the divider are each driven by a 1½ b.h.p. Squirrel cage motor controlled by a star delta starter.

All motors in the bakery are totally enclosed. The total installed motor load of the bakery, including oven fans and cooling exhaust fans, is approximately 23 b.h.p. or 29 k.w. at ·75 P.F.

G. Erection and Personnel Details.

1. *Erection.*—The plant erection took exactly six months and various types of Asiatic labour, including the inevitable coolie, were employed. Table I shows the classes of labour, the total man-days put in by each class of labour and the rates of wage paid.

The figures apply only to labour which was hired, housed and paid by the contractor for the cork insulation, and to the labour employed under the supervision of the British engineer in charge of plant erection, who was sent out by the manufacturer.

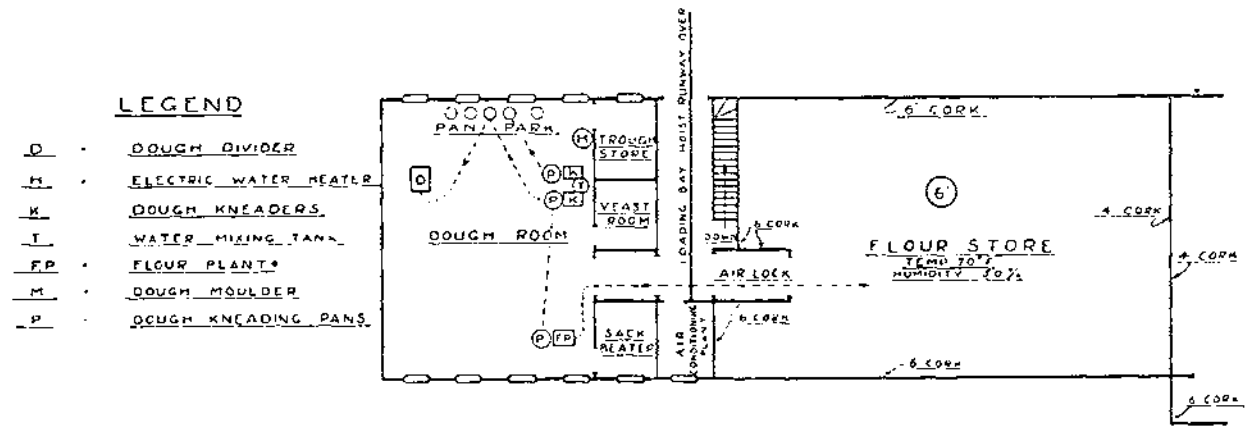
The bakery plant, except the two ovens, was erected under W.D. supervision with directly employed labour. The building of an oven and its careful drying before use requires a specialist if it is to be really successful. Such a specialist was therefore sent out from England to build the two ovens.

2. *Present Operating Personnel.*—One No. 1 Chinese fitter and two No. 2 Chinese fitters were retained after completion of erection

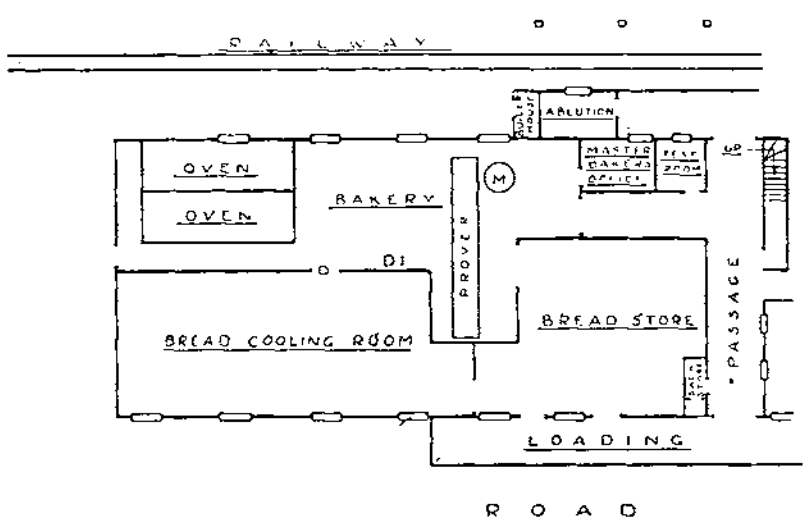
TABLE I.

Type of labour	Work on which employed	Total man days	Daily rate of wage $ c.=s. d.
Masons (Chinese)	Insulation of cold chambers, pipework, plant.	1836	1·55=3 7
Masons' Coolies	Do.	1460	·65=1 6
No. 1 Chinese Fitters	Plant erection.	383	3·75=8 9
No. 2 Chinese Fitters	Do.	503	2·15=5 0
Fitters' Coolies (Indian)	Do.	2031	1·35=3 1
Carpenters (Chinese)	Insulation of cold chambers, timber work for pipe insulation.	931	1·65=3 10
Carpenters' Coolies (Indian)	Do.	18	·65=1 6

of plant to operate the Cold Storage. The No. 1 Chinese fitter is well up to a Class I fitter and after he had taught himself sufficient English (at our expense in time and patience !) was fully qualified to start, operate and stop the plant. He knows the plant thoroughly



FIRST FLOOR PLAN



GROUND FLOOR PLAN

SINGAPORE - ALEXANDRA COLD STORAGE & BAKERY

DRG No. 2

and is now employed as foreman at a monthly wage of \$80= £9-6s.-8d.

R.A.S.C. personnel operate the Bakery but the plant is maintained by an R.E. fitter. The operating staff for the Cold Storage and Bakery is shown below in Table II.

TABLE II.

Place	Duty	Controlled and paid by	Numbers
Cold storage	Operation of refrigerating and air conditioning plants.	R.E.	1 Foreman, 2 Engine-Drivers } Chinese
Cold storage	Making and harvesting of ice.	R.E.	2 coolies (Indian)
Bakery	Operation of bakery plant.	R.A.S.C.	Not known. European and Chinese
Cold storage and bakery	Receipt and issue of supplies.	R.A.S.C.	Do.
Bakery	Maintenance of plant	R.E.	1 Fitter (Indian)

There is a Military Mechanist R.E. in charge of the R.E. duties in the Cold Storage and Bakery and 60 per cent of his time is costed to the Cold Storage and Bakery.

A FIELD COMPANY, SAPPERS AND MINERS, ON CONSTRUCTION WORK IN WANA, N.W.F.P.

By CAPTAIN P. A. EASTON, R.E.

1. INTRODUCTION.

SINCE the reoccupation of Wana in 1929, the Wana Brigade has lived in tents. In 1934, limited funds were made available for the construction of a permanent cantonment, which was to be built by the personnel of Sappers and Miners, assisted by infantry, with a limited amount of civilian personnel for special work. Being a large project, a garrison engineer, with the necessary staff, was appointed for the reconstruction, which was to be completed in five years.

2. TYPE OF ACCOMMODATION.

It is not proposed here to enter into the details regarding the type of design that was finally selected but, briefly, the construction was to be as follows :—

Double-storied barracks for infantry half-companies or equivalent units.

Single-storied buildings for officers' messes and quarters, stores, schools, armouries and coalhouses.

The average size of a double-storied barrack was 110 feet by 18 feet. Permanent buildings were to be constructed for the following :—

One squadron Indian cavalry.
One mountain battery, R.A.
One field company, S. and M.
Three battalions, Indian infantry.
Two animal transport companies, R.I.A.S.C.
One field ambulance.

In addition, offices and quarters were required for the following :—Brigade H.Q. and signal section, section of an armoured car company, a Class I hospital, supply issue section, R.I.A.S.C., the garrison engineer and staff, audit authorities and a dairy. The whole amounted to thirteen equivalent battalion units. A power house and water-supply system were also included. This accommodation has been altered during the last year.

The type of construction decided on was hollow block concrete walls, P.C.C. ground floors, R.C.C. first floors and their verandahs, C.G.I. roofs fixed to trusses and with Celotex ceilings. Verandahs were to be built on one side only of buildings. The size of the standard block was 16 inches by 8 inches by 8 inches. There were, of course, smaller and special sizes.

3. Work Involved.

Wana is sixty-two miles distant by road from the nearest railhead at Manzai, the terminus of a 2 feet 6 inch gauge line, which meets the broad gauge of the N.W.R. at Mari Indus. Transport of the material, therefore, formed a very vital factor, and the speed of construction depended upon the capacity of transport available and also upon the order in which material arrived in Wana.

It was decided that, owing to the cost of transport and also to other factors, all items involved in the construction should, as far as possible, be made up in Wana, *e.g.*, doors, frames, stove pipes, oil cookers, window sashes. Roof trusses were received in sections from the I.S.D. The construction of these items required the organization of considerable workshops by field companies, in addition to the building and fitting work.

4. Available Labour.

A field company of the Q.V.O. Madras S. and M. is normally stationed at Wana. This company, in itself, was not sufficiently large for construction of such magnitude. Accordingly, one army troops company from the K.G.V's.O. Bengal S. and M. and a field company from the Royal Bombay S. and M. were sent to Wana. Unskilled labour was to be furnished by the infantry of the Wana Garrison.

5. Allocation of Tasks to Units.

Considerable preliminary work was required before construction was commenced, not the least of which was the construction of a platform for the making of concrete blocks. This work, however, does not come within the scope of this article.

It was decided that the first construction should be that of the barracks for one infantry battalion and for the field company. One field company, assisted by a large party of infantry, carried out the work of the block-making platform and the construction of the barracks for the field company. The army troops company constructed the power house, perimeter piquets and the Indian officers' accommodation in the infantry barracks. The second field company carried out the remainder of the lines for the infantry battalion. It is with this field company that it is proposed to deal.

6. AVAILABLE LABOUR IN A FIELD COMPANY S. AND M.

The peace strength of a field company S. and M. is as follows :—

British officers 4, British N.C.O's 3, Indian officers 6.

Indian N.C.O's (Havildars and Naiks) 29. This includes those N.C.O's who are drivers and clerks.

Lance-naiks and sappers 284.

The last figure is, however, reduced by six clerks and twenty-five sapper drivers, leaving a net total of 253.

The Indian soldier is allowed on the average two and a half months' leave or furlough annually. The numbers available for work are still further reduced as follows :—

Leave and furlough (25 per cent) ..	66
Courses and trades classes	15
Sick (average)	12
Guards, duties and employed ..	12
Total deduction	105
Available for work	148 *say* 150

For two months in the year, owing to leave parties overlapping, the figure rose to two hundred. This, however, was regarded as a windfall, as, in a frontier station such as Wana, it is not known how long the party may be detained at railhead before onward dispatch to its unit.

The figure for sick may appear to be high, but it was a safe working figure in the case of Wana, where malaria and influenza are prevalent.

7. TRADES STRENGTH.

The peace establishment of building trades in a field company S. and M. is as follows :—

Blacksmiths 32, Bricklayers and masons 60, carpenters 60, sawyers 12, fitters 16. Also painters, engine drivers, tinsmiths, surveyors and electricians.

In addition to the technical labour from the sappers, unskilled labour from the infantry was obtained in parties from 50 to 75 in strength. Parties of infantry up to a strength of 120 could have been employed with efficiency, but such numbers were not available. It may here be mentioned that, owing to the failure of a local "bad man" to carry out the instructions of the Indian Government, infantry parties were frequently reduced for protective duties to meet with the situation.

8. Organization of Work inside the Company.

(a) General.

Normally, the news of a small work of building construction is hailed with enthusiasm by a field company commander. As there is probably no rigid time limit, it will be possible to exercise each man at every portion of his trade that is involved in the work.

During the construction of Wana, the whole problem was one of a race against time. It was, therefore, found essential to carry out the work according to mass production methods as far as possible. It may, however, not be out of place to mention here that, during the period of two years, it was possible to employ every sapper on all parts of his trade that were involved in the construction, so obtaining the maximum amount of training.

The first and most important question to be decided was whether the existing company organization was adequate and could be retained on building work of such magnitude. After experiment, it was quickly proved that section organization could not be maintained without retarding progress. The trade distribution by sections, remembering casualties, was inadequate. Buildings were too big to be made section tasks. Each type of building required standard parties, that could not be furnished by a single section.

Section organization was, accordingly, discarded and the sappers of the company were grouped by trades, irrespective of class. The effect of mixing classes was, if anything, beneficial as affording opportunity for competition.

(b) Main Organization.

The organization of the work, therefore, resolved itself into four main heads :—

(i) Masons' work. Building walls, concrete work, lintels and pillars, pointing.
(ii) Roof work. Erection of trusses, fitting C.G.I. sheets and securing.
(iii) Workshops. Carpenters, smiths, fitters and tinsmiths.
(iv) Stores. Drawing from the M.E.S. and accounting.

One British officer of the company was placed over the whole company task. An Indian officer was placed in charge of each of the above divisions, except workshops, which were put in charge of the trades havildar, aided by junior N.C.O's. British non-commissioned officers were not placed in charge of parties, but assisted Indian officers in all technical matters and carried out a general technical supervision, according to their trades.

Indian officers were allotted N.C.O's from all classes in the company in proportion to the number of men and parties involved.

N.C.O's and sappers remained as far as possible with a "standard" party during a particular task or period.

Owing to shortage of labour it was not possible to maintain standard parties from day to day. As certain tasks became essential, parties had to be broken up to form other standard parties for a particular job and reformed when that job was completed. Again parties were reformed for a long period, when buildings had reached a certain stage. For instance, masons would be taken off the laying of blocks in order to assist concreting, to build chimney breasts, pointing, etc. Standard parties were determined, as will be seen later, thus avoiding confusion. It may be mentioned here that a definite minimum number of blocks had to be laid daily in order that progress might be assessed. It was, therefore, impossible to withdraw all masons from laying. Weekly returns of the number of blocks laid were forwarded through the garrison engineer to the C.R.E. and thence to higher authority. The blue curve showing progress became famous from Wana to A.H.Q. at Delhi.

(c) *Workshops.*

To find a suitable organization here was more difficult and depended upon the amount of available machinery allowed to a field company, which was as follows :—

> A small machine shop containing:—one circular saw, cutting up to 12-inch timber, one 12-inch planing machine, one power drill, one mechanical hacksaw, one grinding machine.

All machines were driven electrically.

In addition, there were a portable electric welding set, a portable electric hand drill and a hand-power mortising machine. A mechanical concrete mixer was available for concrete work.

Difficulties occasionally arose when the machinery in the machine shop was required by parties, actually working on buildings, at the same time as they were required by the workshop party. The avoiding of confusion required careful reconnaissance by party commanders, who were then able to hand their work to the workshop party for execution of the work, several days ahead. It was, however, occasionally necessary to work overtime, in which case personnel were given "time off" on another day.

In addition to the machine shop, two separate workshops were established, for carpenters and for smiths, each under a separate N.C.O.

Work was organized on mass production methods as far as possible. A single sapper rarely completed a job. In the case of joinery, timber was cut to length, planed and rebated in the machine shop, sent to the carpenters' shop for assembly and finally fixed by a third party. This method also applied to all smiths' work.

(d) Control.

Charts were prepared in detail, showing the work to be done and the anticipated completed dates for each stage. From these charts, weekly programmes were prepared and issued to all concerned two or three days before the end of the week, so that there was no excuse for stores not being ready when required.

Frequent and careful checking of the work, complete with charts and necessary adjustment, enabled forecasts of completion dates to be made fairly accurately. Conferences of party commanders were held frequently, so that all might know how progress was being maintained.

(e) Telling off to Work.

Although the total number of available tradesmen remained constant from day to day, the actual number of tradesmen in each trade was apt to vary owing to sickness and duties. This was found to be a very disturbing factor during the malarial season.

To reduce the time between the arrival of sappers on the work and the actual commencement of the work, the following procedure was adopted.

An employment register in book form was prepared, showing in horizontal columns the number of sappers in each trade available for the next day's work, also the number of infantry and the transport that had been allotted. Before the end of work, the B.O.i/c. work collected party commanders, checked the progress of work that day with the programme and then allotted parties for the next day by trades on paper. At first sight this is a simple matter, as the number of parties does not appear to be large. Party commanders, *vide* paragraph 8(*b*) above, however, have several smaller parties. It was therefore found advisable to keep a rigid and rather centralized control in order to maintain progress and to have even the smallest parties detailed in the register by the B.O. The presence of the party commander prevented the control becoming over-centralized and Indian officers were permitted to make minor adjustments in their parties next day, when essential. This system worked extremely well. The centralized control frequently compensated for the lack of technical knowledge on the part of party commanders and also enabled sappers to commence their work immediately upon arrival on the work in the morning. The register also formed an extremely useful record, not only of the actual labour employed, but also as a record of parties employed upon various types of work.

As a matter of routine, the actual personnel were detailed to jobs on the previous evening at roll-call. Infantry were, of course, detailed to jobs when they arrived in the morning, but, being unskilled labour, this was not slow or difficult.

In order still further to minimize delay, certain parties were invariably sent in advance on to the work to prepare such material as mortar, to get stores ready for issue and to start the machine shop.

It is not contended that this organization could not be improved, but it seemed to be as good as many and better than some. Control was maintained throughout and centralized. The system appeared to be flexible and did not seem to be one in which compartments were too watertight. It was not over-decentralized. The proof of the pudding was in the eating, and was proved by the fact that, when casualties occurred among subordinate commanders, they were easily replaced without waste of efficiency or progress.

9. Types of Work Carried Out.

(*a*) *Bricklayers and Masons.*

Block laying, P.C.C. foundations and floors, R.C.C. floors, staircases and verandahs to first floors, R.C.C. lintels and pillars, fireplaces, chimneys and flues, R.C.C. corbels to take floors and verandahs on first floors, pointing (bastard tuck, weather pointing and flush pointing).

(*b*) *Carpenters and Joiners.*

Frames to doors and windows, all sizes, doors, sashes of various types, shelves and racks, framework for Celotex ceiling, fixing Celotex ceilings and battens, newel posts to staircases, construction and the erection of shuttering for R.C.C. work, *e.g.*, verandahs, staircases, floors, pillars, lintels.

(*c*) *Fitters and Blacksmiths.*

Cutting and fixing reinforcement bars to all R.C.C. work, jointing-up sections of roof trusses, fixing trusses and purlins, fitting C.G.I. roofs and securing, construction of latrines of steel framework with C.G.I. sheet walls, fitting of mosquito-proof frames to C.S.W.'s, gates for perimeter walls, steel racks for stores, miscellaneous small jobs, *e.g.*, hooks, oil cookers, holdfasts. The work of fitters and smiths was considerably speeded up by the use of an electric welding set.

(*d*) *Miscellaneous.*

Internal wiring of all barracks and cookhouses for electric light and the connection with mains, painting and oiling all woodwork, glazing of windows, whitewashing, excavation of foundations, flashing of ridges and chimney breasts, stove pipes to cookers (making and fixing).

10. Remarks.

Finally here are some notes of various facts that appeared during the course of construction. They are not comprehensive, but may be of interest.

(a) Labour.

The principles of economy of force apply to a work of this nature just as much as they apply to war. Maximum efficiency cannot be obtained unless there is sufficient unskilled labour. To employ technical personnel in work that can easily be accomplished by the unskilled is waste of effort. However, if troop labour is to be used, this will frequently occur. Unskilled labour in sufficient quantities to replace casualties must be available. It was found that at least 120 infantry were required to keep 150 sappers at work at maximum efficiency. Seldom was more than half this number available.

(b) Co-operation.

The employment of infantry on such work calls for considerable tact on the part of all. It is not a pleasant job for the infantry and everything possible must be done to stimulate interest. Great tact must be observed in obtaining the maximum results. Task work is far preferable in this respect and usually brings out better feeling as well as results. Unfortunately the use of task work is not always possible.

(c) Maintenance of the Objective.

Before construction of such magnitude by troop labour is commenced, higher command must lay down what is to take priority, construction or training, or a compromise. This decision must be made known to all. When the sapper is given a time limit, it is an impossible task if labour is withdrawn in order to carry out certain training. He must be certain of his labour. Local superior commanders are naturally inclined to resent the withdrawal of a large proportion of their force to act as "coolies," but if the decision is made by higher authority, this decision must be supported loyally. The sapper officer on the spot is usually junior in rank and certainly in appointment and, therefore, is placed in a most unfortunate position on occasions, when others will not "play."

(d) Effects on Training of S. and M. Personnel.

From the point of view of trades training, such construction as was carried out in Wana was invaluable, particularly so in the case of Indian officers and N.C.O's, who received valuable training in works organization. Other training suffers and it is a matter for debate as to how long is required to repair the loss in general efficiency that has occurred by the neglect of other subjects, such as education, anti-gas, tactical training and drill. Musketry is not included here, as a period was set aside for firing the annual course. Half-hour parades were held in the morning for other forms of training, but this was hardly adequate.

It must be remembered that the Indian sapper enlists for seven years' colour service, of which approximately the first two years is occupied by recruits' training. In the remaining five years, twelve and a half months are taken up by leave and furlough, leaving a short four years to accomplish the rest of his training. If two years are fully occupied by trades only, what is going to be his efficiency in war?

(*e*) *Morale.*

For those who have not visited the North-West Frontier of India, a frontier station, such as Wana, has to be seen to be believed. The absence of the ordinary amenities of the cantonment are apt to affect the Indian soldier adversely.

It was noticed, however, that during the whole period of two years, the *morale* of the Indian sapper was high. Hard work and the careful organization of games and amusements, such as were possible, seemed to reconcile him to the rather boring conditions of repetition work in rather rigorous surroundings.

ANTI-TANK CLASSIFICATION AND FIELD FIRING RANGES.

By MAJOR R. M. H. LEWIS, M.C., R.E.

1. During recent months anti-tank defence has greatly increased in importance, owing to the increasing tendency on the Continent to rely on massed tank attack to put the infantry on to their objective.

It follows that any improvements in the realism of training facilities and the rapidity with which elementary practices can be carried out must have an important effect on preparedness for war, and on the confidence of the troops in their weapons of defence.

The following article is based on experience at Lydd in searching for a method of producing a realistic A/T range which would provide for both field firing and classification requirements as might become necessary.

SPECIAL CONDITIONS AT LYDD.

2. In considering the adaptation of the schemes adopted at Lydd to other areas, the special conditions prevailing at Lydd should be borne in mind.

The Lydd range is a large flat expanse of shingle, on which the " features " are stunted bushes and an occasional low mound about 10–20 feet high and perhaps 100 feet broad. There are also rolling ridges about 4 feet high running across it, approximately from N.N.E. to S.S.W. The shingle is of considerable depth, and is easy to excavate but difficult to revet. No natural difficulties arise, therefore, with drainage or levels of target runs, but at high tide the water level is only about 3 feet below the surface in places.

Winds at Lydd sweep over the range unchecked, and high velocities have to be catered for.

The range is used for a multiplicity of different weapons and practices, from rifle and mortar practices to anti-tank gun practices, and all these can be used in conjunction in field firing. Therefore anything in the nature of a power station or winch house has either to be proof against mortar and anti-tank gun, or removed outside the danger area, with resultant complication and expense.

Any projection above ground on the range in the way of a bomb-proof power station has to be considered from the point of view of its effect on obscuring the field of fire on the range—and the effect is often out of proportion to the actual size of the obstruction on an all-purpose range. Sinking the power station, etc., below ground means going below the water table and corresponding expense.

EARLY TYPE OF ANTI-TANK RANGE.

3. Up till 1938 the only type of anti-tank target used was a silhouette target, mounted on a skid and towed through a wire rope by means of a lorry.

This arrangement was simple and cheap, but had obvious disadvantages.

The maximum speed attained was low.

In high winds the target skids were liable to be blown off their course.

The towing cable was frequently broken by missiles, or by the unexpected resistance of the skids being blown against obstacles, and repairs entailed long delays. For rapid repetition of firing practices the "turn-round" of the lorry-towed system was slow. This turn-round would have been still slower had the targets been required to jink, as the cable has to be re-arranged round bollards by hand in this system. Where walking is a slow and laborious process, as on Lydd shingle, the time required for any such re-setting of a jinking run would have been almost prohibitive for rapid repetition.

When the danger area is large as at Lydd, a very long wire rope "lead" is required to the lorry, increasing the towing resistance and multiplying the risks of breakdowns.

The number of target skids which can be towed by one lorry, and therefore the number of men who can fire per run, is limited. It is difficult to introduce much surprise element into a skid system.

In considering the present arrangements, admittedly still capable of improvement, a comparison must be made with the previous system outlined above, and consideration must be given to the financial aspect of producing the "perfect" range system.

THE LYDD ANTI-TANK CROSSING AND DIAGONAL TARGET RUNS.

4. This system is given priority of description, as it was used at Lydd before the anti-tank jinking target runs, and the lessons learnt were useful in the design of the jinking runs.

The problem was to produce two straight runs, one across and one diagonal to the line of fire, to the following performance specification.

(a) Speeds up to 30 m.p.h., this speed to be attained as early as possible, and to be kept constant during the firing run.

(b) Four silhouette or box targets to be towed at any one time.

(*c*) The time interval between practices to be reduced to the minimum.

(*d*) To be capable of operation in winds up to 40 m.p.h.

(*e*) To be used for anti-tank gun and rifle practices.

The chief technical difficulties in designing such a system were :—

(*a*) The high towing speed required.

(*b*) The necessity of balancing the conflicting requirements of keeping down the weight of targets against the necessity for weight to ensure stability in high winds.

(*c*) The necessity for firing with the targets running in either direction, so as to reduce the time interval between practices.

5. At Lydd the system installed consisted of :—

(*a*) Two runs of 2-ft. gauge light railway track, running in a trench with a low parapet, the trench being revetted on the firing side. On the Crossing Run 30-lb. track was used and on the Diagonal Run 25-lb. track.

(*b*) A tow on each run consisting of three flat-topped Hudson trucks, each carrying a wooden superstructure and protected by the trench. The silhouette or box targets are carried on the superstructure. Each practice, including return run and marking targets, takes six minutes, but four men could fire in this time. Four trucks could be towed when required.

(*c*) A 1-in. endless wire rope on each of the two runs passing round fixed pulleys at the outer ends, and led back to two wire haulage winding wheels in the winch house. Each wire rope was taken twice round its winding wheel and led through guide pulleys and a tensioning device of the usual loaded truck on an inclined plane variety, reinforced with vertical lifting weights.

(*d*) A winch house outside the danger area incorporating :—

I A 90 h.p. Armstrong-Siddeley air-cooled tank engine and gear-box driving through a multi-belt drive and bevel reversing box to either of the two winding wheels which were mounted on the same shaft.

This engine was chosen because

(*a*) Lydd is an experimental range and future developments could not be foreseen. Therefore a large reserve of power was required.

(*b*) It was known to be very reliable under rough conditions.

(*c*) It was already known in the Service and if no longer required could be put back into a tank with no loss to anybody. All necessary spares were readily available.

II. An indicator gear to indicate position of targets to the engine driver, who could not see the targets at the far end of their outward run; with which was incorporated an automatic ignition cut-out to switch off the engine in the event of over-run or emergency.

III. A brake mechanism for checking the winding wheels, operated by the engine driver.

This system has now been in use for one and a half firing seasons, and after initial teething troubles has been very satisfactory.

The civilian experts consulted were doubtful of the possibility of operating a haulage system at such high speeds, and thought that difficulties would be experienced with "snatch" and consequent snapping of the cable. The problem was complicated by the necessity of putting the tensioning device at the winch house and not at the far end of the runs in the danger area. The difficulties anticipated have not materialized. The tensioning device was incorporated to avoid delays during firing. The North Ireland system mentioned later in this article incorporates no automatic tensioning device. The return pulley in this system is made adjustable, and an initial tension is put on the cable. It is understood that this arrangement has so far proved successful. It would possibly be less successful on the very long cable runs at Lydd and also on ranges similar to Lydd, where the return pulley is in the danger area and is situated so far away from the winch house that time would be wasted in reaching it to make any necessary adjustment during firing.

A further consideration is that an automatic tensioning device provides a certain safety "take-up" in the case of an accident such as a derailment during a run.

The diagonal firing run at Lydd is 1,000 yards long, the direct crossing firing run is 744 yards long and the lead-in to the winch house from the junction of diagonal and crossing runs is 1,285 yards long.

The wire rope between the rails is supported on wooden blocks at intervals of 15 yards.

The wire rope on the lead-in run to the winch house is supported on transverse sleepers at intervals of 20 yards, which prevents the chafing of the rope running through the surface shingle.

Gear change on the tank gear-box has proved quite simple.

No trouble has been experienced with over-running of targets.

The time interval between firing runs is only that required for marking and range safety precautions. The range so far has not been required for speeds exceeding 20 m.p.h.

6. In North Ireland a satisfactory variation of this system has been built, incorporating a Ford V8 chassis with the back axle jacked up and pulleys substituted for the rear wheels. The drive is then taken up by multiple belt to a counter-shaft carrying the winding wheels.

This system is being installed at another range in the Eastern Command. The car forward gears will be used, but a marine type reversing box will be incorporated in the counter-shaft.

The use of a Ford chassis has obvious advantages in first cost over the use of a tank engine unit, and simplifies the problem of spares and replacements abroad.

It has not yet, however, had the testing-out that the Lydd system has had.

7. It is considered that for rapidity in repeated firing practices on straight runs, low first cost and reliability, this system of towed trucks on an endless cable will be difficult to improve on. The cost of the Lydd system, inclusive of trenches and rails but excluding engine and tank gear-box, was approximately £4,365.

8. Where a crowded firing programme has to be carried out, any serious mechanical breakdown involves a dislocation, and either abandonment of certain practices or a re-shuffle of units' training programme.

Some form of standby to the winch gear is therefore necessary.

The original standby arrangement at Lydd was a reversion to lorry-towed skid targets. This year, however, the ground on the range has been cut up by trenches for the anti-tank jinking target runs and a run for skid targets towed by lorries is not possible.

The standby arranged consists of a small petrol-engined truck, towing two targets at 22-foot intervals on flat-topped 5-cwt. Hudson trucks, using the same rails as for the winch-towed targets. While marking is in process at each end of the run the engine truck is uncoupled and hitched on to the reverse end of the tow.

The tow is started from dug-outs at each end of the run, and stops automatically.

This improvisation has been tried out, but has not yet had to be used. The speed attained is unlikely to exceed 20 m.p.h. and will be affected by head winds. The turn round is much slower. It will, however, provide something to enable classification practices to be carried on in the event of breakdown, and is cheap and simple.

If money is not available for winch house, etc., this system if developed would be very cheap. The Hudson truck costs £12 15s.

The same engine truck and controls as are described later in this article for jinking runs can be used for towing.

9. Plate 1 shows a train of targets.

Plate 2 shows a view up a classification run.

Plates 3 and 3A show the layout of the winch house.

Plate 4 shows the tensioning device.

Plate 5 shows a plan of the range, including the field firing jinking target runs and the engine house.

Plate 6 shows the improvised target tow for use as a standby on the classification range.

THE ANTI-TANK JINKING TARGET RUNS.

10. After the completion of the Lydd Anti-tank Cross and Diagonal Runs a demand had to be met for more realistic targets in addition.

This demand was not so simple to meet within the financial limits imposed, as the classification range and the considerations affecting the final design may be of assistance in cases where similar ranges are required.

11. The requirements of the *ideal* range may possibly be summarized as follows :—

(*a*) *General Layout.*

The general layout should be as flexible as possible so that various tactical formations, as likely to be adopted by Tank Sub-units when advancing over the area, can be reproduced. It is important to introduce as great a switch as possible combined with variation of range, angle of approach, and hull-down running. A stereotyped zigzag run must therefore be avoided, the maximum use of natural cover should be made to prevent continuous shooting at targets, and when a target reaches natural cover the gunner should be left in doubt as to the direction in which it will emerge. As the advance should simulate as closely as possible that of a tank unit, it must be possible to run not less than three tanks on the system at any one time.

(*b*) *Variations.*

It is desirable to vary speeds throughout the runs at will, and preferably to vary the speed of individual targets independently.

The desirability of being able to send individual targets on alternative runs follows from the consideration of paragraph (*a*) above.

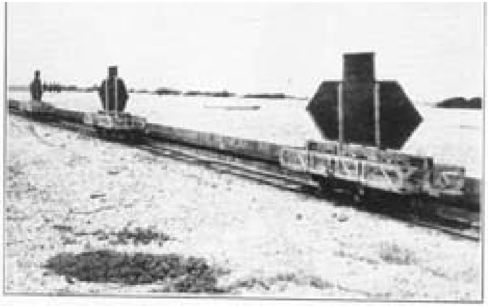


PLATE 1.

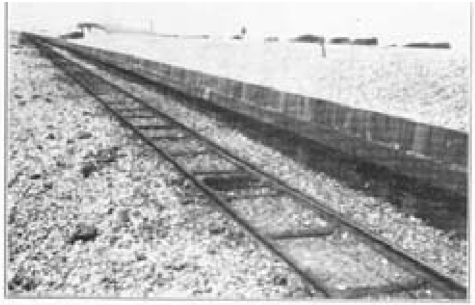


PLATE 2.

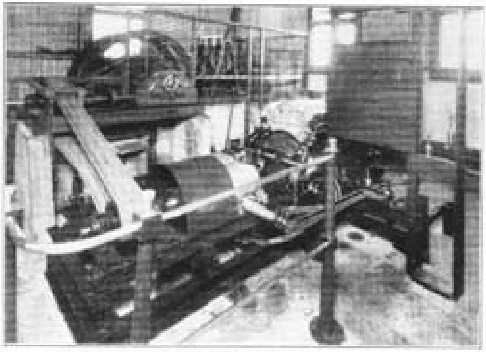


PLATE 3.

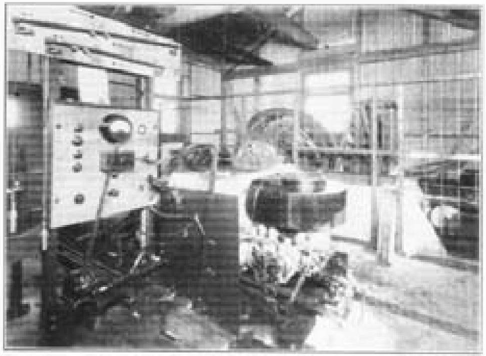


PLATE 3A.

Anti tank classification and field riring ranges 1 - 3 & 3A

PLATE 4.

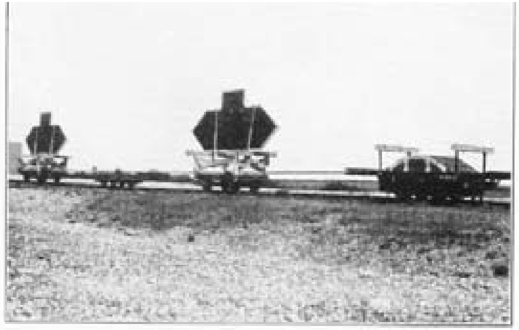


PLATE 6.

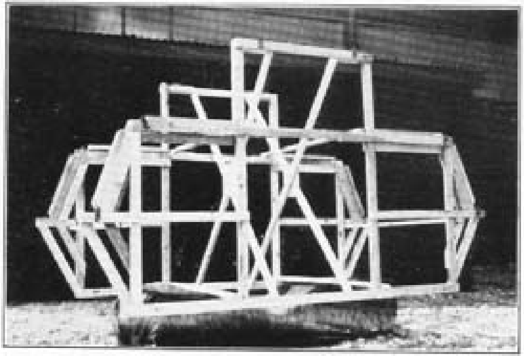


PLATE 7.—Note the clips on upper half of frame from which the side silhouettes are hung.

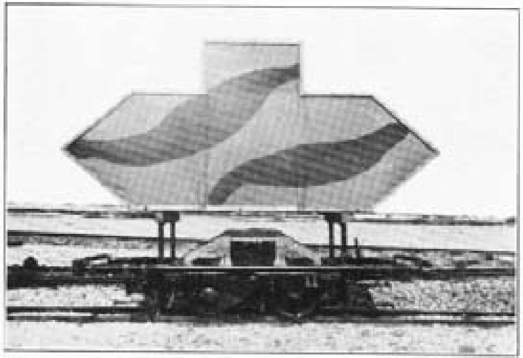


PLATE 8.—The target truck. Note counter-weight strung from front buffer springs to keep the nose down.

Anti tank classification and field riring ranges 4-8

(*c*) *Rapidity of Turn Round.*

As firing at jinking targets is included in the classification practices of anti-tank regiments, it follows that the unavoidable intervals between details should be reduced to a minimum.

(*d*) The performance of targets should be affected as little as possible by weather. This is the condition found most difficult to attain with the Lydd system, where very strong winds have to be catered for. The bulky canvas box target at Lydd has to be carried high above the target truck. Strong side winds have an overturning effect on sharp bends. Head winds tend to lift the driving wheels off the track, and tail winds tend to make the trucks approach curves too fast and to over-run the stops.

(*e*) *The System must be Reliable.*

This consideration implies that no mechanical parts should be exposed to projectiles, and no runs exposed to enfilade fire.

Special consideration must be given to flying debris (shingle at Lydd) which may jam points or render controls inoperative.

As far as possible, curves open to enfilade fire should be defiladed by natural features.

(*f*) The jinks of a tank should be simulated as closely as possible. Curves should be as sharp as possible.

(*g*) The system should be designed so that in the event of a mechanical breakdown—and no range can be guaranteed 100 per cent free against breakdown with high-velocity projectiles flying about—a total shut down can be avoided, and firing resumed as rapidly as possible.

(*h*) The range should be obstructed as little as possible. This consideration implies the use of natural cover, and going below ground for target trucks where no natural cover is available. Such items as power stations should be outside the danger areas if possible. Where it is necessary to defilade a target run, the maximum use should be made of unavoidable obstructions such as B.P. shelters.

(*i*) The running costs should be kept low. This factor mainly concerns the number of skilled men and the staff required to run the range. It is, however, false economy to cut down necessary staff and can only mean that the best results are not obtained from the equipment.

TYPES OF RANGE CONSIDERED AT LYDD.

12. The general layout finally agreed on and which was tactically approved by the War Office consisted of two arms, one up each side of the range, generally as shown on Plate 5.

13. The initial specification called for was :—

(*a*) Light tank box targets.

(*b*) Speeds of 30 m.p.h. attainable in 50 yards and variable at will, with possible increase of speed up to 40 m.p.h.

(*c*) As many targets as possible to be exposed at once.

14. The first system considered was a continuous rail electric system laid out as shown on Plate 5, with bends as sharp as possible, two targets to run on each arm of the range at once—four targets in all—and all controllable independently at will from a special control room. Independent control necessitated two live rails on each arm, one for each truck.

This system has many advantages and is still worth consideration. It has, however, the following major disadvantages :—

(*a*) Rather complicated electrical controls.

(*b*) An electrical fault may put the whole range out of action for an indefinite period.

(*c*) The danger factor in having live conductor rails all over a range area.

(*d*) Possibility of electrical breakdown due to flooding in bad weather.

(*e*) High first cost which, although less than that of the second system considered, was above the money which could be made available by the War Office for Lydd.

15. In the next system considered, the range shown on Plate 5 was divided into a series of straight independent runs of varying length, by the omission of the curves shown on the plate. Each run carried a separate target which was operated by its own electrically-driven capstan, towing the target in either direction by means of an endless wire rope. The target on each run was controlled from a special control room with specially arranged observation over the target area at close range, and the effect of the continued advance of one tank was to be obtained by operating the target on each run in sequence.

This system would have given good jinking effect, but it would have been necessary to provide a target which could be automatically raised and lowered at the beginning and end of each run—a very difficult requirement to meet with targets liable to destruction and necessarily of cheap and readily replaceable construction. The cost of this system with its remote control gear also proved to be prohibitive.

16. The third and cheapest method considered and finally adopted at Lydd consisted of targets carried on very low rail trucks, each propelled by its own petrol engine. Two trucks run down each arm of the range on the same rails, at intervals determined by the control officer. As will be seen from Plate 5 the four trucks start from approximately the same point, two going down one side of the range and two down the other side. The effect is intended to represent light tank sub-sections, one sub-section advancing 'round each flank of their objective, and the system can be used in conjunction with the Cross and Diagonal Runs to amplify the tactical possibilities.

At the triangular junctions shown on each arm, one target on each arm can either be directed down a by-pass run (runs 6 and 9 on Plate 5) or run straight through to the finishing point. If the target is directed down the by-pass, it runs round a tight loop at the dead end and then runs on to the finishing loop. All points are spring operated, but that for the diversion of a target down the by-pass run is under remote control from a neighbouring B.P. shelter.

The trucks run in a trench revetted on the firing side and with a low parapet where required. The cover was worked out to suit trajectories, and the only cover on the trucks is light 8 mm. end and top armour to minimize damage from ·5 practice ammunition, and wire netting at the sides to keep out flying shingle. The maximum use is made of natural cover for introducing variations, such as disappearance of target and hull-down running.

Truck Design.

17. A light rail-car chassis produced by a well-known rail-car firm was used as a basis for design.

The engine is an air-cooled JAP V twin engine, placed across the chassis. It develops 19 h.p. at 2,600 r.p.m. This engine drives on to the front wheels, which are chilled cast wheels, through a hydraulic coupling of the fluid flywheel type and a simple chain drive.

There is no clutch and the engine is started up through the fluid flywheel. At the starting point the truck is left ticking over on a slight incline, a front wheel against a stop. When the truck is released, by remote control from a B.P. shelter, it runs over a throttle ramp placed in the track which operates a lever projecting from the underside of the truck.

This lever opens the throttle one-third, *i.e.*, three throttle ramps in series opens the throttle full out.

Where it is desired to shut off the engine, another throttle ramp in the track engages with another lever and shuts off the throttle. Two throttle ramps in series are used to make sure of this operation.

The braking mechanism consists of a trailing brake arm at the end of which is a sprung pad. Where it is desired to slow the truck down the sprung pad is lifted by a "check" brake ramp, thereby applying the brakes for the length of the "check" ramp. The brake is released at the end of the ramp.

As it is necessary in places to brake the two trucks running on the same line at different places, the sprung brake pad can be placed on either side of the trailing brake arm. Thus the brake pad on No. 2 truck can be made to operate on a different set of brake ramps to No. 1 truck. By carrying two sprung brake pads, No. 2 truck can operate on No. 1 truck's brake ramps as well as on its own.

To stop the truck it is necessary (*a*) to cut off the ignition and (*b*) not only to put the brake on but also to hold it on.

This is effected by the operation of a magneto ramp. This ramp, in conjunction with a "final" brake ramp, operates a dual-purpose trip lever on the truck which (*a*) cuts out the ignition and (*b*) inserts a hook which catches into a loop on the trailing brake arm and holds the brake on after the truck has passed over the brake ramp.

The maximum engine speed, and therefore truck speed, is controlled by a governor and the governor speed is adjustable by varying the tension of a spring.

It is essential that the truck should be very robust and simple. Numerous and spectacular crashes with the experimental model have proved that the design in use meets this factor. The throttle controls and ignition cut-out are liable to damage, but they are of simple design and easily replaced. Occasional minor damage to the trailing brake arm is the only other result of crashes so far met with. The truck is sprung on the driven axle only.

The design of the truck and its controls had to be started from scratch, as there exists no civilian counterpart. Various difficulties had to be overcome, but the most serious ones were :—

(*a*) The design of simple and cheap controls to stand the shock of impact on the ramps.

(*b*) The design of controls which could be relied upon to operate every time.

(*c*) The locating of two throttle controls, two brake ramps, and one ignition ramp all on one side of the track centre line (2-ft. gauge), so that a different set of ramps could be used on the return run.

These truck design difficulties have been overcome, and the mechanical reliability of the controls is good.

PLATE 9.—Truck starting catch.

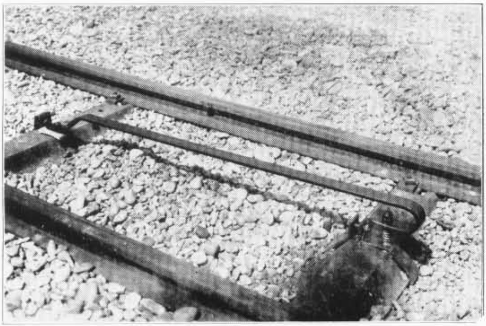


PLATE 10.—Throttle ramp.

PLATE 11.—Finishing loop showing brake and magneto cut-out ramps.

Anti tank classification and field riring ranges 9, 10 & 11

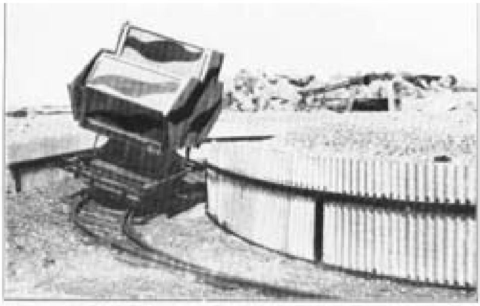


PLATE 12.—Truck on 9-in. super-elevated curve.

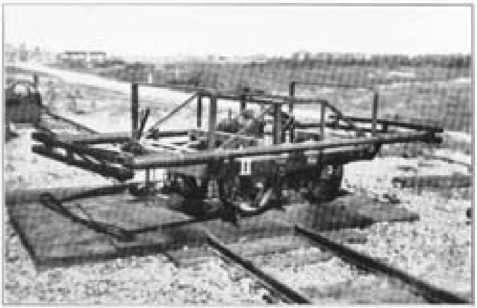


PLATE 13.—Stripped truck showing magneto cut-out trip in front of back wheel.

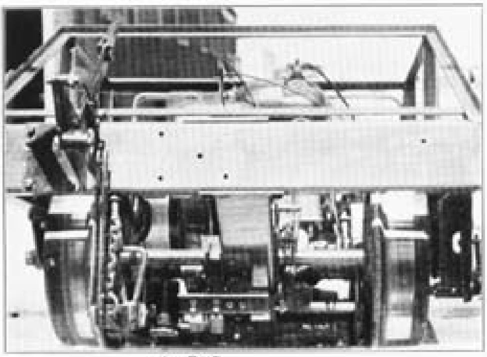


PLATE 14.—A. Sprung brake pad. B, C. Throttle trips. D. Magneto cut-out trip.

Anti tank classification and field riring ranges 12-14

The details of the truck, which are shown in Plates 12, 13 and 14, are :—

Weight of truck	14·0 cwt.		
,, ,, armour plate	3·25 ,,		
,, ,, ballast and cage	1·75 ,,		
		19·0 cwt.	
,, ,, target and bearers.. ..		2·5 ,,	
Total ..		21·5 ,,	

Overall height rail level to top of sparking plugs ..	2′ $4\frac{3}{4}$″
Overall rail level to highest part of armour ..	2′ $7\frac{1}{4}$″
Wheel base	2′ 6″
Length of truck including the long spring buffers ..	10′ 5″

Gear ratio 4 2/11 : 1 { 11 teeth driving sprocket; 46 teeth driven; 16″ diameter wheel }

Hand throttle, and brake and ignition controls for driving the trucks about are included in the design.

The Track.

18. The 2-ft. gauge track is laid with metal sleepers direct on the shingle and has bedded down very well. At curves intermediate wooden sleepers are used. It was originally intended to make all curves 20-ft. radius, so as to simulate the natural tank jinks. Such sharp curves are a practical proposition, but the trucks would have to be slowed down to within fairly close limits at each bend, necessitating a degree of control not really feasible at every bend under varying wind conditions with the present design.

As the layout had to be constructed off the drawing-board, it was decided not to risk such sharp bends on the main runs, and all curves on the main runs were made 150-ft. radius, with one of 65-ft. radius. It was hoped that the consequent faster speed round these bends would compensate for the loss of realism in effect, but this has not altogether succeeded, and the sharp bends at the by-pass loops give a much more realistic effect.

The two by-pass loops, where the trucks turn round on their tracks, are 180-degree 20-ft. radius curves super-elevated to 9 inches. These curves presented a pretty problem to the rail manufacturers, who had never attempted such a layout before. The difficulties were, however, successfully overcome and a very good job produced.

The trucks can negotiate the loops successfully at 15 m.p.h. and so far no derailments have occurred.

The 150-ft. curves are given 3 inches super-elevation, and the 65-ft. curve 5 inches.

Owing to the time factor in producing the range, all curved sections were purchased mounted complete, with 1-in. spread on curves and check rails.

The check rail spacing is $1\frac{1}{4}$ in. on the 150-ft. and 65-ft. curves and $1\frac{1}{2}$ in. on the 20-ft. radius curves.

The laying of the rails was carried out by direct labour, with the assistance of a platelaying gang from Shoeburyness.

The remote control of starting catches and points from bomb-proof shelters was a straightforward job calling for no special comment.

An electrical warning device of the approach of trucks for the pointsman in his shelter is desirable. A system has been designed incorporating a 6-volt battery and relays operated by the truck brake shoes.

The design of a switch which will stand the impact of a brake shoe and be 100 per cent reliable has, however, given trouble, and at present the system is being operated satisfactorily by telephonic control.

There is a possibility of flying shingle jamming between the tongue of the point and the rail and causing a derailment. It is essential that the pointsman should have a gauge to indicate that he has pulled his points right home. In the Lydd system the sleepers under the moving parts of the points are cut away as far as practicable, a pit has been made under the point tongues to allow shingle to drop clear, and $\frac{3}{8}$ in. mesh wire netting has been placed on the parapet to check shingle.

As the trucks are not reversible a starting and finishing loop is necessary on each arm to turn the trucks round.

TARGET.

19. A light target frame, fitted with light sliding end shutters and silhouettes, has been found most suitable. See Plate 7. The silhouettes and end shutters are very quickly replaceable individually on the range if badly shot up.

SIGNAL SERVICES.

20. Independent of the range signal system, the jinking run B.P. shelters are in direct telephone communication with the firing points by means of two omnibus lines, one for each arm. (See para. 12.)

OPERATION AND PERFORMANCE.

21. The trucks are capable of speeds up to 30 m.p.h. Performance can be varied within limits by the governor and by changing the size of the driving sprocket. Once set for a given maximum speed, however, the system is at present rather inelastic, as it is a major operation to move all the ramps on the track to suit any wide varia-

tion in maximum speed which may be called for. As mentioned later, however, this lack of elasticity is more apparent than real, owing to natural variations produced by varying wind conditions.

At present the trucks are being used with the lowest gear ratio that the present design will admit, and with a low-speed governor setting. This setting may be altered after further running experience.

With the present setting a maximum speed of 20 m.p.h. is attained very quickly. The throttle is shut down about 100 yards before reaching every curve, and is opened up again before passing over a short check-speed brake ramp to take the machine round the curve.

The problem has been to select a position for the throttle cut-off ramp at a distance before the curve, which will in high winds meet two conflicting requirements. In the case of a head-wind, the momentum of the truck must be such as to enable it to reach the curve before it stops completely. In the case of a tail-wind, the truck must decelerate to within the safety limit of speed before reaching the curve. As far as can be seen this compromise position has been met satisfactorily, but head and tail winds cannot be laid on to order for experimental purposes and time was very short for trials before the range was taken into use.

No trouble has yet occurred during firing, but only light winds have been met with.

By next year this possible source of trouble will, it is hoped, have been eliminated, by the provision of alternative throttle ramps for varying wind directions which can be very quickly placed in positions determined by trial. (The essence of this solution is the design of a throttle ramp which can be quickly altered in position, and should not be a difficult problem. If trouble is met with, the solution can be applied now, but changing the position of the present design of ramp takes a little time.)

An alternate solution is a modification of truck design, dealt with in a later paragraph.

It will be seen that wind is a major problem. Its variations prevent the trucks being run to any exact performance schedule under all conditions. This aspect of speed variation caused by wind, provided that the truck never comes to rest during the firing run, is actually a natural asset to a field firing range, as it introduces a continuous variation of speed during the run, and between one run and another, which prevents the gunner from noting soft spots for which to reserve his fire and getting accustomed to a constant truck performance. Another trouble due to wind is the wheel spin caused by heavy gusts operating on the top hamper of the target. Once wheel spin starts it is difficult for the wheels to regain their grip. The trouble has, it is hoped, been satisfactorily overcome, by weighting the nose of the truck, but here again we are awaiting the arrival of bad weather conditions to prove the efficacy of the remedy.

The total length of the eastern and western arms of the run are 1,291 yards and 1,242 yards respectively, plus the by-pass runs of 627 yards and 344 yards (total in both directions of the by-pass).

The length of time taken, with a maximum speed attained on each leg of 20 m.p.h. is 6 to 6½ minutes. Firing at the moment is not carried out on the return runs, and the trucks are returned to starting loops at third-throttle. There is, however, no technical reason why firing should not be carried out on return runs.

The overall time of one firing run, checking targets, and return to starting point is 25 minutes. Part of this time is occupied by a very careful inspection of all points and trucks, and will doubtless be reduceable with practice. At present it takes about 1¾ hours from the time when the trucks leave the engine sheds, about 1½ miles from the starting point, to the time the range is technically ready for use, personnel distributed, all controls inspected and two trial trips carried out on each arm.

A most careful and detailed drill has had to be worked out for the technical staff to avoid delays in operating the range.

So far three anti-tank regiments have used the range, and a total of 68 runs carried out on each arm, *i.e.*, a total of 272 truck runs. The weather conditions have been very good. No hitches have occurred of any sort, except one minor derailment which occurred when shingle prevented a point being moved right home.

The range is considered to be realistic and a considerable advance on the old lorry-towed skid target. It is, of course, still capable of improvement, both technically and as regard its layout. It goes a long way, but not the whole way, to meeting the requirements of paras. 11 and 13.

One promising experiment is now proceeding. The experimental truck has been fitted up with a brake operated by vacuum from the induction pipe. The governor, instead of the butterfly throttle, is worked by the throttle trip mechanism operating on the governor tension spring, and when the governor cuts out it also opens the connection between the induction pipe and applies the brake.

Thus the first throttle ramp sets the governor to one speed, the second ramp increases the governor speed setting and the third ramp increases it again, instead of the present system whereby the throttle ramps open the throttle in three stages.

Should the engine over-run, the governor closes the throttle and the same closing movement gently applies the brake, which is released again when the engine speed falls and the governor cuts in again. By this system, early experiments indicate that it will be possible to control target speed within close limits at any portion of the run and under all conditions of wind, without having to alter throttle ramp positions on the track.

Maintenance, Range Staff and Spares.

22. Four spare trucks are kept at Lydd, so that there are always spare trucks available, properly tuned up, to replace casualties.

It is essential to have a test run outside the danger area and near the truck sheds. The run should consist of not less than 300 yards of straight track, with a 20-ft. radius reversing loop at one end and a starting loop at the other.

A small reserve of the assemblies liable to damage should be held, namely throttle trip assemblies, magneto cut-out trip assemblies, and trailing brake arms.

The staff required to run the Lydd range at present consists of one fitter-in-charge, who is responsible for running the range during firing and for the care and maintenance of all trucks, one assistant fitter for maintenance, tuning up and testing of spare trucks, two starters, two pointsmen and two men for returning trucks from the finishing loops to the starting runs. The last six are handymen, part-time employed on other duties. They need to be intelligent men trained to start and return trucks, and to drive them when necessary.

Costs.

23. The Lydd costs may be somewhat misleading but are given for what they are worth.

Owing to the time factor, it was necessary to put in a great deal of overtime in laying the track and digging and revetting the trenches.

The curved track was ordered ready mounted to save time, and the trucks were ordered on a single tender.

Various items of the controls as originally designed on the drawing-board had to be scrapped or modified as a result of trials.

In a repetition job, therefore, it should be possible to reduce costs.

The light trucks without armour or armour framework cost *about* £200 a piece. For obvious reasons the exact cost is not given here.

The cost of laying 2,502 yards of straight, 1,147 yards of curved track and all points and turnouts was £578 approximately (excluding trenching).

Cost of provision of track (curved sections mounted, with check rail), complete with turnouts, etc., was £2,173. The costs of one throttle ramp, 9 ft. length of brake ramp and ignition ramp were 4s. 9d., 5s. 6d. and 5s. approximately, respectively.

Approximate miscellaneous expenditure such as manufacture of armour framework was £2, truck driving seats 14s. 6d., and metal framework for carrying the target superstructure 2s. 4d. each truck.

The cost of manufacture of point-operating levers was £5 7s. 6d. A set of double starting levers (one for each truck) cost £15.

In addition the following items must be supplied :—

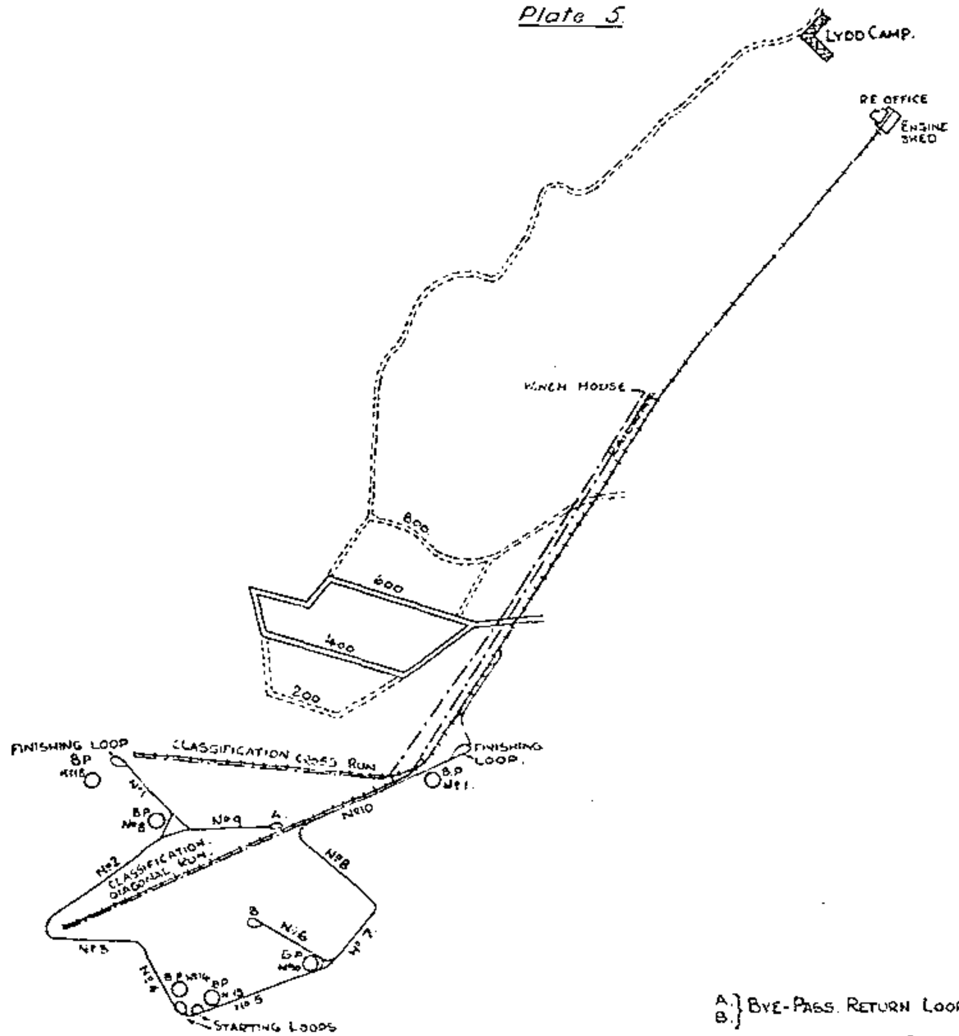
B.P. Shelters, if necessary.
Engine Shed, if not available, Sidings and Turn-tables.
Signal System to B.P. Shelters.
Armour Plate—say £5 10s. per truck.
Trenching and Revetting.
Breakdown Crane } Desirable but not yet provided
Reversible Inspection Truck } at Lydd.

POSSIBLE FUTURE DEVELOPMENTS.

24. Time and money were the limiting factors in the present jinking run layout. Starting from scratch, and with design experiment and production necessarily going on at the same time, a simple layout was aimed at which, if successful, could be elaborated later.

Experience so far indicates that more target trucks could be run on each arm, and more alternative runs introduced, as money can be made available.

Plate 5.



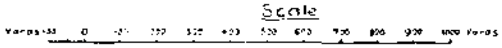
A. B. } BYE-PASS. RETURN LOOPS. 20' RAD. 9" SUPER ELEV.

RUN No.	TABLE OF STRAIGHT LENGTHS
1.	241"
2.	152"
3.	179"
4.	94"
5.	290"
6.	313"
7.	421"
8.	235"
9.	172"
10.	373"

CLASSIFICATION RUNS

DIAGONAL -	909"
CROSS :-	744"

Scale



= WOODEN ROAD. } FIRING.
= CONCRETE ROAD. } POSITIONS.
= ONE PAIR OF WIRE ROPES.
= FIELD FIRING JINKING RUNS.
BP = BOMB PROOF SHELTERS.

LYDD. SCALE 6" TO 1 MILE

LYDD ANTI-TANK FIELD FIRING JINKING RUNS AND CLASSIFICATION RUNS.	PREPARED BY:- [signature]	

QUETTA DEMOLITIONS.

By Capt. R. A. G. Binny, R.E., and Capt. J. B. Brown, R.E.

Opportunities for actual demolitions in peace time are rare. Considerable practice was, however, obtained in Quetta after the earthquake in 1935. It is thought, therefore, that a short description of the most important demolitions carried out there by the Sappers and Miners might be of interest. The following notes on the work done have been prepared by the officers who were in actual charge of the arrangements.

St. Mary's Church.

This was the Garrison Church, and had been comparatively slightly damaged during the earthquake, a fact which speaks well for the resisting properties of the material, which was burnt brick and lime mortar, and also for the strength of the arches. Photo 1 shows the church prior to the demolition.

During the year following the earthquake the condition of the church had deteriorated considerably, and cracks had widened and deepened, until it became a moot point whether the roof was supporting the walls or the walls the roof.

In this condition it was considered unsafe for the building to be dismantled by ordinary labour, and in spite of the fact that considerable damage would probably be done to the valuable materials, particularly the roof trusses, which were hammer-beam of very well-seasoned teak, it was decided that it must be blown up. The work was entrusted to 21st Field Company Royal Bombay S. and M.

The governing factors in the demolition were that, firstly, only gun-cotton was available; secondly, that it was only necessary to break it up sufficiently for coolies to remove the debris; and finally, that the neighbouring buildings, particularly the temporary tin church, which was only fifty yards away, must not be damaged.

The church was of normal cruciform design, the overall length of nave and chancel (including porch) was 201 feet and that of the transept (including porches) was 188 feet 10½ inches, the heights of the roof ridges were :—

Nave ..	..	70 feet.
Transept	..	60 feet.
Chancel	..	55 feet.

Owing to the dangerous state of the building, it was decided to fire all the charges simultaneously. These were laid against all pillars, the walls supporting the main roof, and the gables; 680 lb. of gun-cotton were used in 72 separate charges, varying in size from 2 lb. to 53 lb. In the case of the pillars, a small "flat" to receive the charges was prepared by company masons. Eighty-four detonators were used, some of the larger charges having two.

The charges were fired electrically, using the Quetta Electric Supply Company's overhead 3-phase distributor, which gave a voltage of 230, phase to neutral. The six "balanced" sub-circuits were in parallel, and each consisted of 14 detonators and 800 feet of cable.

When the sightseers had gathered in their multitudes, the latest Sapper bride depressed the switch, with the results shown in Photo 2. All the charges exploded, and all pillars and columns were cut, bringing down the whole roof. The cutting charges in the walls were also successful, except in the transept gables, where the stone door frames remained standing.

The farthest fragments travelled about 200 yards, and the temporary church, whose windows had been opened and boarded up, was undamaged.

SANDEMAN HALL.

This was situated in the heart of Quetta City, where the earthquake was at its worst, and had stood the shock remarkably well. As can be seen from Photo 3, it was built on Moghal lines, with a large central dome supported on pillars and arches, which formed the central hall, and four smaller domes over outer rooms. The base of the building was 66 feet square and the material was burnt brick in lime mortar, including the domes which had, in addition, been pointed with cement mortar. The pillars and walls were badly cracked, although the domes were undamaged.

The plan of demolition was to put cutting charges of gun-cotton against the four brick pillars supporting the main dome, and concussion charges of gunpowder under the four small domes. 269 lb. of gun-cotton and 100 lb. of gunpowder were used. The cutting charges were well tamped and were about half the calculated amount for an untamped cutting charge.

The charges were fixed simultaneously on two separate circuits, each with its own exploder. Some practice is required beforehand by the operator for this method, but the result was satisfactory.

The building was completely broken up except for the central dome, which settled down on the debris as on a cushion, and one small dome which was turned upside down, but otherwise unharmed, Photo 4 shows this.

St. Mary's Church

No. 1.

No. 2.

Sandeman Hall.

No. 3.

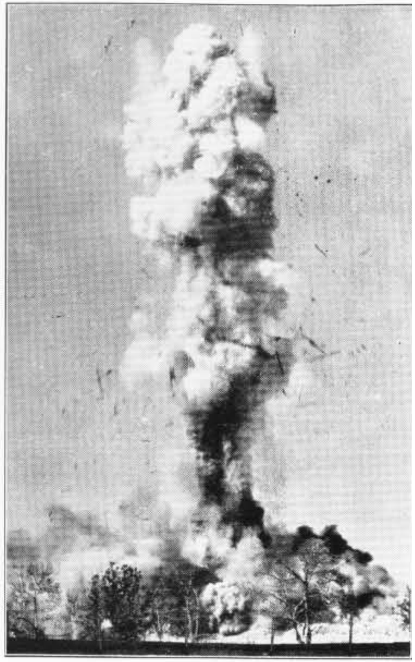
No. 4.

Quetta demolitions 1, 2, 3, & 4

ST. ANDREW'S CHURCH.

No. 5.

No. 6.



No. 7.

Quetta demolitions 5, 6 & 7

These domes consisted of 18 inches brickwork in lime pointed with cement, and to break them up a line of holes 10 inches deep and 9 inches apart were made in the brickwork with a pneumatic drill. Two ounces of dynamite were placed in each and the result was completely successful.

St. Andrew's Church Tower.

The nave and transept of the St. Andrew's Church were demolished by coolie labour. In December, 1937, 42nd Divisional Coy. Royal Bombay S. and M. was allotted the job of demolishing the tower. This was badly cracked high up, but was in fairly good condition lower down, see Photo 5.

There was an entrance at each side of the tower and a spiral staircase in one corner. A chase was cut in the brickwork at ground level. A small chamber was made at the three corners, and a larger one under the staircase. 131 lb. of gun-cotton was used, the charge under the staircase being well tamped with sandbags. All four exits were also completely closed with sandbags. (See Photo 5).

The charge was fired electrically with a double circuit.

The result can be seen from Photos 6 and 7.

THE WAR OFFICE.

By Q.M.G.8.

WE do not think (note the We, of which more anon) that an article on the activities of R.E. officers in a branch of the Fortifications and Works Directorate has appeared previously. The acquaintance of many officers with the War Office is limited to interviews with A.G.7, and few have probably more than a hazy idea of how the Works machine here functions, so this is an attempt to show in a somewhat lighthearted way how we justify our existence.

"Well, what do you do?"

This is always a difficult question to answer unless the job is very cut and dried and has a limited scope. The work of D.F.W's directorate is as varied as the duties of the joint monarchs in *The Gondoliers,* but not so clearly defined. It may be summed up in the last line of their immortal duet.

"To run on little errands for the Ministers of State."

It is as true as the honest fisherman's tale, to say that there is no policy decision affecting the Army which does not evoke some response from one of the branches.

"How," you may ask, "would a decision to change from brass to leather buttons affect you?"

The answer is that we should probably be called upon to estimate the possible reductions in the size of the N.A.A.F.I. shop, and of the soldiers' wardrobe, since less metal polish would be used!

Estimates, in fact, form one of the most important parts of our labours. Within the War Office the spadework for the greater part of Vote 10 is done by us. All the items which go to make up the annual Estimates come from ideas, and these are born either within the War Office or in Commands. In either case the infant must be fed with suggestions, exercised with criticism, and equipped with designs until it grows into a full-blown project ready to be entered for the financial stakes.

The way in which the cost of services is arrived at varies with the nature of the scheme. First, there is the prosaic scheme wherein all factors are reasonably fixed, and type designs and so forth are used. This is dull, as the answer ought to be reasonably accurate.

Next, there is the somewhat half-baked scheme for which the Command concerned has provided an approximate estimate. This has to be adjusted by guesswork, because various factors have changed since the Command were approached and time does not permit of reference back. In this case an intelligent guess can produce gratifying results.

But for pure joy nothing can touch the third type, which is arrived at somewhat as follows. The telephone rings—" We are going to send a division to X " or " We are going to put fifteen-inch guns at one mile intervals round the coast of Y " or " We want every man to have an electric iron, blanket and kettle." " What will it cost? We want the answer to-day as it will be considered by the so-and-so committee to-morrow."

Follows a rapid search through ready reckoners and establishments; much multiplication of amounts per head perhaps; add a bit for externals, local conditions, luck and anything else you can think of, not forgetting contingencies, and finally rounding up to the next highest £10,000.

This figure goes into high circles with a qualifying label " Approximate only," and in due course finds its way into Estimates. An accurate figure eventually rolls along, and when the two are in the same sheet verily there is balm in Gilead. The best record to date is within 10 per cent on a £750,000 job for this type.

So far as Vote 10 is concerned, the races for the various Financial Stakes take place during the winter. Entries have to be received by October 1st, and the first meeting is usually held early in November. This is D.F.W's meeting, and, as the jumps are pretty severe, only about two-thirds of the entries complete the course. All the rest are disqualified, the inexorable " Out " is heard, and they may race no more that season. The survivors from D.F.W's meeting compete again at the Q.M.G's meeting a fortnight later. The winners from this run in the Army Council Stakes in December. After this last trial a Service stands a very good chance of appearing in printed Estimates. But there is one last snag. It is not unusual for Army Estimates to get cut at the eleventh hour. This may lead to a last-minute slaughter, or severe pruning of appropriations.

Imagination plays a great part in the prosaic business of the War Office. It supplies reasons which have been omitted by Commands when submitting schemes; reasons which may be self-evident to the man on the spot, but which do not occur to the guardians of the public purse in the finance branches. It says what will happen if certain action is or is not taken, and generally tries to fill in gaps without constant reference back to Commands. The memory of voluminous correspondence may here induce a cynical smile, but the volume would have been greater but for imagination. It did boggle, however, at attempting to prove the logic of putting the matron on the top floor of certain quarters for nursing sisters, when the maids recruited from the local population were left on the ground floor. There was also a lift involved, also the view from the top floor . . . the subject is a painful one.

Design, like the brook, goes on for ever. Better standards of living, new machinery, improved armaments, all call for new construction. It is difficult to get finality in a single type because constant improvements are made. As a nation we are obsessed with this desire for going one better, with the result that we rarely obtain standardization, and constantly allow the better to be the enemy of the good.

Designs from Commands are submitted to the War Office, who try to improve them in the light of recent tendencies unknown to Commands, and designs are also issued from the War Office for local adaptation. These are simple processes, but the fun begins when adaptation of a type design is attempted by War Office and Command simultaneously. There was an instance of some garages, of which the walls were to be local masonry. The Command were to send plans to the War Office, who would order the correct amount of standard roofing. The plans when received showed that Command had confused centre line with internal dimensions, and had forgotten the extra thickness of the masonry walls. Nothing daunted, we adapted the standard roof to fit the walls and were about to order steel work when

(*a*) the establishment of vehicles was altered

(*b*) Command discovered their error and laid foundations to a new plan.

There should undoubtedly be a thought-reading branch here!

No article about the War Office would be complete without some reference to files. It is popularly supposed that a man spends all his time Hoovering them, and there is certainly a full-time Weeding Section of the Registry. New arrivals are inclined to find it difficult to understand why they are so complicated, but on reflection they feel that, if a simpler method of arranging things could have been found, generations of toiling captains, majors and colonels, not to mention the brains of the Civil Service, would have found it out.

The first thing that an officer has to learn on joining here is that, in writing a minute, he must never say "I" but "we," the reason being that the minute gives the opinion of the branch. The first person is reserved for Directors and Upwards. An Assistant Director who writes sometimes for a Director and more often as head of a branch has to be very careful about his pronouns!

In the case of a question which cannot be classed as urgent, the time occupied in obtaining the written opinions of branches interested, and the purely mechanical business of "transiting" files (often to buildings outside the War Office proper) is fairly considerable. So it must be clear that in the nature of things it is impossible to get an answer from the War Office by return of post. In the case of urgent matters, however, there are certain ways by which action can be speeded up :—

(*a*) By the attachment of brightly-coloured labels to files. There is one in a pretty shade of pink with IMMEDIATE on it, and for obvious reasons its use is confined to officers holding 1st grade appointments. Special arrangements are made for the speedy transit of files so marked and branches have to deal with them without delay.

(*b*) By arranging for a small conference of branches concerned to discuss the question. This is useful in rather complicated cases, as objections can be dealt with on the spot.

(*c*) By "walking the file round." In this case one of the branch takes the file personally to the right man in each of the branches concerned, and endeavours to get his agreement on the spot.

It may be asked why method (*c*) should not be frequently used, and become the normal way of doing business. The answer is that it takes too much time. When one has, say, 40 files to deal with in a day, and allowing 10 minutes per file on an average it is obvious that one cannot spend a great deal of time walking files round, and cope with the rest of the work. Furthermore, one would be very lucky to catch all the right people at a given moment. So method (*c*) has to be reserved for really urgent matters.

We hope that what has now been written will supply some answer to the question "What do you do?" We have not touched on matters of the ordinary routine work common to all military offices, nor does space permit of enlarging on such things as helping to supply answers to Parliamentary questions, attending conferences at other Government offices, and dealing with pertinacious inventors and gentlemen with grievances. Given a sense of humour, the capacity for changing gear rapidly so as to be able to work at top speed at any moment and a not too strong distaste for adopting the garb, deportment, and habits of a Whitehall official, we see no reason why a tour of duty in the War Office should be other than an interesting experience.

THE DEMOLITION OF THE CZECH BRIDGE AT BREITENFURT.

A Study of the Blasting of Reinforced Concrete.

By CAPTAIN GERLOFF.

(*Translated from an article in the February,* 1939, *number of the "Vierteljahreshefte für Pioniere."*)

WHEN the German troops marched into Sudetenland, they came across a reinforced-concrete bowstring-girder bridge at Breitenfurt (Silesia) that the Czechs had demolished. The bridge lay on the main road from Niklasdorf to Freiwaldau, and spanned the Biela, a water-course 20 metres wide at medium depth, but dangerous on account of its liability to flooding. (The Biela was the cause of a flood disaster at Neisse in the summer of 1938.)

The bridge had been designed with a reinforced-concrete arch and tie-beam, the latter carrying the roadway. The fixed support was on the east bank; the sliding support on the west bank. The bridge had been built with an unnecessarily large factor of safety, and an extravagant use of steel reinforcement. The latter had been put in carelessly. The aggregate had been badly selected—there was hardly any medium or fine ballast.

PREVIOUS EVENTS.

By cross-questioning German inhabitants of the village it was possible to re-construct the story of the demolition with tolerable accuracy as follows:—

A guard of twelve Sappers, under the command of a Czech N.C.O., had been placed on the bridge. At the beginning of September preparations had been begun for its demolition. Recesses were cut into the abutments immediately behind the heavy stone templates carrying the girders. But no explosives were put into them, in fact, an inspecting officer ordered the holes to be filled up again. It was still possible to identify the excavations in question.

On Thursday, the 22nd September, 1938, orders were received to prepare the bridge once more for demolition, apparently with more precise instructions as to the exact points of fracture. The Czechs seem to have considered the time available as very short: all attempts at deliberate destruction were abandoned, and only hasty demolition was attempted. The detachment of engineers had no boring apparatus or cutting tools.

Thirteen cases of ecrasit, containing 50 kg. apiece, were used, a total of 650 kg.

General Result of Demolition.

The result of the demolition can hardly be considered satisfactory. The arched beams and the tie-beams had been fractured evenly at points equidistant from the abutments, and the whole bridge had dropped, without the slightest tilt to one side or the other, on to the stony bed of the river. An attempt appears to have been made to get it to overturn by means of an explosive charge on the upstream roller saddle on the west bank, but with no result.

It is true that the bridge could no longer be used for vehicles and mounted men, but engineers could have made it passable for scouts, cyclists, and even motor-cycles. The central portion of the bridge, lying in the bed of the river, could have been utilized as the foundation of an extemporized bridge. The construction of such a bridge presented no technical difficulties, but would have been inadvisable on account of danger from floods.

Assumed Distribution of Charges.

Local inhabitants made observations of the position of explosive charges. In so far as their evidence agrees, the procedure appears to have been as follows :—

Four concentrated charges were placed against the arched beams, on the inner face, between the first and second uprights from the ends. (See photo No. 1.) They were wedged into position by a framework of planks. For the demolition of the tie-beams, crib piers were built up on the roadway beyond the first upright, on both banks. In each of these four piers a concentrated charge was lowered on a plank, by ropes, down to the level of the tie-beam.

An examination of the points of fracture confirmed the accuracy of these statements. In addition, a ninth charge was located with certainty at the roller saddle on the upstream side of the west bank. The inhabitants of the village knew nothing about it.

The separate charges were placed symmetrically near the four ends of the arched beams, as well as near the four ends of the tie-beams. The points of fracture of the arched beams and the tie-beams were "staggered" by a distance of about 1·5 metres, in order to give the fracture an inclination to the vertical. The arched beam charges were placed midway between the first and second uprights, the tie-beam charges close to the first uprights. The latter were, in each case, completely destroyed. But no oblique line of fracture resulted in a horizontal direction.

The distribution of the 650 kg. of ecrasit over the different points selected for placing the charges can only be a matter for conjecture. It may be assumed that a primitive type of mind, such as that of the N.C.O. in charge, would make for symmetry, and divide the available explosive equally between the charges. Thus, 6 cases would appear to have been utilized at each end of the bridge, and, of these, 3 would have been placed upstream and 3 downstream. Of the 3 cases (containing 150 kg.), half would have been expended on the arched beam, and half on the tie-beam.

It seems probable that the 13th case of 50 kg. was expended on the upstream roller saddle, so as to dispose of the balance.

RESULT OF INDIVIDUAL DETONATIONS.

(*a*) *Roller Saddle Charge.*

The comparatively trifling results obtained lead to the assumption that a weak untamped charge was used. Only a few blocks of masonry were blown away, others were slightly cracked, the rollers were merely blown off the saddle. From the discoloration caused by the explosive gases, it would appear that the charge was placed on the topmost layer of masonry behind the saddle. But if this extra charge was fired in the hope of destroying the saddle, it failed in its object. The base of the arch slipped, but was not overturned.

(*b*) *Arched Beam Charges.*

All four charges on the arched beam had approximately the same results. Measurements made at the four ends of the arched beams showed that in each case a length of concrete of between 1·50 and 2·00 metres had been blasted away from the reinforcement. As the bridge fell, the reinforcing bars were bent, but no measurable stretching of the steel could be established. The fact that all steel was bent outwards towards the stream confirmed the report of the inhabitants that the charges had been placed on the inner side of the arched beams.

Of the last uprights but one only a few fragments remained. They were all forced outwards. This confirmed the accuracy of the assumption that the charges had been placed to the landward side of these uprights, that is, between the first and second columns. Except for two round rods of 40 mm. diameter, the reinforcement was undamaged.

Three of the ends of the arched beams dropped vertically, and were not forced outwards towards the stream, in spite of the lateral application of the charges. On the other hand, the solid end of the upstream beam on the west bank was forced outwards, with its point some 1·50 metres out of alignment. (Photos 2 and 3.) The

9th charge had been applied on the saddle that supported it. This result is to be explained as follows:—The effect of a detonation is first disruptive and then propellant. In the three normal positions of the charge the detonation shattered the concrete, while the steel, protected from rupture by the concrete covering, was forced outwards by the propellant action. In the fourth case, the strong lateral thrust on the end of the beam was taken up by inertia and the friction of the saddle. The 9th detonation removed the contact between the beam and the saddle, thus eliminating the frictional resistance, and allowing the beam to move laterally. It is worth noting this result when it is desired to upset or twist heavy blocks of masonry.

(*c*) *Tie-Beam Charges.*

The tie-beam reinforcement consisted of three double riveted steel plates 30 mm. wide and 12 mm. thick, spaced 17 mm. apart. (Photos 4 and 11.) All the plates were bent outwards, a proof that the charges had been laid from the side of the roadway.

The outermost plates were bent most (Photos 4 and 5); a proof that the propellant action of a detonating wave at first increases in intensity with the distance from the centre of detonation. The inner steel plates had taken the shock, but were protected from damage by the concrete covering. This shows that the propellant effect of a detonation on uncovered steel is stronger than the disruptive effect.

The charge must have been applied at the point where the tie-bars show the maximum indentation. This point was 25 cm. from the first column in the direction of the stream.

Features in Connection with the Demolition.

The wind-ties only show very slight cracks.

Except for the places where the charges were fired, the arched beams were quite undamaged.

The roadway was snapped clean across at the level of the cross fractures; in other respects it was left constructionally sound. In a few places on the foot-path the detonation had forced concrete up from below.

On the other hand, the columns had suffered considerably. The columns carried the roadway; they were the means by which it was suspended from the arched beam. They were, normally, only intended to work in tension and were designed accordingly.

When the bridge crashed, a strong crushing action took place, and the weight of the arched beam (some 220 tons) was transferred to the columns as the structure came down.

CRITICISM OF THE CZECH DEMOLITION PLAN.

The symmetrical cuts in the bridge caused it to drop about 4 metres below its normal position. But the tactical object, to render it impassable for all arms, was not fully attained, as it would have been possible to patch it up, in a short time, sufficiently for scouts, cyclists, and even motor cyclists to cross over it.

The charge detonated on the roller saddle had practically no effect.

The charges used, totalling 650 kg., were unnecessary, as the following calculations show :—

All charges were laid, untamped and concentrated, against the members of the bridge. We assume that it was only intended to shatter the concrete and not trouble about the reinforcement.

The width of the arched beam, as also that of the tie-beam, was 0·60 m. W, with the addition of a small factor of safety, may be taken as 0·70 m. This fixes the length of the gap to be blasted at approximately 1·40 m.

$L = W^3 \times c \times d = 0{\cdot}34 \times 6{\cdot}5 \times 4{\cdot}5 = 10{\cdot}345$ kg.

With eight charges of this amount, $8 \times 10{\cdot}4 = 84$ kg. all told, gaps 1·40 metres wide could have been made in the arched beams and tie-beams, and the same result would have been obtained as with the charges totalling 600 kg. actually used for the 8 demolitions. 13 per cent of the explosive expended would have sufficed.

In official instructions, the width of the cut in compression- and tie-beams is laid down as "at least equal to the distance between them." In this particular case a gap of about 3·5 metres would have been necessary. Actual experience shows that the same object could be attained with a more modest outlay. It is essential that the width of the gap should be sufficient to enable the reinforcement to give way, and not to hold together when, in the course of falling, the individual portions of the bridge are displaced with reference to one another. Moreover, the distance between compression- and tie-beam does not seem to be as essential as the actual depth of the compression-beam, the fragments of which are to be forced apart. A trial test of our theory on this point would be valuable, if only in view of the 50 per cent economy in explosives.

The demolition was probably carried out on the "rough and ready" principle, as there can have been no intention to cut through the reinforcement. If this had been in view, a far larger quantity of explosive would have been required :—

The cross-section of the arched beam is 60×110 cm., or, at right angles to the surface, 60×100 cm.

F is therefore 6,000 cm².

$L = 2 \times F \times 25 = 2 \times 6{,}000 \times 25 = 300{,}000$ g., or, for four explosive charges : 1,200 kg.

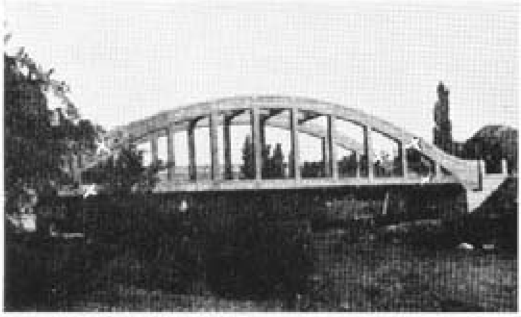


PHOTO No. 1.—The Bridge over the Biela shortly after its completion. The position of the charges is indicated thus : X

Length of roadway	33·00 metres.
Width of roadway	4·80 ,,
Over-all width of bridge	8·60 ,,
Height to crest of girder	7·35 ,,

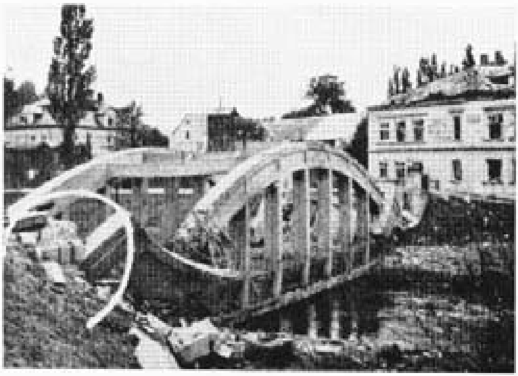


PHOTO No. 2.—Condition of the bridge when found. (View upstream from the west bank.) In foreground (enclosed in circle) the damaged support.

Demolition of Czech bridge at Breitenfurt 1 & 2

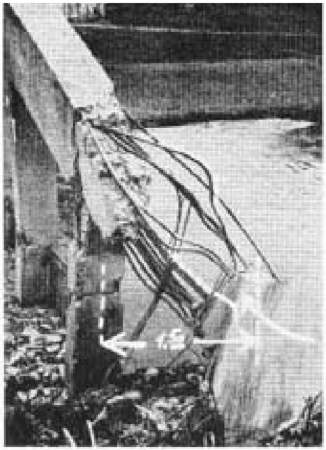


Photo No. 3.—Demolition of upstream arched beam on west bank. The reinforcement has been forced out towards the water. The end of the beam has been moved sideways about 1·50 m. on its support.

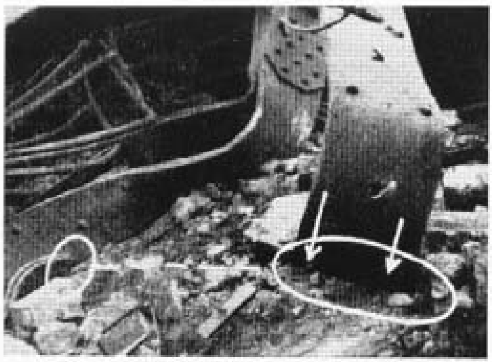


Photo No. 4.—Demolition of Tie-Beam. The rivets have been torn out of the outer tie-bar by the force of the explosion; the steel is undamaged.

Demolition of Czech bridge at Breitenfurt 3 & 4

The cross-section of the tie-beam is 60×64 cm. F is therefore 3,840 cm^2.

$L = 2 \times F \times 25 = 2 \times 3{,}840 \times 25 = 192{,}000$ g., or, for four explosive charges, 768 kg.

The total amount of explosive necessary would thus have been 1,968 kg., roughly three times that actually used. Moreover, in this case the charges should have been applied to give a maximum shearing effect, a point that was missed in carrying out the demolition.

Proposal for the most Satisfactory Demolition, both Tactically and Technically.

(*a*) *Surface Charges in the Abutment.*

On the assumption that time was short for placing surface or bore-hole charges on the arched beams and tie-beams, a demolition of the abutments would have had the most far-reaching results. The Czechs' original intention seems to have been somewhat on these lines.

If two abutments, that is both abutments either upstream or downstream, are thoroughly wrecked, the bridge will tip over, either upstream or downstream, and will remain in a tilted position. In that case it will be impossible to make use of it as a substructure for a temporary bridge, even if it happened to remain intact. Moreover, it would take longer to repair the abutments and re-erect the bridge with the aid of hydraulic jacks than it would to erect a temporary bridge.

It is advisable to destroy the wind-ties, so that the right girder may, by its own weight, snap the columns and so remove any possibility of the bridge being made serviceable again.

The left girder will very likely also break in falling. It is far more effective to allow a reinforced-concrete bridge to wreck itself by its own weight than to destroy it with explosive charges.

For a demolition of this kind the following explosives are required :—

The abutment is to be blown away for a breadth of 6 metres and a depth of 3 metres. The distance W from the centre of the charge to the saddle is 4 metres.

$L = W^3 \times c \times d = 64 \times 5 \times 1 = 320$ kg., for two abutments, 640 kg.

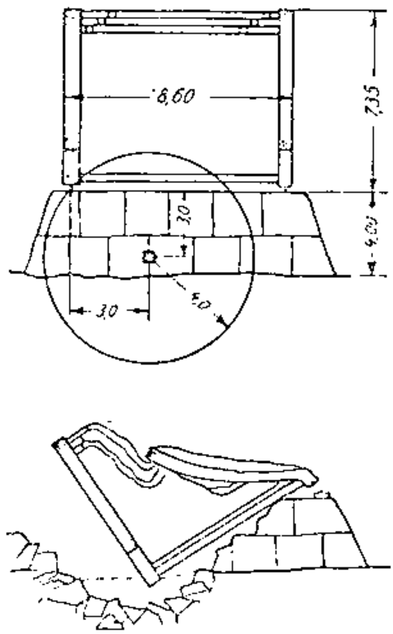
In order to make sure of the required depth of demolition of 3 metres, the charge should be laid 2 metres behind the face of the abutment.

The four horizontal wind-ties each have a cross-section of 40×60 cm. Instead of making a broad cut, a narrow strip of

40 cm. will be laid bare, exposing the steel, so as to obtain a link action and take all stiffness out of the tie-beam.

We will assume that no boring plant is available. The work will have to be carried out with surface charges.

$L = W^3 \times c \times d = (0{\cdot}4)^3 \times 6{\cdot}5 \times 4{\cdot}5 = 1{\cdot}75$ kg., for eight explosive charges: 14·4 kg.



SKETCH No. 7.—Result that may be expected from an explosive charge in the abutment.

Altogether, 655 kg. will be required: the exact amount that the Czechs had at their disposal.

Time required:

2 square holes, 2 m. deep: 1 officer and 8 other ranks: 2 hours (including placing charge).

8 small charges	4 O.R. ..	2 hrs.
Total	1 officer and 12 O.R. ..	2 hrs.

(*b*) *Surface charges to make a cut across the bridge.*

Whereas the Czechs only succeeded in getting the bridge to drop 4 m. vertically without tilting, by making two cuts near the end of the girders, a far better result, tactically, could be obtained by a single cut. The place for such a cut is at the fixed end of the girders on the east bank, between the 1st and 2nd upright on the upstream side, and between the 3rd and 4th upright on the downstream side. The main portion of the girder on the upstream side will thus have an appreciable excess of weight (about 30 tons) over the portion on the downstream side. In order to utilize this to overturn the bridge, an auxiliary bursting charge should be placed on the upstream roller saddle, to remove the latter completely. This is what was done in the Czech demolition—it is not known whether intentionally or unintentionally.

The Czech demolition proved that it was only necessary to destroy the compression zone in the arched beams by shattering the concrete for a distance of 2 metres. On the other hand, the tie-beam should be severed right across to facilitate the tilting movement.

Arched beam. L (charge) $= W^3 \times c \times d = 1{\cdot}0^3 \times 6{\cdot}5 \times 4{\cdot}5$
$= 29{\cdot}25$ kg.

Tie-beam. $L = 2 \times F \times 25 = 2 \times 60 \times 64 \times 25 = 192$ kg.

For 2 arched beams	58·5 kg.
For 2 tie-beams	384·0 kg.
Upstream roller saddle	10·0 kg.
Total explosive charge	452·5 kg.

A further supplementary charge of 10 kg. on the fixed saddle on the downstream side will bring about the tilting of the end portions of the bridge—in this case downstream—as they have an equal excess of weight in that direction.

(*c*) *Bore-hole charges.*

These will be based on the same principles as under (*b*).

1. *Demolition of the arched beam.*

Two rows of horizontal bore-holes will be drilled into the arched beam, which measures in cross-section 1·10 m. by 0·60 m. The rows will be 30 cm. from the top and bottom edges respectively. The holes will be 80 cm. apart, and staggered. There will thus be two rows of three holes apiece, viz., 6 bore-holes, taking effect over a length of $3 \times 0{\cdot}80$ m. $= 2{\cdot}40$ m.

Calculation of charge.

For every running metre of bore-hole, 1 kg.

Width of reinforcement, 0·60 m.

Length of bore-hole, $0{\cdot}60 - 0{\cdot}10 = 0{\cdot}50$ m.

Length of charge to be inserted, 0·50 m., equivalent to 5 cartridges.

With 6 bore-holes holding 5 cartridges apiece, 3 kg. will be required for each arched beam, *i.e.*, 6 kg. altogether.

Trial charges were fired to test the accuracy of the above calculation. It was necessary to bear in mind that the Czech explosion had strained the steel-work, and, perhaps, caused some loosening of the concrete. This may have affected the value of the experiments carried out. At the same time, no definite loosening could be established either by the formation of cracks on the surface, or in the course of drilling the bore-holes.

In any case, to avoid arriving at incorrect conclusions, and because I was anxious to prove that it is a comparatively simple matter to demolish the compression zones by blowing the concrete away from its reinforcement, the calculated number of bore-holes was reduced from 6 to 4 (see photo No. 8), and the number of cartridges in each was reduced from 5 to 3. Instead of the calculated charge of 3 kg. per arched beam, only one charge of 1·2 kg. was used. The unmistakable success of the trial charge is shown in the illustration. (See photo No. 9.)

The objection that might be put forward, that the same success would not have been obtained with an undamaged structure, will not hold water. The effect of a detonation is lessened if the shattering effect of the detonating wave is allowed to expend itself on an elastic object. But such a contingency is much more likely to occur in the case in question than with an entirely undamaged member of a bridge. Moreover, the trial was repeated in eight different places, and each time with equal success. It might be worth while for the official instructions to lay greater stress on this form of demolition.

In the official instructions it is laid down that "in reinforced-concrete beams bore-holes should always be drilled at right angles to the reinforced zone." In our example the reinforcement runs parallel with the line of the bridge. To comply with these instructions, a bore-hole may be either vertical or horizontal, *i.e.*, parallel with the flow of the river. This point might be elucidated in the instructions.

From an illustration given it might be assumed that it is intended that bore-holes should only be driven vertically. This raises the following point. As a rule, the reinforcing bars are held together by straps at the top and bottom of a beam. It will be easiest to blast away the concrete to the sides, which are unarmoured. If the bore-holes are driven vertically, the charge will expend its energy towards the sides throughout its full length.

In our trial demolitions we made the bore-holes horizontal. It might be assumed that the broadside of the detonation wave would be taken up by the reinforcement. The result proves the opposite. The steel bars were not even bent upwards and downwards; the whole force of the explosion was taken up by the concrete.

The horizontal direction of the bore-holes—in opposition to the official instructions—is based on the following grounds:—

In the example (sketch 10) in the official handbook a cross-

Photo No. 5.—Demolition of Tie-Beam. The outer tie-bar has been bent out furthest; the roller saddle is undamaged.

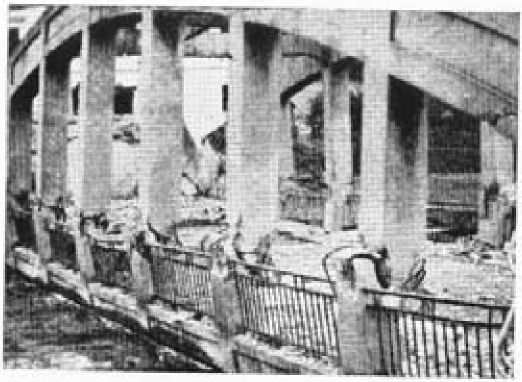


Photo No. 6.—Suspension members snapped across by the shock.

Demolition of Czech bridge at Breitenfurt 5 & 6

PHOTO No. 8.—Arrangement of bore-holes on an arched beam.

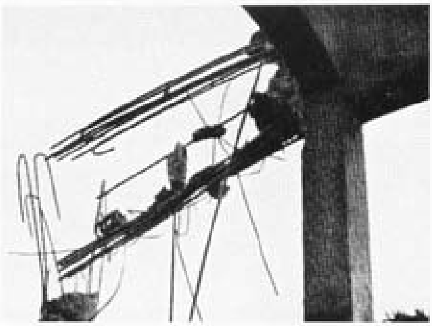


PHOTO No. 9.—Arched beam after demolition.

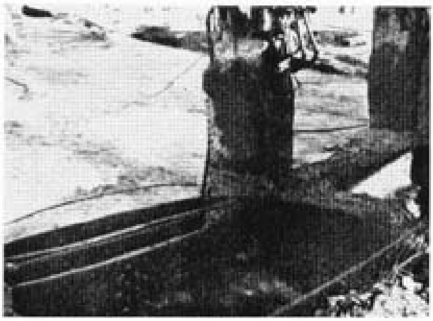
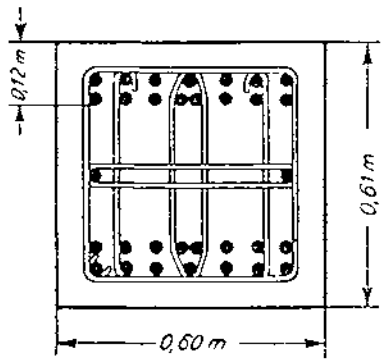


PHOTO No. 11.—Uncovered tie-bars.

Demolition of Czech bridge at Breitenfurt 8, 9 & 11

section of a beam is given. In the width of 50 cm. there are eight round bars of about 3 cm. diameter. Thus a width of 24 cm. is enclosed by steel. The remaining 26 cm. are divided up into 7 interstices of 3·5 cm. each. A bore-hole is, theoretically, 3·5 cm. wide ; in actual practice at least 4·5 cm. It is, therefore, technically impossible to drive the bore-holes vertically, as the drill cannot get through between the bars.

Photo No. 9, which shows the bars laid bare, makes it clear that it is impossible to make certain of finding, from the top, a gap between the bars, through which the drill could be driven. On the other hand, it is much easier and safer to work from the side, without impairing the effect of the detonation.



SKETCH NO. 10.—(From official text-book).

As similar conditions prevail in all constructional members, often carelessly put together, it is recommended that the official regulations should take this point into consideration.

2. *Demolition of the tie-beams.*

The demolition of the tie-beams requires some preparatory work, in order to have the bars bared to receive the charge.

The three pairs of tie-bars are embedded in concrete. The amount of flat-steel reinforcement provided (6 mm. in thickness) is trifling. The concrete does not adhere to the smooth flat steel. It is possible, after a few hours' work with chisel and hammer, to lay bare a length of 20 cm. of steel. The construction and carrying capacity of the bridge are not impaired in the slightest. But a charge of explosive is a quicker method of doing the job. A single cartridge, placed in each of the spaces between the three ties, will lay them bare, without damaging them, as photo No. 11 shows.

A pair of tie-bars measures in cross-section : $2 \times 30 \times 1{\cdot}2$ cm.

$F = 72$ cm^2.

$L = F \times 25 = 1{,}800$ g.

Three pairs of tie-bars will require 5·4 kg.

Total for tie-beams on both sides 10·8 kg.

Thus, for the demolition of the bridge in accordance with proposal (*c*) there will be required: 10·8 kg. for the tie-beams + 6·0 kg. for bore-hole charges in the arched beams = 16·8 kg. in all.

Add to this 10 kg. for each of the saddle charges, *i.e.*, another 20 kg. of explosive. (This will not be necessary in the following comparative scheme.)

Personnel: 1 group.

Tools: 1 large or 2 small boring drills with compressed air plant and hammers.

Time: 3 hours.

A Comparison.

The official instructions quote an example of a similar bowstring-girder bridge with tie-beam. In order to find a basis of comparison to which no objection can be taken, the following points should be considered:—

Both in the official example and in my calculation it is proposed to destroy the tie-beams simply by cutting the steel ($L = F \times 25$). The two examples agree on this point. It is a different matter with the arched beam. In my proposal it is intended to demolish the bridge by breaking up the compression zone, *i.e.*, the concrete. In the official example, on the other hand, it is contemplated to shatter the reinforcement. With this object in view, recesses for explosives are cut immediately below the upper layer and above the bottom layer of bars. The bars, respectively above and below these chambers, are demolished in accordance with the formula for steel reinforcement:

$$L = 2 \times F \times 25.$$

Of this, $\frac{L}{2}$ is applied in the explosive chamber, and $\frac{L}{2}$ in the upper portion, that is, just below the bars, to produce a shearing effect.

In the official example such an explosive chamber, if made large enough to hold the calculated charge, will have to be 85 cm. long, with a cross-section of 16 × 13 cm. The cutting out of such a chamber will entail endless labour; in fact, according to our experience at Breitenfurt, it will take at least 16 hours. In area the chamber will be equivalent to 22 bore-holes, and, since the depth is nearly twice as great, the contents will be equivalent to 35 bore-holes. Since two chambers are necessary for cutting one beam, the relative labour expended is in the proportion of 70 bore-holes to 6 similar ones in accordance with my calculations.

The arched beam of the Breitenfurt bridge is 60 cm. wide, compared with a width of 90 cm. in the official example. If the same method of demolition is adopted, the explosive charge required in the two cases will differ by one-third. In the official example

640 units, *i.e.*, 128 kg. of explosive, are required for two cuts. From this it follows that two-thirds of this amount, *i.e.*, 85 kg., will be required for the Breitenfurt bridge. In my solution I require—not by the same method, it is true, but with the same result —only 6·0 kg., that is, about 7·7 per cent of the above amount.

This huge difference in time and explosives is explained by the following considerations :—

In reinforced-concrete construction, compression stresses are taken up by the concrete, tensile stresses by the steel. Steel demolitions are more difficult to prepare, and require very much more explosive. They should, therefore, be avoided if possible.

In demolishing tie-beams, the steel must be attacked. But in compression zones, as here in the arched beam, it is inadvisable to attack the steel reinforcement, when the same result can be obtained, much more rapidly and economically, by shattering the concrete.

In this respect it seems advisable to reconsider the official instructions that lay down that in reinforced-concrete construction tension members should be demolished first. This does not apply in a general way.

The example of the Breitenfurt bridge rather proves the following, it being understood that the reference is to this particular form of bridge construction only :—

1. It is enough to break up the compression zone in the arched beam by shattering the concrete.
2. The width of the cut to be made depends upon the depth of the arched beam. It should be about 1½ times the latter to be on the safe side.
3. Bore-holes should be driven horizontally, unless this involves the use of complicated scaffolding and a waste of time.
4. A cut through the tie-beam does not appear to be essential. All that is necessary is to expose a portion of the steel. This allows of the beam bending at the moment when the whole weight of the bridge bears upon the tie-beams, which are only designed to take tensional stress.
5. Auxiliary charges on the supports facilitate a tilting action.
6. That formidable material, reinforced concrete, loses its terrors if the points are sought where it is most vulnerable. On account of their heavy weight, concrete bridges are more vulnerable than iron ones.

What iron bridge of 35 metres span could be brought down with a charge of about 17 kg. ?

Note by Translator.

The formulæ in the original article are taken from official German text-books. References to the pages of the latter are here omitted.

ANTI-MALARIAL.

By LIEUT. R. A. BARRON, R.E.

INTRODUCTION.

THE enlargement of the garrison of Hong Kong and the fact that two battalions had, for ten years, lived in temporary huts, made it necessary to build a new cantonment, for which a site was selected in an area called Kau Lung Tsai.

Malaria is bad in many parts of Hong Kong and of these Kau Lung Tsai was one of the worst. Measures had therefore to be taken to safeguard the cantonment and the workmen engaged on its construction.

The writer, henceforth called the Garrison Engineer, was in charge of the work and it is hoped that an account will be of use to anyone faced with a similar problem.

TOPOGRAPHICAL.

(In subsequent paragraphs the writer is indebted to the Officer, R.A.M.C., responsible for the original survey of the area, for information obtained from his article in the *R.A.M.C. Journal* of August, 1937.)

The area, Kau Lung Tsai (Plan I), consists of decomposed granite hills, intersected by numerous streams in all of which mosquitoes flourish.

On the north of the area a massive chain of hills runs from east to west, from which subsidiary ridges run north and south. The site for the new cantonment lies on the foothills to the south of the main ridge. A natural feature which influenced anti-malarial work was the main subsidiary ridge traversing the cantonment site, east of which the streams flow into the sea in the Kai Tak area on the east of the Kowloon Peninsula, while those on the west flow into the sea in the vicinity of Tai Tok Tsui on the western side of the Peninsula.

The area east of this subsidiary watershed is open in character, the ridges running south being short and situated some distance apart; in consequence the hill streams, after their initial steep descent, have little fall. The valleys run into an open low-lying plain, which is sparsely wooded but which has large areas under cultivation, both wet and dry.

The population is dense, mainly engaged in agriculture and living under poor and insanitary conditions.

The streams themselves are boulder-strewn, and their beds are composed of rocks and sand. In some places the water flows over lengths of slab rock. Three swamps, apart from those caused by wet cultivation, exist in the area.

West of the subsidiary watershed, the area is characterized by longer spurs divided by steep narrow valleys and the gradients of the hill streams are on the whole steeper than those to the east. The northern half of this area is heavily afforested and the streams, although boulder-strewn, are largely overgrown with vegetation.

On the northern slopes of the main ridge, no cultivation or habitation exists and the danger of mosquito flights from this quarter is negligible ; while to the south of the cantonment site, the area is already built-up.

Malarial Survey.

Before recounting the results of the Malarial Survey of Kau Lung Tsai, it must be stressed that any anti-malarial work must be preceded by such a survey, as the breeds and habits of mosquitoes vary the world over.

The survey of this area started in March, 1935, and continued for two years. It covered the whole area inside the black line shown on Plan I.

A frightening number of Anopheline larvæ were collected and identified, a slaughter which showed that nine breeds existed in considerable numbers. Culicines were also examined and produced 18 breeds which, together with the Anophelines, were identified on a map of the area by coloured dots representing their observed breeding places.

From dissection it appeared that six breeds of Anopheles carried malaria, chief of which were *A. Minimus* and *A. Jeyporiensis.* In considering the measures to be taken for their destruction, the habits of these latter two breeds were taken as those to which the lesser breeds aspired.

The most prolific breeding places were the pools in the flatter portions of the hill streams, where vegetation supplied the necessary anchorage for the larvæ. The mosquito prefers sunlight for her breeding so that the hill portions of the western streams were not so dangerous as those to the east. Also, the larvæ are unable to withstand swift currents and here again the east was the more dangerous.

Anopheles are normally averse to pollution—a nicety of taste not shared by their Culicine cousins—but, at the same time, the Culicine is a pest and even polluted water should be avoided.

Wet cultivation is a dangerous source of breeding places, but experiments with different forms of crop showed that watercress is avoided by the female Anopheles.

It is believed that the majority of breeds prefer animal blood to that of human beings.

Normally, the range of flight of the female Anopheles from her breeding place to her blood feed is unlikely to exceed half a mile. She prefers flying down-wind on the light breezes of dawn and dusk and dislikes soaring.

Her incubation period is from seven to ten days.

Investigations were also made into local conditions and the following factors were added to the report of the survey.

Wind averages taken over a period of years showed a 45 per cent prevalence from the east.

Investigations into the lives and habits of the Chinese population showed that the utterly insanitary conditions, under which they live, favour Culicine breeding. They are also careless both in their irrigation and in their allowance of standing water. They appear to be inured to living with a multitude of mosquitoes and care little if they are bitten.

In themselves, the villagers constitute a powerful reservoir of malarial infection ; it is, in fact, proverbial amongst those who deal with cooli labour that the Chinaman must not be kicked, as under such treatment his malarially-enlarged spleen tends to burst.

Lastly, certain types of fish were found which eat the mosquito larvæ.

RECOMMENDATIONS.

On these factors the recommendations, put forward in the malarial report, were based. They were extensive, as it was considered that the concentration of troops in the cantonment and the large number of mules which were included in the cantonment establishment would prove a powerful attraction to the mosquitoes. It was also essential to safeguard the coolis working on its construction.

Primarily, it was recommended that all streams and swamps should be permanently trained in an area enclosed by a line drawn half a mile outside the cantonment boundary, including, however, Stream B.1, to the east which was probably the most dangerous source of breeding places and was also to windward.

Within the cantonment boundary, as any permanent construction would be destroyed in the subsequent levelling, the streams were to be rough-trained to safeguard the coolis.

Because of the built-up area to the south-west, the streams in that area were considered of secondary importance, to be done if time and money allowed.

It was recommended that wet cultivation should be prohibited with the possible exception of watercress, and that any irrigation channels essential for dry cultivation, and pools or wells for washing or drinking water should be included in permanent construction. Where this might be impossible, use was to be made of larvicidal fish.

The normal preventative measures with regard to casual breeding in old tins, burial urns, tanks or other receptacles were to be taken.

The preference of mosquitoes for animal blood was to be used in the encouragement of the breeding of pigs, which in China, are favoured household pets. They are chiefly remarkable for their shape as, owing to a lack of calcium in the water, they suffer from a severe dip in the spine.

No recommendation was put forward about the local population, but it could be assumed that, if mosquito breeding was prevented, the reservoir of malarial infection was dammed.

It was also recommended that all channels, after construction, should be inspected weekly and cleared of silt and that pools should be constructed so that they could be fully drained and cleaned.

Methods Adopted.

Based on these recommendations, contract plans were evolved. It was decided that work on the eastern half, as the most dangerous, should be completed before construction of the cantonment started. At the time, this was intended to be in the near future and it was therefore essential to get on with the job. Experience did not justify this urgency.

The Garrison Engineer was therefore dispatched to carry out a reconnaissance of the whole area, and, for fifteen days in the hot weather, he and a party of four Sappers struggled up each stream, measuring the lengths of the streams and noting any details which might affect subsequent canalization. Time and the absence of Survey staff precluded any detailed survey.

It had been decided to canalize all streams between the cantonment boundary and the half-mile line including Stream B.1 to the east, but excluding Streams C and D in the built-up area, which were not considered of importance. It was also decided to stop canalizing at 700 feet above M.S.L., as mosquitoes were unlikely to breed any higher. Normally, the streams dried up below this height and it was unnecessary to work as high.

In the plans for the cantonment, all the streams entering the area were to be carried in culverts under the fill when levelling was completed. Therefore, the lower terminus of the channels north of the boundary occurred where the estimated line of fill ended and it was left to the cantonment contract to carry on from there. The same principle applied to the upper terminus of Stream B.

Streams inside the cantonment were to be rough-trained at minimum cost, and, for this, gangs of eight coolies each were to be obtained from the contractor to hand-pack stream banks, cut drainage channels in the swamps and generally tidy up the area.

Encouragement of pig breeding was considered to be outside the scope of the Corps.

A conference was held with the local government authorities to decide what measures, if any, could be taken to prevent wet cultivation. The answer was that virtually nothing could be done.

The control of irrigation channels, pools and wells presented difficulties, but it was decided that, where possible and where funds would permit, pools for washing and drinking water should be replaced in permanent construction. Wells were not considered a serious danger and it was decided that they might remain as long as the villagers would provide covers for them. Owing to the distance of some of the fields from the nearest channel, and the fact that water was essential even for dry cultivation, "run-offs" to feed the irrigation channels were to be constructed, but they were to be designed so that the water could be cut off if the villagers failed to keep the channels clean.

The incubation period should have been outside the engineer responsibility, as it had been decided that the P.W.D. should take over the channels on completion. This, owing to pressure of work, they were a long time in doing and an effort was therefore made to inspect and clean them regularly. Lack of staff made this difficult and little could be done except occasional clearing of silt.

PLANS AND SPECIFICATIONS.

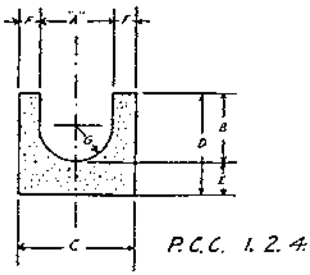
The first step in producing the contract documents was to calculate the sizes of channel required.

A plan, of which Plan I is a reduced copy, was divided into catchment areas; each area being obtained with a planimeter. An assumption of 4 in. rainfall per hour, with perfect run-off, was made; a figure which, it was considered, would cover all normal rain with the exception of typhoons and cloudbursts. These latter were incalculable and it is believed that on one occasion a cloudburst produced 11 in. in an hour, a fall which would need absurdly large channels, and which it could only be hoped would not occur again.

A table of channel sections and the flow they would carry for various grades was obtained from the P.W.D.

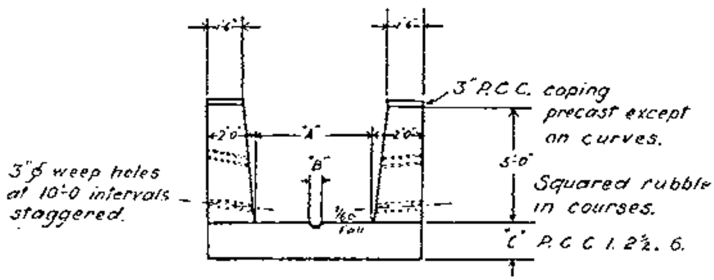
Multiplication of the catchment areas by the 4-in. run-off gave a figure of cusecs which the channel had to carry; the catchment area being subdivided, moving upstream, where changes in section would occur. The grades were taken off the contour lines of the map and it soon became obvious that these were not accurate.

PLATE I.



DIMENSIONS							
A	B	C	D	E	F	G	Remarks
9"	9"	15"	13"	4"	3"	4½"	
12"	12"	18"	16"	4"	3"	6"	
15"	15"	23"	21"	6"	4"	7½"	
18"	18"	26"	24"	6"	4"	9"	
21"	21"	29"	27"	6"	4"	10½"	
24"	24"	32"	30"	6"	4"	12"	
30"	30"	40"	37½"	7½"	5"	15"	
36"	36"	46"	43½"	7½"	5"	18"	
48"	48"	60"	57"	9"	6"	24"	

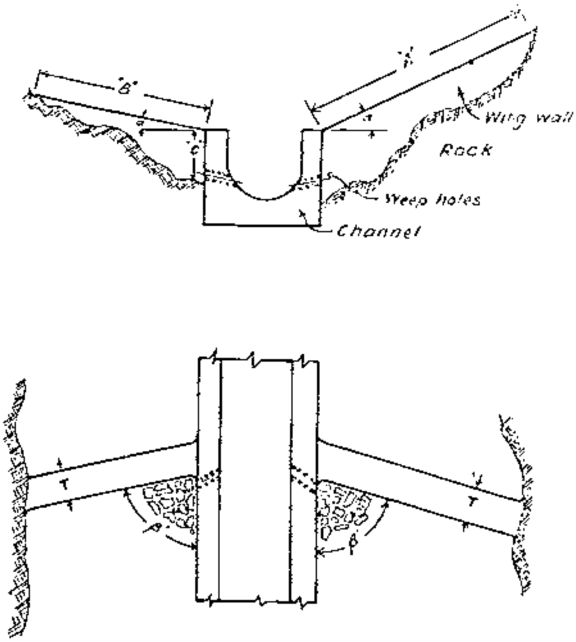
CHANNEL



Wing walls, if required, are as for channels.

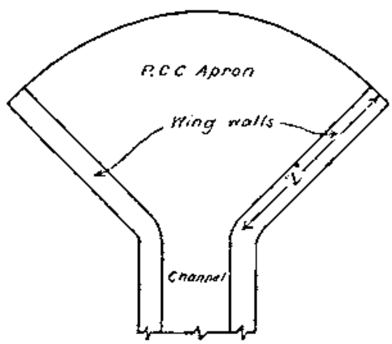
DIMENSIONS			
"A"	"B"	"C"	Remarks
5·0	6"	1-6"	
7·0	8"	1'-6"	
10'·0	10"	1'-6"	
15'·0	12"	2'-3"	

STONE NULLAH

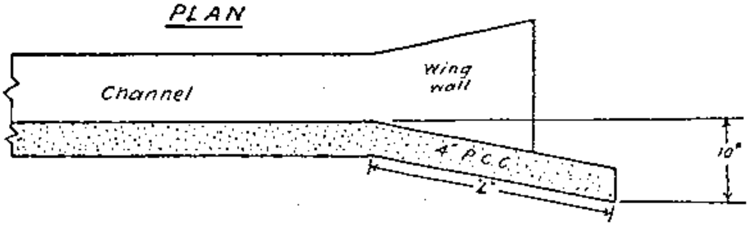


Weep holes: 3" up to 36" channels, 6" for 48" & upwards.
T=6" or 9" as directed. All other dimensions as directed by supervising officer on site.

WING WALLS FOR CHANNELS



PLAN



APRON TO WING WALL

By juggling the grade and the calculated cusecs the required size of channel was obtained, and, where later experience on the ground showed that the answer was inaccurate, it was a simple matter to alter the section when laying out the stream.

These figures for channel section were then transferred to the log book of the original reconnaissance and it was possible to produce a rough estimate. This, based on normal cube rates for Hong Kong, worked out at $450,000 (£28,125).

With the exception of channel, nullah and bridge details, type designs only were produced. It was realized that different circumstances and experience would call for fluid design.

Channel sections were taken from the figures provided by the P.W.D. but it was decided that, over 48 in., channel sections were too unwieldy and should be replaced by nullahs (Plate I). These were designed in four sizes—5 ft., 7 ft., 10 ft. and 15 ft.—with walls of equal height—5 ft. The walls were specified as "squared rubble in courses," battered, and designed to retain the stream banks with an assumed superload of 10 ft. falling at 60° to the coping. The P.C.C. floors were cambered at 1/60 to a centre dry-weather channel.

To counter seepage from behind the channel and nullah walls, 3-in. weepholes were specified ; two rows staggered at 10-ft. intervals in nullahs and single rows, with spacing varying from 10 ft. to 20 ft., depending on the fall, in channels. They were to be placed at 45° to the line of the channel wall and at 45° to the vertical.

In the first two contracts the lower row of weepholes in the nullahs was placed one course above the floor, but it was later found that floor level gave better results. In channels the best height appeared to be at the tangent point, where the vertical side walls joined the curve of the floor.

Even when weepholes are provided, surface water will continue to flow down outside the walls. Baffle or "wing" walls were therefore added (Plate II). These walls of P.C.C. were keyed into and inclined back from channel walls at approximately 60°, a weephole giving entry just upstream of the wall. To be efficient they had to key into firm ground for their full length. A 50-ft. spacing between successive walls is none too short, except when the fall is less than 1/200. In any case this can only be decided on the ground, depending as it does on side tributaries, seepage and the nature of the soil.

To give a clear run to the water outside the channel, down to the next weephole or wing-wall, hand-packing was specified, 6 in. wide for channels up to 12 in., and 1 ft. wide for sections over that size. In the early stages of the first contract hand-packing was forgotten, but it soon became clear that water was lying in the clay banks. The addition of the extra 6 in. or 1 ft. on each side of the channel also acts as a form of overflow in very heavy rain, and prevents scouring behind the channel walls.

Made banks needed revetment and turf was therefore laid, but it should be remembered that turfing must not be carried over the hand-packing, otherwise the earth chokes the packing and ruins its utility as an overflow channel.

To control the flow of water in a stream its speed needs reduction, and it was therefore decided to limit the fall in any channel to 1/5, which meant that, in the steeper reaches, steps were necessary. The fall in the tread of the step was made 1/5 and weepholes were placed in each rise. To preserve full channel section, the step on the wall must be staggered downstream of the step on the floor of the channel. (Plate IV.)

A cloudburst in the early stages of the first contract showed up one or two faults in the first designs. For instance, no allowance had been made for centrifugal force at sharp corners. Calculation of the height to which the water would rise at corners was difficult owing to the many factors involved, such as the speed of the water, the angle of bend and whether there were any steps above the corner to break the flow. Experience from the cloudburst, however, showed that an additional height of outside wall of from 1 ft.–2 ft. and a length of 10 ft.–15 ft. was sufficient. The lesser dimensions applying to curves of radius 20 ft. and channels up to 18 in., increasing to the higher dimensions for curves under 15 ft. radius, and channels 24 in. and over.

At one time the idea was played with of cambering the channel by tilting its whole centre line inwards on curves. This presents too great a difficulty in fixing the casings.

In some cases streams fell over falls of considerable height. A cascade pool was therefore designed to break the fall at the bottom, while, above the fall, the channel was splayed and dipped to throw the water into the pool. (Plate III.)

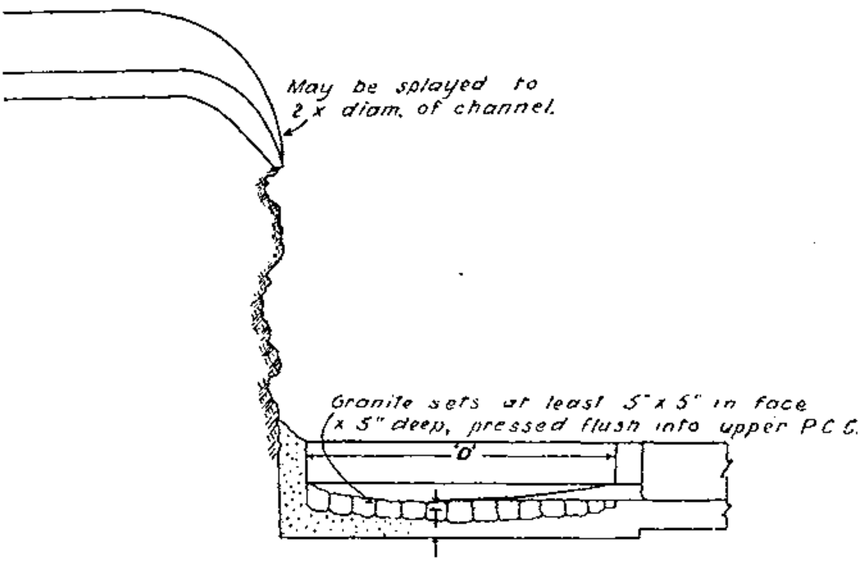
The pool, itself, was designed with concrete walls the same height as the channel below the fall and with a granite-sett floor. From any considerable height the wear on the floor would be great and it was therefore decided that the floor of the pool should be built with a fall to the centre, forming a bowl from which a small section channel led to the main channel below the fall. This, it was hoped, would form a shock-absorbing pool under heavy flow, while under light flow the small section channel would drain off the pool.

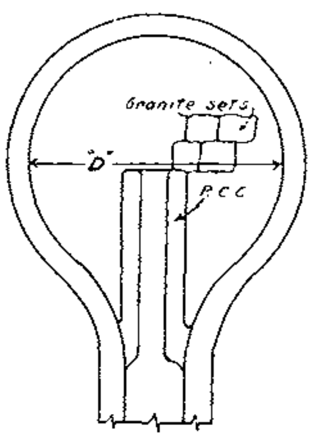
In practice, few of these pools were used, as they are not worth their cost unless the fall exceeds 10 ft. This occurred seldom and it was normally possible to concrete the floor of the fall and to steer the water into the channel between wing walls.

These pools were designed in four sizes—5 ft., 7 ft., 10 ft. and 15 ft., depending not on the size of channel but on the width of the original cascade.

Where two channels of approximately equal size join, a swirl pool

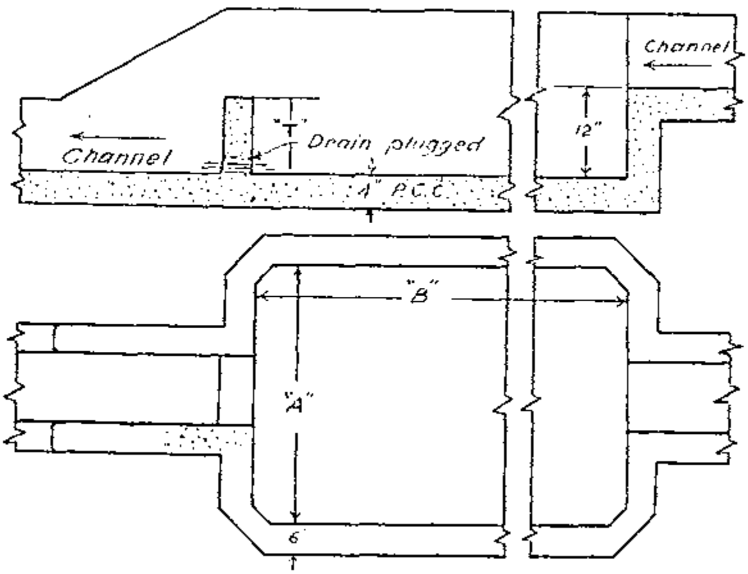
PLATE III.



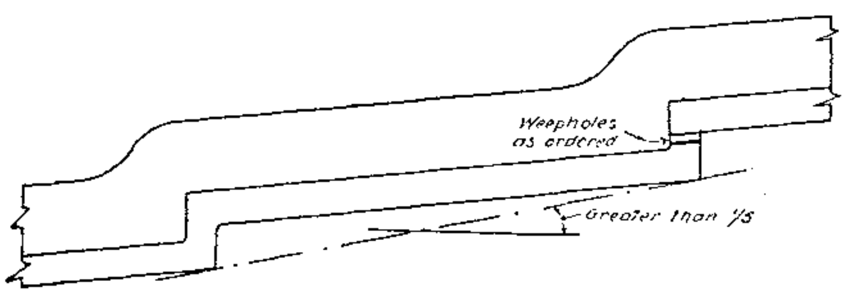


CASCADE POOL

PLATE IV.



POOLS FOR CULTIVATORS



STEPPED CHANNELS

is needed to prevent silt choking the channels when it is dropped at the junction by back eddies. A swirl pool merely implies that the outer walls of the two channels are bellied to form a cup.

At the head of each stream or branch channel it was decided to place an " apron " joining the toes of two wing walls. This apron was inclined at 1/10 below horizontal, with the idea that it would prevent any surface water from finding its way under the channel. (Plate II.)

Bridges were designed for all spans and the general policy was to replace all those which had existed before work began.

These designs applied directly to the canalization of streams and, although they were not all—swirl pools, for instance—included in the first drawings, they were introduced early in the first contract.

Various designs were also necessary to deal with the problem of providing water for irrigation and for drinking.

Pools were designed both for channels and nullahs, to replace the mud pools which previously existed in the stream beds. For channels, rectangular pools, normally 10 ft. × 10 ft., were designed. The water dropped 6 in. or 12 in. from the upstream channel into the pool, the floor of which ran level or fell a further 6 in. to the outlet. Across the mouth of the downstream channel a wall, either 1 ft. or 1 ft. 6 in. high, formed a dam to the pool. The sides of the pool at this end were made high enough to give full channel clearance over the wall, from which the water dropped to the lower channel whose invert was the same as, or below, that of the bottom of the pool. A plug could then be placed in the bottom of the dam wall in a 3-in. pipe, which allowed the pool to be drained completely. (Plate IV.)

In some cases, there was not sufficient fall to allow of this design and the dam wall was therefore placed across the width of the pool, whose walls were brought together to the channel below the wall. This was the only way of retaining a cross-section area equivalent to that of the channel, and at the same time making it possible to drain the pool.

The medical report had recommended that, in pools, all corners should be 45° in order that breeding might be prevented in the back eddies which occur in right-angled corners. This was tried out in the first designs but, as the majority of pools were continually disturbed by the villagers when drawing water, it was decided that it was unnecessary.

In nullahs, a dam wall 1 ft. 6 in. high was designed, fitted with a similar plugged hole through which the dry weather flow channel passed. To retain the correct cross-section, the walls of the nullah over the dam were raised 1 ft., from 3 ft. below the wall to 20 ft. above it, and 6 in. for a further 20 ft. Steps were also designed which could be placed either on one or both sides leading down to the pool.

To provide irrigation water, it was originally intended to use a sluice gate which could be dropped into the channel and so divert water through a run-off pipe. In China no wood is safe from the villagers, and this design was therefore scrapped with only one exception which will be mentioned later. To replace the sluice gate, a low concrete dam was placed across the floor of the channel and water could then run out through a pipe, unless the villagers themselves closed it or the G.E. decided that a punitive measure was needed. This had the disadvantage that the trench leading away from the pipe was sometimes deep.

Not all these designs were included in the contract drawings but were evolved as work proceeded. Various additional modifications which were found necessary will be mentioned in a later paragraph.

ORGANIZATION.

(*See Plan I.*)

Owing to difficulties in working in the neighbourhood of the rifle ranges, which cover part of the eastern half of the area, without upsetting the entire musketry programme, it was decided to launch a first contract including only those streams considered dangerous to the intended coolie camp. These were B.1, B.2, B.4 and B, between the junction of B.4 and the point where it passed the half-mile line.

At the start, in September, 1937, this contract had a civilian Clerk of Works with a Chinese land bailiff as assistant. The latter was responsible for liaison with the local villagers and was eventually allowed to supervise elementary concreting. When the contract was three-quarters finished, the civilian Clerk of Works was discharged and replaced by a Sapper Staff Serjeant and, at the same time, a civilian was engaged as a sub-overseer and a Sapper was borrowed for the same job.

Five months afterwards, a second contract was launched covering Streams B.3, B.3a, B.5, a cultivated area between B.3a and B.1, and the remainder of Stream B, up to the cantonment boundary. This contract was placed under the same Clerk of Works and staff.

In September, 1938, the third and final contract was sent out to tender, including all the remaining streams—those to the north of the cantonment boundary and the whole G.1, and G.2, system to the west. This contract was under another Clerk of Works with two Sappers to help him. As work on the first two contracts finished, the civilian and the Chinese land bailiff were transferred to him.

Rough-training inside the cantonment boundary was dealt with in the first contract.

The second contract was given to a European firm and the remaining two to Chinese.

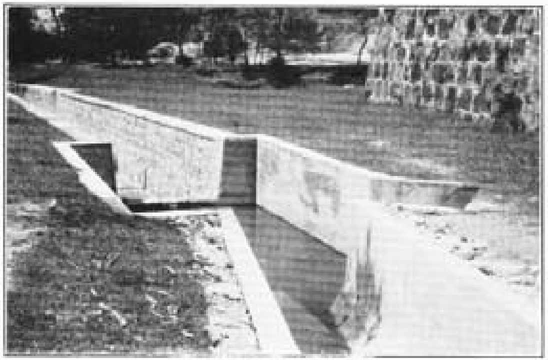
1.—Excavation for the 15-ft. nullah.

2.—"Pigs were encouraged."

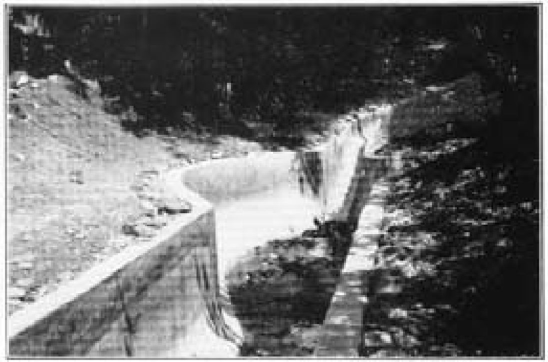
Anti malarial 1 & 2

3.—Early work on the walls of the 15-ft. nullah.

4.—Reservoir on stream G2 drained and work started.



5.—Agricultural pool.



6.—Swirl pool.

Anti malarial 3-6

Finance.

Actual price figures would have little value, as labour and material costs in Hong Kong differ from those anywhere else, but some idea of the quantities involved in a contract of this sort should be useful.

The following summary of some of the quantities in the third contract is given as a guide to an area, which was probably average in its difficulties. It contained a fair amount of wet cultivation.

Channels.	9″	46	foot run
	12″	820	,, ,,
	15″	1,667	,, ,,
	18″	1,232	,, ,,
	21″	1,615	,, ,,
	24″	4,721	,, ,,
	30″	2.469	,, ,,
	36″	303	,, ,,
	48″	375	,, ,,
Nullahs.	5′	1,156	,, ,,
	7′	Nil	,, ,,
	10′	1,526	,, ,,
	15′	2,418	,, ,,

Blasting boulders exceeding 4 cubic feet ..	4,324	yard cube
P.C.C. in wing walls, pools, etc.	1,300	,, ,,
Excavation in o.g. other than for channel sections	17,085	,, ,,
Hand packing in channels and French drains	2,770	,, ,,
Stone found.s to nullahs in bad ground 12″ thick	4,681	yard super
Turfing	6,940	,, ,,
Extra for hard rock in various channels ..	589	foot run

The remaining items:—steps, casings, cascade pools, bridges, weepholes, day labour and number plates for wing walls depend on the nature of the ground and do not need enumeration.

The final figures for the three contracts were as follows:—

First Contract.	Estimate,	\$120,000	Actual Expenditure	\$121,219
Second ,,	,,	\$100,000	,, ,,	\$108,978
Third ,,	,,	\$130,000	,, ,,	\$137,653

Making a total of \$367,850 (just under £23,000) against the original rough estimate of \$450,000. This large over-estimate can be accounted for partly by the fact that the Streams C and D were not canalized, and partly by the high allowance for contingencies.

Practical Application.

The drill for setting out the work was simple. The G.E., accompanied by the Clerk of Works, the contractor's foreman and a gang of coolis, started at the bottom and advanced upstream. The G.E.

indicated where he wanted wing walls, pools, or any other diversion, and pegs were driven in at these places and at 100 ft. intervals. He also gave the size of channel from the original calculations, with an occasional increase where the bed of the stream showed that the calculations might be at fault. His directions were written down on the same lines as a chain survey book, both by the Clerk of Works and by the contractor's foreman.

The contractor then set up boning rods for the full length of the stream and a line of levels was taken, from which the rises of any steps in slopes over 1/5 were calculated. Superficial clearing of small rocks and undergrowth was then started.

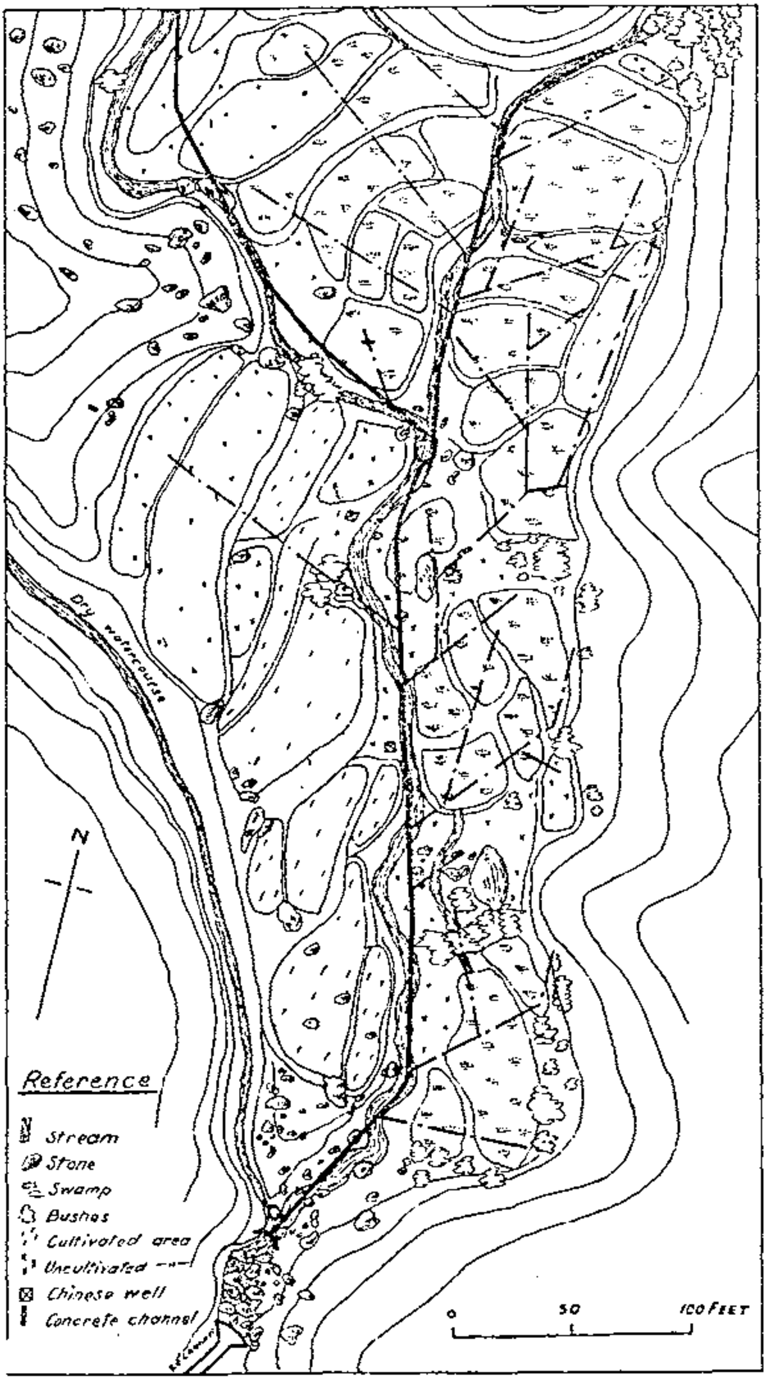
Seldom was difficulty experienced in the line of the channel, but acute bends were cut through and the channel was led round, or under, peculiarly large boulders.

The bill of quantities contained two items for blasting, one for "blasting boulders exceeding 4 cubic feet" on a cube basis, and the other an item "extra for hard rock" which was used when the channel ran over lengths of slab rock or in gullies which were choked with boulders. Below 4 cubic feet, boulders were included in "excavation in ordinary ground." Consequently, as soon as clearing was finished, the Clerk of Works set out to measure boulders for the blasting item, and the G.E. decided on any stretches where the "extra for hard rock" applied. For many days afterwards, in and out of licensed hours, dull thuds could be heard and one or two not so dull; these latter when the Chinaman in charge felt doubtful of the efficacy of the explosive he was using, and multiplied the estimated charge by his personal factor. On one occasion, a slab of rock 4 ft. long passed close to the G.E.'s head when he was standing at what should have been a very safe distance. On another occasion, not on this contract, half a hundredweight of rock was put through the roof of a battery office. The repercussions were similar.

In the specification it was laid down that, while concreting was in progress, the water should be led clear of the stream bed. In a few instances this was possible, but, whenever the stream banks were steep and high, it was necessary to run the water under the channel by French drains until its full length was complete. This worked well and did not appear to wash away much cement, but it was fortunate that, during the whole job, rainfall was far below normal. When laying nullah floors, it was possible to cast in two sections, the water running down one half of the bed while concrete was poured in the other.

The floors of all channels were poured as a horizontal section with the outer wall casings in position. While still green, the inner shaped casings were placed and plugs left for weepholes. Wing wall casings were also placed and the whole lot poured together in sections about 50 ft. long.

PLAN II.


Dry watercourse
N
Reference
Stream
Stone
Swamp
Bushes
Cultivated area
Uncultivated
Chinese well
Concrete channel
0
50
100 FEET

Pools, both cascade and agricultural, and bridges were constructed as they were reached.

In anti-malarial work, in which it is essential to trap all water, channel construction should start at the bottom and work upstream.

As long sections of channel were completed, weepholes were laid in the walls, hand-packing was placed, banks were trimmed and, after a period for settlement, turf was planted on fills. It was then purely a question of seeing that the turf was watered and of watching for any signs of collapse. One cloudburst almost broke the heart of the G.E., as it left 75 ft. of 24-in. channel completely in the air. However, as soon as packing had been laid under it, the small crack which had appeared closed up and all was well.

It had originally been intended to finish channel walls with the steel trowel, but, owing to the inefficiency of the coolies, this had to be replaced by rendering, which, although it might have been expected to chip badly under the flow of water carrying stones, stood up very well and made a tidy job.

In swampy areas a system of French drains, "herring-boned" from subsidiary channels, was used. The general idea is well shown in Plan II, which applies to an area of fallow paddy fields on Stream B.5. The mud banks between the fields dammed the surface water and turned the ground into a muddy swamp, but after the drains had been in for a short time the whole area was dry.

To work efficiently it was found that the drains should be approximately 2 ft. deep, filled only with large stones, and that they should not be covered with earth. In cases where springs of any size existed and French drains could not compete, 9-in. channels had to be used.

The design of apron at the head of each channel worked well, but to avoid the formation of a pool over the apron, stone packing was added above it.

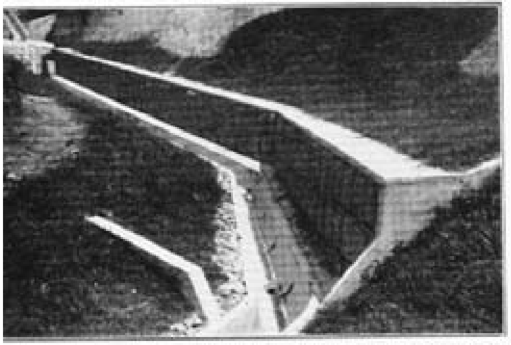
The junction of channel to channel, or channel to nullah, sometimes needs a little thought. Obviously, if a smaller channel joins a larger so that their invert levels are the same, a gap, which might be dangerous under heavy flow, will be caused unless the walls of the smaller channel are never allowed to fall below the level of those of the larger. The same principle applies when a channel joins a nullah; here again the channel wall must never fall below the top of the nullah wall. If, however, there is sufficient fall, the minor channel can drop into the larger so that their wall levels are the same.

9-in. and 12-in. channels were sometimes brought in through a short section of spun-concrete pipe, but this cannot be used in any larger size of channel.

When slab rock extended for any length on steep slopes, no attempt was made to canalize, but the whole run was cleared and all cracks and crannies were cemented. This worked well and saved a

7.—The "canal" system on the 15-ft. nullah.

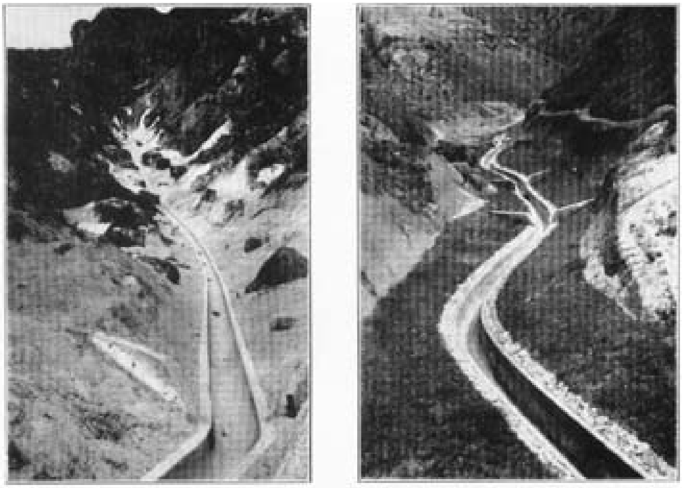
8.—7-ft. nullah.



—Retaining wall at a point where seepage was exceptionally bad.

10.—48-in. channel joining a 7-ft. nullah below a pool.

Anti malarial 7- 10



11 and 12.—Lengths of channel, one in cut and one in fill, showing wing walls and handpacking.

13.—Steps.

14.—Added wall on a sharp curve.

Anti malarial 11-14

good deal of very hard work. Similarly, when exceptionally large boulders lay across the stream, the channel was, when possible, taken underneath the boulder and no blasting attempted.

In the more heavily cultivated areas the control of wet cultivation presented endless difficulties. The Government had said that there was little they could do to abolish wet cultivation, but they had added that they could take steps if the villagers were "committing a nuisance." After the exercise of considerable patience and a lot of hard swearing, the G.E. decided to invoke this clause and reported the inhabitants of the entire area for committing innumerable nuisances. This, surprisingly, produced results.

The Public Health Officer inspected the area and agreed about the nuisances, covering a multitude of sins ranging from "allowing Anopholine breeding" to "leaving open a tub containing human excreta." The latter is used by the villagers as manure and the smell on a hot day is unbelievable. The sanitary department began issuing summonses right and left, although, now and again, they found themselves issuing a summons which the recipient refused to accept. There appeared to be no legal technique to answer this recalcitrance. Eventually, a large proportion of the land had left wet cultivation and the problem then arose of providing water for the dry crops, as wells were none too plentiful. Run-offs from the channels were provided upstream of the fields and the villagers were allowed to run their own subsidiary channels, provided they were concreted or "chenamed" and kept clean. Once they realized that it was easy to stop the run-off, they co-operated well.

Wells were left to the sanitary department, who ordered covers to be fitted over them.

On one occasion only fish came into their rights. The G.E. found his way into the gardens of a Confucian temple where he noticed, with concern, a number of open tanks. Arriving at the inner precincts, he was introduced to an old gentleman writing backwards in a large book. After expostulation, the old man promised to fill his tanks with gold fish rather than cover them up and so spoil his peaceful contemplation.

An interesting problem arose in providing irrigation water to fields at the lower end of Stream B. The 15-ft. nullah, which carries the stream, had the bare minimum fall from the foothills to its lower end and it was only possible to squeeze out a spare 2 ft. To raise the water to bank level, the "canal system" was used. The floor of the nullah was dropped the spare 2 ft. in two steps and, below this fall, 12-in. channels were incorporated in the nullah walls in place of the top 16 in. of masonry. A wall 1 ft. square in section was placed across the top of the steps, into which one centre pillar and two side supports for sluice gates were built. It was then possible, by dropping the gates, which were 18 in. high, to raise the water

4 ft. 6 in. from the invert level below the steps. At this height 6-in. pipes led through the nullah walls into the 12-in. channels and the water was ready for distribution to the fields. The walls over the gates were raised 1 ft. and sloped below the fall to the nullah walls. Arrangements were made with the Elder of the local village to take up the gates once a week and whenever any heavy storm appeared in the offing; this helped to keep the nullah clear of silt and the gates from destruction.

In cases like this, where a dam exists in a nullah, it is obvious that the lower line of weepholes will be flooded for some distance by the banked-up water. Normally, these lower weepholes were blocked, but, even if they were not, it was found that any water which found its way out rejoined quite happily through weepholes below the dam.

At the junction of Stream G.2c and G.2, two reservoirs exist and it was decided to replace their original grass-covered earth banks by concrete. The design was simple—a 9-in. P.C.C. wall inclined back at 30° to the vertical and " toed " on a 1 ft. square section horizontal base. The P.W.D. co-operated in emptying the reservoirs in turn.

DIFFICULTIES.

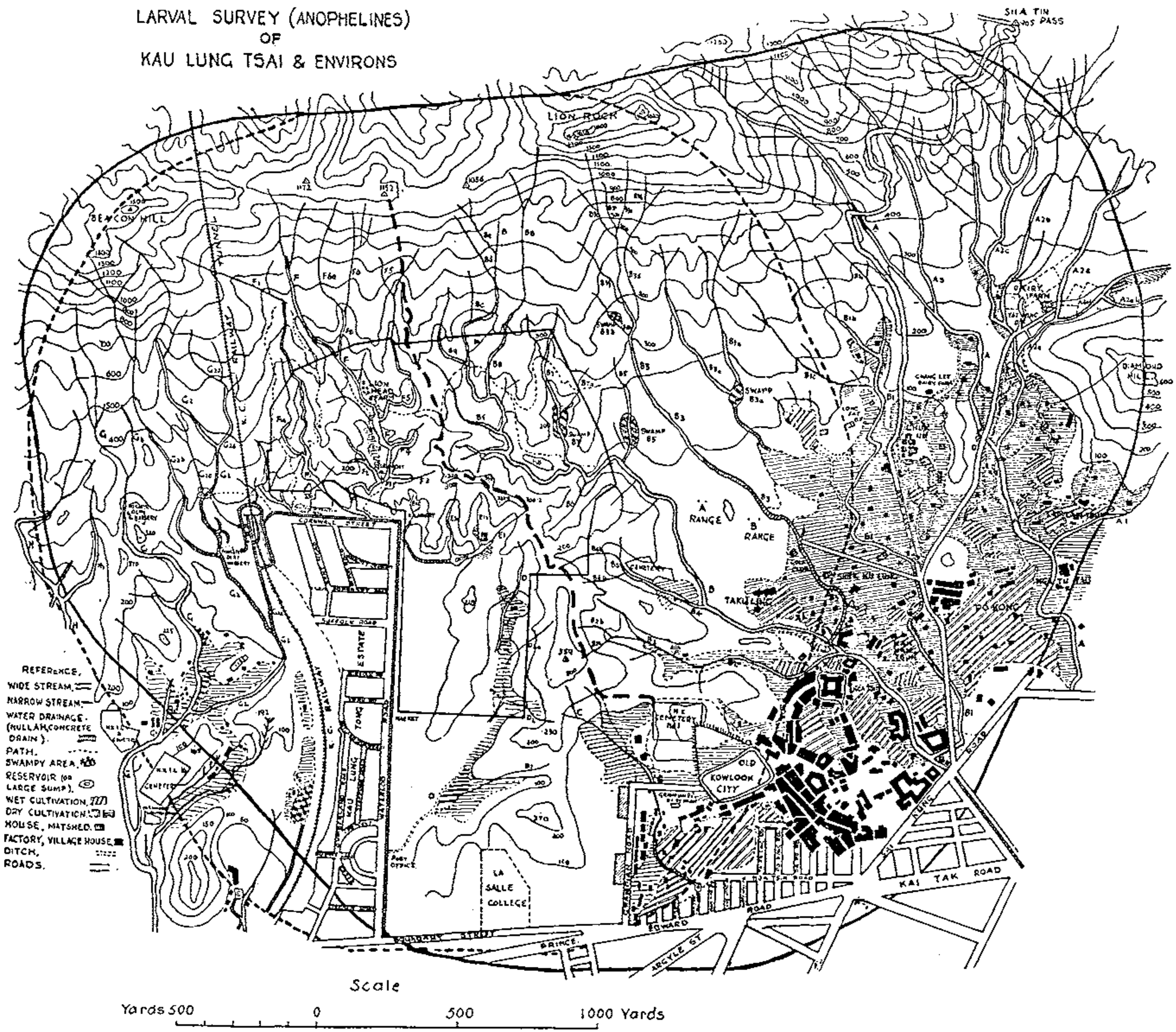
Certain snags were general to all streams. In particular, a good deal of balancing was needed between fall and excavation when a stream, which might be wide and shallow, was replaced by a channel or nullah. As long as there are plenty of weepholes, it does not matter greatly if the channel wall is higher than the original banks, although it should obviously be avoided where possible.

In one exaggerated instance, the stream originally ran between garden walls. The calculated size was a 5-ft. nullah, but the width between the walls, which could not be moved, was a bare 5 ft., and it was therefore only possible to fit in a 48-in. channel. An additional foot was added to the channel walls, which brought the section to within reasonable distance of the calculated size, but this added foot raised the channel walls 1 ft. 6 in. above the original bank level of the fields above the point where the garden walls started. As the surrounding country was very flat, it was not felt that weepholes would be sufficient and a 9-in. channel was run parallel to the 48-in. at bank level, ultimately discharging through a pipe into the channel at the point where the garden walls began.

After a time, every channel, owing to heat expansion and contraction and possibly to settlement, showed transverse cracks at an average distance of 50 ft. apart. Expansion joints seemed to be indicated, but, as it was difficult to produce a suitable design, the cracks were disregarded and seldom deteriorated beyond their original hairline.

Ordinary constructional difficulties were numerous and were

Plan I.


LARVAL SURVEY (ANOPHELINES)
OF
KAU LUNG TSAI & ENVIRONS
LION ROCK
BEACON HILL
SHA TIN PASS
DAIRY FARM
DIAMOND HILL
"A" RANGE
"B" RANGE
TAKU LING
CEMETERY
OLD KOWLOON CITY
LA SALLE COLLEGE
KAI TAK ROAD
ARGYLE ST
PRINCE
EDWARD
RAILWAY
ESTATE
TONG
POST OFFICE
SUFFOLK ROAD
CORNWALL STREET
REFERENCE.
WIDE STREAM.
NARROW STREAM.
WATER DRAINAGE. (NULLAH, CONCRETE DRAIN).
PATH.
SWAMPY AREA.
RESERVOIR (OR LARGE SUMP).
WET CULTIVATION.
DRY CULTIVATION.
HOUSE, MATSHED.
FACTORY, VILLAGE HOUSE.
DITCH.
ROADS.
Scale
Yards 500
0
500
1000 Yards

caused largely by the unskilled type of labour employed by the contractors.

Stone particularly needed careful watching. Entire families settled down to breaking and the women and small boys preferred the soft decomposed granite, and every pile was full of it. Sacking the breakers had little effect, as they invariably reappear edelsewhere, banking, presumably, on the fact that they all look exactly alike.

It was also difficult to make the masons produce properly squared blocks for the rubble walls. Their normal idea was to pack wedge-shaped blocks with splinters.

Another shortcoming, which fits in with their sense of humour, occurred in hand-packing. With a cheerful disregard for the specified upper limit in size of stone, which was 6 in., the coolies, unless closely watched, packed anything up to 3-ft. boulders under the "face-saving" top layer.

Conclusion.

In any widely-spread contract of this kind in China there is bound to be a great deal of interest, partly supplied by the varying circumstances which have to be met, and partly arising from the foibles of the Chinaman himself.

The villagers vary from the meek and humble, usually so because they have no right to be there, to the truculent, who have a right but consider any orders as an incitement to do exactly the opposite. As a case in point, the G.E. had decided to replace an old well by a pool in the nearest channel. One old gentleman, who had been accustomed to keep two ducks in the well, resented the idea and the spring which fed the intended pool mysteriously dried up. His protests, that there was now no water, were overruled when his jacket and a large rock were removed from the back of the weephole through which the spring fed.

Some excitement was also caused because one firm was employing men from Shanghai and the other Cantonese. Strict orders were issued by the G.E. that his expensive channels were not to be used as latrines, an order which was disregarded by the Southerners, who were promptly attacked by the Shanghailanders. Fortunately, at the moment when crowbars came into action, the Sapper in charge arrived and laid low the leader of the offensive party. The riot ended.

The only effective way of correcting the Chinaman's shortcomings as a workman is to destroy what he has just built. This infuriates him, as he loses money.

The whole job was full of interest and not a little quiet fun, although the future alone can say whether those channels actually drain.

MEMOIR.

LIEUT.-COLONEL THE RIGHT HON. SIR MATTHEW NATHAN, P.C., G.C.M.G., D.L.

LIEUT.-COLONEL SIR MATTHEW NATHAN, who died on the 18th April, at the age of 77, had a very varied career, mostly outside the Army. Educated privately, under the guidance of a clever mother, he passed second on the list into the R.M. Academy at the youngest possible age; but after the first term was head of his class. He was Senior Under Officer and on passing out received the Sword and the Pollock Medal and seven prizes, including those for German and Italian—those were the days when, as he said in later years, he could learn a new language every six months. In the final report his success was ascribed to sheer hard work, then somewhat rare at Woolwich. But this was unfair to him, as his classmates did their best to prevent him working—going to the length of burning his notebooks—and he came of a very talented family, his brothers being Sir Nathaniel Nathan, K.C., Sir Robert Nathan, I.C.S., Colonel Sir Frederick Nathan, R.A., the expert of his time on explosives, Major Walter Nathan of the Corps, who left to join a China trading corporation, William Nathan of the Indian Public Works, who died young, and George Nathan, of the publishing firm of Constable and Company.

Shortly after leaving the S.M.E., where rowing, riding and argumentation were his forms of exercise, he was ordered to the office of the Inspector-General of Fortifications (now represented to some extent by D.F.W.), and at the end of 1883, when the defence of "coaling stations" for the Navy was to the fore, was sent to Sierra Leone on survey duty. He was to go there again as local Captain and C.R.E. in 1886-7, and this was not to be the end of his connection with the West Coast. In the intervals he was employed on the Sudan railway in 1884-5 and saw his first active service; went to India 1887-91 for duty in connection with coast defences, and constructed them at Bombay and Rangoon, and took part in the Lushai Expedition of 1889. Returning to the fortifications branch of the I.G.F.'s office 1891-9, he acted at the same time, from 1895-1900, as Secretary of the Colonial Defence Committee. It was in the latter capacity that he came under the notice of Mr. Joseph Chamberlain, the Colonial Secretary. Sent at his own

Lt Col Sir Matthew Nathan GCMG DL

suggestion to fill a temporary vacancy in the Governorship of his old station at Sierra Leone, he acquitted himself so well that a year after his return, at the end of November, 1900, he was appointed Governor of the Gold Coast Colony, a post which he held for 3½ years. There was plenty to do, as the Ashanti troubles of 1900 were only just over; and whilst organizing the resources and finances of the colony, he naturally developed its communications, including a railway into the interior. At the same time, by his hospitality and accessibility he established a reputation and a popularity—though he was not always lucky in the selection of his staff—which was to accompany him in all his Colonial Governorships. Created K.C.M.G. in 1902, at the end of his tour on the Gold Coast he was transferred to the Governorship of Hong Kong (June, 1904 to April, 1907), and thus was head of the colony at one of the periods of its greatest prosperity. Incidentally, being now a regimental major, he was passed over for promotion to lieutenant-colonel, as he had not attended the examination for "tactical fitness." He had offered himself for the test, but the Home authorities held that it would be improper that he should be examined in his own colony by officers officially junior to him as Governor and Commander-in-Chief. He was given the consolation prize of a brevet lieutenant-colonelcy and advanced to G.C.M.G. It happened soon after this that his brother Walter, who was in China, was promoted to a majority without examination, it being held in his case that a captain, who could command a salary running into thousands of pounds in the civil world, was fit to be a major of engineers. Apparently a Governor of a great colony is not fit to be ranked among the lieutenant-colonels of the Corps.

From Hong Kong, after four months' leave at home, Nathan was transferred to Natal, where he remained till the beginning of 1910, when the federation of the four S. African States into the Union of S. Africa was accomplished. Thus he was the last Governor of Natal.

His administrative and financial talents now led to his career taking another turn, as he was appointed Secretary to the General Post Office, but only held the post for eight months, being promoted to be Chairman of the Board of Inland Revenue, his predecessor passing on to be Permanent Secretary of the Treasury and head of the Civil Service. In his new post he remained three and a half years, until October, 1914, when, possibly on account of his experience of arranging the change in the form of government in Natal, he was chosen to be Under-Secretary for Ireland, to prepare the way for Home Rule. The German war gave the Irish extremists the opportunity for which they had been longing; Mr. Asquith's Government did no more than "wait and see;" and the intelligence service was apparently either very efficient or very defective, for the Chief Secretary (Birrell) was in London, and the general officer commanding the troops in Ireland, Major-General L. B. Friend (R.E.) was on short leave, when the rebellion broke out at Easter, 1916. The Government's excuse was that they had not been warned (the same excuse had been made in 1899 at the outbreak of the S. African War), so the Lord Lieutenant and Chief Secretary resigned, and Nathan was transferred to the post of Permanent Secretary to the Ministry of Pensions.

The Royal Commission on the Irish Rebellion reported as regards Sir Matthew Nathan:

> "In our view he carried out with the utmost loyalty the policy of the Government, and of his immediate superior the Chief Secretary; but we consider that he did not sufficiently impress upon the Chief Secretary, during the latter's prolonged absences from Dublin, the necessity for more active measures to remedy the situation in Ireland, which on December 18 last, in a letter to the Chief Secretary, he described as 'most serious and menacing.'"

As the Government had refused to repress by prosecution written and spoken seditious utterances and suppress the drilling and manœuvring of armed forces known to be under the control of men who had openly declared their hostility to His Majesty's Government, and the Arms Act had been allowed to lapse, there was little that could be done. The authorities, it seems, did not expect that there would be an armed insurrection unless assisted by a German landing. Whenever Major-General Friend did anything strong in the way of suppressing the organisers or deporting them from Ireland, the Irish Parliamentary Party and their Press at once protested and such action was stopped.

In 1919 it came to notice that, owing to the variety of his employments, Nathan was not entitled to any full pension except that of a Major R.E., and from the Ministry of Pensions he was appointed Governor of Queensland in order to qualify for a full Colonial Office pension, holding the post for five years with the success which had attended his governorships elsewhere.

On his retirement in 1926, whilst staying with friends in Somerset, he heard that the old Manor house of West Coker, 3 miles west of Yeovil, was in the market. This he purchased, added a wing to it for his large library, which exactly imitated the original part and in a few years could not be distinguished from it. He took up county work with the same zeal and energy which he had exhibited in his official capacities, so that in a short time no local "function" was complete without him. He was an alderman of the County Council, president of the Somerset Archæological and Natural History Society, and "pricked" for Sheriff in 1934. His special interest was the collection, preservation and classification of the West Coker records. Much foreign service in his younger days had little affected his iron constitution, but from 1934 onwards he began to consider himself an invalid. What really was the matter with him was the lack of the work to which he had been accustomed, and he gradually faded away.

An effective speaker, with a deep bass voice, thorough in all he did, fond of entertaining, a good host, an amusing conversationalist, full of both book and worldly wisdom, and with the polished manners of a diplomat, he was a man with many staunch friends and beloved of his relatives. He never married, never seems to have made any effort in that direction. Perhaps he had no time.

J.E.E.

CORRESPONDENCE.

CEMENT STABILIZATION OF SOIL.

12th July, 1939.

To the Editor of *The Royal Engineers Journal.*

DEAR SIR,

The article on "Cement Stabilization of Soil," which appeared on page 267 of the issue of *The R.E. Journal* for June, 1939, begins with an introductory "Note," which quite obviously was not contributed by Mr. Markwick.

A lecturer taking as his subject the stabilization of soil by the use of bituminous emulsions is not likely to mention the use of other materials, whether cement, calcium chloride, or molasses, quite irrespective of the fact that he is interested in the sale of bitumen. So far as I am aware only one such lecture has been given at the S.M.E., and it lasted a good hour and a half, so some of the audience may have been thankful that stabilization by means of other materials was omitted.

With regard to the remark at the end of the introductory "Note," that the problem is not solved by the use of bitumen, this is expressed too categorically to be allowed to pass without comment. It would be, of course, foolish to claim that the problem of "providing quickly a temporary hard surface until time, men and materials allow a better road to be provided," can *in every case* be solved by the use of bitumen.

The assumption underlying this criticism appears to be that the difficulty in using bituminous soil stabilization is mainly the length of time required to dry out work of this character. Provided the work is done during the warmer season of the year, the time required is not inordinate, and work done in conjunction with the Royal Engineer Board has demonstrated that this factor should not be overrated.

The work done in the summer of 1932 at Thornhill Barracks, Aldershot, using Terolas and the local soil pre-mixed in a paddle mixer, indicated the possibilities of using bitumen, for, though the process was slow, there resulted a satisfactory temporary road surface. (See *R.E. Journal*, December, 1932.)

The next trial was in April, 1934, at "C" Crossing over the River Avon, and was carried out using Terolas and the local soil by mixed-in-place methods. This temporary road surface is still in use, and only requires surface dressing from time to time. (See *R.E. Journal*, March, 1935.) The weather during this trial was most unfavourable.

This trial at "C" Crossing showed up the difficulties due to slow drying in wet weather. So the next trial, in May, 1936, on the east side of the River Avon on the slope leading down from the Bulford–Netheravon road to "C" Crossing, was used to see what the effect would be if Army Track and, alternatively, Cleavecrete Canvas was laid on the surface. As a result it was found that the surface could be used without any difficulty in the afternoon of the day on which the work was done.

The above experiment was carried out in ideal weather, so in order to find out if Army Track or Cleavecrete would shorten the delay in taking the road into use in really wet weather, a further trial was made at Bulford in May, 1937, on the same lines, but the road surface was flooded with water before the Terolas was applied. This experiment showed the value of "selvedged" Army Track, and the result confirmed the previous conclusions.

It should be noted that all these trials at "C" Crossing and Bulford were with a most unfavourable soil, and yet the temporary road with Army Track was usable without delay. Similar work carried out recently in the Aldershot Command confirms the value of bitumen stabilized earth roads.

If work must be carried out under inclement conditions, then experiments, in which Army Track was applied to the soil stabilized layer to allow it to carry traffic while still soft, show that the advantages to be obtained ultimately from soil stabilization need not necessarily be sacrificed if quick drying cannot be obtained, due to unfortunate climatic conditions.

It may, however, be asked what are these ultimate advantages, *vis-à-vis* cement stabilization, and to this I would reply at once that the situation must be considered where a stabilization effected with cement is unsuccessful, possibly due to the passage of axle loads greater than what the somewhat weak nature of the cement-soil mixture will carry. Once a cement-stabilized road cracks, it would not seem possible to do anything about it, other than to reconstitute it entirely. This is not so with a bitumen-stabilized road where, if cracks occur, they may be readily kneaded together by a grouting treatment with bituminous emulsion, followed by rolling. In some cases even, the grouting treatment may not be necessary. This final advantage, which under campaign conditions does seem to be important, would out-weigh the initial hydraulic drying, which is produced by the use of cement. It is possible that the ultimate process for adoption may involve both the use of bitumen and cement, but this is yet to be investigated.

Yours faithfully,

E. G. WACE, *Brig.-General* (*Retired*).

Hillside, Vicarage Lane,
Chigwell, Essex.
4th August, 1939.

CEMENT STABILIZATION OF SOIL.

To the Editor, *The Royal Engineers Journal.*

DEAR SIR,

In the Note, that precedes the article "Cement Stabilization of Soil" in the June 1939 issue, it is said that the use of bitumen definitely will not solve one of the early problems in a European war. The problem presumably is the one outlined in the opening words of the article, and by the use of bitumen is then presumably meant soil stabilization with cut-backs or emulsions. I do not propose to discuss the validity of the statement in question, beyond expressing surprise at its very sweeping nature and my hope that it will not represent your last word. Whatever the merits may be of soil stabilization with bituminous products, I should be grateful if you would allow me to suggest that there would seem to be other bituminous methods that are also worthy of full investigation, such as the surface treatment of dirt roads, as applied to various kinds of soil—including high capillary clays—in the U.S.A.

Yours faithfully,
W. L. CAMPBELL, *Captain*.

All Reviews of Books on military subjects are included in the provisions of K.R. 535c (*1935*).

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

THE OFFICIAL HISTORY OF THE GREAT WAR.

MILITARY OPERATIONS: FRANCE AND BELGIUM, 1918, MAY–JULY.

Compiled by BRIGADIER-GENERAL SIR JAMES E. EDMONDS, C.B., C.M.G.

(Macmillan. Price, 12s. 6d.)

For the bulk of the British Army the period covered by this volume was one of recuperation and reorganization. Not till the close of the period did it begin to contemplate a return to major offensive operations. The threat of attack by Prince Rupprecht's Army throughout imposed a defensive attitude and it was largely due to an outbreak of influenza in the German Army that this long-prepared blow was postponed till events elsewhere caused its final abandonment. Yet, although on the defensive, the offensive spirit was revived as soon as the condition of the troops allowed; and the minor operations described in Chapter XI are well worth study, for they showed a refreshing ingenuity and confidence in planning and had a marked influence on the conduct of major operations carried out in subsequent periods.

It was on the French front that the chief events occurred; yet for all that the period has, at the present moment, a special topical interest for British officers. For British divisions were interpolated in the French front and were called on, when in a depleted and under-trained state, to take part at short notice in major operations, both defensive and offensive. On each occasion they were embodied in French Armies and at times in French Corps. They depended largely on the support of French, and on occasions of Italian, Artillery, and their lines of supply ran through areas organized on French principles. In the pages of Chapter XVII headed " Franco-British relations," General Edmonds discusses the difficulties which inevitably arose. Difficulties of language, accentuated by the facts that many English-speaking French officers had been withdrawn to assist American training, and that those employed as interpreters had often little military experience. Difficulties arising from various differences in method; for as General Edmonds points out there had been no attempt to familiarize either army with each other's methods. The will to co-operate displayed by both sides to a large extent minimized difficulties, but it was apparent how important it is for the average officer to have a working knowledge of an ally's tongue and system.

Owing to the part played by British troops in the French operations, these are unusually fully described in this Volume. The account of the Chemin des Dames battle, in which the unlucky IXth British Corps was involved, is particularly full. It is made clear how little the Corps was responsible for the disaster—which in the event proved a blessing in disguise—and how gallantly it fought despite the enfeebled condition of its units. The battle of Matz which followed is chiefly of interest in its bearing on strategical problems and the handling of British and French reserves by Foch, in a period of uncertainty as to the direction of the German intentions.

In the second battle of the Marne four British Divisions, after being summoned to support the defensive front, were thrown hurriedly into action when the counter-offensive stage was reached. Two attacked under a British Corps commander, the others on the opposite side of the German salient under French orders. In its defensive stage the battle is instructive as illustrating the right and the wrong way in which new defensive theories were applied by French commanders. It gives a notable example of counter-offensive action, of its difficulties and of its moral effect even when not entirely successful.

The battle, too, is remarkable for the number of nationalities taking part; French, British, American and Italian Divisions were brought together by the Generalissimo.

In his last word General Edmonds claims the 8th August as the great turning point of the war, but the claim might, I think, with equal justice, be made for the second battle of the Marne. For in that battle the German offensive was defeated so decisively that the threat of Prince Rupprecht's "Hagen" offensive vanished. If the menace had remained, it is hardly conceivable that the battle of the 8th August could have been staged.

The volume has unique interest from its account of the strategic problems of the respective G.Os.C.-in-Chief and of the Generalissimo. The development of the latter's authority is marked and it was fortunate that the Allies had found a leader with breadth of vision and capacity to assert his will in spite of protests made with special vehemence by his own compatriot. Haig, too, made his protests backed by solid arguments but he loyally accepted Foch's decisions, greatly to the benefit of the establishment of mutual confidence. When the barometer showed set fair, the task of the Generalissimo became comparatively simple but it is because the period under review was one of anxiety and uncertainty that it so well illustrates the value of unified command and furnishes a psychological study of the relations of allied armies.

C.W.G.

"THE DEFENCE OF BRITAIN"

By CAPTAIN LIDDELL HART.

(Faber and Faber. Price 12s. 6d.)

"If you wish for peace, understand war" is the amended maxim which prompts Captain Liddell Hart to write this book. There is a very real need for close study and investigation of the problem of Imperial Defence at the present juncture, when storm clouds are brewing up, and national rearmament and service are uppermost in the thoughts of at least the majority of the nation. Therefore a comprehensive treatise on our defence problems, and the means we have adopted and are adopting for meeting them, by one who has had the leisure and desire to study the subject, is very welcome. But naturally the professional student must approach the study with a critical mind, for the problems are not so simple that conclusions, apparently obvious from premises propounded, can be accepted without informed and closely-reasoned investigation.

The book opens with a consideration of the international and political events leading up to the present time. Captain Liddell Hart criticizes the policy of the Government for its temporary abandonment of the policy of "Collective Security" (Blessed word!), and lays the fault of the deterioration in international relationships to that abandonment.

He examines the warlike potentialities—economic, industrial and purely military,—of the various states concerned, and draws the inference that, without Russia, the democratic powers are militarily inferior, but economically superior to their totalitarian protagonists. He draws the conclusion that, with the superiority of defence over the attack, a defensive policy is indicated for the democracies, and that their forces will be sufficient to prevent the quick victory, which is essential to the totalitarian powers on economic grounds.

The author then stresses the vital importance of the security of the base, Great Britain, and makes some sharp strictures on the military authorities for their slowness in providing sufficiently for the anti-aircraft defence of the country.

He then passes on to a strategic study of the defences of the " Forward positions," the frontiers of Holland, Belgium, France and Switzerland.

Having reviewed the problem, he passes in his fourth section to consideration of the reorganization of the Army past and present, and finally to some remarks on certain aspects of military affairs which have specially interested him.

Such is the scheme of the book, and the student will at once see what possibilities lie in it, and will be anxious to hear how the author fulfils his task.

The first impression is that either Captain Liddell Hart has been personally and practically solely responsible for the advice on which all changes for the good have taken place in our armed forces, or else he must be classed with the immortal " Bill Adams " who, we all know, won the Battle of Waterloo in his own estimation. The author quotes at length papers he wrote at the request of Cabinet Ministers, many of the recommendations of which have since been put into practice. We see the author guiding the " progressive spirit and receptive mind of the new Secretary of State for War " up to a certain point in 1938.

A study of his quoted papers displays a certain tendency to shift his ground as conditions alter, a very desirable trend in a tactician, but dangerous when dealing with the organization and armament of forces. Those who have had to do with munitions production will testify the necessity of continuity of policy, and the regimental soldier will bear witness to the impossibility of co-ordinated training when organizations and methods are changing almost daily. Again, those who have borne the responsibility of higher command will realize the, at times, over-ruling importance of administration—a subject which is here barely mentioned. For example, experience in the Mobilization Branch, which the author imagines is under the Quarter-Master-General, would show how small changes have far-reaching effects.

Without this responsibility and experience it is easy to make recommendations and modify them on later experience, but those responsible for the Army must be certain of a reasonable permanency before promulgating reforms. It is true that there is for this reason in high quarters a danger of reforms being unduly delayed. This is particularly the case when, as has been the rule up till the last very few years, the national purse strings are pulled tight. If there has been a rush of reform and re-equipment in the last two or three years, it has been that national interest has been roused, and that money has been available, rather than that soldiers in high places did not realize earlier that such things were necessary. In an Appendix to Chapter XVII, Captain Liddell Hart gives a list of reforms advocated by himself in 1937 and achieved partly or wholly by midsummer, 1939, and one is led by the context to assume that their introduction was due principally, if not entirely, to his influence. Even those who were not in close touch with the highest military circles know that many of these reforms had been urged by responsible soldiers long before 1937. Further, it is incredible that the official advisers of the Secretary of State could have remained at their posts if their advice had been neglected in favour of " irresponsible " counsel (to use the expression of the reviewer in the *Sunday Times*) of a private and not necessarily fully informed individual.

Probably the point which will raise most discussion is the author's plea for a defensive policy and action by our forces in war. His main point is that attack against organized resistance can succeed only at the cost of inacceptable losses. Therefore he claims that the correct policy is to remain on the defensive and let the enemy batter himself to pieces in the attack. It is not clear, and the author fails to answer the question, how the aggressor in, say, Eastern Europe is to be prevented from attaining his object by defensive action by the Western powers. This is one of the main problems of the moment and must be faced. The author is evidently uneasy and is certainly unconvincing as to how this defensive policy is to be applied in practice. He appears to favour the counter offensive, "an essential card in the "hand" (page 121), but an operation the timing and conduct of which Napoleon has stated to be the most difficult operation of War. But then we know Napoleon and, for that matter, Foch ("the second-hand student of the Franco-German War" (page 118)) cut little ice with Captain Liddell Hart. But later we find that an aggressive power may seize "lightly guarded points by rapid movement and thereby induce the "opponent to waste his strength in counter-attacks." Then again, the counter-attack comes back into favour (page 121) where the author proposes "an active and mobile "defence, in which the effect of direct resistance is extended by ripostes, both "strategical and tactical."

Such confused argument cannot carry much weight with the critical student. The scientific method, as was pointed out in a review in this Journal of a previous work by the same author, demands a careful examination of all the factors affecting the situation before a conclusion is drawn. The "wilful wishing" method of selecting facts to support a conclusion is unscientific and dangerous.

The author's works are valuable, and that under review is no exception, in that they propound theories based on considerable study; careful and critical study of them cannot but help the military student in conjunction with independent study to form views on military matters which otherwise might be taken for granted.

While reading with interest *The Defence of Britain* let us at the same time avoid a defeatist attitude, and remember in the words of Captain Liddell Hart (page 102) "It is the soldier's duty to seek new means in favour of the offensive. . . . Only "by the offensive can an enemy country, or position, be occupied."

R.P.P-W.

MARSHAL FOCH.

By CYRIL FALLS.

(Blackie and Son, Ltd., 1939. Price 5s.)

This little volume of only 184 pages has been written for the "O.M." Series, in which it is intended to include short biographies of each recipient of the Order of Merit.

It can be unhesitatingly recommended for a place in the military library, however limited, of every student of war.

The author has been for many years one of the principal assistants of the compiler of the *Official History*. Readers of those volumes will acknowledge the ability and skill with which the mass of available material has been condensed by Sir James Edmonds; those who read this little book will realize that Captain Cyril Falls has acquired—if he did not already possess it—the same gifts.

In the course of his researches into what has already been written about Foch, Captain Falls found that there were many doubtful points to be cleared up in the record of such an eventful career. He has gone to immense trouble to arrive at the truth. He has visited the Marshal's right-hand man—General Weygand—at his home in Finisterre, and Madame Foch in Brittany. From the lips of both he has gathered, at first hand, information which has never appeared in print and might have remained sealed, had it not been sought by so sympathetic an admirer of the great Marshal. In his preface, which might in itself serve as a review of his book were it not for the modesty of the author, Captain Falls outlines the goal which he had in mind when he undertook to write another "Life of Foch." He writes:—"If we confine "our study wholly to his character, his doctrine and his deeds in Warfare, that "should not deprive it of profit.... The theme of a man, his mind and his pre-"dominant part in one of the most momentous events of history ought not to be "lacking in significance .... The evidence is all available. The task is but to draw "on it fairly and honestly."

The reader will find that Captain Falls does not hesitate to mention failures and mistakes. Foch would have been the first to admit them. He does not venture to criticize, but he shows how they reacted on the mind of the man and how they made him all the more determined to win through—adhering to the principles which he had laid down for himself whatever the circumstances.

General Foch was 62 years of age at the outbreak of the Great War. He looked considerably younger. Despite what to most men might have been a sedentary life, he had always kept himself hard and fit by taking constant walking exercises and riding—he was a first-rate horseman—for two hours every day. Although he had enlisted in the infantry on reaching the age of 18, three months after the commencement of the Franco-German War in 1870, he had never seen a shot fired in anger until August, 1914, by which time he had risen to the command of the renowned XX Corps and was faced with the duty to cover, from Nancy, the mobilization and deployment of the French Second Army.

But though the ensuing battles were his first experience of active service, Foch knew what war meant. He had studied deeply and had taught military history and strategy all his life, and was prepared to prove that he could confront age's hardest task—to adapt himself to circumstances and continue to learn from them. He was one of the first modern soldiers to study the moral or psychological aspect, as well as the material side of war, and he knew its ups and downs.

If Captain Falls had done nothing else than give us a truer estimate of the achievements of the Marshal, the book would have been worth reading, but he has done much more. He has corrected some of the false impressions of the acts and beliefs of the great soldier. The book is a valuable contribution to the final history of the Great War when that comes to be written. The reviewer will confine himself to calling attention only to three of these false impressions which have been so widely circulated in the twenty years since the war. They concern :—

1. The views of the Marshal on the theory of the offensive.
2. The handling of his reserves.
3. His share in the Peace Treaty.

It has been said that Foch shared with the bulk of the officers of the French Higher Command the cult of the offensive. It is true that he believed in the spirit of the offensive. But Captain Falls produces evidence to show that, thanks to the teaching of his one-time chief, General Millet, Foch's theories differed from the extravagant ideas which prevailed in the French Army and the doctrine—based on the teaching of General Grandmaison—that the offensive had some sort of magic virtue enabling it to dispense with fire support. Millet, basing his argument on 1870, and Foch, who had made a special study of the campaign of 1866, believed that fire preparation—assault—exploitation of advantage gained—must be the stages of a modern battle. Grandmaison, or the extremists of his school of thought, had almost suggested that artillery was redundant and that battles could be decided by dash and cold steel. In the early stages of the Great War the French equipment, both gun and rifle, was inferior to the German with the exception of the q.f. 755. This fact proved very unfortunate in the battles of the frontier, and very nearly brought France to the brink of disaster. Foch was quick to recognzie the danger, and he never forgot the lesson he had learnt in his first battle east of Nancy—that, with a much superior heavy artillery against him, "space" is not the least important form of protection (*sûreté*).

Basing his studies on military history,—continues Captain Falls—Foch in his lectures at the *École de Guerre* had always laid stress on four general principles of war—economy of force—liberty of action—liberty of disposition of forces—protection. "*Sûreté*" was his favourite word, and it recurs in his lectures much more frequently than the word "*Offensive*," though the latter is always associated with his name, and sometimes as a matter of reproach.

If "*Sûreté*" was his favourite word, he had also a favourite phrase—"*De quoi s'agit il?*" (What is it all about?). The isolation of the problem was for him almost another principle of war. "I do not know"—he used to say later in the war to General Weygand, if the latter seemed to be forgetting it—"I do not know whether "you are intelligent enough to answer two questions at once. I'm not."

Incidentally, Captain Falls mentions the fact that although, like many senior French officers, Foch was a good German scholar, he most unfortunately had no English. "It is valuable"—he writes—"to know the language of your future "opponent in times of peace, for the study of his military literature. In war it is "ten times more valuable to know the language of your ally." The reviewer can support this opinion from his own experience in France, and particularly when his Division was attached to the First Army under General Debeney. "To be able to "converse with a colleague of another nation without calling in interpreters—who in "the Great War frequently justified the army slang title of 'interrupters'— is "a priceless advantage." It is a matter for regret that our young officers are no longer encouraged to study foreign languages at "The Shop" to the same extent as they used to be. Many of them may have cause to regret it, even if they do not aspire to be Staff Officers. To listen to a Chief Staff Officer trying to explain to Marshal Foch in Robertsonian French the details of the situation on the Army front would have been amusing, had the situation not been so serious. He might have been understood, had he spoken slowly in English.

In a chapter on "The Defensive," Captain Falls quotes from what he had learnt from his conversations with General Weygand as to Foch's ideas on defence, and this leads us to the handling of reserves. His principles were:—

1. *Jamais céder du terrain* (or give the enemy an advantage without fighting for it).

2. *Jamais faire la relève pendant la bataille* (or commit to an obscure situation twice the number of divisions already engaged).

3. *On fait ce que l'on peut* (with the means at one's disposal).

The first two were not absolute rules—in fact, they had on occasion to be completely disregarded—but all three were the first guiding principles which he applied to every problem of defence.

Like the great Professor of the *École de Guerre*, Captain Falls gives us concrete examples to illustrate those principles. Space forbids reciting them at length, but they are all illustrated in his brief account of the Battle of the Lys on April 9th, and following days. During the battle, Sir Douglas Haig considered that he ought to have been earlier supported by the French. Foch, however, was convinced that all the forces at the enemy's disposal were not yet committed, and he was therefore determined not to commit the French reserves prematurely. He refused Haig's urgent demand that the French should take over a portion of his front so that he (Haig) could increase the number of the British reserves further north. Foch was not blind to the danger: indeed, it appeared to him that the German advance on Hazebrouck might only be a prelude to an advance on Calais. He was, in fact, more disquieted by the Lys offensive than by that subsequently carried out by Ludendorff on the Aisne. Foch had the liveliest faith in British doggedness. That he was bleeding the British to save the French, as Haig was tempted to believe, was not the case. Ironically enough, Pétain virtually accused him in June, and some French critics do so still, of bleeding the French to the advantage of the British! Foch moved up his reserves, but he refused to commit them. He kept them in a position *en potence*, so that they could move into Flanders, intervene in case of a renewed German offensive at Arras, and yet not lose touch with the Somme Front. He was justified. The British and Belgians resisted the German offensive with complete success, though the British were fought nearly to a finish. The reader of Captain Fall's narrative will admit that all the three rules mentioned above were applicable, and led to a successful result.

For another example of Foch's long-sightedness in the handling of his reserves, Captain Falls gives us an account—wonderfully condensed—of the operations between May 27th and June 4th on the French front, after Ludendorff had launched what Captain Falls describes as the most perfectly " mounted " of all the German offensives against the Chemin des Dames position on May 27th, 1918. Foch had been taken by surprise. He had expected Ludendorff to continue his policy of destroying the British Army, for he knew that the Crown Prince Rupprecht still had some 30 divisions in reserve ready for that purpose. It was perhaps the most critical moment of the war on land; it was certainly the crisis of Foch's career. But in the end Foch prevailed. In spite of Pétain diverting the last available division in reserve on his own initiative, Foch collected, one might say created, a reserve of 4 fresh divisions, with which Mangin made his famous counter-attack on June 11th, the prelude to Foch's great counter-stroke on June 18th, which caused Ludendorff to abandon his plan to destroy the British Army. Captain Falls points out that Foch himself, as well as Pétain and Duchêne, must bear a share of the responsibility for the initial disasters, but neither he nor Pétain can be blamed for the fatal handling of the local reserves, which were hurled into the battle instead of being directed to hold the line of the Aisne.

Speaking of the late General Mangin—Captain Falls describes him as a remarkable man with the accipitrine head. It was, indeed, a remarkable head, broader almost than it was long. He had, as the right-hand man of Nivelle, shared in his successes and been involved in his catastrophe. Known as " Le Boucher " and accused of sacrificing his men, he had been deprived of the command of his Army, he had even been forbidden to live within a prescribed distance of Paris. The writer met him after he was brought back to command a Corps in the French First Army, and re-introduced to him a distinguished General Officer of the Corps of Royal Engineers, who had last seen him at the time of the Fashoda incident when he was serving under Marchand. It is said that Mangin led his counter-attack on June 11th. He was quite capable of doing it. " He was "—writes Captain Falls—" not easy to handle, but a wonderful " instrument of war for the superior who knew how to do so." He and Foch were associated for the remainder of the war, and his portrait hangs in the late Marshal's study at Trofeunteuniou.

In the chapter entitled " The Counter-Offensive," Captain Falls clears up another point on which there has been some discussion—the alleged differences between Foch and Haig as to the conduct of the final advance to victory in the autumn of 1918. The subject is too long to discuss, but Foch gave way and adopted Haig's plan that the further advance of Rawlinson's and Debeney's Armies which Foch had ordered for August 16th, should be held up until Haig's Third Army had launched its attack on August 21st. They buried the hatchet and on more than one occasion later Foch availed himself readily of Haig's proffered advice. The chapter deserves study.

In his final chapters, Captain Falls describes the part Foch took in the discussions on the terms of Peace. Foch, he writes, put forward for the first time his proposal for a Rhineland State when he accompanied Clemenceau to London, November 30th, 1918. He soon discovered that Mr. Lloyd George did not approve of the idea. He wanted the Rhine boundary, the frontier of 1814, for France. " Germany, so " ran his reasoning, with her growing population and the militaristic spirit, which "would endure under no matter what *régime*, would constitute an increasing menace "to peace." "The only natural barrier between us," he said, "is the Rhine. Whoever holds its bridges is master of the situation."

Captain Falls declines to discuss the practicability of Foch's purely military solution. The French Government accepted it, but with a feeling that they were beaten before the battle began, because they had small hope that Great Britain and the United States would agree.

Foch was not appointed a delegate to the Peace Conference and was advised, at the last moment, not to attend its first meeting on January 18th, 1919. He had certainly hoped to be allowed to plead his case. He contrived, however, to make his views known. The story of his struggle to be heard by the delegates in conference, is too long to recite, but Foch failed to get his way, and when the Treaty was signed on June 28th, he was not present. "The Treaty," writes Captain Falls, "was not "made by soldiers. They might have made a harsher and less moral Treaty, but "they could scarce have made one less successful."

Marshal Foch died on March 28th, 1929. "He leaves a memory not only of victory "and deliverance but also of faith, of goodness of heart, and of honour untarnished."

H.B.-W.

LORD KITCHENER.

By LT.-COL. H. de WATTEVILLE, C.B.E., M.A.

(Blackie and Son. Price 5s.)

This is one of the short biographies in the "Order of Merit" Series, based mainly, as the author indicates in his preface, on Sir George Arthur's three volume biography. The main difficulty in a biography of this nature lies in its size. Kitchener was a big man in every way, and the big canvas is essential for the production of his portrait. Wherever he was, and whatever he was doing—in Egypt and the Sudan, South Africa, India, or in Whitehall—he was always the centre of reforms, upheavals and political controversies, which can only be delineated on the big canvas and not in a miniature. Within the limits of size of this volume, however, the author, in spite of a somewhat irritating style in his earlier chapters, has produced a readable and competent biography.

The character of Kitchener is produced as that of the "cat who walked alone," and the simile, although at times overworked by the author, does go some way to explain his apparent loneliness and aloofness, even as a young officer. He started the important part of his life in survey, which, according to the author, laid the first foundations of his methodical ways and power of organization. Then came his leap to fame in Egypt and the Sudan, of which a clear account is given, showing the steady development of his strength of character. It was his work in this period that laid the next foundations of his mental make-up—centralization in himself of all control.

The next phase was South Africa, where Kitchener showed himself to be the perfect staff complement to the leadership of Lord Roberts, though the author is inclined to refuse acceptance of the usual view that he was a greater staff officer than a commander by producing a defence of his tactical failure at Paardeburg. But, on the departure of Lord Roberts, all Kitchener's clear perception and powers of patient organization became most evident in the most difficult later years of the war, and the author shows that there is little doubt that it was due to Kitchener's influence and vision that the atmosphere was created in which not only the peace treaty could be signed but also the possibility of the future Union of South Africa could be seen.

Of his Army reforms in India and of his controversy with Curzon much has been written before; the author has nothing new to say, but, within his limits of space, he has produced a clear and unbiased account, which is assisted by an appendix on the controversy at the end of the book.

After Kitchener's further tour in Egypt, he enters the arena of Whitehall, and it is in this part of the biography that the author is so inevitably cramped for space. The canvas becomes of truly gigantic size, and a small picture is an inadequate substitute. In many ways Kitchener's previous experience had unfitted him for so much that he now had to do. He had no knowledge of the system at home, of the Territorial Army, or most important of all, of politicians, and that centralization in himself, started in his early days in Egypt, had become almost an obsession. "After some months," writes the author, "long hours of work and unaccustomed opposition began to hamper even that massive personality in the course of protracted meetings with a cabinet of twenty-one nimble-tongued civilians who never understood him—any more than he understood them. For he could not claim either the gift of conducting a clear discussion on paper or the silver-tongued ability to sway his colleagues. Indeed, Kitchener fully realized his own limitations. In the past, he had steadily declined to take up work in the War Office, because of his own incapacity to persuade by honeyed words." To add to his difficulties, of course, the whole of the War Office staff had gone. The author shows how, by sheer force of personality, Kitchener overcame so many of the disadvantages and how clearly he saw into the future.

On the various controversies over munitions, with Sir John French, over the Dardanelles, and with the politicians, the author writes clearly and without bias, though he throws no new light. His real summing up of the character of his subject can best be expressed in his own words:—

"For all the greatness of his work in creating the new armies, it was as a visible inspiration to his countrymen that Kitchener rendered them his greatest service. He enjoyed a prestige among the people such as no other modern soldier had ever acquired, and he turned it to the best account. . . . It was not Kitchener's military achievements in the high offices that he had held which mattered, but his personality, determination and devotion to his Country."

Although, as already indicated, this small biography produces nothing new and can only give an outline of the subject, it can be strongly recommended to anyone who wishes to get a brief, unbiased account of a life so particularly full of major controversies.

H.G.E.

THE ARMIES OF THE FIRST FRENCH REPUBLIC AND THE RISE OF THE MARSHALS OF NAPOLEON I.

By the late COLONEL RAMSAY WESTON PHIPPS.

(Oxford University Press. Price 21s.)

The volume under review is the fifth of a series based on material collected by Colonel Ramsay Phipps, and edited after his death by his son, Colonel Charles Phipps, and then (volumes IV and V) by his granddaughter, Mrs. Sanders.

This fifth volume deals with the Armies on the Rhine, in Switzerland, Holland, Italy, Egypt, and the *Coup d'état* of Brumaire—1797 to 1799. The object of the series is to study the military education, experience, character, and rise of Napoleon's Marshals.

The authors have accordingly found themselves faced with the difficult problem of compromise between Chronology, Geography, and Biography. To trace the history of each Marshal independently would entail endless repetition, and it would be difficult to show the reactions of one with another. With several largely independent campaigns proceeding simultaneously, and with the constant transfer of troops and leaders from one theatre to another, it is difficult to maintain true chronology and at the same time to preserve the narrative of each Marshal in its correct sequence. The editress admits that the difficulty has been most acute in this volume, and that her solution of taking each theatre in turn, and of treating it chronologically, means that the story of a Marshal, who was transferred late in the period from a theatre described late in the book to one covered earlier, is out of chronological order.

In spite of this real difficulty, the development of each Marshal is reasonably easy to follow, and Mrs. Sanders is to be congratulated on the result.

The figure of Napoleon so overshadows the period, that modern English writers have done scant justice to those campaigns of revolutionary France, which were neither directed by, nor influenced the campaigns of, the "Little Corporal."

The Phipps family have delved deeply into the records, and have not only succeeded in their task of illuminating the rise and character of Napoleon's Marshals, but have produced, within the limits of their task, valuable sketches of these little-studied campaigns.

It must be remembered that this volume deals with only two years in the life of each Marshal, and that the origins, character, and earlier service have been described in earlier volumes. For the study of the individuals, the study of one volume is not enough. But much value in the study of Military History, more especially on the effect of events on Commanders, can be gained by a study of this one volume.

Some of the pen pictures are quite brilliant, more especially the reactions of officers and men to Napoleon's campaign in Egypt, and the politico-military manœuvres leading up to "Brumaire."

The military judgments are, on the evidence submitted, fair and reasoned.

It is to be hoped that the editress will gain the support necessary to enable her to produce a further volume dealing with the Peninsular War from 1808 to 1814. This volume, while of special interest to English readers, would show how the Marshals' "turned out" after their apprenticeship in the Republican Armies.

R.P.P.-W.

THE WAR GASES.

CHEMISTRY AND ANALYSIS.

By DR. MARIO SARTORI.

Second Edition. Translated by L. W. MORRISON, B.SC., A.I.C.

The object of this book is, in the author's own words, "the hope of satisfying requests for a book which should contain all the purely chemical data, at present published in the various manuals of chemical warfare in fragmentary or summary form."

The thoroughness with which this task has been tackled is indicated by the formidable number of names in the "Author Index," over 650.

The first three chapters are on the principal properties of war gases, the relation between chemical structure and aggressive action, and the classification of war gases. Then follow twelve chapters, each of which deals with a group of war gases and in each of which is a short historical note, a description of the physical and chemical properties, method of preparation in the laboratory and in industry, action on the human organism and methods of analysis.

The majority of Royal Engineer officers will probably not require a deeper knowledge of war gases than that given "in fragmentary or summary form" in the official manuals. But should there be any who, by duty or inclination, wish to delve deeper into the subject, then Dr. Sartori's book can be recommended.

Both author and translator are to be congratulated on producing a mass of information on a technical subject in an eminently readable form.

H.F.P-W.

APPLIED AERODYNAMICS.

Second Edition 1939.

By L. Bairstow.

(Longmans. Price, 63s.)

Since the first edition of this book was published in 1919, a vast quantity of information has been accumulated in connection with the allied subjects, aerodynamics and aeroplane design, not to mention airship design. The second edition of the book, as the author tells us in his preface, is in no sense an attempt to produce a text-book of design, but aims at the extraction, from the great mass of data, of those elements which necessarily form the basis of all design.

The book has been described as "a mine of information drawn from the key research reports of the last 20 years." Its compilation must have been an enormous task, and the photographs and other illustrations are excellent. It will be invaluable to research workers.

Any sapper who has taken an interest in flying would be well-advised to get the book out of the Corps Library, though a good deal of it will be quite incomprehensible to anyone who has not actually studied aerodynamics.

F.W.T.H.

ON ACTIVE SERVICE.

By Brig.-Gen. W. W. Seymour.

(G. Bell and Sons. Price 12s. 6d. net.)

The idea of this book is best explained in the author's own words in his preface. "(It) does not pretend to be a history: it is a collection of personal accounts by those who took part in history and themselves fashioned it: officers, men and women who recount what they saw, endured, and sometimes enjoyed."

The author has collected these accounts, for Tangier, the campaigns of William III and Marlborough, the Peninsula, Walcheren and Waterloo, the first Afghan and Sikh Wars, the Red River, Ashanti, and the Nile of 1884-85. The trouble with these accounts is that the individuals concerned could only have the most restricted view of the campaign and of the battles: the value of their stories, then, lies mainly in the personal touches and in the interest of particular incidents: and it is there that the book fails. Much of it is frankly dull, although it is saved by the spice of the famous Kit Welsh during the Wars of Marlborough, and by the predatory instincts of Rifleman Harris in the Peninsula. In the Afghan and Sikh Wars, we get accounts from some senior officers who were in a position to know more, but there is little new light thrown on the screen.

It would seem clear that, while extracts from these eye witnesses accounts provide most interesting and entertaining additions to any general history of the Campaigns, to read them more or less *in extenso* tends to be dull work, always with the exception of the racy Kit Welsh.

H.G.E.

A.R.P.

(1) Air-Raid Precautions Handbook No. 5. (1st Edition) *Structural Defence* (2s.).

(2) A.R.P. Memorandum No. 10 (1st Edition) *Provision of Air Raid Shelters in Basements* (4d.).

(3) *Pamphlet on Shelter from Air Attack* (2d.).

(4) *Directions for the Erection of Domestic Shelters* (2d.).

All the above are 1939 Home Office publications, obtainable from H.M. Stationery Office.

(1) *Structural Defence* is a 60-page pamphlet, which gives a comprehensive summary in a readable form of the effects of aerial bombs and the practical points of design of air-raid shelters and buildings to guard against these effects.

It should be in the hands of anyone responsible for the design or construction of shelters or buildings giving protection against air raids.

The first half of the handbook describes the characteristics of high explosive, the different types of bombs and bomb-case (light, medium and heavy), and the effects of a bomb explosion.

Blast and the suction effect of blast are well described, various formulæ are given for the penetration of bombs into materials, and distinction is drawn between penetration and perforation, where the bomb passes through the structure. In the case of penetration only, the structure must be designed to resist impact.

The phenomenon termed "scabbing," that is the flinging off from the rear of the structure hit of a piece of the structure opposite the part struck, is described.

Penetration into concrete and into soil is discussed, also fragmentation or splintering. Thicknesses given of materials for protection against bomb fragments are the same as those in War Office P.A.D. Pamphlet No. 3, 1939.

The cratering effect of bombs and its effect on underground services, together with the safe distance of an underground shelter from a bomb exploding below ground are discussed.

The second half of the handbook contains a short chapter on "bomb-proof" shelters, a useful chapter on sizes and ventilation of air-raid shelters, and a chapter each on construction of new buildings and adaptation of existing buildings in the light of the need for air-raid protection.

(2) *A.R.P. Memorandum No.* 10 gives rules for sizes of basement shelters, lateral and overhead protection required for them to be splinter-proof, recommendations for strengthening floors over shelters in buildings, with sketches of suggested designs of timber and steel strutting, and points to be borne in mind in the selection of suitable basements.

(3) *Pamphlet on Shelter from Air Attack* is a short pamphlet with an introductory section on the types and effects of bombs, followed by the standard of protection to be aimed at in shelter accommodation for the ordinary citizen, and details of size and siting of shelters constructed in buildings.

This pamphlet was prepared before A.R.P. Handbook No. 5, and consists chiefly of abbreviated information given more fully in Handbook No. 5 and Memo. No. 10, both of which will be of more value to anyone concerned with the design or construction of A.R.P. work.

(4) *Directions for the Erection of Domestic Surface Shelters* is a small pamphlet containing a description of a type of splinter-proof surface shelter of 13½-inch brickwork or 15-inch concrete block masonry or of mass concrete, suitable for 6 to 12 persons, such as might be erected in the back garden of a private house.

A specification and sketches accompany the description.

SURVEY OF INDIA.

Professional Paper No. 29.

MAGNETIC ANOMALIES.

By B. L. GULATEE, M.A. (Cantab.), Mathematical Advisor, Survey of India.

Published by order of Brigadier C. Lewis, O.B.E., Surveyor General of India.

(Price Re1 as8, or 2s. 6d.)

Magnetic observations were made during the years 1935–37 across the epicentral area of the 1934 Bihar earthquake. They were taken in an attempt to elucidate the possible causes of that great and destructive catastrophe. As the geological features, which may account for earthquakes, are usually hidden deep below the surface of the earth, ordinary geological methods of investigation cannot, as a rule, be resorted to. It is, therefore, necessary to undertake what is known as geophysical research, usually employed for finding oil and other minerals. This may be carried out by means of (*a*) gravimetric research, employing a pendulum to ascertain whether there is any abnormal attraction which might indicate the presence of some hidden feature; (*b*) magnetic observations with which this paper deals; (*c*) seismological, or artificial earthquakes brought about by explosions, the velocity of the earth's tremors, so produced, being measured by means of special sensitive instruments and (*d*) electrical, namely, measurements of the conductivity of the material of the earth's crust. It is only by means of a combination of some, or all, these methods that results may be inferred. The magnetic observations disclosed considerable changes or anomalies in the intensity and direction of magnetic force below the alluvial trough lying beneath the plains of Bihar, but as the Geodetic Report of 1937 remarks "it is not found possible to relate them to any probable irregularities in the shape of the alluvial trough." The complicated formulæ contained in this paper are for the interpretation of the magnetic anomalies. In order to make them of practical application, a series of curves have been plotted to suit the variety of cases which may occur. This has been done by substituting various assumed values in the equations, so that any intermediate observed value can be interpolated without undertaking the laborious task of solving the equations. The formul e and the corresponding curves provide for a variety of shapes and depths of possible disturbing elements. It should, therefore, be possible, in theory anyhow, to determine the shape and size of the disturbing deposit. But the magnetic method of locating embedded deposits is burdened with many uncertainties, as magnetism is very liable to small changes in chemical composition of a substance. It is well known that rocks of the same type show considerable variation from one specimen to another. However, as already stated, by a combination of the methods now available to the geophysicist the evidence will often lead to conclusive results.

H.L.C.

MAGAZINES.

THE MILITARY ENGINEER.

May-June, 1939.

Mars, not Marx! Roger Shaw.

Shows how aristocracy and democracy form a regular cycle in ruling the world, depending on the weapons available.

Sending Pictures through the Air. Lenox R. Lohr.

A brief history of television up to the present time, describing the methods that may be employed and showing the stage that this science has now reached.

War without Gold. Gault Macgowan.

"The mystery of rebel finance." The writer shows how rebel Spain, during the recent Spanish civil war, managed her finances, and, against all normal economist ideas, managed to carry on against the heavy odds of having against them Government Spain with all the previous national reserves in hand.

George Washington, the Engineer. Charles Colfax Long.

A short article showing the great foresight in engineering matters that George Washington possessed, in particular as regards communications by land and on inland waterways.

Twenty Years of the Army. Elbridge Colby.

Describes by means of many figures, the ups and downs of the American Army, and shows its present state. There is an underlying feeling that America's preparedness for war is not to be allowed to lag. The opinions in this article are those of the author, and do not necessarily express official opinion.

Flood Control in the Pittsburgh District. W. E. R. Covell.

On March 17th to 18th, 1936, Pittsburgh District was flooded out by a storm which caused the water level in the Alleghany, Monongahela, and Ohio Rivers to rise 37 feet above normal. These floods caused such destruction and misery that Congress authorized nine reservoirs to be made. This article describes the project in some detail.

Seventeen Days of Sunset. J. E. Whitehorne. (Condensed and arranged by W. E. Deaton.)

Extracts from the diary of Sjt. Whitehorne, Company F, 12th Virginia Infantry, Confederate State Army, whilst fighting under General Lee in 1865, for the first seventeen days of April.

Hydraulic Model Design—Distortion of Scale. Herbert D. Vogel.

A short but technical article discussing to what extent distortion is permissible in both the vertical and horizontal scales in hydraulic model testing, the latter not being an exact science.

Portable Steel Bridge, H-10 Capacity. James M. Young.

An article of considerable interest to all Royal Engineers. H-10 capacity is the American standard for 10-ton trucks preceded and followed by 7½-ton trucks.

The bridge is supported by two sectional lattice-type box girders, with end sections triangular. Each section is 12 feet long by 2 feet wide by 4 feet deep, is made of special high tensile steel, and is welded throughout. The rectangular sections weigh 1,140 lb., while the end sections weigh only 820 lb. each.

The design was originally for loads over a span of 60 feet, but on test it was found that the load could be taken in safety up to 72 feet.

A launching nose is fitted, but a block and tackle has to be used to haul the girder into its final position.

Two, three or four girders may be used, the four-girder bridge taking H-10 loads over 108 feet.

The description in the magazine gives the impression that experiments in America on this type of bridge are not so advanced as in this country. It is interesting to compare the test figures with those of the Small and Large Box Girder Bridges.

The Mass Production of Maps. B. B. Talley.

The American Corps of Engineers and the Air Corps are jointly charged with the execution of surveying and mapping, and production and distribution of maps. This article gives a general idea of the methods employed.

The Present Status of Manganese. G. A. Roush.

A lengthy discourse, pointing out the need for setting aside reserve stocks of manganese in the U.S.A. in case of war. Figures are produced in large quantities, and tables show World production of manganese ore, World production of manganese ore by periods, Available supply of manganese ore in the United States, Imports of manganese ore into the United States, Distribution of manganese ore imports in 1937, Estimated stocks of manganese ore in the United States, Utilization of manganese in the Steel Industry, Annual average prices for manganese ore, and Political and commercial control of manganese ore production.

Making an Army Officer. Harry Terry and Loren G. Stevens.

In war, the American Army will have to rely for leadership largely upon officers from the Reserve. The correspondence course system is discussed and criticisms made. Apparently, Reserve Officers in the U.S.A. take correspondence courses for their normal training similar to those which may be taken by officers in this country for Promotion and Staff College examinations.

The Willamette Basin Project. Cecil R. Moore.

The Willamette River is a large tributary of the Columbia River in Oregon, near the Pacific Coast. In summer there is very little rain, but the whole of the river basin is liable to heavy flooding in winter. Congress have just approved a scheme, costing 62,060,000 dollars, for the construction of storage reservoirs, locks and river-navigation improvement, by which means the flood menace will be eliminated, and agriculture will be greatly improved. This article describes the scheme.

Land Reclamation and Shore Protection in the Netherlands. John R. Noyes.

"God made the land, but the Dutch made Holland." A brief description of the great Zuyder Zee dike and the land reclamation of Holland.

While Czechoslovakia was Passing. B. T. Reynolds.

Interesting personal experiences of one of the British "Observing Officers" sent to see fair play when the German Army took over Sudeten Land in October, 1938.

E.S.B.

REVUE MILITAIRE SUISSE.

(*April*, 1939.)—*La psychologie appliquée au service de l'armée.* By Colonel Carrard. The author is a Director of the Institute of Applied Psychology of Zurich and Lausanne, as well as a colonel of the Swiss Army. He gives a technical exposition of those imponderable characteristics which go to the building up of recruits.

La préparation économique à la guerre. By Lieut. Ducret.

Preparation for war to-day involves much more than military (or naval or air) preparation. It needs in addition moral and economic preparation of the whole nation.

Some interesting figures are given on such subjects as the compulsory withdrawal of men from the armies in France to rebuild the munitions supply in 1914, the numbers needed for harvests, etc., and the difficulties in keeping up the national food supply. The Swiss arrangements for the supply of petrol in time of war are far from being adequate, remarks the author. Very few motor vehicles are prepared for, or adapted to, other forms of spirit; yet Switzerland has no access to sea transport.

L'importance du cheval pour la défense nationale. By F. Vouga.

In spite of the progress of mechanization, the author maintains that the horse is still indispensable to the armies, and that more effort should be made in Switzerland to provide for the horse supply. He argues, with good reason, that petrol supplies may fail, breakdowns occur and ground be unsuitable. He quotes the case of Poland, which, next to Russia, has the largest horse population in Europe. The Polish plains are suitable for cavalry operations, but, if the cavalry have to meet armoured vehicles and mechanized weapons, it is not reasonable to suppose that they will achieve good results. But it is not for cavalry operations that Poland maintains her horses. Agriculture is the main occupation of the Poles, and horses are cheap transport. Roads are few, and horses are necessary. Much trouble has been taken in Poland to obtain a good breed, and many countries import Polish stock, especially Switzerland.

(*May*, 1939.)—*Y a t'il une crise du fusil?* By General Clement-Grandcourt.

The author maintains the superiority of the rifle as the best infantry weapon, and urges the importance of a thorough training in marksmanship. He recalls the exceptional care taken in individual musketry training in the British Army prior to 1914 (which had such striking results that the Germans credited us with innumerable machine-guns, instead of the paltry two per battalion, which was all that regulations allowed the B.E.F.).

Careful aimed rifle fire, in picking off leaders, had its effect in rapidly using up officers and N.C.O's, and lowering the morale of the rest. The Germans, with their habitual discipline, avoided many losses by taking cover, and taking care not to expose themselves. They adopted snipers' tactics very early in the campaign of 1914.

Rifle shooting is encouraged in Switzerland. In other countries, the craze for mechanization and machines of all kinds is crowding out the musketry prowess of the individual. We can be too hide-bound; but we can also be too devoted to allowing machines to dominate the man. In between there is the real solution.

La préparation économique à la guerre. (*contd.*) By Lieut. Ducret. Describes the Swiss economical preparation for war. Without having experienced the economic pressure which her neighbours had to undergo in the last war, Switzerland has to prepare herself for a complete organization and regulation of all her supplies.

Un cas de camouflage: les armes fictives. By Lieut. Gaberell. A short article on the value of dummy arms, chiefly referring to the use of dummy machine-guns in conjunction with real ones. No details are given. The object aimed at is to cause wastage of ammunition by the enemy.

(*June*, 1939.)—*Quelques questions d'actualité sur la guerre en montagne.* By Colonel Chatrian. The author, who is head of the Military School of Naples, has recently drawn attention to mountain warfare as affected by modern developments in a series of lectures given to Swiss audiences. Italy has had recent experience of mountain warfare in Abyssinia and in Spain, and the author draws conclusions from their lessons. Mechanical development has not ousted human effort in the mountains, and therefore scope is still left for the highest skill in strategy and tactics. Masses of men and machines cannot decide the issue amidst the snows of the Alps; warfare will be confined to the valley bottoms; and the defenders will have ample scope for taking toll of the invaders.

Troops prepared only for warfare on the plains are not suited to mountain warfare, but the converse does not hold. Mountain troops are assuredly fit for any type of ground.

The Italians are profiting by their recent experiences of active warfare by careful preparation in their mountain regions.

Transport de la mitrailleuse et tirs en hiver. By Lieut. Gallusser. This article appropriately follows the preceding one. It is an illustrated account of the equipment used by the Swiss mountain troops for carrying machine-guns to high altitudes, and on snow surfaces. Simple arrangements of skis or luges are adapted to form light sledges, which reduce the load to be pulled by the gun teams, and enable the mountain patrols to be supported by machine-guns under almost any circumstances. The article illustrates one-man loads, with which a complete gun-team with ammunition occupies a total length of about 30 metres.

Les anomalies psychiques en milieu militaire. By Lieut. Schneider. A discussion on abnormalities amongst military recruits.

W.H.K.

REVUE DU GÉNIE MILITAIRE.

(*March–April*, 1939.) *Les insignes des unités du génie.* By Lieut.-Colonel Fadeuilhe. The French Army adopted, during the War, the habit of painting signs and emblems on their vehicles, like the British. Many of these emblems have been preserved, and, although unofficial, are now recognized as prerogatives. Engineer units have followed suit, and this article describes and illustrates a number of them, with notes as to their heraldic character. A coloured plate shows twenty examples.

Le téléphone automatique rural. By Capt. Leschi. The first part of a long article describing the telephone system now being extended throughout French territory; its organization, and the practicability of its use for military purposes in time of war. The author looks forward to the time—evidently not far off—when any telephone user in any part of the world may communicate easily with any other user, at any hour of the day or night. The continual progress being made in this direction has furnished the military authorities with greatly increased opportunities, and the author describes the rural systems of telephonic communication in detail, for the benefit of engineer officers concerned with telephony.

Les origines de la fortification bastionnée. By General Lazard. A further instalment of this research into archæology for the origins of the bastion. Of little interest to-day, except to students of ancient history.

Le Génie à Madagascar (1895). A short account, by an anonymous writer, of the operations of the engineers who accompanied the French Expeditionary Force to Madagascar in 1895, under General Duchesne. Four companies of engineers were sent out; a total strength of 27 officers and 800 men, of whom 2 officers and 399 men died.

The work performed was of the usual variety familiar in our own Corps history; road construction, bridges, telegraph lines, hutments and hospitals.

An appeal is now being made for subscriptions to restore the memorials to those who fell in this expedition.

(*May–June*, 1939.)—*Les consolidations et assainissements de terrains.* By Colonel Lux. A lecture given by the author to officers of the Railway Engineers on recent practice in earthwork embankments and cuttings, as exemplified on works carried out by the French Eastern Railway during the last fifteen years. The disturbance of soil necessary in all railway works often leads to unexpected accidents in subsidences, and, if these can be met by suitable measures in peace-time practice, in war-time the exigencies of speed in construction usually make it impossible to take full precautions.

The author's object was to put forward practical lessons for the benefit of his military audience, illustrated by actual examples. Photographs show instances where large subsidences have occurred, and the text explains how they were dealt with. He urges his readers to consult the local officials of the *Ponts et Chaussées*, and to make a close study of the geological maps.

Les origines de la fortification bastionnée. By General Lazard. This inquiry into the origins of the bastion is now concluded. The author takes us into Peru and describes the Incas' methods of fortification. His conclusion is that the bastion long preceded the invention of fire-arms; that it was necessitated at all times by the form of the materials available, and that Vauban elaborated the design with all the advantages of fine masonry at hand.

Le téléphone automatique rural. By Capt. Leschi. The conclusion of the article. Further details of the equipment and working of rural circuits in the French telephone system.

W.H.K.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(*April*, 1939.)—*Dix-huit mois de guerre en Chine* (1937–1938). By Capt. Materne. A further short instalment summarizing the operations resulting in the capture of Canton. The easy conquest of Canton, which, by the nature of the ground should have been made exceedingly difficult, was put down to the fact that Chiang Kai Chek had drawn heavily on the defending army for his operations at Hankow.

Étude sur la défense de la côte. By Lieut.-Colonel de Pauw. An interesting study, to be continued, on the defence of Belgium's 60 kilometres of coast line.

Although Belgium has declared herself strictly neutral and independent, she is well aware of the necessity for defence by land, air and sea; and, moreover, she knows from whom she may expect assistance in the event of a menace to her coast line. After discussing the various hypothetical situations in which the country might find itself, the author turns to the direct problem of the modern defence of the sea coast. He deals with the five possible forms of attack; the bombardment by isolated vessels; blockade of the harbours (by surface ships, by submarines or by minefields); raids by isolated ships against the harbours; a large-scale raid on the harbours; and finally, a landing on the coast.

To meet the bombardment by isolated vessels, quick-firing guns sited on the coast, and small motor-boats firing torpedoes, or submarines are the reply. Searchlights and air bombardment are of course to be added.

The blockade of the harbours by surface vessels cruising about to prevent commerce, or by submarines and minefields, has also to be met by naval counter-measures. The raids, either by isolated ships or by larger naval formations, are likewise mostly naval questions. It is the landing on the coast which interests the military student; but very few details of engineer interest are referred to.

If an invading force has managed to set foot on shore, it must be met by overwhelming fire brought to bear on the sea-shore itself. Frontal fire from artillery will be very limited, and the bulk of fire must come from flank positions and from machine-guns and other light weapons of infantry. The invaders are most vulnerable while still in their boats, and approaching the shore. Once ashore, they will endeavour immediately to form "bridgeheads," and to get inland away from the shore. The defence must therefore have local reserves in the right places to counter-attack wherever the invader makes his push inland. Machine-guns under concrete protection will be required on the flanks, but such positions are necessarily fixed, and must be chosen with great care. Barbed wire obstructions, running perpendicular to the coast, are advocated; the object of these being to shepherd the raiders where they can be got at by machine-guns.

The invaders will at first be furnished with only light anti-aircraft weapons, since the heavier ones will require time for getting ashore. Searchlights will of course be essential.

Early discovery of an intended invasion will be a duty of the air service, but, as the North Sea is frequently visited by fog, coastal watch is also necessary.

The important question of command is dealt with. The author urges the appointment of an officer of high rank as Coast Defence Commander, who will command all elements involved in the defence. It would lead to confusion to allow the command to fall to the senior officer who happens to arrive with reinforcing troops; there would probably be a succession of them.

Rôle social et éducatif du Commandement. By J. Verheyen. A chaplain's view of the aims and objects of military education.

(May, 1939.)—L'Armée Royale Néerlandaise. By X.X.X.

A short contribution by an anonymous highly-placed Dutch official on the recent measures taken by Holland to strengthen her military forces since the crises of last September and March. The Dutch, like the Belgians, are resolved to defend the integrity of their country by every means in their power. The totally inadequate period of training—5½ months—for recruits, which was in force until 1938, has now been doubled. Large purchases of modern anti-aircraft guns and anti-tank weapons have been made. The number of subalterns has been increased, and more attention given to the intensive training of both officers and N.C.O's.

The article does not attempt to give an account of the Dutch Army; it indicates the chief directions in which effort has been accelerated recently.

Dix-huit mois de guerre en Chine (1937–1938). By Capt. Materne. The author concludes his review of the eighteen months of war in China down to the end of 1938, and sums up his observations on the results to date. The decision appears to be as far off as ever, and the war of attrition still seems to be in favour of the Chinese. Japan can never hope to stop completely the supply of arms and munitions from the west, even if she does blockade the whole Chinese coast. She has never declared war on China, and is in the position of a marauding invader, riding rough-shod over the usual international conventions. She is creating puppet authorities to govern vast areas, over which the Japanese control extends no further than their military garrisons.

A tribute is paid to General Chiang Kai Chek for his patient strategy. He is not attempting the impossible, by pitting his inadequately equipped forces against the well-armed might of Japan; but he is making full use of the means of attrition offered by the existence of innumerable guerilla bands.

The Russian menace in the north still obliges Japan to maintain the flower of her armies on guard in that direction; the author puts her troops in Manchukuo at 500,000 men, and this must mean a heavy drain on the rest of her man-power.

Étude sur la défense de la côte. By Lieut.-Colonel de Pauw. The conclusion of the article. The author's purpose is to urge the formation of a definite organization, largely utilizing existing means, for the watching and safeguarding of the Belgian coast. In addition to the formation of a permanent staff, and the training and allotment of the necessary artillery and engineer units, and anti-aircraft detachments, the author calls for a small naval force of destroyers, mine-sweepers, trawlers and anti-submarine devices. This, in fact, involves the creation of a nucleus navy for Belgium.

L'Artillerie face aux chars. Défensive. By Lieut. Rousseau. The protection of artillery against tanks is dealt with from a purely artillery point of view. Although no reference is made to it, there is an engineer aspect to this problem, for the laying of anti-tank mines and other obstacles would have some bearing on the protection of the artillery positions.

(June, 1939.)—Pages d'histoire de l'Armée Belge pendant la Guerre, 1914–18. The two instalments this month have a very limited interest. The first, by Capt. Gorremans, describes the adventures of a machine-gun section in the Flanders offensive of September–October, 1918, and the second, by Major Branders, gives a short account of the author's experiences as a train-conducting officer employed in the repatriation of General Haller's Polish Army from France in April, 1919.

La photogrammétrie à l'Institut Cartographique Militaire. By Maj.-General Ley. Belgium, like most European countries, is finding it necessary to overhaul the framework of her national survey, and to provide for the higher degree of accuracy required by modern artillery methods, to say nothing of the need for more frequent revision for civil requirements. Her cartographers are making use of photogrammetric methods, in order to reduce the period of time between revision on the ground and publication. The author remarks that this period amounts to four years; a sheet of the 1/40,000 scale often takes eight years to produce, by which time the detail is of course out-of-date. To reduce this period, speedier methods are necessary, or a large increase in staff and machines.

The author, who is the Director-General of the Military Cartographical Institute, is an ardent enthusiast for the photogrammetrical method, and has given a detailed account of it, with photographs of the apparatus used in his department.

Les modifications entraînées dans la tactique par l'emploi généralisé de la motorisation. By Colonel Bastin. After summarizing the principal characteristics of tanks and anti-tank weapons, the author describes the two schools of thought on the subject of tank tactics. There is the French school, which advocates the close co-operation of tanks with infantry, and the German school, which believes in a deep and rapid penetration by tanks, leaving to the infantry, transported in cross-country conveyances, the task of securing the ground. The French hold that the anti-tank gun is to the tank what the machine-gun is to the infantry. The tanks require the support of the infantry automatic weapons to overcome the anti-tank weapons; the infantry can only secure the ground covered by the tanks by closely following up and preventing the enemy from re-establishing his line after the tanks have passed. The rapid raid by fast tanks dashing in to create havoc in the enemy's headquarters appeals to the imagination, but its possible effects are apt to be exaggerated. Tanks are semi-blind; they cannot fire with serious effect while moving rapidly; the infantry following at speed in mechanical vehicles are equally ineffective while moving. Land mines can cause much havoc among such vehicles, and a field strewn with stranded giants is not secure ground. The moral effect of tanks is chiefly operative only while such tanks are advancing and in view. If they have disappeared behind the main defences into the "blue" and are not followed by infantry, they allow the defenders time to come out of shelter and renew the defence.

The mean between the two extremes offers the best chance of success; namely, successive waves of tanks, each with a different task. The first wave must do the raiding and havoc-creating; succeeding waves must clear up and extend the gap, closely supported by infantry, artillery and aircraft. The leading wave must consist of fast light tanks; they cannot therefore be heavily armoured; they are therefore easily vulnerable to anti-tank weapons; they must therefore depend on light automatic guns. They must be supported by infantry travelling at the same rate; and by demolition parties ready to destroy railways, bridges and so forth.

What is certain is that ground previously pounded by prolonged artillery bombardment affords the worst possible arena for successful offensive by mechanized forces.

W.H.K.

RASSEGNA DI CULTURA MILITARE.

(April, 1939.)—Il combattimento offensivo nella regolamentazione italiana ed in quella tedesca. By Brig.-General Scala.

A comparison of the Italian and German official regulations on the subject of the offensive battle.

Clausewitz e la teoria della guerra.

Lieut.-Colonel Cannevari continues his article on Clausewitz. In this instalment he deals with strategy for the complete overthrow of the enemy, as well as strategy with a limited objective. He goes on to discuss rules of warfare.

Kemal Ataturk. By Major Tosti.

A sketch of the life of the great Turkish commander and reformer.

Organizzazione dei caseggiati nella guerra moderna. By Major Memmo.

The defence of buildings has played an important part in the Spanish Civil War and in the struggle in the Far East. The writer classifies buildings under three heads:

(*a*) Buildings in the country.

(*b*) Suburban buildings.

(*c*) Houses in towns.

In the first case, buildings will only play a secondary part in a system of defence, which will consist mainly of trenches and entanglements.

Suburban buildings, on the other hand, lend themselves to a concerted plan of defence, in which entanglements play a minor part.

In towns, groups of houses can be formed into defensive blocks, capable of putting up a stubborn defence that no attacker can hope to overcome without suffering heavy losses.

L'impiego della saldatura ossiacetilenica nella riparazione del materiale automobilistico. By Captain Belluzzi.

Oxy-acetylene welders not only require long training and practical experience, but a thorough knowledge of the technicalities of their work. The selection of a weld metal is a matter of great importance. For welding cast iron, for instance, it is necessary to use cast iron containing about 5 per cent of silica. Special weld steels are required for soft steel, chrome-steel, nickel-steel, etc. For bronze, a bronze containing a large percentage of tin is necessary: for aluminium, a pure aluminium must be used.

(*May*, 1939.)—*Le risorse economiche dei paesi mediterranei.*

In this article, continued from the March number, General Deambrosis deals with the resources of the eastern Mediterranean, and with the seas connected with it, viz., the Black Sea and the Red Sea. The countries bordering on these seas have a total population of 120 millions. The writer maintains that their economic resources are sufficient to support a population of 400 millions.

Re Carlo Alberto ed il cavallo Sardo.

General Giubbilei has a high opinion of the Sardinian horse for army purposes and describes what has been done to improve the breed.

Il nuovo assestamento nell'Europa centrale.

A brief résumé of the events in Czechoslovakia since the Munich Agreement.

Organizzazione dei caseggiati nella guerra moderna.

Major Memmo concludes his article on the use of buildings for defence in modern warfare, and lays down the following fundamental principles:—

I. Buildings must not be looked upon as only suitable for passive defence, but also as starting points for a counter-offensive.

II. Buildings have no fixed front, not even when they form part of the marginal zone of a group.

III. A building is in itself a complete defensive system, which an enemy cannot pass by without taking it in its entirety. It may, however, be divided up into sections.

IV. Whereas buildings are well suited for defence, they are of little value for attack. An enemy who contents himself with occupying them, gains little advantage by so doing.

V. Buildings abandoned to the enemy, especially those cleared to conform to the general situation, should be demolished.

The points to be attended to in preparing buildings as centres of resistance are:—

Repair and efficacy of defensive action.

Protection from artillery and anti-aircraft defence.

Protection from toxic gases.

Protection from fire.

Lateral and rearward communications.

Destruction in case of compulsory abandonment.

Studio comparativo su alcuni saggi elettrochimici proposti per la determinazione della stabilità delle polvere infumi. By Dr. Tonegutti and Dr. Brandimarte.

A note on the conclusions arrived at by applying modern electro-chemical methods to examine the stability of certain nitro-powders.

(*June*, 1939.)—*Studi di strategia sulla guerra mondiale.* (*Il problema russo.*)

General Ago gives his views on the Russian strategic problem in the World War. Russia's intention was to invade the two salients that threatened her eastern front—East Prussia and Galicia—and then to advance on Berlin and Vienna. It failed owing to the want of offensive capacity on the part of the Russian Army.

The French, also, were wrong in their strategy. They insisted on the main effort being directed against Germany, and Russia was asked to collaborate with them.

Had the Allies worked in unison and directed their main efforts on crushing Austria first, Austria would have been defeated early in the war, Bulgaria would have been kept out of it, and the German resistance would have collapsed much earlier than it did.

Le risorse economiche dei paesi mediterranei.

General Deambrosis dwells on the central position occupied by Italy in the Mediterranean, and on the historical relationship between Italy and Germany. The two countries can develop, each on its own lines, without clashing.

Clausewitz e la teoria della guerra.

Lieut.-Colonel Canevari concludes his article on Clausewitz.

Giuseppe Galliano al forte di Enda Jesus.

An account of the gallant defence, by Captain Galliano, of the fort of Enda Jesus, which he held, with a battalion of native infantry, for forty days against superior numbers of Abyssinians in December, 1895 and January, 1896. On the 1st March of that year Galliano was killed in the Adowa disaster.

Il nuovo assestamento dell'Europa centrale.

In this concluding instalment the writer records the annexation of Czechoslovakia by Germany, in spite of the protests of Britain, France, the U.S.A. and Russia. Hungary proceeded to occupy the Carpathian Ukraine. The next acts were the occupation of Memel by Germany, and the annexation of Albania by Italy.

Calcolo e confronto economico dei vari tipi di muri per le opere di difesa dei campi di tiro per armi portatili.

Captain Parisella discusses the stability of masonry walls against overturning and crushing caused by wind and other forces acting on their surface when the resultant acts in (*a*) the middle third of the base; (*b*) the outer third.

Nota sulle strade di montagna in relazione al traffico militare.

Professor Rizzetto emphasizes some of the points relating to mountain roads. Italy's frontiers are entirely in the Alps, and mountain roads play an important part in the movement of troops. Military considerations will often decide the best location of a road, its width and its gradients. Where possible it should be concealed from view and screened from fire. It is not of much use designing a road to carry two lines of traffic if there are narrow places in it that will only carry a single line of traffic.

A.S.H.

MILITÄRWISSENSCHAFTLICHE MITTEILUNGEN.

(*April*, 1939.)—*Um Prag und das Mittelmeer.*

Major-General Paschek has written his quarterly review of the main military and political events that occurred in the first quarter of 1939. With the close of the Spanish Civil War the tension between France and Italy in the Mediterranean has increased. The end of the Czecho-Slovak Republic and the return of Bohemia and Moravia to the German Reich has instigated Britain (according to the writer's views) to a new policy of encirclement, which has failed in its object.

Deutschlands Weg zur wirtschaftlichen Selbständigkeit.

Major Prokoph concludes his article, of which the first part appeared in the

March number. Germany has developed the manufacture of synthetic rubber to such an extent as to make herself independent of imports from abroad. Wood fibre is now extensively used for the manufacture of artificial silk and other cellulose products, thus reducing imports of raw wool and cotton. Cellophane is largely taking the place of glass. The soya bean is being used for various purposes, besides the preparation of edible oils and fats. Germany is developing her sea fisheries, and whale fisheries have made great progress in recent years.

Die wehrwirtschaftliche Aufgabe und Verantwortung des Betriebführers. By Major Oswald.

Private initiative and private business may sometimes have to be restricted and even controlled by Government guidance and orders, if the desired end is to be obtained. But this leaves plenty of scope for responsibility and collaboration on the part of the business manager.

The importance of having capable and efficient business managers in war-time cannot be overestimated.

Der Konflikt in Ostasien.

In this instalment Major-General von Lerch deals with the operations in the Sino-Japanese conflict between the 10th November, 1938 and the 15th March, 1939. They may be summed up under the following headings: (1) The operations in Central China round Hankow. (2) The operations in Southern China in the Canton area. (3) The occupation of the Island of Hainan. (4) Guerilla warfare in rear of the Japanese armies. According to the writer, Great Britain, France and Russia are supporting the Chinese central government, officially with loans, and unofficially with war material.

Der deutsche Stahlhelm. By A. Brandt.

At the outbreak of the war, as well as for many years previously, the German infantry wore the spiked leather helmet, known as "Pickelhaube." It was found to give no protection against shell splinters, and the spike was inconvenient when entanglements had to be negotiated. The fact that 83 per cent of head wounds were caused by splinters (as against 17 per cent by bullets) led to the introduction of a chrome-nickel-steel helmet. Shooting tests were made on 400 different patterns before a suitable one was selected. The standard pattern helmet has an average weight of 1365 grammes (3 lb.). A new pattern is about to be introduced, rather flatter in the crown.

(*May*, 1939.)—*Vor* 130 *Jahren.* By Colonel Freiherr Wolf-Schneider.

An account of the battle of Aspern, fought on the 21st and 22nd May, 1809, in which the Austrian Army, under the Archduke Charles, inflicted the first defeat on Napoleon. The respect for the Austrian soldier, acquired on this occasion, was not diminished in the subsequent battle of Wagram.

Wehrgeist—Heldenehrung. By General von Epp.

A discourse on the military spirit of the German Reich in the past and in the future.

Wie war die Tschechoslowakei befestigt?

Major-General von Brosch-Aarenau gives an interesting account of the Czechoslovakian fortifications. His information is collected from various sources, and much of it is contained in an article that appeared on pp. 212 to 223 of *The R.E. Journal* for June, 1939. His criticism of the Czechoslovakian defences is instructive, and a number of weak points are brought to light.

The whole system of fortification was based on a scheme of passive defence, except for the Engerau bridge-head at Pressburg. Here the possibility of a counter-stroke against Vienna was contemplated.

The Czechs relied, mainly, on a very large number of machine-gun posts ("ear posts" or "bunkers"). The approaches to these were usually in the open. The posts offered a good target to direct artillery fire—rather less so to curved fire. The protective stone screens could easily be knocked over. The space provided inside was inadequate: the ventilation was bad, rendering the posts exposed to gas attacks. Sanitary arrangements were non-existent. The absence of frontal fire in the front line of defence is adversely commented upon. The experience gained in small posts in the southern Tyrol during the war was ignored.

Next comes a criticism of a shell-proof work south of Znaim, on the former Austrian frontier. (The writer defines as "shell-proof" a work that is proof against shells of 21 cm. calibre and under. "Bomb-proof" means proof against shells up to 50 cm.)

The work was built of poured reinforced concrete. It has now been established that unreinforced concrete resists shell fire better than reinforced concrete, and rammed concrete is much stronger than a poured mixture. Here again the same criticisms apply as in the case of the ear-posts: inadequate space and ventilation, deficiency of water supply and absence of sanitary arrangements. The armouring was not satisfactory: revolving steel cupolas would have given much better results than the existing emplacements with several loopholes.

As regards obstacles, their use was extravagant; some 200 tons of steel per kilometre being used, an amount quite out of proportion to the weak line of posts that they covered. Tank ditches were provided in limited lengths; there was nothing to ensure that tanks would not avoid them.

Das neue ungarische Wehrgesetz. By General Nemeth.

Between 1919 and 1938 the armed forces of Hungary were restricted to the limits laid down by the Treaty of Trianon. In 1938 Hungary repudiated that treaty, and introduced a law making national service compulsory for all. The law is subdivided into eight parts, of which the most important deal with the following:—

The "Levente" prescribes physical training for the whole of the male youths of the country, from the completion of the 12th year until the 23rd year, or the time of calling to the colours. Four hours of instruction are given for ten months in the year.

The "Honved," *i.e.*, army, air force, and river force, prescribes universal service for all males between the ages of 18 and 60. The normal service is for 2 or 3 years with the colours, the remainder with the I, II and III reserves.

Personal services are required from both sexes between the ages of 14 and 70.

Die militärische Bedeutung der Kolonien.

Lieut.-Field-Marshal von Gerabek dwells on the importance of colonies for world powers: for the supply of raw materials, as naval bases and coaling stations, and as training grounds for soldiers, both in peace-time and in war-time.

For Germany the return of her colonies is a question, not so much of territory or of industries, as one of national honour and justice.

Der Bürgerkrieg in Spanien.

Major-General von Lerch brings his account of the Spanish Civil War to a conclusion with the events that happened up to the 31st March, 1939.

The fall of Barcelona on the 26th January sealed the fate of the Catalonian Army and decided the result of nearly 3 years of civil war in favour of the Nationalists. Demoralization set in in the Red Army. With the fall of Catalonia and an effective blockade at sea all communication with outside was closed, and the resistance of the Republican Army collapsed.

(*June*, 1939.)—*Seemachtfragen von heute.*

Captain Handel-Mazzetti deals with various aspects of sea power, but mainly with the position in the Far East and in the Mediterranean. The situation is explained by means of maps.

Attention is drawn to the rapid expansion of Japan in recent years, especially as a great naval power. Her further expansion to the south is blocked by the strategic triangle: Singapore, Hong Kong and Port Darwin. The European Powers have only small naval forces in the Far East, but it is probable that, on completion of the present building programme, Britain will have a battle-ship squadron available for service there.

Das Erdöl auf dem Gebiete des galizischen und des rumänischen Kriegsschauplatzes, 1914–18.

Dr. Friedensburg shows the great value of the Galician and Rumanian oil-fields to the Central Powers during the Great War.

A matter that is of special interest to us is the destruction of the Rumanian oil-fields in the autumn of 1916. By that time nearly the whole of Rumania was in German hands, and it remained with the Germans until the end of the war.

It was then that the chiefs of the British and French missions: Colonel C. B. Thomson, R.E. (afterwards Lord Thomson) and General Berthelot insisted on a complete demolition of the whole of the Rumanian oil-fields and their reserve of oil supply. This was carried out in spite of the strong opposition of the Rumanian officials.

Thomson's share is specially commented on. He secured the services of a number of British engineers, who were given temporary commissions and provided with uniforms. The demolitions were carried out in the most thorough manner. The well superstructures were burnt, tools were dropped into the bore-holes, boilers were destroyed with sulphuric acid, and machinery smashed with sledge hammers. Everything inflammable was set on fire.

Out of 1·8 million tons of oil only 300,000 were left to the invaders. The total value of the damage is estimated at 320 million gold marks.

In February, 1917, two months after the destruction, the Germans were able to use the first bore-hole, and they were gradually enabled to get the refineries working again. At the time of the Armistice the refineries were yielding two-thirds of their normal supply.

The small body of British and French engineers, who carried out their task in the face of the strongest opposition of the Rumanian officials, managed to inflict as severe a blow on the Germans as the latter suffered in any one of the great battles of the war.

Über das Kaliber von Flakwaffen. By Major-General Rieder.

Anti-aircraft weapons are divided into three classes: light machine-guns, heavy machine-guns and A.A. guns. The writer subdivides these classes still further, and gives details of the calibre, weight of shell and range of each.

Der Donau-Oder-Kanal. By Lieut.-Field-Marshal Dick.

The idea of constructing a canal connecting the Danube with the Oder dates back to the Middle Ages, but the chain of events prevented its actual construction. A project was sanctioned in 1901, and work was actually begun in various places. But in 1911 the opposition to the work, especially from the railway interests, rose to such a pitch that the project was abandoned in favour of other waterway connections.

With the formation of Greater Germany the scheme has been revived as one of national importance. On the 19th November, 1938, an arrangement was arrived at with the new Czechoslovak Government regarding the construction of the canal, which was to be completed within five years. The project was extended to make the canal suitable for 1,000 ton ships (instead of 600 ton ships as originally proposed).

The canal takes off the Danube at Vienna, and follows, in part, the valley of the Morava. It reaches the watershed 225 km. from the starting point, and joins the Oder 47 km. further on at Oderberg. The rise to the watershed is 114·7 m., necessitating the construction of 16 sluices; the fall to Oderberg is 71·7 m., for which 13 sluices are required. Where the canal follows a river valley, the river will not be canalized, but a separate channel will be dug alongside it. Ships will be towed by electric locomotives, the speed being limited to 5 km. per hour, to avoid an excessive wash.

The supply of water during the dry months has been the subject of special study; the construction of several dams has been necessary, in order to impound sufficient water to keep the locks filled during the summer.

The Danube-Oder Canal will complete a system of waterways, connecting the

Rhine, the Elbe, the Danube, the Oder and the Vistula. The North Sea, the Baltic and the Black Sea will thus be interconnected. These waterways will not only be of commercial importance, but of great strategic value.

Der Konflikt in Ostasien.

Major-General von Lerch gives us a further instalment of his account of the war in the Far East, comprising the period of 15th March to 10th May, 1939. The main items to be recorded are the Japanese capture of Nanchang on the 29th March, and the great Chinese counter-offensive in April. The reports of the latter are most contradictory. There has been a revolt in the north-west provinces of about a million Muslim Chinese against the Chang-kai-shek regime. A.S.H.

VIERTELJAHRESHEFTE FÜR PIONIERE.

(*May*, 1939.)—*Winke für Anlage und Durchführung kriegsmässiger Übungen der Pioniere.*

Lieut.-General Sachs describes a number of schemes that he has tried in connection with bridging by engineer companies. The idea is to make bridging as realistic as possible. If troops of other arms are available, so much the better, but in these schemes only imaginary troops, other than engineers, are dealt with.

In one particular scheme it is assumed that an attacking force has crossed a river, and is engaged with the enemy some 8 to 10 km. beyond it. The division orders the engineers to construct a bridge for the passage of reinforcements. The time for completion is specified. Approaches on both banks are got ready. The head of the column is represented by empty engineer wagons under the command of an officer.

As soon as the leading troops have crossed, a fire-ship (represented by a motor-boat with smoke candles) drifts up against the bridge. This is to test if proper precautions have been taken.

When normal conditions have been restored, the commanding engineer is ordered to detail a field company for a special task with the division. The company may have to be taken from those at work on the bridge : in any case the order may lead to some confusion.

After a time the bridge is struck by a shell, and it is clear that it has come under heavy fire. Communication with the division is interrupted. The commanding engineer orders the bridge to be dismantled and transferred to an alternative site some distance away. Before the alternative bridge is completed, a gas alarm is given, and the bridge has to be completed by sappers wearing gas-masks.

The commanding engineer now receives an order from the division to strengthen the bridge to carry an armoured regiment (loads up to 18 tons), which will arrive in six hours' time.

Other similar tasks are set, some of which are actually carried out ; others are merely worked out on paper. It is necessary to have an umpire with each field company, and an assistant umpire with each section.

Neuzeitliche Gliederung und Ausstattung der englischen Divisions-Pioniere.

Captain Koller-Kraus, who was recently attached to R.E. units in England, describes the organization and equipment of a British R.E. Field Company and an Engineer Park Company.

Some changes have been made in the Field Company equipment since a previous article appeared in 1936, notably the introduction of an 8-cwt. truck in the place of a light " Austin " car. Other equipment mentioned are the heavy (15-cwt.) truck, an air compressor, a new pattern sail-cloth water tank, and a special cooking apparatus. The writer comments on the small amount of explosives carried, as compared with other armies ; mines are not included in the Field Company equipment, and there is only one light machine-gun per section, mainly for anti-aircraft purposes.

In describing the bridging equipment carried by the Engineer Park Company, which is well illustrated by photographs, the writer notes the similarity between the British and German kapok rafts, but points out that the German rafts have a larger carrying capacity. There have been recent changes in the organization of the collapsible boat bridging equipment. The heavy bridging equipment (for 26-ton loads) forms part of that of corps engineer units.

Eruptivdecken als Stellungsschutz. By Professor Scupin.

In a previous article (No. 3 of 1936) on "Military Geology" the writer pointed out the advantage of a study of geology, particularly in a rocky country covered with humus, where hard and soft strata alternate. During the war, on the western front, in a country where the strata were mostly horizontal, mining was a matter of going down deep, if possible below the enemy's mining galleries.

Professor Scupin has in mind certain places where so-called "eruptive layers" exist (*i.e.*, prehistoric flows of lava). These often extend over large areas. The strata are often inclined—a gradient of 1 in 6 is not uncommon—and the outcrop is barely visible, except to an expert geologist. Sometimes there are two such strata, with a soft layer intervening. If the outcrop is within one's own ground, and the dip is in the direction of the enemy, great facilities are offered for mining under one of these strata, while the enemy will be heavily handicapped in his efforts to countermine.

Anwendung versteckter Ladungen seitens der Araber in Palästina. By Captain Bessell.

This is a detailed résumé, with illustrations, of an article entitled: "An Arab Mouse Trap and other Booby Traps, Palestine, 1936," by Captain E. C. W. Myers, R.E., that appeared in *The R.E. Journal* for December, 1937.

Das Gefecht am Kopratas, 317 v. Chr.

Major Günther illustrates, from the example of an attempted river crossing during the Diadochian wars, how the general principles of such manœuvres have remained more or less unaltered through the ages.

After the death of Alexander the Great, Antigonus, one of his generals, was conducting a campaign against the Greek leader Eumenes. The engagement here referred to occurred in 317 B.C., when Antigonus' and Eumenes' armies were facing each other on opposite banks of the Kopratas, a tributary of the Pastigris, which flows into the Persian Gulf. The Kopratas was about 100 yards wide, not deep, but quite unfordable on account of the rapidity of the current. Antigonus attempted, by means of a flank march, to surprise the enemy. The attempt failed, partly because of an inadequate supply of boats, and partly because Eumenes' intelligence was so good that he was able to oppose the crossing with superior numbers.

Das Pioniermuseum in Klosterneuburg. By Lieut.-Colonel von Schmidt.

The Engineer Museum in Klosterneuburg (near Vienna) contains models and drawings of the equipment and work of the Engineers of the old Austro-Hungarian Army, from the time of Prince Eugene to the World War. The article is well illustrated. A.S.H.

WEHRTECHNISCHE MONATSHEFTE.

(*April*, 1939.)—*Zur Angliederung des Protektorats Böhmen-Mähren.*

In this editorial the writer seeks to justify the annexation of Bohemia and Moravia. In the 1,000 years during which the Czechs occupied Bohemia no attempt was made to Germanize them. In all wars the Czechs were on the side opposing Germany. The ultimate annexation of the country was necessary in self-defence.

Das wehrwirtschaftliche Rohstoffpotential des Protektorats Böhmen-Mähren und der Slowakei. By Dr. Friedensburg.

The writer gives details of the annual production of minerals in the newly incorporated territories. He arrives at the conclusion that these territories do not constitute a great acquisition for Germany except in the matter of coal. Czechoslovakia ranked fifth amongst the coal producing countries of Europe. Nearly half of the coal-mines have gone to Poland, the rest to Germany.

Panzer im Festungsbau.

Colonel Heye concludes his article in this number.

Instances are given of the experiences gained in various French and Belgian forts during the war. Manonviller, the strongest of French frontier forts, was subjected to a terrific bombardment, mainly from 21 cm. mortars. Only slight damage was done to the steel cupolas, but the garrison was obliged to surrender, on account of the fumes caused by bursting shells, and the destruction of the ventilating system.

The writer arrives at the following conclusions for fortifications in the future :—

(1) The best quality cement (reinforced or unreinforced) must be used all round the work.

(2) The front shield must be of the best tough steel, preferably of nickel-steel, and, if possible, cast in one piece. It should be sunk vertically into the ground to a depth of two metres below ground level.

(3) The cupola should be of the best chrome-nickel-steel, and cast in one piece.

(4) The mechanism for ammunition supply, re-lining of guns, and sighting should be of the highest quality.

(5) The approaches should be bomb-proof.

(6) The best form of ventilation and lighting should be installed. The reserve lighting should be reliable. Anti-gas precautions should be provided.

Modelle und Modellregeln.

Dr. Füsgen concludes his article, quoting formulæ laid down by Froude, Cauchy and Reynolds.

Vom Menschenverbrauch der Kriegswirtschaft.

Dr. Leonhardt quotes a number of authorities who have laid down the proportion of men employed in armament and collateral industries during war-time to the number of fighting men. An American authority puts the proportion as high as 17 to 1. Other writers give 8, 9, or 12 to 1. Dr. Leonhardt considers these figures much too high. Dealing with the population of Germany, he considers that 6 million men could be put into the field, and that the number of persons in industry available to maintain such an army would be about 25 million, giving a proportion of 4 or 4·5 to 1. (The idea that Italy could put an army of 9·8 millions into the field is discounted.)

(*May*, 1939.)—*Ein militärischer Rückblick auf den* 50. *Geburtstag des Führers.*

A retrospect of the military progress achieved in Germany between Herr Hitler's access to power and his 50th birthday.

Die Rüstungsindustrie des böhmisch-mährischen Reichsprotektorats. By Captain Ruprecht.

A description of the main features of the armament industry in the recently annexed protectorate of Bohemia-Moravia.

It is calculated that the Czechoslovak armament industry included 76 factories, in which the number of workmen has not been divulged. The most important works are those founded at Pilsen in 1866 by von Skoda, which, similarly to the Krupp works, started in a small way, and expanded until they included almost every branch of steel construction. At the time of the annexation they employed about 39,000 workmen.

The next largest concern was the Czechoslovak arms works in Brünn. Aeroplane construction was developed on a large scale after the World War. The export of aeroplanes reached the value of 91·4 million crowns, almost equal to that of Italy.

Now that the Czech workman is no longer liable to military service, it will be possible to keep the armament works in Bohemia and Moravia working at full pressure in time of war.

Vom Minenwerfer zum Infanteriegeschütz.

Oberingenieur E. Hofmann traces the development of the infantry gun from the pre-war trench mortar to the modern infantry howitzer and anti-tank gun. At the beginning of the war the Germans had a heavy rifled muzzle-loader of 25 cm. calibre. A medium mortar of 17 cm. and a light mortar of 7·5 cm. calibre were subsequently introduced. Various improvements followed, increasing the range and the arc of fire of these weapons.

The introduction of the tank made the employment of a gun with a flat trajectory necessary, whereas, for indirect fire, a howitzer capable of high angle fire up to 75° is essential. No single weapon can combine both these properties.

Die Entwicklung der wichtigsten Schiffstypen. By Captain Rehder.

An account of the development of the main types of naval vessels :—

I. *Battle-ships and battle-cruisers, their guns and armour.* In the Jutland battle the latest types of battleships, both British and German, gave a very good account of themselves, but the British battle-cruisers suffered owing to their armour having been sacrificed to speed. The torpedo weapon has been greatly over-rated in its effects; in some modern ships, torpedo tubes have been entirely abandoned.

II. *Aircraft carriers.* These are subdivided into two classes: aircraft-carriers proper, and aircraft mother-ships. The latter launch sea-planes by means of cranes and davits, and take them on board in the same way. The aircraft-carrier is necessarily a compromise: high speed is essential, but the American requirement, that it should exceed that of battle-ships by 10 knots, has not been attained.

50 *Jahre Erfahrung in der Herstellung von Geschützrohren bei Rheinmetall-Borsig.*

A description of the latest methods of gun construction adopted by the Rheinmetall-Borsig Company. The special methods apply to the manufacture of interchangeable inner tubes for big guns. The alternatives are (1) to increase the toughness and tensile strength (not the hardness) of the steel by the addition of chromium, nickel, or molybdenum; (2) by the process of self-hooping (*autofrettage*) under hydraulic pressure.

(*June,* 1939.)—*Die Verwendung von Flammenwerferanlagen in Panzerkampfwagen.* By Lieut.-Colonel Olbrich.

Flame-throwers in tanks were first used by the Italians in the Abyssinian campaign of 1936. The writer here discusses the theory of the working of flame-throwers, *i.e.*, the range of the stream, and the amount of fuel required to maintain the stream. Many points have to be considered, such as the form of the nozzle, the length and diameter of the hose, the space for fuel storage, etc. The Italian principle of carrying large reserves of fuel in a trailer does not seem practicable, as it necessitates a reduction of speed, and involves the risk of the trailer becoming detached when crossing obstacles.

Die Vorschriften über den Arbeiteinsatz von Metallarbeitern. By Dr. Adam.

The shortage of specialists in the metal trade made itself felt very noticeably in the course of the year 1936. In the autumn of that year, a four-year plan of trade control was started in order to maintain a supply of skilled workmen. The writer describes the regulations regarding apprenticeship, etc., laid down in that plan.

Die industrielle Mobilisierung im Ausland. By Captain Narath.

A first instalment, describing industrial mobilization in foreign countries, notably in Britain, the United States, and France.

In France, during war-time, armament works will be largely controlled by the State, a system not adopted in the other democracies.

The writer describes the shadow factory system adopted in Britain. In the U.S.A. the War Reserves Administration takes up the supply of munitions to the army and navy on the outbreak of war.

Der kriegswichtige bergbauliche Rohstoffbesitz der Mittelmeeranlieger.

Dr. Ruprecht considers the problem of mineral raw materials for the countries bordering on the Mediterranean, in the event of the Straits of Gibraltar and the Suez Canal being closed by Britain.

All the countries in question, with the exception of Turkey, are importers of coal. None, except Turkey, produces enough for its own requirements.

France, Spain and Greece have ample supplies of iron ore; Italy only possesses a very small amount.

Britain (in combination with France) controls the greater part of the oil supply in Egypt, and that derived from the Irak pipe line. Other countries will have to rely on whatever oil they can get overland, or upon Russia and Rumania, provided the Dardanelles are not closed.

Friedrich der Grosse als Wehrtechniker. By Christian Schmitz-Dampfer.

Frederick the Great's interest in military technics is not as well known as it might be. He took a special interest in artillery matters, in gun construction, and in the chemistry of explosives. He was equally well informed in infantry details. He introduced a steel ramrod in the place of the old clumsy wooden one, and, in 1782, a new pattern of musket for general use.

A.S.H.

THE INDIAN FORESTER.

(*April*, 1939.)—There is a note regarding a rhinoceros captured in a trap in Assam; it had been living in a game preserve, but was driven out by a flood. The animal showed little resentment at its capture. It ate fodder and drank water from a fire bucket before being lifted out of the pit, and gave every facility to the author (Mr. M. C. Miri) to enable him to tend a wound on its chest, and to remove ticks from between its legs.

An elephant never forgets relates how one released in the Hailey National Park returned to her old home, 300 miles away, in a fortnight.

Reclamation of the Hoshiarpur Siwaliks.—These hills are constantly being held up as a bad example of the evil effects of disforestation and over-grazing. It is satisfactory to know that, in one valley at least, much good has been done by remedial measures. The hillsides are now clothed with a dense cover of grass, bushes and trees, and on the ground lies a thick mat of vegetable refuse. The ravine waterway has become a narrow channel flanked by wheat fields and fruit trees.

(*May*, 1939.)—*Forestry Beyond the Indus* treats of the N.W.F.P., trans- as well as cis-frontier, and it is interesting to learn what is being done in such out-of-the-way parts as Chitral and Swat. Even Waziristan is provided with a ranger at Razmak, in charge of a nursery where fruit and other trees are grown. During the disturbances of the last two years, fifteen or twenty thousand young trees have been given away to tribesmen, who have been sufficiently grateful to refrain from molesting either nursery or its pipeline.

Another article treats of the capture of wild elephants by means of tame ones; it is illustrated by photos, which must have been taken at uncomfortably close ranges.

The Forest Report for the Andamans for 1937–38 tells us of attacks by a hostile tribe, the Jarawas, who in the year under review ambushed and killed three forest employees. Another two might have shared the same fate, had they not been engaged in blowing up a log at the moment when the raiders, unknown to them, were approaching. The explosion of the charge effectually scared them off. But, we may ask, what is the garrison of Port Blair doing about it?

(*June*, 1939.)—There are some excellent photos of Chitral in the continuation of *Forestry Beyond the Indus*. The exploitation of the deodar there is, as matters stand, impossible for political reasons, as the Kunar river, the only means of transport for logs, runs into Afghan territory, before joining the Kabul and so reaching India. The alternative is to cut the trees into sleeper sizes in Chitral, which could be taken by camel over the Lowari pass to motor roadhead at Dir, an arrangement the cost of which seems to be prohibitive.

Soil erosion in the Bombay Presidency in India and in the Tennessee valley in the U.S.A. forms the subject of two articles. The magazine will have served its purpose if it wakes India to the pitiful waste caused by over-grazing and deforestation.

F.C.M.