VOL. LXV. No. 2 JUNE, 1951

THE ROYAL ENGINEERS JOURNAL

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THE ROYAL ENGINEERS JOURNAL—JUNE, 1951 VOL. LXV. No. 2

THE ROYAL ENGINEERS JOURNAL

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VOL. LXV CONTENTS JUNE, 1951

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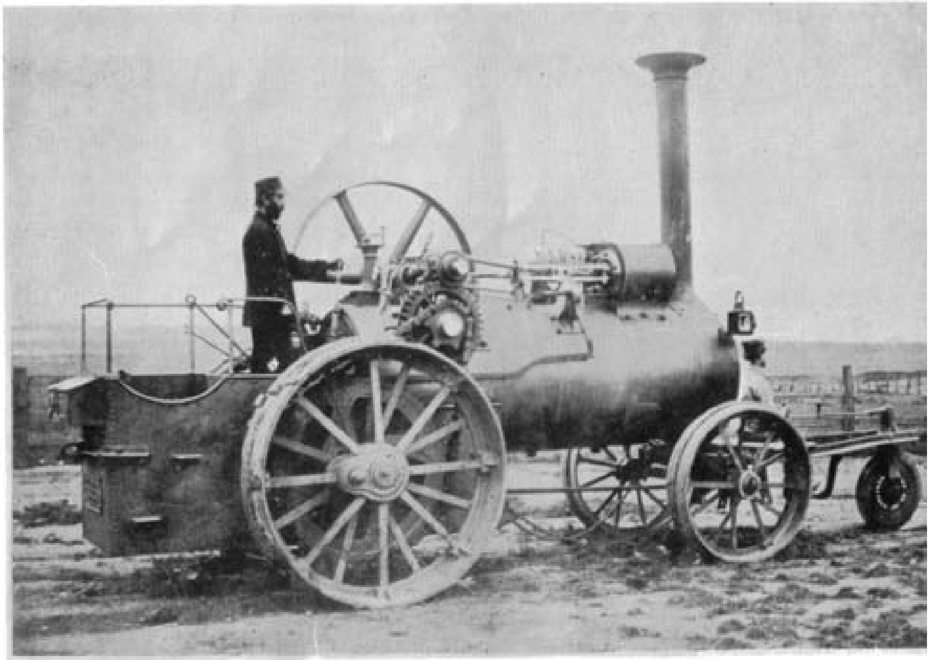

Fig. 1.—Tractor with fifth wheel for steering, about 1855.

A Golden Jubilee With Oil Engines, Akroyd,Diesel and Others 1

A GOLDEN JUBILEE WITH OIL ENGINES
AKROYD, DIESEL, AND OTHERS

By MAJOR-GENERAL A. E. DAVIDSON, C.B., D.S.O., M.I.MECH.E., M.I.MAR.E. (Colonel Commandant, R.E., Retd.)

Extracts from the Presidential Address given at the General Meeting of the Diesel Engine Users Association on 19th October, 1950. Published by permission of the Association, who have very kindly loaned the blocks for the illustrations now reproduced.

INTRODUCTORY

IT is usually the case that the President in his Address dwells largely on the experiences of his lifetime, and to-day I propose to deal mainly with matters of history, particularly military history.

I feel greatly honoured by my fellow members in being elected to the presidential chair, as I cannot claim to have followed directly in the steps of the majority of my distinguished predecessors, in that the care of diesel generating stations has never been my sole occupation. Nevertheless my viewpoint over a long period of time, completing a jubilee this year, has been mainly that of the user; sometimes as inspector for the user, at others in executive charge of engines or, again, in administrative charge. Mostly I have been in close co-operation with manufacturers, who were at all times found to be most willing to co-operate to meet the user's needs.

Right at the start it will be stated that no attempt will be made to reopen the controversial question that interests many members, namely, what exactly constitutes a diesel engine?

Many engines thus named to-day differ so much from Diesel's original specification that I feel no compunction in referring in my address to types far from Akroyd, far from Diesel, and, in fact, quite beyond the pale. Even our own Association avoids the issue by styling its main activity as a " Report on Heavy-Oil Engine Working Costs."

Recently, in France, riding in a motor-coach behind another which was clearly petrol-engined, I asked the driver if his engine was a diesel. This he indignantly denied, adding that the coach in front was " à essence " while his was " à gazoil."

Simplicity in nomenclature will appeal to the taste of the general public rather than technical exactitude.

My engineering training started in 1900, when the general engineering practice in the Royal Engineers of the day was steam-engined military railways and steam tractors for road work, and on the above basis locomotive type boilers for stationary steam plant. We were even taught that the fifth wheel to a coach, Fig. 1, could be not only useful but essential. Steam sets for search-lighting were just being replaced by Hornsby Akroyd oil engine sets, and small horizontal paraffin engines were in use for carrying out the Royal Engineer chores of camp and barrack life, such as water pumping. With all these types of prime movers we were made acquainted. Hiram Maxim's aeroplane, inspected in 1893, at Danson Park, near Bexley, had a steam engine, so it will be realized that at the dawn of this century the Army could only be expected to think of steam for the prime movers it had run for half a century.

In 1901 I commenced my practical engineering training in Chatham Dockyard, being diverted to Road Transport on its conclusion. The Steam Road Transport and Searchlight units with which I served during the South African War were equipped mainly with heavy steam traction engines and steam cars, but there were a few small de Laval steam turbine sets running at 32,000 r.p.m.—the present stage of the gas turbine counterpart.

Military Internal Combustion Engine History

Leaving Hornsby Akroyd history and power station practice to later paragraphs, I would like to take you through a brief review of military internal combustion engineering history. One petrol-engined German built lorry was entered in the War Office lorry trials of 1901 on which I was an observer, but it was out of its class, being rather a 30-cwt. or 2-ton lorry instead of a 3-ton with 2-ton trailer as specified. All the other entries were steam lorries.

The judges of this trial were, however, impressed with the potentialities of the internal combustion engine for road transport and recommended that a lorry should be produced with a "heavy oil engine." "Heavy oil" probably only meant paraffin.

Two such lorries of 40 h.p. were produced in 1905 but did not pass the trial stage. One was handicapped by having tube ignition, which lengthened starting times and impeded restarts.

Petrol was at that time very light and volatile with a specific gravity around 0.68; its retail cost was counted in pence per gallon, and some of it was burnt at the oilfields as an unwanted product. Its retail price did not soar to 1s. per gallon till 1905. So volatile was it that many early cars and motor cycles had true surface carburettors, some without wick or gauze.

Anything But Petrol, 1902–12

For the military user, the first decade of this century can be described as the "Anything but Petrol" era. The reason for this was that after the South African War ended it was decided to send out petrol lorries to assist in the 1902–4 Somaliland campaign. Two types were purchased and, as one of the testers, I can confirm that fortunately they got no farther than Aldershot. The War Office then referred the fuel problem to a petroleum technologist who gave the opinion that petrol was not a practical proposition in the tropics, as evaporation from containers in store was likely to be so high that there would be insufficient residue left to enable the vehicles to function as required. Possibly he had in mind only the 0.68 and 0.70 sp. gr. grades.

The fiat then went forth that paraffin was to be the official fuel for all W.D. vehicles, and despite strenuous efforts to cancel this ruling it was not rescinded till 1912, on the grounds that less than 10 per cent of the vehicles required on mobilization would be owned by the W.D., the remainder being subsidized or impressed petrol vehicles. This ten-year ban was a tremendous bar to progress, as a satisfactory paraffin vaporizer for road vehicles was never devised.

The number of types of paraffin carburettors tested was considerable, eight in 1911 alone. Many more presented on paper failed to materialize when the vehicle owner was instructed to report unloaded to Woolwich Arsenal where a 3-ton weight was ready on a sling, prior to the ascent of certain steep hills leading up to Shooter's Hill. Starting from cold was usually a great difficulty, especially under conditions of very damp cold, i.e., just above 32° F.

W.D. Trials

Reverting to official War Office vehicle trials, those of 1901 only produced at the time one vehicle with an internal combustion engine, and two samples about five years later.

The 1903 trials produced a very good performer, the 13-ton two-cylinder Hornsby Akroyd (see later). As policy had changed by then another type of vehicle was required, a 5-ton tractor to haul 5 tons.

Trials were held in 1909, but only three out of eleven entrants materialized. The prize went to a Thornycroft steel-tyred four-cylinder vehicle giving 50 b.h.p. at 850 r.p.m. on paraffin. This was surely with a little slimming and banting the prototype of many thousands of agricultural tractors, as Figs. 2 and 3 clearly show. Engines were thirty years ahead of the tyres available. Again policy altered quickly, and but few orders rewarded the prize winner. A similar tractor, built by Hornsby under my observation, ran 140 miles in a day, probably a record for its time. A Broom and Wade tractor entered had a single cylinder engine giving 30 b.h.p. at 800 r.p.m.

The petroleum fuel was admitted to the vaporizer with only a small quantity of air. The majority of the air was admitted into the body of the cylinder together with a certain amount of water towards the end of the compression stroke, undue cooling of the vaporizer by cold air was thus avoided. The water injection allowed a compression pressure of 95 lb. per sq. in. to be used.

It may be mentioned that around 1904 water injection was strongly advocated both on stationary and motor-car engines, till in practice the water passed into the crank case and upset the properties of the lubricating oil.

Arising out of the 1909 trials a decision was made to produce a lightweight chain tractor to haul the 40-pounder gun of the day, the equivalent of the 3.7 A.A. gun. This tractor, tested in 1910 running on paraffin, was only a partial success. Tested in 1911, however, on petrol it did very well, but money could not be obtained to duplicate it and so form an artillery unit having a section of two tractor-drawn guns.

The change from paraffin to petrol increased the output of the six-cylinder vertical engine from 72 to 105 b.h.p., an improvement greater than one would usually achieve, 18–20 per cent being a more normal ratio.

This pre-first-war chain tractor (Fig. 4) contained an interesting feature, its fuel tanks were detachable so that when they were shed the vehicle would be light enough to cross the pontoon bridge of the day. This feature was embodied in the later heavily armoured twin diesel-engined Matilda tank of the second World War in order to extend its range of action from 50 miles, as first specified, to 100 miles by carrying outside the armour a further container detachable from under cover.

The Army was very horse-minded and was slow to accept the inevitable change to mechanization. The motor cycle, with its great mobility, had barely been admitted into the improved means of transport by the time the 1914 war broke out. A few were provided for R.A.S.C. transport units, and a special reserve of motor cycle dispatch riders had just been formed, but other units like R.E. companies, which would have benefited so much by the increased range and mobility conferred by motor cycles, were not allowed them. Up till 1911 the standard M.T. vehicle was the steam tractor, finally reduced in weight to some seven tons. After this the 3-ton petrol lorry was substituted, and a W.D. subsidy scheme for civilian owned vehicles was brought into force. One thousand vehicles were enrolled after type vehicles had been subjected to trials.

The 1914–18 war was fought in the field and in the air on a petrol basis. Paraffin was, however, employed on coast defence works, the Hornsby Akroyd holding its own for reliability. Its use was not extended, as it occupied so much more space than the newer high-speed direct coupled sets.

In the between wars period road transport vehicles in the larger sizes of about one hundred brake-horse-power gradually changed from petrol to high-speed diesel engines, whereby fuel consumption was halved. The cooling problem was also greatly eased as the compression-ignition engine only discards to water 90 per cent of the heat units converted to power at its crankshaft, whereas the spark ignition engine figure is 120 per cent. The newer type of engine did not, however, beat its older rival in weight, flexibility, slow running, quietness or r.p.m.

World War II proceeded generally with diesel engines on the heaviest road vehicles and petrol engines on the lighter ones. In all, some 10,000 diesel-engined vehicles were produced in this country for the three Services. Although many tank engines were diesels, both two-stroke and four-stroke being employed, the majority ran on petrol. In a tank, especially in a heavily armoured one, bulk is probably the least desirable quality of an engine and its ancillaries. Although the smaller fuel tankage required, the property of low heat transference to water, and the maintenance of high torque at low engine speeds, had led designers to think that the diesel type was likely to be the better, in the larger sizes required, say 500 b.h.p., the other good qualities of the petrol engine gained it the verdict.

Nevertheless, 2,900 Matilda tanks, fitted with two Leyland six-cylinder engines of about one hundred brake-horse-power each, were put into service. The Vickers-Valentine type, of which nearly 10,000 were built, started with a petrol engine but was soon converted to diesel. The first 2,400 were fitted with four-stroke A.E.C. engines and the remaining 7,000-odd with G.M.C. six-cylinder two strokes, which type ultimately developed 165 b.h.p.

The U.S.A. fitted two-stroke G.M.C. engines to one type of tank, the Sherman Mark III, but otherwise relied on petrol engines. The German production tanks were not powered with diesels, despite other advanced usage of the engine named after their compatriot, but the Russians fitted two types of tank with diesels (T.39 and K.V.1). Since the war, tank design has still tended to favour the petrol engine.

For aero engines the Bristol Aeroplane Co., in conjunction with Sir Harry Ricardo, produced and tested a single sleeve-valve diesel engine based on the Burt patents, but by the time it was ready for large-scale production 100 octane petrol was obtainable in quantities, and as this enabled a compression ratio of over 9 : 1 to be used, the ground was cut away from the feet of the heavier 14 : 1 compression ratio engine and it was not proceeded with.

As Sir Harry Ricardo has told us, the story of the Burt sleeve-valve patents is highly romantic. The engine, first produced on a 1908 patent for the Argyll car, had a short run as the company ceased to build vehicles. Another model was presented for the 1914 R.A.F. aero engine trials and although it did not win the prize (taken by the Green Engine Co.) its performance was considered most promising. War stopped progress and subsequently the patent rights were disposed of in the U.S.A. whence they had to be re-acquired for development by Sir Harry under the aegis of the Air Ministry. The advent of the jet engine has buried still deeper the possibility of the diesel engine being employed in aircraft.

Before finishing this heading of " Anything but Petrol " it is worth while advancing the date and recording that the French Government adopted this same attitude round about 1930 with a view to cutting down petrol imports, and they instituted a series of road vehicle trials for " home produced fuels " in conjunction with the Belgian and Luxemberg Governments. I attended the 1928 trials, traversing parts of the three countries. All sorts of mixtures were in use, benzols, alcohols, etc., as well as solid fuels such as charcoal. Probably the most interesting vehicle was a lorry driven by a small two-cylinder Junkers two-stroke opposed piston compression-ignition engine. This pulled very well on the long grades encountered in the Ardennes, and later an English firm experimented seriously with it, but was never able to overcome the difficulty of keeping piston and piston rings cool enough on the piston at the exhaust end.

There was also a fuel patented by Sir Harry Ricardo in 1920 which has ever since been very popular among racing motorists. It consists of a mixture of about 60 per cent alcohol (now styled methanol), 20–30 per cent benzol, 5 per cent acetone, 3–10 per cent of nitro-benzine. This was supplied by the Distillers Co., and also under the trade name of Discol R. Its use permitted a high compression ratio to be used ; in extreme cases, with very small cylinders, 16 : 1. Thus, although spark ignition was employed, the leading benefit of the diesel engine, namely high compression ratio, was nearly achieved.

Since about 1922 on land, sea and air, the majority of speed records have been made on this fuel.

Military Usage of Hornsby Akroyd Engines

The normal searchlight set consisted of a single-cylinder horizontal engine with long flat belt drive to a D.C. generator. This engine, in two different single-cylinder sizes of 25 and 40 b.h.p., can be considered as the sole standard for the coast defences of the War Department both at home and throughout the Empire from 1895 to 1915, and a secondary standard up till about 1935, forty years in all. The first 25 b.h.p. engine was sent to the School of Electric Lighting, Stokes Bay, Hants, in 1894. The first of the 40 b.h.p. size went to India in 1896. Originally the engine was partitioned off from the dynamo.

At the School of Electric Lighting, the care and maintenance of these engines was taught to classes of R.E. mechanists up to the end of 1934, and an engine remained in the School for instructional purposes till 1936.

The last of these on record in coast defence work were a pair of 40 b.h.p. engines in Belchers Fort, Hong Kong, supplied in 1895 and still operating in 1940. Their ultimate fate was to be dragged out by the Japanese when they gutted the defences after the capture of Hong Kong. There was no trace of them on the reoccupation in 1946.

One of the 25 b.h.p. engines is still kept in running condition for educational purposes in the School of Military Engineering, Chatham, as it does represent an important milestone in the history of the internal combustion engine.

In other than W.D. hands, two 25 b.h.p. engines still remain in working order in the Bradfield (Berks) village waterworks, one being most usefully employed pumping during the 1949 drought. Also two 9 b.h.p. size engines, installed about 1905 in the Admiralty Depot at Upnor for pumping purposes, are still in operation. There may well be others too.

Hornsby Akroyd engines were also employed in other than defence electric lighting (searchlight work). They were standard in Brennan torpedo installations, winding in the directing cables, till this activity was handed over to the Navy in 1905.

It will be seen that the adage " Old soldiers never die, they merely fade away " applies equally to their old servants, their Hornsby Akroyd engines. All users still alive speak of their old reliable retainers in most affectionate terms.

The Hornsby Akroyd engine won another prize of £50 in 1898, when it was the successful entrant in a W.D. competition for a portable electric lighting set. Further manufacture was not pursued.

It has already been stated that the Hornsby Akroyd engine was first introduced into the Service about 1895, primarily because it could be in action so quickly from cold as compared with the steam engines previously in use. The normal time was twenty minutes, reducible in some instances to fifteen minutes.

Ironically it fell out of use for this same reason. In the latter part of the 1914–18 war the method of using coast defence lights changed. In the first half the custom was to run all lights fully exposed from dusk to dawn. This purpose was well served by the reliable Hornsby Akroyd, especially where storage batteries were installed to run the lamp for half an hour till the engine was ready for load. These batteries proved to be so expensive in upkeep that their use was soon discarded. In the latter half of the war, as a general rule, all lights were obscured till actually required for use, the need for saving fuel having become highly important.

Accordingly large numbers of a more modern type of multi-cylinder petrol/oil engine were installed, partly on the score of being available, but largely on account of their quick starting, as they enabled a light to be in action within two to three minutes of an alarm, as against twenty minutes with the Hornsby Akroyd.

Engine starting was either by hand or by air. Pumping up of the air receiver was by means of exhaust from the cylinder and pressure did not exceed 150 lb. per sq. in. After the 1914–18 war further experiments were conducted to get quicker starting, and in one of these the engine was made to start cold.

Despite the introduction of the Hornsby Akroyd engine in 1894, no official handbook seems to have been issued till 1909 when *Military Electric Lighting*, Vol. II was published ; subsequently revised in 1915. This deals comprehensively with the engine, the electric generator, and all other aspects of defence electric lighting. Prior to this an article was published in the *Royal Engineers Journal*, Vol. 32, of 1902, giving some sound general instruction, especially as to the vaporizer heating lamps, and advising those concerned to obtain copies of the maker's handbook. Comparison of the handbook with the 1909 War Office manual shows that the latter was the more comprehensive and illustrated by better diagrams.

Figures regarding maintenance, culled from these two books, may be of interest :—

" An engine in constant use was expected to run for 400 hours without cleaning.

" The vaporizer chamber ran for years without any appreciable deposit. (i.e., a big hot spot in a combustion chamber has a definite value.)

" Gummy deposits on pistons were to be washed off with paraffin. Piston rings were not to be sprung out of their grooves unless absolutely necessary. Piston rings and their grooves need not be clean so long as there was no hard deposit to prevent free movement."

Messrs. Hornsby from an early date did a big trade in the Caucasus oil-fields and they realized the advantage given to the Akroyd cycle by the use of fuel derived from this source, due to its anti-knock properties. They recommended running on Russian based oil, a policy which the W.D. adopted.

The 1894 type, dubbed Mark I by the Royal Engineers, was not convertible to the later type used after about 1900 and dubbed Mark II.

The Mark I type undoubtedly had the longer life, no doubt on account of heavier scantlings and bigger bearing surfaces throughout. When these engines eventually had to be taken out and scrapped it was found very difficult to break up the castings even with heavy sledge hammers. This is a tribute to the excellence of the foundry work in those early days and the probable explanation of the long life and low rate of wear of the engines.

An engine of this type, relying on a fairly steady temperature in its vaporizer, could not be run for long periods alternately on no load and full load. Accordingly, as it was necessary at times, and even for long periods, possibly all night, to put out the searchlight, the normal method of operation was to employ a shunt circuit consisting of a wire resistance frame which came automatically into circuit when the arc lamp was switched off.

With hand starting there was some doubt as to the direction in which the engine would rotate. Skilled drivers could rely on starting correctly, but novices would not be at all sure. Accordingly the instruction was that the dynamo brushes of wire gauze type (carbon brushes were not used on these generators), must be lifted off the commutator until it had been ascertained that the engine was running in the correct direction. In one remote station where two raw recruits (actually they were butchers by trade) started and ran with the engine turning the wrong way round, both the brushes and the charging battery were ruined by the end of the night's run.

Early Locomotives

The five Akroyd engined locomotives put into use between the years 1898 and 1904 have been described elsewhere. It was known that they were put to work in a magazine area which has been stated wrongly to have been Chattenden, near Chatham, and I must plead guilty to having supported this statement. After considerable investigation it has been ascertained that they actually worked up till 1914 in a similar magazine area in Woolwich Arsenal where, entirely hidden from the public eye, they had the advantage of being serviced in one of the best industrial locomotive repair shops I have come across. They were finally scrapped, as the rolling stock and loads they had to handle had increased very considerably since they were first put to work. As these locos had engines of only 9½ and 15 b.h.p., against the 60–150 b.h.p. one might expect to-day, the scrapping of the pioneers after ten to fifteen years' service is not a matter for surprise. Unfortunately, war damage in Woolwich Arsenal has destroyed all written records, but it is known that the engines ran very economically, using paraffin—later "solar oil" at 1½d. per gallon. Their maintenance costs were low, but starting from cold sometimes presented difficulties. There is evidence that one of these engines was sent to Chattenden for a period for trial. Fig. 6 shows the layout of one of these locos of 1900. Fig. 5 shows the 20 h.p. Hornsby locomotive built for powder-magazine service in 1902.

Retired charge hand, Mr. H. W. Baldwin, the last driver of the Hornsby Akroyd locos still living, gives these recollections of his experiences :—

"There were five in number of the locos of the Hornsby Akroyd type, their names being, Alecto, Hecate, Atropos, Clotho and Lachesis. Each loco had four driving wheels and a bogie in front to make them run steady. My views are that they were fine for danger buildings, 100 per cent safe as no sparks came from them. Also they were the cheapest locos on the market for running as they only used four gallons of oil for twelve hours' good work. They were not so slow as some people imagine. The whole point is they were not liked so people condemned them.

"They drove on a male and female shaft with two coil springs which had to be kept well oiled with a mixture of ½ pint of paraffin and 1 pint of machine oil. They were good starters, no trouble at all, taking about a quarter of an hour, then they are ready for a day's work. There is a lamp under the cap end with asbestos string. Fill with paraffin and light, then blow up with a fan by turning handle. It takes about five minutes to burn out, then you pump up oil to get the flow. When you are sure the oil is there you just give it one charge of air then the oil is kept supplied by the pump working off the camshaft. The air cylinder carries 100 lb. of air. Always pump up pressure for next time. Sometimes when not hot enough they will back-fire but are very simple to get running again.

"There are two gears for running. You change the gear when running with levers on footplate. The reversing is quite simple. The loco is stopped by brake, then put in low gear. It is only a matter of seconds to get the engine moving again. Loco Alecto was a two cylinder which rotated the opposite way to the single cylinder and would travel as fast as a steam loco of the same gauge.

"The track was a combined gauge, narrow gauge inside standard ; one rail common to both. I have drawn as many as ten broad gauge trucks behind one of these narrow gauge locos."

Despite the loss of official records it must be admitted that these five Akroyd engined locos operating for twelve to fifteen years have

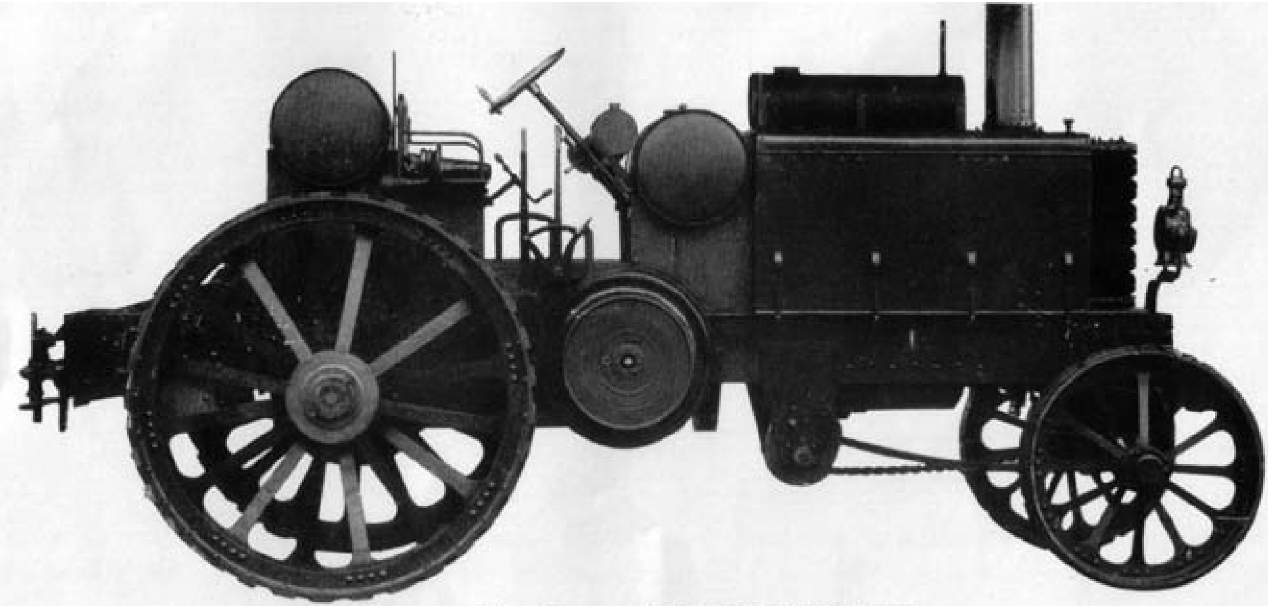

Fig. 2.—50 b.h.p. Thornycroft 1909 prize winning tractor.

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Fig. 3.—David Brown 1950 agricultural tractor.

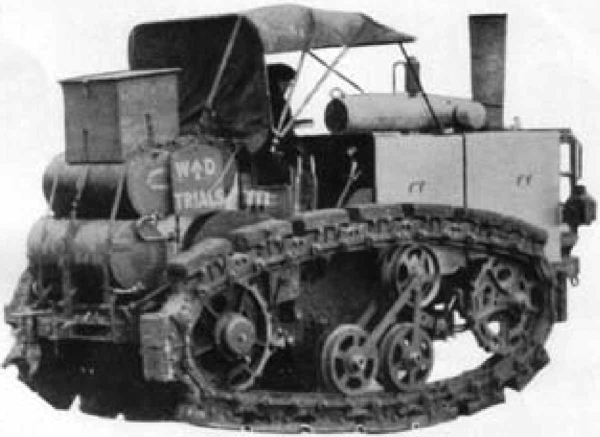

Fig. 4.—1910 Hornsby six-cylinder, 7-ton chain tractor, illustrating detachable fuel tanks.

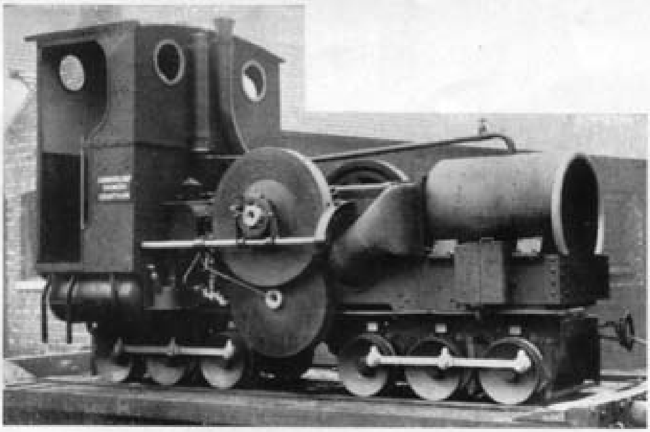

Fig. 5.—20 h.p. Hornsby locomotive built in 1902 for powder-magazine service

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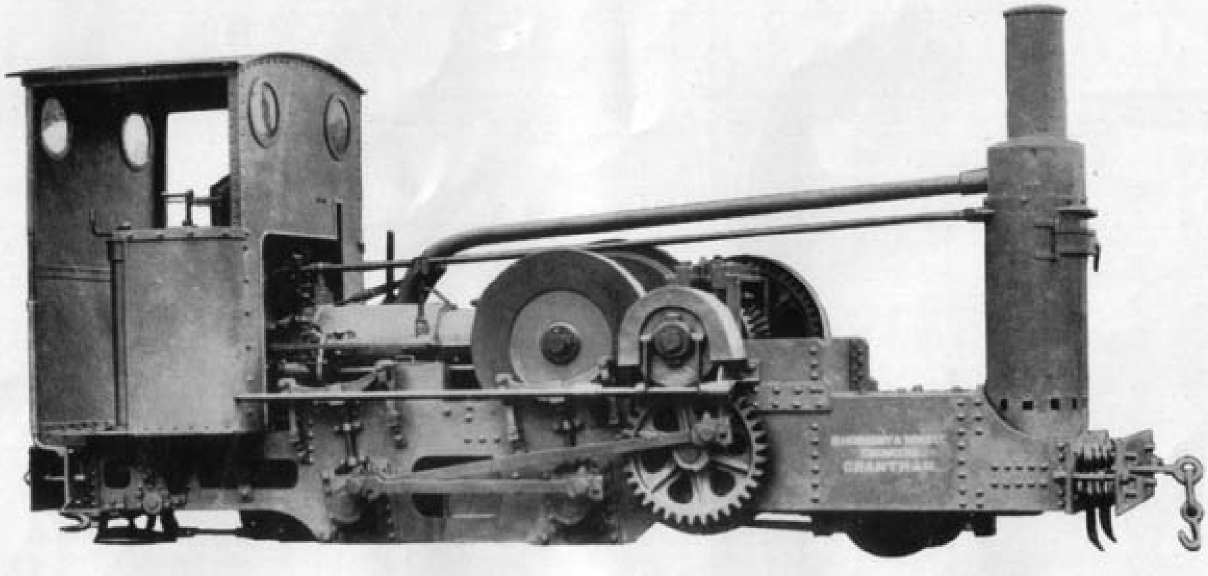

Fig. 6.—Hornsby Ackroyd 18-in. gauge locomotive, 1900.

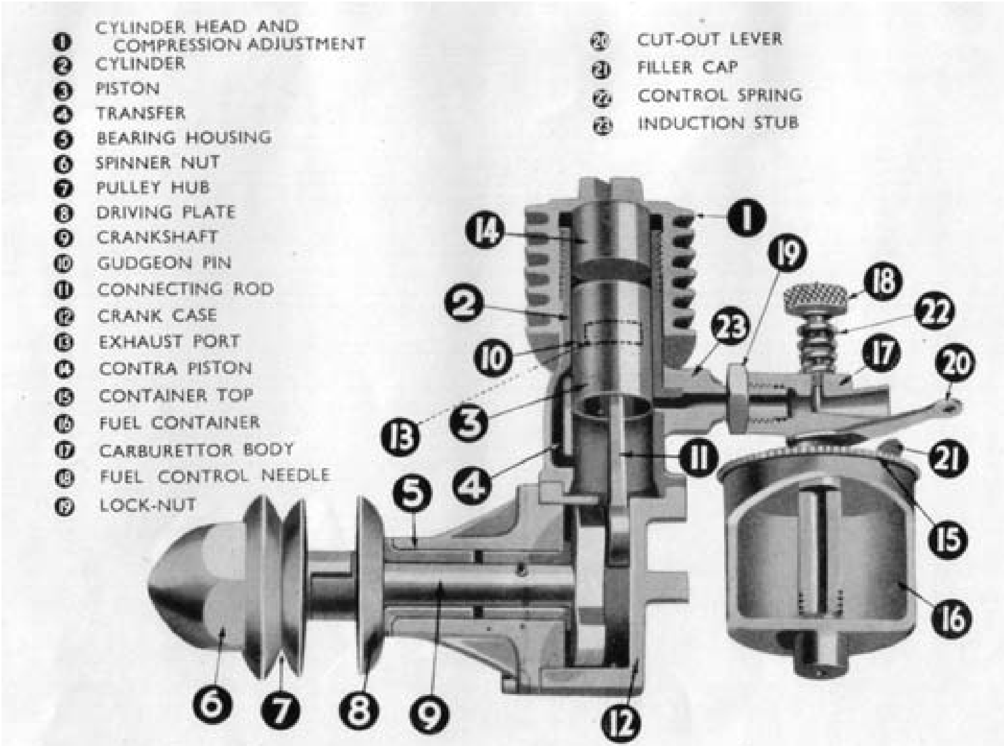

Fig. 7.—Model aeroplane two stroke engine, 2·5 c c. capacity.

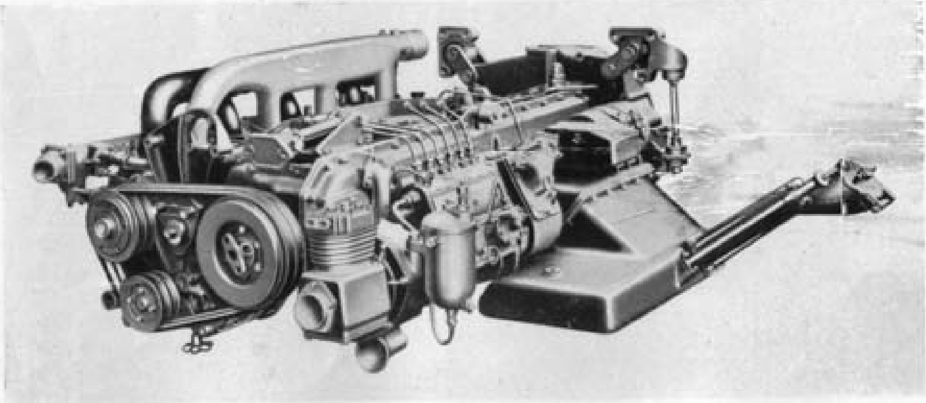

Fig. 8a.—Leyland underfloor C.I. Engine. Bore 4·8 in., stroke 5·5 in., 125 b.h.p. at 1,800 r.p.m.

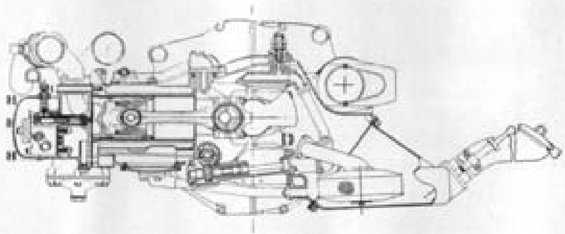

Fig. 8b.

A Golden Jubilee With Oil Engines, Akroyd,Diesel and Others 8a,8b

a distinct claim to be considered the pioneers of oil-engined locomotives, and it is unfortunate that authentic records are so few, as "Out of sight is often out of mind."

13-Ton Tractor

The twin 20 deg. V Hornsby Akroyd 13-ton road tractor, which won a big prize at the 1903 War Office trials has already been described fully, and also its conversion later to a chain track vehicle—"the precursor of modern tanks." It was broken up round about 1920.

Hornsbys, who were not at that time building medium speed petrol/paraffin engines, actually started on their chain track venture with a single cylinder Hornsby Akroyd engine. In fact, it was the performance of this under-powered pioneer that led to the conversion of the 1903 tractor from wheels to tracks about 1906.

Incidentally, although the subject is outside the province of this paper, Messrs. Hornsby about 1906 submitted designs of a caterpillar tracked gun carriage, thus showing that in thought they were a decade ahead of the 1915 tanks.

Being the only observer on the 1903 trials now left, I looked up my private diary to find only few remarks and considerable blanks. The interesting comments are :— 19th October, 1903, on first viewing the machine at Aldershot where the trials were held, "Hornsby most odd! A freak." 23rd Sept. 5 a.m., "Ride on footplate."—In those horse-conscious days one made most progress on tractor trials before 8 a.m.—2nd Nov., "Hill climb. Hornsby burst water jacket." Then came several "Uneventful runs." 17th Nov., "Engine wears out road spur pinion." Later, the use of castor oil as a lubricant (for a hot fan bearing) was hardly known, as a chemist offered his brown mixture as a proven substitute! Finally, with great relief, on 23rd November, a War Office party came down to inspect and found "not much wear." Akroyd had done very well! Unluckily for the makers, in the time that elapsed between drawing up the specification and clothing it with oil engine and steel, War Office policy had changed to much lighter vehicles. The 32-ton, 2 ft. wide steel wheeled, monster that seemed desirable in the limitless veldt was not at all acceptable for the enclosed countries and built-up areas of Central Europe. Even the 13-tonner had to shrink to something that could cross the pontoon bridges of the day. Accordingly this ingenious and well-constructed vehicle was not duplicated.

The above examples were not new developments nor new types of engines : only new tricks played by an old engine. Developments such as took place by the De La Vergne Co. in New York, with compression raised to 195 lb. per sq. in., as reported by Mr. Goldingham, were not attempted in this country as far as available information goes.

W.D. Generating Stations

The first W.D. central electric power station of any size was laid down at Aldershot in 1902. It started with Parson's steam turbines, a fairly early example of this type of prime mover. It continued as a steam turbine station. The W.D. also purchased their first diesel engine in 1902 for £475.

The first important diesel engine station was laid down in Tidworth, in 1913, having a 375 b.h.p. air-blast injection, four-stroke-200 r.p.m. set manufactured by Mirrlees Bickerton & Day. This set, although still in the station, is not now run.

To this were added later a 500 b.h.p. air-injection set in 1921, a solid injection set of 466 b.h.p. in 1928, and a solid injection set of 750 b.h.p. in 1935.

Later, in order not to have too many eggs in one basket, a second and interlinked station was opened at Ratfyn, some fifteen miles off, where between 1925 and 1941, four English Electric Fullagar D.C. sets, totalling 3,470 b.h.p. were installed.

These opposed piston type engines are well known and several are included in the D.E.U.A. Working Costs Reports. Those at Ratfyn, some twenty-five years old, have been found to stand up to load better than the normal four-stroke engines, and reports on their general condition after long running periods are very favourable.

Shoeburyness also received diesel sets from 1925 and these proved to be important prototypes. The delivery of the first set showed up one of the drawbacks to loose nomenclature. When preparations were being made for its receipt the supply department, on hearing it was a heavy oil engine, filled up the main supply tanks with the correspondingly named oil on the W.D. fuel contract. This proved to be a heavy boiler oil, practically solid in cold weather, and not at all to the taste of a somewhat capricious, newly designed, Ruston vertical engine of 25 b.h.p. per cylinder.

One of the major price factors was the cost of keeping engine drivers often merely watching one engine run all night on a light load. We soon got on to better lines, backed by one of many oil engine yarns told by the late Mr. Young, Hornsby's experimental engineer. One day, hearing the obvious beat of an Akroyd engine, he investigated and found it running unattended. On locating its water pumping operator, the latter told him he only visited it once a day to ascertain the reservoir level. He then oiled up, filled the fuel tank with the two gallons of paraffin per ft. required to fill the reservoir, started the engine and left it to stop itself when the fuel was spent. Accordingly, after due trial it was decided to equip one camp with automatic starting high speed diesel sets running in parallel, which would start up as load was added and be cut out as load fell, in conjunction with a storage battery.

This principle was not new in that there were already in use many small house-lighting single-cylinder sets of 1 to 5 kw. working in this manner in conjunction with batteries.

The type of engine selected was a vertical 900 r.p.m. four-stroke Lister set giving 8 b.h.p. per cylinder. In the first installation there were two four-cylinder engines under fully automatic control. The experiment was important in that, when rearmament started a little later and large demands arose for portable generating sets, this type, which had done so well at Lulworth, was selected as a standard, the speed being increased to 1,000 or 1,100 r.p.m., as required.

Standardization was not agreed till cold starting by hand had been established, my own ability to do so being the yard stick. These sets were also used to run the auxiliaries in the bigger power stations. In all some 16,000 of these engine sets were supplied, not only for searchlighting purposes (D.C.) but also for Radar equipment (A.C.). Two-, three- and four-cylinder combinations were used, the best known one being the mobile 22 kw., 100 D.C. searchlighting set.

For the bigger powers both at home and abroad the standard decided on after considerable investigation was the 600 r.p.m. Ruston Hornsby vertical engine. This was used in two-cylinder up to six-cylinder units, say 40–120 kw., to provide power for searchlights, big guns and general lighting, and industrial purposes. The engines gave a good account of themselves whether above ground or under ground. In all 260 of this type of set were supplied.

Royal Engineers Power Plant

During the late war the Royal Engineers were very large users of diesel engines, not only in their numerous power tools but also for supplying electric power from stationary sets to numerous civil engineering activities, such as quarry and road metal work, timber mills, etc. In fact the R.E. could not have carried out their multifarious, if not very well recognized, duties without the aid of diesel sets. The labour and cost of maintenance of petrol sets employed from time to time on some of these arduous duties, especially when the petrol was of low quality, indicated clearly that it would be impracticable to carry them out unless suitable diesel fuel could be made available. Nevertheless there is a fear that in any future war, until an alternative fuel is found for jet-engined aircraft, there may not be sufficient of this particular fraction of fuel available to allow of the R.E. utilizing diesel engines on their equipment—a very bleak outlook as it is clear that the " power tool " is now one of the foremost engines of war, alone making it possible for land and air forces to function at the speed required. As the majority of civilian land transport relies on this same oil fraction, and railways too to a growing degree, the importance of this question must be very evident.

If these R.E. sets in the field are ordered to run on baser fuels, in the interests of simplicity and mobility they cannot be cluttered up with large fuel oil filters and heaters on the scale quite appropriate to big marine and/or stationary installations.

Since the close of the war, while home diesel stations tend to close down in favour of British Electricity Authority's supplies, stations abroad tend to increase considerably up to capacities of 1,000 and 1,500 kw., with individual sets of 500 kw. size.

From the above records of usage in tanks, in mechanical transport, in power stations, in mobile sets and in power tools, it will be realized that the Army has been a very considerable user of diesel engines, mostly of the small cylinder, moderate and high-speed types.

The D.E.U.A.

Now let us turn to the contemplation of ourselves, the D.E.U.A.

The Association was founded in 1913 by a devoted band of enthusiasts, mainly the engineers of central power stations. By the time the 1914–18 war started membership had grown to thirty, and by the end of that war to 210. A small start it may be said, but by 1913, outside the power station line there were but few diesel engines built, that is ignoring relatively low pressure petrol, paraffin and gas engines.

Akroyd's contribution to the engines running to-day under the umbrella title of "diesel" has been given in considerable detail. Turning to those built in collaboration with Dr. Diesel, the first made in this country was the Mirrlees Diesel No. 1 dating to 1897 and believed to be No. 3 of its type in the world. It is now housed in the Science Museum at South Kensington, London. Its particulars are 300 mm. (11.8 in) bore, 460 mm. (18 in.) stroke, 20 b.h.p. at 200 r.p.m.

The cold starting, horizontal type of engine, although marketed by 1912, can hardly be considered as being in general use till 1921.

In 1909, when Andrews read a paper to the Institution of Electrical Engineers, "The Use of large Gas Engines for Generating Electric Power," great interest was centred on that type of prime mover. In fact, at that date a Gas Engine Users' Association might have been considered a more likely body than a D.E.U.A. Andrews included in his paper an embryo type of working costs table. The gas engine, which probably owed its popularity to the availability of surplus coke oven gas in German steel works, fell out of favour owing to its large size for a given power, its low b.m.e.p., its bulk, heavy moving parts and high maintenance costs. Its end was undoubtedly hastened by the availability on the market of Parsons high-speed industrial steam turbine sets.

The first Naval submarine fitted with petrol engines was launched from Messrs. Vicker's Barrow Yard in 1901. Their first diesel submarine was delivered in 1908, and standardization took place in 1910.

By 1913 marine engines for sea-going ships numbered about a dozen in all. There were no high-speed diesels for road transport or power appliances, the former dating generally to 1930 with a few earlier conversions. There was no rail traction of proven merit. Engineers were feeling their way slowly but surely. By 1950, however, there has been a stupendous advance in the utilization of the diesel engine, and a striking change, the trend of which the Association would be well advised to consider deeply.

Since the establishment of the Grid many diesel stations have shut down although, on the other hand, the advent of a body like the North of Scotland Hydro Electric Board, which is determined to supply as many Highlanders as possible with electric power, no matter what the prime mover, has led to the creation of several new diesel stations in isolated areas.

In 1945 our Association decided that the gas turbine should be included in the scope of its activities. It is of interest therefore to be able to record that by this year, 1950, examples have been tested of such applications to transport by air, sea, rail and road in addition to stationary sets on land.

Extremes of Size

It may be of interest to consider here the extreme limits in size of engines styled diesel to-day. The smallest type, if admitted to the family, but not likely to be seen in the Association's Working Costs Tables, is the miniature model aeroplane engine made commercially down to at least 1 c.c.; bore 0.437 in.; stroke 0.406 in. (see Fig. 7.)

Coming to industrial engines, however, Messrs. Tangye might claim to market the smallest in their $2\frac{1}{2}$ b.h.p., crank-case compression, two-stroke, 780 r.p.m., engine, with bore 4 in., stroke 4 in. Starting is by hand after the nickel tube in the vaporizer has been heated by a blow lamp. Fuel, light diesel or gas oil. Pressure (by gauge), compression 105 lb. per sq. in.; maximum 260 lb. per sq. in. These two types are really only quasi-diesels.

The largest to be mentioned is the Burmeister and Wain engine in the Orsteds Power Station, Copenhagen. This is an eight-cylinder uniflow, scavenged double-acting opposed piston, two-stroke engine, in which each main piston has a bore of 840 mm. and a stroke of 1,500 mm. Normal maximum power 23,000 b.h.p.

Road Transport

For heavy road transport, high-speed heavy oil engines may be said to have been in the user's hands by 1930, although experimental sets of moderate speeds were on trial by manufacturers and selected clients considerably earlier. To start with they were generally referred to as compression ignition engines, again a more realistic name than diesel. In 1950 the Commission Technique Internationale, dealing with automobiles, agreed the following definition put forward by the R.A.C. "A diesel engine fitted to an automobile shall be styled a compression-ignition engine. It is an endothermic engine, with separate introduction of air and fuel, in which the ignition is produced without intervention of ignition apparatus synchronized or commanded, and in which the fuel used has an ignition point not inferior to 62° C."

Nowadays, as fuel consumption of the diesel-engined vehicle is less than half that of its petrol-driven equivalent, practically all heavy vehicles operating more than 20,000 miles per annum use the heavier oil, and many heavy vehicle manufacturers no longer build petrol engines. This year is marked by the final stages of the standardization of London's road transport to diesel-engined buses. The present programme of 7,100 vehicles is a notable achievement. The general lines taken by a typical engine would be a six-cylinder vertical, 8.4 litres, 4½ in. bore, 6 in. stroke giving 105 b.h.p. at 1,800 r.p.m. As fuel consumption rises rather steeply at high speeds there is a tendency not to make use of the highest attainable and limit the r.p.m. to 1,800. Further, manufacturers are offering, and users are requiring, the bank of cylinders to be horizontal so that the whole engine can be placed below the floor boards and thus admit of a larger load platform. Figs. 8a and 8b show a Leyland underfloor type.

To the owners of large fleets of road vehicles economy in fuel is probably the most important consideration, as reliability can be taken for granted. This has led to a general preference for direct injection types of heads and has ruled out the two-stroke types such as found favour in certain tanks.

Attention should, however, be drawn to the two-stroke Foden F.D.6 lorry engine (Fig. 9) which, with a b.m.e.p. of 100 lb. per sq. in. at 2,000 r.p.m. on each of its working strokes, needs only half the cubic capacity of its four-stroke rivals. The dimensions of this engine in standard form are, bore 3.35 in., stroke 4.73 in. (85 mm. × 120 mm.); cubic capacity 252 cu. in. (4,090 cc.). There are two exhaust valves of 1.307 in. diameter in each head and the Kadenacy exhaust system is employed. Induction is through ports in the cylinder liners. A Rootes type blower is fitted to ensure both com-

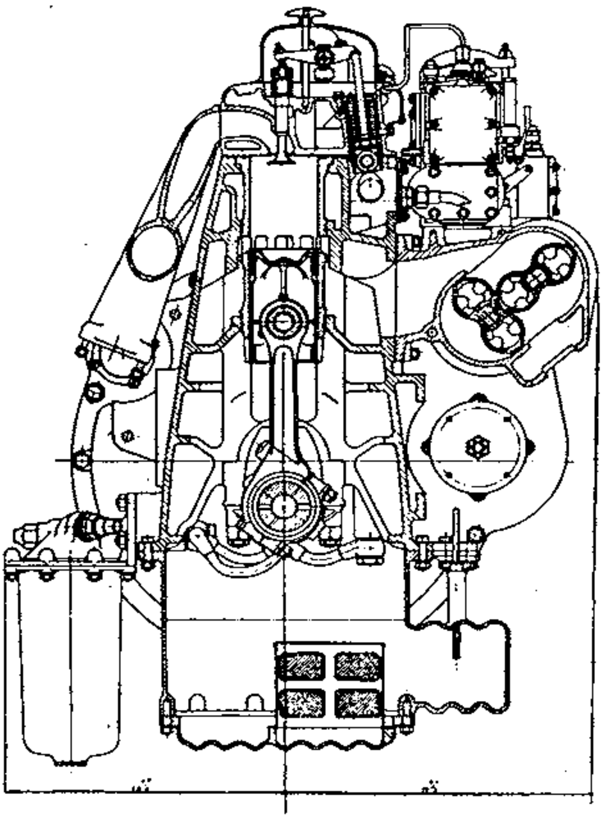

Fig. 9.—Six-cylinder two-stroke Foden vehicle engine; 4·1 litres capacity; 126 b.h.p. at 2,000 r.p.m.

plete scavenging (1·25 times the volume being blown through each cylinder) and complete filling with a fresh air charge at all speeds; supercharging is not achieved.

Possibly the main secret of the success of this relatively small engine lies in the smallness and light weight of its working parts. Quick acceleration and deceleration are thus rendered easy, slow running presents fewer difficulties, and the task of eliminating unusuable heat units is simplified. The small dual exhaust valve would appear to play a big part in enabling such a high b.m.e.p. as 105 lb. per sq. in. at maximum torque to be carried successfully. Even in stationary usage this high b.m.e.p. can be maintained for long periods. As is normal in diesel engine experience, it would be rash to assume that this design could be scaled up without considerable development work to give, say, double or four times the power. Thus a smaller engine with cylinders of two-thirds the cubic capacity and built with a blower on very similar lines, only reaches the lower b.m.e.p. of 92 lb. per sq. in., so far, at 2,000 r.p.m., whereas one might have expected a higher figure. As, however, there is only one exhaust valve per cylinder, the scale down is not exact, and this may account for the less favourable result achieved. Have we here, and in the examples that follow, turned a definite corner? Petrol engines running up to 3,000 r.p.m. in bus and coach, and up to 4,500 in cars are normal. For some time 2,000 r.p.m. seemed to be the upper diesel limit and, indeed, on the bus type engine 2,000 r.p.m. has been reduced to 1,700–1,800 in the interests of fuel economy.

Compression-Ignition Engines for Motor-Cars

A fair number of C.I. engines have been fitted into motor-cars in replacement of standard petrol engines. They are well liked by their owners and doubtless in the near future standard substitutions will be available. The owner has to decide for himself whether he will put up with some rough running at idling speed and whether he can dispense with the top 1,000 r.p.m. of his petrol engine in order to get better pulling at intermediate speeds and a reduction in his fuel bill due to at least doubling his mileage to the gallon. He should select a car with a low ratio to the final axle drive, and/or a car with an overdrive. He must also so drive the car as to make the best of his enhanced torque, instead of seeking his lost revolutions. The additional weight of the diesel engine is not of serious consequence in high-powered cars. Recent tests indicate that the characteristics of these C.I. engines are approached more nearly by a petrol injection system than by a normal carburettor fed engine.

A more recent application, still in the experimental stage by more than one manufacturer, is a four-stroke type of C.I. engine with speeds up to 4,500 r.p.m. (comparably carburettor engines of 2,500 c.c. in touring cars run up 4,500 r.p.m. and racing car engines up to 6,500 r.p.m. some even exceeding 10,000 r.p.m.). The best running speeds are 1,500–4,500 r.p.m. in which range these engines run sweetly. Below 1,000 or 1,500 r.p.m. there is some diesel roughness, but if such a high idling speed can be accepted here is a lively type of car engine in embryo, and certainly an opportunity for capturing C.I.-engined car records, as those now in existence were made with engines whose maximum speeds barely exceeded 2,500 r.p.m.

It may not be known widely that motor-cars fitted with compression-ignition engines are catered for, as such, in car racing records. International class and British records are obtainable in a special compression-ignition class. The earliest of these records dates back to 1935, but none of them reach the speed of the corresponding petrol-engined car.

The Gas Turbine Car

The appearance of the first gas turbine engined car this year, a great British achievement by the Rover Company has now set a nice problem. How are the new prime movers to be equated with existing piston engines which are divided up into eight classes according to their piston displacement? Smallest class, under 750 c.c., largest class, over 8,000 c.c.

Many suggestions have been considered and a solution will have to be found to satisfy the Federation Internationale de l'Automobile, the International Sporting Commission governing motor-car racing and records.

The rating put forward by the R.A.C., and accepted in principle, is the area in square centimetres of the air inlet to the compressor measured in a plane perpendicular to the compressor axis at the leading edges of the first rotating vanes. This proposal lines up well with the petrol engine rating which depends on the readily measured factors of bore and stroke and number of cylinders, and it also appears to give the widest field for improved technique in the future, without hampering restrictions.

Nevertheless, although it is known that four or five designs for gas turbine driven cars are in hand in various countries throughout the world, it must not be anticipated that our roads will be flooded with them just yet. They are more likely to be seen as special cars for individual sportsmen.

[Note.—This question of rating is being put forward for purposes of records and sports. Under present legislation, rating for taxation purposes is not required.]

Diesel-Engined Power Tools

For public works, and indeed in nearly all building work as well as for agriculture, a new industry has sprung up since 1913, the diesel-engined power tool, sometimes driving a central generator, electric or pneumatic, with electric or air transmission to smaller tools, but more often operating excavators, hoists, etc., and agricultural implements direct. Hard usage this, very often, in which the diesel engine receives less consideration than even the proverbial donkey of the East. The major number are small units, but they represent a considerable b.h.p. in the aggregate.

Problems of the Future

The long marches that the oil engine has made in this century since the early work of Akroyd and Diesel have been touched on, and especially the advances since our Association started. There is no reason to suppose that progress has come to a standstill. Far from it. The gas turbine which now comes under our consideration is certainly only in its infancy, and it is not proposed to dilate upon it.

Fuels

Too many classes of engines are seeking to operate on too narrow a band in the distillates of crude petroleum. The advent of the jet engine and the gas turbine has brought about a tremendous demand for the same range of oil as is used in the heavy road vehicle industry and in rail traction. If a world war were to come, the insistent demand for this particular fuel for the air forces of all nations involved would probably surpass the world's possible production. In that case the mundane users would go to the wall, and the air demands would have to predominate. Even in peace-time the increasing demands for jet and gas turbine engines may present a grave problem to the oil refiners and to road and rail users unless the gas turbine can be made to run on heavier oils or on pulverized solid fuels.

Until its efficiency can be raised to a considerably higher figure than now obtains, without crippling complications, the gas turbine is handicapped by its high fuel consumption, particularly in the small sizes. To become a commercial success, therefore, a lower priced fuel than that used in oil engines becomes of paramount importance. Coal producing countries in particular will turn their hopes to pulverized coal, but the difficulties here are very great and not yet solved for commercial use. Already heavy oils can be burnt satisfactorily but the effect on the turbine blading is not yet known. The alternative is higher operating temperatures, but, suitable materials are not yet available.

In piston engines, for marine work in particular—a very large potential field—there is clearly a relatively easy target in sight, the use of undistilled boiler oil. A very good start has been made in this direction and already some highly satisfactory user results by British shipowners are available and have been published.

For smaller engines one may well turn to bi-fuel systems in which a small quantity of the higher-grade fuel is injected ahead of the main supply of less expensive fuel.

In the event of the air demanding complete priority for paraffin and gas oil fractions in the distillation range, it is very important that the " Sapper war," referred to above, can be carried on either by some bi-fuel arrangement or by the complete adaptation of such engines to baser fuels.

High Speed Diesels

Despite their low fuel consumption, general reliability, and ability to stand up to hard work, the high speed diesel engines used in public service vehicles and for heavy and long distance haulage cannot be considered as being yet finally developed. Both users and passengers will be glad to see certain improvements in general use, as apart from laboratory scale trials which may be in hand. Ability to operate on a wider range of fuels has been explained in the last paragraph. Noise, smoke and inflexibility are other ogres to tackle.

Noise and the well-known diesel knock has been considerably reduced by cam design whereby pilot injection with a specially modified fuel pump can be utilized.

Noise in operation is an objectionable feature which has crept into too many types of modern engines. Sometimes this is traceable to the blowers, sometimes to other features especially in the higher specific output designs. If the engine is boxed up these noises may not have objectionable repercussions, but where the engines are in the open, as in land power stations and ships' engine rooms, it is hard on the operating staffs to have to work continuously at such a very high noise level. Or, alternatively, in the interests of high specific output is the diesel set of the future to be looked on like a steam turbine set, entirely boxed in and not even inspected internally for months on end ?

Smoke is to a considerable extent avoidable by careful maintenance —which unfortunately is not always provided.

One wonders, however, how engines on rapidly varying loads, such as those on power shovels and diesel cranes, can continue to work when they throw out such clouds of thick smoke on taking up load after idling. Is the operator alone to blame, or could the engine builders do more to help lame dogs over a black stile ?

Inflexibility, with which should be coupled too high an idling speed and too low a maximum, might not have struck us forcibly had it not been that the similar and older petrol engine which the compression ignition engine has replaced, was very flexible. Comparative figures might be of the following order for a 10 litre engine of 100 b.h.p. :—

	Speed in r.p.m.		
	Idling	Highest working	Range
Petrol engine ..	300	3,000	10 : 1
Compression Ignition	350	1,800	5.6 : 1

Inflexibility of the normal engine shows itself particularly on country services with many sharp corners. Here an entirely automatic variable speed drive, or a box in which a two-step gear change can be made safely in one movement, might assist.

The two-stroke type, employing engine instead of mechanical gear reversing, must, in particular, be made to idle at a very low rate.

For *rail traction* there would appear to be a splendid opening for a satisfactory mechanical drive, particularly for gas turbine locos. Certainly up to 350 b.h.p., and probably up to 500 b.h.p., it may be stated that proven mechanical transmissions are in the hands of users. Higher horse-power drives are in the design or experimental stage. Mechanical drives are badly needed to bring the capital cost of the diesel locomotive nearer to that of the corresponding steam locomotive, the present price ratio being in the neighbourhood of 3 : 1.

Further, many users with transcontinental lines in countries not yet industrialized have a strong feeling that while they can organize good mechanical repair units, say, every 200 miles along their line, they are neither anxious nor able to establish electrical repair and maintenance units on this scale.

Some countries, even less industrialized, pin their faith entirely to the simple form of steam engines ashore and afloat, because they feel more certain of being able to maintain them efficiently.

While electric transmission admits of great flexibility, its weight, bulk and cost offer a magnificent target to the inventor of an improved mechanical drive. The engines are there ; transmissions lag behind.

Engineers will look forward with great interest to the results of the development of the Fell System in which the output of two or more separately supercharged main engines is combined by means of fluid couplings and a system of epicyclic gears in such a manner that the speed ratio is changed without interruption in the transmission of torque to the driving wheels. This is not a small scale experiment as Mr. H. G. Ivatt has in hand for the British Railways, a locomotive with a total output of 2,000 h.p. for main-line working.

One feels that in the case of the gas turbine loco, the electrician and the "thermodynamician" are having a great fight to secure the biggest share of the space available within the railway loading gauge, particularly in the small British gauge. A compact mechanical drive should assist the turbine designer to improve efficiency and so compete more effectively with the piston engine, which latter should in any case be beaten in maintenance charges.

Acknowledgements

In an historical paper such as this no author could by himself dig out the many facts enumerated without the assistance of several investigators into records available to them and to but few others. I therefore desire to express my gratitude to many who have given a great deal of time and trouble to diving into records and giving me the benefit of their advice.

Vote of Thanks

Mr. T. Hornbuckle (Past-President), conveying the thanks of the meeting and of the Association to the President for his Address, said :—" I am sure you will all agree with me that in his Address the President has given us a most valuable review of his long experience in engineering. I think it true to say that very few engineers have had the opportunities our President has had which enabled him to give such a comprehensive review of the development of the internal combustion engine and of the ways in which it has been put to practical use ; also to direct our attention to the possibilities of future development. I am quite sure that the President's Address will form a most valuable contribution to the records of this Association ; it has great historical and practical value.

I am particularly interested in the President's Address because fifty years ago, although we did not know it then, our paths crossed and we were both in close contact with a first-class team of engineers who had been responsible for the successful development of the Hornsby Akroyd engine. Looking back, we realize what a wonderful job of work those men did ; it is one thing to have an idea, or even a blueprint, but to get this translated into actual practice, to get it marketed and put to work over a large part of the world, is a great achievement.

I think their success was very largely due to the fact that they achieved two important objectives which should always be to the forefront in the mind of every engineer. These objectives are reliability and simplicity. To secure reliability is an achievement, but to secure, also, simplicity, puts the crown on that achievement.

So far as my experience goes, every sound engineering appliance is marked by its simplicity. If a machine is complicated, but works satisfactorily, one knows that the designer has not yet finished his work, there is further work to be done to put it on a first-class basis.

I would recall the President's remarks about the importance of the user. I agree entirely that the user has a very great part to play in the development of all engineering appliances. As an example of this we can point to railway experience in this country, where the builder of a locomotive is in very close touch with the user—indeed, so close that the blows which come back are quickly given, and they can be very hard.

There is just one danger to be guarded against in the co-operation of users, they sometimes tend to put the brake on further development. When they have something that works reasonably well and gives little trouble they are apt to decide that they do not want anything better ; if anything new is put forward they often prefer that somebody else should try it first.

With that qualification, I think the user should be taken into wider partnership than seems to be the case at the present time. We in this Association can take pride in the fact that one of our members has shown extreme boldness in applying a new form of transmission to a river craft ; Mr. Mayor certainly deserves a medal for his enterprise.

I have great pleasure in proposing a very hearty vote of thanks to the President for his excellent and interesting Address.

Mr. G. B. R. Feilden.—When the Committee invited me to undertake the very pleasant duty of seconding the vote of thanks to our President for his Address, my first reaction was one of extreme misgiving. I felt that I should prove to be an imposter, since my primary interest is in gas turbines, and the whole of my working life has been devoted to this field of activity. However, on reading the Address, I was reassured, for I found that there were quite a number of references to gas turbine work in it. I have enjoyed it very much, and particularly the anecdotes which General Davidson has included from his experiences in development work. We always profit from hearing of the solution of the trials and tribulations experienced in developing new ideas, and the President's account certainly encourages one to go ahead and not to lose heart if one seems to be facing a very difficult problem.

I hope that General Davidson will be with us on the occasion of his Diamond Jubilee with oil engines, and that he will then be able to present a further paper covering the progress made in the intervening years. My personal opinion is that gas turbines will occupy an important part of that paper, and I believe that a large proportion of future gas turbines will run on non-distilate fuels, and will use a wide range of cheap sources of heat energy, including solid fuels.

From my own experience, I can reassure the President that potential gas turbine users are not holding back. Far from it ; most gas turbine engineers find that they spend quite a lot of time in discouraging enthusiastic potential users who wish to use gas turbines in applications for which insufficient development work has so far been carried out. People want to do all sorts of things with gas turbines and to use fuels ranging from tropical wood refuse to methane. No doubt the use of a wide variety of fuels will be possible ultimately—and this is one of the greatest potential advantages of the gas turbine—but we must first build up a reliable fund of operating experience with those fuels which are relatively easily handled.

I have very great pleasure in seconding this vote of thanks.

(*The vote of thanks was accorded with enthusiasm.*)

THE PRESIDENT, responding, said :—Thank you very much for your vote of thanks, which has been proposed by a practical engineer of the old order and seconded by a scientific engineer of the newest technique, in such generous terms.

It has been exceedingly interesting to me to look into the historical questions ; but, unfortunately, it is not easy to pin down accurate and positive information on matters which occurred many years ago, and it is hard to get the whole truth. Only to-day I received a letter from an officer under whom I served—he is now 83 years old —giving me valuable negative information, but positive information is harder to obtain.

THE S.M.E.

A Statement by the Commandant, S.M.E., at Exercise "Fresco."

THIS is the first time since the S.M.E. concentrated again at Chatham that a large and representative gathering has taken place here. It is a good opportunity, therefore, to explain how and in what shape the S.M.E. has been re-established, to get your views on whether what has been done is sound, and any suggestions you may have for its development in the future.

Secondly, although a syllabus for each course is laid down in some detail by the War Office, there is wide scope for translating it into practice, so I would welcome criticism of the general lines on which the S.M.E. is running, and constructive suggestions for improvement. After all, the matter concerns you all as consumers of the article turned out by the S.M.E. ; for even if the S.M.E. contributes to making only a part of the article, that part is pretty large.

First of all an outline of the story of the reconcentration at Chatham. In December, 1946, at the E.-in-C's. Conference held by Major-General Sir Eustace Tickell, a majority voted for the S.M.E. to move to a new site nearer most of the D.G.M.T's. Schools, and to leave it divided between Ripon and Chatham until the new site could be acquired and a new S.M.E. built. The cost was estimated at 1½ to 2 million pounds.

By the autumn of 1947, the estimate had grown to 3 million pounds and it was becoming obvious to the E.-in-C. that neither the land nor the money for building was forthcoming in the foreseeable future. It had also become obvious that a divided S.M.E. would not work. We were getting into a muddle. Something had to be done. The E.-in-C. therefore decided to return to Chatham, and we started to look around for the extra accommodation necessary. Various camps were proposed, all quite unsuitable. Finally, somebody suggested Darland Camp. We looked at it in February, 1948, and decided it would do. It was the only possible answer, and would have to do.

Darland Camp was erected before the war for teaching boys to become tradesmen. During the war, it was a Military Detention Barracks of unsavoury repute. In 1948, a small portion of the upper part was occupied by an A.A. Battery, the lower by Ordnance. The whole place was in a poor state of repair, and surrounded by a maze of old and blackened barbed wire. The atmosphere was dismal in the extreme.

The Gunners and Ordnance raised little serious objection to being moved out, but Finance at the War Office were dead against the proposal to rehabilitate the place. In my dealings with Finance in the War Office, I learned one very useful lesson. In the Army one is told that in order to get something done, one should see the top chap personally. Without thinking, I bearded the head financier in his office. The only result was to arouse his suspicions and delay approval. It took until the spring of 1949 and the aid of the Army Council to settle the matter. The money was then voted, work started in July, 1949, and Ripon moved down in March, 1950. Darland Camp then became Gordon Barracks. The work of rehabilitation is still not complete, but we have settled in sufficiently to realize that the Camp can provide first-class facilities for our requirements in every way. So I am sure, and so are my staff, that the move has been a success.

The layout is as follows: firstly, there is Headquarters S.M.E. located with the Civil Engineering School, and the Tactical School, in the S.M.E. main building. The E. & M. School is back in its old building of astonishing design. H.Q. S.M.E. and these two schools are fathered by 12 S.M.E. Regiment in Brompton Barracks.

In the S.M.E. main building are also the Publications Section and the Secretary, Institution of Royal Engineers and his small staff. The Corps Library is shortly to be located in the old S.M.E. Lecture Theatre.

At Kitchener Barracks is 10 Trades Training Regiment with the Workshops under its command. This arrangement has proved most satisfactory.

At Gordon Barracks is the Field Engineer School fathered by 11 S.M.E. Regiment, with its fieldworks ground alongside and its wet bridging ground at Upnor. 11 S.M.E. Regiment includes the Officer Cadet Squadron, the Cadets of which spend twelve weeks at the S.M.E. for "Special to Arms" training.

Across the river is the Plant Squadron at Kingshill Camp, two miles beyond Chattenden Barracks, with its own L.A.D. Workshops at Wainscott, one mile on this side of the same barracks.

Chattenden Barracks houses a few married families, and the surrounding ground provides facilities for plant training, growing oats for the Saddle Club, and a very reasonable Point-to-Point course.

Since the R.A.S.C. have come to our rescue by providing a motorboat ferry across the Medway, access to Upnor from this side has presented no difficulties. One reckons to take ten minutes from H.Q. S.M.E. to get by car and ferry to the bridging area at Upnor.

The Upnor side is first class for all forms of wet bridging and pile driving. Not only is the Gundulph Pool big enough, but possession has now been gained of the near half of Whitewall Creek and the intervening ground. The latter provides an extensive hard, large enough for the new technique of erecting Bailey bridge equipment away from the site.

The Darland fieldworks ground, alongside Gordon Barracks, is large enough. A bridging gap, giving varying spans up to 200 ft. has been carved across it.

In Gordon Barracks, the provision of large sheds is on a generous scale, giving model rooms and indoor field engineering and drill facilities, as well as a Study Centre accommodating 150 people around a Cloth Model.

The S.M.E. is well off for sports grounds, both at Gordon Barracks and in the Brompton area.

The married quarter situation is not yet entirely satisfactory but it is easier than at most other stations. New quarters are being built for officers at the Sally Port and for other ranks on the Great Lines, so that in a year or eighteen months the S.M.E. should be very well placed.

On the medical side, there is the Naval Hospital, which is quite first class, always ready to take in our casualties ; there is a M.R.S. in Gordon Barracks itself, and a Families Hospital in the Brompton area that functions extremely well.

We have our own church and an efficient and hard-working Padre who is gradually building up a congregation. Some of you saw the attendance at the Church Service we hold every Wednesday morning. I am often asked whether pressure is brought to bear on the troops to attend this service. The answer is " Yes," but only to this extent, that instead of asking those who want to go to church to fall out, we call for those to fall out who do not want to go to church. As the faint hearted are in the majority, the majority now come to church and, undoubtedly enjoy, it.

The Officers' Messes are good and rapidly recovering a proper standard.

The barracks accommodation for both officers and other ranks is poor in Brompton Barracks, but will be put right in the course of two or three years. No. 4 House, damaged by bombs in the war, has been repaired on modern lines and is comfortable and convenient. Kitchener Barracks has a Sandhurst Block, but also some old barrack rooms. The latter will be replaced in due course.

On a long-term view, the return of the S.M.E. to Chatham is, therefore, working out well. In the earlier plans, it was intended to locate the Field Engineer School and its connected regiment in new construction at Chattenden. As a result of experience, I would now recommend that, should permanent barracks be offered, they should be built at Darland.

Now as to what we are doing at the S.M.E. and why.

Before taking over the appointment of Commandant, I had to think out what to do with the S.M.E. when it was reconcentrated at Chatham. One's first inclination was to return to the pre-war set-up and habits, especially as the pre-war methods had produced so many very successful R.E. officers. One's memories of the pre-war organization and policy were, however, vague ; and while at Chatham on three previous occasions, I had had only a worm's eye view. It seemed best, therefore, to work from first principles and, firstly, to think out what is the main function of the S.M.E. I had helpful discussions with various people concerned with the handling of young officers and other ranks, and I also tackled the head psychiatrist at the War Office. I asked him in particular whether experience in the war had shown that a high proportion of Sapper officers wore out unduly quickly. He said this was definitely so and, although partly attributable to the continuity of responsibility carried by Chief Engineers and Cs.R.E., it was also due to a Sapper habit of taking responsibility too seriously, attention to too much detail and trying to do too much. He suggested that if anything could be done to make the young officer see the wider issues and to approach his responsibilities more lightheartedly, it would be valuable.

The word " training " did not seem to cover the function of the S.M.E. ; because training is the practice of a known technique to meet a special task such as an examination, a race or a battle. The main characteristic of training is rehearsal.

Secondly, " instruction " did not seem to meet the case, because the underlying idea is academic. It is apt to become " cramming." It seemed to me, therefore, that the right word for the function of the S.M.E. was " education " in its true Latin sense of " drawing out the character and abilities of the young." This is not new, and is probably what was done before the war ; but instead of reverting vaguely to pre-war, it gave one something definite to work on. It encouraged one to consult those with experience of real education and to consider what was done at the best public schools, and at Army schools here, in the Dominions and the United States.

I came to the conclusion that " education " would be achieved provided, firstly, the interest of staff and students could be focused on the S.M.E. by a full and well-balanced life within the community ; secondly, a high standard of performance throughout could be attained ; thirdly, the tempo and methods of work could be adjusted so as to give time for the understanding of principles rather than the accumulation of factual knowledge, and fourthly, that the problems of engineering in war could be emphasized throughout, rather than those of peace.

In seeking out ways and means of putting these into effect, I was attracted, firstly, by the system in the public schools of this country where the concentration of interest within the community is so strongly stressed. The organization for doing this is composed of two elements ; firstly, the housemaster whose primary duty is to organize the boy's existence in the best way to develop his character, and to study each boy individually so as to get the best results. Secondly, there is a professor element responsible for teaching. I was fortunately able to secure the concurrence of the War Office in establishing these two elements in the shape of the regiment commanded by a Lieut.-Colonel, who is the Housemaster, and schools under Chief Instructors as Professors. It was important, however, to ensure that the two elements were not separate parts of the community ; so I took steps to ensure that the professors were responsible for communal activities outside their academic instruction.

I had then to decide what activities were required to provide a full and balanced life. Ball games were, as usual, necessary ; but it seemed to me that they were insufficient to produce the characteristics required of an R.E. officer. These characteristics are : firstly, enterprise ; secondly, resource, contrivance and a determination to overcome all obstacles ; thirdly, ability to plan and to organize; and, fourthly, readiness to face risk and put up with discomfort. These characteristics are brought out in varying degrees by such activities as sailing, particularly ocean racing and cruising, flying, equitation in all its forms and ski-ing and mountaineering. To keep the balance, cultural activities such as music, art and drama were also necessary. It was important to insist on a proper balance and not to give rein to activities at the expense of work.

It seemed logical, therefore, to accept all such activities as part of the business of the S.M.E., and to control them through the normal chain of command. This was done by making Lieut-Colonels responsible to me for one or more activities. For example, the Chief Instructor E. & M. is responsible for the Saddle Club and the Drag: the Chief Instructor Civil Engineer School for the Yacht Club and all this involves ; the C.O. of 12 S.M.E. Regiment for the Gun Club and for organizing the Air Day ; the Chief Instructor Field Engineer School for the dinghy sailing and running the Point-to-Point. This arrangement defined responsibility and, by spreading the load amongst all officers of the staff, gave great impetus.

In due course, it was found that such activities as the Horse Show provided scope for a first-class execise in an engineer operation of war. There was, first of all, a full and careful appreciation of the proposal to be made. This was followed by an "O" Group, at which the intention and plan were given out, and responsibilities allocated. These were confirmed later by a formal Operation Order in writing.

The tasks included all those of war, " G," " Q," " A " and Signals. As in war, there was a shortage of labour, stores and transport. Difficulties had to be overcome by the exercise of resource and ingenuity. Unlike a cloth model exercise, the whole of the organization was tested on the day by the performers and spectators. The organization proved so good that the British Show Jumping Association have asked the S.M.E. to run an Area International Trial this coming summer. It is to be held on 13th June at Gordon Barracks.

Other activities, such as the Point-to-Point and the Regatta, are being similarly used as engineer exercises.

To establish a high standard of performance in the S.M.E. required nothing more than the methods used by the British Army since time immemorial. These need no description and I leave it to you to decide, having seen the Officers' Messes and the general running of this exercise, whether a high standard has been achieved or not.

As regards methods of work, to introduce the University system with less lecturing and more private study was desirable. This would mean that students would have to do more thinking for themselves, and would learn to organize their work so as to give time for the other activities in which they were expected to take part. This has now been tried for some time and proved beneficial to both students and staff. To teach students to think, emphasis is being laid on the importance of writing engineer appreciations ; and to teach them to express themselves clearly, cloth model exercises are frequent, and every opportunity is given to students to state their views verbally.

Insistence that schools should study problems of war rather than those of peace has not proved difficult with the Civil Engineer School. Its change of name from the Construction School and the introduction into its curriculum of Roads and Airfields and Advanced Bridging have done much to relegate barrack construction to a less important sphere in so far as the young officer is concerned. By studying Advanced Bridging, with practical work such as pile driving over at Upnor, the Civil Engineer School is always closely in contact with the Field Engineer School.

In the case of the E. & M. School, a change of approach to the subject has not proved so easy. It had been hoped at one time to include plant operation within its curriculum. In practice, however, it has been found necessary for plant to be organized as a unit which can train regimental instructors and carry out productive work. By studying the question of maintenance of plant, the E. & M. School has, however, achieved some degree of battle atmosphere. The construction of pipe lines for bulk fuel is, of course, one of its responsibilities.

The Tactical School deals with tactics generally and engineer tactics in particular. It aims to turn out students at the end of Stage III as potential Adjutants or Intelligence Officers. Within the Tactical School is the Methods of Instruction Team which aims to teach Y.Os. at the end of Stage I at least to be able to put over a simple lesson well.

To sum up, therefore, the S.M.E. aims to teach a young officer to be part of a community, with all the activities of which he is concerned and for some of which he is responsible ; to be active, enterprising and resourceful ; how to think logically and to have enough engineering knowledge to think as an engineer ; how to organize and employ his life to useful purpose ; and, finally, to aim at a high standard.

The following numbers who participated in various activities at the S.M.E. in 1950 are approximately as follows :—

	Officers	*Cadets*	*O.Rs.*	*Civilian Staff*	*Remarks*
Riding	90	—	—	—	
Sailing	61	2	—	—	
Dinghy Sailing	60	50	39	—	
Rowing	30	6	—	—	
Ski-ing	7	—	—	—	In the whole Corps, 20 participated in ski-ing, and 13 in climbing.
Arts Club	16	—	16	16	
Dramatics	23	—	11	10	
Scottish Dancing	40	—	2	—	Plus approximately 20 wives.

In order not to make this statement on the S.M.E. too long, little reference has been made to the N.C.O. and man. In any case, I felt from the start that the policy adopted, and the standard reached for the officer would automatically determine what happened in the sphere of the other rank. This has, of course, taken place.

THE "LEADER" PROJECT—ENGINEER RESOURCES*

By Lieut.-Colonel J. C. R. Fitzgerald-Lombard, O.B.E., R.E.

1. Introduction

THIS article deals with a project for the establishment of a large Ordnance and Engineer Depot at Mackinnon Road, about sixty miles inland from Mombasa, the chief port of Kenya. As the site was virgin bush and far from any town, the scheme had to be complete in all respects, e.g., living accommodation, hospitals, water supply, and so on. The code name given to the project was "Leader," and for the sake of brevity this term will normally be quoted when referring to the project as a whole.

The term "Engineer resources" has purposely been used rather than "Engineer stores" in order to indicate a considerably wider field than might be implied from the latter term. Not only will engineer stores in the narrow sense of the term be dealt with, but also the production and provision of all types of local materials, and the requirements in workshops and engineer plant. There is no doubt that in pre-war days, these aspects of engineer work were inclined to be neglected ; more often than not "stores" consisted in no more than preparing a list of materials for the job, some of which were provided from W.D. sources and the remainder by the contractor ; with the result that, when the war came, we had few officers trained or experienced in the wider aspects of the subject. "Leader" though carried out in peace-time, was essentially a war-time project, and was undertaken in a country where transportation facilities were extremely limited and engineering resources largely undeveloped. It therefore produced all the problems which might be expected to be encountered in a major works service (e.g., the construction of a base) in an overseas theatre of operations.

2. The Stores Problem

When the "Leader" project was originally sanctioned in August, 1947, the object was a perfectly clear and simple one, i.e., to provide the minimum adequate storage accommodation for large quantities of Engineer and Ordnance stores, some of which were being rescued from India, Palestine and elsewhere and others due for evacuation from Egypt. The target date originally set for the completion of the specified covered and open accommodation was September, 1949, but it was made quite clear that the evacuation of the countries

*In view of the subsequent abandonment of the project, it should be explained that this article was written in October, 1949.

mentioned could not wait until then, and that stores would be dispatched to East Africa long before the date mentioned. So far as engineer stores were concerned, there would therefore be a flow which would comprise not only the stores required for the project, but also stores required for holding and, as much of the dispatching, particularly from Palestine, had to be carried out under very difficult conditions, the two categories would inevitably be mixed together.

Furthermore, it will be clear from the above that " time " was an overriding factor, so much so that, contrary to all peace-time procedure, execution of the project had to start before it was planned, except for the barest outline of requirements. Inevitably, therefore, the initial flow of stores for the project had to be based on what can only be described as preliminary guesses. The original forecasts of requirements were prepared by the stores staff of G.H.Q., M.E.L.F., and considering the circumstances and the limited time available, were extremely well prepared, but inevitably and rightly there was a tendency to overestimate and to include doubtful items.

The result of these two factors was that our greatest problem was not too few stores, but too many. Inevitably, of course, there were certain shortages, due either to items being overlooked in the forecasting or to delays in availability. But the real problem throughout the first year of execution was undoubtedly the reception, sorting and handling of far more stores than we really needed with an overcrowded port, extremely limited storage and transportation facilities and, particularly in the early days, an almost entire absence of properly organized and trained stores personnel. All this is, without doubt, very typical of what happens in war-time.

3. Initial Requirements

In tackling the stores problem as set out above, the majority of the tasks fell under one or other of the following heads :—

(*a*) The preparation of detailed and more accurate stores requirements as planning took shape, and the submission of the necessary forecasts and demands.

(*b*) The creation of a Stores Transit Organization at Mombasa.

(*c*) The creation of a project store on a large scale at Mackinnon Road.

(*d*) The movement to Mackinnon Road of the stores required for immediate incorporation, the emphasis in the early days being very much on those for the pipeline from the Tsavo River.

(*e*) The necessary arrangements for local production, e.g., quarrying, etc.

Throughout the first year, these five headings, though often changing their complexions, or developing in unexpected directions, nevertheless continued to form our chief preoccupation. It will therefore be convenient to treat each of them separately in succeeding paragraphs and, follow their development through the first year or eighteen months of the project, by which time the majority of stores problems had been solved, organizations had settled down and provision was proceeding on normal lines. Engineer plant and workshops will be dealt with separately at the end.

4. Forecasting and Provisioning

As already stated, the original stores forecasts were little more than rough estimates on a tonnage basis prepared at G.H.Q., M.E.L.F., in the autumn of 1947 and based on the rough outline of the project as known at that time. These tonnages were then broken down to detailed lists by the stores staff at G.H.Q., and preliminary provision action was taken. By November, 1947, we were engaged in preparing the first detailed forecast of requirements (in effect a demand also) at H.Q. East Africa Command, despite the fact that the G.H.Q. Staff Directive for the Project was not issued until 13th December, 1947, and all planning up to date had been based on preliminary information contained in a Directive from the E.-in-C. At the same time, so far as stores ex-Egypt were concerned, we sent G.H.Q., M.E.L.F., what became known as the " batting-list ", i.e., a list of all the items we required for the early stages in the exact order in which we required them packed and dispatched. Each item was given a serial number, and the order of dispatch could be varied by signal at any time.

Surprisingly enough, these rough and ready methods worked and we were seldom, if ever, seriously short of stores because of failures in provision. This satisfactory state of affairs was of course largely due to the special factors outlined in section 2 above, which produced other problems in their train.

After this initial period was over, the object became to achieve normality as soon as possible. By early 1948, the Chief Engineer, Mackinnon Road was submitting quarterly forecasts and monthly demands for his requirements to the Command Stores Staff, this being necessary because, although the bulk of demands were met from the Transit Store at Mombasa, a proportion of them came from the Command Store in Nairobi. The annual forecast for 1949—50, prepared at Command H.Q. in the summer of 1948, included all the likely " Leader " requirements for that year which had not already been provisioned, and by early 1949 when the first quarterly demand for that year was submitted, " Leader " may be said to have become a normal project, so far as provisioning was concerned.

One special arrangement made is, however, deserving of mention. About June, 1948, when construction work was getting well into its stride, we appointed a newly joined Major, who had had much practical experience on the Works side, as Stores Liaison Officer. This officer visited Mackinnon Road at regular intervals, once a week for the first few months and once a fortnight thereafter and his duty was to iron out the many detailed questions which arose in connexion with immediate requirements of stores for current works. He carried out a difficult task admirably and did much to assist the progress of the works and to reduce unnecessary letter writing. The essential qualification for such liaison is a varied practical experience so that the officer can suggest improvisations or alternatives when the required stores are not available.

5. Organization at Mombasa

Reading through the appreciations now, some two years after the event, it is remarkable, in view of the uncertainties at that time, with what accuracy the E.-in-C's. branch at G.H.Q., M.E.L.F., forecast the transit requirements at Mombasa. They stipulated a transit depot within eight miles of the port, capable of holding 30,000 tons of stores and expandable up to 50,000 tons. In fact our maximum holding was about 40,000 tons in July, 1948. Adequate road and rail services were, of course, obvious requirements, and the vital needs in covered storage were for cement and for the unpacking and testing of machinery. The difficulties which arose were not therefore due to any failure to appreciate what was needed, but to the time taken to implement these requirements in terms of storage accommodation and properly organized and trained stores personnel.

During the war a R.E. Transit Store had been operated in Mombasa, but by September, 1947, this had already been closed down and our only transit organization there was for the handling of timber, which we were still exporting to Egypt at the rate of about 3,000 tons per month. It consisted of an open area of some 15 acres, with a certain amount of covered accommodation, rail-served and within a mile of the docks. The timber was handled entirely by a local civilian firm under contract. For the first few months, all incoming engineer stores were handled by this organization, but by the end of 1947 it was quite clear that the setting up of a proper transit organization could no longer be postponed if a breakdown were to be avoided. At about this time, we were informed by G.H.Q. that they required no more timber shipments for at least six months. This was of fortuitous assistance, so far as Mombasa was concerned (though the repercussions elsewhere were unfortunate), in that we cleared all timber already at Mombasa in a ship which was just due to leave, and diverted all incoming deliveries to Nairobi. The yard at Mombasa therefore became fully available for " Leader " stores, and formed the nucleus of the transit organization.

In considering the possibilities of expansion, consideration was given to selecting and developing a suitable new site on the mainland, but within easy distance of Mombasa Island, but for various reasons this was ruled out. In the first place the country is very broken and as all the best areas are occupied by smallholders, mainly Indian, the selection, acquisition and development of a new site, with all the negotiations which would inevitably have been involved, would have taken time which just could not be spared. Secondly, movement to such a site would have involved using part of the main Nairobi railway (single line) and was outside the area in which " Port use only " wagons could be employed. It was felt that once stores were loaded on to main-line trucks, they might just as well be taken to Mackinnon Road, some sixty miles away. Our efforts were therefore directed to obtaining what sites, open or covered, we could in Mombasa, and largely through the co-operation of the Royal Navy, who loaned us some of their war-time sheds on an unofficial basis, we succeeded by May, 1948, in obtaining seven further sheds in different parts of the Island, and various open storage sites. Even so, a considerable quantity of valuable machinery had to be stored in the open until, after long negotiation, we acquired in November, 1948, a large covered shed which was being vacated by the Director of Disposals. One of the sheds, obtained from the Royal Navy, was fitted with a 10-ton overhead crane, and was, therefore, used for the unpacking and testing of machinery. The general result in the end was adequate, but suffered from the disadvantage of being scattered all over Mombasa Island. It should be mentioned also that, as a reserve, we acquired an option on a 20-acre undeveloped site in the middle of the residential portion of the town, and had plans prepared for developing and rail serving it ; however as events turned out, we never had to put these into operation, much to the relief of all concerned !

As regards personnel, G.H.Q. sent down a detachment (four Officers and fifty-three O.Rs.) from 198 Transportation Stores Squadron who took charge of the Transit Store and in co-operation with the contractor already mentioned did their best to sort order out of chaos. It must be remembered that this detachment did not arrive until March, 1948, and that by that date some 25,000 tons of stores for " Leader " had already arrived. It soon became clear that available military manpower would not suffice for the operation of E.S.Ds. at both Mackinnon Road and Mombasa in addition to the existing Command Engineer Stores in Nairobi. Owing to the primitive conditions at Mackinnon Road at that time, it was not practicable to recruit European civilians in any numbers to operate the store there, and that depot clearly had to have priority for such military personnel as were available. It was therefore decided to operate the Mombasa store as far as possible on a civilian basis. Unfortunately the European population of Mombasa is small and the insecure terms of service which the W.D. could offer for what was essentially a temporary requirement were inadequate to attract suitable staff. We therefore let a contract to Messrs. Owen Thomas Transport, the contractors mentioned previously in this connexion for the entire operation of the store on behalf of the W.D., assisted by a small military liaison staff. The contractors executive staff consisted largely of ex-Naval storekeeping personnel and they proved most efficient, although owing to the heavy drop in tonnage received after the end of 1948, they were never fully extended.

6. Organization at Mackinnon Road

Before we arrived on the site, Mackinnon Road consisted of little more than a railway station on the main line to Nairobi, some sixty miles from Mombasa. Near by was a disused runway, a small but serviceable hangar and the very dilapidated remains of a R.N.A.S. camp. The main road from Mombasa to Nairobi also passed through the area. The physical development of the E.S.D. was therefore based initially on the few facilities which did exist, and its long term expansion was limited only by the necessity for clearing bush and constructing road and rail access and not by consideration of space on the ground, which was unlimited.

The early construction work was essentially pioneering, i.e., the development of accommodation, water supply and so on for the ultimate construction force. Not unnaturally, the stores layout in those early days took the line of least resistance in the development of a yard in a somewhat restricted area adjacent to both the railway station and the main road. This was gradually developed by fencing, construction of Nissen huts, etc., but it was clearly going to be quite inadequate for the long-term requirements of the project.

This, of course, had been foreseen from the beginning and approval was requested for the construction, as one of the essential preliminaries, of about one mile of access siding and the nucleus of the marshalling yard, both of which would eventually form part of the rail services to the depot. This work was undertaken by the railway engineers and as soon as it was completed, the area round the marshalling yard was allocated to the E.S.D. (i.e., as a project store) and soon filled with many thousands of tons of hutting, store sheds, piping and so on. It became known locally as Longmoor, and together with the site near the railway station mentioned above, formed the temporary E.S.D. until such time as the permanent sheds were completed and handed over. A certain amount of covered storage was constructed, and fencing erected where necessary, but the whole installation was essentially temporary.

So much for the physical side ; the personnel problems were just as bad, if not worse than at Mombasa. The initial deployment was one Artisan Works Squadron and one Army Troops Squadron under 57 C.R.E. (Works) and from these squadrons a detachment of one Subaltern and twelve B.O.Rs. was detailed for stores duties. They had to compete, under "bush" conditions, with the reception, checking, stacking, and issue as required of all stores arriving from Mombasa. They were entirely untrained in stores duties and, of course, no serious attempt at peace-time accounting was possible under the conditions existing ; indeed much credit is due to them for the results they did achieve and for their cheerful assumption of an almost superhuman task.

At the same time, and with the utmost priority, stores were arriving for the 70-mile pipe-line from the Tsavo River and the policy in this case was to dump the heavy items at the various railway stations along the line. An Army Engineer Regiment was given the task of constructing the pipe-line and, in fact, the whole water-supply installation, and the Field Park Squadron, stationed at Voi, ran the stores and workshops side, so that in this case better control was possible.

By about March, 1948, a detachment of five Officers and fifty-eight B.O.Rs.all from No. 10 B.E.S.D. arrived from Palestine, but only very few of these had had previous experience of stores accounting. However they formed the nucleus of a proper stores unit, things were gradually got under control, and stock-taking commenced, but it will be a very long time before the lack of accounting in the early days is finally sorted out.

7. Movements Problems

The basic problem was to avoid an undue accumulation of stores at Mombasa which, in effect, meant feeding stores up to Mackinnon Road as fast as the transportation facilities allowed, but avoiding, as far as possible undue overloading of the reception arrangements at Mackinnon Road, which in the early days were extremely primitive and which were always stretched to the uttermost. The transportation facilities consisted of two agencies :—

(a) *The Railway*.—This was the main line from Mombasa to Nairobi, single line metre gauge, which was working to capacity under two handicaps, firstly a heavy backlog of maintenance, renewals of rolling stock and so on, as a result of the war, and secondly an unprecedented increase in the volume of goods being imported into the country, also a repercussion of war-time shortages. The result was that it was extremely difficult to get the rail capacity we needed ; for the first six months of 1948, the tonnage moved averaged only 1,750 per month, but for the second six months we managed to step up the average to just over 3,000 tons per month ; in 1949, after the worst of the rush was over, the average fell to about 1,000 tons per month.

(*b*) *The Road.*—At first sight, this did not look very promising and, indeed, one of the early ideas was to force through the construction of an all-weather road within twelve months to cope with the anticipated flow of stores. This, however, fell through, so a special maintenance contract for the existing road was let, and in the event, it was found that, provided heavy traffic was suspended entirely for some hours, or perhaps one day, during and immediately after any continuous heavy rain, the road stood up to the traffic perfectly well. Admittedly it was rough, and the real damage was not to the road, but to the vehicles, but the stores got through. Special R.A.S.C. companies were put on this work, including some 10-tonner companies, which proved particularly suitable, and the monthly tonnage was worked up gradually to a maximum of over 7,000 in August, 1948. After that, it fell away again, partly due to the removal of companies elsewhere, but by then the need was not so great. The double 60-mile journey on the rough road was, of course, very tiring and monotonous work for the drivers, and it needed very careful organization, but the difficulties were successfully overcome and all concerned may pride themselves on a good job of work.

Meanwhile stores had been continuously arriving at Mombasa at the rate of about 7,000 or 8,000 tons per month and, despite all efforts, the total stock in our transit store kept on mounting until in July, 1948, it reached its peak of 39,700 tons. By then the rate of clearance had begun to overtake the rate of arrival, and although the former later fell off, the latter also became greatly reduced, owing to changes of high policy, except for the two months December, 1948, and January, 1949, when we were stocking up with cement. The result was that the tonnage of stores at Mombasa never again reached danger point, clearance was steadily effected, and, by the autumn of 1949, it was found possible to close down the Engineer Transit Store as such, though certain stocks of piping and cement still remained in Mombasa.

8. Stores of Local Provision

The main items of local provision were the following : hardcore and aggregate, sand, timber, pre-cast concrete products of various sorts, makuti mats and boriti poles, and, on the original timing and scope of the project, they represented in some cases large outputs as compared with existing availabilities in the Colony. A few notes on each may be of interest :—

(*a*) *Hardcore and Aggregate.*—This represented one of the major problems in the early days of the project. The original rough estimate of our total requirements was 350,000 tons of hardcore and 150,000 tons of aggregate. More accurate calculations, however, showed these to be too large and by March, 1948, we had estimated the requirement for the first fifteen months' work at rather over 100,000 tons in all. Meanwhile, consideration had been given to the possible methods of obtaining the required supplies and three alternatives were discussed :—

(*i*) To rely on the joint production of a number of small contractors, mostly Indian.

(*ii*) To organize our own quarries, either under military supervision, or under directly employed civilian managers.

(*iii*) To let a contract for the whole supply to one of the larger European firms.

In the early days, the first of these alternatives had inevitably to be used, though on a small scale, to provide our initial requirements, but the experience gained of these contractors, short though it may have been, was quite sufficient to rule them out from being joint producers of our own main requirement. In the great majority of cases promise and performance were two very different things ; there was one exception however, and one particular Indian contractor provided useful supplies of hand-broken aggregate in small quantities under a series of contracts throughout the project. In the meantime, a local geologist had prepared a report indicating the Taru Hills, some seven miles from Mackinnon Road, as the best source of suitable stone ; and, at the same time, we had decided to go out to tender rather than attempt to operate our own quarry. A contract was let in April, 1948, to one of the leading European firms of contractors, who were just commencing to expand greatly their activities in East Africa. They, also, promised more rapid results than they could achieve, and, despite our assistance, had great difficulty in obtaining and importing the plant they needed. But gradually production got under way, and by the autumn of 1948, the supply of stone was, broadly speaking, no longer a bottleneck.

When dealing with large quantities of stone, transportation is always a major factor. In the early days we prepared an appreciation as to the rival merits of (*i*) all road, (*ii*) use of existing railway from Taru Halt to Mackinnon Road, and (*iii*) constructing a special Decauville railway from the quarry to Mackinnon Road. It was clearly demonstrated that, provided we could obtain a minimum of seventy-five tippers, all road transport was the best answer, and this in fact was carried out. Gradually, however, owing to the heavy wear and tear on our limited numbers of tippers, the transportation commitment was taken over by the main contractor, using some large (10-ton) tippers which he had by then imported.

(*b*) *Sand.*—Ample supplies of suitable sand existed around Voi, some forty miles north-west of Mackinnon Road, and situated on the main road and rail routes from Nairobi, and a series of concurrent contracts was let to each of two Indian contractors, both of whom proved reliable. The only problem was, therefore, transportation, and in the early days we were dependent entirely on our own tippers, which could not be expected to achieve more than one round trip per day each. Deliveries during the peak period in 1948 averaged between 1,500 and 2,000 tons per month, so it will be seen that a considerable number of tippers had to be earmarked for this work. Gradually, however, we were able to replace them by other agencies. By arrangement with the railway, two deliveries per month, each of 200 tons, were made by their engineering trains from a pit which was adjacent to their Voi–Moshi line. Furthermore the contractors were able to arrange sub-contracts for the delivery of a proportion of their sand which, though expensive, relieved the strain on our limited resources of tippers. By and large, therefore, sand never presented any very serious difficulty.

(*c*) *Timber.*—During the war, East Africa had exported large quantities of timber for military use in the Middle East, and in 1947, when " Leader " started, this traffic was still running at some 3,000 tons a month. At the end of 1947, we were suddenly ordered to cease shipments, with the result that we quickly accumulated some 14,000 tons in our store in Nairobi. There was, therefore, an ample stock from which the requirements of Mackinnon Road could be met, and it was not until the early summer of 1949, when our stocks had been reduced by further shipments to Egypt and a virtual cessation of deliveries from the mills, that any shortage began to be felt. Even so it was only temporary, and was quickly remedied by the rationing of other military users and by the acquisition of alternative supplies, mainly from R.A.F. surplus stocks.

(*d*) *Pre-cast Concrete Products.*—A comprehensive requirement for items of this type was worked out in the summer of 1948, based on the scope of the project as then known. It comprised about 250,000 items in all, including poles for overhead electric cables, concrete pipes of various sizes, solid and hollow building blocks, floor slabs, etc. It was clear that the total value of the requirement would be something over £50,000, and that a major factor would be the avoidance of loss by breakages on road or rail. The larger contracting firms were therefore invited to tender for the production of these items on site at Mackinnon Road, suitable factory sites, water supply, etc. being provided by the W.D. In the event, the contract was, by agreement, divided between two firms, who each set up their own factory and both completed their tasks within twelve months.

(*e*) *Makuti and Boriti.*—Makuti mats and boriti poles are standard materials in Kenya for the construction of temporary native accommodation, and in the early days of the project they were perhaps the most urgent requirement for local provision. The supply of boriti poles did not cause any difficulty, but the makuti mats needed careful negotiation and organization, because of the heavy transport commitment, the fact that the supply fell off very quickly during the rains and the virtual monopoly enjoyed by one contractor who appeared to have all the others under his control. However, these difficulties were successfully overcome and though there was a general shortage at one stage, it was never sufficient to interfere seriously with the project.

9. Engineer Plant

When the project was first planned, in the summer of 1947, the plant assets available in Egypt appeared to be more than adequate on paper, though this needed considerable qualification in practice. For instance, although over 2,500 items of plant were listed as available, the great majority of these were old and part worn, and facilities for overhaul were limited ; furthermore the many thousands of tons of spare parts in stock were, broadly speaking, the residue of active operations, and therefore the parts least likely to be required in practice ; they were largely unsorted, and certainly unscaled, and many items which arrived in East Africa proved to be unidentifiable. To mention these facts is in no way to disparage those responsible for planning, but merely to emphasize the difference between paper figures and realities.

It was realized from the beginning, of course, that, owing to the nature of the project and to the necessity for restricting the numbers employed within reasonable limits, engineer plant would have to play a prominent part in the execution. An officer was, therefore, sent down to Kenya from G.H.Q., in August, 1947, to make a preliminary assessment of the total requirement and the order of priority and to arrange dispatch accordingly. In view of the uncertain state of repair of most of the plant, and because, at that time, it was in any case intended to transfer the bulk of the holdings of engineer plant from Egypt to East Africa, it was decided to dispatch plant from the very beginning, up to the shipping capacity available, and to aim at having three items available in the pool for every one required on the project. It was also agreed that, in view of the urgency of the time factor in the completion of the project, cannibalization could be freely adopted where necessary to maintain the supply of serviceable plant.

Shipments started about October, 1947, and for the first few months we suffered much loss from damage and pilfering in transit, so much so that, although all machines were supposed to have had a 24-hour running test before leaving Egypt, in practice not more than 10 per cent were in running order on arrival and some 40 per cent were found to be in need of major overhaul and repairs. After a visit by D.D.E.S., M.E.L.F., in February, 1948, however, this aspect showed a marked improvement ; though there was later an unfortunate incident when a L.S.T. full of tar boilers and road rollers was dispatched during the monsoon. One of the road rollers broke loose, with consequent havoc among the tar boilers, the great majority of which were complete wrecks when they arrived.

For operating personnel, 873 Plant Squadron was available in Egypt. One troop was dispatched to Mombasa in September, 1947, and the remainder of the squadron followed later in the year. The organization set up in East Africa was Squadron H.Q. and one troop in charge of an engineer plant depot, workshops and spare parts store in Mombasa, and the other troop as an operating troop at Mackinnon Road. In the latter part of 1948, the organization was rationalized, an engineer plant depot, with operating troop attached, being set up in Mombasa on a special establishment and an operating squadron with two troops, one for earth moving plant, and one for "contractors'" plant, included in the "Leader" (Works) Establishment at Mackinnon Road. Throughout we suffered from the usual shortages and rapid turnover of personnel. Strictly speaking, of course, the whole of the workshop commitment should have been undertaken by R.E.M.E. It was, however, clearly beyond the resources of the R.E.M.E. strength available in the Command at that time, and in any case the Command workshops were situated in Nairobi, and were quite unsuitably located to deal with plant entering the country at Mombasa and required urgently at Mackinnon Road, bearing in mind the severe congestion on the railway throughout the period concerned. It was therefore agreed that the Plant Squadron should set up its own workshops in Mombasa, partially staffed with civilian tradesmen, and that it should undertake the initial overhauling and servicing of all plant entering the country, the object being that no item should be dispatched to Mackinnon Road unless in running order. In the meantime R.E.M.E. concentrated on setting up a temporary workshop at Mackinnon Road with the object of repairing on the spot all plant in use there. Spare parts, however, were always short, and remained throughout the biggest limiting factor.

In the early part of 1948, when the scope and detail of the project had become much clearer, a plant appreciation was prepared in order to check up and revise the lists of items required and the order of dispatch. In making such an appreciation, it is possible to go to either of two extremes. On the one hand, one might calculate the precise requirement of plant for each item of the project, and by suitably dovetailing these items in the work table, so arrange things that a minimum of plant was lying idle at any given moment ; in other words, the project might be planned on the basis of a minimum holding of plant. On the other hand, it would be possible to provide such a pool of plant that the works executive merely had to ask for what they wanted with the virtual certainty of getting it. The first alternative is equivalent to the tail wagging the dog and plant becomes the master and not the servant of the project ; the second alternative is of course extravagant, and is usually in any case ruled out by lack of operating personnel and maintenance facilities, it being always necessary to remember that, without both of these, plant is merely an encumbrance.

The requirement was therefore carefully worked out in between these two extremes, and in close conjunction with the work table, in the preparation of which, plant requirements and availabilities were merely one of the many factors involved. An officer from G.H.Q., visited the Command in June, 1948, and final dispatches of plant were based on these revised calculations.

10. Engineer Workshops

Leaving out of account, the workshops necessary for the repair and maintenance of engineer plant, etc., which beyond 1st line, is primarily a R.E.M.E. responsibility, the workshop requirement for a major project on the scale of " Leader " may be divided into two main categories.

In the first place, there is the project workshops proper, which must be capable of undertaking the large variety of day to day requirements in connexion with erection gear, formwork, repairs to tools and so on. It would also normally undertake the manufacture of component parts for any of the installations or buildings under erection, which are neither standard items of supply nor repetition jobs. The characteristics of this portion of the workshop requirement are therefore that it must be carried out at or near site, since much of the output will need fitting or adjustment on the spot, and that it does not lend itself to mass production methods or any special organization. The project workshops must be able to undertake any reasonable job which comes along and must be adequately supplied with skilled tradesmen and the normal machine tools. Furthermore it must be under the command of an officer with plenty of experience, initiative and resource.

The other requirement is the mass production of joinery, e.g., doors, windows, latrine seats, and so on, in the very large numbers necessary for a project of this kind, a task which particularly lends itself to standardization. In this case there is no need whatever for the work to be carried out on site ; indeed in " Leader " it would have been a positive disadvantage to have done so, since our whole object was to reduce the population at Mackinnon Road to the minimum possible, thereby avoiding unnecessary commitments in temporary accommodation, hospitals and so on. What is required is a large and well organized shop, with an ample supply of tradesmen preferably drawn from an existing town, so that problems of accommodation etc., do not arise.

In " Leader," the original project workshops was quite a small affair, which expanded gradually on a limited site and which was staffed initially by the E. & M. Section of an Army Troops Squadron. We planned, however, to use the two hangars first due for completion as the more permanent project workshops and these were equipped with machine tools and taken into use about the end of 1948. It was originally intended that these shops should develop into the permanent workshops attached to the E.S.D., but unfortunately, owing to a recasting of the plan, this became impossible. As regards the mass production of joinery the original plan was to use the Command Engineer Workshops in Nairobi to capacity, and to deal with the balance by ordering certain standard items, required in large quantities and easily shipped, from the Base Engineer Workshops in Egypt. This, of course, was wasteful, in that the timber for this joinery originated in East Africa. In the event, the requirement became reduced and the time factor relaxed so that it became possible to undertake the whole of the work at Nairobi. This involved a considerable expansion of the numbers employed there during most of 1948, but by the end of the year supply was well in hand, and output was reduced.

11. Conclusion

It will be apparent from the above that the organization and provision of the Engineer resources for a large project need clear thinking and careful planning over a wide field. Co-operation is essential not only with the Works Staff, but also with Movements and with a variety of civilian agencies. As always in connexion with stores, there will be an immense volume of detailed work which must be carefully and accurately done by a capable and experienced staff. But it is equally essential that the work of this staff should be directed by someone who can see clearly the various objects to be achieved and the factors which may arise, and whose view of the wood is not obscured by the trees. This was one of the great lessons of the war on the engineering side and it was fully borne out by our experience in " Leader."

SAND IN THE WORKS

By E. BAWTREE, B.SC. (ENG.), M.I.E.E., A.M.I.MECH.E.

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WE are told that distance lends enchantment to the view ; this is a truism in the temporal sense as well as spatially. Now that the events described in these war-time reminiscences have softened into memories, readers may, perhaps, find they stir a recollection of their own, or raise a smile over a few of the afflictions of one engineer who struggled to maintain power supplies for military purposes in the Middle East a few years ago.

In the words of the senior officer who first greeted him on his arrival amid the sandy wastes, an early essential in such circumstances is to realize clearly " the evils of good practice." When one is faced with achieving the impossible with inadequate equipment, one chips, files, doctors, bolts down extra hard and drives to a degree which would horrify the designer of the component—if he knew. By the time the principle has been grasped, one ceases to be surprised by results.

A venerable D.C. generator that was subjected to, and survived, this form of coercion, staged such an exhibition of pyrotechnics at its commutator that lights in the engine-room seemed hardly necessary.

From an electrical point of view the climate was treacherous, the absence of a definite rainy season belying the invisible moisture that unfailingly deposited heavy dews by night. A few incautiously incurred " packets " conveyed a warning that it was as well to let the sun get well up before touching exposed wiring that had been roasted through a couple of summers or so. Neither was burial under blazing hot sand for long periods particularly good for rubber insulation. In canvas camps much wiring had to be run in this fashion.

Transmission voltages ranged from 3 kv. to 11 kv. ; in general the lines gave but little trouble, although a glutinous dust in one district caused flashover and the omission of insulator-pin bonding in the haste of construction produced some pole fires. In one of these fires, almost a whole support smouldered away, leaving about 3 ft. of the top and the crossarm swinging on the conductors while drift-sand concealed the butt.

Unearthed neutrals were usual on H.V. systems and not uncommon on L.V. systems for the simple reason that mostly it was impracticable to obtain a satisfactory earth. The only exceptions were hospital X-ray sets, for which electrodes might be driven

60–80 ft. into the ground before establishing satisfactory conductance.

Occasionally, violent thunderstorms swept by ; one such removed part of the roof of a generating station and showered the interior generously with sand, rubbish, and water. In spite of the staff's heroic efforts to rig and work under tarpaulins, the heat proved too much for both men and machines. Another storm forced the window of a sub-station and caused the complete failure of an 11-kv. circuit-breaker.

The station that lost part of its roof was equipped with somewhat elderly 6-kv. alternators, one of which had for a time been registering on one phase of its windings an insulation resistance that fluctuated uncertainly near zero ; yet somehow or other, it never broke down. On the principle that a stitch in time saves nine, an examination was made with a view to repairs, but no sooner had it begun than the machine promptly burnt out when only half-excited. Fortunately the story had a happy ending ; the local (E. & M.) Company R.E., neatly grafted fresh pieces into the damaged coils and a week or so later the set was running again quite merrily.

One regrettable occurrence with an alternator could only be attributed to a new attendant who diligently synchronized an incoming machine but forgot to equalize its voltage. In extenuation of the attendant's culpability it must be mentioned that the synchronizing arrangements were rather primitive !

It was observed from the log sheets of another plant that some of the machines were displaying strange values for familiar instrument readings, for which no adequate explanation seemed to be forthcoming. Several weeks later the mystery was solved ; an unheralded visit by night to the control gallery disclosed that the log-sheet had been filled in for four hours ahead !

Another nocturnal excursion led to the somewhat forcible restoration to consciousness of a dreamy switchboard-hand because a power-factor meter was rotating full circles. This situation naturally prompted an uneasy reflection as to how long the irregularity usually continued before it was noticed, there being no reason to suppose that the instance was an isolated one.

Of the assortment of medium and high-speed oil engines encountered, some were gorgeously new and others were far from it. One of the latter, a local purchase, shed the metal from nearly all its crankshaft and big-end bearings when they were unbolted for inspection. The advantages, under Service conditions, of bearings for stationary plant which could be remetalled, over bearings of the shell pattern, very soon made themselves apparent. The older machines seldom had any spares and improvisation was the order of the day.

There was a certain occasion on which two large, low-speed engines, each a stand-by for the other, simultaneously developed cylinder-head cracks. No spare heads were available, and the only thing which could be done was to run each with one cylinder idle until the heads could be repaired at the heavy workshops fifty miles away. Being exceptionally sturdy ancients, they were none the worse for this ill-treatment.

One day a report came in of trouble with two new 70-kw. high-speed sets. An ominous silence reigned in the engine-room when a visit was paid. The native driver explained in his own way that there had been noises like broken bottles emanating from the crankcase of one engine and it had stopped. The other had just stopped without any warning at all. Suspiciously, the dipstick of the first engine was pulled out for examination, when a clear and sparkling jet of water rose into the air. It was never quite proved, but there was more than a suspicion that fuel oil had been poured in where lubricants were intended, causing overheating and failure of the cylinder liner seals as well as damaged bearings.

Sometimes rather more technical headaches were involved, as when a sequence of cracked cylinder heads was traced to the progressive hardening of circulating water by the action of evaporative coolers, with consequent choking of the ductways with scale. On other occasions outside influences intervened to disturb the peace ; more than once the railway people fly-shunted a 10-ton wagon into a discharging tanker and sent it some distance down the track, wildly spewing oil to waste.

Desert conditions hampered installation work considerably ; sand found its way everywhere ; it drifted over and concealed small parts, and it was very difficult to remove. Small pipework was an especial trap for unwanted grit, although once an initial freedom from the menace had been established, there was not much difficulty in keeping clean afterwards.

Water supplies had to be kept going as well. Two sturdy pump houses were built in a wadi which carried water in the winter only. For many years there had been drought. Then, as if to make up for lost time, heavy floods came down, which, amongst other extensive damage, knocked over both pump houses. But such things were just a part of life !

Senior supervisory staff at the plants were usually Greek or Maltese, with natives in the lower grades. Among them were many excellent and loyal workers, some with long terms of service to their credit. They frequently displayed uncommon craftsmanship and originality in difficult circumstances and made no small contribution towards the maintenance of electricity supplies under the emergency of war.

CONCRETE IN DEFENCE

By MAJOR W. G. F. JACKSON, M.C., R.E.

IN recent months our attention has been focused on the problems of defence. Exercises have been run to study the difficulties of holding wide frontages with far fewer troops than we should like. Amongst the many problems, which remain to be solved, is the question of "Concrete." Are we, once more, to pour vast tonnages of concrete into our defensive positions? Do we believe that we can tame the "Concrete Gremlin" which brought the Maginot, Siegfried and Hitler Lines, or the vaunted Atlantic Wall, to nought? Or do we believe that there is no future in concrete positions? There are, at present, two distinct schools of thought. At one extreme, there is the anti-concrete school who consider, with some justification, that concrete positions have always failed, and, therefore, we should avoid repeating the same old mistakes again. At the other extreme, there are those who maintain that none of the older lines were really tested. They hotly deny that they are "Maginot-minded," but believe that, in defence, our troops will demand the best protection which our engineers can provide. This means concrete.

The aim of this short article is to try to strike a balance between these two extremes. As both schools base most of their arguments on the fate of concrete lines in World War II, these will be considered first. This will provide a background against which we can weigh their chances of success under present conditions.

THE PAST

From the point of view of the anti-concrete school, the great concrete lines of the past had four serious defects.

(*a*) *Lack of surprise.*—Concrete positions take many months, if not years, to build. The attacker can watch their construction as it progresses. It is virtually impossible to conceal even individual pill-boxes. Even if air photography does not supply all the answers, the large civil labour force needed for such work provides excellent cover for enemy agents. The attacker can prepare his methods of breaching such lines at his leisure. He can also ensure that, when the time comes, he has overwhelming strength concentrated against the sector which he has chosen to breach.

Probably the best example of this is our own assault on the Atlantic Wall. Each heavy battery was photographed over and over again during its construction. Exact replicas were produced in this country on which assault troops were trained and rehearsed down to the last detail. When D-day came, these apparently formidable emplacements were overwhelmed in a few hours.

(*b*) *Inflexibility.*—Concrete positions must always be built some time before they are needed. It is usually impossible to forecast the future course of events, and so they are often designed on a false appreciation of their likely rôle. The defences of Singapore were built to repel a seaward attack, but they fell to an attack from landward. The Maginot was turned, and our own 1939 positions on the Belgian frontier were never occupied.

(*c*) *Demoralization.*—Defenders only succeed if their aim is to kill and go on killing. In theory, concrete cover should allow them to forget about their own vulnerability and enable them to concentrate on the use of their weapons. In practice, it has the reverse effect. Concrete dwellers appear to become obsessed with their own protection. They lose their ability and will to fight.

(*d*) *Expense.*—The time, labour and material absorbed by such defences make them capital investments which cannot be abandoned lightly. They become national symbols of a strength which they do not in fact possess, and as such become political millstones around a commander's neck.

In comparison, the hastily constructed field defences built by the Germans and Japanese were more successful. The hastily organized Gustav Line based on Casino withstood three major assaults, while the Hitler Line a few miles in rear possessing concrete positions did not resist more than a day. The apparently impregnable Gothic Line built in the steepest sector of the Appenines failed at the first assault of the Fifth American and Eighth British Armies ; but the hastily dug positions on the Northern spurs of the Appenines resisted for several months. At the other end of the world, the Japanese bunker became proverbial.

Against all this, the "concrete" school argue that none of the major fixed defence lines of World War II were really tested. First the Maginot was turned. Though the morale of the troops in the Maginot forts is known to have been low, this was no fault of Maginot's conception. It was the morale of France as a whole that was low. The Siegfried, which was built at about the same time, was never attacked until so late in the war that it was under-manned with only scratch crews. Singapore was not attacked from seaward. The Atlantic Wall was incomplete ; it possessed no depth ; and it was manned by inferior troops. The Hitler Line was bounced before it could be properly occupied ; and the Gothic Line could not be fully manned because German reinforcements had to be diverted to the crumpling Western Front.

It seems, therefore, that the past cannot resolve the problem. Let us, therefore, consider the future, and try to discover the pros and cons of each course when applied to our present problems.

The Future

We are faced to-day with the difficulty of planning for the defence of wide fronts against the horde armies of the East. Our opponent's strength lies in his great infantry mass supported by excellent tanks and powerful artillery. In the air he has great numerical superiority. His tactics are such that, if his leading troops fail to gain an initial lodgement in our position, he will pause until he has built up sufficient strength to take his main assault to great depth. In meeting this attack, our defending troops will first have to withstand very heavy artillery and air preparation, and then must destroy echelon after echelon of attacking formations once his assault opens.

When considering the policy which we should adopt for our defensive works, we must decide on the proportion of our engineer effort (including defensive work by all arms) that we will allot to :—

- (*a*) Obstacles—designed to hold the attacker in our defensive fire.
- (*b*) Protection.
- (*c*) Concealment.

It is in the emphasis placed on these three tasks that the concrete and anti-concrete schools differ.

Pro-Concrete

Against the weight of preparatory fire which is likely to be brought down before a major assault, the concrete school maintains that we must provide our soldiers with the best possible protection. It is no use having excellent defensive fire and obstacle plans if the garrison is destroyed before the assault comes in. On the other hand, it is impractical in the time likely to be available to provide concrete protection for everyone. The pro-concrete school suggest that the order of priority might be :—

- (*a*) A proportion of Battalion M.M.Gs.
- (*b*) Battalion, Brigade and Divisional Headquarters.
- (*c*) Heavy gun emplacements.
- (*d*) Field ambulances.

As a very rough guide, the effort involved can be judged by the tonnages of material needed. For such a meagre programme, a division would require in the order of 60,000 tons of concrete, and only 6,000 tons of stores for the rest of its defensive works. This 6,000 tons includes extensive minefields round and between battalion positions. It would take about four to five months to complete this plan using two engineer regiments suitably diluted with infantry and civil labour.

Though the time, labour and tonnages involved may be quite practical, the concrete school agree that it will be impossible to conceal the position of the emplacements. The only solution put forward is to turn the whole position into what has been called a "lunar landscape." Tanks, dozers, concrete mixers and so on should be allowed free run everywhere so as to produce a mass of indecipherable camouflage signatures.

Anti-Concrete

From the point of view of the anti-concrete school, the first question to be asked is " What do we get for our 60,000 tons ? " The M.M.Gs. receive 4 ft. of concrete, which will withstand direct hits from medium shells. But they lose concealment and the desire to move to alternative positions if the situation changes. They are fair game for any high-velocity anti-tank gun that spots them ; and they are far more likely to be spotted in concrete than in " cut and cover " positions.

Battalion headquarters will receive protection, but what is the reaction of a battalion likely to be to a concrete encased C.O. ? There is probably more to be gained by protecting Brigade and Divisional Headquarters in this way. They will, however, become the centres of attraction for all enemy unpleasantness because it is so difficult to conceal the concreter's signature.

Heavy guns also receive protection, but is the protection worth it ? The construction of the emplacements will be watched and ultimately they will be bombed. But, if our efforts at silencing German coast batteries from the air are any criterion, the emplacements which we build at great cost are unlikely to be hit. They are not a very suitable target for air attack or long-range shelling. Would it not be less costly and just as efficient to use several alternative field positions ?

Protection of field ambulances seems sound. Morale suffers if wounded are not adequately looked after. But, surely, we cannot give them as much consideration as this ? If most of the division are using slits or cut and cover dug-outs, then the wounded must take their chance in similar protection.

It seems, therefore, that the anti-concrete school have a fair case for saying that this is insufficient return for the expenditure of 60,000 tons and four months' preparation. This stands out even more clearly if we consider the proportions in which the concrete school use up their resources.

(*a*)	Active measures (chiefly minefields)	6,000 tons
(*b*)	Protection	60,000 tons
(*c*)	Concealment	Nil (given up as hopeless)

The proportion of effort expended on active and passive measures tells its own tale.

The second question to be asked is " How often will we have the time or resources to build such lines ? " If the cost is to be 60,000 tons per division and four months' preparation, then the answer must be " once." We must be prepared to fight our defensive battle in one major position. There can be little behind us, because most of our resources will have been spent in the preparation of this main position. Our chances of a successful withdrawal will be slender as we will possess no lines in depth on which to stabilize our front, and we will have had little opportunity to prepare a thorough scorched earth or demolition plan.

There are very few cases, if any, in history of a numerically inferior force winning a war by holding only one position. The essence of most successful defensive campaigns is to kill as long as you can without being overwhelmed, and then withdraw to another position to repeat the process. For this policy to be successful, you must have :—

(*a*) *Concealment.*—You cannot conceal the general line which you are holding, but you can and must conceal your actual positions. You will inflict the greatest casualties on your enemy while he is trying to find your positions and in his initial attacks. Those who despair of being able to conceal their positions have only to turn their minds back to the last two years of World War II. One of our greatest difficulties in attack was to pinpoint the enemy defensive positions.

(*b*) *Several prepared positions in depth.*—If we are to be able to prepare these quickly to meet changing circumstances, 6,000 tons per division and one month's preparation is a more practical figure. This means that we must forego concrete and depend on slits and " cut and cover " dug-outs.

(*c*) *Scorched earth between positions.*—Thorough demolition plans need a large engineer effort. This must be provided at the expense of defensive works which again forces us to abandon concrete.

The Balance

The difference between the two schools is one of basic defence policy. The concrete school must pin its faith to one main position. Its chances in a withdrawal will be slender because there will be little behind it. Most of its effort has been locked in its concrete.

The anti-concrete school retains its freedom. It sacrifices some degree of protection for speed of preparation and concealment. It can prepare a number of adequate positions as opposed to one massive position, and should have sufficient effort available to carry out an efficient scorched earth policy. But the difference in emphasis is more important than all these considerations. The concrete school allots most of its resources to protection. The anti-concrete school plans the destruction of the enemy before its own protection.

The balance is clear. Concrete will give you protection, but it may also give you a free pass to a prison camp.

Editor's Note.—This article, like all others published in *The R.E. Journal*, contains the author's personal opinions only and not necessarily official views.

THE TOWN PLANNING OF MILITARY HOUSING ESTATES

By Brigadier F. C. Nottingham, D.S.O., O.B.E.

ONE can scarcely open a newspaper these days without noticing something in it about the provision and building of houses, even if it is only a complaint that they are not being built fast enough. The cessation of building during the years 1939-45, together with the increase of standards of comfort and living conditions, has created a demand for housing which is unlikely to be met fully for many years to come. This is particularly true in the Army, which was not at all well off in this respect before the war, according to present-day standards, and this factor, together with the increases of entitlement which have been approved since the war ended, means that a large part of the effort of the Army Building Services will for some years be devoted to the provision of houses. We in the Royal Engineers can therefore expect to find ourselves responsible for the design and building of military housing estates of some considerable size. It may, of course, be an easy solution to give the job to a qualified civilian Town Planner, but that does not get rid of the responsibility, and even though the approval of the Ministry of Town & Country Planning to War Department Housing Schemes is not mandatory, it is usual, as a matter of courtesy, to liaise with their local representatives to ensure that any new military housing estate does meet their requirements. It is therefore desirable that we should have some knowledge of what to do and what to avoid in the laying out of a large housing estate. Unfortunately there are no military manuals on the subject to which the military engineer can refer, and the many civilian publications may or may not be available to him. It is with the intention of helping those who may be faced with the problem that this article is written. Although it deals mostly with the larger housing estates, the principles remain the same whatever the size may be.

Object

It is as well to have a clear and well-defined object, which is to create a design for an estate which will be convenient and comfortable to live in, and which will be attractive to look at. If we succeed in attaining the objects of convenience, comfort, and attractiveness, then we shall promote living conditions among married families which lead naturally to happiness, good morale, and good citizenship.

The attainment of this object is beset with difficulties, not the least of which is financial stringency, but it is necessary to have it clearly in mind at all times, and also to remember continually that the mistakes of the planner, unlike those of some other professions, remain above the ground for posterity to see and criticize.

Convenience

When faced with the problem of designing a large housing estate it is extremely tempting to get hold of the map of the area, and to lay out thereon a nice, good-looking geometrical pattern of roads as a framework, and to fill in the area between them with houses. This method may produce a pleasant pattern of estate design, but there is a need for a deeper knowledge of the habits and day-to-day life and needs of the community who will live in the estate, before the design can be truly said to fulfil the conditions of convenience and comfort which is the object of proper planning.

Every housing estate, and military ones are no exception, will have children among its inhabitants. Obviously, therefore, one of the principal considerations which must be taken into account in design is the question of the upbringing and development of the child. If the estate is large enough, or in an isolated position with respect to the neighbouring civilian communities, schools may be provided by the civilian education authority, unless it decides to provide transport to the nearest existing school. If new schools are to be provided they should, of course, be sited so that children can walk there. The small children, i.e., those between three and five years old, will go to a nursery school, and it is now considered that the walking distance to it should not be more than a quarter of a mile. The design of the estate therefore should be such that no house is much more than this distance from the nursery school.

Children of this age will normally be accompanied to their school by an adult—usually the mother. It will be a great convenience to her if when she has delivered her child safely to the school she can, before she returns home, buy her daily needs from shops near by. If she has forgotten anything she can make further purchases when she fetches the child back from school, thus avoiding a special journey.

A great deal of research has been carried out since the war to determine the size of a nursery school, and the number of shops, which should be provided to meet the needs of the community. According to many authorities, the most suitable size of nursery school is one for about forty children, and the normally constituted population required to produce sufficient children to fill a school of this capacity is about 2,000, or between 500 and 600 families.

The number of shops which are required to fulfil present-day needs is still under discussion. The Wholesalers' and Retailers' Association figure for the promotion of stablized trade is one shop for each 250 of the population, but some authorities plan on a basis of one shop for each hundred persons. Generally speaking, it is better in the first instance to underestimate rather than to overestimate requirements. Military housing estates are mostly built near to civilian towns which have their own shopping centres, and all that is necessary in an outlying housing estate are shops for day-to-day needs. Many of these can be provided by the N.A.A.F.I. so that the number of civilian shops necessary will be very small. In any case the shops that are provided should be confined to those that cater for the day-to-day needs of the community, as any special requirements can be met from the main shopping centre of the near-by town.

Allowing for diversions due to road layout, we can therefore take a radius of about one-fifth of a mile from the " centre," i.e., shops and school, to find the area required to fulfil the conditions of the quarter of a mile walk, and to consider what population it can house. A circle with this radius will give an area of about 80 acres, and allowing 10 acres for the shops, nursery school, greens, etc., about 70 acres will be left for housing. The normal gross density* per acre given in the *Housing Manual 1949* is thirty persons per acre, which means that there will be 2,100 people in an area of 70 acres. This agrees very closely with the figures given above. Again, other investigations into the functioning of estates have discovered that such an area readily lends itself to milk distribution by one milkman and an assistant, and is not unduly big for one postman. It also forms a convenient compact area for refuse collection, and is about the right size for a Clerk of Works to supervise for maintenance of buildings, etc.

Pillar box and telephone kiosk layout, as well as communal garages can also be effectively and conveniently laid out in the area, so that none of them are at too far a walking distance from any one house. War Office policy is not yet firm on the question of communal garages, but it is as well to leave space for them in the planning so that they can be easily provided if and when policy and funds allow.

It seems therefore, from the considerations of efficiency of function that an estate to house about 2,000 people, grouped and arranged around a community centre with shops, schools, welfare institutes, etc., covering an area of about 80 acres, in which will be upwards of 500 houses, is most convenient and logical. This unit is known as an "Estate" or ward. A number of these estates or wards can be grouped around a convenient town centre to form a new town. It is on this basis that, in fact, many of the new towns being planned in England will be laid out. The estate of 2,000 also forms a suitable political unit for local government.

It may be argued that this sort of project rarely comes into the orbit of the military engineer, and this is agreed, but on the other hand, at least one such project of this size is now under actual construction in England, and there may be more, if not now, then in the future, especially near large military centres.

The smaller sized military housing estate should, wherever possible, be built near to an existing civilian estate. It is undesirable to

* Gross density is obtained by dividing the population by the area of the neighbourhood in acres. The planning figure for new development is 30–40 persons per acre. Net density is obtained by dividing the number of habitable rooms by the area of the land actually to be developed as dwellings. This area includes, besides curtilages of the dwellings themselves, half the width of any street on which such curtilages abut to a maximum of 20 ft., as well as small open spaces. The net density varies with each locality and is decided by the local authorities. The War Office density is, as far as Married Soldiers quarters are concerned 8–12 houses to the acre. With an average of 3.5 persons per family, this gives a gross density of 28–42 persons per acre.

create a small estate separated and isolated from existing facilities, which is not large enough to justify the special provision of them for itself. It is the essence of sound planning to ensure that extensions and small developments become an expansion of an existing community, and in this respect the rules of proper planning still apply and should be considered in all and every case. This may well affect the choice of the area to be developed by the military as a married quarters estate and will mean close liaison between the soldier and the local authority.

Comfort

Apart from the aspect of convenience or function—as the social planners call it, the question of comfort of living should play a large part in the mind of the planner when working out the details of his plan. The first consideration obviously is to provide the right type of house, of the right size to suit the family, with due account of the needs of children and of the social habits of the kind of people who will live in it.

Standard layouts of various types of houses to suit different sorts of people and size of family are given in some detail in the *Housing Manual 1949*, and there are also a number of suitable non-traditional type house designs available from which to choose. Generally speaking the smaller size of house now falls into one of three types, i.e., the "kitchen-living room" house, with a large combined kitchen-living room and a small scullery; the "working kitchen house," with a working kitchen and large living-dining room or a living room with dining annexe; and the "dining-kitchen house" which has a living room and a kitchen large enough to include a dining space. For military estates the "working kitchen" type of house with dining annexe off the living room is generally most suitable, and is preferred by the War Office.

Design should also allow for the maximum possibility of social relations between neighbours, for in a community of this sort, especially in a military housing estate, there is a great deal of social activity between members of neighbouring families and a great deal of mutual aid in shopping, care of children, and in time of sickness or crisis. The solution to this is only partly one of planning, and in civilian housing estates a great deal can be done by the letting authority if houses are allotted to neighbours of similar tastes and interests. This question may not arise to the same extent in military estates, where all families are those of men of the same profession, and so have at least one interest in common.

An important point is road layout, as properly designed roads make a great contribution to comfort. Their layout must allow easy access from all parts of the area into the community centre. Road widths should vary from 16 ft. for double sized development to 13 ft. for cul-de-sacs, and roads on which there is building on one side only. Cross-roads must be avoided, all junctions should be staggered with intersections at right angles. The radius of the curb at these junctions should be a minimum of 35 ft. and care taken with the building line so as not to produce blind corners. Roads should not be straight, as not only does such a layout make for monotony, but it encourages the young idea to use them as speedways for their cycles or motorbikes. On the other hand, curves must not be so sharp as to be dangerous.

The layout will depend on the contours, and on hilly sites the roads will normally follow them, but care must be taken to avoid an uninteresting and unsightly result, and where the slope is moderate, an occasional group of houses at right angles to the contours, with stepped roofs, or in echelon formation, should be included wherever possible.

Green verges, at least 5 ft. 6 in. wide, should separate paths from roads, so that the danger of children running into the road is lessened. Gardens should be provided, and the back gardens should be capable of being closed, in order that children, dogs, etc., can be kept away from the main road when necessary, especially when the design of the estate takes up for communal front lawns to houses instead of small front gardens.

Proper street lighting is an essential ; and some care should be taken, not only to obtain the required density of light over the area, but also in the design of light standards, which are not always very attractive to look at. Particular attention is necessary in the lighting of greens and open spaces. Dark unlit areas should be avoided, as they tend to be a source of alarm and annoyance to some members of the community.

Communal garages, which consist of individual lock-ups, suitably grouped so that they are convenient to the houses, will make a lot of difference to the comfort of the inhabitants. There must not be too many in any one group ; as otherwise the neighbourhood of the garages becomes too noisy. Not everybody can own a car, but for those lucky enough to do so, some sort of cover should be provided. This will stop car owners erecting " home-made " garages for their cars, and so avoid spoiling the look of the estate. In War Department Estates the policy with regard to garages is still under consideration.

Where so many children live, they must have some place, away from the street, in which to play, where they are safe from the dangers of traffic, and can make such noise as they please with a minimum of annoyance being caused to the near-by inhabitants. The provision of suitable children's playgrounds is therefore of some importance, and they should be so placed that in most cases it will not be necessary to cross the roads to get to them. They should be properly fenced in, and given the necessary equipment. There are often small areas at the backs of houses which can be used in this way. A formal playground is not necessary, as it is better to keep the area as natural as possible. If it can include a forest tree or two it will be an added attraction. Care must be taken that such playgrounds do not become dumps for rubbish from near-by houses, and they will require supervision and maintenance to keep them in good condition.

APPEARANCE

Nothing is worse to look at than the many examples of housing estates, consisting of parallel rows of unattractive terrace or semi-detached houses which have been erected by speculative builders in the past, and all modern planning is devoted to avoiding this type of layout. Nevertheless where estates are restricted to two story semi-detached houses, it is difficult to avoid monotony, especially on level sites, but a great deal of the monotony can be overcome by skilful grouping, and using link walls to join neighbouring blocks, and by the judicious intermingling of end gables and hipped roofs.

Where possible, and where designs exist or can be obtained, it is a good plan to provide an occasional "terrace block" of four to six terrace type houses, as this will also break the monotonous effect. Similarly a breaking of the straight building line along a street, by providing some houses in echelon will also help, but in doing this care must be taken not to place houses so far from the road that the milkman, postman, and dustman, etc., will not call. Estates composed of one single type of house will also be unattractive and dull to look at, however skilful is the design of their layout, and most good estates now consist of a number of types chosen to blend in with each other. The various types of houses should not be scattered casually over the area, as this will give a most disjointed and unpleasing effect, but should be laid out in groups. Generally each street or group of buildings in a street should be considered as a unit of design, and laid out in conjunction with the other buildings near by.

Even so, an estate composed entirely of two storied buildings will have a " flat " appearance unless some effort is made to break the skyline. This can be done by planting forest trees in small groups in open spaces, and also by the towers of schools, churches, etc. Although the War Office have not decided on their final policy as regards the provision of flats and shops, these buildings, should they be provided, may well be three stories high which helps in this respect. Vistas along the roads in the estate are important. A good vista can be formed, for instance, by opening out a road into an open space or green, with forest trees planted thereon, one tree here and there and a clump elsewhere for shade and relaxation. Cul-de-sacs lend themselves especially to the provision of attractive vistas, and a proper layout of terrace type and semi-detached houses with a well-thought-out system of tree planting can be quite charming in its effect. Regimentation, in tree planting, except along roads, should be avoided at all costs. There is a great deal of information about trees and the suitability of various types for planting in estates. Trees with a limited growth of about 20 ft. only should be used on the roadside, and no tree should be planted sufficiently near houses as to interfere with the natural lighting of rooms. Certain trees, especially those with shallow spreading roots, are not suitable for small gardens.

Colour is another most useful and cheap method of avoiding monotony, especially where estates are composed of one or two types of houses only, as is often the case in military estates. The colour scheme should be designed as a whole throughout the estate. Nowadays the fashion is to paint window frames and sashes or casements in one colour, to provide a suitable colour contrast on the doors. It should be remembered that by painting external window reveals a light colour, some increase of reflected light into the interior can be obtained. Down pipes and gutters should be one colour.

Wing walls have already been mentioned in that they help to group buildings together to avoid monotony. They have, however, another most useful contribution to the appearance of the estate in that, properly designed and aligned, they hide the view from the main road into the back gardens of the houses, where washing, chicken houses and rabbit hutches can often spoil what may otherwise be a charming and attractive effect.

The Master Plan

The master plan for the development of an estate should take into account the considerations outlined above. It has been said, with truth, that a successful collaboration between the architect and the knowledgeable client will always produce by mutual inspiration not only a better and more distinguished building in appearance, but also one more efficient for the purpose for which it was designed. This is as true of an estate in general as of a building in particular, and where the War Department are concerned the rôle of the client will usually fall on the engineer officer.

A successful estate plan is not judged entirely from the point of view of layout alone. There are such mundane things as gas, water and electric-light services, and drainage to consider. These important considerations must be kept in the mind of the planner during the whole of the time he is working on the plan, and in many cases may be a deciding factor in the final layout.

Layout

The layout can be formal or informal. An example of the formal layout is the gridiron so beloved in the flat cities of the United States or in parts of Edinburgh. This is unsuitable for sloping sites and may involve expensive road cutting and banking. From the point of view of traffic, it is not easy to regulate and control streets which are all so similar, and to get from one corner of a block to another means walking along two sides of a triangle. It looks nice from the air, but this aspect is not so apparent to those living and walking in the town.

A radial plan such as exists in Karlsruhe is another example of a formal layout and is good from the traffic point of view, giving as it does direct access to the town centre. It may, however, be open to the same objection as the gridiron plan when it is applied to hilly sites.

The informal layouts are those where the plan grows from the natural conditions of the sites chosen, and the matter of direct access from one part to another will not necessarily be a point for first consideration.

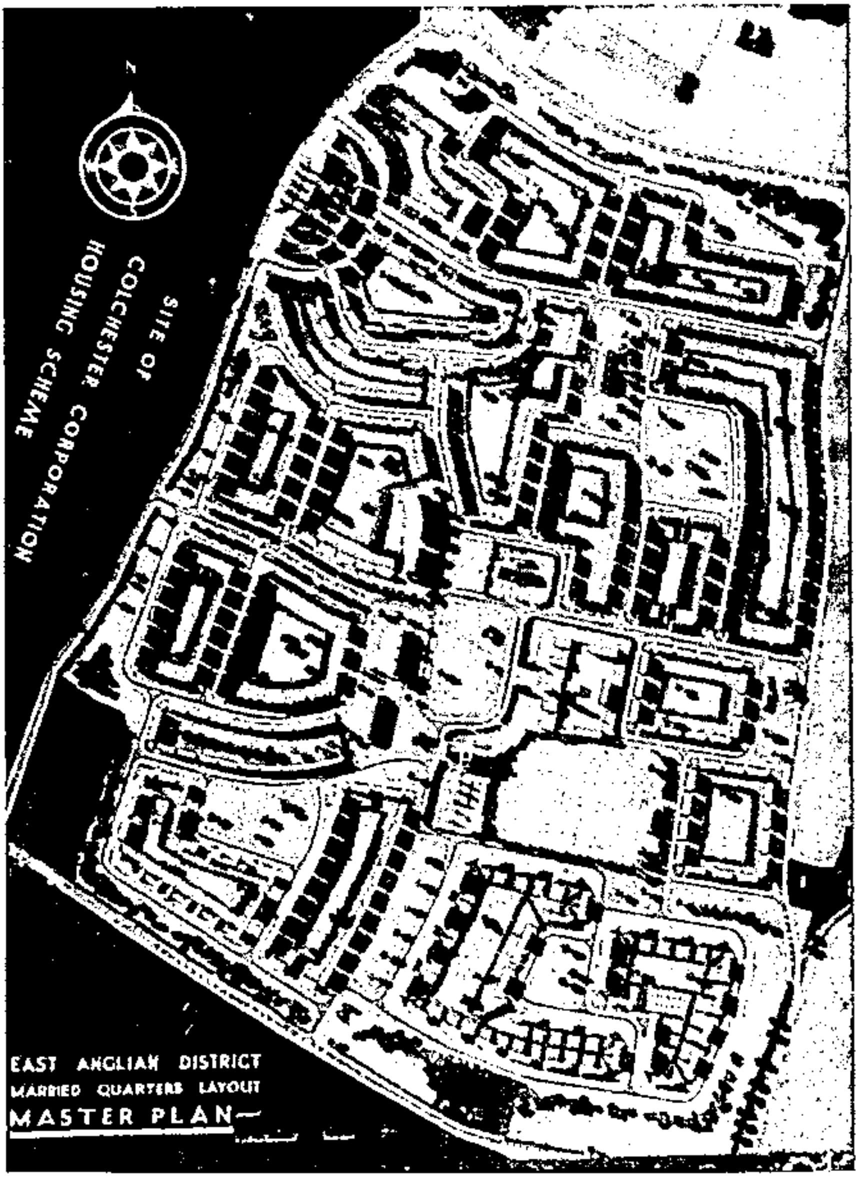
The design finally selected must combine the functional requirements of the town with due regard to the features and natural contours of the site, and there must be definite and good reasons for the shape finally decided on with a real effort to combine function with attractiveness.

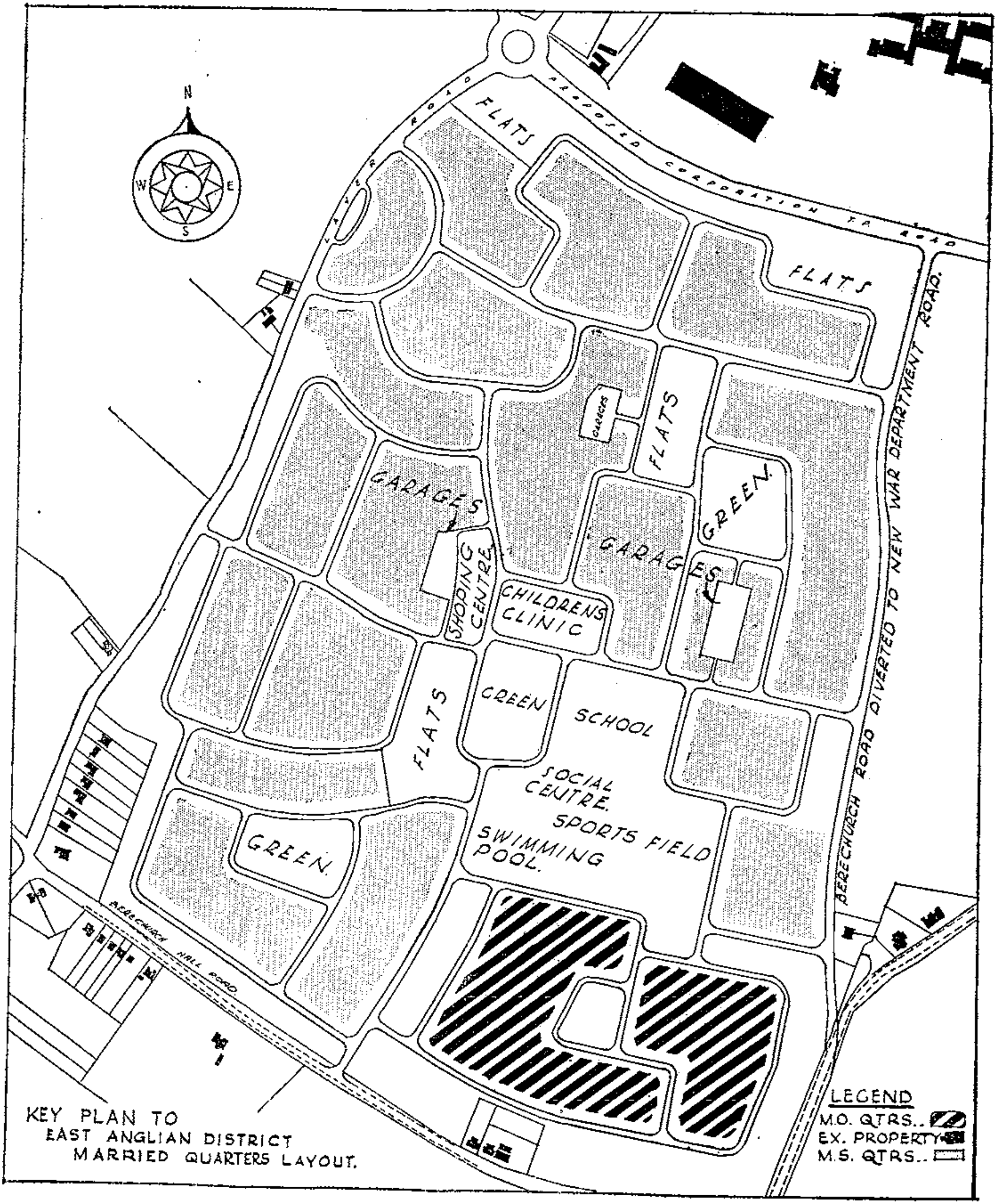
An example of modern planning for the layout of a married families estate is shown on the plate on page 179.

This plan, on which building is now proceeding, was made out in conjunction with a civil housing estate adjoining it, immediately on the west of the main road on the edge of the area. Certain amenities are therefore shared by the two estates, notably the schools for the elder children, public houses, cinemas and churches. The estate is planned around the centre, which is clearly seen in the picture, and which comprises a welfare centre and creche, a school (nursery and infants) with its playing fields, a club and shopping centre.

The requirements of the estate have not made it possible in all cases to adhere strictly to the quarter-mile walk, but the distance is never much farther, and some improvement can be gained in this respect by reserving as far as possible those houses nearer the school for families with children of school age. Spaces have been reserved in the layout for children's playgrounds and communal garages. In the south-east corner, where development is more open, there is an area reserved for officers' houses. The plan is the work of Mr. H. A. Metayers, F.R.I.B.A.

THE TOWN PLANNING OF MILITARY HOUSING ESTATES





KEY PLAN TO
EAST ANGLIAN DISTRICT
MARRIED QUARTERS LAYOUT.

DEMOLITIONS IN THE WITHDRAWAL—THE REMAGEN BRIDGE

By Major M. L. Crosthwait, M.B.E., R.E.

Introduction

On the 7th March, 1945, one of the major bridges across the Rhine was captured intact by the 9 United States Armoured Division. This bridge was part of the most important demolition belt by which the Germans ever attempted to delay the advance of the Western Allies. And yet, despite all the experience which the Germans had gained about "demolitions in the withdrawal" and allowing for the disorganization of the German Armies at that time, the demolition went wrong. This article is an attempt to give the story of the Remagen Bridge. It is based mainly on *The Remagen Bridgehead*, a publication prepared by the Research and Evaluation Division, The Armored School, together with such other facts as the author has been able to ascertain.

Background

At the beginning of March, 1945, the 9 U.S. Armoured Division was operating on the right flank of the First U.S. Army. It had orders to advance on the Rhine with all speed and having reached it to turn south and join up with the Third U.S. Army, so cutting off the German troops remaining on the west bank (see Sketch 1). The immediate plan was to capture Remagen and then to turn south and to establish a bridghead over the Ahr River at Kripp, preparatory to linking up with the Third U.S. Army. (See Sketch 2.)

At 1256 hrs. on 7th March, 1945, a task force consisting of:—

1 Platoon Recce Squadron
2 Companies Tanks (90 mm. Pershings)
1 Platoon Engineers
1 Infantry Battalion

arrived on the bluffs overlooking Remagen, and saw the Ludendorff Bridge standing intact. This was a railway bridge suitably planked over to take vehicles. The railway approached the bridge on an embankment and a causeway from the main north-south road, which ran along the west bank of the river, had been built to allow access up the embankment and on to the bridge (see Sketch 3).

Topography

Sketch 3 gives some idea of the topography. The ground on the east bank climbs precipitously from the river, rising to 500 metres inland through rough wooded hills, The east bank roads consisted of a river road and two mountain roads, any of which could easily be blocked. On the west bank only one primary road ran into Remagen, and even this, running north-south, did not run along the normal supply axis. Only a steep mountain road ran into the town from the west. It is probable that very few places along the whole stretch of the Rhine were less suited for a large-scale river crossing.

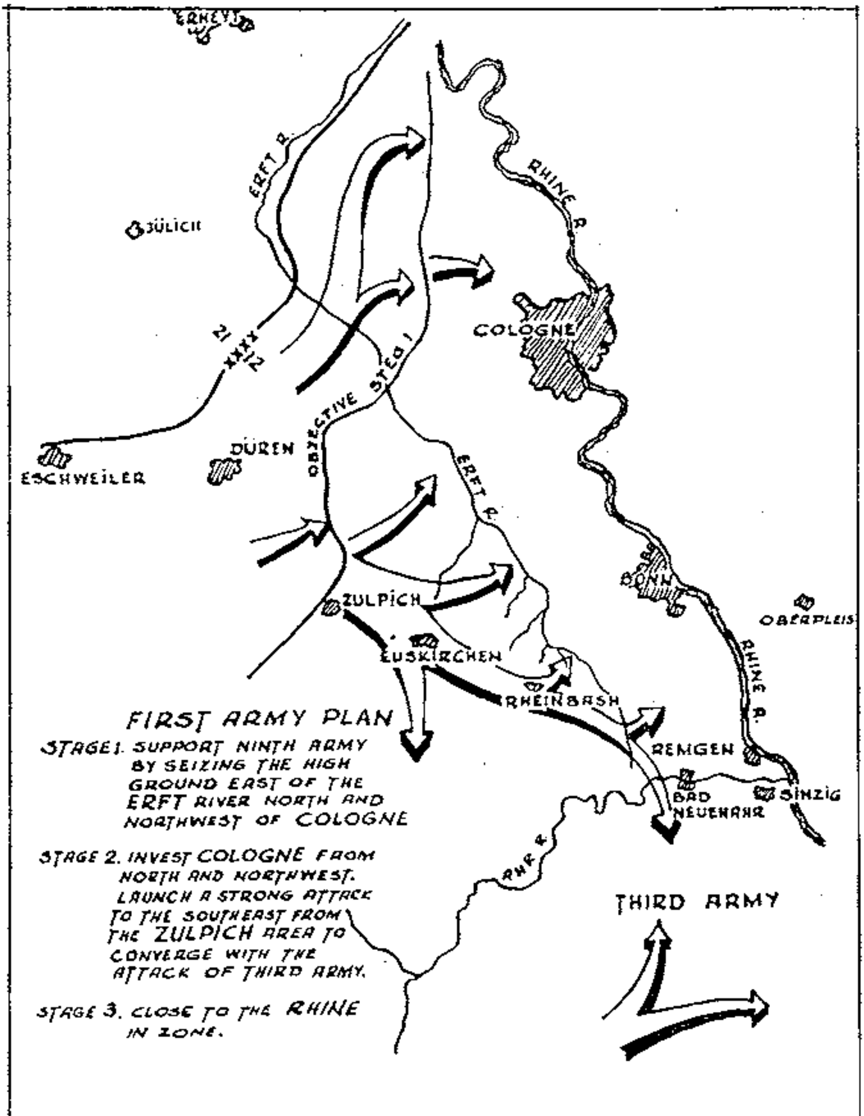
The Decision to Cross

At first sight it seems quite obvious that to capture the bridge and to exploit it as quickly as possible was the only course for the Divisional Commander to choose. But there were several factors against it. There was the extremely unsuitable site. There had been no supply build-up in anticipation of a crossing. Furthermore to build up supplies would be difficult, as the site lay near the junction of two armies and communications were most unsuitable. There was the possibility of a German trap on the far side—the exact enemy strength was unknown. The bridge might be destroyed soon after the division had crossed and before stand-by bridges could be built—leaving all U.S. troops on the east bank at the mercy of counter-attacks. Finally, although the possibility of the bridge being intact had been discussed with the Task Force Commander, no specific orders had been issued to anyone to seize the bridge and attack east. The Task Force Commander, however, made an immediate plan to capture it. The decision whether to exploit its capture and advance east could be made by the Divisional Commander later.

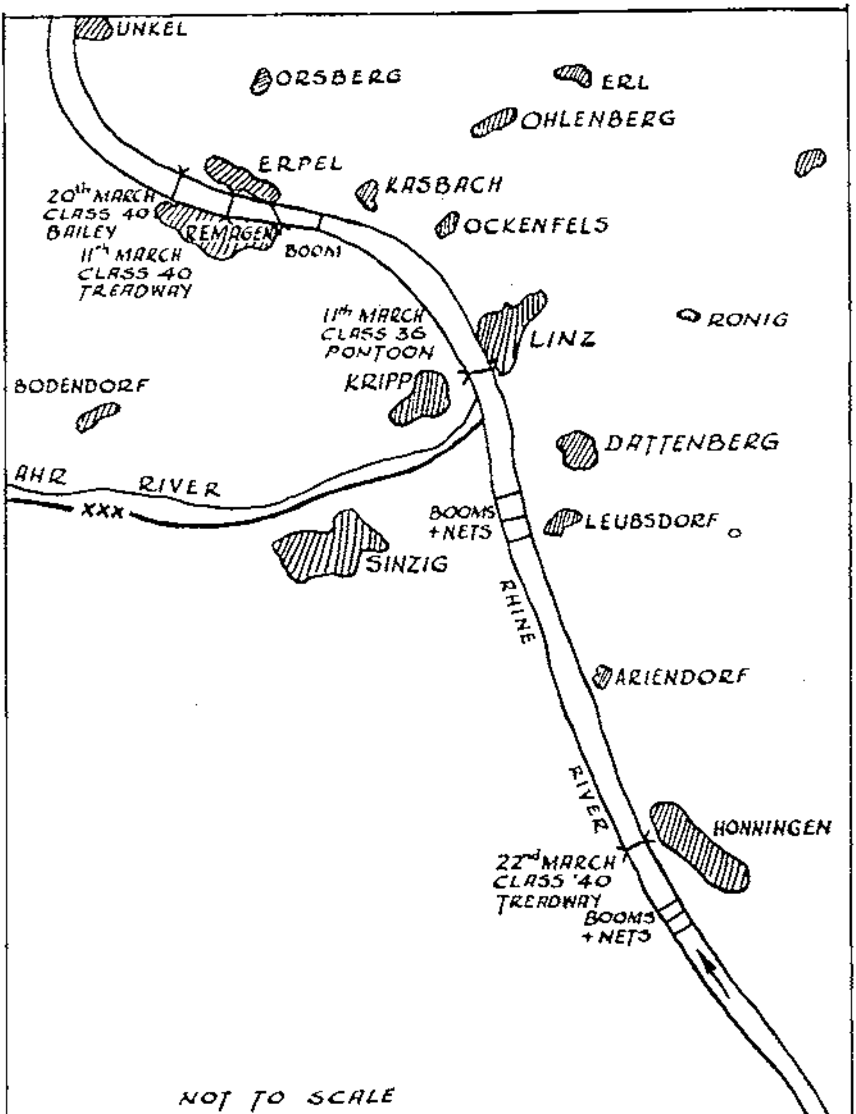
The Capture of the Bridge

The plan was for one company of infantry and one platoon of tanks to advance into Remagen as quickly as possible, followed by the rest of the force in route column. The attack was to be supported by assault guns and mortars. Enemy troops and vehicles were still moving across the bridge, and the column commander asked for time fire on the bridge by the divisional artillery. This request was, however, refused owing to the difficulty of co-ordinating the infantry and the artillery during the assault.

The infantry company set out at 1350 hrs. along a track running


JÜLICH
ERFT R.
RHINE R.
COLOGNE
DÜREN
ESCHWEILER
ERFT R.
BONN
OBERPLEIS
ZULPICH
EUSKIRCHEN
RHEINBASH
REMGEN
BAD NEUENAHR
SINZIG
RHINE R.
AHR R.
THIRD ARMY
FIRST ARMY PLAN
STAGE 1. SUPPORT NINTH ARMY BY SEIZING THE HIGH GROUND EAST OF THE ERFT RIVER NORTH AND NORTHWEST OF COLOGNE
STAGE 2. INVEST COLOGNE FROM NORTH AND NORTHWEST. LAUNCH A STRONG ATTACK TO THE SOUTHEAST FROM THE ZULPICH AREA TO CONVERGE WITH THE ATTACK OF THIRD ARMY.
STAGE 3. CLOSE TO THE RHINE IN ZONE.

SKETCH. 1


UNKEL
ORSBERG
ERL
OHLENBERG
ERPEL
KASBACH
20th MARCH
CLASS 40
BAILEY
REMAGEN
BOOM
OCKENFELS
11th MARCH
CLASS 40
TREADWAY
11th MARCH
CLASS 36
PONTOON
LINZ
RONIG
BODENDORF
KRIPP
DATTENBERG
AHR
RIVER
XXX
BOOMS
+ NETS
LEUBSDORF
SINZIG
RHINE
ARIENDORF
RIVER
HONNINGEN
22nd MARCH
CLASS 40
TREADWAY
BOOMS
+ NETS
NOT TO SCALE

SKETCH. 2.

down the bluffs. Half an hour later the tanks moved off down the steep and twisting mountain road which led into the town from the west. The move was so timed that the tanks and infantry should arrive at the outskirts together. In the event, the tanks arrived ahead of the infantry and, meeting no resistance, continued into the town. The town appeared deserted—only some small-arms fire was encountered and cross streets were enfiladed by 20 mm. flak guns from positions on the east bank.

The tank platoon reached the west end of the bridge at 1500 hrs. followed shortly by the infantry. By 1512 hrs. the tanks were in position and were covering the bridge with fire. At this stage a crater was blown in the causeway, followed shortly by another charge two-thirds of the way across the bridge. This second charge damaged one of the main diagonal supports and blew a 30-ft. hole in the decking.

Once the bridge was reached the mortars and assault guns started firing white phosphorous into Erpel to try and mask the bridge. Soon afterwards the rest of the infantry battalion arrived and more tanks took up fire positions covering the bridge.

At 1520 hrs. a captured German soldier reported that the bridge was to be blown at 1600 hrs. that day. This information, which appears to have been widely known, was substantiated by several civilians. However, despite the fire from the 20 mm. flak guns and unco-ordinated small-arms fire, the infantry had crossed the bridge by 1550 hrs. Troops from the engineer company followed closely, cutting every wire in sight and tearing down the charges from their fixings. The tanks were unable to cross because of the damage to the bridge caused by the partial demolition.

The infantry, once they had reached the far bank, at once started to expand their foothold, one company turning upstream to Erpel, one scaling the cliffs immediately north of the river and a third attacking towards Orsberg. The engineers were unable to proceed with immediate repairs to the bridge and had to wait until dark, because of the very accurate and heavy fire from snipers on both banks.

It is of interest to note that the Combat Commander, under whose orders this task force was operating, received a wireless message shortly after the leading troops had crossed the bridge, to the effect that missions to the east were to be abandoned and he was to "proceed south along the west bank of the Rhine." The Combat Commander decided, however, to continue exploitation until he had seen the Divisional Commander himself. By 1650 hrs. this conference had taken place and the decision taken to expand the bridgehead as quickly as possible. The subsequent conduct of operations is outside the scope of this paper.

The German Story

The German difficulties at this time are well known. Hitler's order that the Allied advance must be halted west of the Rhine and that there must be no withdrawal across the river, coupled with incessant air attacks, increased the difficulties of the German Command a hundredfold. There was a needless and fruitless expenditure of troops in the Rhine battles—troops which would have been better employed in methodically withdrawing over the river and preparing in proper order the defence of the Rhine itself.

This situation was particularly hard on the engineers. Time was being wasted on preparation of defence lines on the west bank, and insufficient attention was given to the Rhine itself—in particular, of course, to the bridges. Reliance for work on the Rhine had to be placed in the first instance on improvised labour organizations, as there were insufficient engineer troops available for the task. When the fighting troops were at last permitted to withdraw over the river, the engineer units available were sadly depleted and exhausted. Above all, perhaps, the disorganization seems to have been so great that the vital question as to who should give the order to blow the bridges, and when, had been largely left to chance and improvisation.

Despite all this, and on the credit side to the German engineers, a very large proportion of the German troops on the west bank were withdrawn across the river, in particular, the artillery and divisional combat vehicles. This was only done by the skilful use of rafts and ferries as well as the permanent bridges.

Preparations at Remagen

Remagen was originally prepared for demolition some time before the fighting front came near the Rhine. However, the charges were later removed after the destruction of the Cologne–Muehlheim bridge during an air attack. This was believed to have been caused by the premature detonation of the charges. It was thus considered advisable to place the charges in position on other Rhine bridges only when the need became more directly apparent. Later, as the fighting drew nearer the Rhine, the charges were once more put in place, but the primers and detonators were not to be connected until the enemy was in the immediate vicinity.

Exact details of the actual demolition plan are not to hand, but it appears to have been as follows (Sketch 3. refers) :—

(*a*) Bulk charges in the footings of each of the main piers at " A " and " B," placed in built-in demolition chambers.

(*b*) Cutting charges at important points, such as on the main chords, near where they passed over the piers at " A " and " B."

(c) A miscellaneous collection of cutting charges placed here and there in—apparently—a not very useful or intelligent manner.
(d) A crater in the approach road.

In the event, only the crater and a part of one of the main cutting charge at " A " went off. It should be noted that these charges went off separately and must, presumably, have been wired up by different circuits.

The firing point was in the railway tunnel at the north end of the bridge. On the 7th March the charges were in position, but the demolition circuits had still to be connected.

Security

As the demolition circuits were only to be completed when the enemy was in the vicinity, this presupposes some sort of local protection so that the bridge could be defended against surprise attack, at least long enough for the engineers to complete their preparations.

At Remagen there does not appear to have been any force provided with the sole responsibility for the protection of the bridge. It is true that even on 6th March the local bridge protection commander (Captain Bretze) had 350 men, eleven machine-guns and two 20-mm. and one 37-mm. battery (for A.A. protection). This force, however, except for the A.A. batteries, was mostly composed of elements from units which happened to be located in the vicinity of the bridge and which had no direct interest in the bridge as such. Indeed, once orders had been received for units to withdraw across the Rhine, the unfortunate captain was left on 7th March with only thirty-five men and the 37-mm. battery to guard the bridge from attack from the west. These thirty-five men, to add insult to injury, were from a convalescent company, so were not even part of a proper fighting unit.

Events at the Bridge

The German Army Group H.Q. at this time were not particularly worried about Remagen, as they thought that the Americans would concentrate their drive on Bonn. However, H.Q. 67 Infantry Corps, the formation directly responsible for the bridge, became anxious early on 7th March and the Corps Commander sent a General Staff Officer (Major Scheller) down to Remagen, with orders to take over all responsibility for the bridge, including giving the orders to blow. Major Scheller's orders on the latter appear to have been that the bridge should be blown at 1600 hrs. that afternoon, and the engineers were instructed to time their work accordingly.

At about 1130 hrs. the first reports were received that enemy tanks were in the vicinity. The major, presumably pinning his faith to the soundness of the army appreciation of the direction of the American thrusts, still did not consider that the situation was serious, and a valuable half-hour was lost before he told the Engineer Commander (Captain Fresenhahn) to complete the demolition circuits as quickly as possible.

By 1400 hrs. the Engineer Captain reported one circuit to be complete and asked for permission to fire the bridge, as already the first rifle shots had been heard in the sector. Major Scheller refused, but instructed that the reserve circuit should also be completed as quickly as possible. At 1440 hrs. the first Americans were seen to approach the bridge.

Captain Fresenhahn at once ordered the causeway charge to be blown, and then ran back into the tunnel where the exploder for the main charges was located. By inference it appears that the crater charge was blown from a point on the west bank and was not controlled from the main firing point.

At this critical juncture Major Scheller was not to be found—he had apparently gone off to choose a new location for his command post and he was only run to earth about twenty minutes later. At 1520 hrs. he gave the order to blow with the result already described. Only a part of one of the main charges went off. The bridge still stood.

All the engineers had gathered in the tunnel, and attempts by Captain Fresenhahn to get a party organized to try and sort out the charges failed, as the mouth of the tunnel was under heavy fire from the American tanks. Soon after, the American infantry were across the bridge and all those in the tunnel were captured.

A message (by runner) had in the meantime been sent to the Engineer Regimental Commander, whose H.Q. was about seven miles away at Hönningen. This message did not reach the Engineer H.Q. until evening. On its receipt a counter-attack party of engineer troops was at once dispatched, with the task of capturing sufficient of the bridge to effect demolition of the eastern abutment, but this attempt came to nothing.

As already stated an account of further German attempts to reduce the bridgehead are outside the scope of this paper.

Technical Reasons for Failure

There seems little doubt that the German engineers were the victims of exceedingly bad luck. That the final connecting up of the circuits was hurried is true, but that one lot of charges went off shows that the rest of the circuits may well have been complete too. Furthermore, when dismantling the charges the Americans found that the detonator in one of the main bulk footing charges had gone off, but had failed to set off the charge. The explosive must have been of poor quality and was probably damp. The charges had already been in place once, they were then removed and later replaced again. It is probable that the same explosives were used throughout, and any initial water-proofing arrangements were upset.

Two circuits were to be employed. Whether the second was to be of primacord or another electrical circuit is not known. If the explosive was bad probably no other firing methods would have been any more successful than the first. It also appears that the original demolition plan relied only on the bulk footing charges in the piers. The cutting charges were added later. When the charges were removed to prevent premature demolition the circuits themselves must have been left in place, as the wires to the bulk charges were very much more weather beaten and corroded than those to the cutting charges.

Thus the material, which the German Engineer unit had to use and which was in all probability handed over to them by those who had been previously responsible for the demolition, as being in good order, put the unit at a grave disadvantage from the start.

Thus, reasons for technical failure in order of priority may well have been :—

(*a*) Poor quality explosives.
(*b*) Corroded wires forming the circuits.
(*c*) Too hurried preparations—detonators not pushed home, joints not insulated, etc.

It would appear, however, that had Captain Fresenhahn had only half an hour or so more time after the initial fiasco he would probably have been able to break the bridge in at least one place.

The Order to Blow

On his arrival at the site Major Scheller had a difficult decision to make. He had to ensure the destruction of the bridge, but as German vehicles were still crossing, the later this could be done the better.

He clearly did not anticipate blowing in the face of the enemy, his mind being full of the Army Group appreciation, and therefore decided to blow at a fixed time—1600 hrs.—which decision seems to have been widely broadcast.

That he did not act with more urgency when the Americans were reported in the vicinity is both to his credit and to his disadvantage. Having made his appreciation he was not to be stampeded into precipitate action by alarmist reports, as a less strong-minded commander might well have been. In the event he was wrong and he denied Captain Fresenhahn a vital extra half-hour. It was the age-old problem of command. " Is this a feint designed to make me commit my reserves—to blow this bridge—prematurely? Or is it the spearhead of the main effort ? " As far as an officer at an important demolition is concerned his problem can be much eased by :—

(*a*) Good communications so that he has all relevant reports before making his decision whether to blow or not.

(*b*) First class liaison with, and the mutual confidence of the Engineers.

The Engineers must be quite certain of the technical solution of their task and they must present their case, and the General Staff must pay careful heed to it, as to how much time must be allowed for preparations if there is to be a minimum chance of failure.

Major Scheller lacked all these pre-requisites.

The Aftermath

The Germans never succeeded in reducing the bridgehead. Every available means was employed to destroy the bridge. Besides constant ground attacks it was under incessant air attack. Plans were made to use frogmen, but before these were available the Americans had so much of both banks under their control that the attempt was called off. Finally, allegedly by direct instruction from Hitler, V2's were used, four falling near the bridge.

One of Hitler's dreaded special military courts (really political) visited the formations concerned shortly afterwards and five officers were convicted and shot for dereliction of duty. Who these officers were is not known, but they did not include either Captain Bretze or Fresenhahn.

This latter event made the whole Officer Corps extremely conscious of the personal responsibility for failure. As a consequence the justification of acts and decisions became the paramount thought in most minds. In addition a bridge complex swept the command, which caused officers of all grades to spend a disproportionate amount of time, energy and explosives in blowing all sorts of bridges, often needlessly. In many instances bridges were blown in rear areas, for no other reason than clearing the individual of responsibility for an unblown bridge.

The Subsequent American Engineer Effort

The Remagen bridge finally collapsed on 17th March. But by this time a Class 36 Pontoon bridge at Knipp and a Class 40 treadway at Remagen had been built, together with protective booms and nets. Remagen bridge itself was protected by a contact boom, a log boom and a net boom. L.C.V.P. and DUKW ferries also had been in operation since 8th March. By 22nd March a Class 40 Bailey had been built at Remagen and a Class 40 treadway upstream at Hoenningen. The position of the bridges booms and nets and the dates on which they were opened are marked on Sketch 2.

Taking into consideration the very bad roads leading into the area from the west and the vast amount of combat, supply and engineer vehicles which had to be provided for, often under artillery fire, the American achievement measured in terms of the traffic and road problem alone, was a very remarkable one.

American Protective Measures

A summary of the measures taken to protect the bridge is as follows :—

A huge deployment of A.A. defences. At one time nine A.A. automatic weapon battalions and four A.A. gun battalions were deployed.

Barrage balloons.

Contact, log and net booms.

Twelve depth charges per hour were dropped at night.

Radar to detect underwater craft.

River and shore patrols were maintained.

Searchlights illuminated the river at night.

High velocity guns were available to destroy floating objects.

Comments

The lessons from the German side of this incident are obvious—painfully so. It is easy to criticize. No proper plan, insufficient bridge garrison, apparently no proper communications whatsoever, lack of liaison, no co-ordinated scheme for the withdrawal over the Rhine, technical risks as regards circuits and quality of explosives—all are there. Such a combination of circumstances *might* happen to us, but as long as our present teaching on the subject is properly carried out, it is unlikely. Above all we may reasonably hope that any operations in which the British army is engaged will be planned ahead and not incompetently directed, down to tactical details, from Whitehall. If the German General Staff had had a free hand to plan their withdrawal over the Rhine in a properly phased and co-ordinated programme, it is unlikely Remagen would have happened.

A large and important bridge like a Rhine bridge, subject to heavy air attacks will always be an unpleasant problem. If the charges are placed early there is the risk of premature demolition (cf., the Cologne-Muehlheim bridge) besides the ever-present risk of the long and necessarily complicated firing circuits being upset at the last moment by air or artillery attack. On 9th March, as a result of Remagen, Field-Marshal Model ordered the bridge at Engers to be blown directly the engineers were certain of their circuits, etc., despite the fact that long columns of troops were waiting to cross. This was no panic measure. Model considered that it was better to blow the bridge and resort to ferries, inevitably losing a proportion of his troops, than to risk the bridge being captured due to a last-minute hitch—technical or otherwise.

As far as the Germans were concerned, in general the situation was so chaotic that it was not considered possible to have any centralized plan for the demolition of a Rhine bridge. It appears that the power to give the order to blow was delegated from Army Group downwards, finally ending up with the local engineer officer or bridge guard commander. Such a system depends on good communications, which in the event were conspicuous by their absence. As the Army Group Chief of Staff stated in his interrogation report, " The decision had to be entrusted to the alertness and good luck of the individual tactical and technical commanders at the river bank." " Good luck " is an insecure foundation on which to rely, in such an important operation of war.

Conclusion

Remagen was an example of brilliant and forceful leadership. To exploit the capture of the bridge was not an easy decision to take, but taken it was. To quote General Eisenhower, " At Remagen we encountered one of those rare and fleeting opportunities which occasionally presents itself in war, and if grabbed have incalculable effects in determining future success." One criticism of British Command is that it is apt to be conventional, sound and cautious. To quote the German Chief of Staff already mentioned above—speaking of the Rhine battles he said : " It is really astonishing that the superior enemy forces did not succeed in cutting off the retreat across the Rhine and destroying the remnants of the German Army. Allied leadership, which preferred to win victory by an unbroken series of limited successes rather than by a risky attempt to gain a complete decision at one time, had demonstrated its moderation once again. Judged by basic principles of German military leadership, the enemy habitually failed to go deep enough after a break-through to achieve decisive victory." Remagen, anyway, was an exception.

The object of this paper has not been to discuss allied leadership. The object has been to illustrate a " hussar-like incident." Every credit must be given to American leadership. One can only hope that had it been British troops involved, British leadership would have shown the same confidence, resolution and skill.

Finally it must be stated that except for the American side of this incident, which is accurate, the facts of the German side have not all been available. The writer has taken such facts as he was able to gather and filled in details as seemed most likely to him.

Author's Note

Since writing the above the author has read two separate articles which appeared in German weekly magazines. One, dealing with the V1, showed that at one time it was planned to use piloted rocket bombs and a suicide force of 5,000 men was recruited and trained for this purpose. However the only recorded attack in which a piloted bomb was used was in an attempt to destroy the Remagen bridge. The bomb was shot down before it reached the target.

The second article was more significant. It attempted to show that the apparent crass carelessness at the bridge—no proper explosives, no proper bridge guard except a few convalescents, Major Scheller's prevarications and determination to stick to 1600 hrs. as zero hour, the wholesale broadcasting of this timing, etc., were all part of a deliberate plot. The German High Command, it is alleged (but without, of course, the knowledge of Hitler) in order to quicken the advance of the Allies allowed them to take an undestroyed bridge, so that as much German territory as possible should be in their hands, as opposed to Russian hands, before the Armistice came.

This theory is certainly interesting and is obviously an attempt to vindicate the efficiency of the Wehrmacht. It may, of course, be true. But in so far as the other published records of the incident go, the theory does not hold water, and the foregoing account seems a more likely one. The same article brings out the fact that Hitler was furious and demanded that "Köpfe müssen rollen" (heads must fall). Scheller's was one. He was executed with a "Genickschuss" (shot in the back of the neck) by the permanent execution team which used to accompany Hitler's "flying Court Martial". The Commander of the Engineer Regiment, who organized the counter-attack from Hönningen was another. He was sentenced because, despite his many other responsibilities, he personally did not lead the attack on the bridge.

THE PARTY

By The late Major-General G. E. Grimsdale

It was one of those hot steamy nights that are so trying in the southern Chinese tropics ; a night when one dreams nostalgically of the ice and fans of less primitive places. After a strenuous day's march we had at last reached our goal, a small Chinese town on the Yunnan-French Indo-Chinese frontier. My party consisted of two British officers and an American officer from General "Joe" Stilwell's H.Q. in Kunming.

We found the usual small Chinese country town, little more than a village of a few badly paved streets between single story mud brick houses. Open-air barber shops, restaurants, pedlars and beggars, innumerable semi-naked children and mangy dogs, would doubtless have formed a picturesque sight, had we not all been so familiar with it. And, of course, everywhere there were clouds of flies. We were glad enough to find the single room allotted to us by the local military authorities clean and the hot water supply adequate.

Before it got dark we were conducted to the edge of the town, where a small river, once spanned by a narrow stone bridge, formed the actual frontier. The old bridge had been demolished, but a wooden footbridge had taken its place. On our side of the stream, making little or no attempt to conceal himself, stood a tired and hungry-looking Chinese sentry ; a few yards away across the river, equally visible, paced a rather bored Japanese sentry. Everything was quiet and peaceful in the red glow of the setting sun.

It was to see for myself something of this peaceful war routine, of which we had heard in Chungking, that my trip had been undertaken. At this time, the early summer of 1943, the Japanese had been in occupation of French Indo-China for over two years, but they had made no attempt to cross the frontier into China. In their quaint oriental way the Chinese officially described the frontier as "closed" ; unofficially, they and everyone else knew that there was a constant stream of traffic across it in both directions. The so-called "smugglers" were having the time of their lives. In fact, trading on a wholesale scale was in progress. Even if they had wished to, it would scarcely have been possible for either side to block all the many mountain trails over which this trade was carried ; as it was, it suited both sides to avoid interference. Since one of the major exports smuggled from Indo-China was raw rubber, much of which eventually found its way to India, the trade was not without benefit to the Allied war effort.

A few months prior to our arrival an unfortunate " incident " had occurred. A Chinese sentry, newly arrived and on duty for the first time, suddenly saw his Japanese opposite number across the river. Having had no orders to the contrary he at once put up his rifle and had a shot at the Japanese. Unluckily for both of them, the shot found its mark, and the Japanese was killed outright. An immediate protest at this " outrage," of which no warning had been given, was lodged by the local Japanese commander. The Chinese commander was in a very awkward position. It was essential to preserve his own " face " and the peaceful *status quo* to which both sides had tacitly agreed. There could be only one solution ; the Chinese sentry must pay with his own life for that of the Japanese he had so wantonly destroyed ! This decision, so I was informed, had promptly been put into effect. It gave one a peculiar feeling to look across a few yards at an armed member of the enemy's forces. Our Chinese hosts assured us that the shooting season was closed ; I must confess that I remembered that in England, anyway, there was no close season for vermin, and wondered whether, to a Japanese country boy, British and American officers might not come into that category.

The village was full of Chinese soldiers, for it was the headquarters of the General commanding a sector of the frontier defences. He was delighted at our arrival. He knew that to get to his headquarters had meant a walk of over one hundred miles from the nearest railway or motor road for us, and he took it as a great personal compliment that a foreign General should have come so far under such circumstances to see him. He at once gave orders for a banquet to be prepared in my honour the same night.

It was a fine night as we walked through the outskirts of the village to the General's house, where we found him accompanied by his entire staff, and it was obvious that no effort had been spared to produce the best possible feast in our honour. Even in this remote corner of the country a great variety of delicacies had been produced, some of them from the sea coast, at that time entirely in enemy hands. Nor was the standard of the General's chef below that of the food. Only one thing was lacking ; for once it had proved impossible for local resources to obtain any of the usual Chinese rice-wine. Each guest nevertheless was provided with his wine-cup, the tiny and delicate porcelain vessel without which no Chinese meal is complete.

I was surprised, but by no means disappointed, when my host apologized for the lack of wine, offering me beer instead. I recalled the many occasions on which, after a Chinese dinner party, one had woken up next morning wishing that this apparently innocuous yellow spirit, the so-called " rice-wine," had never been invented.

Beer, on the contrary, to the foreigner in China in 1943, was an almost unknown luxury. I was therefore perfectly sincere when I assured our host that the absence of wine would in no way spoil our enjoyment of his hospitality. But beer by the thimbleful was something new, especially the rather thin and pallid liquid such as this Japanese stuff proved to be. After a few toasts had been drunk I felt that something simply had to be done about it. As tactfully as possible I brought the conversation round to the drinking habits of other countries, and finally to those of my own country. I explained that in England we were accustomed to use tumblers when drinking beer. Like nearly all Chinese, the General was a perfect host and promptly took the hint. He ordered tumblers to be brought and in a very short time convinced himself of their superiority over Chinese wine-cups.

Half-way through the meal a sudden crisis developed. In obvious trepidation the responsible A.D.C. approached the General. Preparations for the entertainment had not included beer in quantities commensurate with drinking it out of tumblers ; if this went on much longer the supply would give out. The General faced the ugly situation with soldierly calm. Calling for ink and paper, with his brush he wrote a short note. Handing it to the A.D.C., he gave instructions for it to be passed across the frontier without delay. The meal continued, the foreign guests tactfully sipping their beer. Within a few minutes a reply was received. To the general's consternation this was a politely but firmly worded intimation that the hours for drawing beer were from nine to ten in the morning, and that there was nothing doing at nine o'clock at night.

Undismayed, the General returned to the attack. In a further note he pointed out that he was at that moment entertaining distinguished British and American officers ; unless the Japanese commander could let him have some more beer immediately, his " face " would inevitably suffer a serious loss ; and he felt sure the Japanese commander was aware of the large drinking capacity of these foreigners. Within a few minutes the messenger returned, beaming with delight and this time bearing a case of beer. He also brought a further reply from the enemy commander. In this the Japanese stated that, having now learnt of the circumstances, he was sorry not to have sent the beer the first time ; he hoped however that it would still be in time to preserve the face of so eminent a soldier as he knew the General to be. Honour having thus been mutually satisfied, the banquet was resumed ; it finished simultaneously with the emptying of the last of the bottles in the new case. The General had learnt how to drink beer ; I, and the other foreigners, had learnt that chivalry in war is not an entirely forgotten art.

"OPERATION PLAINFARE"

(Concluded)

By COLONEL A. MACG. STEWART

ELECTRICAL AND MECHANICAL WORK IN R.A.S.O. AREA

WUNSTORF

Water. Boiler houses for hot showers and heating the N.A.A.F.I. required a boiler capacity of 2,200,000 B.T.Us.

Sewage. 2,200 metres of piping were laid to connect the camp to the existing sewage system.

Electricity. Supply was brought in by 400 metres of 15 kv. overhead line; a 117 kva. sub-station and a 50 kw. stand-by plant were provided. The camp area distribution required 3,000 metres of L.T. 3 phase 4-wire O.H.L. to 560 points. The total load was 53 kw.

FASSBERG

Water. Potable water was required for the N.A.A.F.I. and ancillary buildings, a locomotive watering point was also required. The N.A.A.F.I. and the watering point were 1,200 yds. apart and the nearest water main was 1½ miles away. Requirements were estimated at :—R.A.S.O. area 6,000 gallons/day.

Loco point 4,000 gallons/day.

Water was urgently required and was being carted for concreting and locomotives.

A geological plan showed that there was plenty of water at the site and existing bore holes in Trauen Camp showed that it would be within suction limits. So two bore holes were sunk at the R.A.S.O. area, each capable of yielding over 3,000 gallons an hour. One 3,200-gallon tank on a 30-ft. tower was erected near the N.A.A.F.I. in the R.A.S.O. area, and a 6,400-gallon tank on a similar tower was put up at the locomotive watering point.

A specialist firm sank the bore holes in two days each to a depth of 20 ft., water being found at 10 ft. Chlorination plant was put up. The pumps were engine-driven at first, but as soon as electric power was available they were changed to electric motors controlled by float switches. Water was being distributed ten days after work started.

Central heating was provided in the N.A.A.F.I. Canteen, N.A.A.F.I. staff accommodation and aircrews' restaurant. Total boiler capacity 600,000 B.T.Us.

Electricity. The R.A.F. undertook to light the runway. The Sappers undertook the remainder of the work which included:—

(*a*)	Forty points each 300 watts, on poles, for illuminating railway sidings—1,200 yds. of 4-wire, 400/230 volt, 3 phase, A.C., O.H.L.	12 kw.
(*b*)	Two wireless control points	2 kw.
(*c*)	Lighting N.A.A.F.I. and vicinity	15 kw.
(*d*)	Lighting ancillary buildings	6 kw.
(*e*)	Power for bore hole pumps	5 kw.
(*f*)	For R.A.F. use in and near R.A.S.O. area the first demand was 25 kw. and later raised to 80 kw.	80 kw.
		120 kw.

To provide light and power quickly five generating sets between 5 and 22 kw. were installed. These could not be relied upon to maintain a certain supply throughout the twenty-four hours. The nearest H.T. supply was a 20 kv. line near Trauen Camp and a 20 kv. O.H.L. was brought 1½ km. from this line to a 200 kva. substation near the N.A.A.F.I. Two stand-by sets one of 85 kw. and the other of 50 kw. capacity were also provided; the small sets were then removed. This supply served the R.A.S.O. area, administrative huts, aircrews' restaurant etc., and needed 3 km. of 3 phase L.T. and 1 km. of single phase L.T. to distribute.

TRAUEN CAMP

General. External water and electrical lines were planned so that they served both the original tented camp and the later hutted camp.

Sewage. An activated sludge plant was found near the edge of the camp site. A German consultant confirmed that it would cater for 4,000 men provided that nine additional drying beds were added. Bucket latrines were used until these beds were ready, and the camp structure bucket latrines were then taken down and the water-borne system taken into use with the blessing of the D.A.D.H. Two thousand metres of sewage pipes had to be laid.

Water. Camp structures were erected with an essential minimum water supply to serve the tented camps until the hutted camp for 3,500 was ready. Two large central boiler houses were fitted up in derelict buildings to provide water for shower baths. Central heating was installed in the G.C.L.O. canteen. The total boiler capacity installed was 5,330,000 B.T.U. Fire hydrants were also provided. Supply was from an existing bore hole at 6,000 g.p.h.

Electricity. There was an existing 400 kva. sub-station on the camp site. A 100 kw. 400/230 volt, 3 phase, A.C. generating set was installed as a stand-by. Some 1,200 metres of L.T. 3 phase 4-wire overhead lines, 3,600 metres of single phase line and 1,000 light points were put in. The total load was 175 kw.

Water was pumped by an old German submersible electric pump; this proved inefficient and was replaced by a British pump which worked satisfactorily.

CELLE

Water. The airfield and its barracks are some miles from the town on the opposite side of the River Aller from the waterworks. The barracks were designed for about 1,500 men. The airfield population in barracks and camps rose to about 8,000. The R.A.F. undertook to increase the water supply. They sank tube wells on the airfield ; the town authority wished to bring in a new pipe-line from their own wells.

We merely distributed the available water, and this was just, but only just, sufficient in winter.

Steam boilers were installed to provide hot water for showers and steam for hot closets. If central heating is put in later the existing boiler house can be incorporated in the system. In winter the new boiler house which will be needed will be able to provide all hot water and steam, the small boiler house being laid off. In summer the big boiler house can be laid off, the present one providing baths and domestic hot water as at present.

To enable maintenance of aircraft to be done, central heating in several hangars was reconditioned, which necessitated replacement of boilers and many unit heaters. Central heating was put into an old gymnasium and the detention compound. Total new boiler capacity installed is 4,686,000 B.T.Us.

Sewage. A water borne system discharging into the town mains strained them to capacity. The town purification plant was already overloaded by a civil population double that of 1939.

Lighting on railway sidings and lorry loading areas was dealt with by the Army, while the R.A.F. did the runway and aircraft parking area lights.

A 6 kv. underground cable 9 km. long, with necessary alterations to the switching station near the airfield was put in in one month.

Two new sub-stations were constructed and connected to the 6 kv. cable; 400 kw. stand-by capacity was provided. The distribution system used 3,200 metres of 3 phase 4-wire mains, and 11 km. of double and single phase line. Three thousand light and power points give a load of 285 kw.

Stores

In the beginning over-enthusiasm and determination to get on with the job caused trouble and waste of time and effort. A decision would be taken on an airfield and before the C.E. or his Staff Officer had got back to Divisional H.Q. to order release of the stores, there would be a representative of the Camp Commandant, an Airman, and a Sapper, all drawn up in a variety of vehicles at the D.E.S.D. with a list of stores for the job, marked " Plainfare PRIORITY," but generally unsigned. The lists were never the same and the harassed Depot Commander did not know whether the stores were wanted for three different jobs, or for one and the same job. That was soon under control, by insistence on one channel of demand for stores. The order of the day was " when in doubt issue."

The total tonnage of stores (excluding Tn.) from all sources used by the Sappers at the three airfields was about:—

Fassberg	28,600 tons.
Celle	12,500 tons.
Wunstorf	6,700 tons.

Some details of the breakdown of these totals is given in Appendix " C."

Handling Stores

The object of the man in charge of stores must be to feed them to work sites without builders having to come back and ask for them. At Celle a Subaltern and at Fassberg a W.O. I were charged with receiving consignments by rail and road and checking that they agreed with demands and releases. This worked well.

The word " dump " should be abolished. The last thing one wants is a dump, which implies a heterogeneous pile of stores of all sorts. A properly organized stores area, with items properly stacked, is an essential to smooth working.

German foremen employed on this work were given lists of Nissen hut parts and markings, mounted on a piece of plywood, and written both in German and English. This made possible rapid and accurate checking and sorting.

Stores Difficulties

When planning from the Expeditionary Force Camp store lists one must remember that they make no allowance for anything but the finished building. Nothing for shuttering, nothing for scaffolding, nothing to make a shack out of and nothing to light one with. A reasonable quantity of common stores should be put on the site right away at the beginning to avoid hold ups for small but essential items and to allow replacement of stores which get broken or lost in transit.

Even careful loading of railway wagons in the depots and delivery direct by sealed wagon to the site did not always ensure correct delivery when required. Seventy-five 16-ft. span Nissen huts were loaded complete at Hamburg and all wagons left the depot on the same train, but the wagon containing all the bolts, nuts, drive-screws, windows and doors did not reach Wunstorf until six days after the rest of the consignment.

The hutting stores had been lying in the open since 1945 and much of the corrugated sheeting was rotten with rust. There was no time to check every bundle in the E.S.B.D. and so 40 per cent extra sheeting was issued. This gave an over-all saving of time but added to the work on the site.

Stone was troublesome. Quarry work is not popular, and stone crusher jaws had not been renewed for years, so we did not always get the sizes we asked for, but after the initial rush supply caught up with demand.

Engineer Stores for Berlin

As well as issuing stores for the airfields the Depot Commander had to crate many tons of engineers stores of all sorts from generating sets to stone forks, for dispatch by air to Berlin. The large generating sets were a troublesome load, for they would not go into the Yorks in the crates in which they had come from the U.K. They went in with a squeeze, when the crate had been dismantled except for the bottom, which had to be left to spread the load on the floor of the aircraft. A total of 181 generating sets, with a total output of 1,000 kw. were flown to Berlin; many of them were small 3 kva. sets.

Initially the R.A.F. could not provide all the restraining gear required for stores, and it fell to the D.E.S.D. and the E.B.W. to make a variety of S-hooks, adjustable strainers, and chains. To begin with the R.A.F. were apt to throw all these things out at Berlin, and demand a new set for the next sortie. This could not continue, for apart from any question of waste we could not make new ones quickly enough. That trouble too soon sorted itself out.

The D.E.S.D. showed ingenuity in experimenting with various types of loading devices for aircraft, using Bailey bridge equipment, sectional rollers etc. It would be of no use including details of these experiments, for each type of aircraft, indeed different marks of the same type, needed different bays or ramps, as did each type of bag, box, or crate.

Road Trouble at Fassberg

For about a week at the beginning of the Fassberg project there was very heavy rain. There was only one unsurfaced fairweather single lane track from the R.A.S.O. area to Trauen Camp. Not only did C.R.A.S.O.'s labour live in this camp, but also the D.C.R.E.'s labour, and there was constant traffic between the two places which turned the track into a canal of mud some 2 ft. deep. There was good agricultural land at one side of the track, and the railway was being laid on the other side of it. The track could not be improved without adequate drainage. All traffic was diverted from the camp via the nearest proper road, but this lengthened the distance from Trauen to the R.A.S.O. area from 4½ to 15 km. A Killifer plough towed by by a D 8 tractor ploughed a drain each side of the old track for its whole length, and far enough apart to enable a two-way road to be laid between them. Each drain was 2 ft. 6 in. wide at the top and 2 ft. 6 in. deep. This drainage was an absolute success, and dealt with all later heavy rain. Within forty-eight hours of its completion the mud had dried and a single way Sommerfeld Track was in use on the old alignment, and the 15 km. detour was eliminated. A two-way tarmac road was then built.

Odd Troubles

Americans are far ahead of the British in domestic engineering. They have never had to be economical of water and use far more than we do; so much more than we do that not only must care be taken to provide enough, but extra large drains (by our standards) must be provided to get rid of it.

The Enlisted Man displayed originality in stopping up drains. Examination of a blocked up battery of W.Cs. discovered in the drains four complete folded newspapers, one complete roll of toilet paper, and handfuls of glass wool. How the American airmen managed to get them past the traps of the W.Cs. is an unexplained mystery of "Operation Plainfare." Even the American S.M.O. expressed surprise that their men were tough enough to prefer glass wool to paper.

They use electricity more than we do, and arrive with batteries of refrigerators, coca cola machines, ice cream machines, wireless sets, electric irons, razors, juke-boxes and other mysteries, all of which they proceed to hitch on to the nearest electric wire, with the result that there were complaints of men getting electric shocks when sitting on their beds. Some of the electric shocks were eventually traced to the use for internal wiring of electric cable which was not up to specification. Several hundred metres had to be removed and replaced by sound cable.

The sort of thing which no one foresaw was that when flying several sorties a day to Berlin the aircrews had no time to take off their flying kit, have a meal in the mess, and get on board in time for the next take-off. We had therefore to provide restaurants actually on the edge of the runways. A snack bar was insufficient for the aircrews began to suffer from lack of proper meals; so the restaurants had to have proper cookhouses.

The American driver's truck is to him what her little lamb was to Mary. Everywhere the driver goes the truck is sure to go. He drives it everywhere and at night likes to park it outside his window. So one has to do two things to prevent the whole camp becoming a bog; first provide plenty of roads, and second erect anti-tank obstacles at places where the Station Commander does not want trucks to go.

Things which Helped

The Weather

The weather was abnormally mild throughout the winter. There was no snow until the end of February, and no heavy falls even then. There was no continuous frost. Work therefore continued almost uninterrupted by the weather throughout the whole winter.

Progress Charts

Progress charts were made out in the C.E.'s office for each main subdivision of work on each airfield. On these the date was marked by which all Works Services had to be completed to ensure that the airlift was not impeded. From this final date finishing dates were worked backwards for each item; these dates were those by which the C.E. thought the item should be finished in order to achieve completion of the whole project on time. Labour, stores, and transport had to be provided to keep work going at adequate speed; they were provided with the help of the staff and contractors, and work throughout kept well up to time. Our only failure was on one N.A.A.F.I. where for various reasons we did not manage to replace tents by huts for Christmas as we had hoped to do.

Currency Reform

The Reichsmark, which was in use up to 20th June, was of little value and cigarettes were the common German currency. People just did not bother to work because the R.M. they earned were worth so little. Provided they earned enough to buy their rations, which were not expensive as prices were fixed, they were perhaps not satisfied, but were less dissatisfied to do nothing than to go on working for a valueless pay packet. Contractors for the same reason did not want work. The replacement of the Reichsmark by the Deutsche Mark produced an immediate change. The very first morning of the new money, before any of us had ever seen any, a contractor went to a D.C.R.E. and offered to pay cigarettes for a contract. The previously empty shops miraculously filled with goods, and men began to work to earn Deutsche Marks with which to buy them. Without this timely change of currency we should have had to do more work by G.C.L.O. labour, and less by contract and the contractors more skilful and experienced labour, and would have been very hard put to it to keep to our finishing dates. There was a shortage of actual notes and contractors lost most of their capital on the change of currency. It was necessary to ensure that the German authorities paid contractors' accounts at once, otherwise the contractor would have had no money to pay his labour, and so work would have stopped. This was not always easy as the authorities themselves were short of cash. More could not be printed, for if it were the D.M. would have followed the R.M. and lost its value.

Morale

A big job to be done quickly, and the feeling of all, both British and Germans employed on it, that it was a worth-while job, put everyone on their metal. Daily works worries about leaky taps and inefficient gas stoves could be forgotten while one got down to organizing the biggest task any of us had been employed on since 1945. This acted like a tonic. Eventually we had enough tonic, and were quite ready to revert to our normal diet by the time the operation ended.

Railway Construction Work For "Operation Plainfare"

General

New railway construction work was carried out at Fassberg, Celle and Wunstorf. Requirements were worked out by Q(Mov) and R.E. (Tn) Branch H.Q., B.A.O.R., and the work was carried out by German railwaymen, the Hannover Reichsbahndirektion, under the supervision of the C.C.G. Railway Inspectorate.

The airfields were already rail-served, but existing facilities were only sufficient for the airfield's domestic requirements.

The following new work was required:—

(*a*) Sidings close to the runway, where all wagons of a train could be unloaded at the same time. (A forty-wagon train, holding 600–750 tons (depending on the commodity carried), and occupying about 400 yds. of track, was taken as the standard unit.)

(*b*) Holding sidings alongside the unloading sidings, so that directly a train was unloaded another could be taken from the holdings and out in its place.

(*c*) Alterations to the layout on the airfield, and at the take-off from the normal railway system and certain other stations close by, to deal with the additional rail traffic anticipated.

(*d*) Ancillary construction such as extra sidings for aviation petrol, loco watering points, coaling stages, level crossing gates, lighting, extra railway telephone circuits and additional signalling.

WUNSTORF

Requirements

It was decided to peg out a siding for thirty-five wagons but that no further work should be done. The estimated time for laying this siding, if it were ever required, was given as three to four days for thirty men. Later on 900 metres of track and three turnouts were laid to provide:—

(*a*) A temporary off-loading siding for stone, required for construction of a new hard standings.

(*b*) A short spur to hold six cistern wagons for tarmac purposes. The Reichsbahn did this work in a week.

FASSBERG

Requirements

(*a*) Two new unloading sidings parallel to the runway, the one in prolongation of the line of the other, clear length of each to be 380 metres.

(*b*) A grid of four holding sidings each 400 metres clear length with a backloading spur.

(*c*) A new connexion approximately 1,550 metres long from the new sidings to the line joining the existing airfield sidings to the ordinary railway system.

(*d*) Construction of a loco watering point and loco stage. Work was divided into two phases, to deal with the foreseen traffic.

Phase 1. The new connexion, two sidings of the grid and one off-loading siding to deal with:—

Coal	2 trains each 40 wagons
Petrol	1 train of 20 cisterns
Works Stores train	1 train of 35 wagons
Workmen's train	1 train
Total:	5 trains per day.

Phase 2. The remainder of the requirements, which together with Phase 1 would have to deal with:—

Coal	5 trains each of 40 wagons
Petrol	2 trains each of 20 cisterns
Works Stores train	1 train of 35 wagons
Workmen's train	1 train
Recreational train	1 train (possibly)
Total:	10 trains per day.

Progress of Work

Phase 1. The formation was prepared by removing the grass with a grader while a bulldozer dealt with any further ground irregularities. The track was brought up in complete lengths, and laid down with the aid of a German type mechanical track-layer, which greatly speeded up construction. The work progressed rapidly, aided by good weather, and the first phase was completed without difficulty in nine days.

Phase 2. Followed immediately, again favoured with good weather, and this part of the job, as far as work on the airfield was concerned, was completed in a fortnight. In the meantime an examination of the facilities available for handling trains at Poitzen made it clear that additional facilities would have to be provided there. Accordingly, alterations to the layout of this station were planned, to provide two loops each capable of holding a complete train. This involved the laying or relaying of 1 km. of track and nine turnouts, with consequent alterations to signalling installations. This work at Poitzen took some six weeks. Construction of a water tank, coal stages and lighting facilities on the airfield meanwhile had been carried out, as well as two small extensions to the two petrol sidings and general maintenance work to all existing track.

CELLE

Requirements

Temporary. (*a*) One siding 400 metres long for use as an off-loading point for materials for the new aircraft hardstandings.

(*b*) One further siding to run alongside, and the full length of the existing runway. This was to deal with materials for the reconstruction of the runway.

Permanent. (*c*) A grid of four sidings parallel to the R.A.S.O. area and ending in a 100 ft. loco runround. Each siding was to be 400 metres clear. One of them was to serve as an off-loading point, two were for holding and marshalling purposes and one was to be a through line.

(*d*) An extension of the existing railhead to serve as a loco watering and coaling siding.

(*e*) Three sidings two of which were to serve a P.O.L. off-loading point with a capacity for 200 tankers, the third to serve a coal dump.

(*f*) Certain alterations at the local stations of Wietzenbruch and Celle. These alterations were to include additional loops capable of holding forty wagon trains.

Traffic Anticipated

The traffic to be dealt with by the temporary sidings was given as 1,000 tons of stone per day increasing to 2,000 tons per day. These figures were liable to increase later. (In fact, they increased to approximately 3,000 tons daily; on one particular day 5,000 tons—300 wagons—were dealt with.)

The railway construction work was arranged into two phases.

Phase 1. The two temporary sidings.

Phase 2. The remainder of the requirements.

Progress of Work

From a construction point of view no great difficulties were met with, as the ground was level, but certain difficulty was found in the designing of the general layout, because the R.A.S.O. area was next to the existing railhead which served a supply depot. Here the layout had to be designed to cross the existing track in such a way as not to interfere with the traffic to the supply depot; this was overcome by means of a diamond crossing.

The two temporary sidings were built to time, and work went straight ahead with Phase 2. The temporary sidings were laid along the line of the grid, which was laid with a small break in the track, where the temporary sidings crossed over the layout. As the work progressed on the construction of the runway, the siding serving this area was dismantled bit by bit and the material used in the grid layout.

Whilst the above work was being built, alterations to the local station layouts were in hand. Alterations at Wietzenbruch entailed the filling of an area of ground approximately 400 metres × 10 metres × 1 metre deep, material being obtained from a near-by sand pit.

The P.O.L. and coal sidings, were constructed away from the R.A.S.O. area and as close as possible to the existing underground tanks. The P.O.L. point consisted of two parallel sidings 10 metres apart with off-loading cocks and pipe installations in between these two sidings, which would each hold ten cistern wagons.

Work on these sidings involved crossing two roads and a field. After running alongside the road for approximately 150 metres the track ended in the P.O.L. off-loading site.

In addition to foreseen requirements various other necessities came to light, in the course of the work, e.g., erection of a level crossing, warning signs, and telephone communications, etc. These extra items were completed in time to avoid any hold up of flying.

Later on, when it was decided to increase the number of aircraft operating from Celle, a request was made for a further siding to be taken off the existing R.A.S.O. sidings and run round the airfield to serve:—

(*a*) As a temporary stone off-loading siding for new hard standings.
(*b*) As a permanent additional P.O.L. installation.

This work entailed approximately 1,360 metres of track ending with a loop, each siding 400 metres clear, with a 100 ft. loco runround. Where the track crossed the end of the runway rail level had to be ground level. There was no difficulty in arranging this. The top grass was removed by grader and the track laid in sand.

Safety precautions in the form of Stop and Go lights were installed each side of the runway and close liaison was kept between the Reichsbahn and Flying Control whilst construction work was in hand across the end of the runway, because aircraft were continually landing during work.

Transportation Statistics are given in Appendix "D."

Limitation of Report

"Operation Plainfare" involved the Control Commissions, Air Forces and Armies in both the British and American Zones of Germany. This report deals with the British Zone only. The C.C.G. provided what was to be sent to Berlin for the civil population. H.Q., A.A.T.O., had over-all control of the supplies on the airfields, at each of which was a C.R.A.S.O. The Air Forces flew the stores to Berlin where they were unloaded by C.F.A.S.O. and handed over to the C.C.G. for distribution.

The working of the R.A.S.O. has been described briefly to show its building requirements. The Air Force operations are not included.

The Royal Engineers were concerned only in building work which the R.A.F. Works Organization could not undertake in the time available. The R.A.F. Works Organization did a tremendous amount of work; this work has also been mentioned briefly because it is conceivable that it might all fall to the Royal Engineers were a similar operation to be planned somewhere, where no R.A.F. Works Flights were available.

The article deals only with three airfields in one British Divisional area and does not mention airfields in other districts, of which the compiler has no first-hand knowledge.

It therefore covers only a small part of a vast organization, which after nine months' working was still growing. It is necessary to make that clear, because the British Forces Radio Network (B.F.N.) discoursed on our labours one morning to such good effect that there were several pained telephone messages from our R.A.F. colleagues asking whether we were aware that they too were taking part in "Operation Plainfare," and pointing out that some aircraft were also involved.

Compilation

The paper has been compiled from reports by the Staff of the Chief Engineer, 7th Armoured Division, the D.Cs.R.E. concerned, the O.C., D.E.S.D. and the A.D.Tn., H.Q., B.A.O.R.

Lessons Learnt

There is nothing new in any of these lessons, but they have impressed themselves on the compiler either because they made something go particularly well, or because they were forgotten temporarily.

1. One operation one commander. The solution is to put the resident R.E. Officer "in support of" the R.A.F. Station Commander. The latter is on the spot and has to operate the airlift; he alone really knows what he wants. The R.E.O. cannot be "under Command" of the Station Commander because he might then be employed for tasks which were not in accord with Army/R.A.F. policy, and would have no appeal to his own C.O.

2. Such a project is an Operation and must be dealt with without too strict an insistence on Regulations for Engineer Services (Peace).

3. Rumours that the camp will not be wanted etc., must be scotched at once, otherwise everyone stops working. An ill-timed comment overheard and misunderstood by a workman may have the same result.

4. Plans must be agreed and signed by all concerned and thereafter must be adhered to. "Wouldn't it be better if . . ." must NOT be listened to. Maybe it would have been better if it had been thought of at first and agreed by everyone. A reasonable plan energetically carried out produces a workable answer on time. An amended plan might produce a better result—but too late. If it is too late it is not really a better plan, but it is hard to convince the man who has the brainwave that this is so.

5. A decision once taken at a conference must never be altered for the benefit of one interested party unless all those who took the original agreed decision are consulted. Still less must anyone deviate on his own from the agreed plan, otherwise the man who comes to erect a bridge at an agreed site finds another man has put a railway siding across one of his abutments.

6. Having found out how much accommodation, electricity, water, petrol storage, railway sidings etc., everyone wants, plan it; but have a solution ready when every demand is doubled. Leave room for expansion; even the most expert planner will not think of everything when dealing with a type of operation which is new to him.

7. If you put up anything temporary, even if everyone agrees that that is all they need, have a plan, at the back of your mind, to replace it by permanent work.

8. Stick to standard designs and store lists. Even if they are not quite what you want use them and modify them; it is far quicker and easier than doing everything from the beginning.

9. Plans for anything affecting flying must be signed by someone who flies.

10. If working for an Allied Force or another British Service, there should be a liaison officer of that force or service on the spot. He must be both authorized and willing to give decisions on the spot, without reference to a far away superior.

11. Tippers. Get all you can. You will rarely have enough. You will never have too many.

12. Plant. Use it. It is meant for work, not to stand all painted and shiny in a park. But even if you knock its paint off and make it dirty maintain it properly. So make sure that you have so much plant that you are not forced into working it to destruction.

13. See that stores on delivery to site are what they purport to be. Bell wire when used for electric lighting is liable to turn a warm bed into a hot seat.

14. Remember to give the Resident Engineer stores for his own essential purposes, including shuttering.

15. Do not be so imbued with a sense of urgency that you forget that time old adage—More haste less speed.

16. The success of an Engineer operation depends upon the drive, self reliance, and power of organization of the Royal Engineer officer in charge of the work.

He should be given clear orders and allowed to carry them out in his own way. If his way is a bad way do not waste time trying to change it, change him. (No changes were necessary on these airfields.)

17. The three greatest services that his superiors can do for the man in charge of the job are:—

(*a*) To prevent other people interfering with him.

(*b*) To prevent avoidable changes in plans to meet individual's whims or brainwaves.

(*c*) To see that he gets all the stores, plant, labour, and transport which he needs.

Planning a Future Airfield

An attempt was made to produce some yardstick by which an R.E. officer involved in a similar operation would be able to work out, from the tonnage to be handled, the accommodation, water, electricity, railway sidings, petrol storage etc., required.

Length of flight, day or night flying, the type of M.T., the type of aircraft, R.A.F., U.S.A.F., or civilian scales of accommodation are all variable factors. As a result the figures for the three airfields varied so much that no reliable guidance can be given.

APPENDIX "C"

Some Details of Stores Used

Nissen huts 16 ft. span	1,635
Nissen huts 24 ft. span	81
Nissen huts 35 ft. span	2 (Supplied by N.A.A.F.I.)
Romney huts	9

Tonnage of other stores issued by D.E.S.D. 7,338.

Besides these stores D.Cs.R.E. drew on their own stocks. Bricks, cement and other common building stores were delivered direct to sites, as were trainloads of stone.

The following E. & M. stores were used :—

Generating sets	Ranging in size from 3 to 150 kw.		11
Pumps (water)	3,000 to 6,000 G.P.H.		9
Pumps (sewage)			4
Steam and H.W. boilers	40,000 to 1½ million B.T.U.		54
Transformers 6,000/400/230 volts	400 kva. transformer		3
	250 kva transformer		1
	100 kva. transformer		2
U/G cable	4 core 6 kv.	kilometres	12
O/H conductor	4 wire 400/230 volt	kilometres	10
O/H conductor	two and single phase	kilometres	16
Braithwaite tanks	3,200, 6,400 (two)	gallons	3

Approximate weight of all E. & M. Stores including internal wiring stores, water, sewage main, internal water and sanitary fittings, line poles, cooking equipment etc. 120 tons

APPENDIX "D"

Transportation Statistics

Fassberg

		Track	*Turnouts*
Materials used	Phase 1	3,000 m.	3
	Phase 2	2,340 m.	6
	Poitzen Sta.	1,000 m.	9
		6,340 m.	18

No. of men employed—approximately 120.

Plant :—1 Grader, 1 Bulldozer, 1 Track-layer.

Celle

Materials used :	Phase 1 and 2	8,900 m. of track. 17 Turnouts. 10,000 tons ballast.

Additional Sidings

Materials used	1,400 m. of track. 2 Turnouts.
No. of men employed	125 Reichsbahn. 1 British sergeant on the site who acted as liaison between Reichsbahn and H.Q., B.A.O.R.
Plant	1 Grader. 2 Excavators. 1 Track-laying machine.

CONSTRUCTION WORK IN WINTER WARFARE

By MAJOR S. H. CLARK, R.E.

WINTER warfare envisages temperatures as low as $-20°$ C. continuously and therefore is sub-arctic. At temperatures much below this construction cannot be carried on. The following notes are extracted from experience on the Western front in the 1939–45 war and may be of assistance to anyone who may be required to do this type of work. Chiefly of note is the fact that the special precautions taken against frost are few and relatively simple.

EXCAVATION

Draglines with the bucket capacity of less than 1 cu. yd. are useless in frozen ground. 1 cu. yd. machines will deal with frozen depths up to 6 in. Beyond that depth the ground will have to be broken up first by explosives.

When using a face shovel or back actor the bucket must be at least 1 cu. yd. capacity and it should be used as a hammer to break through the frozen surface by the force of the blow. Used like this approximately 1 ft. 6 in. depth frozen ground can be excavated, it must NOT be Permafrost, and must have soft thawed ground beneath it.

Excavating operations once started must be continuous, for if left overnight the face will become frozen and have to be broken out with explosives. In the same way all earth removed must be cleared away before it has a chance to freeze into a solid lump which will be very difficult to break.

Wet ground although unfrozen when excavated may freeze in the bucket to the cold sides and refuse to come out. This can be got over by electrically heating the buckets.

Concreting.—Aluminous cement requires a temperature above freezing for the first two or three days to enable it to take its initial set. If not, at twenty-eight days it will not attain its expected strength. Having allowed it to get its initial strength special precautions do not have to be taken.

Gravel.—If this has to be washed it must be done in closed premises and it is necessary to ensure that no frozen lumps are left in the material, heating may be necessary to remove this. It is better to crush gravel and stock pile it, if possible before the winter, or to use a crushed material that does not require washing. In any case it is more advantageous to heat the water than the materials as water has five times the heat capacity of the material.

In laying concrete in foundations the base and walls of the excavations must be thawed prior to pouring the concrete. As an alternative, string electrodes may be laid on the ground and the concrete poured approximately two hours after switching on the current.

Reinforcement

Snow and ice must be carefully removed from steel work before concreting starts ; this applies equally to shuttering. It is normal to thaw it with steam, ensuring that the concrete is poured before the damp from the steam can freeze again.

All reinforcement must be kept clear of spattering whilst pouring concrete from above. Small quantities of concrete will freeze at once and prevent a proper bond between the steel and subsequently laid concrete.

Concreting must as far as possible be continuous. If any break has to be made for dinner, etc., the concrete joint must be carefully insulated and reheated with live steam and cleaned before work is resumed. The concreting of columns should not be done from above in long lifts, but from the side in lifts of about eighteen inches, otherwise there is a fear of honeycombing and crazing.

Laying tarpaper or roofing felt over wood shavings is sufficient to insulate the concrete from the cold while seasoning. The insulation must not be laid flat on the concrete as it will absorb moisture and lose its insulating properties.

Slabs

In concreting a slab it may be necessary to keep it heated with panel electrodes. Care must be taken to get a very smooth finish without too much water or slurry on the surface. This ensures good contact between the panel and slab, it also necessitates a slab being cast of such a size that the whole of it can be heated within two hours of starting to pour. Care should be taken if the steel structure is made to take a heating current that all workmen wear insulated boots and gloves.

It is normally impossible to keep shuttering on until concrete has attained its complete design strength. It therefore freezes on removal of the shuttering and has no further increase in strength. In the spring the hardening process continues as the concrete thaws and therefore it must be remembered that it will require watering as in normal curing. If heating is done inside a building the air must be kept at a high humidity and the heat must not be directed straight on to the concrete.

In its frozen state concrete loses moisture. Therefore the longer it has been frozen the more watering it will require to attain its full strength in the spring. The overdrying of the concrete can easily be seen by the occurrence of whitish spots on the surface.

Repairs to Concrete

To ascertain whether concrete has become prematurely frozen in setting the following rule of thumb guide may be taken :—

(*i*) Good concrete is grey.
(*ii*) Prematurely frozen concrete is greenish-grey.
(*iii*) The surface of frozen concrete is covered with white dashes.

To test it a sample should be cut out. Then it will be found that :—

(*a*) If the concrete froze in setting : on heating it acquires the colour of new concrete, crumbles and sticks to the hands.
(*b*) If frozen on the second day : it easily crumbles from a blow with a hammer and has a grey-green tint.
(*c*) If frozen on the third day : it crumbles after several blows with a hammer and has a dark grey or green tint. This may respond to careful treatment and thawing.

Construction

In laying slabs it is a good thing to include in the middle third, at intervals of 3 ft., reinforcing bars ½ in. dia. and 3 ft. long which by redistributing the stresses serve as adequate protection against frost heave.

The foundations must also be separated from the walls so that if severe frost heave occurs subsidence of any one part is independent of the whole building structure.

Laying of tarred, bituminous or asphalt floors does not differ in principle from normal practice. This is because there is no water present. The area to be covered must be cleared of snow or ice, sand laid and heated to 100° C. to ensure that all water is driven off and the binder laid as normally. Extra care has to be taken against loss of heat in bitumen tanks and heaters and laying has to be done rapidly before heat losses render the binder unworkable.

Partition Walls.—In buildings where the concrete has been allowed to freeze the settlement of the foundations must be remembered when it thaws. This will affect the floors and therefore clear gaps of twice the expected settlement should be left between the ceiling and the partition walls.

From the above it can be seen that construction in these conditions is largely a matter of common sense and being forewarned of the likely results of frost and allowing for it. Little specialized equipment or knowledge is required that the average builder does not have, but a study of the affects of frost on ground and building materials will give the engineer a very good idea of what is likely to happen when it freezes and therefore what precautions must be taken to combat it.

MEMOIRS

BRIGADIER-GENERAL A. L. SCHREIBER, C.B., C.M.G. D.S.O.

ACTON LEMUEL SCHREIBER was born on 30th March, 1865. He was the son of the Rev. J. E. L. Schreiber, Rector of Barham, Suffolk, and came of a military family; his grandfather was one of four brothers who fought in the Peninsula and at Waterloo in the 11th Light Dragoons.

Educated at Tonbridge and the R.M.A. he was commissioned in the Royal Engineers in December, 1884, and after the usual course at Chatham he was posted to India, but was shortly afterwards invalided home suffering from dysentery. He served with the 36th Fortress Company at Chatham and Cork and the 38th Field Company at Shorncliffe.

In 1892 he returned to India and was posted to the Military Works Department, but in 1897 he was appointed Assistant Field Engineer with Tochi Field Force. Although there was not much fighting on this operation there was a great deal of sickness as it was carried out during the hot weather. He had been promoted Captain on 1st August, 1893.

The following year, 1898, he returned home and after a short spell commanding " E " Company at Chatham he was posted to command the 12th Field Company at Aldershot and proceeded with that Company to South Africa, but on mobilization Major Graham Thomson was brought in to command.

In March, 1900, he was made Staff Officer to Major C. Maxwell, who was C.R.E. of General Brabant's Colonial Division. Maxwell and Schreiber were specially mentioned in connexion with the successful attack on the Boer position at Labuschagne's Nek and Schreiber was awarded the D.S.O. He was slightly wounded in this action, but he rejoined the 12th Field Company for the advance on Bloemfontein and Pretoria.

Later he contracted malaria and was invalided to Cape Town, but shortly afterwards he was appointed Staff Officer to a Mobile Force under Lieut.-Colonel Bogle Smith.

In August, 1902, he returned to the U.K. and was posted as Staff Officer to the Chief Engineer at Chester. The following year he was appointed Brigade Major at the S.M.E. where he remained for four years until ordered to Gibraltar as Staff Officer to the Chief Engineer and later as C.R.E. He was a keen sportsman and hunted regularly with the Calpe Hunt and rode in the point-to-point races.

In June, 1910, he returned again to the U.K. and was appointed C.R.E. 1st Division, and proceeded to France in that capacity in August, 1914, and was present at the first battle of Ypres and subsequently at Givenchy and Quincy. He was slightly wounded and came home to command the R.E. Training Centre at Newark in May, 1915.

H. L. P. writes: "As C.R.E., 1st Division, Schreiber found himself laying the foundations of the methods of trench warfare, which were being evolved in 1914 and 1915, and was constantly in the trenches supervising these methods.

"His previous record of active service and training in field units made him quite at home at this work.

"His subordinates found him a strict taskmaster, but also realized that he had an extremely kind nature."

Having beeen promoted Brevet Colonel and A.D.C. to the King he was appointed Chief Engineer of III Corps in July, 1915, with the rank of Brigadier-General, and was present at the battles of the Somme, and was awarded the C.B. in 1916.

In 1917 he was appointed Commandant, S.M.E., where he remained till he retired in January, 1920, having been awarded the C.M.G. in 1918.

He married in 1889 Evelyn Amy, daughter of Lieut.-Colonel Darcy Hunt of the Inniskilling Dragoons. She died in 1947. He had two sons who both joined the Royal Artillery, the elder is now Lieut.-General Sir Edmond Schreiber, K.C.B., D.S.O., and the younger was killed at Ypres in 1917.

R.L.B. writes: "I first came under his command when he was C.R.E. 1st Division at Aldershot in 1912, and I joined the 23rd Field Company R.E. as a very young Subaltern. He took us to France in 1914 and remained with the division until the middle of 1915. He was an able soldier and Sapper, a hard taskmaster and strong disciplinarian but eminently just. If one had failed in any way in one's duty the C.R.E. could, in a few biting words, make one feel that one had indeed erred. But he was always ready with praise when praise was due. Off parade he was a genial and cheerful host and he had an unexpectedly warm side to his nature. I well remember a very young subaltern having the temerity, at 6 a.m. on a chilly morning on a divisional exercise, to seize an opportunity of breaking the news to his C.R.E. that he was engaged to be married. Instead of the expected explosion, a twinkle came in his eye, the familiar gesture, hand to mouth, as he sat down on his shooting stick and said, 'Ho! Ho! that's it is it? Well, I mustn't censure you, I married very young myself.'

"Schreiber was a splendid trainer of Sappers and saw a long way ahead. In a divisional exercise, in the summer of 1914, for carrying out a defensive scheme with large working parties, he planned the system of highly camouflaged centres of resistance in depth to which the Army returned in 1918.

"During the dark days of the Ypres Battle in October and November, 1914, Schreiber handled his Field Companies in masterly fashion and many thought that he knew more of the confused situation, through the intelligence he received from his units, and had a greater grip on the defence than anyone in the division.

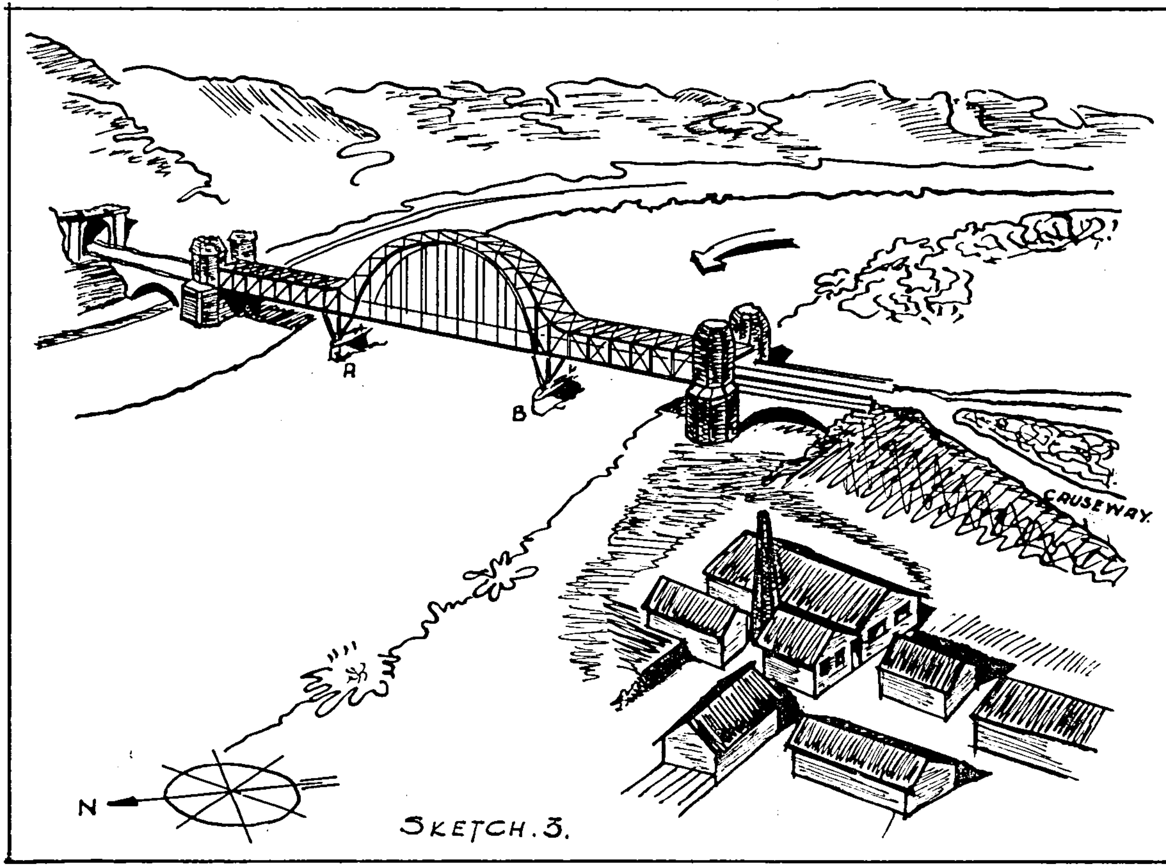
"Later on, in 1915, I was to be his adjutant at the R.E. Training Centre, Newark. His high sense of duty and discipline and great knowledge made an indelible mark on the thousands of officers and men, the 'left-overs' of divisions that had gone overseas, and set a standard which made the tasks of adjutant no sinecure.

"No memoir of Schreiber would be complete without mention of the charming and gracious lady who was his partner. They were a devoted couple and she did much to soften the asperities of his character. A delightful hostess, her warm friendship will never be forgotten by those who were privileged to receive it. Advice she once gave to a young married couple was typical and always remembered. 'Wherever you go settle into your house and garden at once as if you were going to be there for three years at least ; if you don't you will never have a real home in the Army.'"

After retirement he lived at Wickham Market in Suffolk, where he was connected with many public services and was Deputy Lieutenant of the County, a J.P., Alderman of East Suffolk County Council and local Chairman of the Conservative Association.

Shortly before the death of his wife in 1947 he went to live in Devonshire, where he died on 11th January, 1951.

C.C.P.



SKETCH. 3.

Brigadier-General AL Schreiber,CB CMG DSO

Major-General Sir Ernest D Swinton KBE, CB, DSO

MAJOR-GENERAL SIR ERNEST D. SWINTON, K.B.E., C.B., D.S.O.

ERNEST DUNLOP SWINTON was born at Bangalore in India on 21st October, 1868. He was the third son of Robert Blair Swinton of the Madras Civil Service.

Educated at Rugby and Cheltenham he passed into Woolwich in 1886 and was commissioned in the Royal Engineers in February, 1888, being fourth in his batch.

From Chatham, Swinton went to India in 1890: served in the Military Works Department, and was accepted for the Survey of India, but after five years in India reverted to the British Establishment. At home he did regimental duty with the R.E. at Chatham; assistant instructor in survey in 1896; assistant instructor in fortification from 1897 till October, 1899, when he went on active service to South Africa as special Service Officer for railway bridges. In December, 1899, he was appointed adjutant of the Railway Pioneer Regiment, under the command of Major J. E. Capper, R.E. This was a combatant battalion formed from the technical men and tradesmen who, as *uitlanders*, had been expelled from Johannesburg by the Transvaal Government. It was 1,100 strong, and most of its officers were either civilian engineers or mine managers. In 1900 Swinton obtained command of the battalion. Later on in the war, he commanded three other battalions which were raised. He returned home in 1902 when the regiment was disbanded on the conclusion of peace, and was appointed Staff Captain under the Inspector General of Fortifications at the Horse Guards.

For his services in South Africa he was awarded the D.S.O.

It was what he had observed in South Africa that caused Swinton in 1903 to write the tactical pamphlet *The Defence of Duffer's Drift*. This became a classic, unofficial textbook in the British and American armies, and was translated into Spanish, Urdu and, it was believed, also into Japanese. It was largely based on the well-known reluctance of the British Army to dig itself in and undertake defensive measures. Only last year a new edition was brought out at the request of the late Field-Marshal Earl Wavell, who wished to send copies of it to the young officers of his regiment serving in Germany.

In 1907, he took up the post of Chief Instructor of Fortification at the R.M.A. Woolwich, from which he moved on in 1910 to be Secretary of the Historical Section of the Committee of Imperial Defence.

He was awarded the Chesney Gold Medal of the Royal United Service Institution for his work on the official Naval and Military History of the Russo-Japanese War. When Winston Churchill received the same award in 1950 he paid a special tribute to Swinton.

It was before and during his time at the R.M.A. that he wrote, under the pen name of "Ole Luk-Oie," the set of military stories called *The Green Curve*. These showed great vision and imagination and made Swinton well known as a military author. The book was translated into French.

Amongst these stories one, "The Joint in the Harness", was remarkable as being the first detailed description of bombing from the air. It was written in 1907, soon after Swinton had learned what the Wright brothers had achieved in America.

In August, 1914, he was mobilized as Deputy Director of Railways, B.E.F., but after a month was sent out by Lord Kitchener to G.H.Q. France, to act as the official correspondent with the B.E.F. By the newspapers he was known as the "Eyewitness". This work Swinton, with two officers to assist him, continued till July, 1915, when the professional war correspondents were allowed to go to the Front.

In view of recent developments, it is instructive to note that for ten months the whole of this work of information was carried out by three officers. During the second World War, at the beginning of 1944, the War Office alone had over 500 people engaged in the duties of information and public relations.

Acutely conscious of the value of psychological warfare, he was the first to start carrying out propaganda by leaflets dropped over the enemy from the air. As early as October, 1914, he had 25,000 copies of a leaflet written by himself dropped over the German front-line troops in Flanders and France. But the military authorities in France lacked the vision to see the value of this psychological weapon, Swinton's action was not approved, and he was not permitted to continue it. Towards the end of the war the practice was re-started on a large scale under the control of Lord Northcliffe and Lord Beaverbrook—with very great effect.

In October, 1914, Swinton conceived the idea of the Tank (his own word) as a life-saver to enable our infantry to overcome the enemy's wire and machine-gun defences in our repeated efforts to break through their lines.

He met with little encouragement, but on returning to London as acting secretary of the C.I.D. in July, 1915, he was well placed to push his views. The result of his effort was that tanks were constructed, a unit to man them was raised under Swinton's command, and a small number of tanks took the field on 15th September, 1916, during the battle of the Somme.

Swinton was against this disclosure of the existence of the new arm and expressed his opinion strongly. In this all those responsible for the conception and creation of the new weapon agreed. Swinton, who had raised and commanded the Tank unit, then called the Heavy Section Machine Gun Corps—the forerunner of the Royal

Tank Corps and the parent of the present Royal Armoured Corps—was not allowed to command it in the field, being judged by Sir Douglas Haig to be too old at 48—a decision had been made that no one over 35 should be given command of an Infantry Battalion. As a recognition, however, of what he had done for the introduction of a new arm he was, in 1916, gazetted a Brevet Colonel.

It does not redound to the credit of the authorities of the day that after November, 1916, when Swinton handed over the command of the H.S.M.G.C., he, the creator, was never asked one single question as to the tactics or design of the tanks or the rôle of mechanical warfare generally, by the War Office or the General Staff.

He returned to the War Cabinet Secretariat, and served on it till the end of the war, twice accompanying Lord Reading to the U.S.A., where he spent three months touring the country, speaking most successfully for the third Liberty Loan.

In 1917, he received a Civil C.B. for his work in the C.I.D. and War Cabinet Secretariat.

In November, 1918, on demobilization, he was appointed to the Demobilization Branch of the Ministry of Labour as Controller of Information and Publicity.

In May, 1919, he retired and took up the post of Controller of Information in the department of Civil Aviation at the Air Ministry. Here he made efforts to help the aircraft industry take advantage of the chance of playing a great part in the coming development of aviation all over the world. But the many aircraft manufacturing firms were unwilling to merge their separate interests into a joint national effort.

In 1920, while at the Air Ministry, he put forward to Mr. Churchill, then Secretary of State for War and Air Minister, a proposal to save money by replacing the large numbers of ground troops then holding Mesopotamia by much fewer holding defensive posts, connected by mechanical fighting vehicles on the ground and by the R.A.F. in the air. Shortly afterwards this scheme was put into operation and the whole of the garrisoning of the country was entrusted to the R.A.F.

He resigned his post with the Department of Civil Aviation in 1921. From 1922 to 1925 he worked for Mr. Lloyd George, collecting material for his war memoirs.

In 1923, through the instrumentality of Lord Derby, then Secretary of State for War, he was created K.B.E. as a recognition, seven years after the event, of the work he had done for the nation in the introduction of the tanks.

It is a curious sidelight on the way in which honours are distributed that for his work on the C.I.D. and War Cabinet, all of which was of a military nature, he received a Civil C.B. More curious still, for the conception of the tank he was created a Civil K.B.E.

In 1925 he was elected Chichele Professor of Military History and War in Oxford University, and a Fellow of All Souls College. He was twice given an extension of the tenure of that Chair, finally vacating it on reaching the age limit in 1939. On his retirement he was elected a Distinguished Fellow of his College for life.

In 1932, under the title of " Eyewitness " he wrote the account of his experiences during the first two years of World War I. This book contained the narrative of the birth of the tank.

Shortly after the outbreak of the second World War, he broadcast for four months the weekly War Commentary for the B.B.C. His talks were very instructive and immensely popular.

From April, 1940, he took up journalism. In addition, to contributing occasional articles on military subjects to the papers, he wrote every week a military commentary for the *Empire News*, a Sunday paper with a large circulation.

From 1934 to 1938 he was Colonel Commandant of the Royal Tank Corps, which had developed from the unit he had raised in 1916 ; and he had the honour of leading the tanks past King George V at the Royal Review in 1935.

In 1936, he attended the Nazi Party Festival at Nuremburg, as one of the honoured guests. He was deeply disturbed by his suspicions of what the Nazis intended, whilst we in this country were dreaming, obsessed by appeasement.

In addition to his books above mentioned, he edited the following translations from the Russian by Colonel S. B. Lindsay : *The Truth about Port Arthur*, by E. K. Nojine, and *The Russian Army in the Japanese War*, by General Kuropatkin. He also translated from the French *King Albert in the Great War* and *La Croisière Jaune*—an account of the Citroën Central Asian Expedition, which appeared under the title of *An Eastern Odyssey*. He published also in 1915, a second collection of military stories, much on the lines of the *Green Curve*, called *The Great Tab Dope*. He had many connexions with France and was a Commander of the Legion of Honour.

He married Grace Louisa, daughter of Sir Edward Clayton in 1897, by whom he is survived. He had two sons and one daughter.

He died at his home in Oxford on 15th January, 1951.

In a short obituary notice published in *The Times* of 15th February, 1951, " Archimedes " says of him " His was one of the happiest of lives : he was too modest to be a ' climber,' too even-minded to be ambitious. One can do a lot of good in this world if one does not mind someone else taking the credit for it."

C.C.P.

COLONEL C. TOPHAM, O.B.E., M.C.

CLEMENT TOPHAM, who died on 4th November, 1950, at the early age of 53, was born in India on 28th December, 1896. Educated at Yardley Court, he was commissioned into the Royal Engineers from Woolwich on 19th February, 1916, and embarked for the B.E.F. in France some five months later. He there joined 4th Divisional Signals and whilst with them he was awarded the Military Cross for his gallantry and energy in laying out signal lines at all hours of the day and night during preparations for an allied counter-attack. He continued to serve with Signals in Ripon, and later in the Army of the Black Sea, until recalled to Cambridge in September, 1921, for his Supplementary Course. A course at the R.E. Mounted Depot led on to his posting to 9th Field Company, where he remained for nearly two years, before being appointed Adjutant of 27th (London) A.A. Battalion R.E. (T.A.).

In 1930 he went to India for five years, attending the Staff College during this period, and on reversion to the home establishment he was posted to Western Command.

In May, 1939, he was given command of the 2nd Field Company in Egypt, and on the outbreak of war he relinquished this to become D.A.A & Q.M.G., B.T.E., a post which he held for nearly a year. He then started a series of appointments as C.R.E. Works which culminated in February, 1942, in his selection as D.C.E. Western Desert with the acting rank of Colonel. He was Mentioned in Despatches in 1941 and awarded the O.B.E. in 1943.

In March, 1944, he reverted to Southern Command for duty, first as Chief Engineer, Hants and Dorset District and later as Chief Engineer, Salisbury Plain District.

About two years later he went to Nairobi as Chief Engineer, East Africa Command, where he remained until his retirement in 1949.

He leaves behind him a great number of friends, to whom he was endeared by his frank simplicity of outlook and consistent generosity and friendliness.

He is survived by his wife and two daughters.

A.D.C.

CORRESPONDENCE

THE WEIGH-BATCHING OF CONCRETE

From :—Major A. F. Allen, M.I.C.E. (late R.E.),
Vernon House,
Briton Ferry,
Neath, Glam.

To :—
The Editor, *R.E. Journal*,
Chatham, Kent.

DEAR SIR,

With reference to the article by Major E. H. Jenkins on "The Weigh-Batching of Concrete" it is stated therein that "On large works weigh-batching offers the only satisfactory means of rapidly and accurately measuring the large quantities of material involved and is now a normal practice."

The reference to "accuracy" is only correct if the machines are receiving regular and careful maintenance ; in particular the cement weighing buckets should be frequently checked by adding weights up to the full amounts ever required.

If these calibrations are plotted out to the full limit it is quite possible for differences to be positive up to (say) 400 lb. on the dial and negative beyond (say) 600 lb.—or of course any other variation.

The moral, therefore, is that to obtain the highest efficiency from weigh-batching machines maintenance and checking should be made a regular "drill."

Yours faithfully,
A. F. ALLEN.

From:—Major E. H. Jenkins, M.R.San.I., R.E.,
C.E. Wing, S.M.E.,
Kirkee, Poona, 3,
India.
3rd April, 1951.

DEAR SIR,

I am in complete agreement with Major Allen as to the necessity for regular and adequate maintenance of weigh-batching plant but must point out that my article was not intended as, nor is, a comprehensive treatise in weigh-batching. Its main objects were :—

(*a*) to endeavour to show that weigh-batching can, with advantage, be used in the smaller works, and

(*b*) to compare it with volume batching to the detriment of the latter.

To my mind, and I hope Allen will agree, weigh-batching offers such advantages over volume batching that any engineer having tried it out will never, except for the very smallest and most unimportant works, revert to volumetric methods.

Incidentally, at a meeting of the Reinforced Concrete Assn. in London on 10/3/48, Dr. L. J. Murdock presented a paper on concrete control which was later published in the *Reinforced Concrete Review* of January, 1949, and various other technical papers. This contained details of defects likely to occur with weigh-batching plant and the errors in calibration arising therefrom. This paper may possibly be of interest to Major Allen and other readers.

Yours faithfully,
E. H. JENKINS.

BOOK REVIEWS

FORTRESS TOBRUK

By JAN YINDRICH

(Published by Ernest Benn Ltd., London. Price 8s. 6d.)

A siege lends itself to literature and the scene, being static, allows the reporter to get an eyewitness story after every event even if he has not himself seen it. Consequently in an account of the Siege of Tobruk in 1941 one expects something Homeric. There were, indeed, Homeric episodes and occasionally they are treated in Homeric vein. But mainly they are treated in the rather sickly way of war-time reporting, when everything done by our side is magnificent and everything done by the enemy is the reverse. One of the best chapters is the Epilogue contributed by Generalleutnant H. Von Ravenstein, wherein you see something of the enemy point of view.

In 1941 this would have been hailed as a great book, for it was quite an achievement for a newspaper man to get into the fortress, and then to stay there and report the scene when he had a chance to get out: but not to-day.

However, *Fortress Tobruk* will conjure up a few scenes for those whose memories are dim; and that is the spirit in which to read it.

M.C.A.H.

WAR IN THE SOUTH-WEST PACIFIC
SAIPAN AND PELELIU

(Published by Historical Division U.S. Marine Corps)

The United States Marine Corps have produced seven operational monographs on their battles in the South-West Pacific, of which the two now under review are the latest.

The invasion of Saipan was undertaken by the Fourth Marine Division (Reinforced). The first landings were on 15th June, 1944, and the operations ceased officially on 1st August. It was the supreme challenge to the inner defences of Japan. The Japanese had little option but to fight it out, and this book shows how the Americans beat the Japanese in their own jungles and swamps. It is a tale of fine achievement.

Somewhat similar is the tale of the First Marine Division (Reinforced) at Peleliu beginning on 15th September, 1944. Here, however, the Japanese "made no suicidal *banzai* charges. . . . He nursed from his inferior strength the last ounce of resistance and delay, to extract the maximum loss from his conquerors."

It is to be hoped that a volume will be produced that relates each of these operations, described in the series of monographs, to the whole strategy. As they stand, and a previous monograph in the series has also been reviewed in these pages, each one appears to have been written independently of the others. While this is necessary to do justice to the troops involved, and is, in its way, convenient, it fails to give the reader, unfamiliar with the theatre, much idea of how these various campaigns were co-ordinated, or indeed, why they took place at all.

Here are two excellent studies of the "trees." We now want a picture of the "wood."

M.C.A.H.

BALL OF FIRE

By Anthony Brett-James

(Published by Gale & Polden Ltd. Price 25s.)

Ball of Fire, though you might not guess it unless you were in the know, is the history of the 5th Indian Division in the 1939-45 war. It takes its title from the divisional sign—a red ball on a black background.

The author, Mr. Anthony Brett-James, has made an excellent job of a good subject. He has produced a history that is readable ; and it is accurate as far as one can see. There are many passages from war diaries, quotations from personal letters, and anecdotes contributed by eye-witnesses of events. There are also some reflections by divisional commanders on a fascinating theme—command in battle.

The story takes one through the Sudan, Eritrea, Abyssinia, Cyprus, the Desert, Iraq, India, Burma, Malaya and Java, for the division is one of the few that fought the Germans, the Italians and the Japanese. It took part in some of the most famous battles : Keren and Knightsbridge (incidentally the C.R.E's. account of the withdrawal that followed—he likens it to a "gold rush"—is very vivid), Alam Halfa, Kohima and Imphal. The author contrives to get the "feel" of these battles most convincingly. He gives pen portraits of the "characters" in the division. Those of officers I know are accurate enough, and one may reasonably assume that the others are no less true to life. There are photographs of many scenes and photographs of the divisional and brigade commanders.

The foreward is by Earl Mountbatten of Burma.

The "Surrender with Honour" of the Duke of Aosta in May, 1941, to General Mayne, commanding the division, is a curious episode : the old-world courtesies between the principals being tinged with comic opera in the style of the Gondoliers. It is in singular contrast with the tone of the final Japanese surrender and the reoccupation by the division of Singapore in 1945. Much water had flowed under the bridge in the years between—and blood too, which makes a difference.

It was a fine division, this 5th Indian Division, and those who served in it will approve this history.

M.C.A.H.

CONTRACTORS' PLANT

By H. O. Parrack, A.M.I.Mech.E.

(Published by Sir Isaac Pitman & Sons Ltd. Price 25s.)

The title of this book is apt to be confusing as it does not deal with plant as such. It is confined mainly to the organization of personnel and workshops to ensure that the best value is obtained from it. Mr. Parrack has had a great deal of experience in this field, and presents a good case for the control of plant, at all stages from purchase to disposal, by a mechanical engineer. There is no doubt that most of his proposed organization would lead to increased efficiency. In some cases, however, power of control seems to be usurped unnecessarily, and would not be likely to meet with the approval of a civil engineer. Whilst written primarily for the civil engineering contractor, much of it makes very worth-while reading for the military engineer if for "increased profit" we substitute "time saved."

A.R.T.

SITE INVESTIGATIONS

(Civil Engineering Code of Practice No. 1 (1950) issued on behalf of the Civil Engineering Codes of Practice Joint Committee by the Institution of Civil Engineers. Price 10s.)

This is the first of a series of codes of practice in course of preparation by a joint committee convened by four of the leading professional engineering institutions and dealing with civil engineering practice. A draft copy of this code was reviewed in the *R.E. Journal* for June, 1948. Comments and suggestions made by individuals and professional and industrial organizations have now been considered by the code committee and taken into consideration in the code as now published. Though responsibility for its compilation has changed since 1947 when the draft code was issued, the general form is on similar lines.

The code deals with the investigation of the suitability and characteristics of sites as they affect the design and construction of civil engineering works. It summarizes in a convenient form the information it is desirable to obtain, but has been drawn up for conditions existing in the British Isles. Occasional reference is made, however, to conditions existing in other parts of the world.

Though this code deals with permanent construction and hence is of principal application to peace-time practice, the R.E. officer will find it gives detailed consideration to both soil and geological conditions in connexion with foundation problems. An excellent appendix deals with the application of geology to engineering and provides an interesting and logical approach to the subject. Other appendices deal with soil classifications for roads and airfields, field tests, methods of collecting, handling and testing soil and rock samples, and geophysical surveys.

A code of practice is said to represent a standard of good practice and take the form of recommendations. This one presents a wealth of relevant data and information to any officer who is called upon to investigate the practicability of any project involving civil engineering techniques.

M.B.A.

THE COMPACTION OF SOIL

A Study of the Performance of Plant

(Road Research Technical Paper No. 17. Published by H.M.S.O. Price 1s. 6d.).

This Road Research Technical Paper deals with an experimental study of the compaction of five different soils—heavy, silty and sandy clays, a sand and a gravel-sand-clay—by 2¾ ton and 8-ton smooth-wheel rollers, club-foot and taper-foot sheepsfoot rollers, and a frogrammer.

The results of this experimental study are clearly put forward in the form of tables and graphs, which show the effect of the various types of compacting plant on the different soils at varying moisture conditions.

One conclusion drawn concerns the sheepsfoot rollers. They have very poor performance on granular soils and their optimum moisture contents in clay soils would rarely be obtainable in the British Isles. This indicates that the sheepsfoot roller is more suitable for use in dry countries, but is less satisfactory than other rollers in this country.

It is also shown that none of the rollers are able to effectively compact to a greater depth than 6 in. and that from 4 to 16 passes of the smooth-wheel and pneumatic-tyred rollers are required for effective compaction.

Because this paper only deals with those soils commonly found in the British Isles, its use to the military engineer is restricted. However, it draws fundamental theories on soil compaction and it is recommended for reading by all R.E. personnel concerned with the construction of roads and airfields.

The paper contains 8 pages of illustrations and 24 graphs.

W.A.M.

PROCEEDINGS OF THE SCIENTIFIC AND TECHNICAL CONGRESS OF RADIONICS AND RADIESTHESIA

(Published by the Congress Committee, 8 Ashburn Gardens, London, S.W.7)

The first British Congress of Radionics and Radiesthesia was held in London from 16th to 18th May last year. It had been organized by a committee, representing three scientific bodies, the British Society of Dowsers, the Radionic Association and the Psychosomatic Research Association.

Leading lights of these societies had felt that the time was ripe for a further advance against the indifference and ignorance of the general public, and their well-known concomitants, and that strength for such advance would be gained by joining forces.

Accordingly a committee of eleven was chosen from all three societies, including a large medical contingent, and bristling with degrees and other distinctions.

This committee recommended that a congress be called together in London of the members of all three societies and of others interested in radionics and radiesthesia "with the object of assisting the advance and co-ordination of these subjects in relation to physics, biology, electronics, radiology, geophysics and medicine, to clarify and integrate physical and instrumental data, and to encourage technical developments."

This formidable task thus fell upon the shoulders of the chairman and his committee, either as a whole, or individually, according to enthusiasm and self-sacrifice. The *Proceedings* just published are striking evidence of the committee's success in balancing and reconciling interests, and in fulfilling the requirements of their terms of reference.

The programme of the congress consisted of twelve lectures, followed generally by a discussion, while demonstrations were relegated to a third (evening) session. These lectures (excepting only Dr. Campbell's Applied Radionics, which was unfortunately not recorded) are given *in extenso* in the *Proceedings*, and are already so much condensed as to be, within the limits of a short review, hardly amenable to further condensation.

It must suffice here to record what each lecture was about, without attempting a summary. Titles and authors run :—

"Vis Medicatrix Naturae" (Dr. Westlake) ; "Research Work on the Human Electromagnetic Field" (Dr. E. A. Maury, of Paris) ; "The Earth and its Effects on Life" (H. Larvaron) ; "Detection of the Radiesthetic Stimulus" (Dr. Ash) ; "Physical Investigations in Radionic Research" (Dr. Corté) ; "Aspects of Radionic Research" (G. de la Warr, Esq.) ; "Radiographic Prospection for Underground Water"

(Cecil Maby, Esq.) ; "The Gravitational Wave" (Rev. A. J. K. Glazewski) ; "Phycho-physical Effects of Conducted Radionic Emissions from Drugs and Bloods" (L. E. Eeman, Esq.) ; "New Conceptions in Nuclear Physics" (Dr. R. C. Thornton) ; "Short Waves and Human Resonance" (Dr. W. E. Arnould-Taylor).

Treating these as a whole they cover the interests of all three societies concerned, and will undoubtedly contribute towards the incorporation into scientific thought generally of many truths at present only partially realized.

It is remarkable that such a collection of scientific lectures affords evidence again and again that the so-called conflict between religion and science is dead. The ideas of the general public on science fifty years ago appear to have been based too much upon the materialism read into Darwin's *Origin of Species*, and deduced from Dalton's atomic brick theory. In the later light of Rutherford's planetary atom, with its comparatively vast empty spaces, people nowadays may be less certain about the necessity of believing only that which they can see.

The field of science increases daily, and its possibilities widen with every advance in instrumental technique. Workers in the field are therefore needed in order to educate the public, and this includes overcoming the public's disconcerting indifference, active or passive. Meanwhile science relentlessly moves forward ; and we find barriers going down almost unnoticed. Especially is this so in therapeutics.

The *Proceedings* are attractively put up in pale blue and silver, printed in good type and on good paper. There is evidence of careful proof-reading since, apart from certain spelling mistakes, printer's errors are obvious and not important. The book goes into its place as a text-book, and one looks forward already to the Proceedings of the second Congress.

As the book has been printed privately it can only be obtained direct from Colonel A. H. Bell, York House, 6 Portugal Street, London, W.C.2. Price 7s. 6d.

F.A.I.

DRAINAGE (SEWERAGE)

(Civil Engineering Code of Practice No. 5 (1950). Published by The Institution of Municipal Engineers. Price 15s.)

This Code of Practice deals with the conveyance of sewage from the curtilages of houses and other premises to the sewage treatment works. It indicates good practice in average conditions, and takes the form of recommendations. Observance of this code or any other code in the same series does not obviate the necessity for conforming to the relevant provisions of statutory bye-laws.

Of particular interest to the engineer officer, is the section dealing with preliminary site investigations. All the site factors are covered in a simple and concise manner, as are the definitions of technical terms. Standard definitions in this field were long overdue.

It is interesting to note that the old standard of 30 gallons per head of water consumption per day has been increased to 50 gallons, due to the higher standards of hygiene and personal cleanliness now prevailing. This increase in consumption is, however, offset in the aggregate, by the tendency to family limitation in this country.

A most useful section of the code deals with the choice of sewerage systems; very clearly describing what the "separate," "partially separate" and "combined" systems of sewerage are, and making recommendations in each case.

In the section on general design, the layout of sewers and the factors governing their size and shape are dealt with in some detail. The code admits the modern tendency to omit intercepting traps before house connexions into the main sewer. On these grounds it is recommended that sewer ventilation be on a scale less than that formerly considered necessary.

For the executive there is a section on the construction of sewers. This section covers (in considerable detail) all the operations from setting out to the restoration of trench surfaces.

The design and construction of manholes, pumping stations and mains, and the use of tidal outfalls are clearly demonstrated.

The whole of the text of this code is amplified by sketches and drawings forming end papers and it is recommended as an essential reference book, to the engineer officer concerned in any sewerage project.

R.C.N.S.

THE DESIGN OF PRISMATIC STRUCTURES

By A. J. Ashdown, A.M.I.Struct.E.

(Published by Concrete Publications Ltd. Price 8s.)

The graceful sweep of a reinforced concrete roof, consisting of a thin arched shell covering an apparently impossible span, is a familiar and encouraging feature of modern architecture. The design and placing of these curved slabs, however, is a difficult, complicated and expensive business. If, instead, we use flat slabs, inclined at an angle at their longitudinal junctions, both the shuttering problems and the designer's nerves are eased, and the effect is no less pleasing. This form of construction is known as prismatic, "faltwerke," or "hipped plate."

Mr. Ashdown's book deals with the analysis of prismatic structures by a method of progressive relaxation analogous to the method of "fixing moments" used in an ordinary indeterminate framed structure. Design practice hitherto has been to consider only the effect of transverse bending in the slabs, with a bit for luck to cover the undetermined longitudinal stresses between the slabs. Mr. Ashdown claims (and who will dispute it?) that his complete analysis enables more economical design, and that it is, in fact, justified by experiments on models. The book covers single-bay, multiple-bay, and continuous cases, with a chapter covering asymmetrical buildings and sloping ends. Beyond this, imagination must surely boggle.

The military application of this work is, to say the least, doubtful. Nevertheless, for the successors of the Sappers who designed the Albert Hall, this well-written book provides a ready solution to an extremely advanced problem. For myself, I confess to prefer:

> "A chart they could all understand,
> A perfect and absolute blank."

D.A.S.

TECHNICAL NOTES

THE MILITARY ENGINEER

(Published by the Society of American Military Engineers)

January–February, 1951. "Engineer Equipment for Air Transport." COLONEL O. B. BEASLEY, Corps of Engineers.

The author, head of the Engineer Research and Development Laboratories at Fort Belvoir, considers Air Transportability to be one of the primary considerations to-day in the design of equipment for military purposes. This applies also to the so-called heavy construction equipment such as tractors, dozers, cranes, scrapers, graders, power-shovels and allied items. After continuous research and experiment which commenced shortly after the outbreak of the last war, a complete new range of earth-moving and other engineer equipment had been developed to a weight limit of 16,000 lb. for air transport. In general the lost advantage of weight has been made up by speed of operations and a shorter life, compared with commercial models, has been accepted. To facilitate mass production, wherever possible, standard and commercially available lightweight designs have been selected, but in cases like tractors special designs expressly for air transport have had to be developed. A series of twelve excellent photographs of typical earth-moving equipment illustrates this article, and includes one of a 5-ton road roller fitted with hydraulically operated retractable wheels. Not only is this suitable for air transport at a weight of only 10,400 lb., but with its pneumatic road wheels down gives a road roller capable of being towed at normal road transport speeds without the necessity of a low-loading transporter. The 125 h.p., rubber-tyred, air transportable tractor at 16,000 lb., is provided with ballast tanks over the driving wheels to increase traction where necessary. Another excellent photograph shows the D-4 crawler tractor-dozer, at 15,315 lb., moving under its own power into the cargo hold of a Fairchild C-119 Packet.

March–April, 1951. "Atomic Bomb Shelters." ARSHAM AMIRIKIAN.

The provision of atomic bomb shelters for a community involves a huge construction task, its success will depend on ability to make optimum use of available materials and labour in the limited time available. The author's personal view is that precast reinforced concrete is the best medium, and that in view of the vast quantities required (*a*) the scope of protection to be given should be restricted to rule out an unqualified assurance of safety and admit the possibility of danger as a calculated risk and (*b*) the basis of design should include the full development of the strength of the structure, not only through the normal elastic range of the materials, but beyond their yield point to utilize the plastic range and permit very large deflections under blast loading, where the duration of the pressure wave is very short.

A concrete shelter designed on these lines will accordingly suffer considerable damage, but will still serve its protective purpose. The anticipated damage will be in the form of extensive cracking, spalling and local fractures which may subsequently be repaired. Where it is considered desirable to reduce the extent of induced damage, the permissible deformations may be limited to a more conservative value of say 3 per cent elongation of reinforcing bars. For a simple supported member an average strain of this magnitude will result in a modest deflection of about one-tenth of the span length.

These views on design offer refreshingly interesting and economical possibilities, but before the reader rushes to apply them to his own housing problem it should be remembered that under ordinary load conditions, such as dead, live, snow, and wind the additional strength which may be developed in a member or framing beyond the elastic range of strain is relatively a small percentage of the total resistance. This is not true, however, under blast loading, where the duration of the pressure is very short, the intensity rising sharply to a maximum then dropping to zero. In this case, the greater part of the required strength in the resisting member may be developed by plastic yielding. This is a simple corollary of the principle of work or energy which may be stated : for a member of given mass, the greater the deformation due to an impulse or blast loading, the larger is its resistance or energy absorption capacity.

The author then considers various types of r.c. framing necessary in the area bounded by a circle of $\frac{3}{4}$ mile radius, having as its centre the assumed target or ground zero of the air burst bomb (20 kilo-ton at 2,000 ft.). Using a pressure of 51 p.s.i. at ground zero, and peak over-pressures due to reflection of intensities three times those of initial values at various ranges, the following thicknesses for slab and earth cover are recommended :—

Distance from target (miles)	$0-\frac{1}{4}$	$\frac{1}{4}-\frac{1}{2}$	$\frac{1}{2}-\frac{3}{4}$
Thickness of r.c. slab (inches)	4	3	2
Thickness of earth cover at crown (inches)	36	24	12

The reinforcement of the slabs will consist of 2-in. square wire mesh of gauge varying from 6–10. For a shelter of 20 ft. span a 4 × 12 in. rib section will be adequate.

The earth cover is required for protection against nuclear radiation, beyond $\frac{3}{4}$ mile it can be dispensed with. The design is a ribbed-shell circular frame or the precast concrete version of the well-known "Quonset" hut. The arch is formed by two segments, joined together at the crown by bolting, and similarly anchored to a poured or pre-cast concrete foundation. Ends are of flat ribbed panels. Concrete floor is optional. In cross-sectional detail, a typical arch segment is composed of a thin shell stiffened by two edge ribs and a series of cross ribs which divide the slab into approximately square sub-panels. The width of the segment may vary from 2 to 4 ft. At ranges of over a mile from ground zero the panels may be reduced to thin slabs of not more than $1\frac{1}{2}$ in. thickness, similarly stiffened by ribs. This excellent article is very well illustrated with a variety of alternative designs.

PRE-TENSIONED CONCRETE

(Part II of an article by Dr. K. Billig, A.M.I.C.E., M.I.Struct.E., M.Am.Soc.C.E., published in *Civil Engineering and Public Works Review* for March, 1951)

The employment of concrete structural members in which the tensile stresses are reduced by pre-compression is now well known as "prestressed concrete." This article, on the other hand, deals with pre-tensioning for use in compression members and pre-bending for members subjected to bending. By a combination of pre-tensioning and pre-compressing in a member subjected to simple bending, this method can result in the reduction of the concrete stresses over the whole cross-section to zero, for any loading stage specified. This loading stage will normally be that of the average live load and as production is arranged in such a way that the pre-stressing moment and the dead weight become effective simultaneously, they approximately cancel each other out. The dead weight can therefore be high and unsupported spans can be of great length.

The method of pre-tensioning consists of a series of hollow steel struts bonded to the concrete and temporarily compressed by means of cables running through them. The compression applied by these cables is progressively released as compression is applied by normal methods to the tension side of the members.

The article concludes with some notes on the application of the method to gravity dams in which pre-compression of the up-stream face and pre-tensioning of the down-stream face can result in the reduction of the importance of dead weight and hence opens up the possibility of hollow dams.

SULPHATE SUSCEPTIBILITY OF PORTLAND CEMENT

(*Civil Engineering*, dated December, 1950)

A new approach to the question of tests to determine the susceptibility of Portland cement to attack by sulphates has been developed in the U.S.A. by the National Bureau of Standards.

Former methods involved tests on bars or slabs of cement mortar, but were necessarily lengthy and the physical character of the test pieces tended to affect the results.

The new method is a test on a sample of the cement itself, which is adjusted to a known sulphate content and continuously shaken with a saturated lime—water solution. The difficultly soluble calcium sulphoaluminate is formed from the sulphate and aluminates and a measurement of the amount of sulphate removed from the solution is made after six hours. This quantity is expressed as a percentage of the sulphate originally in the cement and is designated "sulphate reaction value."

Values so far obtained for a large number of cements show close agreement with long-term observations on the corresponding mortars and concretes.

TENSION CABLE DREDGER

(*Civil Engineering* dated October, 1950)

Some particulars are given of a tension cable dredger which appears to combine the best features and advantages of slack line cableways, power drag scrapers and tautline cableways.

A trolley carrier is supported on a tension cable and the scraper bucket load cable passes through this trolley carrier.

This enables the bucket to have a long contact with the ground and at greater depth than would otherwise be possible. Underwater working is also put on a profitable basis.

When the bucket leaves the ground it comes up to a vertical position, with the cutting edge on top, so preventing spilling. On reaching the trolley carrier it releases a catch and both trolley and bucket proceed together till they reach the dumping position.

Full particulars are given in F.I.A.T. Final Report No. 1290, *The Tension Cable Dredger*, price 3s., from H.M.S.O.

THE BAILEY BRIDGE IN CIVIL ENGINEERING

(*The Engineering Journal*, dated October, 1950)

The military engineer will probably be interested to hear that his civilian opposite number is making good use of the Bailey bridge. A total of more than 5,550 tons of Bailey bridge sections were used to expedite construction and to build permanent structures in connexion with the Ottawa River Power Developments.

The Temporary Structures. These include: (*a*) A giant concrete conveyor consisting of a Bailey bridge roadway carried on Bailey bridge section piers, 80 ft. in height, and extending the full 2,400 ft. length of the main dam. (*b*) A power house access bridge 580 ft. in length and capable of carrying loads up to 75 tons. The bridge was of double triple construction with maximum spans of 120 ft. supported on Bailey bridge section piers. (*c*) An aggregate conveyor over a mile in length with Bailey bridge sections forming the framework.

Bailey bridge sections were also used to conserve form timber and carpenter man-hours in the dam concreting operations. The salvageable qualities of the sections enabled the sections to be used over a number of projects.

The Permanent Structures. These included: (*a*) A concrete-decked restrained-truss bridge spanning 120 ft. over a waste channel. (*b*) Tower supports for chutes. (*c*) Bridges on the transmission line patrol road.