VOL. LXX. No. 1 MARCH, 1956

THE ROYAL ENGINEERS JOURNAL

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PUBLISHED QUARTERLY BY THE INSTITUTION OF ROYAL ENGINEERS
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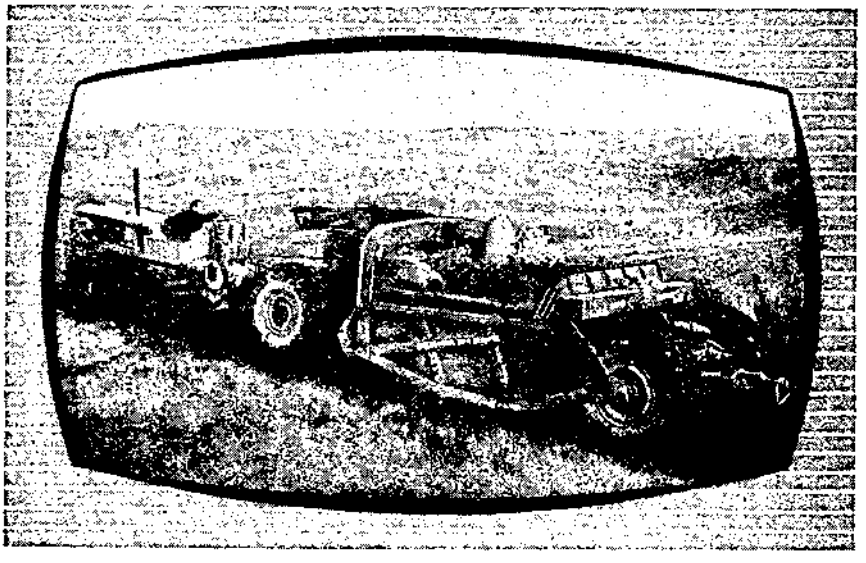

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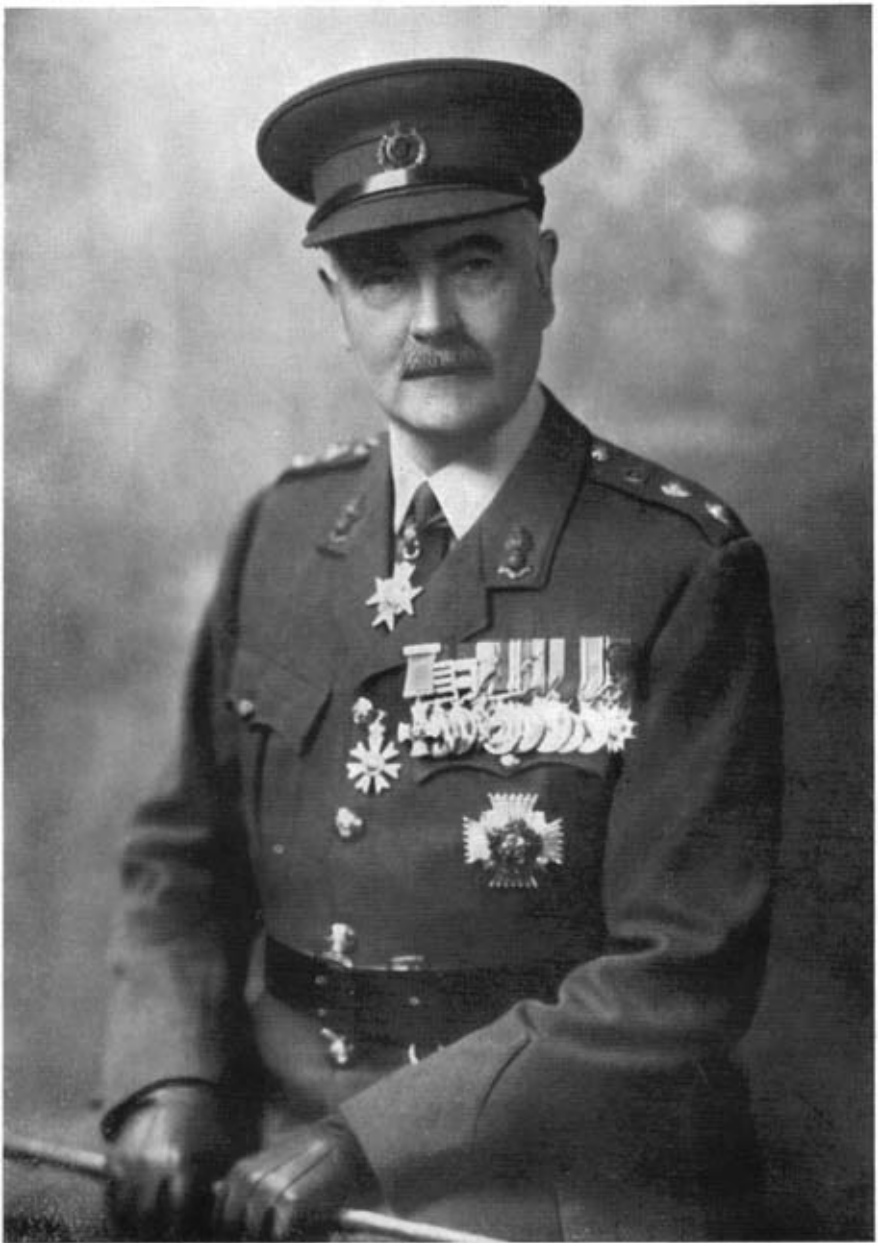

Lieut-General Sir J Ronald E Charles KCB CMG DSO

LIEUT.-GENERAL SIR JAMES RONALD EDMONDSTON CHARLES, K.C.B., C.M.G., D.S.O.

(CHIEF ROYAL ENGINEER, 1940–1946)

By L.V.B.

THE death, on Christmas Eve, 1955, of Ronald Charles removed from the Roll of the Corps a great figure, a figure greater indeed than his rank and the enumeration of his high appointments might suggest. For Don Carlos or Carlos, by which name he was known to innumerable friends and to the Army at large, possessed in an eminent degree the power of "personality" which makes a man stand out in any assembly of men. By ability, character and experience he was well qualified for, and might with greater fortune have attained, the highest positions in the Service.

Born at Calcutta on 26th June, 1875, the son of Dr. T. Edmondston Charles, retired Deputy Surgeon-General and an Hon. Physician to the Queen (Victoria), and of Ada, daughter of General Francis Rundall, C.S.I., R.E., he was the second of four brothers, all of whom became Winchester scholars.

In view of his splendid physique in later life, it seems strange that he should describe himself as having been, both at Winchester and at "The Shop", a "weed" with a strong dislike of any ball game. But he was a good scholar and, in 1892, he passed seventh into the Royal Military Academy, Woolwich, mainly on his classics and French. There he was selected to be Senior Under-Officer and gained the Sword of Honour. He passed out fourth in A. ffolliot Garrett's batch and was gazetted 2nd Lieut. R.E., on 17th August, 1894. From Chatham, where rowing and yachting were his recreations, he was posted to the 26th Field Company at the Curragh, and was fortunate to come under a fine commander in Captain (afterwards Lieut.-General Sir George) Fowke. The company moved to Aldershot in 1897.

In September, 1899, Charles, as junior subaltern, sailed with the 26th Company for South Africa but, soon after landing at Cape Town, he was transferred to the 1st Field Troop, commanded by Major (later General Sir Aylmer) Hunter-Weston and attached to French's Cavalry Brigade in the Colesberg area. In February, 1900, the Troop joined the Cavalry Division on the western line and took an active part in the cavalry sweep which relieved Kimberley and encircled Cronje's force at Paardeburg. Then followed the advance on Bloemfontein and the actions of Driefontein and Poplar Grove.

On two occasions, before the occupation of Bloemfontein and again during the advance northward to Pretoria, Charles was selected by Hunter-Weston to accompany him, with a few men of Charles's section, on raids through the Boer lines to cut the railway behind the retreating enemy. On each occasion, after the line had been blown up, the party encountered parties of the enemy whom they successfully engaged. On the second of these raids Charles went forward alone to cut a wire fence and was challenged by a party of three Boers who ordered him to "hands up". Pointing his wire cutters as a pistol at the enemy, Charles called to Hunter-Weston and the two officers, drawing their revolvers, took their opponents prisoner. For his conduct on these two exploits Charles was twice mentioned in Despatches and was awarded the D.S.O. With six years' service he was now a marked man, but luck seemed to turn against him; he developed enteric and reached Johannesburg in an ambulance. There he was nursed back to convalescence and was sent to the base, whence phlebitis in the left leg caused him to be invalided to England.

In February, 1901, after seven months' sick leave, Charles was ordered to India and was posted to the Cordite Factory which was then under construction at Coonoor in the Nilghiri Hills. But his experience of "Works" was to be very short; in August, 1901, he was transferred to the Bengal Sappers and Miners at Roorkee. He was at once posted to No. 6 Field Company, then employed on the construction of the Khushalgarh-Kohat Light Railway, under the command of Captain (afterwards Major-General) "Bill" Beach, most lovable of men and to be Charles's lifelong and greatest friend. The weather was intensely hot, the work continuous and Carlos contracted malaria which troubled him from time to time in India.

At the end of the hot weather of 1902, and now back at Roorkee and in command of No. 6 Company, he was fortunate to be ordered to take his company for a year's duty in Chitral. There, cut off entirely from India except during the annual reliefs, hill-roadmaking and bridging provided admirable training and there were opportunities for markhor shooting: an ideal command for a subaltern.

Back again at Roorkee in September, 1903, Charles was able to enjoy to the full the opportunities for polo, pig-sticking, big game and duck shooting in which, in those halcyon days and at that delightful station, we were able to indulge on our meagre pay. In 1904 he was promoted Captain and shot ibex in Baltistan; and in 1905 he took leave home.

In the autumn of 1905 the present writer joined him as company subaltern. To a Y.O. fresh from Chatham, Carlos, with his D.S.O., his commanding figure—he was 6 ft. 2 in. and broad-shouldered—and his even more commanding personality and obvious efficiency, was decidedly awe inspiring. There was indeed a reserve, a *gravitas*, about him, which increased with the years and made him seem to

many in later life, stern and forbidding. They might be surprised to hear that he was the life and soul of a very cheerful Mess. He had a strong sense of humour; he was an excellent raconteur with an unlimited fund of anecdote suited to the camp or the boudoir; and he was the possessor of a good baritone voice and of a repertoire drawn from the current musical comedies. He took his duties seriously and insisted on a high standard. He was a strict disciplinarian, but no martinet. If he did not suffer fools gladly he never showed it by any loss of temper or of self-control: he was invariably kind and forbearing. His judgements were sound, his decisions firm and immediate, fear of responsibility and procrastination in any form were, then and always, foreign to his nature. It was an education to serve under him.

In the autumn of 1906 the company moved to Peshawar. Here, after the exclusively Gunner and Sapper society of Roorkee, we found ourselves, as the only S. & M. Company in this "frontier" division, among a fine collection of Highland and "Piffer" units. Carlos appeared at once to establish himself in the confidence of Divisional H.Q. and as a leader in the vigorous life of the station where he made many excellent and lifelong friends. During the following summer he worked for the Staff College and, in the autumn, passed into Quetta, top of the list.

He joined the College in February, 1908, but, in the pleasant habit of those days, he returned to the 6th Company in March, to command it in the first of "Willcock's Week-end Wars" against the Zakka Khel of the Bazar Valley. He returned to Quetta in April, only to be back with his company in May to lead it into the Mohmand country. For these two small affairs he was twice mentioned in Despatches and promoted Brevet-Major. This reward, says a fellow student at Quetta and a future fellow Army Councillor, "'delighted his fellow students who recognized his outstanding ability and qualities of leadership. A great worker, he never spared himself, but he was always cheery and the best of good company."

From the Staff College, Charles was posted as G.S.O.2 of the Kohat Independent Brigade, where he gained further frontier experience; and in September, 1912, he was transferred to Army Headquarters, Simla, as G.S.O.2 in the Staff Duties Branch under Sir Douglas Haig, then C.G.S. It was a strenuous time of reorganization. Charles is described as being "a tower of strength in the office, most popular in society and a genial member of the hospitable Order of the Black Hearts".

In September, 1914, on the dispatch of the Indian Corps to France, under General Sir James Willcocks, Charles joined it as G.S.O.2 at Corps Headquarters and was present at the battles of Neuve Chapelle, Festubert and Loos. In August, 1915, now a Major and brevet Lieut.-Colonel, after two months as G.S.O.1 3rd (Lahore) Division, he became B.G.G.S. of the Corps. When, at the end of 1915,

the Indian Corps was moved from France to Mesopotamia, Charles remained behind as Brigadier-General, General Staff of XVII Corps with which he remained, apart from a short period with XV Corps, until the summer of 1918, through all the heavy fighting on the Arras front in 1917 and 1918. Air Chief-Marshal Sir Guy Garrod has given us—in *The Times* of 4th January, 1956—a picture of Charles at this period as seen by him when commanding an Army Co-operation Squadron attached to XVII Corps; "Under his influence the staff of the Corps was a powerful and highly efficient team, and also a very happy one since they had all complete confidence in one another and in their B.G.G.S. This was the only Corps whose Headquarters were not compelled to retreat under the German onslaught of the spring and summer of 1918. Charles had organized, with all his skill as a sapper, a system of defence in depth which the enemy failed to pierce. He and his Corps Commander (Lieut.-General Sir Charles Fergusson) had inspired all ranks with their own indomitable spirit." Other officers speak of his physical and moral courage, and of the admiration which they felt for his clearness of brain and imperturbability under stress.

He had now been continuously on the Staff since he left the Staff College. He was 43 and it was high time for him to command troops; perhaps he had made himself too indispensable. In the early summer of 1918 he was given a short experience in command of the 76th Infantry Brigade, 3rd Division, then holding the front east of Hinges. The Brigade-Major, also a sapper, says: "The four C.Os. were all old hands, all regulars, experienced and efficient. In command of them came a 'staff-wallah' and a sapper at that! Any fumbling by the new brigade commander would have been noticed very quickly. However, he soon had them eating out of his hand. He led them from the outset, and impressed them (and his staff and attached units), by his strength of character, courtesy, military soundness, bearing and personal courage, and by his manifest intention to put up with nothing second-rate. We soon found that, in spite of his somewhat stern manner, he was a friendly and understanding man."

At length, in August, 1918, Charles was appointed to command the 25th Division. This fine division had been dispersed in the summer after suffering very heavy casualties. On the 15th September it began to re-form near Abbeville, with nine infantry battalions combed out from various divisions in Italy, its divisional troops being withdrawn from attachment to other formations in France. To weld this collection of units and headquarters into an integrated division was, for its untried commander, a formidable task; the more so since by the 24th September the division was already moving forward by rail and road to its concentration area with XIII Corps, Fourth Army, east of Albert. Here it met its artillery and its M.G. Battalion, and on the 4th October it was committed to battle. Yet it was a task which Charles successfully accomplished. Officers who

served under him at the time speak of the impression made by his fine appearance, always well turned out and well mounted, of his severe manner covering great fairness and appreciation of good work, of his expectation that others would have his own high standards, of his tireless energy and personal courage, and of the invariable soundness of his organization and judgement which quickly gained for him the complete confidence of his subordinates.

During the night of 3rd/4th October, the division after a long approach march took over the front of the Australians who had broken through the Maisnieres-Beaurevoir line. The position was fluid and uncertain, there was no time for reconnaissance and the relief was still incomplete when the division was ordered to attack, on the morning of the 4th October, the well-prepared and strongly held position of Beaurevoir-Guisancourt Farm. It is not surprising that small progress was made and that a further attack at dawn on the 5th was but little more successful. Charles decided to wait till evening, when his attack completely surprised the enemy. Beaurevoir village was quickly over-run and Guisancourt Farm captured before dawn. From this moment the division never looked back.

The Fourth Army now entered upon a period of semi-open warfare against a stubbornly resisting enemy, in which the 25th Division played its full part. Charles, we are told, determined as always to see things for himself, was always well forward and would permit no slackening of pressure. After taking part in the fighting about Le Cateau, the 25th Division was engaged, on the 23rd and 24th October, in the capture of Pommereuil and in clearing the Bois l'Eveque and, on the 4th November, to quote the Divisional History, "it carried through, with brilliant success, the passage of the Sambre Canal and the capture of Landrecies." Charles was later gratified and touched by an invitation to visit Landrecies to receive an embroidered *tricolor*, inscribed "A leur Liberateur", subscribed for by the women of the village and accompanied by a book of their signatures. The "Boulevard Charles" was named in his honour. He was already a C.B. and a Brevet-Colonel and he now received the C.M.G. and Légion d'Honneur.

The 25th Division, which had suffered some 5,000 casualties in these operations, was now withdrawn for rest and demobilization, and in March, 1919, Charles was posted as Brigadier-General and Senior Chief Instructor, under Major-General Sir Hastings Anderson, to reopen the Staff College at Camberley. He spoke of the period of preparation and of the first (1919) Course as the most laborious of his service; nor was his special subject, Imperial Strategy, either easy or susceptible to lightness of treatment. As always, he took his responsibility very seriously, worked untiringly and was determined to master every facet of his job. But undoubtedly some of the students—the majority themselves ex-Brigadiers—comparing him with his charming fellow Chief Instructor "Jack" (later

Field-Marshal Sir John) Dill and with the Commandant, both of whom we loved, found Carlos rather stiff. Yet a fellow instructor speaks of him as "most helpful and human", and a senior student of the 1920 Course, who came to know him well and who himself rose to high rank, noted his patience with the foolish, his kind yet firm treatment of the students, his sound military views and his complete grasp of every problem. All the students would, he thought, by the end of the Course, have agreed that, as a teacher, a soldier and a man, Charles stood out, head and shoulders, among his fellow instructors. Off duty he and many others found him "natural, charming and amusing."

Early in 1921 Charles was posted to Army Headquarters India, as Director of Staff Duties, which post he vacated on promotion to Major-General in January, 1923. From April to October, 1923, he officiated as G.O.C. Waziristan, a post for which his former frontier experience and his fluent Urdu well qualified him. It was a time of engineer rather than of more active operations, yet counting as active service. One of his staff remembers, as his salient characteristics, his kindness and generosity, his untiring energy, his understanding, his clearness of thought and expression, and his determination never to eat any food that came out of a tin. Charles, he felt, achieved much in a short time and many were disappointed when the permanent incumbent unexpectedly returned from sick leave.

In May, 1924, he was appointed Commandant of the Royal Military Academy, Woolwich. The senior officer of his staff describes him as "a first-rate Commandant on both the instructional and social sides. He was popular with the staff and cadets, all of whom he entertained at his house. It was remarkable how he knew not only the names of all the cadets but also personal details about them. He entered with great zeal into their games and was a strong supporter of the Woolwich Drag. When, in July, 1926, he went to the War Office (as Director of Military Operations and Intelligence), the Staff and cadets felt that they had lost a friend."

During his four and a half years as D.M.O. and I., Charles had, among other things, to deal with the Shanghai Defence Force and with the persistent claims of the Air Staff which sought to reduce the rôle of the Army to that of aerodrome guards, claims which he was largely instrumental in resisting. An officer of the Operations Directorate speaks of him as "a grand chief, kind, firm and outstandingly able. His instructions to his staff were models of clear concise wording." Another in M.I. noted the wisdom and speed with which he dealt with his problems, and drafted masterly minutes in his beautiful handwriting. Serious as always in his duties, fun and humour would break through. He became a notable and popular figure at the War Office and it was held to be a sign that spring had come when Carlos appeared in his "sponge bag" check trousers.

In March, 1931, he was appointed an Army Councillor and Master General of the Ordnance, previously a Gunner preserve, and a month later he was promoted Lieut.-General. In 1932 he was made a K.C.B. His time as M.G.O. was, in some sense, a period of frustration. Funds were scarce and the policy of "no war for ten years" remained in operation. Industrial mobilization was starved and Charles' pleas for a more vigorous policy were unheeded. He was a strong advocate for mechanization and much useful experimental work on weapons, amphibious tanks and heavier bridging etc., was done under his direction. As usual he made himself a master of every aspect of his job and established excellent relations with the Civil side and with his opposite numbers of other Services. A senior Gunner officer who worked with him speaks of him as "a great M.G.O."

In 1934 Charles was approaching the end of his appointment. In 1935 he would be 60 and, although generally regarded as well qualified for the highest positions, he was not well placed. He could, he felt, look forward to a "Command" and to promotion to General, but to no more. He had been invited to join the Board of the British Aluminium Company, a position which would give scope to his powers and in which he might look forward to many years of interesting and useful employment. He was in full mental and physical vigour, still a bachelor and with a dread of being "on the shelf". The invitation could not remain indefinitely open. It was, he said, the hardest decision of his life. He decided to accept and applied to be allowed to retire 'at his own request'. On the 5th May, 1934, he was placed on the Retired List.

In September, 1931, he had been appointed Colonel Commandant, R.E., and in April, 1940, he was selected to succeed General Sir Bindon Blood as Chief Royal Engineer. In 1940 also he was appointed Colonel of the K.G.V's.O. Bengal Sappers and Miners, a post which he held until 1945.

It was also in 1940 that he took a very wise and easy decision. On 10th April of that year he married Margaret Lilias Prioleau, eldest daughter of the late Major Prioleau, The Manchester Regiment, and so secured for himself sixteen years of great domestic happiness.

As a member of the Board of the British Aluminium Company Charles took a more than an ordinary Director's share in the operations of the company, taking from the start a particular interest in the subsidiary companies. On the outbreak of the war in 1939 he was bitterly disappointed when the War Office refused, on account of his age, his application to serve in any capacity. But he found plenty to do with the B.A. Co., taking charge of their London Office throughout the war, helping out with a number of executive jobs in the absence on service of other Directors and members, and in connexion with the Civil Defence of factories. In 1941 he went, at the

request of the Government, to Australia to investigate and advise on the production of aluminium in that country. For eight months he travelled widely and he addressed the House at Canberra. In 1943, he visited India for three months on behalf of his Company and took the opportunity to visit the Headquarters of the three Corps of Sappers and Miners and other Engineer establishments. After the war he continued to take an active part in the Company until he retired from it in 1950. Letters received from all its branches, after his death, show not only admiration for his efficiency, but also the great affection in which he was held, a rare and moving tribute.

In addition to his business interest, Charles held, during his years of retirement, a variety of honorary posts, being a member of the Councils of the Institute of Metals, the British Non-Ferrous Metals Research Association, the United Service Trustees, the Royal Hospital Chelsea (as a Commissioner), and of the Army Benevolent Fund. But the appointment in which he most greatly delighted was his election in October, 1946, to succeed the late General Sir Hugh Elles, a brother Bengal Sapper, as President of "The Old Contemptibles". He had an intense admiration and affection for these grand old soldiers of 1914–15 and they returned that affection in full measure. "He was held," writes the General Secretary of the Association, "in such love and reverence by our members—we are all old men—as to seem beyond belief." He was indefatigable in serving his "Chums", in visiting branches and attending meetings, and he was proud of the erection of the 1914 Expeditionary Force Memorial in the crypt of St. Martin's-in-the-Fields, the result of years of hard work.

In 1946 he had moved from his pleasant house in Albion Street to Ilminster, where he took up gardening *con amore* and took part in many local activities. Latterly his heart began to give him trouble and it was with great sorrow that, in June, 1954, he found it necessary to resign from the Presidency of the "Old Contemptibles". From then onward he had to restrict his activities in a way very irksome to his eager spirit and active mind. With the summer of 1955, when he reached the age of 80, the trouble with his heart increased. It was hoped that his magnificent constitution would carry him on, but the end came swiftly and he died on Christmas Eve—a great soldier and a very great gentleman.

The writer, his disciple for fifty years, cannot do better than to quote from the tribute by Air Chief-Marshal Sir Guy Garrod, already mentioned: "His high sense of duty and service was an example to all who knew him and was typical of his fine character. Our country will remain great so long as it can produce men who reach his high standards in their lives and in their work."

SOIL STABILIZATION WITH CEMENT

By Lieut.-Colonel R. T. Weld, M.A., A.M.I.C.E., R.E.

General

MUCH has been written recently about soil stabilization and the subject was fully covered by an article in the *R.E. Journal* in 1952. For the Army the process of stabilization with cement is now a reality.

The aim of this note is to sketch the present position and to attempt to state the main possibilities and limitations of the process in proper perspective.

One of the main bogies is the "laboratory control" which tends to frighten people off the process as a scientific trick beyond the capabilities of the normal contractor. A later section of this paper will attempt to show that this is a groundless fear. The process is not new, but big strides have been made recently. It has been practised in England on a small scale for some thirty-five years and during the 1939–45 war a great number of airfields were built by the Germans by soil stabilization.

Soil stabilization is defined as "any process aimed at maintaining or improving the performance of a soil as a constructional material, usually by the use of admixtures". Thus stabilization in some degree can be achieved by:—

1. Compaction of a well graded soil.
2. Addition of different soil, to improve grading, and compaction of the mixture.
3. Addition of additives, particularly cement or bitumen, and compaction of the mixture.

The first two of these are called "mechanical stabilization", a process which is often suitable for sub-grades, but seldom, if ever, will produce a running surface.

Stabilization with bituminous additives is generally suitable for dry countries when the moisture content of the soil is low. In North-West Europe the natural moisture content of the soil is frequently too high for satisfactory stabilization with bitumen. In this paper only stabilization with cement will be considered.

The process consists of removing the vegetable topsoil, mixing a layer of the existing subsoil with cement, and water if necessary, and recompacting the mixture. The result is *not* concrete. The aim is to achieve a material with an unconfined compressive strength in the region of 250 lb. per sq. in. This low strength soil cement then behaves as a flexible pavement; it will probably contain a large number of hair cracks, while concrete would develop more widely spaced wider cracks. The result should be similar to a well compacted limestone base, except that there are no fines.

It should consist of irregular shaped pieces of material, closely interlocking but divided by hair cracks. It can, therefore, take compressive stress, a measure of shear through the interlocking faces, but no tensile stress. This material is normally achieved by the addition of 8 to 15 per cent of cement by weight, although pavements have been constructed with lower and much higher additive percentages.

The mixing can be carried out by mix-in-place, travel mix or by central mix methods. In mix-in-place the plant runs over the ground mixing cement with the soil *in situ*. In travel mix the soil is picked up by the machine, mixed within the machine and then relaid. Owing to lack of suitable plant this process is not considered elsewhere in this paper. In central mixing the soil has to be carried to the central mixing plant, mixed there and the mixture brought back to the site and relaid. Mix-in-place is the more attractive method as it is much quicker and cheaper.

On the other hand central mix plant can be designed to mix more thoroughly and thereby achieve an economy in cement. In cases where, for some reason, borrowed soil has to be used for the pavement, central mix is less inefficient, because the soil has to be handled anyway. In both processes the vegetable matter and humus from the surface must be removed before stabilization.

The advantages of soil cement, particularly by mix-in-place methods, are speed and cheapness. Where the soil is suitable, an airfield or road base can be stabilized far quicker and at about half the cost of other forms of construction. On the other hand this is not an invariable rule. Some organic soils are difficult to stabilize and may require special additives and increased cement for satisfactory work. Heavy clays are difficult to process and often demand high cement contents. Peat soils are impossible. In these cases the cost of stabilization will be increased and its advantage over other methods will be reduced accordingly. When labour is very cheap, or stone or good well graded hoggin is easily available and cheap, it may well be that a stone or hoggin base is actually cheaper than cement stabilized soil. So for civilian work, each case must be considered on its merits, taking into account cost of labour, cost of cement, cost of plant, availability and cost of alternative materials, suitability of the soil, and the importance of speed.

For military use, particularly for forward airfields, the situations when stabilized soil is the most suitable material are less limited. The cost factor is likely to be less important in this case than the time factor. Furthermore it may be possible to use a soil cement surface for aircraft without further surfacing, whereas stone or hoggin base will always require surfacing before use. Soil cement produces a surface which is not very resistant to abrasion and, when clay is present, is liable to be very slippery. Use without a surface dressing is therefore not always practicable and in any case should only be

allowed in emergency and when only a short life is required for the landing strip. So for military use it is suggested that soil cement will be the normal method of rapid construction of a forward airfield. For this purpose the chief competitor is Pressed Steel Plank (P.S.P.), which suffers the objections of heavy maintenance requirement and the enormous quantity of steel used. It is not, however, suggested that P.S.P. should be eliminated, but that limited quantities should be available for the occasions when soil cement is unsuitable.

It must be remembered that the use of a soil cement airstrip without further surfacing calls for a higher standard of material quality and surface finish on a military airfield than is necessary in civilian practice, when a "black top" will be the invariable rule.

Process Details

The process consists of the following steps:—

(*a*) *Reconnaissance*

This is in two parts: (*a*) siting, (*b*) technical reconnaissance and design. Siting will be determined primarily by tactical considerations and minimum earth-moving requirements. If the soil conditions are exceptionally poor it might be necessary to consider them in siting the airfield.

The technical reconnaissance includes soil sampling and grading and measurements of C.B.R., crushing strengths of prepared soil cement samples, moisture contents and compaction properties. From these can be deduced the thickness of pavement required, amounts of cement and water to be added, special additives required and compaction necessary.

The earth-moving and drainage plans must also be made during the technical reconnaissance and arrangements put in hand for control of levels, etc.

(*b*) *Earth-moving*

This is usually the largest part of a forward airfield project. It includes clearing of trees and obstructions, removal of organic topsoil, cut and fill levelling as required and drainage. The stabilizing machines leave the surface as they find it. It is, therefore, necessary that great care be taken in the earth-moving to leave the surface compacted, at the correct levels and cross falls and as smooth as the final surface is required. This calls for very accurate work in the final grading.

(*c*) *Final Compaction*

After all the cut and fill is completed and the fill compacted during its placing, the whole area should have a final heavy compaction. The object of this is to achieve a uniform deep compaction of the

base under the layer to be stabilized. After this compaction some further fine grading of the surface may be necessary to make good sinkage which has occurred.

(*d*) *Stabilization*

This, in the mix-in-place method, consists of running a number of trains of plant over the site, each of which adds cement and water, mixes them with the soil and recompacts it. Joints are always a potential source of weakness and it is therefore desirable to process the full width of the airstrip in one day, taking a suitable length of run to enable this to be done. This means that longitudinal joints are only done with "green" soil cement and the following machine can then cut into the work of the previous one, giving a reasonably homogeneous joint. Fortunately the preliminary earth-moving will usually move down the airstrip completing full width in the same pattern. After thorough compaction, which is vital for a strong pavement, a spray coat of bitumen emulsion assists curing and waterproofing the surface.

(*e*) *Surfacing*

When the requirement for the airstrip allows sufficient time or when the strip is required for permanent use, light surfacing over the soil cement is necessary.

Reconnaissance

At present the laboratory work involved in the pavement design occupies seven to eight days and is apt to be regarded as a somewhat forbidding item. The work is not really complicated and the feeling that a "laboratory" involves retorts, bunsen burners and all the paraphernalia peculiar to boffins should be resisted. It is no more complicated than a bridge reconnaissance and it is for this reason that "technical reconnaissance" and "airfield reconnaissance vehicle" or similar terms are preferred to the present "laboratory work" and "mobile soils laboratory".

Essentially the information required is:—

(*a*) Thickness of pavement.

(*b*) Amount of cement.

(*c*) Amount of water.

(*d*) Special additives.

It should be mentioned here that, when soil is highly organic, the effect of this can usually be overcome by the use of special "417" cement containing calcium chloride, or by the addition of a small percentage of calcium chloride to a normal Portland cement mix.

(*a*) The thickness of pavement is calculated from "C.B.R. curves", soil classification, local C.B.R. values and, of course, the design load.

(*b*) Cement content is calculated by experiment. Specimens with various cement contents are made up and tested for crushing strength after seven days.

(*c*) Water additive is assessed by a B.S. compaction test in connexion with the type of compactor to be used. The object is to achieve a moisture content which will give the greatest density when compacted with the plant available.

(*d*) Special additives. Calcium chloride is used with cement when the required strength is not obtained with an acceptable proportion of Portland cement alone. In the future other additives may become available for special purposes.

Thus the essential measurements to be taken are soil classification, C.B.R., Proctor compaction test and crushing strengths with and without calcium chloride. This careful technical reconnaissance is essential if best quality work is required with minimum risk of failure and economy of cement.

It is possible for an experienced engineer to design a soil cement pavement by rule of thumb and some simple tests. But he will necessarily err on the safe side and the pavement produced will be uneconomical and will carry a greater risk of failure.

The full laboratory work occupies about a week or ten days apart from control tests during the progress of the work. This may at first sight sound alarming, but it should produce reliable data which can be followed with confidence. The tests involved are simple and though the testing staff need practice they need not be highly technical.

For military forward airfield construction a week of technical reconnaissance sounds frustrating, but in fact it will be seldom that preliminary earthworks will take less than that time. So that provided the technical reconnaissance is put in hand immediately the site is fixed, it will normally be completed before any part of the work is ready for stabilization.

At present, it is therefore recommended that thorough laboratory investigation should be the rule, in the interests of economy and reliability, except in the case of very small projects. Nevertheless the aim is, and should be, to cut this preliminary work to the barest minimum and efforts are being made to this end. But it must be remembered that in reconnaissance, as in the processing, there is no substitute for training and experience.

Plant

Various types of mix-in-place stabilization plant are available on the market. Notably among them are:—

Seaman Pulvimixer	U.S.A.
P. & H. Stabilizer	U.S.A.
Howard Single Pass Train	U.K.

For military purposes multi-pass work is not recommended. The Seaman is such a machine and complete processing involves travelling over the soil six to eight times or more. This tends to complicate site organization, it makes it difficult accurately to control the depth

of cut and it involves very careful control of the number of passes to achieve good mixing without segregation of cement. Last, but not least, military work will frequently demand the use of rapid hardening cement to permit early use of the pavement; multi-pass work is not suitable for rapid hardening cement.

The P. & H. Single Pass Stabilizer is a large and heavy single-pass machine equipped with three or four rotors. It does not, at present, add cement nor produce any compaction though it is equipped with spray bars for water or bitumen. It has a high rate of output. Various models are available and of course output depends on the soil condition and the quality of mix required, but an average rate of 600 sq. yds. per hour is not unreasonable. On account of its high output it is a suitable machine for large tasks, such as airfields, and its use effects an economy in skilled personnel required. On the other hand, the high rate of output and relatively high price mean that the total number of machines likely to be held by the Army would be small. For carriage by air it is necessary to dismantle the machine.

The Howard Single Pass train is the only British built special purpose stabilizing machine. It provides a mechanical cement spreader and a compactor trailer, so that the whole process is completed in the single passage of the train, except a final smoothing with a steel wheel roller. This plant is air portable without dismantling. Its rate of output is about 200 sq. yds. per hour.

Cement

Cement in bags is expensive to purchase and very uneconomical to handle. The bag is a suitable package for small jobs, but an airfield project involves something of the order of 5,000–15,000 tons of cement and the labour involved in handling this in bags is prohibitive. A recent paper scheme for a military forward airfield constructed as rapidly as possible arrived at a labour force of about 2,000 men. About half of these were handling bagged cement.

Alternatively, cement can be handled in bulk and various devices exist for this purpose. Bulk cement can be handled loose in hoppers, etc. It can be conveyed about by belt conveyors, screw conveyors or air lubricated "airslides". It can also be blown through pipes under pressure with compressed air. Finally it can be packed in containers which are crane handled on rail and road transport, and emptied by gravity from bottom doors. In addition some form of silo or site storage is necessary.

For the Army probably the most attractive proposition is the container which covers both transport and site storage. However, to ensure flexibility, it is felt that the military soil stabilization equipment must be designed to accept, at the site, cement in any form. Accordingly, investigations are required for suitable cement containers, pressure bulk lorries, site storage silos and silo loaders for loose bulk.

Army Uses

The Army has three main requirements for soil cement stabilization plant:—

1. Airfields and possibly major roads.
2. Airfield ancillary works and minor road construction.
3. Training.

It is understood that complete specialist Airfield Construction Regiments, R.E., are unlikely to be available, although a specialist cadre might be provided. This appears to imply that specialists will be available for the technical reconnaissance and design, but that construction will be carried out by ordinary sappers (though possibly with specialist operators for special plant). The operation of cement stabilization is not difficult, but it does call for the experience in handling the machines and the material in order to provide a good mix and to maintain good surface levels.

Therefore all sappers must be trained in soil cement stabilization.

In view of the fact that road and airfield construction covers such a high proportion of the total R.E. commitments in war, its inclusion in annual training does not seem unreasonable. Further there will be many cases, such as approach roads to camps, roads round dumps, approaches to ranges, etc., where the product of the annual training can be put to subsequent practical use.

The small single-pass plant, such as the Howard train, lends itself to Army uses in many ways. It is very suitable for small tasks yet can tackle large ones. It is easily transported and is air-portable. It is relatively cheap so that considerable numbers could be held to facilitate training. It is available on the civilian market in U.K., and therefore production is easy and a war reserve of machines and trained men exists in the country.

Nevertheless a forward airfield is a big task. It requires a team of twelve small machines or four large ones. It is felt that the Army should also have some large machines particularly for airfield work when air-portability is not essential. But the output of these machines is so large that only small numbers would be necessary.

Therefore it is suggested that the Army should be equipped with large numbers of small machines and a few large ones. The small ones should be distributed throughout Commands to allow all R.E. some annual training with them. The large ones should be allotted to schools or training establishments. It is also considered that annual training and the training of the specialist reconnaissance cadres should commence as soon as plant can be made available.

Soil Survey

Construction of airfields by soil cement involves large quantities of cement and these quantities vary considerably according to the soil. Furthermore a particular organic content in some areas makes

the use of calcium chloride, or "417" cement containing calcium chloride, essential. A general soil survey of an area will not take the place of the local reconnaissance of a proposed site but it would give a basis for planning. It appears, therefore, that a special survey should be done of possible theatres of war showing types of soil, existence of the organic trouble and incidentally location of cement works.

This survey would assist store planning in war and in addition would provide a basis for assessing the value of cement stabilized soil in that area.

Aircraft Development

Very recent developments in aircraft show that designers are tending towards aircraft which will require shorter landing strips. This is good news to the airfield engineer, but regrettably the method employed appears to depend on the deflection of jet streams into a vertical or nearly vertical direction. The blast from a jet engine is very severe and it may well be that soil cement will prove inadequate to withstand it. If the result of this development in aircraft is to demand shorter landing strips of much higher quality, the last state for the airfield engineer may be worse than the first.

Summary

1. Soil stabilization with cement is now a reality and work is being done every day in U.K. by contractors using British plant.

2. Whether or not stabilized soil is the right material for a particular task is a question which must be determined by local conditions. No sweeping statement can be made and each case must be treated on its merits.

3. Soil stabilization with cement is to the Army an entirely new technique which is likely to be very valuable to the Royal Engineers. It is quite simple in essence, but it is quite different from any previous work and demands experience and thorough training.

4. Technical reconnaissance is necessary, but it is a straightforward matter which calls for practice rather than great technical skill.

5. Plant exists and training should start immediately as "individual training", leading up to a major stabilization exercise in a few years' time.

Author's Note

The ideas submitted above are personal views and are not necessarily the policy of any official department or body.

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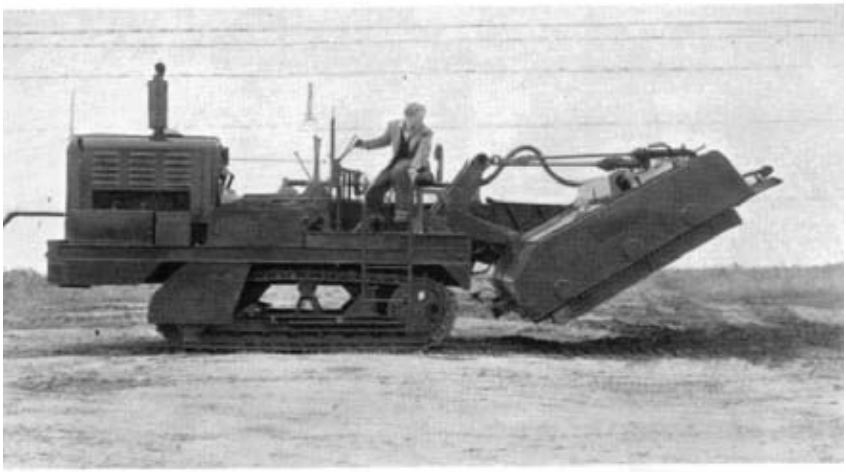

Photo 1.—The P. & H. single pass stabilizer model EA56.

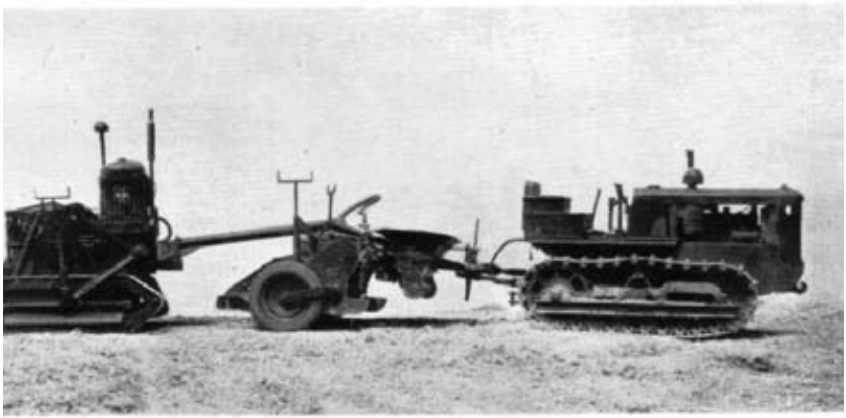

Photo 2.—The Howard stabilizing train.

NEW HEADQUARTERS IN GERMANY

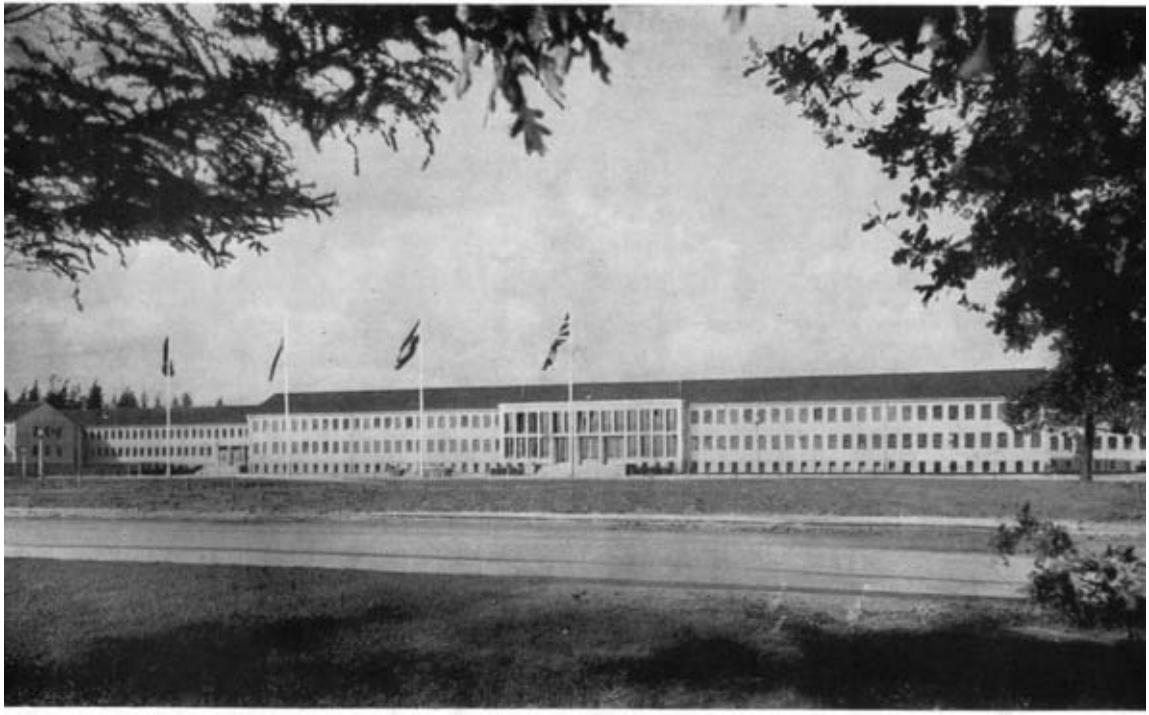

Photo 1.—Office building, H.Q. Northern Army Group and 2nd Allied Tactical Airforce.

New Headquarters In Germany 1.

NEW HEADQUARTERS IN GERMANY

(Part I)

By COLONEL H. GRATTAN, C.B.E.

This account, together with Part II which will appear in the June issue, was written in September, 1955.

BACKGROUND

IN May, 1945, the unconditional surrender of Nazi Germany was achieved, and the victorious Allied Forces met in the central axis of the mutilated remains of this country. Their immediate task lay in controlling the Zones into which Germany had, by agreement at Yalta, been divided. That task is described in its full complexity in Churchill's *War History*. In each Zone it consisted in feeding the stricken and swollen population, and disarming the Wehrmacht, setting up civilian administration, reviving agriculture and peaceful trade, and re-educating the people for a growing measure of responsible government.

The British Zone Forces, consisting of the 21st Army Group and 2nd Tactical Air Force, set up their Headquarters for this task in Bad Oeynhausen and Bad Eilsen respectively. These are two Spa towns in Westphalia, centrally located in the Zone, well served by road and rail, and consisting of commodious Kur houses, hotels and villas. Fences were thrown round these towns, and the populations evicted (except those as were needed to build up services for the proper comfort of the Headquarters). Until 1952 these arrangements suited the functions of the occupying Forces. The Headquarters of Flag Officer Germany was similarly settled in Minden, and directed the process of German Naval disarmament.

In the choice of these suitable and salubrious places there was no strategical concept, and indeed at that time no apparent need for one.

The scene has changed. It soon became evident that peace and disarmament were not likely to proceed undisturbed. By 1950 thoughts were inclining to the establishment of a peace-time Headquarters for the British Occupation Forces, West of the Rhine, and fitting into the N.A.T.O. scheme for the defence of Western Europe. The concept of a new headquarters so situated on the lines of communication took shape. This was stimulated by German pressure to restore the Spa towns and by the principle that after the ratification of the Bonn Convention, the cost of requisition of occupied properties would fall no longer on the German Occupation Budget, but on the British taxpayer.

Early Plans

In 1952, plans and a preliminary rough estimate for a new headquarters were prepared at Headquarters B.A.O.R. and were presented to the Treasury on the following assumptions:—

(*a*) The new headquarters would be a joint headquarters for Northern Army Group, and 2nd Tactical Air Force, and for Flag Officer Germany. (I put the Royal Navy last from no disrespect, but only because their strength of twenty-two officers and ratings would occupy an infinitesimal portion of the scheme. In fact, in 1955 the Navy decided to move their headquarters to Bonn, and not to the new headquarters built for them.)

(*b*) Provision of office and living accommodation would be based on *Barracks Synopsis* 1948 scales (less 20 per cent).

(*c*) All three Services would be governed by that scale.

(*d*) The cost of the whole work would be borne by the Occupation Budget in Deutschmarks, with not a penny subscribed by the U.K. Treasury.

In June and July, 1952, zoning plans were started by the existing staff in Engineer Branch, Headquarters, B.A.O.R. The assumed site was in hilly country outside Aachen in the Belgian enclave. War Office blessing was given to continue planning, subject to the all important proviso that the work would be done entirely from German Deutschmarks, and no sterling expenditure would fall on the British taxpayer. This was the overriding factor at that time. It dictated the speed and urgency with which the project was undertaken.

In July a special Chief Engineer (Works) Establishment to plan and conduct the project was approved by the War Office. On the 6th August, 1952, I was appointed Chief Engineer and given my brief. From that day, therefore, my story starts.

A book could be written on this project. This is not a technical paper but a running account, without detail or indigestible appendices. Appendix "A" facing page 46 is the plan of the site. Appendix "B" on page 48 gives the strengths for which it was built. Appendix "C" on page 49 gives brief notes on the accommodation and services provided. This account sets out only to describe features which were unusual, interesting or instructive.

Comparison with Cyprus Project

It is appropriate at this stage to mark the striking contrast between this project and the Dhekelia project, which has been described in the *R.E. Journal* for December, 1954, and March, 1955. The only factor common to these two projects is that they were both estimated to cost about £14 million. There the similarity ceases. The Dhekelia project has been subject from its inception in 1948 to the normal scrutiny required in every detail under Vote 8A procedure and has been phased over the years in accordance with the amount of money

which can be annually allocated to it. The new headquaters project was conceived to live or die on the condition that the whole of it could be planned and completed before the end of the period in which Deutschmarks from occupational costs would remain available. Therefore the first consideration was *speed,* which far outweighed exactitude of scale or perfection of planning.

Speed

In August, 1952, it was thought that the ratification of the Bonn Convention might be achieved on the 1st January, 1953, or at the latest June, 1953, and that only a year might remain after the ratification date for the allocation of Deutschmarks. *Speed* was therefore paramount. In comparison with speed other considerations were secondary. This did not give licence for extravagance or for ignoring *Barrack Synopsis* scales, but it meant that as far as possible standard barrack construction and existing drawings and contracts would be adopted—just as they existed—to make up the bulk of the building, and that such special planning of buildings and services as was necessary would be decided on the spot without reference to the War Office. The War Office, in order to satisfy themselves that there would be no sterling "tail", demanded pretty firm assurance that we and the Germans would be able to spend Deutschmarks at a rate which they prescribed as the major consideration in granting approval to go ahead with the project.

The expenditure rate they prescribed, and of which we were asked to confirm the possibility, was:—

Twenty-five million Deutschmarks by 1st January, 1953, DM.70 million by 30th June, 1953, and the bulk of the remainder by 1st January, 1954. (For ready calculation DM.12 = £1.)

The new headquarters, then estimated at DM.130 million, was to be ready for occupation by June, 1954.

The operation named "Op. Humane", described in the *R.E. Journal* for September, 1953, for housing new armoured divisions in Germany (at DM.90 million) was by then coming to a close. It provided the plans, schedules, and ready-made contract experience for standard barracks, messes, stores, etc., and was the basis upon which work could be put in hand rapidly on the new headquarters project.

Provided "Op. Humane" designs were used for standard buildings, the D.D.W. undertook to get somewhere near the target of expenditure, and planning was allowed to proceed.

On the 6th August, 1952, I received my brief. This was:—

(*a*) The schedule of accommodation based on the strength of the headquarters of the three Services as they then stood. This had been prepared earlier, and had been the basis for such planning as had by then been started.

(*b*) A preliminary rough estimate (P.R.E.) of DM.130 million (about £11 million).

(*c*) An announcement that the Belgians, in whose enclave Aachen lay, had now decided that they did not want the new headquarters there, but had offered other sites. (This nullified the embryo zoning plan which had been started, but the areas required had been worked out and the early planning could be applied to another site.)

(*d*) Orders to accompany a Board consisting of representatives of the Federal Government and of the Land Commissioner Northrhine/Westphalia, and "Q" Branch, Headquarters B.A.O.R., Belgian Army, British Resident, and German Ministry representatives to reconnoitre five various sites offered in the triangle Aachen, Roermond, Moenchen Gladbach, on 8th/9th August.

(*e*) A draft copy of my establishment (Chief Engineer (Works) Special) with an indication by the D.D.W., that he had already got some of the places in it filled.

(*f*) Plans of all standard "Op. Humane" structures. The construction was single-storied barrack huts, cook-houses, officers' and sergeants' messes, offices, stores, N.A.A.F.I. canteens, garages, etc., with district heating and the usual public services. (The P.R.E. had been based on this type of design.) Having as a C.R.E. taken over several "Op. Humane" camps for maintenance, I was familiar with the design.

(*g*) Instructions to find some suitable accommodation to open my new office on any site I should choose.

(*h*) An indication of the sums of money I was to strive to spend as described above.

The job promised to be exciting, and in its nature, size and financial independence, unique. The D.D.W. said it could be done, so who were we to say it could not?

On the 7th August, I set up a temporary office in a room of Engineer Branch, Bad Oeynhausen, familiarized myself with the schedules and plans, such as they were, and met Kirby and Dollery (both newly commissioned Superintending draughtsmen), who had been working on the Aachen zoning plan since 15th July, and were appointed to my staff.

Site Selection

On 8th/9th August, with Lieut.-Colonel H. J. Lord, who was to be my A.Q.M.G., and with the representatives described in paragraph (*d*) above, we saw five different sites in the area indicated. The first four were sandy wastes with sparse conifers and bushes, in the low hills on the Dutch border. None of them had independent access to services and communications, and it appeared at a glance that the development of any of them would add alarmingly to the cost given in the P.R.E., which had been prepared on the conditions existing on the Aachen site. The fifth and final offer was the Hardterwald some seven kilometres west of Moenchen Gladbach, near the main road to Holland through Roermond. It was thick woodland,

sufficient in area, slightly undulating, sand and gravel soil, and within reach of the H.T. electric grid, gas, and of established water works at Rheindahlen, Uvekoven and Waldniel. It stood out as the only possibility, and not a bad one. It was owned, together with the Rheindahlener Wald adjoining it to the south, by a textile magnate, whose hobby was arboriculture. Single ownership would simplify acquisition and no agricultural land was involved. Everybody was pleased except the owner and the city of Moenchen Gladbach, for whom these forests were their rural lungs. The site was near main rail and road communications, and within reach of such social amenities as Moenchen Gladbach and Rheindahlen could offer.

So on the 10th August, we started a zoning plan on the Hardterwald site, including a road network, water mains and a temporary overhead electrical supply. On the 12th August a final board of officers under the chairmanship of Air-Marshal Sir Robert Foster, A.O.C.-in-C. 2nd A.T.A.F. assembled to ratify the choice of the site. In the intervening two days, however, the Germans had changed their minds, and offered the adjoining Rheindahlenerwald instead of the Hardterwald, with adjacent extra wings of forest land to make up the total area. The same advantages applied to this site, so it was finally accepted, a blanket requisition was immediately placed upon it, and detailed planning went ahead. From that moment it was ours. The site consisted of mature timber, both deciduous and coniferous, some scrub, large nurseries of immature trees and saplings and millions of roots of forests felled in previous generations. It had forest roads of sand with no bottoming. It was 3 kilometres long and about one kilometre broad. The soil appeared to drain well and had good bearing properties.

Assembly

On the 11th August, the main complement of my staff had been appointed, and were arriving. My S.O.R.E.I was Major (T/Lieut.-Colonel) J. M. H. Lewis, whose quality, as a D.C.R.E., I had already appreciated. My S.Q.S. was Major (T/Lieut.-Colonel) J. S. S. Biggs, and S.O.II (E. & M.) was Major D. White, both posted peremptorily from the War Office having dropped everything there. My planning officers, Lieutenants Kirby and Dollery, had already been working since mid-July. I was allowed to choose men I knew to fill other key posts. I had Major (Retd.) J. W. Dix, as Assistant Superindent, in charge of Works, W.O.II Prentice as Superintending Clerk (to form my new office) and 2nd Lieutenant D. M. Brancher and Mr. Burrowes as Garrison Engineers. The obvious urgency of the project, if 25 million Deutschmarks were to be spent in four months, was not only a spur to us all, but was our "open sesame", for every reasonable demand for personnel, transport, tools, etc. Never before was such support given to a Chief Engineer and it was often at the expense of other over-burdened establishments.

Method

It is now appropriate to describe briefly how Works were done in Germany under the Occupational Statute, with particular reference to this project. We were briefed by my A.Q.M.G. sitting at Northern Army Group Headquarters. No better choice could have been made than Lieut.-Colonel Peter Lord, as he had been for two years "Q" Quartering in that Headquarters, and knew everybody and everything. A similar post for a Squadron Leader (Org.) had been written into my establishment for briefing on the R.A.F. side. He never materialized. Peter Lord had to extract R.A.F. requirements from their H.Q. at Bad Eilsen. The consequences of the lack of a R.A.F. "Q" officer were exasperating both to me and to the R.A.F. There have been many misunderstandings and some misinterpretations of their intentions.

As soon as items of work were planned and agreed by the staff and the user services they were passed with line plans and broad specifications and a requisition order to the German authorities. Thenceforward it was for them to detail the work, make bills of quantity, call for tenders, submit tenders to my staff for acceptance and finally to conduct and supervise the work. It will be appreciated that whereas our work was limited to line plans and broad specifications, the German task was many times greater. Work for the Occupation Forces is conducted by the agency of the Land Finance Ministerium who have a department for the purpose (the *Finanzneubauamt*), which corresponds in some measure to our Ministry of Works. For the Moenchen Gladbach project they opened a new office which was called the *Finanzsonderbauamt* (literally Finance Special Building Office) referred to hereafter as the F.S.B.A. The F.S.B.A. was our opposite number on the German side. It was established with great celerity, but was from the beginning even more hard pressed than we were. With all the will in the world they could not establish themselves as quickly as we did, and were rushed off their feet by the speed with which we fed them with the plans. They were, however, impressive in their performance, and the major credit for the job must go to Baudirektor Schmalbruch and his engineers of the F.S.B.A.

Start of Work

The first requisition that was made on the F.S.B.A. was for a survey of the site. This was started immediately after the acquisition. It was a survey at 1/2500 with contours at ½ metre intervals. Meanwhile our zoning plan was being done on a rough enlargement at 1/2,500 scale from the German 1/25,000 map.

On 6th September I was able to hand the Germans the plans of the road network with specifications, and the layout of the water mains. These were put to contract immediately, together with a temporary overhead system of H.T. electrical supply, so that in the spring con-

tractors would have roads and services ready to reach their jobs. The roads were to be of 20 cm. unreinforced concrete on sand and of widths to conform with standard road-laying machinery.

Meanwhile conferences were held in Moenchen Gladbach under the chairmanship of the British Resident, Colonel Cowgill, to define with the German authorities the exact boundaries of the land to be acquired. In the course of these meetings a superb air photograph of the whole site, which had been made by Hunting Aerosurveys Ltd., for the German agricultural authorities the year before, was produced. This was enlarged by the Survey Production Centre R.E. to a scale of 1/2,500 and enabled much detailed site planning to be done in the office. I cannot over-emphasize the value of a good air photograph enlarged to the planning scale from the beginning of planning. It was complementary to our detailed knowledge of the ground and saved many hours of foot slogging in the open and brain slogging in the office. On 12th September, I was able to get the broad agreement of the A.O.C. and his staff to our zoning plan, the Army Chief of Staff having already approved the plan from the Army standpoint. Three weeks later the clearing of forest for some twenty kilometres of road and work on road formations had begun, and on the 28th October, the road contractors having set up a massive batching plant on the site, had started laying concrete roads by machinery. By that time the permanent water mains ring was going in and had been filled by a temporary main from the Rheindahlen Water Works. Temporary overhead electrical supply had been established where it was first needed. Site offices for my staff and for branches of the F.S.B.A. were being erected. There was a magnificent and infectious spirit of urgency and endeavour, to which the Germans responded with typical industry.

On the 29th/30th September, Mr. McGregor, D.F.(c), Major-General Ritchie, Director of Quartering, and Mr. Gardiner, A.U.S.(S) came out to see for themselves whether the potentialities of progress justified their approval of the project and gave permission to proceed. The meeting was held under the Chairmanship of the M.G.A., Major-General G. S. Hatton, and after a visit to the site he and the D.D.W. persuaded the V.I.Ps. that the project could be conducted quickly enough to ensure no sterling hangover.

C.E. (Works) Office

Up to this time my staff and I had been planning largely in the Bad Oeynhausen office, with dashes by night to Moenchen Gladbach for local liaison conferences. I had found in Moenchen Gladbach a suitable office building, a bank, with a large hall for a drawing office. I myself drafted the details for its conversion to a C.E's. Office, there was nobody else sufficiently unoccupied to do it. In a few days the local D.C.R.E. had done the conversion, and early in October we moved to Moenchen Gladbach and got down to it in

earnest. Within a day we had our first contractors' representatives arriving to show us their wares. The very first was a beautiful gentleman with wavy hair in a plastic mackintosh who suggested we should need a *maison* for the troops, which he was competent and ready to furnish with attractive *filles de joie* (he did not bring any samples). It was necessary to explain that *Barracks Synopsis* does not make this particular provision.

Accommodation for C.E's. Staff

There was already a formidable waiting list for married quarters in Monchen Gladbach; and no prospect of married accommodation for my staff for nine months, so I obtained approval for the rapid building of twelve Officers' and twelve O.Rs.' houses on our new site. Plans existed for quarters already being built in Germany, and these were taken for immediate application to the first twenty-four houses without prejudice to our special planning. These houses were started on the 4th November and were occupied between the 5th/6th March, four months later. This achievement and that of forcing the concrete roads ahead in winter can only be appreciated in relation to the weather, which produced conditions which the Germans likened to the Russian battle front. It was the wettest winter for fifty years, with November rainfall of 207 per cent of the average. The German workman came to the rescue as he does at the grimmest times. Admittedly overtime was authorized for these early rush jobs, but we felt it would be a good lesson to the building trade in England to have seen houses started and occupied within eighteen weeks in the face of severe winter conditions.

With these achievements and the stock piling of some 9½ million Deutschmarks worth of pipes, steel, sanitary equipment, cooking stoves and kitchen equipment, and boilers for the heating installation, and by paying advances on all contracts let for standard barrack building, we were able, in fact, to pass payment for over 20 million Deutschmarks by 1st January, 1953. This fell short of the 25 million target, but was considered sufficient assurance against the danger of eventual sterling expenses.

I have already much emphasized the urgency with which it was impressed upon us to spend money. This factor dominated everything over the first five months of the project. By the 1st March, 1953, we had made payments of 40 million Deutschmarks, and by the 1st June, 55 million Deutschmarks. As the ratification of the Convention was longer and longer deferred, this particular urgency subsided. Foundations for most of the standard types of buildings had started in February, and by June the whole site was a hive of industry. If mistakes in planning have been made, it was because of the headlong rush. It will certainly be argued in the future that two or three storied barracks and messes should have been built, and would have been cheaper if more compactly sited, but in the early

days the overriding consideration was to put to contract and pay running bills for every item of work for which standard designs already existed.

Description of the Project

(*a*) Site
(*b*) Headquarters, offices
(*c*) Single accommodation
(*d*) Married quarters
(*e*) Amenities
(*f*) Services
(*g*) Communications
(*h*) Recreation grounds and site work.

(*a*) site

The nature of the site has already been described. It is 3 kilometres long and averages 1 kilometre in width. It is 7 kilometres from Moenchen Gladbach, an industrial textile town of little attraction. It is 20 kilometres from the Dutch border. The extent of the site is about 960 acres. It was full of roe and fallow deer, which used to surprise us by dashing through busy building sites months after our gross activities should have banished them to the Hardterwald. In the first winter we shot pheasants where the married quarters now stand.

History and Archaeology

Julius Caesar mentions the locality in his *Bellum Gallicum*. A Roman road borders the south of the site. A burial ground (A.D. second/third century) lies in the area occupied by the officers' messes. To the south, the village of Peel is undoubtedly Paludus (a swamp) to which reference is made by the Romans. In 1954 the nearest town, Rheindahlen, celebrated its 600th anniversary. It is clear from historical accounts that Rheindahlen was raised to the status of a town by the first Earl of Cambridge. He it was who as Count Wilhelm of Juliers was created Earl of Cambridge by Edward III in 1340 for services rendered to the English, and who in 1354 founded Rheindahlen. It also seems certain that in 1703 the Duke of Marlborough, having left his Dutch General Overkirk to guard the line of the Maas, traversed the Roman road to the siege of Bonn, and billeted some of his 19,000 Redcoats in this forest. They were Dragoons, Dragoon Guards, the Royal Scots, and other Infantry, and Artillery and Engineers.

Near our site office hut has been found a Cossack cutlass bearing the initial and crown of Alexander II of Russia, who in 1813 sent a token force of 300 cavalry to assist Wellington against Napoleon.

A Roman well and pottery works have been discovered and explored. This work is still going on.

(*b*) HEADQUARTERS

A level plateau of the right size and position, the highest part of the site, was chosen for the headquarters office block (Photo 1). The building has nearly 2,000 rooms on three floors of which the ground floor is a semi-basement, primarily for storage. It is 300 yards long and 180 yards wide in blocks with inter-connecting passages. The principles of its design were evolved at the War Office, but the details of allocation of space to branches was done by the "Q" and "ORG." staffs of Northern Army Group and 2nd A.T.A.F. respectively, with half a block for Flag Officer Germany and his Naval staff. The line plans were done by my office, and the architectural detailing by the German F.S.B.A.

The first foundations were dug and drainage work started on 9th April, 1953, after the forest had been cleared. The foundation stone was laid jointly by the Flag Officer Germany and the Commanders-in-Chief of Northern Army Group and 2nd A.T.A.F. on 1st July, 1953, by which time the roofs were being laid on the more advanced blocks.

It was occupied and Command passed to within its walls on 4th October, 1954.

The execution of the carcass work and roof was a lesson in efficient mechanical erection. There was no part of this vast building not within the arms of travelling gantries or scotch derricks from beginning to end, and material and cement were fed to their orbit of action by diesel trains from a batching plant at the east end (see Photo 2). All roof tiles were on by 30th September, 1953, after only five months work.

As was to be expected increases in Headquarters establishment and changes in plan enforced many changes on the design during the course of work. Therefore apart from the structural shell of the building, which is of hollow concrete block construction, most internal partitions were designed to be of factory-made interlocking wall plates of Heraklith and gypsum, not bonded into the floors or walls. These can be easily removed or can have doors or hatches sawn in them. They are remarkably soundproof and have the incidental virtue of holding drawing pins (so that thousands of square metres of map boarding are saved).

Apart from the standardization of office area imposed by *Barracks Synopsis* scales, there is little standardization in practice within these buildings. The functional requirements of Signals, Telecons, Cyphers Ops'. Rooms, Photographic Processing, Steel Lined Safe Rooms, and of many other specialist activities necessitated a tremendous amount of detailed planning and deviation during the course of the work.

These factors led to the full availing of the elasticity of interior arrangement that had been made possible by the adoption of easily movable internal partitioning.

The building lies within a perimeter of unclimbable fencing (to the

Photo 2.—H.Q. building. Well mechanized construction. This block is 315 yds. long.

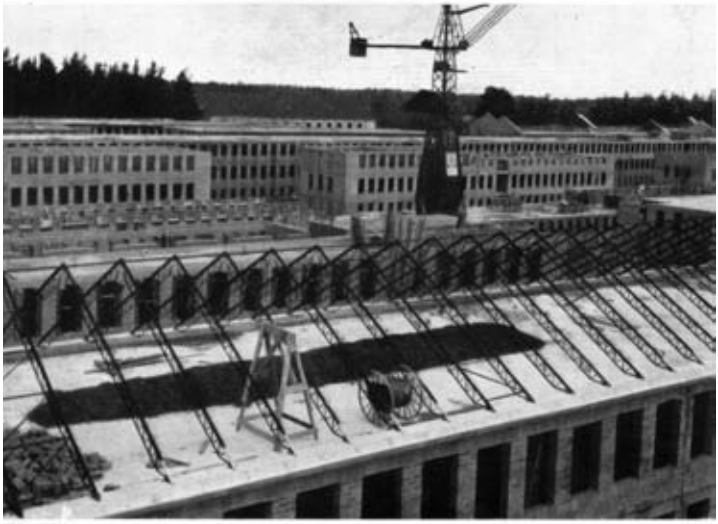

Photo 3.—The H.Q. building, showing "Filigran" roof trusses.

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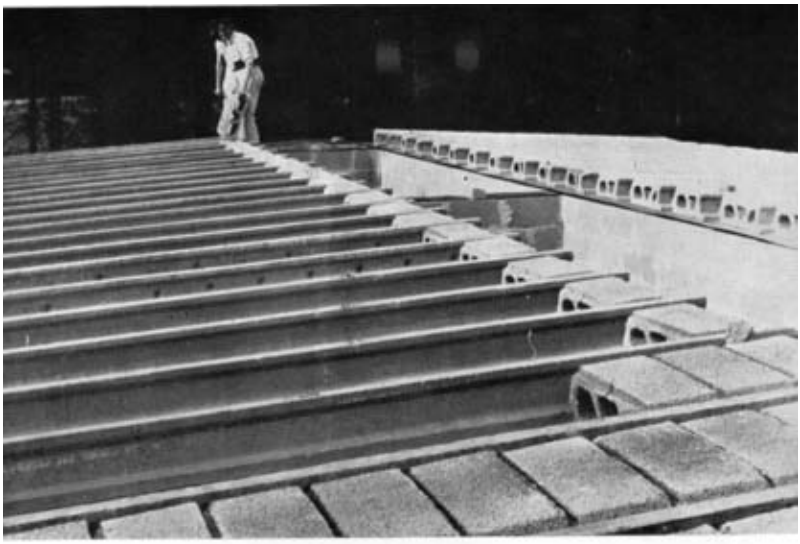

Photo 4.—One of the types of flat roof construction. Its insulation from walls by felt is visible.

Photo 5.—Standard officers' messes, with spiders of single quarters.

Photo 6.—M.T. garage. Length 1,016 ft. Span 92 ft.

Photo 7.—The 1/1000 scale model of layout.

New Headquarters In Germany 6, 7

Photo 8.—Heating duct showing concrete cover (with tarred rope seal), and Vermiculite. The glass wool plug is to contain the vermiculite at a point of change.

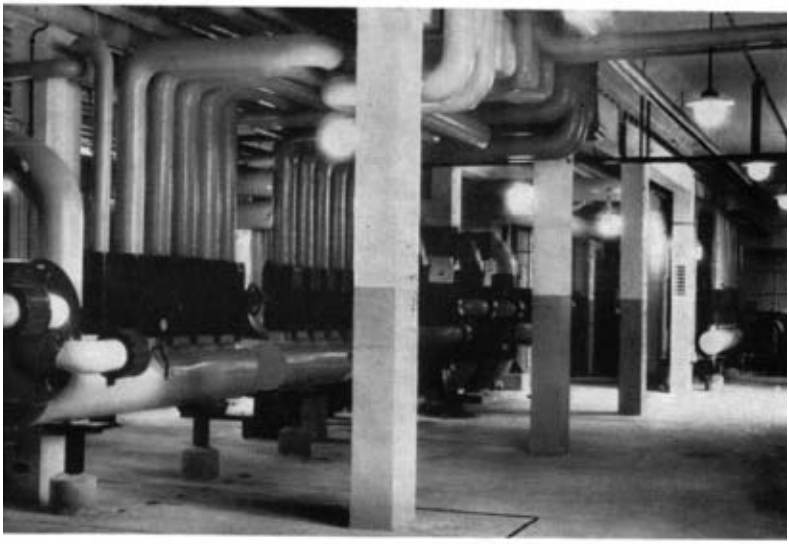

Photo 9.—The calorifier station under the Headquarters office block.

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extent that it would be unclimbable by an intruder with a guard dog hanging on to his pants). A guardroom is sited at one corner, and the area within the perimeter is liberally lighted at night.

Roof trusses are of "Filigran" light pressed steel trusses carrying tiles (Photo 3). Windows (of which there are 5,600) are steel with small panes 15 centimetres wide, so there is no need for steel bars. The degree of security for ordinary offices is then no less than that provided by any standard window with a steel grille. Windows are not hinged in the normal manner, but are pivoted top and bottom a quarter of their width from the edge; thus when they are open they can be cleaned externally by the charlady instead of demanding a window-cleaning contract, which in future would be a charge on sterling costs.

Situated within the perimeter of the Headquarters is the telephone exchange building, which was finished in October, 1953, so that the *Bundespost* (who have installed the automatic and manual exchanges therein, and are responsible for all telephone inter-communication) should have nine months in which to complete the formidable task of installation. I was told that there are something like 20 million soldered joints in the apparatus.

(*c*) SINGLE ACCOMMODATION

Barracks

Existing "Op. Humane" designs were adopted for all single accommodation. The reason has already been given. The single accommodation lies to the west of the main H.Q. block, the nearest to it being the lines of the Royal Signals and the Guard unit (Mixed Services Organization of Yugoslavs and Poles) who have night duties and therefore require to be near the Headquarters. The Army and R.A.F. personnel who work daily in the Headquarters offices are within ten minutes' walking distance of the main building. Standard barrack blocks for male and female O.Rs. of all Services are seventy-man blocks, providing living space of 60 sq. ft. per man, with toilet facilities, concentrated in the end of each block.

In the original "Op. Humane" design it was found that this type of building developed serious cracks which have called for much expenditure of maintenance money. In this project we isolated the roofs from the walls by omitting the metal ties which connected them in the original design, and by inserting two layers of smooth roofing felt (Photo. 4). This lets the roof move about without pushing the walls around. Further we inserted expansion joints at not less than 20 metres interval in every building as was done in the reconstruction of Quetta after the earthquake. It would appear that these modifications have been entirely successful.

The architecture in single storey flat roof blocks is inelegant, but is relieved by tasteful landscaping with broad expanses of grass and plantations and groups of immature trees.

Messes

Officers' messes are of similar construction. There are five 60-member messes for the Army, with an addition of an "A" mess for forty senior officers, and a standard mess for forty members of Royal Signals and R.A.S.C. which have their spider of single officers' quarters with connecting covered ways (see Photo 5). As far as possible the natural beauties of the site have been carefully used to give an atmosphere to each mess of "standing in its own grounds". The R.A.F. declined to accept two standard messes for sixty, and designed one for themselves for 120, still using the same standard type of construction.

W.O's. and sergeants' messes are similar in principle.

M.T. Garages

Barracks for two M.T. Companies R.A.S.C. are built to the west end of the site, near their vehicle garages. Garage designs were based on standard "Op. Humane" plans, but in order to eliminate the central line of supporting columns which naturally restricted the floor space (and always seemed to hit vehicles) the roof has been spanned in prestressed cast *in situ* beams, on the Remy system (see Photo 6). Garages therefore have a span of 28 metres (about 90 ft. clear). They have heated bays for L.A.D. They are functionally admirable and architecturally impressive and satisfying.

Admininstrative Offices

The Army and R.A.F. have their respective administrative camp headquarters with offices and barrack stores. There is a combined works office for the D.C.R.E. and the R.A.F. Works Unit.

M.I. Rooms, Fire Stations, Miniature Ranges, and all the normal complement of buildings for a headquarters make up the remainder of the accommodation.

German Accommodation

During the course of the years in Germany both Rhine Army and 2nd A.T.A.F. Headquarters have employed German clerks, typists, draughtsmen, personal assistants and the like, who have become key personnel in the peace-time functioning of the two headquarters. In order that those of them whom it was essential to retain should have housing in the new headquarters camp, barracks for 1,000 single Germans (half for female and half for male employees) were designed, using standard "Op Humane" sergeants' accommodation. These are at the western end of the site, and are served by a canteen whose function is the double one of providing for the 1,000 resident Germans and also for the midday meal of some 2,000 German employees who come in from the surrounding towns to work in the Headquarters.

Married German key personnel who have moved from Bad Oeynhausen and Bad Eilsen have been accommodated in 316 houses newly built for them in the surrounding villages. These were not part of our new headquarters project, but were built through the agency of German building societies. A further 190 such houses are being completed.

(*d*) MARRIED QUARTERS

To the east and south of the main headquarters building lies a township of married quarters. The total numbers included in the original plan of the Project, for Royal Navy, Army and R.A.F., were 282 Types "B" and "C" for O.Rs., and 500 Types III, IV, and V for officers up to and including the rank of brigadier. Houses for the C.-in-Cs. and other officers of general's rank have been acquired in the surrounding country, and were not part of this project.

In the middle of 1953, it was decided that the British Intelligence Organization (Germany) then quartered in Wahnerheide near Bonn should also be accommodated in the locality of the new headquarters. Hence as a much later phase of the project, another 244 houses (together with the single accommodation and messes required for the B.I.O.(G) Unit) were sited and started in the south-west extension of the site which lies to the south of the Royal Air Force playing fields. This raised the total numbers of houses planned to 650 for officers and 476 for O.Rs., a total of 1,126.

The money-spending schedule of 1952/53 demanded a very rapid rate of planning and building of the married quarters estate, which forms so large a proportion of the cost of the whole project. In August, 1952, the Federal Government had promised our headquarters that for the construction of this project we would have to deal with only *one* Ministry as our agent. This, we assumed, would be the *Finanzministerium*, whose F.S.B.A. was already established for the purpose. When, however, we got down to planning, the *Wiederaufbau Ministerium* (the Ministry of Reconstruction), who are responsible in Germany for all building of dwelling houses (as opposed to public structures) were not prepared to surrender their right to the planning of the housing estates in this Project. It had, therefore, to be conceded in the course of a succession of difficult conferences in October, 1952, that the Ministry of Reconstruction would be responsible for putting our requirements for the 1,126 houses into effect.

Previous experience had given sufficient reason for prefering the performance of the Finance Ministerium to that of the Minister of Reconstruction. However, architects were appointed by the Ministry of Reconstruction (under the nominal control of the F.S.B.A.) and were let loose on the town planning and the interpretation of our line plans and requirements for the various types of houses. This was a most unwelcome development.

It would be tedious to describe the difficulties that this dual control introduced in the planning and conduct of the married quarters construction. Suffice it to say that to design a mere eight different types of houses and to site them on the ground, a task which was promised to be fulfilled in October and November, 1952, took until April, 1953. The exasperation of the process of agreeing designs with the architects is now mercifully forgotten, but the consequences were serious, for the married quarters were not started till May and June, 1953, and to get them completed and furnished in time for the move which had been planned for July, 1954, was clearly going to tax us to the limit.

Design of Houses

German tradition demands a cellar. It is an excellent tradition. It is not provided for in *Barracks Synopsis*. The War Office was obliged to concede a half cellar for every house. The two main floors were based on *Barracks Synopsis*. There is a floor in the roof space which is good for box-room storage and also for children to play in. Houses for brigadiers or equivalent were provided with a servant's room in the attic over and above the scales. Servants are not easy to get in the Rhineland, nor will they be easily afforded after the financial privileges granted under the Occupation Statute are withdrawn, so in general the houses are designed to be run with the minimum of help, as at home. The architecture has many German characteristics about it, and is somewhat unattractive to our tastes. Officers' houses were built 3½ to the acre and O.Rs.' seven to the acre, which is less congested than the scale laid down by the War Office or for housing estates in England.

Even so the effect is thoroughly suburban, especially as only the Type III houses are detached, every other type of officers' house being in semi-detached pairs, and the type "B"s in terraces of four houses.

Building started in June, in about twenty-three different contractors' lots, under the direct supervision of eighteen architects nominated by the Ministry of Reconstruction. In command of all these architects was he who had been appointed to design the houses and their lay out, and with whom during those maddening months of work over the drawing table, we had eventually come to agreement in design.

In the planning of houses, the latest labour-saving features were given emphasis. The kitchen has a gas cooker, a refrigerator, a sink with hot and cold water, draining board, plate rack and ample cupboards and work-tables. In the case of officers' houses a hatch leads to the dining room. Floors on the ground floor were of oak and beech parquet and upstairs in Marley or similar tiles. In concession to English tradition a fireplace was provided in the drawing-room of

every officer's quarter. This was in addition to the ample central heating. It is a much appreciated amenity. German architects thought we were queer! Two heating coils were fitted in the linen cupboard, one heated off the central heating, and the other connected with the hot-water circuit, so that a degree of warmth is ensured in winter or summer. Similarly, the bathroom has a small radiator and a hot towel rail off the hot-water circuit. A radio aerial was incorporated in the roof of every house. This, of course, was extra to *Barracks Synopsis* scales, but will save a forest of unsightly amateur aerials slung over the roofs.

In Service populations it is found that about 5 per cent of officers and men have five or more children. Such "outsize" families are normally allotted two houses. We therefore provided interconnecting doors on each floor of 5 per cent of pairs of semi-detached Types V and Type C quarters.

Large families so accommodated have expressed themselves very conveniently housed.

Prototype Interiors

By August, after two months work, we had internally completed one house of each of the eight different designs. These were then furnished to scale by the R.A.S.C. Barrack Department. Committees of ladies, the wives of Army and R.A.F. officers and O.Rs. ranging from brigadier to corporal, were invited down from Bad Oeynhausen and Bad Eilsen to criticize the finished fittings and furniture. Particular attention was directed to the kitchens, which had been initially designed by mere men. There were several visits, and there was seldom much unanimity of opinion, but the average findings of the Committee were of immense value. Thereafter, we knew exactly what was required for the other 1,100 houses and were able to plan accordingly. At the same time, those responsible for the design and provision of furniture, carpets, curtains, etc., were able over the course of the next year, to make modifications in their scales to suit the houses as they would be built. The value of this fearsome enterprise (the deliberation of a ladies committee) cannot be overemphasized.

Gas Cooking

I have touched on gas cooking. German gas ranges are very much behind the times compared with the equivalent article at home. For an order of this size we were able to make the manufacturer of the ranges modify his ideas to suit the British housewife. Ovens were made large enough to take a turkey. Grills for toasting and grilling were incorporated and at a later stage a "Regulo" thermostatic control was fitted.

Services

The central heating which is piped to all houses is described later. The male reader will have appreciated that when he is posted to this station he will be free from such chores as humping coals in the early morning. Drainage was of course by water-borne system.

Estate Planning

In the planning of the housing estate provision was made for a common grass area between the road and the front door with access paths, and decoration by flowering shrubs, etc. The maintenance of this would be a "municipal responsibility". On the private side of the house each house was provided with a garden small enough to be tended by a householder of average keenness. It is surrounded by a dog-and-child-proof fence and has a small shed for garden tools, prams and bicycles. This feature was an essential but expensive outcome of the deliberations of the ladies' committees supported by the D.D.W. The exterior plaster colours of houses were chosen by a committee of architects. Four pastel shades were distributed broadly over the estate. The exterior painting of windows and doors was selected by a committee of officers and ladies. There was some diversity of opinion among them, but their average taste prescribed a variety of bold plain colours. There was German participation in these exercises. The general effect, set in surroundings of grass and natural trees, has been to give enlivening variety to the estate. The utmost advantage was taken of the existing trees on the site to screen houses from their view of each other and to give a rural effect.

(*e*) Amenity Buildings

(i) *Schools*

A primary school for 450 infants is provided in two standard B.A.O.R. type school buildings, so placed as to be within children's walking distance of most of the housing estate, with the minimum of main roads to be crossed. They are sited to catch the maximum of sun, and were designed with the classroom outlook almost entirely of glass. A third infant school of the same type was incorporated in the south-west extension with the further 244 houses which were approved to be built. The secondary school, which was not originally part of this project, but which had been under consideration to serve Army and R.A.F. stations west of the Rhine, was at a later stage sited within the new headquarters perimeter. Though it was started only in June, 1954, it was opened for the September term, 1955. It is a non-boarding school, catering not only for the considerable population on site, but also for the Army and R.A.F. units within transporting distance.

A misappreciation of the fecundity of the forces has thrown out the calculations which governed the provision of school places. In 1952 when the project was planned, the figure for children of primary school age was .55 per family. It has now proved to be .76 per family. Schools are overcrowded. Another primary school has just had its foundations laid on the site to meet the unforeseen demand.

(ii) *Shops*

A N.A.A.F.I. shop, Y.M.C.A. book shop and Malcolm Club shop with canteens, are sited in the amenity centre of the estate. The only detail worth noting in this group is the N.A.A.F.I. shop main hall, where the heating radiators are placed in the ceiling so as not to interrupt or desiccate wall space for show cases.

An area of three acres was earmarked in the zoning plan for the erection of German shops under private enterprise. Although this possibility was presented to the local Chamber of Commerce and the German Government very early in the planning, it was not until November, 1954, that loans had been negotiated to make the private building of German shops possible. Some thirty shops will be ready during 1955. In the same area B.P. erected at their own cost a petrol pump for private cars and a small servicing station.

(iii) *Churches*

A Church of England for 500 and a R.C. church for 300 were in the original project in Phase III. Later, the Free Churches and the Church of Scotland obtained approval to the building of a third church. The design of these involved some months of collaboration between German architects, padres and myself. Whether the designs meet with approval is a matter of personal taste. The third church was blessed (in an unfinished state) by the Moderator of the Church of Scotland in May, 1955. The Church of England was dedicated by the Archbishop of Canterbury on the 18th September, and the Roman Catholic Church jointly by Bishop Keenan and the Cardinal Archbishop of Cologne on 9th October, 1955.

(iv) *Cinemas*

There are two cinemas. One for 600 operated by A.K.C. and the other sponsored later by the R.A.F., run by their cinema service. The former was of high priority and was opened in June, 1954, for the benefit of those already living on the site. The latter was not started till the autumn of 1954. Both are of the latest design employing Cinemascope and stereophonic sound. Both were designed for smoking to be indulged in, but only the R.A.F. permits smoking.

(v) *Hostels*

An officers' hostel for forty-two families and an O.Rs. hostel for

thirty families with private rooms and communal dining-room and ante rooms were planned and erected for the reception of families from England who thereby are enabled to join their husbands promptly in anticipation of quarters on the estate falling vacant.

A visitors' mess embodying the same principles of design provides for touring officers and their families who may require a few nights in the station.

(vi) *Clubs*

An officers' club for 750 designed to be operated by N.A.A.F.I. was sited in the most attractive part of the grounds. There are many special features of internal design and finish, which gave to all concerned with it much interest and satisfaction in the planning. N.A.A.F.I. architects took over the internal architecture and in combination with their furnishing experts from England they produced a building of singular attraction. It has three squash courts, skittle alley, billiard room, gents' and ladies' hairdressing saloons, and a small shop and a goldfish pool as necessary adjuncts. Fourteen officers' tennis courts lie near it.

By private enterprise a 9-hole pitch-and-putt golf course has been laid out on the green sward fronting the club and H.Q. building.

A small sergeants' club in the sergeants' mess area provides some of the same amenities for W.Os. and sergeants and their families on a smaller scale.

(vii) *Junior Ranks' Clubs*

Junior ranks' clubs for 1,250 for the Army and 750 for the R.A.F. are sited conveniently near the men's lines and give club amenities unsurpassed in any other station in the world.

A regrettable lesson has been learnt in the men's N.A.A.F.I.s In planning I adhered to the theory that if men are given a place to be proud of they will value it—and against advice I prescribed parquet floors for the main rooms. They are now burnt beyond recognition with cigarette ends. The task of cleaning them is a great burden on the staff. It is apparently considered "soft" by a certain type of man in both services to use an ash tray.

This is a trivial point, but it has its lesson. Linoleum would have been suitable and labour saving.

(viii) *Swimming Pool*

A swimming pool of Olympic standard dimensions, with a 10-metre diving-board, is sited in the corner of the Sports Grounds, equally distant from the O.R's. barracks and the Married Families estate. The main peculiarity of this pool is that a small rectangular bay extruding from one side of the bath provides the deep water into which high divers can hurl themselves without the danger of landing

on top of rising swimmers, polo players or children. It was found that by giving the main pool two shallow ends and a deep middle (7 ft.) and by building the rectangular bay for diving (15 ft. depth being obligatory for a 10-metre dive) there is actually less excavation and building. We think this is unique. It is certainly attractive.

(ix) *Gymnasia*

Two gyms started late in the project have just been completed.

(x) *The Model Room/Theatre*

A headquarters of this size and function requires a tactical model room and lecture hall. This was not included in the first schedule of the scheme, but approval was obtained by the late Chief of Staff, and added as a deviation to the project. In the course of planning, it was found possible to give it the additional function of a theatre. It was started late in 1954, and since completion has served admirably in both the purposes for which it was designed. It is sited near the main Headquarters for its military purposes and near the officers club for its social function.

(xi) *Private Garages*

The War Office relegates private garages to the status of an amenity, that is why it finds itself in this paragraph. A concession of garages for 50 per cent of the number of houses was included in Phase III of the main project. Approval in detail of the building of this item was not granted until the project was half finished. Garages therefore (with the exception of those which had been designed to be part of the house of a brigadier's Type III quarters) were sited in blocks spread conveniently over the housing estate. These are not convenient. They are the cheapest possible, and without electric light or heat. They were difficult to site, and for the owner who arrives back in his car on a snowy night, and has to walk two to three hundred yards to his house after putting his car away, they give little satisfaction. Much more distressing than all this is the fact that in the twentieth century many more than 50 per cent of a population own cars. The surplus cars now clutter up the roads in front of people's houses, and make it impossible for ration lorries, road cleaning machinery and conservancy wagons to get past without mounting the kerbs and turf. The result reflects badly on the planners. However, the planners *did* plan the roads in accordance with the standards laid down in the English Town and Country Planning rules. In a properly planned town a car owner has a garage or at least a run-in, and does not have to leave his car on the road. As it has been impossible to overcome official resistance to building a rational scale of garages, it has become necessary since the occupation of this town to widen many of the roads. The cost of this must be

considerably greater than would have been incurred in providing garages. This criticism may show reprehensible disloyalty to those who lay down scales, but it seems, however, the more justified by the fact that if garages had been built out of German Occupation Deutschmarks they would subsequently have earned sterling rents.

(xii) *Education Centre*

A large education centre with all the normal facilities for military education has been provided in the amenity centre of the town. Besides the usual provision it houses the Command library, and provides a room for a museum containing archaeological relics found on the site, and pictures and objects of worth lent by the museums at Bonn and Moenchen Gladbach. A scale model of the site at 1/1000 which was completed in December, 1952 ((see Photo 7) and largely used during the course of the work for purposes of planning and lecturing, also finds itself a permanent home in the museum. A German travel agency has set up a sub-office in this building for the convenience of the population.

(xiii) *M.I. Rooms*

There is a small hospital containing the Families M.I Room, Dental Centre, S.A.A.F.A., and Ante-Natal Clinics for the station. There are Men's M.I Rooms in the Army and R.A.F. barrack areas.

(xiv) *Fire Stations*

A fire station under R.A.S.C. control manned by German firemen is sited in the centre of the area.

(xv) *Post and Pay Offices*

There is an Army post office and a cash and pay office near the Headquarters block.

(xvi) *Clocks*

Clocks of appropriate size with aggresive faces are sited at convenient points on the estate. These, together with the clocks suspended in the intersecting passages of the main Headquarters, are all operated by a master clock in the Signals Centre, and ensure that nobody walking or riding to work can be late without being aware of it.

SERVICES

(*a*) *District Heating and Hot Water*

No attempt is made in this description to be technical on E. & M. matters. My E. &. M. officer, Major White, is writing a technical account for the *R.E. Journal*. It was decided early in the planning that heating and hot water would be provided from central boiler

houses burning coal. This is the cheapest fuel in the vicinity of the Ruhr. Owing to the shape of the site this was most conveniently achieved by dividing the area in half and providing two boiler houses. In the zoning plan the eastern half, which included the first 882 houses with schools, hostels, shops and the main Headquarters building, was allotted to one boiler house which was placed at the eastern end of the site. A criticism of this siting has been that the boiler house is not in the centre of its load, but past experience had shown that the curse of smoke nuisance made it expedient to site the boiler house on the lee side of its load.

The western half of the site, consisting of barracks, messes, garages, etc., was covered by a similar boiler house, sited to the north of that lot, for the same reason. The eastern boiler house has ten boilers and the western boiler house twelve, each boiler being of 2.0 million kilocalories per hour capacity. This allowed in the original planning for about 20 per cent unforeseen expansion. The main Headquarters block, which uses 5.5 million kilocals/hour, was designed primarily to be run on the eastern load, but can be supplied from either boiler house. The two high pressure hot-water systems are interconnected at two other points, so that in mild seasons one boiler house could carry the total load of the estate, and in the summer, when the heating is not required, a few boilers in either boiler house could sustain the hot water and cooking demand. In June, 1954, when the south-west extension of an additional 244 houses with schools, messes, etc., was sanctioned a third boiler house of four boilers was incorporated in the plan for that extension. In principle, the functioning of this separate boiler house is similar to the other two, so no further mention is made of it.

Fuel is brought in by 6-ton tipper wagons, which were bought for the purpose. The provision of rail services for fuel to these boiler houses was dismissed in September, 1952, when planning started. It was unfortunately re-opened again in September, 1953, when it was too late to be feasible. Tippers dump the coal into a pit at each boiler house. This gives 1,300 tons reserve, which at the maximum demand of 100 tons a day per boiler house in the sharpest winter allows thirteen days reserve. The fuel pit is covered by a gantry, on which runs an electric travelling grab which hauls up 1 ton at a time and carries it into the hoppers high above the boilers. Therefore, instead of the master of each individual house doing his early morning coaling chores, one mechanical operator at the boiler house does all the work which would otherwise be required in 900 houses and other buildings. The hoppers over each boiler each hold 10 tons, which is a winter day's reserve. Fuel which is in the form of granular nuts falls on to the moving chain grate, the speed of which is adjusted by a four-speed gear-box to give the depth and intensity of fire required for the season. At the end of its run the

chain grate tips ash into a vast helical corkscrew which mechanically draws the ash into wheeled tubs, in which it is pushed by attendants into a lift and carried out of the boiler house above the ground to the ash pit. Thence the mechanical grab loads it into returning tipper wagons. The whole conception is designed to save labour.

The boilers (at full load) generate steam at 10 atmospheres pressure and pass it to a cascade, where it is mixed with the returning cold water in the distribution system, and heats the water to 175° Centigrade in the storage cylinder.

The hot water at 10 atmospheres pressure and 175° C. is then pumped from the boiler house through primary heating circuits. These heating circuits enter calorifier stations (of which there are seventy-one over the whole area), and provide heat for secondary circuits, one of which pumps hot water through the radiators of the buildings, and the other heats the inflow of domestic hot water to provide for the hot water taps in all dwellings and barracks. Direct high-pressure hot water is supplied to cook-houses for steam heating. There are no troubles due to hardness or impurity of water, because by good fortune the water in this locality is neutral and fairly soft.

There are over 1,000 miles of pipes for all purposes in this camp, a high proportion of which serve the heating and hot-water installations. Piping is of wrought steel of various sizes from 7½ in. for the mains, down to ½ in. for the house services. All is joined by welding; most of it was welded during severe winter seasons—and reflects much credit on the German worker. All systems were hydraulically tested to 2½ times their working pressure.

The pipes run in brick-work ducts underground with pre-cast concrete cover plates. The normal practice in the past has been to lag pipes with magnesium 80 per cent or glass-wool lagging. It had been represented to the planners early in the project that in a heating scheme in Holland, all main arteries and subsidiaries were lagged with a new material which was quicker and cheaper to employ. I therefore sent Major White and his German counterparts to see district heating installations at Schipol airfield (Amsterdam) and in Hamburg where the new system had been employed, and to judge their efficacy together with the engineers who had been responsible for them. The new system consisted in building a watertight duct of very much smaller cross section, in which the pipes were laid naked and then packed in with a light insulating material called vermiculite. This is a micaceous mineral mined in Africa, which when subjected to heat in a furnace at 900° C. exfoliates into a light mass, rather reminiscent of those comic little fireworks one finds in Christmas crackers.

The exfoliated material which looks rather like granulated cork, and is very light, arrives in paper sacks, and is loaded into the ducts

around the pipe and is levelled off with the top (Photo 8). The filled ducts are covered with concrete slabs and made watertight with strips of roofing felt, tarred over and covered up. The virtue of this system lies in its speed and cheapness. Difficulties of maintenance and of the diagnosis of leaks were discussed for a period, and it was eventually decided to adopt the new system not only for cheapness, but for speed. A vital pre-requisite of this method is that the vermiculite shall remain dry, so it was important that ducts should be waterproof and not laid in waterlogged land. At swan-necked expansion bends, where movement of the pipes is taken up, traditional lagging with glass wool was adopted. (The expansion at the bend is 27 cm. from the 100-metre length to the anchorage of the pipe for a range of 180° C. of temperature.)

At this stage it is appropriate to remark that in the exceptionally bad weather of August, 1954, when 3.4 in. rain fell in one night, while all the heating was under test, the man-hole covers in many instances were open to the flood. There was a gloomy period when the water and mud ran into some of the ducts and was quickly boiled by the super-heated pipes, and blew up a considerable length of the ducts. These teething troubles appear, in the intervening year, to have been eradicated. The new lagging system does not appeal to all E. & M. experts. Figures of performance have not yet confirmed the assertion that heat losses by this method are not materially greater than those by traditional methods. It appears that this is the case provided the vermiculite remains dry and in place.

All the seventy-one heat exchange stations work on the same principle, they are varied in design according to siting and load. Some of them are above ground, others in cellars below buildings or houses (see Photo 9). There were distressing cases of early teething troubles when groups of houses received inadequate heat and hot water, but this has been a matter of balancing and adjusting, and has been cured.

(*b*) *Electricity*

By the end of 1952, a temporary overhead system, supplied from a public service, had been established on those parts of the site where contractors needed power for their work. This was extended *ad hoc* during the course of the project.

The permanent distribution system supplied at 15,000 v. from Rheydt, consists of an underground ring main round the site. There are seventeen transformer stations supplying low tension electricity to all buildings. A stand-by generator set is installed near the main Headquarters, to serve that building and the telephone exchange, and at each of the boiler house installations, and at the water works.

Standby sets are particularly important in boiler houses where there are twenty-eight separate electric motors, including the main

ones driving the high pressure hot-water pumps which supply the circulating system. A break-down of the supply to these during cold weather peak periods would be highly inconvenient, for it would be impossible with the few boiler attendants employed to draw fires quickly. Pressure within the boilers would rapidly rise to blow-off point, and it would take some time to restore balanced functioning.

The street lighting for this town is based on British standard practice. Mercury vapour discharge lamps are used and the system is controlled by time switches. For economy of power consumption the lighting in the main office building, and in clubs, messes (and in fact everywhere where it is expedient) is done by the use of fluorescent lamps of various kinds. The capital cost of this form of lighting is two or three times that of tungsten filament lighting of equivalent intensity, but the electrical consumption is reduced thereby to about 35 per cent.

(c) Drainage

Foul water drainage is by a normal water-borne system. In September, 1952, we obtained ready-made plans for a sewage disposal works already built on a similar site in the American Zone which we proposed to site in the lowest part of our estate. I had hoped that this could be put to contract immediately so that it would assist towards swelling our expenditure, which was then ever in our minds. The German authorities were anxious, however, to combine our treatment on this estate with their plans for the long-term development of the drainage of their neighbouring villages. After some conferences on the subject we eventually made a grant-in-aid (equivalent to the sum which we would have spent on the sewage works) towards a comprehensive scheme which was planned and carried out by the Stadt Moenchen Gladbach. Our system now falls by gravity to a collecting chamber in the north-west corner of the site whence it is automatically pumped by rising main straight across the site to a public collecting chamber at Genhodder, 1 kilometre to the south of our estate. From there it is pumped by the Stadt authorities 13 kilometres, over a rise of 15 metres, to an up-to-date sewage works north of Moenchen Gladbach.

Storm Water Drainage

On the whole the site drains well. The soil is substantially sand and gravel with a loamy top soil bearing heather and fir trees. It is not unlike that of Camberley Heath. There is, however, in its top ½-metre an annoyingly fine silt, almost approaching clay, which when puddled up by machines and tyres becomes pretty impervious. On this account the performance of the site in draining itself has been less good than was expected.

Drainage gulleys are provided on one side of all roads with a cross

fall to them. Roofs of all houses and buildings are provided with down pipes to gulleys, which discharge into the road-side system and eventually gather to a 1-metre pipe away in the low ground in the north-west corner of the site. Thence a natural stream, which was broadened and canalized, takes the storm water away to a near-by river.

The general conformation of the ground is a little flatter than would have been desired for ideal conditions, but no mechanical boosting is provided or has proved necessary either in the foul-water system or in the storm-water system, although some of the slopes of drains are less steep than is demanded by English practice. Both systems work, and since completion have not given much trouble in maintenance.

Test holes were dug all over the site in the early stages of the project to enable an appreciation to be made of the inherent drainage qualities of the land. On the whole the site absorbs all but the most violent rainfall fairly well, but it was proved in the first summer that some of the large areas of grass playing fields required agricultural drainage to free them from the formation of lakes. Over a small proportion of the playing fields herring-bone systems were dug in after the grounds had been finished. These led to the main drainage system, and have proved successful. The quality of playing fields is now very good, having been rendered more absorbent by the activity of roots and of worms.

I was confident in the early planning that much capital economy could be effected by using soak-away pits in the married quarters estate rather than connecting pipes to main drains. I overruled the German authorities on this point, against the advice of some of my staff. I proved wrong, for soak-aways would not function speedily enough, and we had to connect up much of the housing area to the system later. Moral: be cautious in ignoring specialist advice.

(d) Water Supply

In the site reconnaissance in August, 1952, I was glad to know that German water works existed at three points, within 8 kilometres of the site, and to have the assurance of the German authorities that these could be developed to supply sufficient water.

One of these, the one at Rheindahlen, was called upon immediately to supply water in temporary measure for contractors during the period of building. A 5-in. pipe was laid in September, 1952, for this purpose from Rheindahlen, a distance of 3 kilometres, to the south-east end of the site. On 6th September, 1952, the main water supply rings within the site had been planned and the laying of these mains (10-in.) went ahead during the winter. By February, when contractors were on site to start building, a temporary water supply system had been established, fed from these mains.

At this stage it cannot be over-emphasized that the general level of tendering for building work is substantially reduced if roads, water and electricity exist at the tendering stage or are known to be available when work starts. Therefore, we were very keen to have these three items established as early as possible in the spring, and in this, due to the German workmen's capacity for carrying on in the worst winter weather, we were successful.

As for the permanent water supply, chemical analysis of water from public undertakings showed that the waters available were hard and distinctly alkaline. At the same time it was observed that the local well supplying the hunting lodge of the owner of the site *in the middle of the estate* gave good water from a depth of 7 metres, which was both soft and neutral. I was, therefore, interested to see whether we could develop our own water supply to become wholly or partially independent of public supplies. This was additionally important from the point of seeking a good benevolent water for the extensive district heating system. Consequently a bore hole was put down and as expected water was found at 7 metres, but the bore was continued through a heavy clay stratum from 15 to 20 metres—*whereupon another source of water in a gravel and sand stratum was struck.* The bottom of this water-bearing stratum lay at 26 metres, where black clay was again encountered. This continued down to 40 metres depth, so boring was stopped. The water at the 20–26 metre depth proved to be soft and slightly acid. The most encouraging feature of this was that when the water-bearing stratum lying between the two clay layers was penetrated by the bore, water was forced up 10 metres above its imprisoned height by artesian effect. This indicated, I thought, that the field was a large one deriving its artesian pressure from the Dutch frontier hills. It therefore became evident that further exploration might prove advantageous and provide water of acceptable quality to satisfy the whole or part of the needs of the new town. At this juncture (March, 1953) I called in the German geological experts, who gave the opinion that there was insufficient water under the site because a geological fault running north to south through the very centre of the site would prelude the extension of the water-bearing stratum to the east of that fault, and because the River Schwalm running north and south, 1 kilometre off the west of site, would in their estimation prove to be the western boundary of the water-bearing stratum. On this advice the F.S.B.A. refused to continue water exploration. I was at this juncture very strongly backed up by my Chief Engineer and the staff who issued a letter ordering me to go ahead with explorations for water, on the grounds that for security reasons this Headquarters should be independent of public supply to any extent which might prove possible. I therefore continued exploration, and the F.S.B.A. continued to bore holes where we directed them.

During the course of the summer, it was proved by trial boring that the "sandwich" (the water-bearing stratum enclosed above and below by impervious layers of clay) extended horizontally at approximately the same level of 20 metres below the ground over an area of some 27 sq. kilometres. Seventeen bores were put down, some of them lying well out on the perimeter of the area in which I had reason to believe water would be found. They all gave this well defined sandwich of strata, and pumping from the wells produced similar water everywhere, a soft and slightly acid water. It is interesting to note that one of the outlying test bores in this exploration was put down within a quarter of a mile of the existing Uverkoven water works. *This proved by analysis that the water for which we were prospecting was from a different source to the water at that water works, only a quarter of a mile away.* Ours was soft and acid, theirs was hard and alkaline. The original German prospectors appear to have missed our source of water by a very small margin.

The reason why our source of water was unknown to the German authorities and not previously discovered, is that the area is rural and sparsely populated. For the farms fresh water had been found at 7-metre depth adequate for their purposes and the need to dig deeper had never arisen. My invitation to the geologists to comment on my findings (of which of course I sent them full reports) was never accepted. I do not think it is scandalous to suggest that public water undertakings, who are anxious to expand their services, do not encourage the development of supplies which will be independent of their provision.

In the final design of our water works an experienced consultant was employed to plan our development. Four 80 cm. tube walls were sunk on the site, from which water is pumped to the new water works for treatment and distribution. Deep well pumps of 100 m^3/hr. capacity installed in the well filters are controlled by push-buttons at the water works. Water is discharged in the top of the building through a spray aeration system, thence through sand filters, and chlorine dosage plant to two underground reservoirs, each of which holds 2,000 cubic metres (440,000 gallons). Planned at 75 gallons per head per day, of a population of 10,000, this gives a reserve of more than a day's supply. In fact, since the occupation of the Headquarters, the consumed rate has been considerably less than this figure, varying between winter and summer from 40–55 gallons per head.

Water is pumped by electrically driven centrifugal pumps via air pressure vessels into the mains. The function of the pressure vessels is to replace the necessity for an overhead tank. They create a head of 6 atmospheres on the water at source. The supply pumps cut in and out automatically as water is drawn off from the pressure chambers. For fire-fighting purposes the pressure can be boosted up very rapidly

to 9 atmospheres. The fire hydrants are placed on the water mains and branches.

In the development stage, exhaustive pumping for three weeks showed that after an initial drop in level in the bore holes, the pumping level remained constant. This does not prove conclusively that the source of water will last for ever, but at the normal rate of supply to this town, a source of 27 square kilometres in extent, averaging 5 metres in depth, will in fact last for forty years without being replenished seasonally. The sources of replenishment of water in this stratum has not been discovered, but it is reasonable to suppose that there is in fact a seasonal topping up of the source of supply, and the source can be said to be established, and permanent, and is of good quality. An important point of interest is that the normal supply rate for water from public undertakings in that locality is 25 pfennigs per cubic metre. (Supply companies were willing to reduce this to 20 pfennigs for our bulk supply). This would have cost about £20,000 sterling per annum to keep the Headquarters supplied. The running of the newly established water works has not yet been costed over a full-load working year, but it is thought that it will be appreciably cheaper than the public supply. A great saving in maintenance will result from the avoidance of the aggressive waters which would have been drawn from public undertakings, the effect of which on heating and pipe system would have been most adverse.

I was gratified when sitting at lunch with a visiting American colonel one day, when he raised his glass with a twinkle in his eye and said: "Say, this is as good as a cocktail." The Americans are supposed to be judges of water.

The moral of the water story appears to be that one can sometimes ignore specialist advice.

(e) Gas

The cookers in 1,126 houses and in the two or three dozen messes and canteens are run off gas. (In men's cook-houses and canteens there is also steam cooking off the district heating, and electrical frying, but the main running is by gas. There is no handling of solid fuel anywhere in this estate). Gas in the Rhineland is supplied from the coke ovens near Duisburg, some 30 miles away from this site; it is fed into a high pressure pipe grid which serves Moenchen Gladbach. A high pressure line was laid from Moenchen Gladbach to the eastern end of the Headquarters site, where break-pressure valves in a small chamber pass gas at domestic pressure to the mains in the new town. The gas is of excellent quality and at constant pressure.

(f) Telephones

A sum of DM7¾ million was included in the scheme for the establishment of Signal services within the Headquarters. This was not an R.E. responsibility, but a word about them is necessary.

Automatic and manual telephone exchanges, the provision of which was included in this sum, absorbed the major part. All officers' houses besides offices and technical buildings, are connected to the exchange. Work of establishing this system was done by the *Bundespost* (German G.P.O.) authorities on behalf of SX Branch. The work impinged to some extent on R.E. Works, because together with our underground services, it made still another trench-digging activity calling for co-ordination with our many excavations, and confusion was not uncommon.

Signal services also included the land lines from the radio receiver stations and transmitter stations, which were built by us and which formed part of this project. The receiver stations, separate ones for the Army and R.A.F., were built, with a network of forty masts, 2 kilometres to the north-west of the main Headquarters site. Transmitter stations very similar in layout and also with forty masts were built near the city of Rheydt, 5 kilometres to the south-west.

(g) Communications

The main railway from Düsseldorf, via Dalheim to Holland, runs 3 kilometres south of the site. The nearest railway station is at Rheindahlen (3 km.) and Moenchen Gladbach (7 km.) away. The latter is used as the main railway station.

The two main roads from Moenchen Gladbach to Holland, via Roermond and via Aachen, run within 3 kilometres of the site to the north and south respectively.

For air communications there is the R.A.F. station at Wildenrath, 15 kilometres away, and the civilian airport at Düsseldorf is little more than one hour's drive from the site. There is no Auster strip, but helicopters can and do alight at the front door of the main Headquarters block.

There are efficient tram services to Moenchen Gladbach on the main roads described, and thanks to the planning and stimulous of the British Resident, in combination with the local bus companies, four different transport services run their new buses through the site and to the adjoining towns.

(h) Recreation Grounds and Site Work

The site was untouched forest with great clearings devoted to saplings and small trees. It appeared that the task of establishing recreation grounds and landscape in the spaces would not be so complicated as in the standing forests, but in fact, almost the whole area was studded with stumps of previous growths of conifer trees. In the original zoning plan the pattern of forest roads and the disposition of cleared space had a large influence on the layout. We all quickly concurred in the general shape of things, and it was not difficult to demonstrate to senior officers, up to the C.-in-C., how the layout and landscape would fall into its natural place. The

German authorities, not without reason, were apprehensive that we might be ruthless in the destruction of the natural amenities of the site. In fact, within our own staff we had very definite views about landscaping and in the main these fitted in very well with the sentiments of the British and German authorities who were concerned with the preservation of the natural surroundings.

The provision of sports grounds and grass was broadly defined by what we could do under the authority of *Barracks Synopsis*. The R.A.F. wanted their games area separate, and the Army wanted theirs with common facilities for all, provided by the garrison grounds in the centre of the site.

A central open space also fitted in with the architects' and planners' conception as giving a fair uninterrupted vista from the comparative eminence of the main Headquarters building.

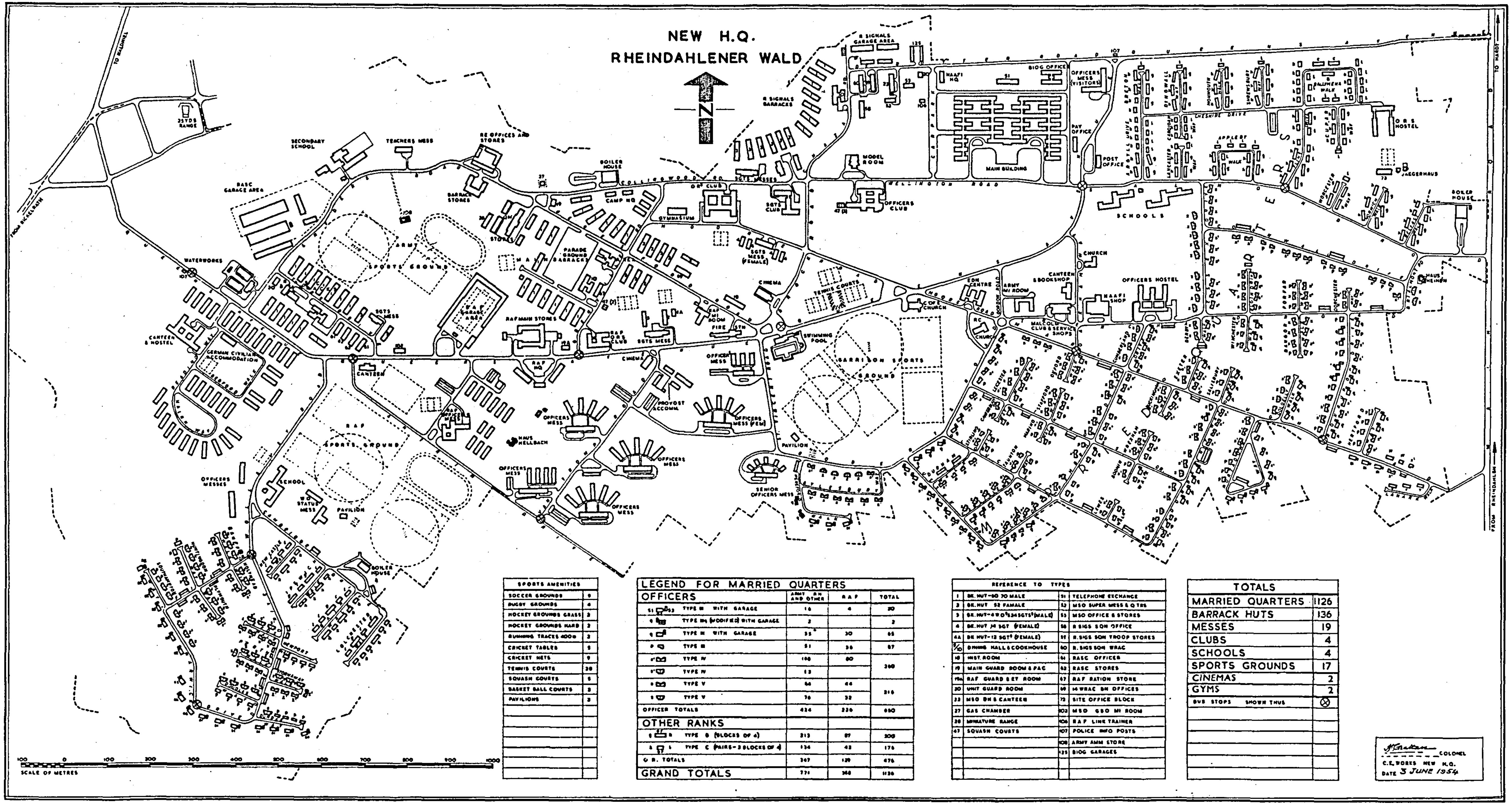
In order to allow the maximum development of turf we were keen to get the main grass areas, including the playing fields, down to grass in the first year of work, so that when the Headquarters moved in they would have mature turf to play on. It was easy once the zoning plan was fixed to give orders for the development of these areas. They amounted to some 300 acres. The work of converting this land to turf was considerable. It involved felling trees, uprooting stumps, ploughing, tearing out roots and stragglers, re-ploughing with fertilizers and lime mixed in the soil, harrowing and rolling and sowing. Experts on soil analysis were brought in and our contracts for this work were based on their recommendations, which were given in detail, including weight per square metre and types of seed which was suitable to the soil.

In all, some 200,000 major roots and 750,000 small roots were removed. The successful contractor who did this part of the work (and who also did the clearance of roots and ground treatment of playing areas) devised an ingenious machine for root extraction. This consisted of an R.B. 19 Back-actor, with a vast steel walrus tooth, which was plunged into the ground on the far side of the root stump and tore the root out in one motion. It was a pleasure to watch the monster working.

The main areas were seeded to grass, not as early as we had hoped, in June and July, 1953. In the wet summers of 1953 and 1954 conditions were admirable for the development of turf (if for nothing else), and by the time the Headquarters moved down in October, 1954, much of the area was covered with good playing fields and grass. After financial resistance had been overcome pavilions were approved. Equipment for games fell within *Barracks Synopsis* scales.

Landscaping

The opinions of senior officers as to the treatment of trees varied between wide extremes. One would find the heavily forested country oppressive, and with a sweep of the hand would adjure me to see



SPORTS AMENITIES	
SOCCER GROUNDS	9
RUGBY GROUNDS	4
HOCKEY GROUNDS GRASS	2
HOCKEY GROUNDS HARD	2
RUNNING TRACKS 400m	2
CRICKET TABLES	5
CRICKET NETS	9
TENNIS COURTS	20
SQUASH COURTS	5
BASKET BALL COURTS	3
PAVILIONS	2

LEGEND FOR MARRIED QUARTERS			
OFFICERS	ARMY RN AND OTHER	R A F	TOTAL
TYPE III WITH GARAGE	16	4	20
TYPE III (MODIFIED) WITH GARAGE	2		2
TYPE III WITH GARAGE	35*	30	65
TYPE III	51	36	87
TYPE IV	108	80	200
TYPE IV	12		
TYPE V	66	44	218
TYPE V	76	32	
OFFICER TOTALS	424	226	650
OTHER RANKS			
TYPE B (BLOCKS OF 4)	213	87	300
TYPE C (PAIRS - 2 BLOCKS OF 4)	134	42	176
O.R. TOTALS	347	129	476
GRAND TOTALS	771	355	1126

REFERENCE TO TYPES			
1	BK. HUT - 60 70 MALE	51	TELEPHONE EXCHANGE
2	BK. HUT 52 FAMALE	52	MSO SUPER. MESS & QTRS
3	BK. HUT - 4 W.O's 24 SGTS (MALE)	53	MSO OFFICE & STORES
4	BK. HUT 14 SGT (FEMALE)	58	R SIGS SQN OFFICE
4A	BK HUT - 12 SGTS (FEMALE)	59	R. SIGS SQN TROOP STORES
9/10	DINING HALL & COOKHOUSE	60	R. SIGS SQN WRAC
18	INST. ROOM	61	RASC OFFICES
19	MAIN GUARD ROOM & PAC	62	RASC STORES
19A	RAF GUARD & ET ROOM	67	RAF RATION STORE
20	UNIT GUARD ROOM	69	14 WRAC BN OFFICES
23	MSO BN & CANTEEN	73	SITE OFFICE BLOCK
27	GAS CHAMBER	102	MSO GSO MI ROOM
28	MINIATURE RANGE	106	RAF LINK TRAINER
47	SQUASH COURTS	107	POLICE INFO POSTS
		108	ARMY AMM STORE
		125	BIOG GARAGES

TOTALS	
MARRIED QUARTERS	1126
BARRACK HUTS	136
MESSES	19
CLUBS	4
SCHOOLS	4
SPORTS GROUNDS	17
CINEMAS	2
GYMS	2
BUS STOPS SHOWN THUS	⊗

that most of the objectionable forest was removed. Another with a cautious wag of the finger would instruct me solemnly not to remove a single tree that could be left standing. Between these extremes it was obviously impossible to judge, so we asked for a committee of officers to decide on the extent of tree clearance and the planning of new growth. The committee assembled in October, 1953, when most of the buildings were up to roof height and the estate taking shape. It was a senior one under the chairmanship of the D.A.G. (who was interested in horticulture). It took seven days of careful marking of plans, in the course of which almost every tree with any character was individually considered, and an accurate plan was produced to define what should be cleared or left standing. The committee's deliberations also included the laying out of new trees, flowering shrubs, gardens, etc. We had by then already layed out and cultured half a dozen sample gardens in the married quarters estate. These also came under review, and the recommendations (within the costs that we could allow) formed the basis upon which the 1,126 gardens were planted. As far as was possible deciduous trees of every kind (of which there were all too few) were left standing, and the more dense conifer plantations, which harboured horse flies by the million, were removed to open up vistas. Thousands of shrubs were planted, and 1,000 creepers of various kinds have been encouraged to decorate the walls of the buildings. The future will see whether the committee did their job properly. On Christmas Eve, 1954, a slight amendment of the committee's plan was caused by a gale which blew down 1,200 trees which had been selected to remain standing.

We were astonishingly fortunate in having attached to us during the appropriate periods of the project 2nd Lieutenant Clegg, R.E., a National Service officer whose civilian trade was forestry, and Captain Allaway, R. Sussex, a short service officer who is a nurseryman. We could not well have done without them.

Road Naming—Notice Boards

The naming of roads was an important operation in which personal favour might have played a part. This also was undertaken by a committee of officers under the chairmanship of the D.A.G. Since the move a forest of internatonal traffic signs has arisen.

A military cantonment must have adequate notice boards, direction posts, and traffic lights. These are being tastefully designed, and though they grow in density as the months go by, they have not yet overwhelmed the landscape. They have a crystalline surface which shines in the lights of even the oldest pre-war car.

(*To be continued*)

APPENDIX B

MAXIMUM POPULATION IN PLANNED ACCOMMODATION—NEW H.Q.

ALLIED ARMY AND AIR FORCES

BRITISH AND ALLIES

Item	*Men*	*Women*	*Children*	*Remarks*	
Married quarters	1,126	1,126	1,689 (at 1½ per family)		
Single officers	374	107			
Single W.O's. and Sgts.	341	112			
Single O.R. male	1,589			In 22 barracks of 70 men.	
Single O.R. female		416		In 8 barracks of 52 women.	
Fire station	25				
Hostels	72	72	108		
Haus Hellbach	9			Converted to flats for C.V.W.W., etc.	
Haus Heinen		1		Dep. Director S.S.A.F.A., B.A.O.R.	
Visitors' mess	15				
Transmitter site (W/T)	26			Personnel for receiver site live in barracks.	
Total	3,577	1,834	1,797	Total British and Allies	7,208

GERMAN AND OTHERS

D.E.L. male	504			In 35 blocks of sergeant type accommodation each for 28.	
D.E.L. female		476			
G.S.O.*	700				
M.S.O.*	200				
M.S.O. supers	7				
Domestic help in married quarters		347		Assessed.	
N.A.A.F.I. staffs	19	59			
Caretakers' quarters.	3	3	5		
Officers' messes resident staff	20	4			
Other messes' resident staff	9			Total German and M.S.O. on site	2,356
Total	1,462	889	5	Total on site	9,564

MARRIED D.E.L. OFF THE SITE

Hardt	225	225	338		
Waldniel	60	60	90		
Rheindahlen	31	31	46		
Total	316	316	474	Total German off the site	1,106
				Grand total	10,670

* NOTE:—G.S.O. German Services Organization
M.S.O. Mixed Services Organization

The German contingent consists of disciplined Units of civilians organized with a small Britsih element for M.T., Artisan or Labour Services.

The Mixed contingent consists of Yugoslav and Polish emigrés used as Guard Companies under British Officers.

APPENDIX C

NOTES ON THE NEW HEADQUARTERS PROJECT

A *Main Building*

3 storey. Nearly 2,000 offices and stores. Over-all dimensions approx. 300 × 180 yds.

B *Residential Areas*

476 O.Rs. married quarters. Types "B" and "C".
650 officers' quarters. Types III, IV, V. District heating. Fireplace in officers' drawing-room.
Gas cooking. Built-in cupboards in bedrooms.
Family hostels.
Generals' houses acquired, not on the site.

C *Community Area*

Schools for 720 infants, 5–11 years.
Separate project for secondary school for 400.
3 Churches, N.A.A.F.I. shop. M.I./S.S.A.F.A./Dental centres.
Swimming pool, two cinemas and model room/theatre.
Officers shop and some private shops.

D *Barracks*

93 "Op. Humane" type living quarters
5 dining halls and cook-houses.
Single Sgts type accommodation for 1,000 German D.E.L.

E *Sergeants' Messes*

5 "Op. Humane" types.

F *Officers' Messes*

Standard "Op. Humane" types

"A" Mess	(40 members)
H.Q. Mess	(40 members)
Visiting Officers' Mess	(30 members)
Women's Mess	(60 members)
Sigs./R.A.S.C. 4 male officers' messes	(60 each)

R.A.F. mixed mess for 120. R.A.F. design.

G *Clubs*

Officers, Special design by N.A.A.F.I.
Warrant Officers/Sergeants.
Army O.R's. N.A.A.F.I. (based on "Op Humane") for 1,250.
R.A.F. O.R's. N.A.A.F.I. for 750.

H *Sports Grounds*

Football/hockey	17
Tennis courts	28
Basket ball	2
Cricket tables	5
Squash courts	5

J *Roads*

All concrete

Main artery	7½ m. 2 side walks.
Secondary net	6 m. 1 side walk.
Minor net	4½ m. 1 side walk.
Cul-de-sacs	3¾ m.

Approx. length all roads is 25 kilometres.
Class "B" street lighting, and lighted signs.

K *Water Supply*

Found on site by boring. Good quality. Treated and distributed through own waterworks. The existing temporary supply from Rheindahlen will serve as a standby.

L *District Heating and Hot Water*

From 3 boiler houses. One covering the married quarters area; a second the area inclusive of and westwards from the main office block; the third covering S.W. extension. The first two will be interconnected to sustain summer load from one boiler house.

M *Electricity*

Off the grid at 15,000 v., and distributed internally to 13 transformer sub-stations. All cable underground.

N *Gas*

Off the Duisburg grid from Moenschen-Gladbach. All domestic cooking by gas. (There is no solid fuel used.)

O *Sewage Disposal*

Water-borne by pipes to a collecting chamber and thence pumped to a joint disposal plant shared with Stadt Moenchen-Gladbach. The joint collecting chamber is located at Genhodder, 800 metres south of the H.Q. site.

P *Site Works*

Only such trees as have had to be removed for roads, buildings and sports grounds have been cleared. The treatment of the landscape has been decided by a committee.

Q *W/T Transmitters and Receivers*

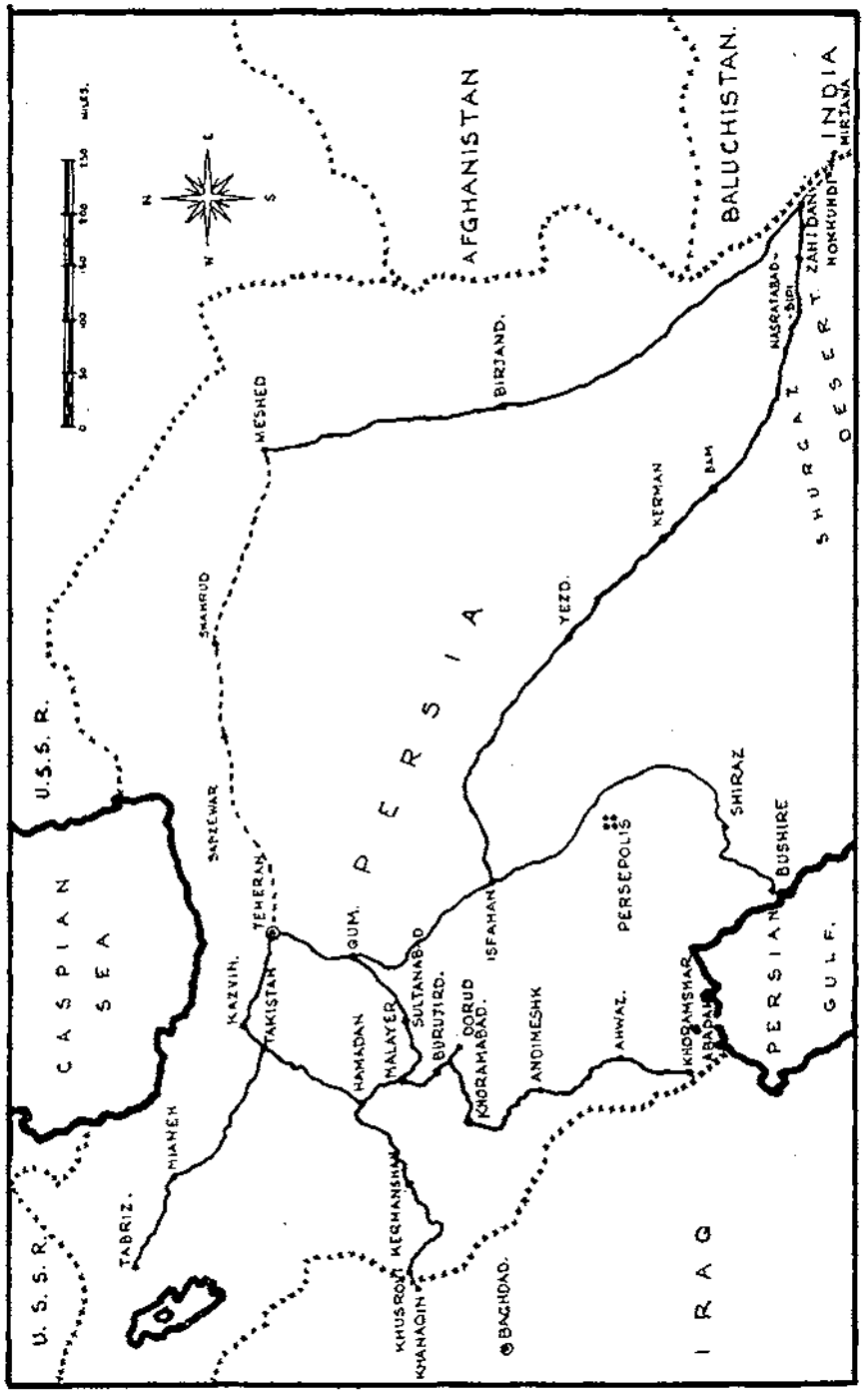
Stations are located some distance from the H.Q. There is an Army and a R.A.F. installation at each site.

R *S.W. Extension*

This is a residential area with the following accommodation:—

241 married quarters. (Included in total at B.)
Primary school for 240 pupils.
1 officers' mess for 11 male (2 storey).
1 officers' mess for 42 mixed (3 storey).
1 W.O. status mess for 100 mixed.

This area has district heating and hot water from its own boiler house.


U.S.S.R.
CASPIAN SEA
PERSIA
AFGHANISTAN
BALUCHISTAN.
INDIA
MIRJAVA
NOKKUNDI
ZAHIDAN
NASRATABAD
BAM
KERMAN
YEZD.
SHURGAZ
OESERT
BIRJAND.
MESHED
SHAHRUD
SABZEWAR
TEHERAN
KAZVIN.
TAKISTAN
QUM.
ISFAHAN
SULTANABAD
BURUJIRD.
DORUD
KHORAMABAD.
ANDIMESHK
AHWAZ.
PERSEPOLIS
SHIRAZ
BUSHIRE
KHORAMSHAR
ABADAN
PERSIAN GULF.
HAMADAN
MALAYER
KERMANSHAH
KHANAQIN
BAGHDAD.
KHUSROI
MIANEH
TABRIZ.
IRAQ
U.S.S.R.
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PERSIAN ROADS AND THEIR DEVELOPMENT IN AID OF RUSSIA

This article is based on memoranda prepared by the late LIEUT.-COLONEL A. J. R. HILL, R.E., and LIEUT.-COLONEL G. W. KIRKLAND, M.B.E., late R.E., and covers the period from the Declaration of War on Persia in August, 1941, until the formation of 10th Army (subsequently Paiforce) in early 1942.

INTRODUCTION

PERSIA is a country of extremes of climate—from the blizzards which rage on the passes at degrees below zero, to the fierce heat of the deserts and the intolerable humidity of the Gulf. A considerable portion of the country, however, consists of an elevated plateau at between 5,000 and 6,000 feet, where the climate is reasonable, and water from the higher mountains enables comparatively small areas at the foot of the hills to be cultivated. Water is scarce, the average rainfall being about 10 in. Only the Mazandaran district, comprising the northern slopes of the Elburz range and the coastal strip south of the Caspian, has heavy rainfall and this is extremely fertile and malarial. But for the mountains, the country would be wholly desert instead of, as it is, about two-thirds. As a considerable length of road has been constructed or developed across the desert it is worth quoting Sir Percy Sykes, one of the first authorities on the country.

"I have crossed it in various parts and found stage after stage of hard gravel tracks to be succeeded by square miles covered with sand dunes. Where water has flowed down from the ranges there is 'Kavir', the salty ground dangerous to cross, covered with a white efflorescence or again a yellow slime. Water is very scarce and either salt or bitter; so that apart from the risk of losing the way or being overwhelmed by one of the terrible storms which spare neither man nor beast, there is much sickness among travellers owing to bad water and scanty food supplies."

There is no sanitation in Persia. Teheran has no piped water or sewage disposal. Water for baths comes off the streets, and for drinking by cart from deep wells or the British Legation. There is much disease throughout the country.

The educated Persian is cultured, rather sensitive, artistic and inclined to vanity. The Armenians occupy an important position in the country. They are traders and business men and their position corresponds somewhat to that of Jews in other countries. The settled peasants are agriculturists. They are pitiably poor but have a sense of humour and provided the bulk of our labour on the roads. As workers they are not great shakes but probably, with reasonable supervision, give the best average output of any class between the

Mediterranean and the Indus. About a quarter of the population is nomadic, and consists of many once-powerful tribes, namely Kashgais, Bachtiaris, Kurds, Lurs, etc. They are of virile stock and robbers by habit. Shah Reza, in his efforts to "settle" the tribes, exercised much cruelty and repression and the effect is doubtful.

For several years before the 1914–18 war, Persia was practically in a state of anarchy. The central government had no control over the more distant provinces, and Russia was gaining a tremendous influence in the north-west. Outlawry was rife. Persia could hardly have been worse equipped to defend her neutrality and the outbreak of war was the signal for Great Britain, Russia, and Turkey to walk in and defend their interests. The resulting dog-fights would take too long to describe, but at different times Turks were within 80-miles of Isfahan and the whole of south-west Persia was closed to the British through the work of the German agent Wassmuss. After the Armistice, an Agreement between Great Britain and Persia was under negotiation but conditions were too unsettled to favour its conclusion. The Reds were in occupation of the Caucasus and British troops remained in the country. In the spring of 1920 the Reds occupied Resht and set up an independent ruler. The British were blamed for not ousting them and eventually the Persian Cossack Division was dispatched, had a temporary success but retired in disorder. Later the same division rallied, marched on Teheran, effected a *coup d'état* and after various intrigues, its leader, Reza Kuli, became dictator and later Shah. This ruler effected a favourable treaty with Moscow but showed himself extremely hostile to Great Britain, a policy which was maintained throughout his reign.

Reconnaissances and Negotiations

The British and Russian forces marched into Persia on 25th August, 1941. Some weeks later Brigadier C. G. Martin, V.C., then Chief Engineer to the British troops in Iraq, ordered Major A. J. R. Hill, R.E., his S.O.R.E. II (Roads) to carry out a recce. in Persia. It was evident that we should soon be ordered to start improving the main north to south routes to Russia. Reports received from formations operating forward were scanty.

Orders which were approved by the Force Commander were to make contact with Lieut.-Colonel Jacques, C.R.E. 10th Division at Sultanabad, obtain all information available and then carry out any reconnaissances necessary to supplement this information.

Hill started from Baghdad on the 23rd September, making Kermanshah the first day and Sultanabad the second day. At 10th Division H.Q. he discovered that the C.R.E. had gone to Teheran. General Quinan would also be there to meet the C.-in-C. and one of the things to be discussed was roads. On the way to Teheran the next day a field squadron was contacted and the C.R.E. shortly turned up. From conversation with him it was apparent that the roads

question had progressed considerably further than was known in Baghdad. The following is the sequence of events up to that time.

The Foreign Office had signalled the British Legation to take up the question of improvement and maintenance of road routes for supplies to Russia.

Lieut.-Colonel Davis had arrived from Moscow and was temporarily and solely in charge of all Transportation matters (to which had had to be added, for the time being, roads).

Sir Reader Bullard, the British Minister, had signalled to the Foreign Office a proposal that the *Persian Government* should employ a reliable firm of contractors to carry out the necessary work on the roads. The British Government were to foot the bill except that the Persians would be induced, if possible, to contribute their average road budget. The British Government would attach a small engineer staff to supervise the work.

A further signal had been received from the F.O. (crossing with the Minister's signal) ordering (i) immediate recces. of the routes northwards to Kazvin from Dorud, Andimeshk and Khaneqin, and (ii) that arrangements for improvement and maintenance of these routes should be put in hand *forthwith*.

The United Kingdom Commercial Corporation had been appointed to undertake the road transportation of supplies to Russia on the western routes.

Certain improvements to the railway including the provision of extra locomotives had been ordered.

The total length of the routes specified in the Foreign Office signal was 740 miles, and the Bushire–Shiraz–Isfahan–Qum–Teheran route which would be added shortly afterwards, a further 770 miles, making a total of 1,510 miles which had to be proceeded with immediately. It was confirmed that 10th Division had neither the staff nor organization to start such an undertaking, and it appeared that Hill should remain in Persia to get things moving. This was proposed to General Quinan's "G" Staff, and the next morning the Force Commander advised that he had signalled the Chief Engineer and had obtained his consent to this proposal. At the same time General Wavell said that he would like to be informed of the full details at tea-time that afternoon.

The Immediate Task

In the meantime it had been necessary for Hill to decide his task and responsibility, and these he judged to be as follows:—

(*a*) To examine the British Minister's proposal, particularly as regards our relationship with the Persian Government, and to prepare a scheme either on these or other lines for the C.E.'s acceptance.

(*b*) To decide a design and specification for the roads, bearing in mind urgency, materials, lack of plant, scant supervision over long distances, etc.

(*c*) To consider the R.E. Establishment required.
(*d*) To consider our relationship with other interested parties.
(*e*) To complete the necessary recces.

Consideration of the above problems took three days, and involved a large number of discussions at which (*a*) turned out to be by far the most intricate, and the considerations involved are given in some detail. Casual comments by officers who arrived later from other theatres of war show that it is necessary to be explicit about the factors which decided the peculiar method adopted for carrying out the work.

Firstly, there was an acute shortage of R.E. Officers and practically no subordinate works staff in Iraq. There was not the slightest likelihood of being able to find more than a very few who knew a single word of Persian, or had any knowledge of the country.

Secondly, Persia, a profoundly nationalist country, had been defeated in military operations by superior forces of two Allied countries who were at the time occupying the territory, with the consequent disturbance to the internal security.

Thirdly, Foreign Office policy dictated the necessity of easing the signing of the Tripartite Treaty and to facilitate this Allied troops were to be withdrawn from the capital. After signature of the Treaty occupation would cease, and we and the Russians would become Persia's allies there by tacit consent. A month had passed, and the treaty had not been signed, and pending its completion British supervision (particularly military) was to be as inconspicuous as possible.

The British Minister's proposal, examined in the light of the above factors, appeared sound as regards employing a firm of reliable contractors, and when he telegraphed this proposal he had in mind a particular firm, Kampsax. The method proposed for employing such a firm seemed anything but satisfactory. We were clearly going to spend about twenty times the usual Persian budget on the roads, yet the Persians, through Kampsax, were to let and execute the contracts. Sir Reader convinced Hill of the political necessity for this arrangement, but as will be seen, economics played a part in causing the Persians to decline to take the contract on.

Kampsax

Kampsax had been formed by two Danish engineers. They had been engaged on the Turkish railway construction, where they acquired a good reputation. Later, as this work came to a conclusion the Shah's projects were starting and they transferred their interests to Persia. They had acted chiefly as consultants to the Government, dealing with the design work, making the contracts and supervising their execution. They employed only European engineers, who by then knew the country, and the firm enjoyed a reputation among European residents of the highest integrity.

On our arrival, Kampsax activities were more or less at a standstill. The two original directors had gone back to Europe, but Kurt Olsen, the resident "Directeur Delegé", had the reputation of being an astute business man, and Laerum, the chief engineer, was reputed to be a very reliable engineer.

Kampsax, therefore, had the necessary organization, offices, laboratories, etc., for taking on a big job and had the call on a number of trustworthy engineers who could speak Persian and English and who knew the country. No other firm in Persia combined all these qualifications. The Foreign Office instructions were that work was to start forthwith, yet there was not sufficient R.E. staff even to do the reconnaissances.

At Davis's request, Kurt Olsen had drafted a tentative contract. Hill therefore proposed to go through this, and if agreement could be reached on the *form* of contract he would ask him to tender and would pass his tender to the Chief Engineer. Should this not be accepted, we should go to open tender. Olsen naturally agreed and also agreed to assist in carrying out reconnaissances and surveys.

Hill was convinced that Olsen's draft contract was bad. It seemed to him that the only possibility, if we had to save face for the Persians and yet to secure the necessary powers, was to make a tripartite agreement between the British and Persian Governments and Kampsax. He redrafted the contract accordingly and included safeguards for the proper control of progress and expenditure. He also particularized that Kampsax, under our control, were to be responsible for keeping the routes open in all circumstances, having chiefly in mind snow-clearing on the passes. This agreement was to be hacked about a great many times, and few of the original clauses survived in the final document.

Further Considerations

There were no figures available as to the density of traffic to be expected. It was assumed, for a start, that we had to produce a road capable of carrying one continuous line of traffic in each direction, say, 10-ton lorries at about 3 v.t.m. Gravel roads were the best that could be hoped for, at any rate during the first six months. The specifications and design which Hill then proposed were taken as a guide on the first recces. and these after very slight modification were the basis of all the original contracts. We found that these proposals followed the Persian Roads Department's own standards for main roads (as laid down, but not followed) quite closely.

Hill proposed that the establishment for the western routes then ordered would be a C.R.E., an A/C.R.E. with G.E.s and A.G.E.s at about one officer per 150 miles of road. This scale, of course, was never achieved. An establishment based on 2,000 miles of road was eventually sanctioned, but before it was completed to strength, the

total roads taken over considerably exceeded 3,000 miles, besides the addition of other work.

Hill agreed with the U.K.C.C. that provided our roads were good enough to take the number and size of lorries they wished to operate, their requirements would be satisfied. Hill asked for any information and constructive criticism brought in by their drivers.

When Hill reported to the C.-in-C. on the evening of the 28th September, he had arrived at most of the above conclusions. He gave the C.-in-C. a short note on the proposals for carrying out the work and told him that (*a*) the Minister's proposal, though not very satisfactory, would be workable as we should be able to introduce sufficient safeguards, and (*b*) from what had been seen up to date, we should be able to keep pace in our improvements, with the likely increase in the volume of traffic. General Wavell expressed himself satisfied with the general proposals, and with the progress made up to date.

The same night Hill wrote to the Chief Engineer saying that he had certain proposals nearly ready and asked him to signal whether he would visit Teheran (preferred) or whether Hill should return to Baghdad when they were completed. In the meantime it was essential to get on immediately with recces., after which he would be in a position to give him a full report.

The Western Routes

For the first recce. Hill arranged with Kampsax that two parties, of which Laerum would lead one, and himself the other, would start off together via Kazvin for Hamadan, afterwards splitting to Khusrovi and Andimeshk respectively. In this way they would see representative types of road together and decide the detail of work required on typical sections, thus checking both design and specification. At the same time they would standardize their method of estimating and ensure reasonably uniform reports for the future, whether carried out by officers or civilian engineers.

Departure was fixed for 0800 hours on the 30th September. As they were to pass through the Russian occupied area it was necessary to obtain a pass. These were obtained at the Legation at 0830 and when translated it revealed that a Major Holodov would accompany the party. Jarvis of the Legation kindly spent two hours telephoning in Russian before Holodov could be traced, and the party eventually moved off about midday.

They consisted of two Norwegians, a Dane, a Russian, one Persian, an Armenian, two P.M.s, a Madrassi, and Hill. The delayed start prevented them from going farther than Kazvin the first night, but had the advantage that they were able to study and discuss the Kazvin–Hamadan section in greater detail next day.

Laerum's trip to Khusrovi was of no particular interest, but Hill's route through the terrific gorges and geological jumble of Lurestan

PERSIAN ROADS
AND THEIR DEVELOPMENT IN AID OF RUSSIA

Photo 1.—A Persian Labourer.

Photo 2.—Section between Isfahan & Shiraz.

Persian Roads And Their Development In Aid Of Russia 1,2

Photo 3.—Pir . I . Zan Pass between Shiraz & Bushire.

Photo 4.—Completed Gravel Road. Section between Qum & Isfahan.

Persian Roads And Their Development In Aid Of Russia 3,4

called for some special consideration. Considerable stretches in the gorges and over the Chul Pass were virtually only single tracks, and huge expense would be involved in increasing to double-way. Hill had been given no figures for density of traffic and therefore decided, pending more detailed instructions, that the most difficult sections of this route should be left as one-way roads with passing places.

Hill reached Sultanabad on the return journey on the afternoon of 5th October. As this was an up-train night he went on to Teheran by rail, arriving next morning, having left Kufud to follow with the cars.

Return to Baghdad

No signal from the C.E. in reply to Hill's letter had arrived and so he sent one off reporting his return and requesting a reply to his letter. Next morning an "Immediate" signal dated the 1st and received the 6th was handed to him ordering his return to Baghdad.

An aircraft was leaving next day. He saw Kurt Olsen immediately and asked him whether he was prepared to make a definite tender, on the terms which had been discussed, by some time that evening and Kurt Olsen replied that he would deliver it personally by 7 p.m.

Hill flew with this tender to Baghdad, landing at Habbaniya and reaching the C.E.'s office after lunch. The tender was in the form of a flat fee to cover specified services of the directing organization of Kampsax, and a percentage on cost of works to cover organization and supervision of the work to an extent which was separately specified. During the afternoon the proposal was discussed with General Bird, E.-in-C., India, who was visiting Iraq, and Brigadier Martin.

Next morning the C.E. had a conference with the F.A. and as a result of these and further discussions at the C.E.'s office it was decided that the price tendered was too high, and that the form of the tender was unsuitable. The C.E. decided that we would not agree to paying a percentage on costs in any case, in view of all the attendant difficulties of accounting, but would pay a flat fee for the central organization and refund all other expenses incurred on the work. In order that work should not be delayed he authorized Hill to accept a tender of up to £5,000 a month. It was also decided that a tri-partite agreement was impracticable of operation, and that we should stand out for a direct contract between the British Government and Kampsax.

Hill was ordered to return to Teheran and negotiate a new agreement on these lines. For this purpose Major Kirkland, S.O.R.E. II Works, was detailed to accompany him and, to form a nucleus of the future R.E. organization in Persia, Lieut. Gaywood, Lieut. Sampson, and a sergeant were added to the party. This party left Baghdad on 10th October, in three 15-cwt. trucks, stopping at Kermanshah and Sultanabad, and arriving Teheran on the evening of the 11th. On the way up Hill gave Kirkland the draft agreement to read and

explained the alterations required by the C.E. On arrival they immediately got down to redrafting, which occupied them to a late hour.

Negotiations

During Hill's absence, Brigadier Sir Godfrey Rhodes had arrived as Director of Transportation. Hill and Kirkland saw him on the morning of the 14th and explained the Chief Engineer's decisions in Baghdad. Brigadier Rhodes, however, said that the British Minister was emphatic in his view that the contract must be between the Persian Government and Kampsax, and they had to agree, though reluctantly, that the necessary safeguards could probably be obtained by means of a separate agreement to be negotiated by the Legation with the Persian Government. Kirkland accordingly re-drafted the agreement and later handed it to Kurt Olsen for a revised quotation to be submitted within twenty-four hours.

Gaywood departed on the 15th with two civilian engineers to reconnoitre the Bushire route and the same evening Kurt Olsen brought his tender for £3,000 a month for the services specified, and next day Kurt Olsen signed the draft contract.

In the meantime General Bird and Brigadier Martin were on their way up from Iraq. Leaving Baghdad on the 15th, they reached Sultanabad on the 16th. Sampson met them there and brought them on to Teheran next day. Here they spent a couple of days and approved the contract, design and specifications.

At a meeting with the Director of Transportation, General Bird confirmed the policy of improving and maintaining all roads required for supplies to Russia. Priority and general policy were to be laid down by D. of Tn., but the C.R.E. (Roads) would be responsible only to the C.E. for control and organization of the work. They would also do any other work, such as accommodation, required by Transportation, but in fact no such demand was ever made.

The Baluchistan–Meshed route was also discussed and Hill suggested that it might be easier for the Persian organization to do the work on this road than for it to be organized from India as had been proposed. General Bird agreed to this and said he would give the necessary instructions on his return to India.

The E.-in-C. and Brigadier Martin left by train on the night of the 19th, and before departure the E.-in-C. told Hill that he had signalled G.H.Q. India proposing his appointment as C.R.E. Persian Roads, and that he was to act as such from then on.

Relations With Persian Government

Two things then had to be got on with; the placing of contracts, and the conclusion of the agreement with the Persian Government. It will be noted that although it was proposed that the agreement should be between the Persian Government and the Consultants, we

had already come to a working arrangement with Kampsax, but had not so far revealed our plans to the Government.

Hill asked for an interview with the Minister of Ways and Communications (a Dr. Sa'adi) and explained our proposals, and Sa'adi agreed to everything in principle. It is now certain, that had the arrangement then proposed been carried through, we should not have made one half of the progress that we did in the early stages.

Instead, two days later, at a meeting with Laerum and Hill, the Head of the Roads Dept. (Ahmad Mossadegh) told them that the Minister had been through the draft agreement in detail, but he regretted he could not advise his Government to be a party to the operation of the Contract. He was quite prepared, however, to place the services of their permanent roads staff at our disposal, at our expense. Since the country's economics had been upset by the invasion, spending of the occupation forces, and the detachment of agricultural and other labour for road-works, and the road staff referred to had received no salaries for some months, the Minister's attitude was understandable.

Kirkland redrafted the whole contract once again as between the British forces and Kampsax direct, got Kurt Olsen, who preferred this arrangement, to sign it and sent it off to Baghdad for ratification.

To cover the desire for Persian participation, Kirkland and Hill prepared a draft of what they considered should be a Governmental Agreement, whereby the Persians acknowledged the existence of the Contract and authorized its operation in His Imperial Majesty's Domain, and at the same time relieving us of all obligations for compensation for land taken over for road widening, re-aligning and other improvements. This document was left with Sir Reader, but circumstances outside the purely Military field no doubt prevented negotiation or implementation, and some months later the last point regarding compensation was covered by a *Proces Verbal* from the Persians to us.

First Contracts

Directly the C.E. had approved Olsen's tender the machinery for getting work started was put in motion. Oyan, Section Engineer Elect for Hamadan, left Teheran on the 18th and Laerum, with four contractors and Polvsen, destined for Burujird, left on the 20th. Sampson left for Hamadan on the 19th and acted as G.E. there, controlling the whole work spread over 700 miles of road for three months. Laerum took batches of contractors over the western routes in two trips, bringing back their tenders for Kirkland's decision.

It was evident that Hill's time would be spent chiefly on the roads, and he was lucky to have Kirkland to run things during his frequent and protracted absences. Kirkland's position became that of a deputy exactly doubling Hill's powers and responsibilities, which he was called upon to exercise continuously and to the fullest extent.

The East Persian Route

On 23rd October a signal was received from India ordering improvements to the route Mirjawa–Meshed. Brigadier Rhodes decided that this was to have priority over the Bushire route, and as Gaywood was due back next day Hill decided to take him off the latter route and form a party including himself, Gaywood, Kampsax engineers and contractors, proceed to Meshed, reconnoitre the whole route and place contracts on site.

Meshed, the nearest point on the route, is 600 miles from Teheran and the route itself is over 650 miles, so that it was no small undertaking. The route had actually been reconnoitred already from India but the recce. report was not sent until after the work had started. The signal did contain the information that the Kal-i-Shur Bridge was unsafe, and irreparable, but this as a matter of fact turned out to be the only point on which there was disagreement with the previous report.

Accordingly, the party which set off from Teheran on 27th October for Meshed were about twenty strong, with eight vehicles, including a 15-cwt. truck containing kit and supplies. On the first day the truck burst a front tyre and went into a ditch. It took some time to unditch it and when they set off again it was evident that the driver had completely lost his nerve. Hill therefore took the truck over and drove it the rest of the way to Meshed.

The delay over the truck prevented the party from reaching Shahrud the first night, and from completing the journey to Meshed in two days as had been hoped. However, a day's delay was of no particular consequence and, stopping the second night at Sabzewar, they reached Meshed on the 29th, and Gaywood and Hill enjoyed the comfort of the British Consulate General. They intended in any case to halt a day in Meshed. Owing to the truck's burst tyre and the impossibility of getting a military size in Meshed, it was necessary to hire a bus. The Acting Consul General, Lieut.-Colonel Watts, had come from Zahidan recently and confirmed that very scant supplies would be found en route. They therefore laid in a big stock of stores and hired a cook.

Watts also confirmed what had been heard, namely, that the route was by no means secure. A number of Persian soldiers who had deserted with their arms when the Russians occupied Khorasan were still ranging the hills south of Meshed. The Governor General was either weak or anti-British, but there was some truth in his contention that as the Russians had disarmed his amnieh, he could not do much about restoring order.

Farther south there was always the chance of a Baluchi raid and this was increased by the fact that men were dying of starvation in the streets of Zahidan. They saw the Governor-General with Watts and he insisted that some amnieh should accompany them—at any

rate as far as the borders of his province! By the time therefore they had rearranged their kit and got the amnieh and their kit packed in, the bus was by no means redundant, in fact they could not have managed with the 15 cwt. truck alone. They paid a courtesy call on the Russian Commandant, who though reserved was friendly and tremendously optimistic.

That evening Hill got the contractors together and explained the method by which the contracts would be placed. The road would be inspected in as much detail as was possible at the rate of about 150 miles a day. Halts were to be made as often as the character of the road changed and agreement reached on the quantities of work involved. After returning to Zahidan from Mirjawa, the contractors were to make their tenders which would be decided on the spot.

As a provisional basis for tendering, the road would be divided into three sections, and if the tenders were reasonable, all three contractors had a chance of getting a section. If, however, any one contractor was considerably higher than the others, the road might be divided into two halves; thus each contractor was to give detailed quotations by stretches, so that any particular subdivision might be decided after opening the tenders. The contractors agreed to these conditions, but all three insisted that the time available would not permit of estimating with any accuracy the proportion of rock that was likely to be encountered in the earthwork. They suggested quoting for earthwork plus a sliding scale from 0 to 100 per cent rock to be decided later by a commission. This proposal seemed sensible and was accepted.

To what extent the contractors collaborated over their tenders may never be known. That they did to some extent, is fairly certain. Their eventual quotations came out remarkably level and, though on the high side, were not unduly so when the factors of distance from Teheran, lack of security, uncertainty about the supply of bread, lack of water, and the terribly severe climatic conditions were considered.

Meanwhile one more officer had been posted to the establishment, but on his return Hill still only had four officers besides himself and one sergeant to control work which had already been ordered on 2,000 miles of road. Other important work was also starting. The Air Officer Commanding had been to Teheran and ordered Kirkland to put in hand extensive work, including several concrete runways on four aerodromes.

Hill returned to Teheran on the 11th November. On the 13th he got a "Most Immediate" signal ordering his return to India to give evidence at a court martial. This necessitated his leaving Teheran the same evening and took him away for over a month at a critical stage in the work. During his absence three more officers arrived and were sent out by Kirkland. The establishment—a special one—had by now been sanctioned, but the "bodies" were terribly slow in arriving.

Nature of the Work

In the west of Persia the roads were fairly standard in having a well consolidated crown about three and a half metres wide, either with some soling, as in the case of part of the Khusrovi–Kermanshah section, or at least a good deal of metal well beaten in by traffic. Maintenance had however been negligible, and some sections were so badly corrugated as to be almost unmotorable. Nearly everywhere the berms were worn away to such an extent as to be non-existent over considerable distances. The standard of the Eastern Route was lower, particularly the southern 350 miles, which was little more than a track.

Generally speaking, stone of varying quality is available adjacent to the roads, but practically no water. Of machinery there was very little, and as soon as the aerodrome projects came on it was obvious that what there was would be fully employed on that work. There were reputed to be about nineteen rollers in working order in the whole of Persia, but this afterwards proved to be an exaggeration. Hill asked for 200 but saw little prospect of shipping space being allotted.

In the west, the roads were fairly well bridged and culverted, but many were too narrow for our purpose and many weak and dilapidated. In the east, not only were Irish Bridges the rule, but in some cases the road ran in a dry nullah bed for miles, being remade after the infrequent spates. The standard which was aimed at in framing the specification was 6 metres of metalling, with extra soling where necessary, and 1 metre earth berms on each side. During the following winter, when much of the new earthwork was fresh, there were a few accidents as a result of vehicles running on to the new earthwork. It was unfortunate, but almost inevitable with the extent of the work which was being carried out, and in any case, only a fraction of what would have occurred with the increased traffic had the widening not been got on with quickly.

In the contracts placed up to the end of March, 1942, it is estimated that about 40,000 cu. yds. of soling, 1½ million cu. yds. of metalling was supplied, and about 6½ million cu. yds. of earthwork executed. The largest number of men employed at one time was estimated at 67,000 together with 14,000 donkeys.

Maintenance, as with all gravel roads, consisted chiefly in keeping sufficient gravel on the surface of the road and keeping it raked over evenly so that no part of the formation was allowed to be uncovered. A lot of patience had to be expended on the coolies who had all sorts of bad methods. The gangers and supervisors seldom used their common sense and, generally speaking, were all infected with the graft system, i.e., as long as everyone gets their "rake-off", all will be well and very little work need be done. It was impossible to eradicate this idea, of course, but one eventually hammered some idea into

them that men were paid to work. Conditions vary considerably, and the number of maintenance men found necessary varied, on different sections and at different times, from one to three men per kilometre.

Coming back from India, Hill travelled by way of Quetta where he saw Brigadier Papillon, Chief Engineer, Western Independent District in order to report to him his proposals on the Meshed route and ensure that we were working on the same lines. At this time we were still pulling up the railway from Mirjawa to Nokkundi and the dismantling was four-fifths complete. The first report on the Meshed route had strongly emphasized the desirability of reconstructing this section of line. The Persian section from Mirjawa to Zahidan was still intact, though in need of repair, and the whole section Nokkundi to Zahidan constituted the worst part of the route to Meshed for M.T. Hill contributed his recommendation to the same effect and the line was eventually relaid.

Hill's car met him at Nokkundi and he returned to Teheran via Meshed. On the whole he was disappointed by the poor start on the eastern route, but in fact this was hardly surprising in view of the immense distances involved and the lack of facilities. As it turned out, the organizing of the transport on this route was even slower and the work of improving the road easily kept pace with increasing traffic.

The Trans-Persian Route

Hill returned to Teheran on 12th December and found that three other officers had reported, though two of these were not to stay long. Kirkland had sent them out on the work. Instructions had also been received to reconnoitre the Isfahan–Yezd–Kerman–Bam–Zahidan route and Kirkland had sent two civilian engineers on the job, one, Rukhstuhl, who was afterwards to do excellent work in the desert, and Kufud who had done the original recce. of the Andimeshk road. Kirkland had decided in this case that a preliminary recce. was essential before contractors could be taken out to quote for the work.

The route, as it was then, deserves some description. From Isfahan to Bam was an ordinary, though particularly bad, motorable track, practically unbridged or culverted and growing progressively worse as one went eastwards. From Bam it gradually petered out in the desert where the customary track followed more or less, for about 40 miles, the old Eastern Telegraph line. The desert here follows Sykes' description, quoted earlier. It is really a neck connecting the Makran desert with the huge Lut which is the heart of Persia. Here or hereabouts two conquerers returning from India, Alexander and Jelal-u-Din, both lost the greater part of their armies. Nadir Shah built two or more towers to guide travellers, one remains, and the ruins of another, but as there are frequent sandstorms their utility was not great.

The petrol engine has, of course, reduced the risks of crossing the desert provided plenty of water is taken, the established route followed and cars do not go singly. Lorries are in the habit of crossing fairly regularly except at the hottest season. They would wait until three or four had collected and cross together, one or two such groups crossing per week. They had the drill of debogging well taped and by mutual assistance crossed without much difficulty.

The chance of accident was not of course altogether absent. On one occasion Hill was following a contractor's car—the two partners had offered to lead the way. There was a light sand-storm blowing and they had hardly gone a mile when they unwittingly ran up the gradual slope of a sand dune. When they reached the lip the contractor's local driver evidently lost his head and tried to swerve, with the result that the car rolled over about three times and landed on its roof. Hill following, suddenly seemed to be diving right on top of the overturned car, but kept straight and the Buick stopped with its nose in the soft sand a foot from the other car.

Hill and his party had a few cuts and bruises but the two contractors, when extricated, were found to be seriously hurt. Both had multiple and compound fractures and one looked particularly bad. They had over a hundred miles to go and still the worst part of the desert to cross. Fortunately there were other cars and a truck following and they eventually got the injured men into Zahidan about midnight. They both recovered.

On another occasion Hill had to cross the Shurgaz River bed a few days after one of the rare occasions when water comes down. The surface had dried into a thin crust; underneath it was treacherously soft. He had two cars, but sand equipment only for one. From noon till dark he made less than a mile's progress and spent the night in the river bed. Now there is a road (of sorts) and it is doubted if many will regret that some of the adventure has been removed from this route. After all, bandits remain.

After crossing the Shurgaz desert the many tracks gradually united again and very slowly (or so it seemed) turned into the semblance of a road at Nasratabad-Sipi and thence to Zahidan. The total distance from Isfahan to Zahidan is 800 miles.

Later a question was raised as to why a more southerly and apparently straighter route from Bam to Zahidan was not followed. Actually there are two other known routes, one slightly shorter and one longer, than that selected. The reconnaissance party investigated both, partly on the ground and partly from local information, and established that the shortest route had about the same amount of bad desert and a greater length of completely unmade road than the existing route. The longer and southernmost route had less bad desert but much more unmade road. In any case the existing route was well established and farther from certain unsettled tribes in the south than the other two.

Sanitary Service

In self protection, included in the first works contracts was a clause making contractors responsible for the well being of their labour. First aid boxes had to be provided, together with medical attention. The welfare of directly employed maintenance labour had also to be considered.

In the days of the Railway Construction, Kampsax had inaugurated a form of Health Insurance, which on completion of the construction programme was handed over to or adopted by the Railway Administration. It was called the "Service Sanitaire".

Kirkland negotiated with the Railway Administration of this Service for their part transfer to our work. The arrangement concluded with them was that we would deduct 1 per cent of the Contractors' Accounts, the contractors making a similar 1 per cent deduction from labourers' wages paid. The Sanitary Service undertook to look after the welfare of labour working on our behalf over a length of road of about 2,000 miles.

At the end of the Railway Construction period, the Service Sanitaire held such considerable cash balances, that they were able to endow a hospital in Teheran to the extent of some 10 million rials (£100,000).

The agreement made provided for the return of any cash balances remaining on the completion of our work, and for taking over the entire inventory (furniture, medicines, instruments, transport, etc.) purchased from the road contract and works contributions.

The Sanitary Service assumed responsibility for compensation claims for death and injury, epidemics of typhus and typhoid, etc. There was no Military Claims organization and the Service was indispensable. The arrival of an Army Claims Formation later caused a modification of ideas, but investigation of the magnitude of the undertakings caused the Claims Formation to hold up their hands in horror and to decide to leave the Sanitary Service alone.

The Service worked as well as could be expected for Persia in the early days, but complaints were inevitable; sections of roads not visited for weeks on end, ambulances being used as buses for the personal benefit of the M.O., with "rake offs" for the drivers, dressers, and attendants were typical of those received. The increase in military personnel reduced these abuses.

Demands for medical stores all passed through Kirkland's hand, and they frequently contained luxury articles, which were of course not approved. "Kepler", cod liver oil and malt, for Persian labour did not appeal to his imagination after one report of a labourer suffering from bronchial pneumonia being treated with a saline injection! He died.

Snow

For the next few months Hill was continuously on tour, watching the progress of work and the effect on it of climatic conditions; heat was now in abeyance, but there was rain, frost and snow to contend with. They had their effect of course. There were serious wash-outs on the eastern route and work on whole stretches of road on the passes had to be abandoned for snow and frost. Little can be said about snow for want of space, but there had been a Foreign Office cable that the passes "must repeat must" be kept open and this it was possible to do.

One further length of road had been added, namely the link from Malayer to Qum, making the total charge up to over 3,000 miles. Another, and more important, decision received from Baghdad in January was the increase of the specification from 6 to 7 metres of metalling and 9 metres total formation the whole way from Andimeshk to Takistan. Even allowing for certain sections which it was out of the question to bring up to this standard, the additional work was very considerable and nearly equalled the total cost of the original contracts. It was necessary to give the work to the same contractors as it would have been impossible to have two working on the same road. With these additional works the total value of contracts let up to the end of March was about £2,200,000, while maintenance during this period cost in the region of £80,000.

Kirkland left at the end of January. He had only been attached, but until something approaching the sanctioned establishment had been reached, it had been impossible to spare him. Now it was insisted upon and Sampson came in from Hamadan to be A.C.R.E.

A number of lorries had to be bought for "line service". In all, about fifty-five cars and forty lorries were purchased. The first few Buicks, secondhand, year-old, cost about £650 at the current rate of exchange. Later as much as £1,800 was paid.

The Qum–Bushire Route

Gaywood carried out the original reconnaissance of this Qum–Bushire route, but the placing of contracts had to be deferred. Laerum did this about the middle of November while Hill was in India. Hill's tour of the road was delayed for a variety of reasons until the middle of January by which time the work was well in hand and when, incidentally, one could see the passes under their worst conditions. The route is a famous one, passing through Isfahan and Shiraz and by Persepolis. The section Bushire–Shiraz was made by Sappers in the 1914–18 war. The present Bishop of Isfahan was one of them. They made a light railway over the flats from Bushire, the embankment now being used for the road, and then first a camel track, later to be developed into a rough motor road, over the passes to Shiraz. The route has been described often but it has to be seen to be believed.

Politics and Economics

In a large undertaking of this nature it was inevitable that political and economic considerations would play a large part. Little will be said here, as these will be better judged in retrospect when the mysterious workings of our foreign policy are revealed. From the beginning, most contractors insisted that to ensure quick completion of the work they must have a sure supply of wheat and be properly protected against outlaws. Bread for labourers was always a problem and remained so. Security was less of a problem than was expected. There were minor disturbances and robberies but not such as to interfere seriously with the work. Two of the civilian engineers were held up and stripped, but officers were lucky, though one missed an ambush by ten minutes. Two Europeans of the A.I.O.C. were regrettably killed in a hold-up believed to have been intended for the Kampsax pay car.

Reorganization

With the formation of Tenth Army, Major-General (later Sir Brian) Taylor came out to Iraq as M.G.R.E. Brigadier French was appointed Chief Engineer, North Persia, which title was a misnomer since his responsibility, as Hill's, covered the whole of Persia except a small area in the south-west. Two further Cs.R.E. were appointed, "Jug" Stuart to take over the eastern side, and Wavish for the Qum–Bushire route, while Hill retained the western routes and made his headquarters at Hamadan.

Hill met Brigadier French at Sultanabad on the 25th February, did a trip to Andimeshk together and then went to Teheran to start the hand over. Brigadier French had brought Kirkland back with him, and it was decided that Sampson should be transferred to his staff so that in this way handing over was much simplified. The M.G.R.E. from Baghdad and Major-General Hughes, E.-in-C. Middle East, from Cairo, both came on a visit to Teheran early in March. Brigadier French and Hill next toured the eastern route together, parting at Mirjawa, he to return via the Shurgaz desert and Kerman, Hill to cross over into India to buy some cars and spare parts, and return to work with the new organization.

SOLAR HEATING FOR MARRIED QUARTERS

By BRIGADIER S. A. STEWART, C.B.E., A.M.I.C.E., M.I.Struct.E.

INTRODUCTION

THE article by Major Christmas in the *R.E. Journal* for June, 1955, has inspired me to describe the experiments in solar heating for hot water systems in married quarters which we are at present conducting in M.E.L.F.

In this part of the world the sun shines for almost the whole of every day, all the year round. In the Canal Zone and Aqaba it averages up to twelve hours per day in summer, and about eight in winter. In Cyprus and Libya these figures are reduced to some extent, as there are occasional periods of cloud and rain in winter, but in general there is a large amount of sunshine nearly all the time. In winter this is a most pleasant amenity, but in summer it can only be described as an unavoidable evil. It would therefore be a matter of great satisfaction if it could be induced to perform some useful function, but this it has not hitherto been asked to do, at any rate as far as the Middle East is concerned.

Solar energy for heating water, etc., has, however, been employed in India and in parts of U.S.A. but it has not been easy to find details of any designs actually used. The subject has been under consideration in the War Office for some time as a long-term investigation, but at low priority, and pressure of other work has prevented much time being spent upon it.

In September and October, 1954, however, two articles by H. Heywood, D.Sc., Ph.D., appeared in the *Heating and Ventilating Engineer*, and this prompted us to take some more positive steps. The Chief Engineer and I happened to be visiting London for E.-in-C's. Conference shortly after this, and the matter was discussed with D.F.W. and his staff; we were very pleased to find that they shared our keenness to give the scheme a practical trial. Mr. Bradshaw of E.13 made the basic calculations, and was able very quickly to produce a sketch design of a heat absorber panel for mounting on the roof of a married quarter, and I brought this back with me to M.E.L.F. a few days later.

The M.G.A. took a personal interest in the idea, and it was decided to build and test two prototypes as a Part II service. As I was sponsoring the scheme, it was decided that the first of these should be erected in my married quarter in Fayid. Certain detailed modifications to Mr. Bradshaw's original sketch became necessary during manufacture, but the basis remained as originally conceived.

After the inevitable teething troubles during installation, the first prototype became fully operative on 16th April, 1955, and has functioned without attention ever since. The second prototype embodying certain modifications was then built and installed in the house of Lieut.-Colonel J. P. Thorp, R.E., and both sets have been a remarkable success. This article attempts to give an account of the theory, design, operation and possible economics of solar heating, based on the performance of these two prototypes.

Requirement

Contrary to what might be expected, there is a considerable demand for hot water in hot countries in summer. Medical opinion encourages hot showers rather than cold, and these are taken with greater frequency than in winter; the amount of clothes washing increases in summer, and the requirements of the kitchen are considerable, as always. The sceptic may say that solar heating only produces hot water when it is not wanted, but I am certain that he is wrong, though I cannot prove this, since as far as can be determined, no research appears ever to have been done on this subject. However, when the project was first initiated, I had a separate electricity meter installed on my hot water system, from which data has been available since January, 1955, and by deduction from this, some forecast of annual consumption of electricity for heating water can be made. It is at once evident incidentally that my household can be classed as an "extravagant user" of hot water, for in January and February the meter showed that we were using an average of 23 units (kW.h.) per day for water-heating. In March and April, which was the experimental period during which installation of the solar heater took place, some solar help began to be felt and a considerable drop in consumption resulted, but much heat was wasted in draining the system at intervals for mechanical reasons. In May the solar heater was in full operation, and after a due interval a check-back was made by disconnecting the panels and covering them from the sun, while the system reverted to full electric heating. For four days consumption averaged sixteen units per day. From this it can be deduced that my extravagant household was probably averaging about eighteen units a day for hot water heating throughout the year—a terrible thought, but one which is borne out by my electricity bills.

Since May my household has had what feels like unlimited hot water, at no cost whatever.

Theory

Water (or indeed any material) exposed to the sun's rays will absorb heat by radiation until equilibrium is reached, i.e. until the losses balance the rate of absorption. If therefore it was possible to create perfect insulation around all extraneous surfaces of a tank of water without interrupting the sun's rays, the water would continue

to absorb heat until it eventually boiled. This would happen in any part of the world, not necessarily in the tropics. However, the farther this experiment takes place away from the equator, the greater time will elapse before boiling temperature is reached, since the sun's rays lose power when they have to penetrate increased distances through atmosphere. In practice, of course, it is virtually impossible to achieve perfect insulation, though solar heaters can go some way towards it. However, the point to be made is that heat input is measured quantitatively, and if insulation is good, the temperature of water will continue to rise above that recorded on a thermometer placed in the sun, as long as exposure continues. Thus it is perfectly possible for water to become "hotter than the sun temperature", if this expression may be used to indicate the thermometer reading, and indeed this is the principle of solar heaters. As will be described later, however, readings on a thermometer placed in the sun have little meaning, as they are subject to a number of variables.

No apology is made for this brief dissertation on radiant heat, because many of us will have forgotten the lectures on the subject which we attended some time ago.

General Design

The general principle adopted in the M.E.L.F. solar heater is to arrange for the water to pass through a thin tank placed in the sun, probably on the roof of a house or forming the top of a verandah (see Photo 1). Water heated in this tank passes up into a well-lagged storage cylinder, the circulation being arranged as in Fig. 1 on page 73. Air convection losses are prevented by one or more layers of glass placed over the tank to create a greenhouse effect. Absorption is increased by painting the top surface of the tank matt black, and losses due to conduction through the back are reduced by painting the lower surface white, and placing it upon a layer of glass-wool insulation.

Various other designs of absorber are possible, but the above is the one we have adopted in M.E.L.F., and it appears to work with good efficiency. In particular no attempt has been made to concentrate the sun's rays by reflection or by other means; it may be that this might produce a more efficient absorber, at the expense of simplicity, but the present design is very satisfactory, and we must never forget that "the best is the enemy of the good".

The storage cylinder is fitted with an immersion heater for topping-up in the event of there being insufficient sun.

It is not desired to burden this article with too many figures, but a rough indication of how the size of the absorber panels was arrived at may be of interest. Again for those not fresh from school, it may be mentioned that one British Thermal Unit is the amount of heat required to raise 1 lb. of water 1° F. To heat 60 gal. (600 lb.) of water through 70° F. therefore requires 42,000 B.Th.U. (This incidentally

Photo I.—Solar heater absorber panels on eaves of bath-house. Chimney on right and fuel tank on wall are irrelevant. Header tank on ridge was part of original hot water system, and now serves solar heater.

would require about seventeen units (kW.h) of electricity, allowing for normal efficiency—a figure which checks closely with the recorded consumption in my household.)

The sun's radiation external to the earth's atmosphere is almost constant, and produces about 430 B.Th.U. per sq. ft. per hour—this figure being known as the Solar Constant. Not all of this reaches the earth however, since losses occur due to diffusion by air, water vapour, gases, dust, etc. A study made by the Laboratorie Central de Poudres (Etude No. 93) has plotted the reduction suffered by the Solar Constant for various parts of the world, and from this it can be deduced that for Mediterranean countries at about 30 deg.–35 deg. N., the sun produces an average of about 260 B.Th.U. per sq. ft. per hour at the earth's surface.

The decision now has to be made whether one, two or even three layers of glass are required to cover the absorber tank. The more layers provided, the better will be the insulation against convection losses, but the greater the interruption to the sun's rays. For an

absorber panel designed for U.K., if this was ever thought to be worth while, at least two layers of glass would be required, but for M.E.L.F., with its relatively high ambient temperature, calculations show that the optimum effect is produced by one layer. Losses due to this, and to leakage of heat by conduction through the back of the tank reduce the 260 B.Th.U./sq.ft./hr. to about 220.

This figure is for the sun's rays arriving at right-angles to the absorber surface, which, with a fixed heating panel, will only occur at two given moments per year. On the assumption that heat is absorbed for six hours out of the twenty-four, and that the average B.Th.U. reaching 1 sq. ft. is 60 per cent of the 220 due to angle of incidence, i.e. 132, the amount of heat arriving in six hours is 6×132, say 800 B.Th.U. per sq. ft. Reducing this again by 25 per cent to allow for periods of cloud and haze, the effective heat produced by the sun on 1 sq. ft. per day is 600 B.Th.U.

To produce our required 42,000 B.Th.U. therefore requires $42{,}000 \div 600$, or 70 sq. ft. The above is a somewhat simplified description of the calculations, and the figures used in it have been rounded off for convenience; in fact the area of panel made for the first prototype was 75 sq. ft.

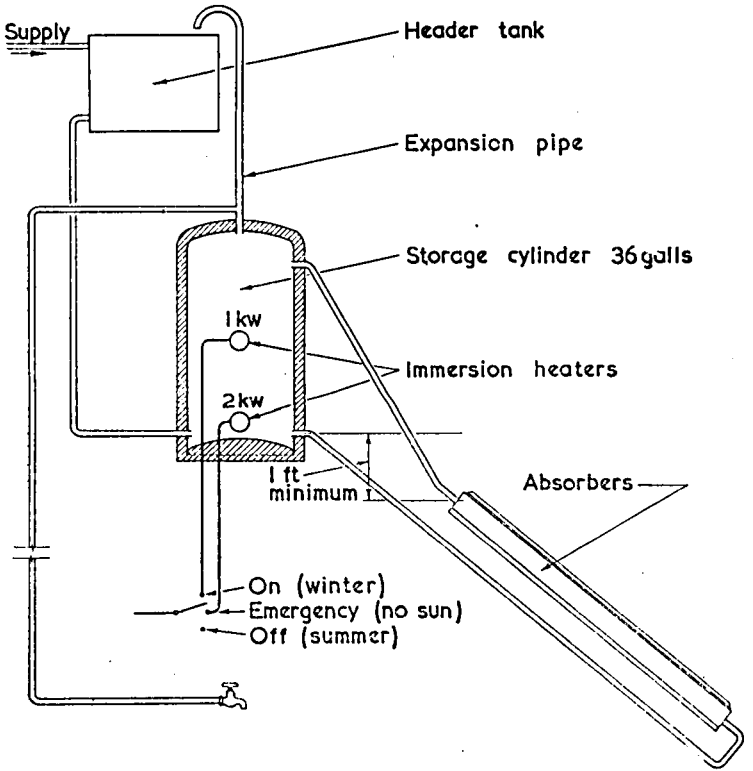
Detailed Design

(*a*) *Absorber Panels*

The actual absorber tanks in the prototype were made of 20-gauge copper, which combines ease of working with good conductivity. It is desirable to keep the metal as thin as possible for economy, but the tank must at the same time be capable of withstanding a head of about 20 ft. of water, since it may possibly have to be erected at ground level in some installations. It was not practicable to provide the 75 sq. ft. in the form of one tank, so three units were made, each 5 ft. $\times$ 5 ft. $\times$ $\frac{5}{8}$ in. thick. To resist the water pressure, these were stayed all over by a grid of spacer rivets at 9 in. centres, as indicated in Fig. II. Each tank thus contains about 8 gal. of water. For production purposes this design will probably be modified in detail, and it may be that steel will be substituted for copper in view of cost. Some method of rust-proofing will of course be essential.

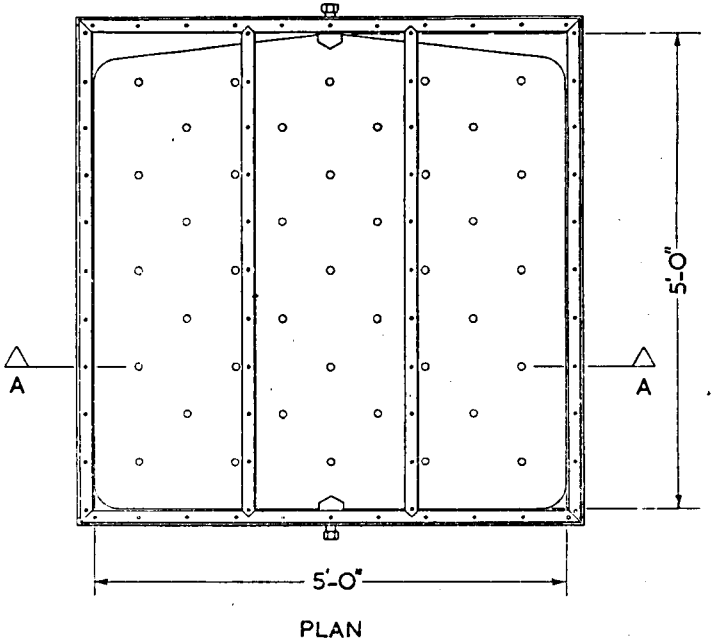
The thickness of the glass is unimportant but it should have sufficient mechanical strength to span the area of the tank without needing too many ribs, since these naturally cause interruption to the sun's rays. The glass in the prototype is $\frac{1}{4}$ in. thick, with one central rib per tank. The final design employs two ribs (See Fig. II), since the large panes were found to be too vulnerable.

Each tank with its layer of glass wool at the back, and its glass cover on top, was assembled into a wooden frame. The air-space between the glass and the tank must not be hermetically sealed, as considerable expansion of the air occurs, but at the same time through draught must be prevented, otherwise convection losses will result.



DIAGRAMMATIC ARRANGEMENT OF SOLAR HEATER

FIG I



HEAT ABSORBER PANEL

FIG II

Three such panels form the absorber surface for married quarters of Types IV and V, and two for Types B and C, which have smaller hot water systems. The first prototype has three panels, and the second two.

(b) Storage Cylinder

A particular point has been made of arranging for the storage cylinder to be of relatively tall shape, erected in the vertical position. By this means better separation between the hot and cold water inside it is achieved. The capacity of the cylinder in the first prototype is 36 gal., which, with the 24 gal. contained in the three absorbers, gives a total capacity within the system of 60 gal. Heat contained in the absorbers will however be wasted if some of the water is not used by about 7 p.m., since back radiation from absorber to atmosphere cannot be prevented in the evening. The main effective content of the system is therefore the 36 gal. contained in the storage cylinder, and the whole efficiency of the installation depends on the lagging of this cylinder, since heat put into it during six hours has to be retained for the remaining eighteen. A minimum of 2 in. of glass wool is essential, covering the whole of the cylinder, and all the pipes of the circulation system should be lagged with 1½ in. of asbestos-magnesia composition.

Perhaps too little faith was shown in the efficacy of the absorber panels, since the immersion heater for topping up was placed at the bottom of the cylinder. The object was to have a simple system which would function automatically, without requiring the housewife to operate valves or switches repeatedly. It is now obvious (why wasn't it before?) that if the immersion heater is at the bottom of the cylinder, it will cut in during the night and morning, and replace the hot water used before the sun has time to do it. The correct place for the immersion heater for normal topping up is clearly about half-way up the cylinder, thus ensuring that at least 18 gal. of hot water are always available, but not wasting electricity in doing the sun's work for it. For emergency use when there is no sun, a second immersion heater is required at the bottom of the cylinder, with a change-over switch between the two. These two heaters can be smaller than the normal 3 kW: the upper can be 1 kW. and the lower 2 kW. The switch movements that the housewife therefore has to carry out are:—

(1) Switch both electric heaters off for the whole summer.
(2) Switch the 1 kW. heater on for as much of the winter as found necessary—once switched on it will function automatically with its thermostat set at say 125° F.
(3) Change the switch over to the 2 kW. heater in emergency, when there is no sun.

The above is based on experience with the prototype, in which electrical topping-up has been unnecessary since May and will prob-

ably not be required again until late October. It may prove in practice that some economical families who do not mind being without hot water periodically in winter will never switch on at all.

Installation

(*a*) *Inclination of Absorbers*

The absorbers function at maximum efficiency when they lie in a plane normal to the sun's rays. At latitude 30 deg. N., the sun is 6½ deg. off the vertical at noon in midsummer and 53½ deg. off in midwinter. At the periods of equinox (March and September) it is 30 deg. off the vertical. Between these months, throughout the summer, experience shows that the heater will work with capacity to spare. The hot weather however lags behind the calendar, i.e. September is always warmer than March, and since the spring is the critical time when the heater should begin to work unaided, maximum efficiency is required at this time. It was therefore decided to incline the absorbers so that the sun's rays should be normal to the glass in March, which meant inclining them at 30 deg. to the horizontal. This angle of course also gives maximum efficiency in September, during which month the summer surplus of hot water should continue, and this has in fact been borne out by experience. From October to February there is therefore loss of efficiency due to low angle of incidence, and it must be accepted that this must be made up where necessary by the immersion heater. For Cyprus, which lies roughly in latitude 35 deg. N., the inclination of the panels to the horizontal will be 35 deg. It remains to be seen whether these angles should be increased slightly, but this can only be decided when the winter readings are known.

(*b*) *Aspect of Absorbers*

As regards aspect, the absorbers should face as nearly south as possible, but about 15 deg. on either side of south could probably be tolerated. It would be preferable for any deviation to be towards the west if possible, since better heating effect would occur towards the evening, when the main use of hot water takes place. Any deviation from true south will of course result in loss of efficiency, since the best use of the sun's rays will not be made when they are at their most efficient, i.e. at midday. It is at this time that they have to penetrate the least distance through atmosphere, and are probably subject to minimum interruption by clouds.

(*c*) *Circulation System*

Maximum absorption of heat takes place when the water is at its coldest, and the sun's radiation at its greatest intensity. By restricting the flow, a small amount of water can be heated to a higher temperature, but heat losses will be greater. The flow should therefore be as free as possible, and to this end 1½-in. pipes are adopted.

(d) Relative heights of Absorber and Cylinder

It is essential that the top of the absorber should be below the bottom of the storage cylinder, otherwise reversed circulation will occur at night with consequent heat loss. In the first prototype this difference was not easy to obtain for structural reasons, and the panels were therefore erected initially with their tops about one-third of the way up the cylinder. By experimenting with the immersion heater it was clear that considerable heat losses were occurring at night. An attempt was then made to prevent this by the insertion of a non-return valve in the circuit, but this was a failure, as it was found that the thermo-syphonic pressure was insufficient to lift the flap of the valve, and no circulation took place at all. The non-return valve was therefore taken out, and a stop valve for research purposes substituted; at the same time the panels were lowered further down the roof until their tops were level with the bottom of the cylinder—this was as low as they could go, without major structural problems becoming involved.

In the second prototype a special non-return valve with a light flap was made and installed, and this operates successfully, though it may eventually be unnecessary if the top of the absorbers can be kept 1 ft. below the bottom of the cylinder, which is the intentiou in all future installations.

Operation

The calculations outlined earlier contain a number of assumptions, and it is interesting to see how the behaviour of the prototype has compared with theory. In general there is little to choose between the performance of the two models, except that the two-panel set seems to produce hot water temperatures about 4 deg.–5 deg. lower than the three-panel, as might be expected. This difference is by no means constant however, as much depends on the amount of water used.

Unfortunately the teething troubles which have already been described, wasted a good deal of time, and it was not until April, as already mentioned, that the heater was working in its final form. By this time the sun temperatures were such that there was almost no need for electrical topping-up at all, so the critical period of the equinox was missed. Even then it was necessary to waste several further weeks carrying out various experiments, altering valve settings, operating with the immersion heater on and off, varying thermostat settings, etc. (a number of valves and thermometers had been installed for research purposes). It was not until 11th May that these experiments finished, and electricity could be finally switched off for the summer. It is probable that this could have been done early in April had these experiments been dispensed with.

Complete daily records of temperatures have been kept, but it will

be sufficient to give average monthly figures here. These are as follows:—

TABLE I

Month	Av. daily hrs. sun.	Shade temp.		"Sun temp."	Max. H.W. temp.	kW.h. used during month
		Max.	Min.			
Jan.	7.9	70°	49°	N.R.	130° (*a*)	790 (*b*)
Feb.	8.5	74°	53°	N.R.	130° (*a*)	614 (*b*)
Mar.	9.0	78°	54°	100°	130° (*a*)	410 (*c*)
Apr.	9.1	82°	55°	108°	134°	150 (*d*)
May	11.2	86°	60°	110°	141°	40 (*e*)
Jun.	12.0	94°	67°	114°	148°	0
Jul.	11.8	96°	70°	118°	152°	0
Aug.	11.3	93°	69°	120°	153°	0
Sept.	10.3	90°	66°	124°	153°	0
Oct.	9.7	85°	64°	118°	145°	0

Notes: (*a*) Setting on thermostat.
(*b*) Normal electric heating, before solar heating in operation.
(*c*) Solar contribution began late in March.
(*d*) Experimental period during installation.
(*e*) Reading would have been 0 but for experiments.

The record high temperature so far occurred on 4th September, 1955, when the hot water reached 162° F. The shade temperature on that day was 102° F. The absorber's theoretical maximum efficiency in September is thus borne out by fact. Its performance is actually better than was expected.

The column headed "Sun temp." gives readings taken from a thermometer hanging in the sun near the absorber. They are relatively meaningless, as wide variations can be obtained by altering the position of the thermometer, its degree of exposure to wind, and even between one type of thermometer and another. They are nevertheless included here for interest, as they give some indication of the degree of sensible heat prevailing at the time.

Unfortunately it is impossible to determine what electricity the household would have used had there been no solar heater, nor can the amount of hot water actually used each day be assessed. However we have never run out of hot water since the solar heater has been operating solely on the sun, though we have been near it once

when three guests were staying in the house, and four or five baths plus the washing-up from a dinner party were required. It appears therefore that the 36-gal. cylinder is about the right size.

The measurement of the temperature of the make-up water has presented some difficulty. A thermometer is positioned on the inlet pipe, but the temperature of the incoming water varies considerably throughout the day, depending on the time that hot water is drawn off. My household usually takes one bath in the morning, and the water to replace this enters at about 75° F. in summer. If however water is used in the afternoon, replacement water is at about 90°–95° F. It has been impossible to record these temperatures owing to this variation, but 80°–85° F. can be regarded as a fair average for the temperature of the incoming water in summer.

The maximum water temperatures shown in Table I are very close to those forecast, and the calculated temperature rise of 70° F. has been obtained in practice on most days in summer, though a fair average is probably nearer 65° F. The impression one gets on turning the tap on is that the water is *very* hot, far hotter than the hands can bear. The normal maximum temperature of a hot bath which most people find comfortable is about 102° F., but the solar-heated hot water emerges from the tap in the afternoon and evening at over 150° F. It reaches its maximum at about 2 p.m., at which time water is drawn off for the lunch-time washing up. The heat lost due to this is replaced during the next hour, after which absorption gradually ceases. The temperature of baths drawn off before dinner will be at about 145° F., and running hot water off at this time has the advantage that use is made of the water in the absorber, which will still be hot, and which moves up into the cylinder. If water is not drawn off until later, this bonus will be wasted, as back radiation takes place soon after the sun goes off the absorbers.

Hot water drawn for baths at 10 p.m. will be at about 140° F., and at 6 a.m. next morning at about 125° F. Cold water has of course always to be added to reduce the water temperature to a comfortable level. These temperatures do not seem to vary much, whether baths are drawn off or not, though if none are taken at night, the temperature in the morning may be up to 130° F. It is therefore evident that the lagging in my installation could be improved. The above figures are all for summer, and will of course be less in winter, but no data on this is yet available.

On one occasion during experiments I inadvertently left the valve (installed for research purposes) between the absorbers and the cylinder turned off all the morning. Domestic complaints about shortage of hot water at lunch time caused me to discover this, and on turning the valve on, water at 170° F. immediately entered the cylinder. This occurred on 21st April, when the maximum "sun temperature" recorded was only 103° F., thus proving the point about heat being absorbed quantitatively.

The best hot water seems to be obtained on bright clear days which do not feel particularly hot. However, quite reasonable heat is sometimes obtained when the sun appears to be totally obscured—a rare occasion in the Canal Zone, but it does happen sometimes. This is because the infra-red rays which contribute largely to the heat input, can pass certain types of haze. Those who know the Middle East will know all about Khamsins (Ghiblis in Libya)—most unpleasant hot winds usually laden with sand—during which life feels at its lowest ebb. This feeling is shared by solar heaters, as Khamsins which produce almost unendurable hot air, produce relatively poor hot water. They do not occur very often, however. After a Khamsin, the glass of the absorber will be covered with sand, and this then has to be cleaned. This operation has to be carried out in any case every three or four weeks, as dirty glass causes a noticeable drop in water temperature.

The only other practical point that I can record is the feeling of satisfaction which results from lying in a hot bath, knowing that all the effort required to heat it has been provided by nature.

The above account and figures refer to the first prototype: Colonel Thorp's experience of the second prototype is generally similar.

Cost of Solar Heaters

The two prototype installations have of course been made by hand, and no production costs are yet available. However, preliminary inquiries with the trade in U.K. indicate that the cost of one absorber complete in wooden frame will be of the order of £20. The storage cylinder with its two immersion heaters and switch costs about £20, and piping, lagging and other work in the house say another £30. For officers' quarters which require three panels, therefore, the cost of the whole installation is of the order of £110. For a two-panel set the cost will be about £90. In comparison with this, the cost of an oil-fired boiler plus immersion heater, which is the alternative system, together with its boiler house, chimney and fuel store would be some £125.

It can therefore be said that the installation of a solar heater costs no more than the oil-fired alternative system, provided that it is installed while the house is being built. Solar heaters fitted to houses after construction may well cost 50 per cent more than the above figures, and in addition the boiler will have already been installed.

Economics of Solar Heating

At first sight there would appear to be little chance of obtaining approval to schemes for the installation of solar heaters in married quarters, since the occupants seem to be the only ones who will benefit. Fortunately however this is not so, as in all stations abroad, occupants are charged for electricity at the flat rate of 1d. per unit (kW.h.), and the remainder (normally at least 1.6d. per unit) is

subsidized by the War Department. Thus for every penny saved by the user, the W.D. saves 1.6 pence. Should solar heaters ever be installed in Benghazi and Tripoli, where the local electricity costs 7d. per unit, for every penny saved by the occupant, the W.D. would save 6d. As may be imagined, however, electrical heating of hot water in married quarters in these localities is not at present used to any great extent, as the W.D. dislikes paying this subsidy intensely.

Although there may be little to choose between the capital cost of installing a solar heater and that of the oil-fired alternative system, in operating costs the solar heater shows a substantial advantage. The operating costs for the oil-fired system have to include for delivery of oil, and for greater maintenance charges, and an approximate comparison of the figures is as follows:—

For consumption of 18 *kW.h. per day* (*extravagant user*).

	Cost per year to		
	Individual	*W.D.*	
(1) Full electric	£27	£44*	(£165)
(2) Oil-fired plus electric	£13	£19	(£63)
(3) Solar	£8	£12	(£45*)

For consumption of 9 *kW.h. per day* (*average user*)

(1) Full electric	£14	£22*	(£82)
(2) Oil-fired plus electric	£7	£12	(£34)
(3) Solar	£4	£6	(£23*)

First figures shown under the column headed W.D. are based on the cost of electricity at 2.6 pence per unit. Figures in brackets are for electricity charged at 7d. per unit, on which the extra cost is solely borne by the W.D.

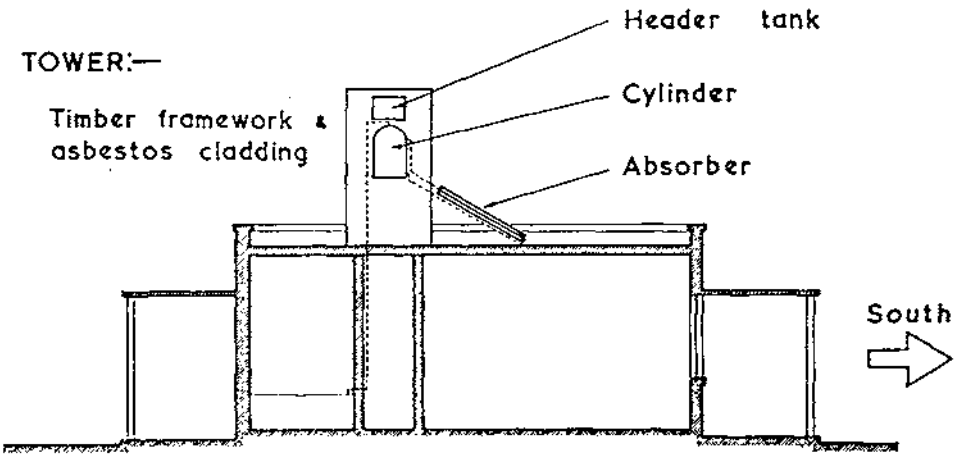
It should be noted that with solar heating, the cost to the W.D. even at the 7d. rate is little more than that already cheerfully paid in subsidy for normal electric heating at the 2.6d. rate. (These two cases are marked*.)

Apart from the aspect of cost, the solar heater requires no attention, functions completely automatically, and makes no mess.

The above figures are based on the performance of the prototype, and can hardly fail to be improved upon in the more efficient production models.

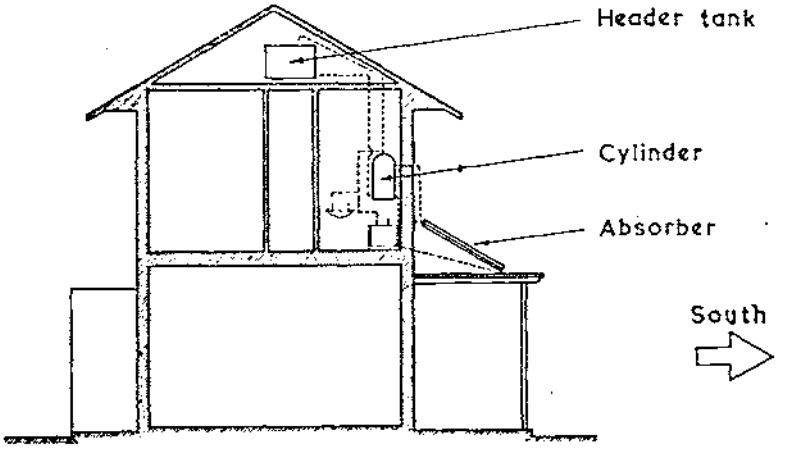
Fitting of Solar Heaters to Standard Design Married Quarters

In Cyrenaica and Tripolitania, the type of married quarter at present being erected in considerable numbers is known as the Libyan Lodge. This is a house built of concrete blocks with a flat roof. The fitting of solar heaters to these is extremely easy, since the absorbers can be placed on the roof, with storage cylinder and supply tank in a small timber and asbestos tower adjacent. This is shown in Fig. III.



DESIGN FOR LIBYAN LODGE

FIG III



DESIGN FOR 'C' TYPE MARRIED QUARTER

FIG IV

In some W.D. standard designs of quarters with pitched roofs, as now being erected in Cyprus, the addition of solar heaters is comparatively easy. In other designs however the problem is more difficult owing to the centralized position of the hot water cylinder inside the house. The best place for the panels appears to be on the roof of the veranda, which enables them to be reasonably accessible for cleaning. One such arrangement fitted to a standard Type C quarter is shown in Fig. IV.

If a house with a really difficult hot water system has to be converted to solar heating and major structural alterations are to be avoided, it would always be possible to place some arrangement such as that shown in Fig. III in the garden alongside the house. This might appear unsightly, but would nevertheless function satisfactorily if the piping could be kept reasonably short.

Alternatively, use can be made of the roof of any garage, workshop, etc., which may be adjacent, provided that the correct aspect can be obtained.

Possible Disadvantages of Solar Heating

The world is full of unbelievers, so let us now try to look at the subject through their eyes. The only fault that can possibly develop, as far as can be seen, is that scale may form inside the absorbers, since much of the water in the Middle East is hard. This, however, is unlikely to happen below temperatures of 170° F. which are rarely reached. The intention in any case is to arrange for the panels to be easily removable, when they can be chemically de-scaled. The Garrison Engineer would require a small pool of spare panels for this purpose, and the operation would be carried out as part of normal maintenance.

The only other possible cause of failure appears to be the failure of the sun to shine, which seems an unlikely phenomenon in the Middle East.

Present Position

Observation of results on the prototypes will not be facilitated by the fact that we have to move from the Canal Zone to Cyprus in November, just at the critical period of transition between summer and winter operation of the solar heater. The intention is to convert the second prototype to a three panel set, and move it to Cyprus, so that readings can be initiated on this before the first one is dismantled. This will then also be moved to Cyprus.

Although it would obviously have been desirable to complete a full year's trial on the prototypes, the disadvantage of this would have been that we should not have had a complete answer before May, 1956. By this time there will be a large number of permanent married quarters reaching an advanced stage of construction in M.E.L.F., and, as has been said already, conversion of existing houses is not

always easy. The War Office have therefore been asked to agree* that the trial carried out so far is sufficiently satisfactory to warrant the provision of one hundred sets for troop trials. It is proposed to distribute these between Cyprus, Aqaba, Cyrenaica and Tripolitania, spreading the trials over as many classes of user as possible. Each house involved in the trial will be fitted with a separate electricity meter to record consumption on water heating, and a similar number of houses without solar heaters will also be fitted with separate meters on their hot water systems, so that a true comparison can be made.

Even with this arrangement, if it is ever decided to adopt solar heaters for all quarters, considerable difficulty will arise in converting the hot water systems in some designs of house. The idea has really been thought of about two years too late, as it would have been comparatively easy to design houses for solar heating in the first place.

It is proposed to have the absorber panels and special storage cylinders manufactured in U.K. The absorbers would be shipped as assembled units, only the glass requiring fitting at the site.

Conclusion

In writing this article I have tried to keep strictly to the factual results of the experiment, and not to indulge in sales talk. The point which cannot be denied, however, is that whether the use of hot water is great or small, solar heating is almost bound to be the cheapest method, since it taps a free source of energy. It is a very great pity to have to regard the sun as an enemy, when, by the provision of comparatively simple apparatus, it can be made to contribute materially to our comfort, and to our purse—both private and official.

I myself am enthusiastic about this scheme, and would like to see all married quarters fitted with solar heaters wherever climatic conditions are suitable. This would appear to include all countries in the Mediterranean area, and many other stations abroad where reasonable periods of sun occur every day. The present design of solar heater would fail under frost conditions, and although this particular problem could be overcome by redesign on to an indirect system, it would probably not be an economic proposition for U.K.

I am sure, however, that the Editor will wish me to conclude by saying that in advocating the use of solar heating abroad on a large scale, I am voicing my personal opinion, and that this does not necessarily bear any relation to official policy.

* Approval has since been given.

THE FAREWELL ADDRESS
of
MAJOR-GENERAL G. WALKER, C.B., C.B.E., D.S.O.
(Commandant S.M.E. and R.E. Depot)

13th February, 1931.

Editor's Note.—This address was originally published in the *R.E. Journal* for June, 1931. As all the remarks made at that time are equally applicable today it has been decided to republish it.

I HAVE asked you to meet me here today, gentlemen, as I want to say a few words to you regarding what I conceive to be the duties of a British officer generally and a British Engineer officer in particular.

Our responsibilities are, I think, twofold:

(*a*) In respect of our position as English gentlemen.

It is our duty to maintain before the world, wherever we go, by our conduct, demeanour and appearance, the prestige which has belonged for many centuries, and which, I trust, will remain for many more, to what is called a gentleman—a man who cannot be better described than one who does justice, loves mercy and walks humbly and in fear of God. It is no question of rank.

(*b*) In respect of what is due to the Service.

Here the first essentials in our conduct are, loyalty and discipline and the avoidance of anything that savours of intrigue.

A good officer must obey orders with alacrity, a loyal officer must obey them in the spirit, if circumstances prevent obedience to the letter. Your duty is to carry out the work that is set you by your commander without hesitation, to the best of your ability and without obstruction or criticism.

Criticism, and destructive criticism especially, is only too prevalent with some people. It is a frame of mind that is absolutely unsoldierly. It is a golden rule never to criticize unless you have a better solution of the problem at issue to put forward. A soldier's first thought must be how can I possibly get this thing done, not how shall I be able to avoid doing it.

An officer's duty is to lead men, and the leadership of men in war must be his constant study. Leadership does not mean making people do unpleasant things, but teaching them to do these things because they have to be done, and to like doing them for that reason.

The power of leadership depends on the following, amongst other things:

(*a*) Personal control of oneself and of one's temper.
(*b*) Sound professional knowledge, as intelligent men will never follow an ignorant one.
(*c*) Personal sympathy for the troubles and shortcomings of one's subordinates.
(*d*) Personal integrity and the realization that there are some things which an officer cannot do.

I must now say a word as regards our responsibilities to our Corps. We have a great tradition and a long and honourable history. These have been built up, during a long period, by the zeal and industry of our officers and men. Our predecessors have always realized that the duty of a Royal Engineer is first and last to help other people, to apply his art in such a way as to make the work of other people less difficult in war. It is our duty to maintain this tradition to the best of our ability.

I would like to warn you against a horrible expression which I sometimes hear, viz., "That is not a Sapper's job." In my humble opinion it is a damnable thing to say or even think. Whatever will help the work of the Army along is a "Sapper's job" every time.

May I add a few words of more personal advice which may be of value to the younger members of my audience. Avoid unprofitable speculation as to the future either as regards yourselves or the Corps. Just do what comes to your hand zealously and ungrudgingly and give an honest opinion when you are asked for it.

Your personal future will depend upon your efficiency and nothing else.

An R.E. officer must have a broad general knowledge of the work of his Corps and an intimate knowledge as to how it provides for the needs of the Army. As he gets older he must try and be a master of one branch but must not fail to keep in touch with the others.

Versatility is what is required. He must not get into a rut by tying himself up to one line for too long.

Most important of all, we are military engineers, and we must continue to study soldiering all our lives.

Lastly, never allow yourselves to think anything you have to do a rotten job. There is not a rotten job in the Army if it is done in the right spirit.

Those are the things which I have tried to do during my 42½ years' service. I have had a happy life and have enjoyed every minute of it. If I had to start again, even with my long experience to guide me, I should do what I did so many years ago, and become a Royal Engineer.

BOOK REVIEWS

AGAINST GREAT ODDS

By BRIGADIER C. N. BARCLAY, C.B.E., D.S.O.

(Published by Messrs. Sifton Praed & Co. Price 15s.)

General von Manstein criticized the original German plan for the invasion of France in 1940 as only good for an "*ordinäres Sieg*" and suggested the change, which aimed at a decisive victory—General O'Connor had rather similar views about the initial plan for the 1940–41 offensive against the Italians in North Africa. He felt that the authorities aimed at mediocre results and not at a great success. The original battle was, in fact, intended as a big raid which, if successful, was to be exploited as far as meagre resources permitted. The whole affair was not expected to last more than five days. Under O'Connor's inspiration, however, it developed into a decisive two-months campaign, which completely destroyed the Tenth Italian Army of 250,000 men.

As a prisoner of war in Italy, O'Connor wrote a short account of the operations, which was smuggled to England whilst the war was still in progress. Written secretly and from memory, this narrative is a remarkably accurate story of the campaign as seen by the victorious British commander. The official historian, General Playfair, has naturally made full use of it in his admirable *History of the War in the Mediterranean and the Middle East*, Vol. I. Yet a first-hand account, such as this, of one of the great triumphs of military history deserves a separate printed record. This Brigadier Barclay has now supplied by making General O'Connor's narrative the basis of *Against Great Odds*. The author skilfully fills in the general picture of events and corrects a few unimportant inaccuracies. In the last two chapters he cuts loose on his own to discuss the fateful implications of Greece and the lessons of the campaign. An article from the *Army Quarterly* of January, 1950, by Lord Wavell, on the British Expedition to Greece appears in a most useful appendix. Sir John Harding, in a foreword, stresses the important part played by Commonwealth troops. The combined result of all these writings is a short but fascinating book of just over a hundred pages. The style of it is refreshingly direct and there is some new material. The withdrawal of the 4th Indian Division, for instance, came as a complete surprise in the middle of the battle for Sidi Barrani. The interesting details of the British commander's move forward to the H.Q. 7th Arm'd. Div., before the final battle of Beda Fomm, are also new. About Greece, one must remember that Winston Churchill, who completely dominated the political and military scene, was eager to help her. If he had been at Athens when General Papagos changed the agreed plan, things might have gone differently, for by then Churchill was apprehensive of the enterprise. The lessons of the campaign are numerous. Specially to be noted are the rehearsal of the approach march and the economy of paper during the preparations for battle. XIII Corps consisted of one infantry division and one armoured division and never numbered more than 31,000 men. This pattern and size of formation is in favour at the present time, which gives an added interest to the action of XIII Corps.

Brigadier Barclay is to be congratulated on a notable book which presents much controversy, truly and fairly, in a small compass. Some missing names mar the maps, which is a pity.

B.T.W.

RED SHADOW OVER MALAYA

By BRIGADIER M. C. A. HENNIKER, C.B.E., D.S.O., M.C.

(Messrs William Blackwood & Sons Ltd. Price 18s.)

Clausewitz hardly mentions maritime warfare in his famous book, but few aspects of land fighting escape his attention. The second sentence of the chapter on what are now called resistance movements, suggests that their inward effect on the law and order of a country may be just as dangerous, as their outward effect on the enemy. Aftermaths of resistance in France, Greece, Burma and Malaya seem to show that Clausewitz is not far wrong. In Malaya the Communist leaders mostly learned the technique of rebellion from experience gained in resisting the Japanese. Yet Japan was utterly defeated in 1945, whereas the Malayan affair has been going on for nine years and still continues. Are resistance movements worth while?

Those who wish to study this important question should not omit to read *Red Shadow Over Malaya*, for it gives an excellent general picture of the Malayan problem. Its author writes well. Grave and gay in turn, and always observant, he finds something interesting in every detail. The "Communist terrorists", alias bandits, pay the forces of law and order the compliment of copying official organization diagrams so closely that the one is hardly distinguishable from the other. Imitation being the sincerest form of flattery, the security organization is probably very effective. The engaging thickheadedness of Gurkhas delights their Brigadier, just as much as it will his readers. His views about gin coincide with those of General Templer, who has recently reminded us that a man has only one stomach and should therefore be careful about what he puts into it. Although V.I.Ps. begin "to date" at home, they still flourish in Malaya, where fine specimens continue to keep their hosts on tenterhooks of anxiety and apprehension.

More serious topics include first-class descriptions of operations, conferences and committees. The Brigadier wonders whether committee work with its endless compromises is good experience for soldiers, especially young ones. He would have them trained to be commanders, not committee men. Surely the soldier of today must strive to fill both rôles? A modern commander has to be subtle and persuasive to gain his ends. He cannot start too young learning how to win people to his views, particularly on committees.

The author also seems to have doubts about the political future of Malaya. This is disquieting since he spent three years there in close touch with the problem. Nevertheless there are some redeeming features. Malaya is rich for an Asian country. Relieved of the costly incubus of terrorism, the country's economy should forge ahead and bring contentment. The maritime power of the West can, if necessary, quickly support the early struggles of a democratic Malaya. Red China has, so far, taken little interest in Malaya, which looks across the oceans for her future existence and not to the Continent of Asia. On the whole the omens for democracy might be much worse. The years to come will show what they are worth.

In the meantime the omens for the success of *Red Shadow Over Malaya* are highly propitious, since its publication coincides most happily with a critical juncture in the long struggle with the terrorists, about which the general public may perhaps wish to be better informed. Brigadier Henniker is to be congratulated on a lively and provocative book, which is a worthy companion to three other notable books on the military art recently written by officers of the Corps.

B.T.W.

RIDEAU WATERWAY

By ROBERT LEGGET

(Published by University of Toronto Press. Price $5. London Agents, Oxford University Press)

During the past year there have been celebrations in Canada to mark the centenary of Ottawa. These have included many special references to Colonel John By of the Royal Engineers, who is looked upon as the founder of Ottawa, by reason of the fact that when he built the Rideau Canal between the years 1826 and 1832 he based his headquarter camp at the junction of the canal with the Ottawa River. The camp grew into a village and was called Bytown. In 1855 the name was changed to Ottawa.

It is very appropriate therefore that Robert Legget should produce this most interesting book at this time. It describes not only the historical background, but also the engineering details of a truly remarkable work carried out by a Sapper officer under considerable difficulties. It is only now, more than 120 years after the event, that his achievement has been properly recognized.

The author, himself an engineer, who has been engaged on much heavy engineering work in Canada, and more recently has been a Professor in Civil Engineering at Toronto University, and is now a Director of Building Research in Canada, is eminently suited to write on the subject.

He has, undoubtedly, spent much time in gathering information for his book, as can be seen from the bibliography at the end. In this he has been fortunate in finding much of the original correspondence and other information in the Canadian Archive offices.

In this connexion he has thrown more light on the facts concerning the expenditure on the canal for which By was brought to task by a Parliamentary Committee, and although exonerated he received neither praise nor reward for a wonderful engineering achievement, and he was not employed again.

Details of the waterway, which is only a canal in the true sense for a comparatively short distance, are well described and so are the engineering difficulties which arose. The total length of the waterway is about 120 miles, and there are no less than forty-seven locks, with a total lift up and down of 439 ft.

To overcome the difficulties of rapids in some of the river portions of the waterway he built dams to raise the level of the river. Dams were also used to ensure a sufficient water storage for the locks. The two principal dams were larger than anything previously built in either the U.S.A. or Canada.

All this work had to be designed by By and the Sapper officers with the two R.S. & M. Companies, specially raised for this work, which had to be carried out in virgin country with no means of transport or communications other than the existing waterways, which before the canal was built could only be used by canoes with portage round the many rapids.

The book is a most fascinating story for any Sapper to read, and shows how it was possible to construct large engineering works without all the plant and equipment nowadays considered necessary. It also shows how, even more than 120 years ago, a rigid control of expenditure was exercised by Parliament.

The fact that the canal is still in use, although now almost entirely for pleasure craft, and that comparatively little maintenance has been required on the locks and dams, shows how well By's work was designed and constructed. This has now been recognized when last October a Memorial Fountain, erected near the Ottawa entrance to the canal, was dedicated to By's memory.

C.C.P.

THE SUPERVISION OF CIVIL ENGINEERING CONSTRUCTION

By A. C. TWORT

(Published by Edward Arnold (Publishers) Ltd. Price 25s.)

This is the book for which the resident engineer and, in fact, all those engaged on the supervision of civil engineering work have been waiting for a long time. The author has systematically and skilfully covered the "nuts and bolts" of site work and the real "bread and butter" of the supervising engineer, which is so often inadequately described in so many textbooks and left to the imagination.

It is conveniently divided into three parts: Part I covers site organization, including programme and progress control and the important items to which the site engineer must give his undivided attention if the contract, as a whole, is eventually to prove a successful undertaking. Part II gives a clear account of how the work develops on the site, with special reference and details of certain important phases of construction. Site work concerned with setting out, excavations, foundations, steelwork, formwork, concrete and a number of main building trades is adequately described, with an eye always on the realistic and practical difficulties which occur on any civil engineering contract. Part III deals very clearly with specifications, bills of quantities and drawings, all of which are so vital to the sound technical and administrative control which the resident engineer must exercise.

The book is thoroughly recommended for use by both experienced engineers and those who are about to undertake their first appointment on site supervision of civil engineering work. A copy should be available in every site office to serve as a quick reference for the experienced engineer on points on which he may be in doubt, and for the young engineer as a guide to sound principles and good supervision.

It is specially recommended for those more senior engineers who may have become rather set in their ways and methods, because, on reading through it, they will undoubtedly find that there are a number of items which for many years they have misunderstood and are consequently going the wrong way about them.

If there is any criticism to be offered at all it is that although the book is entitled *Supervision of Civil Engineering Construction* and, no doubt, sets out to cover this subject, a fair amount of the site work, methods and administrative items described are in fact applicable to building construction and not to civil engineering. G.T.F.

BUILDERS' MATERIALS

By BERNARD H. KNIGHT and RENA G. KNIGHT

Third edition

(Published by Edward Arnold. (Publishers) Ltd. Price 30s.)

This publication of some 300 pages is both a text and reference book and is intended not only for the practitioner but also for students preparing for professional examinations. It is eminently suitable for all personnel engaged in the Engineer Works Services. A vast amount of useful information has been condensed into a comparatively small space. An excellent feature of this book is the numerous references to appropriate B.S. Numbers, Codes of Practice and other authoritative sources of information.

It was first published in 1939 and revised in 1948. It has now been almost entirely re-written and six new chapters added to cover most of the

new building techniques developed since the war. These deal with wall, floor, roof and ceiling linings, asphalts, plastics, adhesives, decorative materials etc., in a well laid-out and readable form. It gives valuable information on such subjects as efflorescence in brickwork, plasticizers for mortars, concreting in cold weather, laying granolithic concrete floors, painting new plaster and asbestos cement etc. It has a realistic approach to modern conditions and materials and offers practical remedies for many of the common failures. The tests for materials are simply and clearly defined.

Chapter I on bricks and clay products and Chapter IV on timber and timber products are excellent. Included in the latter are facts on plywood and veneers, together with methods of timber preservation. Walling, roofing, wall and ceiling linings, floorings, etc., are adequately dealt with in Chapter VIII. Several pages are devoted to insulating boards aud hardboards, common sizes of the more widely used variety are quoted and reference is made to flame-retardant treatment.

The information on flooring is clear and concise and deals with wood, concrete, terrazzo, asphalt, magnesium oxychloride, tiles of every description and types of jointless flooring developed since the war.

Heat and sound insulation properties of building materials, condensation problems and the question of fire resistance has been allotted a special chapter under the heading of "Comfort Criteria". This again is of first-class value and, although brief, is adequately referenced to B.S. and other authorities.

This is a publication of eleven well-written chapters on most of the materials used in present-day building. It concludes with an appendix containing certain model by-laws relating to building materials, weights of materials and lists of relevant British Standards and Codes of Practice. The book is amply indexed.

A first-class practical book that may be recommended to all who desire to keep abreast of the continual advancement in technical and scientific knowledge of builders' materials.

F.A.A.

HYDRODYNAMICS

By BIRKHOFF

(Published by Dova Publications, Inc., New York)

(Price $3.50 Cloth; $1.75 Paper)

This is not a book for the general reader, nor indeed for anyone unfamiliar with the higher mathematics of fluid motion. The specialist reader, however, with sufficient mathematical knowledge, will find the book of considerable interest. It deals essentially with two special aspects of fluid mechanics, the complicated logical relationship between theory and experiment, and the applications of symmetry concepts. It examines in detail a large number of hydrodynamic paradoxes in which theory is at variance with observed results, and shows how in many cases the paradox arises from the incorrect assumption that small causes will have small effects. Of interest to the military reader will be a brief discussion on the theory of cavity charges and the penetration of armour plate by fluid jets.

The book is intended to stimulate enlightened thought on the bases of hydrodynamic theory, and as such should be of interest to advanced students of the subject either at Cambridge or the Military College of Science.

J.E.L.C.

TECHNICAL NOTES

CIVIL ENGINEERING

Extracts from *Civil Engineering*, July, 1955.

Current Trends in Structural Design

Nowadays the task of the practising engineer trying to keep abreast of the latest developments in engineering science, even in his own particular line, is not one to be envied. With numerous ideas, theories and reports of work being published, many with results mutually contradictory, it is often difficult to distinguish the more significant developments leading to economy, from those of lesser importance. This is particularly true of structural engineering in which the principal economic factors involved (of material, labour, and transport costs) are variables over a period of time. For a particular problem the most economical solution will not always remain the same from year to year—the designer must, therefore, reconsider his opinions regularly in the light of the latest developments.

Among the mass of available technical data, certain definite trends may be discerned, however. In trying to assess the relative importance of modern concepts, it is helpful to investigate firstly the historical background to the methods of design now in vogue in engineering offices.

The article goes on to discuss the development of the "Permissible Working Stress" notion, the Evolution of Design in Reinforced Concrete, and the Semi-Rapid Design Method. The article is illustrated with photographs and makes extremely interesting reading on this subject.

Nottingham Flood Protection Scheme

This article describes the work which is being done on the difficult problem of flood protection in the River Trent area.

The valley of the River Trent has always suffered periodical inundation, the earliest recorded flood was in the year 1346 and in the past 100 years there have been seven major floods when the peak levels have risen approximately 12 ft. above normal.

The article is well illustrated with photographs and goes on to describe the details of the new Protection Scheme which is now estimated to cost approximately £1,100,000, and for convenience is designed into three sections; Beeston to Wilford Power Station, Wilford Power Station to Trent Bridge, and Trent Bridge to Radcliffe Viaduct.

Deep-Water Drilling Tower

An extremely interesting engineering operation is taking place in the Firth of Forth. The operation is in search of coal. The article describes the erection and use of a deep-water, coal, drilling tower built for the National Coal Board. The tower has been designed for use in water up to 20 fathoms deep and will remain steady in bad weather, withstanding gales of 80 m.p.h. and waves measuring 30 ft. from crest to trough.

The boring tower is constructed of tubular steel upon a heavy steel X-shaped box girder base. The two members forming the base are each 163 ft. long, 3 ft. wide and 7 ft. deep. They are hollow and provision is made for flooding them with water or for pumping them dry when the tower is to be floated. Fully equipped, the tower weighs nearly 500 tons and measures about 185 ft. from the underside of the base to the top of the drilling rig.

Two pontoons are used to float the tower which is then towed into position by tugs.

Review of Contractors' Plant

100 ft. Piling Frame

A 100 ft. Pile Driver has been built to the order of Christiani and Nielsen, Ltd., for the Hampshire County Council Langstone Bridge Contract. The equipment is built up of welded units which are individually small enough to permit transportation by road to the site, where it is assembled and runs on a specially laid railway track.

In the raised position, the height of the telescopic leader is either 100 ft. or 85 ft. The leader may be raked backwards or forwards, the maximum backwards rake being roughly 1 in 2.5, and the greatest forward rake about 1 in 4. The approximate dry weight of the complete equipment less the hammer (single-acting, 7 tons; drop type, 4 tons) and the 6-ton counter weight, but including single boiler, is 53 tons. The Pile Driver is expected to be called upon to handle piles up to 80 ft. long and weighing over 9 tons.

New Motor Scraper

There is a full description of a new Motor Scraper, Model TS.360, produced by the Allis-Chalmers Manufacturing Co. It has a 280 h.p. engine, a truck capacity of 15 cu. yds. and a heaped capacity of 20 cu. yds. The transmission employs a newly designed spur-type low gear set, and provides four forward speeds from 3 m.p.h. to 20 m.p.h. and one reverse.

The basis of unit construction used on the TS.360 is a welded box section main frame. This frame carries the various components of the tractor. The push block at the back of the scraper is 56 in. wide for protection to the tyres when a bulldozer is used for pushing. When the machine is empty, 66 per cent of its weight is carried by the tractor wheels and when fully loaded, the weight is distributed on all wheels.

Extracts from *Civil Engineering*, August, 1955.

Triangular Frameworks with Rigid Joints

A large number of experiments have been carried out to study the behaviour of isolated columns with either pin ends or ends which have been fixed in some artificial way, but comparatively little has been done to study the behaviour of struts in actual frame works. In the case of isolated columns the moments at the ends of the member are constant, or bear some simple relation to the end rotation, but when the strut becomes a part of a structure its behaviour is determined by all of the other members of that structure.

The article gives a clear account of the experiments which have been made on various frames, and forms the first part of a series on this subject. The work is being carried out at the Department of Engineering, University of Manchester.

The Allt-na-Lairige Project

An article has been written on the extremely interesting tunnelling work that was carried out during the driving of the Allt-na-Lairige tunnel in Argyll, for the North of Scotland Hydro-Electric Board.

The tunnel was only 8 ft. high by 6 ft. 6 in. wide and was driven through granite. The most interesting feature of this tunnelling operation was the use of unusual mucking arrangements. A shuttle car some 70 ft. long was constructed, and the floor of the body consisted of a steel slat conveyor belt on rollers propelled by hydraulic rams. The loaded rock was thus moved steadily back from the tunnel face as required to make room for the new fill, and was discharged from a space at the bottom of the car into tubs of 2 cu. yds. capacity.

The use of this shuttle car enabled a continuous mucking operation to be carried out without the normal delay of skip changing. A sketch of this apparatus is included in the article.

Review of Contractors' Plant

Wheel Washers

The Moseley Wheel Washer is semi-automatic and will remove mud and clay adhering to the driving wheels of road vehicles operating in quarries, pits or construction sites.

It is a most useful machine and it consists basically of a heavy duty steel grid, in the centre of which there are two free-running rollers spaced to allow a maximum contact with the rear wheels of the average four-wheeled lorry. The rollers can be locked by means of a hand-operated brake. A pipe which runs under these rollers supplies the water necessary for the washing operation through a series of nozzles, the water flow being controlled by a valve inter-connected with the brake operating device.

Although the washer is built to withstand the weight of an average four-wheeler, it can be moved from site to site, as little pipework and supporting concrete foundations are involved in its installation.

Extracts from *Civil Engineering*, September, 1955.

The Moisture Content of Concrete Aggregates

To obtain concrete of uniform strength it is necessary to adjust the amount of water added at the mixer to suit the moisture content of the aggregates, and for high-class work the determination of the amount of moisture in both the fine and coarse aggregate should be made at frequent intervals. This article describes the use of a buoyancy moisture meter which has been developed and which, after calibration for the particular aggregate, enables the determinations to be carried out accurately and rapidly by semi-skilled labour. The instrument consists of a balance arranged so that when a long-handled sample bucket, hung from one arm of the beam, is immersed in water in a suitably placed tank, the system is out of balance by 500 g., the other arm carrying the scale pan being the heavier.

A second sample bucket is provided having a short handle and of such a weight that when it is hung in place of the long-handled bucket it is clear of the water and the system is again out of balance by 500 g. with the rider at zero. A number of hollow counterpoises, each 250 g. in weight, are provided, so that at one time the instrument can be calibrated for use with several aggregates. The article contains a very full description of the method and theory of calibration, and a very clear sketch of the instrument.

Pump for Small Discharges

This article describes how some years ago one of the authors was approached by the International Committee for Re-settlement of Assyrian Refugees in Syria with a request to design a pump for lifting water to small heights for irrigation. The pump was to replace the ancient water wheels or "Nourahs", which although picturesque, were very inefficient and expensive to construct and maintain. Due consideration was to be given to local conditions, the design being based on the following requirements:—

(*a*) Low cost; the pump to be made locally by semi-skilled labour and to require very little maintenance.

(*b*) Adaptability to any form of power; animal traction, wind power, water power, etc.

To meet these requirements, a "Centrifugal Reaction Pump" was designed. This was similar to an old type of reaction turbine, known as "Barker's Mill" or "Scotch Turbine", modified to suit its new function. This pump would be able to pump water up to a height of approximately 20 ft., as limited by atmospheric pressure.

The paper is extremely well illustrated with photographs and drawings of the apparatus, and a set of graphs giving the hydraulic efficiency and the relationship between discharge and r.p.m. for the first type of pump developed.

Suitable Linings for Earthen Canals

In practice, the volume of water reaching the water courses of fields irrigated by an earth channel is about half of that which enters the channel. Within the fields, absorption losses through the earth banks of water courses account for about 40 per cent of the water actually supplied by the main channel. If the absorption losses in the main channels, distributaries and water courses were either stopped or appreciably reduced, considerable additional areas could be provided with irrigation facilities from the water already available in the canals. The article considers seepage losses and discusses various methods by which a suitable lining to prevent such losses can be obtained.

Types of linings which have proved extremely satisfactory are Shot-Crete cement mortar ½ in. to 1½ in. thick, cement concrete 3 in. to 6 in. thick, brick masonry in cement or lime mortar, precast cement concrete blocks, stone masonry, clay puddle, bitumen, sodium carbonate, etc. Unreinforced concrete linings function almost as well as reinforced linings, and hence to reduce cost unreinforced linings are widely used.

Because of the mobility and economy of Shot-Crete lining, this method is well suited to canals. The cement mortar can be easily placed on an irregular surface without the need for fine trimming. A very satisfactory mix has been found to be 1:5:9:3 cement: kankar lime: surkhi: sand mortar, for a lining ½ in. to 1 in. thick.

Review of Contractors' Plant

Concrete Vibrator

Cable Covers, Ltd., Prestressed Concrete Division, have produced the CCL-Tremix ultra-high frequency concrete vibrator. It is of the electrically powered immersion type and weighs approximately 60 lb. complete. It has a high vibration rate at a frequency of 17,000 vibrations per minute obtained by the simple centrifugal action of a rotating impeller moving at a rate of 3,000 r.p.m.

The standard vibration head is only 1½ in. dia. which means that it is small enough to pass through restricted spaces between reinforcement bars, but a 2½-in. diameter head can be obtained if required.

A brief specification is as follows:—

Weight	60 lb.
Vibrations per minute	17,000
Impeller speed, electric	3,000 r.p.m.
Impeller speed, petrol driven ..	2,850 r.p.m.
Vibration head, standard	1½ in. dia.
Vibration head, optional	2½ in. dia.

Extracts from *Civil Engineering*, October, 1955.

The Cost Factor in the Design of Reinforced Concrete Roofs

The first part of an interesting paper on this subject appears in this edition and the object of the paper is to show how a simple beam and slab roof can be designed and how the prices and materials affect the design specifications. Although some of the results derived here may have been arrived at by engineers as a result of experience, there appears to be no published literature available on a systematic study of this aspect of design. The study in this paper is based on the usual assumptions of the elastic theory as applied to reinforced concrete and it includes a study of the following items:—

(*a*) Determination of the prices of materials which will make the minimum depth of slabs uneconomical.

(*b*) Economical depth of beams.

(*c*) Economical spacing of beams in a beam and slab roof.

(*d*) Economical spacing of columns in a beam and slab roof supported over columns having shallow foundations.

Fibre Building Boards

Few materials introduced during the last half century have proved more versatile than fibre building board. It is impossible to assess with accuracy the total number of applications for which this material is suitable. One well-known manufacturer lists over 300, ranging from concrete shuttering to children's toys.

The principal raw material in fibre board manufacture is, of course, wood, although other materials such as straw and liquorice roots are sometimes used. The article is extremely interesting, it is well illustrated and there is a most useful table showing the standard types of hardboard and softboard in use in the building industry and the various engineering properties of different types.

Review of Contractors' Plant

Perigraph Control Device

An ingenious instrument has been invented and manufactured by F. Bordes, 15 Route de la Chartreuse, La Bronche (Pres Grenoble), Isere, France. It is possible to record directly, rapidly and with precision any cross-section of a mine gallery, road or railway tunnel, vertical mine shaft, etc., during boring operations. The following plottings are typical of the purposes for which the instrument may be used:—

(*a*) To check the tunnel gauges obtained and compare them with the design cross-sections, and to ensure that the work is progressing according to design levels and directions.

(*b*) To make a cross check of the volume of material extracted.

(*c*) To predetermine the quantities of lining concrete required.

(*d*) To measure the area of surfaces to be coated.

(*e*) To keep a permanent check on the strains and deformations of existing tunnels and galleries; and

(*f*) To gather the necessary data for measuring the possible hydraulic flow of rough-hewn galleries.

It is possible with the apparatus to carry out measurements on cross-sections ranging from $4m^2$ to $50m^2$, and it is possible to measure from 20 to 30 cross-sections per hour. The apparatus weighs 65 kg. including the pedestal trolley, and can be easily moved.

The apparatus would seem to be a most excellent aid to the tunnelling or mining engineer and one which would, no doubt, quickly pay for its cost in the time it saves.

THE MILITARY ENGINEER

(Journal of the Society of American Military Engineers)

JULY–AUGUST, 1955

"The Corps of Engineers 1775–1955"—180 years of service to the Nation in peace and war.

This interesting article of four pages summarizes the history of the American Corps of Engineers from its inception to the present day. The genesis of the United States Army Corps of Engineers dates back to a resolution by the Continental Congress on 16th June, 1775, under which General George Washington appointed Colonel Richard Gridley, Chief Engineer of the Continental Army. The history of the Corps is then traced through revolutionary times to the Mexican war and exploration of the West, the Civil War and after, World War I, World War II, up to Korea and afterward.

It is interesting to note that the Corps' traditional dual rôle of civil and military service stems from an Act of Congress in 1802 which authorized President Jefferson to "organize and establish a Corps of Engineers . . . and said Corps shall be stationed at West Point . . . and shall constitute a military academy". The Act also stated that the Chief of Engineers would be Superintendent of the Academy, and it provided that the officers of the Corps would do such duty, at such times and at such places as the President might ask. This provision of the Act set the pattern for participation by the Corps of Engineers in Civil Works activities. For many years, West Point was the only Engineering School in America, and it remained a part of the Corps of Engineers until 1866. For half a century almost all American Engineers were either West Point trained or pupils of West Point graduates. Being the only organized body of Engineers in the United States, the Corps' services were constantly sought to help with the works of internal improvement. The Army Engineer laid out roads, built lighthouses and canals and surveyed and mapped the new country. They opened the way for steam boat traffic, which was so important in developing the Middle West, and as late as 1855 there was scarcely a railroad in the country which did not bear the influences of the Corps of Engineers both in construction and management. They improved harbours, built the first iron bridge in the country and rendered many other general engineering services.

The article concludes with the following statement by the Chief of Engineers, Lieut.-General Sturgess:—

"The Corps of Engineers' dual civil-military organization has become a basic instrument of the American people. By virtue of the Corps' Civil Works functions, our nation maintains in existence an engineering and construction agency around which its technical resources can be mobilized in case of national emergency. This dual mission organization has been put to the supreme test twice in this generation and was found worthy: in 1941, after Pearl Harbour, when the Congress assigned it the responsibility for accomplishing all Army and Air Corps construction; and, later, when it was given the task of developing the first atomic bomb. Who knows, in this day of nuclear retaliation and megaton bombs, when it may be called upon to perform even more difficult tasks more important to national survival than anything yet assigned us?"

SEPTEMBER–OCTOBER, 1955

"Thoughts on Annihilation"—by Colonel Elbridge Colby.

No suggested solution to defence or protection against enemy aircraft carrying A-bombs and H-bombs can afford to be neglected. The author, a veteran of two world wars, considers that defence by retaliation no

longer constitutes effective protection in an atomic war. Enemy planes must be stopped with certainty before they reach our own, or friendly frontiers. To do this he advocates an H-bomb carrying plane capable of flying soon enough, fast enough, and high enough to drop an H-bomb on every enemy formation of planes. The effective area of burst by heat or blast must be big enough to ensure knocking out every enemy plane. None must get through. Just as the answer to artillery was bigger and better counter artillery he considers the answer to the H-bomber is a faster and better H-bomber. It only remains for our scientists and inventors to perfect the idea.

"Le Génie Américaine vu par un Français"—by General Robert J. L. Pinson, Inspector General of French Army Engineers.

In this article by General Pinson, a senior French Army Engineer and a member of the French "Army Council", it is interesting to note that the General attributes the engineering proficiency of the Corps and its high degree of mechanization to the system of Civil Works control which gives to American Engineer Officers such valuable and diverse training in all phases of engineering construction and affords opportunity for association with business, industry, and government administration. This training, alternated with postings with troops and for duty on military engineering school staffs, is ideal particularly when it is remembered that it enables the Chief of Engineers to command the Corps and at the same time maintain continuous contact with the latest industrial developments in engineering through his control of the Civil Works programme. The editor very appropriately prints this article in French. (It is interesting to note that Civil Works control by the Army Corps of Engineers has recently undergone critical scrutiny of the second Hoover Commission and came through with flying colours on both the technical and administrative control of its vast construction programme. These responsibilities have recently been recognized by the promotion of the Chief of Engineers to the rank of Lieut.-General.)

"The Territory and Peoples of Malaya"—by Brigadier M. C. A. Henniker, C.B.E., D.S.O., M.C.

It is refreshing at any time to read an article from the facile pen of this well-known Royal Engineer Officer. It is particularly encouraging to find an American Military Journal and American readers share this view and appreciate the author's unique experience of Malaya, gained during his years in command of a Gurkha Infantry Brigade fighting the Communist guerrillas, by publishing from his pen a third interesting article on this country and its peoples.

This excellent epitome of the geography, jungle, resources, crops, climate, communications and people of Malaya might well be reprinted for issue to all service personnel posted to Malaya.

ENGINEERING JOURNAL OF CANADA

Notes from *The Engineering Journal of Canada*, September, 1955.

SOME ENGINEERING ASPECTS OF THE MONTREAL GENERAL HOSPITAL

A large modern hospital, equipped with the latest aids to medical science, poses many interesting problems in design. This comprehensive description contains much useful information about boiler plant, heating and air conditioning systems, plumbing and other services, while a complete section on electrical work covers numerous communication, hygiene and treatment systems as well as lighting and power facilities.

Problems in Producing Power from Nuclear Fission

The real problem in producing power from nuclear fission is economic. To appreciate the practical factors involved it is not necessary to understand the nature of the atomic nucleus, and this short though inadequately edited summary sets out the main elements of the designer's problem. The conservation of neutrons is the first requirement, and the various fissionable materials and types of reactor are briefly discussed in relation to it. Safety in operation demands immediate and positive control: this has already been achieved for both experimental and production reactors. Technically the problem has been solved, but capital and operating costs at present hamper competitive production.

Notes from *The Engineering Journal of Canada*, October, 1955.

Tropical and Sub-Tropical Factors in the Design of Hydro-Electric Plants

After a brief and admirably clear summary of the principles governing the development of the power resources of a river, the author of this interesting paper analyses the features of tropical and sub-tropical regions which may affect design and then summarizes, with examples, their influence on components of an installation. High temperatures, extremes of humidity, high flood levels and liability to hurricane winds are factors which must be considered in the design of any structure in such regions. Generally speaking, the design of hydraulic structures—reservoirs, dams, intakes, flumes, etc.—is simplified by the absence of ice, but it is often prejudiced by severe floods, soil erosion and silting. Ventilation and insulation need special attention in buildings and in electrical installation.

The Intakes for Sir Adam Beck—Niagara Generating Station No. 2

The very serious complications in the design of hydraulic structures, caused by the likelihood of ice-formation, are clearly exemplified in this paper which is a further tribute to the value of test models, previously illustrated in an article on Niagara development in *The Engineering Journal* for April, 1955 (*R.E. Journal*, September, 1955). The effectiveness of the design adopted is convincingly proved by two excellent photographs.

Strengthening Steel Structures by means of Prestressing

Steel structures have an important advantage over reinforced concrete in that they are, if need be, readily strengthened by riveting or welding. The author of this paper contends that strengthening by prestressing is more economical and has many practical advantages, especially for strengthening existing bridge structures when traffic cannot be interrupted.

Design technique at present involves rather ponderous mathematical equations, which are set out in detail, but the method would often simplify the adaptation of a structure and save working time.

Notes from *The Engineering Journal of Canada*, November, 1955.

Influence of Soils on the Design and Construction of the Trans-Canada Highway

This is an interesting example of the practical application of soil survey and classification in road construction, although generally speaking the paper contains nothing that is new. There is a short description of the group-index system used for classification, but this seems to have no particular advantage over the C.B.R. method. Perhaps the main point of interest is the proposal to use a sand-bituminous base course in areas

where gravel deposits are not available. The technique is not described, which is unfortunate as sand-bitumen mix is used in military construction only as a waterproof carpet, either above a subgrade of adequate strength or on a prepared base.

STRUCTURAL MODIFICATIONS USING HIGH-TENSILE STEEL WIRE CABLES

This short paper describes an interesting example of the modification and strengthening of an existing structure by post-tensioning steel wire cables. By using this prestressed concrete technique to induce compressive stresses in existing roof beams under dead load conditions, the roof was adapted to carry the original load over double the original span, thus enabling central supports to be removed in order to clear the way for new construction.

THE POSSIBILITY OF COMPLETE SOLAR HEATING OF CANADIAN BUILDINGS

By the end of the present century the demand for oil bids fair to outstrip supply, and diminishing coal reserves further accentuate the need for alternative sources of energy. Nuclear energy is being developed, but solar energy may well prove an economical alternative, especially for non-productive loads such as space-heating. This paper describes results achieved experimentally in Canada and is most interesting in view of the similar experiments carried out in Egypt and Cyprus and described in the article by Brigadier S. A. Stewart on page 68 of this *Journal*.

CORRESPONDENCE

MEMOIR ON MAJOR-GENERAL SIR JOHN E. CAPPER, K.C.B., K.C.V.O.

Brig.-General Sir James Edmonds, Kt., C.B., C.M.G., D.LITT.
Brecon House, Sherborne, Dorset.

The Editor,
R.E. Journal.

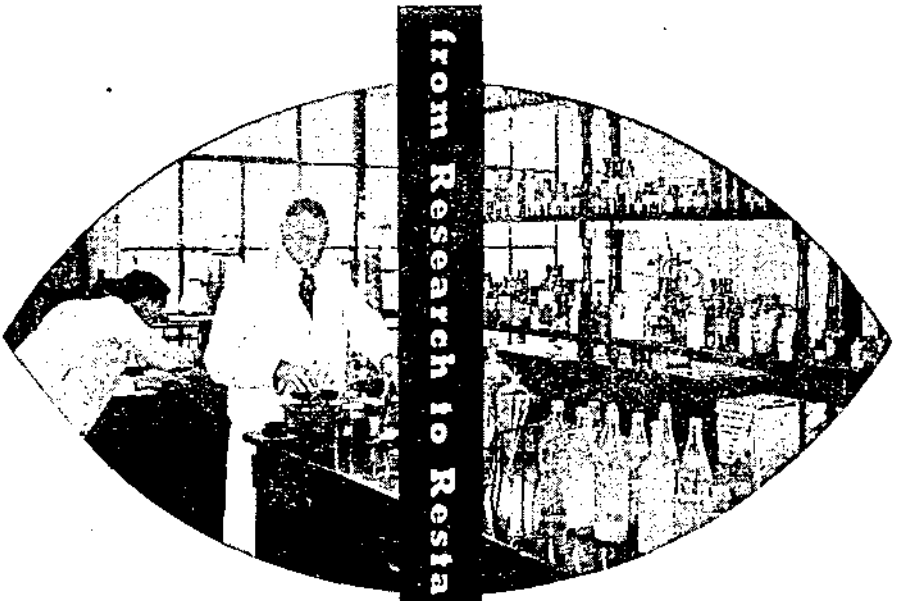
15th November, 1955

Dear Sir,

A memoir on Major-General Sir John Capper written by me and printed in the September, 1955, issue of the *R.E. Journal* contained a remark that ". . . the 24th Division, one of the two new Army divisions which had failed so lamentably in the Battle of Loos owing to indifferent training and bad leadership . . ." It has been pointed out that this remark is unfair to the division. There was no intention whatever of criticizing the division itself, which fought most gallantly, and suffered immense casualties.

It was no fault of the division that they were pushed into a large battle within a few days of landing in France, and before they had had a chance of any experience of active service conditions, nor had their Commander had sufficient time to study the situation. Lack of reserves made it necessary to push in unseasoned and inadequately trained troops, but they did not lack courage, and fought magnificently, and lost some 4,000 casualties in twenty-four hours.

Yours truly,
J. E. EDMONDS.



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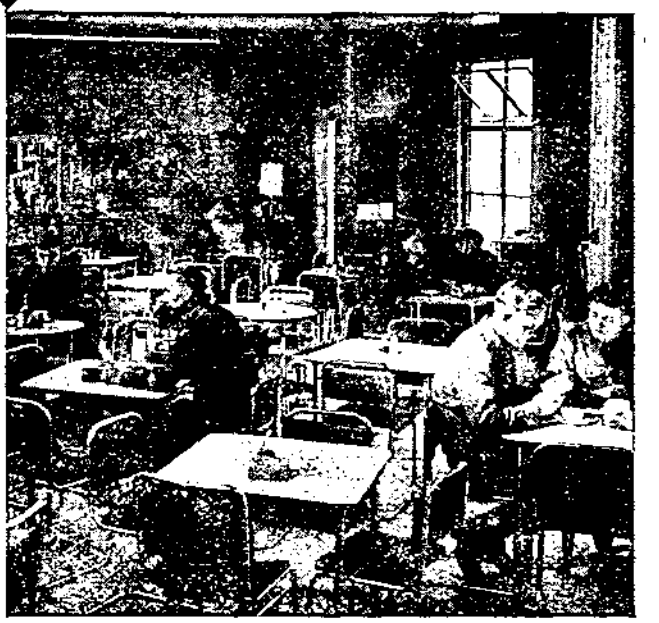

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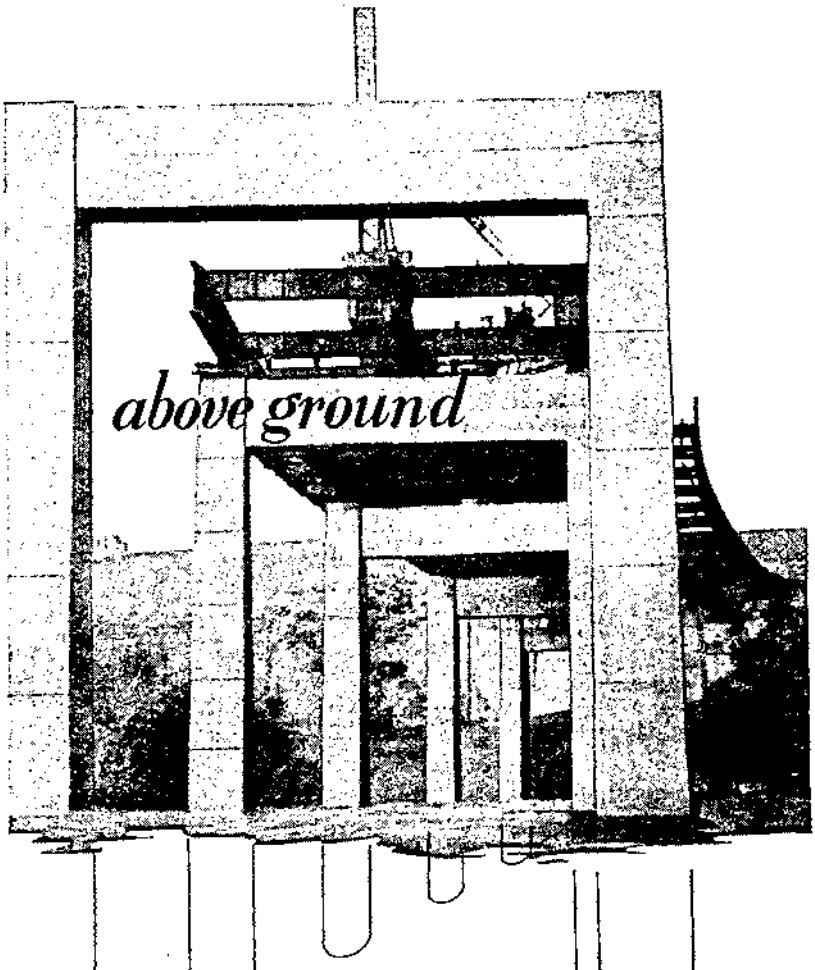

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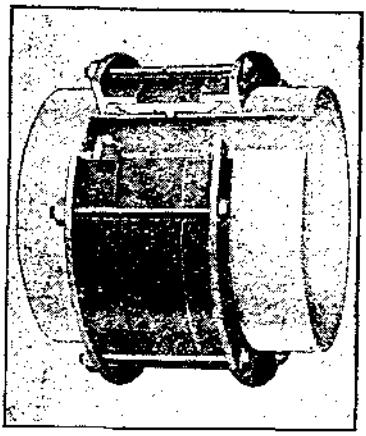

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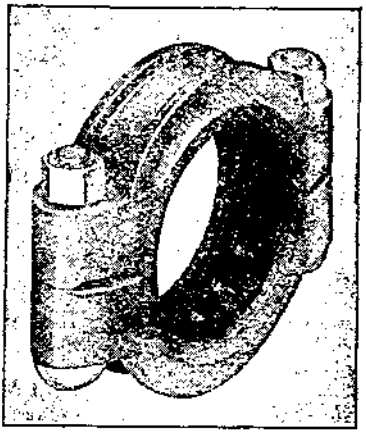

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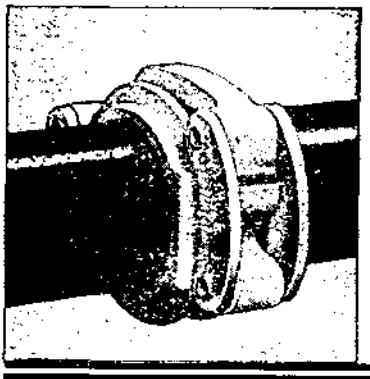

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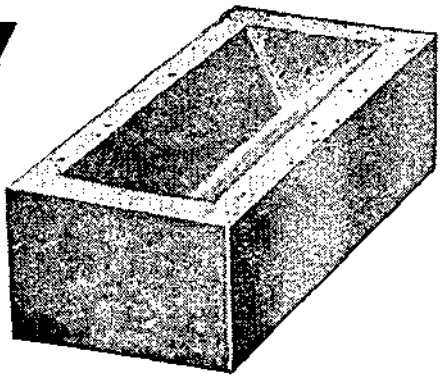
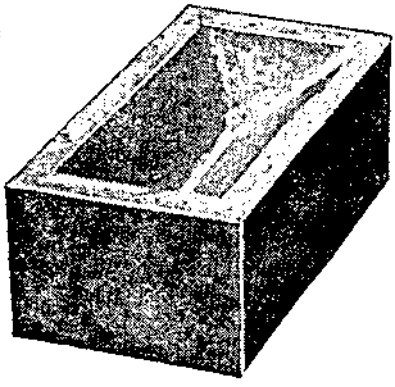


WET

6 lbs
12 ozs



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