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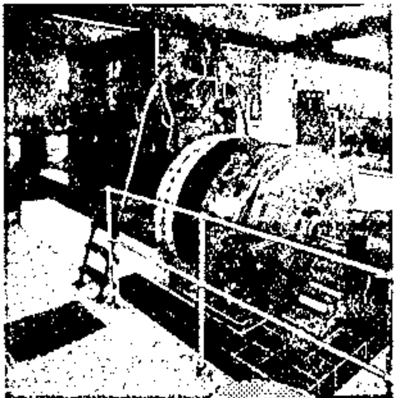

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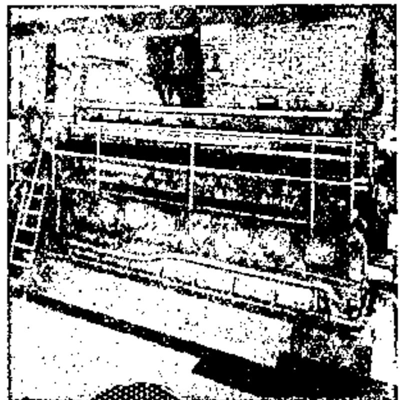

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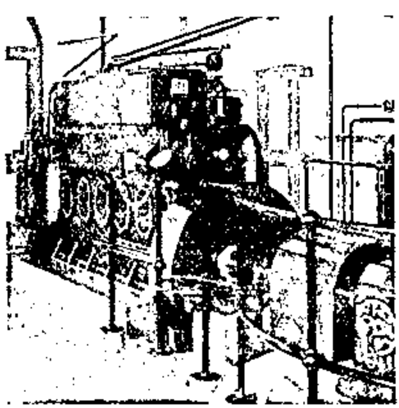

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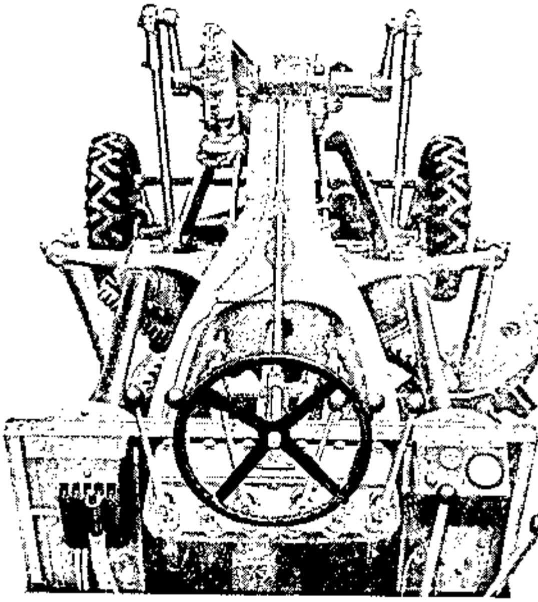

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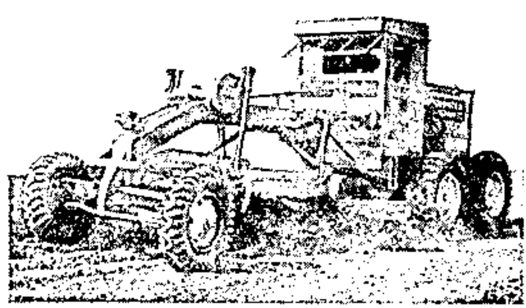

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THE ENGINEER TASK IN FUTURE WARS*

By Major-General G. N. Tuck, C.B., O.B.E.

(A paper read to the Institution of Civil Engineers on 19th January, 1954, and published by permission of that Institution and of the Controller of H.M. Stationery Office.)

Synopsis

Any future war will be profoundly influenced by new scientific discoveries and their engineer application.

Military success may depend on skilful adaptation of novel engineering methods to tactical or strategic aims.

A vital contributory factor is peace-time collaboration between the Royal Engineers and Civil Engineers in engineer planning, organization and the solution of military problems by the latest technical developments.

In the land and tactical air force battle, defence works may demand more machinery and prefabrication. New types of land obstacles are also needed.

In equipment and assault bridging, mainly a military interest, vast improvements have recently been made. Civil bridges will require classification and strengthening.

Problems of airfield construction are complicated by operation of heavier jet aircraft. Soil stabilization and new surfaces suggest possible solutions.

Other vital tasks include: fuel pipelines, "across the beach" delivery, rapid repair and construction of roads and railways, accommodation, field workshops, field tools, power supply, lighting, project illumination and stores handling.

Military plant and equipment should, where possible, correspond to standard civilian practice. Often some specifically military feature enhances the commercial value of a machine, especially for export to undeveloped countries.

THIS Paper deals with those tasks which fall to the Royal Engineers in war. They include not only construction and destruction, but also range over the whole field of civil, electrical, and mechanical engineering, including transportation and survey. They do not include signals, vehicle repair, motor transport, electronics, or armaments.

In seeking to define the subject of this Paper the attention of the Author was drawn to the meaning of the word "engineer." In his opinion the dictionary definition fails to convey the popular or the technical meaning of the word as it is used to-day, and the Author suggests that the engineering institutions should take action to have included the notion of "one who studies a profession."

It is necessary to draw some distinction between engineering in peace and engineering in war. The conception of engineer work in peace is of something completed and fulfilling a definite utilitarian purpose ; examples range from a Sydney Bridge or an Aswan Dam to a jet engine. Through the range of pictures conjured up in the mind two factors predominate which are not entirely fulfilled in war-time engineering : first, a tidy job completed in every detail of the designer's conception ; secondly, a clear-cut specification of functional requirement. Perhaps a third factor should be included, though not always achieved in peace ; it is that of a work adding to man's heritage of aesthetically beautiful possessions.

War is governed by the principles of war—the soldier's creed, sacrosanct and immutable. These principles concern equally the Royal Engineer and the infantryman. It often falls to the engineer to lead the way in offensive action. In offence and defence, destruction is an important engineer task. Engineering is vital to mobility in both the battle-area and in movement forward from base. The time factor in war has an overriding priority which is not experienced in civil engineering. Surprise, economy of force, and the uncertainty commonly known as the " fog of war," frequently present the engineer with an ill-defined requirement to be met with inadequate resources and with every chance that the governing conditions will change during the execution of the work.

These reflexions must be related to the march of science. The motto of the pure scientist and of the research engineer at the present time is like that of the Red Queen's " Faster, faster." In peace, applications can be fully tested before the introduction of a new technique into practice. In preparation for war, the engineer must be ahead of the enemy in application. The advance of science is so rapid and new discoveries so revolutionary that it is not easy for the soldier without technical knowledge to be up to date in the method of waging war. The professional engineer, in collaboration with the scientist and the research engineer, has opportunities to recommend how new methods can be evolved by applying new techniques.

From these general considerations the Author suggests two tentative conclusions :—

(1) That the approach of the engineer to future war problems should not be " I will wait until the Military state a firm requirement and then I will study the job." The engineer should, in the Author's opinion, venture to say " From my study of the military problem, I find this application of modern engineering would contribute to its solution. I consider the engineer task should be framed accordingly and that the military plan should conform." Maybe that is going too far, but should not engineers risk an

advanced position initially, although it may subsequently be convenient to withdraw some little distance? Professionally, are they not too inclined to wait for other people to tell them what should be done? This attitude may be the right one in peace-time civil life (although it is not suggested that it is), because professionally qualified engineers hold a sufficient proportion of influential appointments in government, in Parliament, in the Civil Service, and on boards of directors. But in time of war, and in planning for war, surely the profession will be doing the country a disservice if it does not throw the full weight of its knowledge, skill, experience, and imagination into deterring the aggressor by the application of superior technical skill in warfare.

(2) That Clausewitz's theory of the whole nation at war is applicable, while a world is suffering from ideologies, to " cold war " as well as to a future major war. The aim is to win the " cold war " to prevent a " hot war." " Cold war " seems to resolve itself into minor shooting campaigns in the less developed parts of the world and into developing a firm military front to give security in more civilized countries. The civilian and the soldier are involved together in the " cold war " all the time—politically, economically, and militarily. Every individual civil engineer would be called out for the nation's defence in a " hot war," indeed, in a sense, all engineers are unpaid Royal Engineer reserve officers. Engineers also have opportunities to contribute their services during the " cold war," for example, the Public Works Department are already busy in Malaya and Kenya.

This Institution is actively assisting both engineer planning for future war and the technical training of Royal Engineer officers. To quote one of the Past-Presidents, Sir William Halcrow, who wrote the foreword to the symposium of sixty-eight Papers published by the Institution* after the 1939–45 war:—

" . . . the war gave rise to many novel engineering problems, and to the exercise of considerable ingenuity in their solution. . . . The Papers give evidence of the close collaboration that existed between the regular and temporary members of the Services, and it is to be hoped that this collaboration will continue no less strongly in times of peace."

The first part of this Paper has dealt with the mental approach of civil engineers in peace-time to their tasks in a future war. Since it is the spiritual concentration of force which wins battles, it is the Author's belief that the engineer contribution to defence in a future war depends primarily on the interest taken by the profession in

* "The Civil Engineer in War." Instn. Civ. Engrs., 1948.

military problems during peace-time. The initiative of this Institution, by encouraging its members to study military engineering, is inspiring to the Royal Engineers and of great service to the Army.

The second part of the Paper attempts to forecast some of the practical problems of a future war, but first it is well to mention and dispose of a complication. It is traditional in the Corps of Royal Engineers that they pioneer any new thing. Mechanized road transport began with steam tractors in South Africa, and aircraft, tanks, signals, and bomb-disposal are a few examples pioneered by the Corps. There will be new things to pioneer, possibly things with only a tenuous connexion with engineering as such. Appropriate civilians will find themselves wearing the Sapper badge, whether as pressed men or volunteers, to pioneer novelties. The Corps are no longer responsible for the novelty once it has emerged from the experimental stage into a new commitment, otherwise it would distract the Corps from its proper task of engineering. The civil engineer has, in war and peace, his share in this pioneering task of the Royal Engineers.

Turning then to engineer tasks in a future major war. The first step must be to imagine what a modern " hot war " will be like. Looking back, there seem to be only three things common to recent wars : first, someone else starts it ; secondly, during the first year Britain hangs on grimly ; and thirdly, she wins the military contest in the end. A fourth could be added : that modern wars are too big to handle without allies—and to quote Field-Marshal Sir William Slim, " When thinking about our allies, it's wise to remember that we are an ally ourselves."

The lesson learnt from history is that in any other respect the next war will be very different from the last, but a fair assumption is that it will start by enemy aggression, with superior forces on the ground and in the air, and a considerable nuisance value at sea. These are important assumptions to the engineer, because the first phase will pose major engineer tasks before the country is mobilized and organized for war production.

It can be accepted that major war aggression will never stem from democracies or from a United Nations organization. Aggression will be by a dictator, who must aim to exploit surprise and the initiative to gain quick results, otherwise the rest of the world will have time to rally against him. If this is right, ruthless committal of the full weight of armed forces to gain the maximum success from the initiative must be anticipated.

It seems vain to hope that mankind will not be so mad as to release the forces of scientifically developed " mass destruction." Should this disaster happen, it must be assumed that the aggressor possesses plenty of atom bombs, aircraft, and guided missiles, for without a full armoury he dare not attack. The newest known factors in aggression are the destructive power of atom war-heads against concentrated targets, the greatly increased range of delivery, and the greatly increased range and speed of guided or piloted air-missiles.

Sir Winston Churchill has said that land-war will become a broken-backed affair because the attack on communications will paralyse supply systems. In the Author's opinion the difficulty of maintaining logistic movement will present engineers with one of their biggest problems. This problem will be considered by examining a campaign in a highly developed area, say Europe, and by confining the argument to the engineer tasks overseas.

In such a campaign the first concern of the engineer is to assess the existing civilian resources of transportation, communications, engineers, and labour. In addition there will be some strategic airfields, magazines, communications, etc., prepared in peace-time.

It will be the enemy's aim to demoralize the civilians and destroy the means of movement of supplies and reinforcements. His atom weapons are most effective against concentrated targets such as cities and ports, and he has at his disposal high-explosive weapons which can be delivered at long ranges to tackle smaller targets. He may also be able to organize sabotage.

In the battle-area, in the air and on land, modern air forces and armies require delivery of much greater tonnages of fuel, ammunition, and almost everything else, than were provided for them in the last contest. It is important at this point to remember that superior numbers can be withstood only by superior technique and superior fighting equipment. The cost per piece of equipment, aircraft for example, is becoming astronomical. Active defence forces maintained in peace will tend to be very good, rather small (because nations cannot afford large forces), but very precious. Everything will depend on keeping them amply provided logistically from the very start so that their superior quality can achieve maximum results.

Broadly speaking, the answer to weapons which destroy concentrations is to disperse the resources under attack, but the dispersion must not become too expensive in manpower, communications, and overheads. Military problems will, of course, centre on certain commodities, such as fuel, because the civilian lay-out of reserves and distribution will have little relation to military requirements, either in protection or in end-location of delivery. The Army will be equally concerned with centres of communication, such as ports, where stores are transferred from one form of transport to another or which present vulnerable sea or land defiles. In particular the human element, skilled and unskilled labour, is physically and morally very vulnerable to attack by mass-destruction weapons.

There will be, in fact, all the known engineer problems of the 1939–45 war, multiplied several times in magnitude, and of these, transportation remains one of the major problems. Because of the scale of destruction, new solutions to logistic problems must be found.

The lesson learnt from history is that, broadly speaking, the engineer solution to providing the means of movement from base to battle has been to develop existing civil resources to meet military requirements. In the last European campaign it proved to be quicker and more economic to repair airfields than to make new ones. This was unexpected, for air-photographs of the French, Belgian and Dutch airfields, continuously attacked by Allied heavy bombers and abandoned by the Luftwaffe, showed overlapping craters filled with water. To all appearance, drainage systems had been wrecked beyond repair and there was no possible way of siting a new runway without first filling a large number of craters. Reconnaissance on the ground of the first airfields recaptured, at Evreux and St. André, indicated that repairs sufficient to provide minimum facilities for forward fighter wings was not so formidable a task as had appeared from the air-photographs. The truth is that destruction generally looks more frightful than it really is. A permanent Dutch airfield can be quoted as a typical example, where access roads, aircraft standings, and a surprising percentage of the original facilities were found to be intact. The main drainage system, as was usual, was damaged rather than destroyed. The whole airfield area had originally been properly drained, consolidated, and formed, so there was no need to fear the soft spot which was very often a delaying factor in making a virgin-earth strip. There were other factors not fully appreciated until St. André was repaired. Local labour employed by the Germans on the airfields was quickly traced and re-employed. Airfield plant was found locally—often it had been dismantled and hidden by the "underground." Plenty of hangar rubble was handily placed for filling craters. In Holland and Belgium bricks and pavé from parts of the airfield that were not required could be taken up and relaid by local tradesmen skilled in the work.

The Author has described repair of airfields in 1944 at some length because the example illustrates several basic lessons of the 1939–45 war which may well apply in the future.

The first of these lessons is that a well constructed utility, particularly if it is designed in peace-time with a view to war-time requirements, can often be kept in action or repaired to meet military requirements. The best examples are the German strategic railways and the autobahnen, where strategic requirements were overruling factors in both lay-out and design. The narrow canal-bordered roads of southern Holland, on the other hand, were not suitable for modern military traffic. This is a point on which civil-engineer influence can be brought to bear in peace-time, even where construction is not specified to cater for war requirements. Indeed it may not be a question of extra expense in the original construction, but only of forethought in design. It is an aspect of peace-time construction that should be kept in mind in the United Kingdom, in the Commonwealth, and wherever British engineers undertake construction for allies.

Restoration of utilities after large-scale destruction entails a major commitment in clearing a way through the debris to uncover the objective for repair. With atom weapons this process is complicated by contamination, particularly contaminated dust. Two examples, from the 1939–45 war, serve to illustrate this type of problem.

During the battle of the bridgehead in Normandy, heavy bombers were let loose on German centres of communication. When No. 30 Corps broke out of the bridgehead southwards, the engineers under the Author's command had to make a route through two small towns, Aunay and Pont de Conde. The tanks and forward infantry had bypassed the towns, but the Corps could not advance farther through these two towns without roads capable of carrying at least 3-ton lorries, and the time factor was of the order of 24 hours. Examination by air from an Auster aircraft failed to discover even the alignment of the original roads ; in fact, these two towns were just a heap of rubble. There was no way round ; it was impossible to go through, because there was neither the gear nor the time to shift tons of rubble, and there was no space into which to bulldoze it to one side. The solution had to be a rough lorry-track right over the top. This example was the result of a heavy bomber raid on poorly constructed old country villages, and perhaps it serves to help the imagination to assess the effect of atom bombs on a city.

The second example is from the first months of reoccupation of the Ruhr and deals with opening a canal for coal barges. In a stretch of about 10 miles, more than a hundred heavy steel-girder bridges had collapsed into this canal. Among them were many railway bridges, one long clear-span autobahn bridge, and several main road bridges, with lengths ranging up to 1,500 yards and spans often up to 300 feet. The destruction in this instance was almost entirely caused by enemy demolition ; it is, however, the kind of girder clearance task which is to be expected from atomic weapons.

Nevertheless, it is the Author's opinion that it will very often be quicker to repair than to build something new. The technique of clearance and repair is therefore an important study in relation to future war. The Author suggests that one possible way of producing results quickly, in spite of mass destruction, may lie in the mass employment of machines. Indeed, in war, many kinds of rapid new construction, in particular those entailing earth-moving, demand a military engineer plan based on the deployment of plant in quantity, for example, new airfields and roads. The practice is common in certain types of civil works, such as earth dams, except that the time factor is perhaps not so critical. Where the machines and skilled operators are to come from, and how to get them overseas if they were available in the United Kingdom, is an interesting planning problem. Furthermore, it is not easy to give Royal Engineer officers in peace-time the knowledge or the proper experience of war-time technique.

From the foregoing examples two points stand out ; first, the autobahn conception or the strategic railway conception, so well executed by the German Wehrmacht in both world wars, were civil utilities laid out to be easily adapted to war needs ; and secondly, the application of massed plant to deal with mass destruction. It is believed that civil engineers in peace-time can contribute something to both of these war-time problems.

Engineers should be encouraged to think out the logistic problem *ab initio*. The requirement is to deliver commodities, without delay or stoppage, from the United Kingdom arsenal to the user overseas. The present logistic system relies on holding buffer-stocks up the line of communication, using bulk delivery part of the way and breaking down commodities at stock-holding points for detail delivery to the user. Is this the best solution, given modern engineer facilities? Suppose that freighter aircraft on a daily supply round from the United Kingdom to division could deliver everything needed. The problems of maintenance areas and of dispersion would then be of minor importance. Of course this suggestion is not practicable in face of enemy air-power, but it serves to illustrate how speed of transportation and through-delivery without transhipment can help to solve such problems. The modern PLUTO across the Channel, expanding into a gridded piped system overseas, was a solution based on the same principles. With cranes and fork-lifts designed for cross-country movement, heavy packages could be handled at the receiving end, however far forward it might be. Safe carriage and ease of breakdown from bulk to item may be improved by advances in methods of parcelling and packaging. Long-distance belt conveyors might be adapted to solve movement without transfer of loads or manhandling. It may be possible to deliver electric power by grid to forward areas or to install mobile power stations in forward areas ; the Services to-day have far too many small power plants for every little workshop, headquarter, and depot, each requiring its delivery of fuel. These few possibilities are mentioned only to stimulate ideas and illustrate the problem.

In considering solutions it is important to remember that in this selected example the overseas theatre is thickly populated. Allies may well need military engineer assistance to keep their civil utility services functioning. Their civil utilities will equally be required to allocate resources for military purposes. The military engineer problem must never be divorced from the civilian problem. Indeed, one of the essential components of the solution must be an inter-allied organization to allot resources and decide priorities ; and the organization must have the authority to do these things across territory belonging to several allies. Local manufacture to save transportation from the home-base must also be considered.

The next problem is : " What is happening to the enemy ? " His logistics will certainly be suffering severely, and his difficulties must be examined. Sad as it may be for the ally who is closest to the aggressor ; the hard fact must be accepted that against modern weapons it may not be possible to halt the superior air and ground forces of an aggressor at the frontier. Of course an aggressor can be hit at long range, but his momentum will carry him so far. In this event, while offering tenacious resistance, it would be possible to create in the path of the enemy a transportation desert in order to slow his advance. The Germans did this effectively in their 1917 strategic withdrawal, but of course they had time to do a methodical and painstakingly thorough job. Even in limited time, and in face of rapid advance, it is suggested that engineers to-day, 35 years later, equipped with modern machines and power, could rip the bottom out of every airfield, road, railway, bridge and bridle path, and sow mines in the resulting debris. The enemy cannot fight without forward airfields or without means of transport for fuel and ammunition. Certainly hardy troops could live on the country for a while, but even Napoleon's Revolutionaries were halted by the desolation east of the lines of Torres Vedras. Behind such a belt of scorched earth the defending tactical air forces should be able to regain air superiority, and the land forces should have time to reinforce and to organize offensive counterthrusts. It is doubtful if there is opportunity to practise the technique of destruction in civil life, but the subject presents interesting engineering problems.

Some aspects of defence in battle must be considered. There are two modern theories of " start of war " tactics. One is great mobility with armour, wide dispersion (hence no atom targets), and much manœuvre. The other is a defensive strategy after a first withdrawal, to gain time for the air force to win the air battle and to prepare for offensive action while manœuvring astride a broad obstacle which armour cannot penetrate without deliberate assault. Whichever turns out to be the answer, quickly made defences are still needed, either to provide secure bastions round which to manœuvre, or to protect the defenders behind the obstacle. Manual digging and hand-made overhead cover are effective, but slow and fatiguing. Prefabrication, the use of machines, the mechanical handling of stores to site, the mechanical laying of mines, and many other improvements are in sight and give scope for application in future wars. Of course there are equally important engineer assault problems in breaching gaps through defences, minefields, and obstacles.

To construct effective obstacles economically is another "battle" problem. There is a requirement to save mines by covering a greater frontage per mine and to make the whole process of mining more mobile. A further requirement is to find a substitute for barbed-wire. Farmers now use simple electric fences, but although electric fences have been used by the Army in the field, no satisfactory military solution has yet been found. Barbed-wire is certainly effective, but it is difficult to handle, heavy, and objectionable in almost every characteristic. The 1939–45 war saw no development progress in this type of defence equipment and improvement is overdue.

It is not intended to expand the many ways in which engineering can contribute to the "sharp end" of the land battle. Broadly speaking, the effectiveness of the engineer effort depends on increasing mobility and speed of execution, in reducing the weight and bulk of material, and in doing more with fewer men. One of the tools needed is some form of mobile cross-crountry machine combining the attributes of tractor, fork-lift, and excavator, which will save manpower and time, and will get there under its own power at convoy speed without a trailer or transporter.

In one Paper it is not possible to discuss every engineer responsibility, but there are two specific tasks which demand detailed examination, namely, bridging and airfields.

Assault floating-bridges are the Sappers' own particular problem without exact parallel in civil life. It can be claimed that in equipment bridging, British military designs are ahead of those of any other country. Modern developments have made possible the assembly of floating-bridges well back from the river bank, and from this point assembled components are taken forward and launched into the river direct from trailer. If conditions are difficult, monorails or sledges are used. Simplicity and speed of assembly can be achieved on good ground and under cover where cranes, dim lights at night, and other facilities are available. No vulnerable targets are presented on the river bank and men have no heavy weights to handle from the bank or while afloat. Power tugs are employed for rafting bridge sections into position. When the loadings stipulated for modern armies are taken into account, this is a remarkable achievement, and it is believed that this technique will be the pattern for future wars. Further advances in the technique of assault bridging will depend on the solution of tactical problems arising from the vulnerability of bridges to long-range missiles and on the time factor in the requirement for heavy armour on the far bank.

For clear-span bridging there is now a new design of heavy-girder Bailey-type bridge. This has been erected and launched off flat firm ground by one man with a fork-lift truck. This is not the normal procedure, of course, and it entails remote control of levers by wire attachments, but it serves to illustrate the simplicity of design and the manageable size and shape of components. The Army uses equipment bridges for a number of reasons ; first, for speed of erection ; secondly, because in war there is seldom time to collect and prepare local materials or alternatively there are no materials available ; thirdly, to ensure delivery to bridge site, often by bad roads or tracks ; fourthly, for ease of erection by field engineers without the assistance of tradesmen or tools ; fifthly, for flexibility in span and loading ; and lastly, so that when a bridge has served its purpose it can be dismantled and re-erected. Some of these factors do not apply to engineer projects in peace, but some of them may often condition the approach-bridging problems of large works in undeveloped countries, and possibly there is a latent demand for equipment bridging in civil life.

Bridging requirements include the very quickly made short-span bridge, a need now met by the tank bridge-layer, and the short-span sectional-truss railway bridge. In addition, a future war requirement is foreseen for strengthening existing bridges. The inspection and classification of existing bridges is in itself quite a problem. Investigations have shown how far bridges fall short of modern load requirements and particularly of Army requirements. Even in the United Kingdom, bridges are a bottle-neck ; surprisingly enough many of the bridges on main roads cannot carry heavy military transport loadings. Our present solutions include a design for a sectional prestressed-concrete girder suited to a wide range of requirements and the compilation of tables and data to assist engineer units in employing local Continental resources which are, of course, based on metre gauge.

In connexion with Army equipment generally, it is obviously desirable for the Army to use standard commercial patterns rather than to have special designs. Special designs entail tooling-up of production lines and the holding of war-stocks including spare parts. This is a Ministry of Supply rather than a War Office responsibility, but naturally it is very much to the advantage of Royal Engineers to use standard articles. It is believed that developments to meet specific military requirements often produce results which it is commercially profitable to apply both to home and export markets. When this happens, every encouragement is given to civil engineering firms to market the particular line. Nevertheless, the Author believes more can yet be achieved, both by the Royal Engineers, in closely watching new civilian products to see whether they fulfil adequately enough the military requirement, and by civil engineers, in designing equipment suitable for modification for military use.

The airfield requirement has changed considerably since the 1939–45 war. This Paper mainly deals with its most difficult angle—the hasty airfield. To-day the engineer is faced with single-wheel loads of 20,000 lb. and tyre pressures of 300 lb. per square inch. The runways must have jet resistance, be proof against fuel spillage, and be dustproof.

There are, of course, several lines of approach, for example, stabilization, stabilization combined with a metal track surfacing, or untreated soil with a prefabricated surfacing. It is not proposed to go into the progress of development but mention must be made of some general problems. Special surfacing not used in civil life needs war reserves ; also, with the length of modern runways and the requirement for protective dispersion, the coverage area will involve huge tonnages. If material is to be saved by stabilization, a battery of mixing machines is needed to compete with the time factor of completion ; also detailed and scientific reconnaissance is necessary to obtain accurate knowledge of site conditions. Thus the problem of the hasty tactical airfield is a difficult one.

In civilized countries there is every prospect of a steady increase in the number of civil airports. Trends in aircraft must surely be towards both increased range and increased speed. In the Author's opinion air transport will be used for both passengers and freight in war. The prospects then for the airfield engineer in war-time are the maintenance of existing military air bases, the adaptation of civil airports for military operational or transport aircraft, the hasty construction of airstrips for the tactical air forces or as satellite fields, and the construction in undeveloped countries of both semi-permanent and hasty airfields. The probability is that airfield construction will absorb a far higher proportion of engineer effort in a future war than it has done in the past. There are two main facets to the problem of development and design : the semi-permanent airfield constructed with maximum economy in time and material ; and the hasty airfield. The uncertainties perhaps lie even more in aircraft development than in changes in strategic plan. If the aircraft designer can bring a fast heavy aircraft to earth slowly and softly, the engineer can resuscitate the earth strip and the metal surfacing of the 1939–45 war. However, the present forecast must anticipate strong surfaces stretching long distances.

To show that the many other engineer tasks are not forgotten, a paragraph is devoted to miscellaneous items ; they are included in this category, not because they are unimportant in quantity of effort or quality of technique, but because there is no space to enlarge on every problem. First, there are roads: an interesting problem is how to protect a secondary road very quickly, as the first division moves forward over it, so that the surface, bottoming, and drainage are not severely damaged before the engineers have opportunity to repair the pot-holes. Further problems include :—

Railway construction, destruction, repair, and railway operation, including locomotive design.

Field workshop machinery and power supply, and field unit tools.

Generating sets, lighting, and both battlefield and project illumination.

Port construction, operation, and maintenance across beaches.

Fuel supply, including flexible cross-country pipe-lines, ship-to-shore pipe-lines, pumps and both temporary and semi-permanent rapidly installed tankage.

Water-supply.

Accommodation, in which interesting problems of dispersion and protection arise from threat of air or long-range missile attack.

Bomb disposal, which must now include the possibility of an atom bomb failing to explode, entailing new techniques in reconnaissance and disposal.

In considering a future war, the military engineer is forced to apply to every problem the limitations and flexibility imposed by geography and by climate. The lesson of major wars is that each successive war spreads farther around the world than the last. Engineer designs, organization, planning, and equipment have to cater for cold, heat, drought, and humidity. The Author suggests that great circle routes, the shortest way from point to point, may well attract attention to the polar regions. Engineers may be faced with projects on the permafrost, and in arctic regions which can be reached only by air or by a sea route open for but one or two months during the year. Polar travel and polar experiment is being developed rapidly and it seems probable that polar routes will come into everyday use in peace, and may need extension in war. Thus, the problems and techniques of arctic transportation and construction are likely tasks for engineers in a future war. Lastly, the extension of possible theatres of war to new territories creates work for the Survey directorate which is already fully committed to mapping new areas. Survey problems concern not only unmapped territory, but also new degrees of accuracy developing from progress in electronic methods of survey, and the need to provide data for long-range missiles. It may not be accurate enough to know that the Atlantic bulges upwards about 50 metres, and that Europe is also on a bulge, while India is in a depression about 60 metres deep. Geodesy and space measurement are likely to present new problems of survey in a future war.

In this Paper it has not been possible to do more than to indicate in the most general terms the broad nature of engineer tasks in a future war. Indeed, special problems have been neglected to the extent of omitting reference to campaigns in forests, deserts, and mountains. The Author has made certain forecasts and assumptions based on known weapons and on a war in the air, on land, and at sea, bearing some resemblance to recent experiences of warfare. So rapid is the progress of scientific discovery that new weapons and new methods of warfare are very likely to evolve within the next decade. It is rash to venture any opinion of future trends ; nevertheless it would be unwise to expect any diminution in the magnitude of the tasks of the engineer. Indeed it is on this theme that this Paper should be concluded. Whatever the precise nature of engineer tasks in a future war, it seems inevitable that their urgency, their scope, and their magnitude will impose a very severe test on the whole engineer resources of the Country, on its engineering skill, on its engineer manpower, on its equipment, and on its production. Security in war may depend as much on the success in mobilizing and deploying engineer resources as on any other single factor. It is therefore with gratitude that the Royal Engineers welcome the valuable collaboration of the Institution of Civil Engineers in holding a meeting such as this in order to discuss future military engineering problems.

Note.—It is proposed to publish some extracts from the discussion after the lecture, in the June, 1954, issue of "The Royal Engineers Journal."—

EDITOR.

A PRESTRESSED CONCRETE RAILWAY AND CONVEYOR BRIDGE

(Published by permission of the Cement and Concrete Association.)

A 75-ft. span combined railway and conveyor bridge in prestressed concrete has been constructed for the East Midlands Division of the National Coal Board in connexion with the construction of a modern colliery at Calverton, Nottinghamshire.

Design

The layout of the colliery is such that the winding shafts are separated from the coal preparation plant by an existing roadway, and it was therefore necessary that there should be a railway bridge to connect the two, and it was also necessary to transport coal and refuse between the pithead and the coal preparation plant.

The planning authority would not permit a separate overhead conveyor structure, and it was therefore decided to try to utilize the space between the deck and soffit of the bridge to accommodate the conveyors. To do this a minimum headroom of 5 ft. was required between the underside of the upper (railway) deck and the lower floor which would carry the conveyors. The design was therefore required to attain a minimum thickness of railway deck and conveyor floor.

The Ministry of Transport headroom requirement of 16 ft. 6 in. determined the minimum height of the bridge soffit, while to avoid steep rail gradients on the approaches to the proposed bridge the level of the deck had also to be kept within certain limits.

A further consideration which had to be borne in mind in designing this bridge was the need to ensure the minimum interruption to traffic using the road beneath during construction. To effect this it was obviously desirable to precast as much of the work as possible ; and to precast it in convenient lengths. To meet this and all the other requirements it was considered that prestressed concrete was particularly suitable. Moreover this material provided the additional advantages of saving in materials, reduction in weight, increased rigidity giving reduced deflexion, and the elimination of shrinkage cracks.

The bridge as finally designed has two precast, prestressed girders placed parallel at 16 ft. 8 in. centres. Spanning between the girders there is an upper deck to carry the railway and a lower floor to carry the conveyors. The underside of the lower floor forms the soffit of the bridge. Prestressing was carried out on the Freyssinet system throughout.

The abutments are of mass concrete faced with mottled Alton stone and are sited on the colliery shaft pillar, so that the customary provision for the jacking of bridge foundations in mining areas was not required.

The maximum permissible live load on the bridge is 104 tons and is occasioned by two diesel locomotives and a loaded truck, weighing 42 tons and 20 tons respectively. The speed of any train is restricted to 10 m.p.h.

The weight of the coal and refuse conveyors are 135 lb. per ft. run and 115 lb. per ft. run respectively and the maximum loads on the coal and refuse conveyors at any one time for the span of the bridge are 4.46 tons and 3.8 tons respectively.

For the purpose of computing the maximum stresses in any member, the requirements of B.S.153 (Girder Bridges) were observed and suitable provision was made for impact and other forces. Provision for deflexion and expansion was made by means of Freyssinet type hinges at the girder bearings.

Construction

The two main girders were 77 ft. long over all and 5 ft. 9 in. deep, with a web thickness of 4 in. at the centre of the span increasing to 7 in. at the ends and a camber of 2 in. Each girder was precast in three sections in a products works, the end sections weighing 5½ tons each and the centre sections 8½ tons each.

Lifting hooks were incorporated in the precast sections so that on arrival at the site each section could be lifted into position on bearings and temporary timber towers which were ready to receive them.

Once the complete girders had been lifted into position six Freyssinet cables of twelve 0.2 in. diameter wires were threaded through ducts which had been formed in the units during casting by using "Ductube." The ¾-in. joints between the sections of the girders were filled with a dry mortar of cement and sand in equal proportions. Stressing was carried out from both ends of each beam and, after stressing, the cables and ducts were grouted under pressure.

The conveyor floor was then constructed. This was formed mainly of hollow precast units spanning between the girders with precast concrete channel units at 4 ft. 6 in. centres to accommodate the transverse cables which had plastic sheathing. The hollow channels were then filled with *in situ* concrete. Longitudinal sheathed cables were located in the 2-in. concrete screed on top of the precast units and anchored in *in situ* strips between the girders over the bearings and thus afford considerable assistance to the main girders.

The transverse cables were stressed up first, thus forming the main beams and the lower (conveyor) floor into a monolithic whole. The longitudinal cables were then stressed to provide sufficient prestress in the beams and lower floor to carry the upper (railway) deck and the live load.

The top deck was cast *in situ*. The transverse cables, sheathed in plastic, were placed before concreting began and were looped so

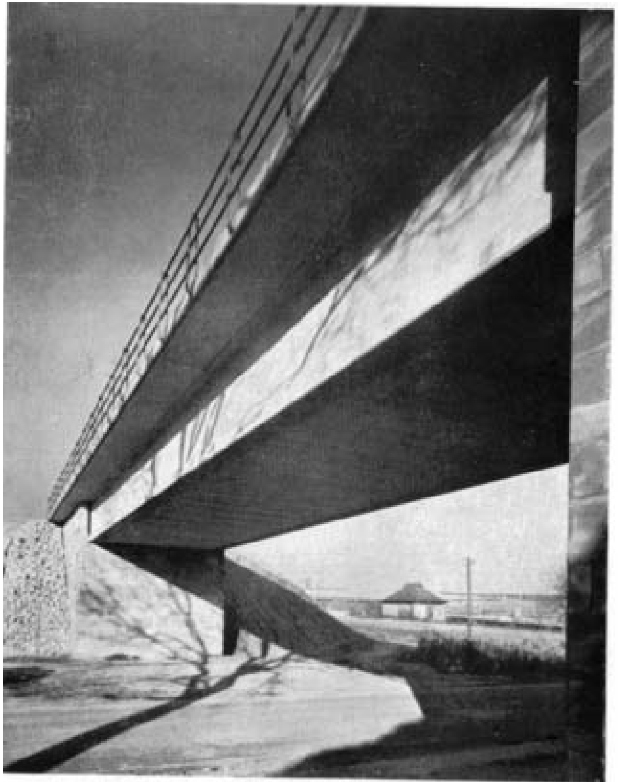


Photo 1.—View of underside of completed bridge.

Photo 2.—Stressing one of the main girders.

A Prestressed Concerete railway and conveyor bridge 1,2

Photo 3.—Arrangement of transverse looped cables in the upper deck of the bridge.

Photo 4.—The lower deck of the bridge under construction. The post-tensioning of the main girders is complete and the precast hollow units of the lower deck can be seen in position in the foreground.

A Prestressed Concerete railway and conveyor bridge

3 , 4

that both ends of each cable were anchored on the same side of the bridge and cables were anchored alternately on opposite sides of the bridge. The loop of each cable was bared and the wires separated to bond with the concrete and stressing was carried out from both ends of each cable. This slab rested on hinged supports in order to avoid transmitting bending moments to the web of the main beams.

Finally the cantilever footways were constructed. The reinforcement for these had been left protruding from the top flange of the main beams.

On the approaches to the bridge the conveyors run below ground and the conveyor housing roof is a 9-in. prestressed slab which carries the railway running above.

Concrete

The concrete mixes used in the construction of the bridge were as follows :—

Prestressed work :	1 cement : 1½ fine aggregate : 3 coarse aggregate
Reinforced concrete work :	1 cement : 2¼ fine aggregate : 3¾ coarse aggregate
Topping on the conveyor deck and bridge :	1 cement : 3 fine aggregate

All batching was by weight and ordinary Portland cement was used exclusively.

All concrete was vibrated, *in situ* concrete being vibrated both internally and externally at the same time.

A minimum crushing strength of 4,000 lb. per sq. in. was required in the concrete at the time of stressing and a minimum of 6,000 lb. per sq. in. before the bridge was used. Cube tests gave results in excess of the required minimum strengths.

The maximum design compression, due to the train load, is 1,472 lb. per sq. in. The design does not permit tension to develop in the concrete under any condition of loading.

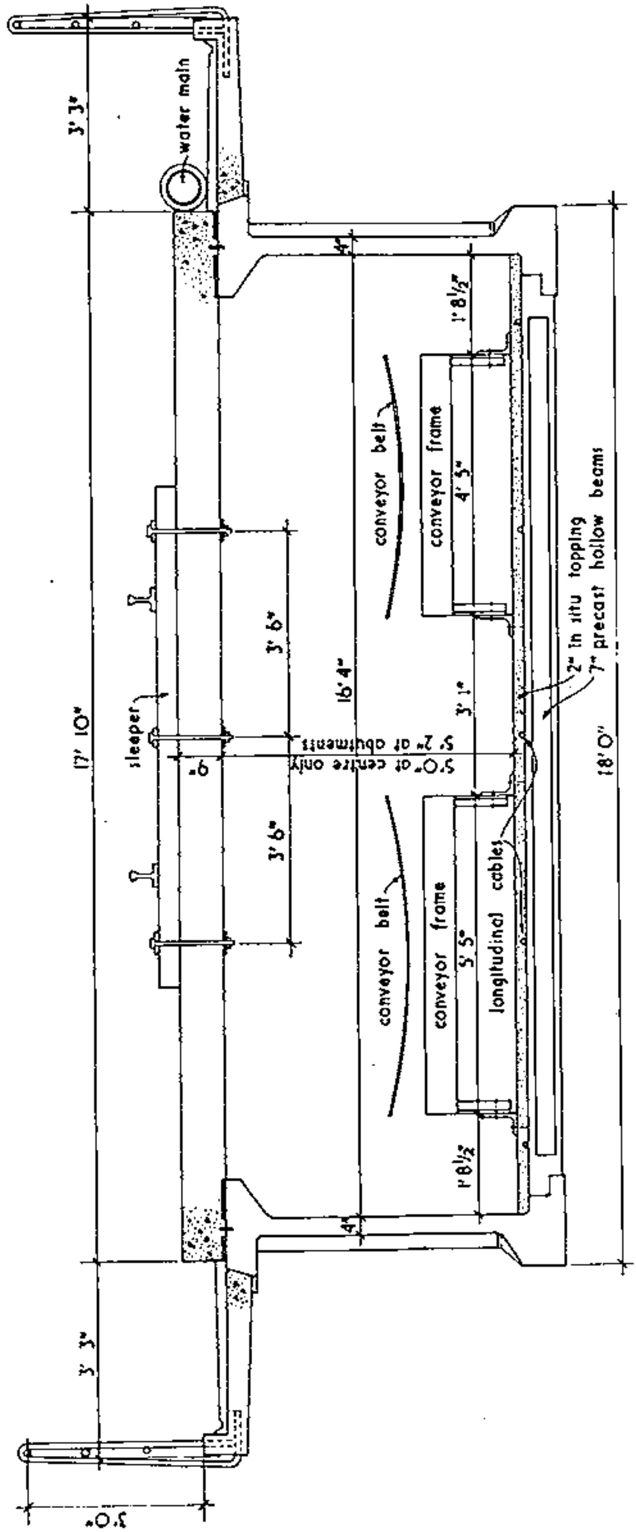
Preliminary Works Test

A specimen section of railway deck was cast and tested to destruction at works, under the supervision of the Building Research Station. The deck specimen, which was 5 ft. 4 in. wide and 9 in. deep, was supported on a clear span of 16 ft. 3 in. The concrete was cast on 30th December, 1950, and post-tensioning of the slab was commenced on the 11th January, 1951.

The prestress was imposed through eight Freyssinet cables, each consisting of twelve 0.2 in. diameter wires.

The slab was subjected to a loading test on the 2nd February, 1951.

When the slab was cast, a series of cubes and prisms was made for the determination of the crushing strength and modulus of elasticity of the concrete at the time of prestressing and of testing.



water main
3' 3"
17' 10"
sleeper
9"
3' 6"
3' 6"
16' 4"
5' 2" at abutments
5' 0" at centre only
4"
4"
conveyor belt
conveyor belt
conveyor frame
conveyor frame
4' 5"
5' 5"
1' 8½"
1' 8½
3' 1"
longitudinal cables
2" in situ topping
7" precast hollow beams
18' 0"
3' 3"
5' 0"

Method of Test

At various stages, arrangements were made to record the following :—

(*a*) The strain in the concrete resulting from prestressing, creep and shrinkage in the period prior to the test, and the application of the increments of load in the test ;

(*b*) the deflexion of the slab during prestressing and in the loading test.

The strains in the concrete were measured on each side of the slab at mid-span with a Whittemore gauge on a gauge length of 10 in. Before prestressing commenced, four sets of gauge points were attached to the concrete on each side at depths below the top surface of the slab of $\frac{3}{4}$, $1\frac{1}{2}$, $6\frac{3}{4}$ and $7\frac{1}{2}$ in. respectively. Measurements of strain were obtained before and after prestressing, and at intervals until the loading test commenced, when further readings were obtained as each increment of load was applied. The accuracy of the strain recordings was approximately $\pm$ 0.00003.

The deflexion was measured at mid-span on each side of the slab with dial-micrometer gauges reading to 0.001 in. Similar gauges were fixed at the supports so that corrections could be made for their movement. This arrangement of gauges was used during prestressing, and subsequently during the loading test when they were supplemented by simple scales reading to 0.01 in. for recording large deflexions in the later stages of the test.

For the loading test, a frame was erected around the slab to provide the reaction for two calibrated hydraulic jacks. The load was applied by the jacks to the slab through two steel beams, spaced symmetrically at 4 ft. $8\frac{1}{2}$ in. centres, on either side of the transverse centre-line of the deck specimen.

The slab was loaded in increments of 4 tons, at each of which strain and deflexion readings were taken. After the maximum load was reached, the load was removed and re-applied.

It is interesting to note, briefly, that an upward deflexion of $\frac{1}{8}$ in. was induced at post-tensioning and that the deflexion under the simulated train load was approximately $\frac{3}{16}$ in. leaving a net deflexion of approximately $\frac{1}{16}$ in. The upward deflexion induced at post-tensioning is used as a two-way fall to drain the railway deck.

Whereas the maximum operational load for the test specimen comprised two 7-ton wheel loads, the concrete actually failed in compression under a load of 36.8 tons, at which time the deflexion was approximately $2\frac{1}{4}$ in. After removal of this load, the residual downward deflexion at the centre was $\frac{1}{8}$ in. The second application of this maximum load gave a net central deflexion of 3 in. and a final residual deflexion after removal of the load of $\frac{5}{8}$ in.

ENGINEERS AT THE BATTLE OF ALAMEIN

The Southern Sector

By COLONEL J. M. LAMBERT, O.B.E.

IN its initial stages, the Battle of Alamein was an assault on a fortress. The tactics employed were reminiscent of those of the Peninsular War—when small parties, mainly engineers, sallied forth against say Badajoz or Ciudad Rodrigo; and in the walls of the fortress opened up the narrow breaches through which the storming parties were to pass.

At Alamein the "walls" of the fortress were minefields; and then, as a century and a half previously, the Sappers were vitally concerned in the breaching of them. Cuneo's picture in the R.E. Headquarters Mess admirably portrays an aspect of this operation—of what might be called "A division advancing on a one-man front."

This kind of attack was a far cry from those made during position warfare in World War I. On the Western Front in 1917–18, the front-line trenches before an attack were crammed with men; and when the time came they went "over the top" together in their thousands. At Alamein, on the night of the 23rd October, 1942, three parties numbering in all only a few hundred men, led off from the XIII Corps start line towards the enemy. It is the object of this article to give some account of how their task was reconnoitred, planned and executed.

One of the requirements in "Operation Lightfoot" (as the Battle of Alamein was then known) was for XIII Corps to break through the enemy's protective minefields near his southern flank. It was necessary, therefore, to find out as much as we could about those minefields—their number, positions and widths, and if possible the pattern, density and nature of the mines within them. None of this information was easy to come by; and even when obtained it had to be checked and kept up to date.

A favourite analogy for a minefield breaching operation is that of an opposed river crossing. There are points of similarity—but not in the reconnaissance. The position and width of a river are static, or at least predictable; it can be seen, photographed and roughly measured, at any rate from the air. A minefield may double its width invisibly in a night; its near bank may advance, or its further bank recede (the latter may occur even whilst the breaching is actually in progress). The banks may be invisible, or, if visible, may prove to be false banks. It is often very difficult to be certain whether an apparent minefield is fact or fiction.

During the four months we had been in occupation of the Alamein position, a lot of information about enemy minefields had been obtained—but not much of it was of value. C.R.Es. of divisions used to keep plans of all known, suspected and reported enemy minefields on their divisional fronts. These plans would be covered with a mass of little arrows, and notes in circles such as " Noises of minelaying heard here "—" Carrier patrol blown up "—" One teller mine found here "—" Cattle fence—no mines "—" Some mines—no fence." Visitors seeing the title of the picture. " Enemy Minefields " would look at it with interest, but they soon changed the subject.

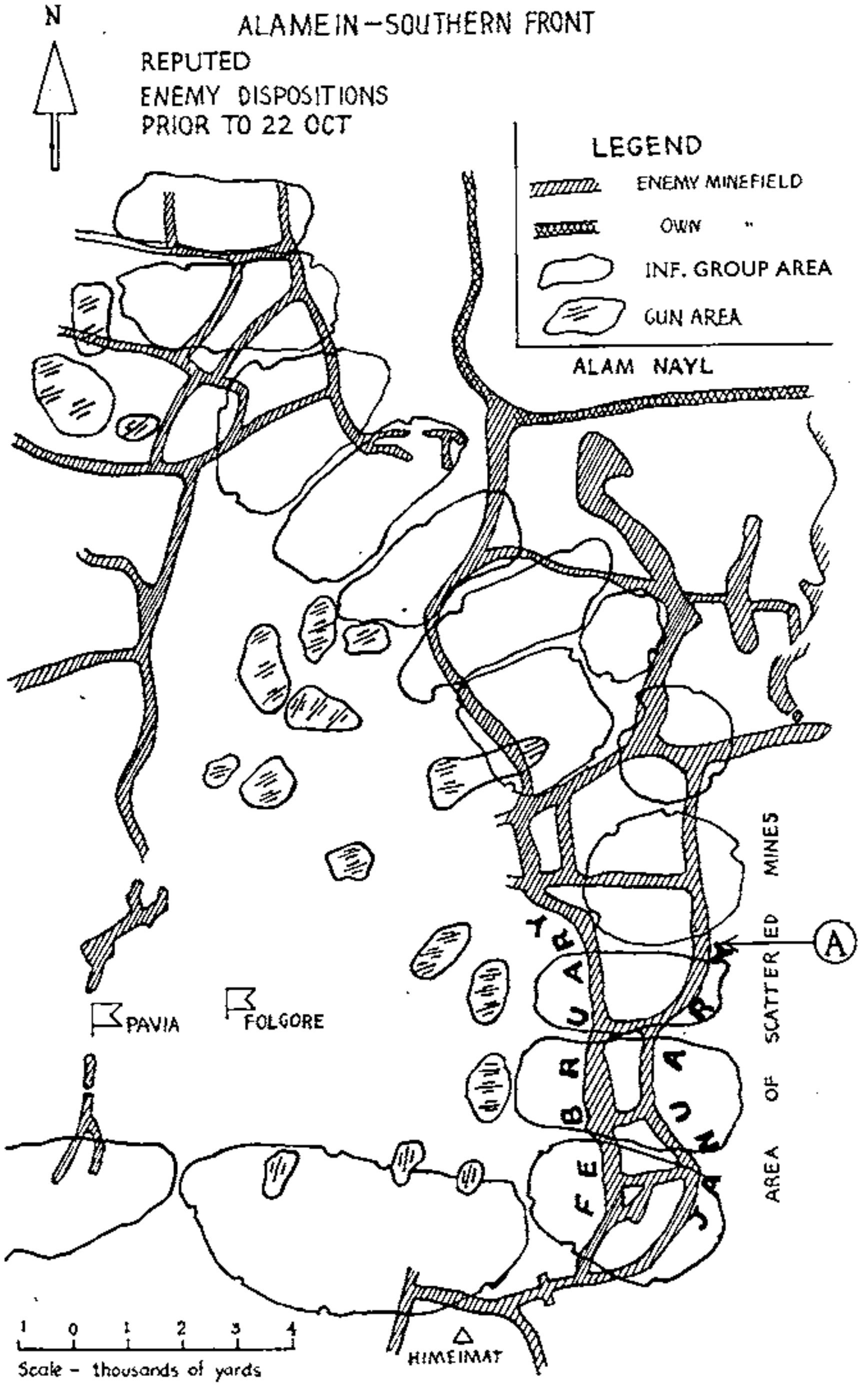
The sources from which information was obtained were as follows :—

(*a*) *Air Photographs.*—The existence of a minefield, and its general run, could sometimes be inferred from vehicle tracks converging on the gaps. But the shape of the minefield between the gaps could be only guessed at. Where boundary fences existed they could sometimes be distinguished on low level obliques taken when the fencing posts threw long shadows. In long-established minefields the desert vegetation such as camelthorn, being undisturbed, sometimes grew sufficiently to be distinguishable.

(*b*) *Reports from Prisoners.*—Very little use. According to most prisoners at this time they spent nearly all their time laying mines. But they never knew where. As there were practically no landmarks this was not surprising.

(*c*) *Listening Reports.*—" Sounds of enemy minelaying " were reported nearly every night from various parts of the front. Range and direction were usually vague and the reports not much use ; except as an indication of the degree of enemy minelaying activity.

(*d*) *Patrol Reports.*—Infantry patrols went out every night and, latterly at any rate, a Sapper N.C.O. accompanied each patrol. Sometimes a R.E. recce party would go out with infantry protection, but this didn't seem to work very well. Sapper N.C.Os. leading infantry patrols became exceedingly skilled at visual mine detection, or rather mine avoidance. They knew the sort of place in which the enemy was apt to lay mines, and could recognize, even in starlight, the sort of ground on which it was safe to tread. They usually carried a " short-arm " detector, but seldom used them. Mines were often " stolen " from enemy minefields and brought back by these patrols, but the position from which they were lifted could seldom be pin-pointed. Nor could negative information (e.g., that a certain area was *not* mined) be entirely relied on. It was possible for a patrol to walk right through a minefield at night without being aware of it.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ALAMEIN—SOUTHERN FRONT
REPUTED
ENEMY DISPOSITIONS
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ALAM NAYL
A
AREA OF SCATTERED MINES
FEBRUARY
JANUARY
PAVIA
FOLGORE
HIMEIMAT
1 0 1 2 3 4
Scale – thousands of yards

(*e*) *Daylight Ground Reconnaissance.*—This was the best and perhaps the only way of getting really reliable, useful information ; but it was difficult, and limited in scope. It was done by Sapper officers, usually alone—sometimes in pairs. On a hot day the best time was the early afternoon when there was a considerable heat haze—and the enemy were apt to be somnolent ; otherwise at dusk. An officer, saying merely that he was " going snooping," would wander off into the haze about 3 p.m., carrying only a compass and binoculars, and return after dark. The haze obscured or completely distorted a crawling man at about 200 yards. But about 5 p.m. it cleared and compass bearings could be taken. So the dodge was to get right up to the enemy minefield in the haze, lie up for an hour or so, reconnoitre and take bearings, and lie up again till dark. It was a good game and the players were seldom spotted.

Reconnaissance on the lines described above had been going on over a period of months and we had in consequence a general idea of the enemy's minefield layout opposite the Corps front, but very little detail. The plan opposite is from one made at the time. It is by no means accurate, but was roughly what we had to work on in planning " Lightfoot." It shows the supposed enemy dispositions in his foremost defended localities, from Alam Nayl on the north to Himeimat in the south. A number of suspected tactical minefields, have been omitted. The enemy F.D.Ls. were occupied by an Italian parachute division (*Folgore*) and by a number of German " groups " ; of these latter the Hubner and Burkhardt groups had been identified. And it was suspected, rightly, that the 21st Panzer Division had been brought south for the pending battle.

Alam Nayl, known also as the New Zealand Box, was garrisoned by an infantry division and we regarded it as impregnable. It lay at a slight elevation, rising gradually towards the Rubreiset ridge to the north.

Himeimat, marked on the maps as " curious twin peaks " dominated the whole southern flank. It stood like a sentinel against the southern horizon and on a clear day can be seen from the Mediterranean shore, some thirty miles distant. Unfortunately it was in enemy hands and provided him with a magnificent O.P. Immediately south of Himeimat lay the impassable Qattara Depression.

From Alam Nayl to Himeimat ran the two former British minefields named " January " and " February." These had been laid by us as defensive minefields during the previous spring ; but on the enemy's arrival at Alamein he had captured them, together with Himeimat, and used them as his protective minefields. He was well dug in behind and between them and to a small extent in front of them. Of what additions or alterations he had made to them we had little information. We had replaced them, so to speak, by laying two more parallel minefields about three miles to the east.

In Operation Lightfoot, therefore, the breaching of "January" and "February" seemed likely to be the main engineer tasks. We had no up-to-date knowledge of "February." Of the nearer "January" we knew the following :—

(*a*) The front fence of the minefield was still on its original alignment as surveyed in at the time we constructed it. The further fence, where it could be seen, also appeared to be intact and unmoved.

(*b*) No material alterations to the mines appeared to have been made, at any rate near the front fence. All mines "stolen" out of it to date had been British Mark IVs or E.P. (Egyptian Pattern) and none had been found trapped.

(*c*) No anti-personnel mines had been found, other than a small number of Mark II shrapnel mines originally laid by us (most of these, incidentally, had become non-operative). No "S" mines had been discovered near the front fence—which was the enemy's favourite place for putting them.

(*d*) The enemy had laid Teller mines on our side of the front fence to a depth of at least 300 yards. They appeared to have been laid at random in groups of up to five. They were just buried, sometimes only half buried, in patches of soft sand and unmarked. It seemed probable that every enemy patrol going out had been given five mines and told to leave them lying about. (During the course of the battle more than 1,000 of these scattered mines were lifted—all were Teller mines. No anti-personnel mines had been laid—for obvious reasons.)

(*e*) The enemy's foremost defended localities were immediately in rear of "January," or possibly inside it in some cases. Some small posts dug just in front of it appeared to be occupied only at night.

(*f*) There were no substantial barbed wire or other obstacles.

When the plan for "Lightfoot" became firm, it was decided to carry out an engineer reconnaissance of the line of advance up to the "January" minefield at the place where the breach was to be made (Point A on plan). This reconnaissance had obviously to be made on the quiet. Any reconnaissance in force, or any preliminary mine-clearing operation in front of "January" at this point would have given the game away, and defeated its object by leading the enemy to alter his minefield layout at the crucial point.

At dusk, a few days before the battle, a Sapper officer from 44th Division, R.E., was dropped by an armoured car about a mile due east of Point A. He then walked and crawled on a compass bearing due west. The going was reasonably good until about 200 yards short of the minefield where the ground became broken. He got up to the minefield but could not see beyond as it lay on a slightly hump-backed ridge. On returning to the armoured car in bright moon-light he was fired on, presumably by a patrol, but got back safely. The site seemed suitable ; the broken ground might necessitate some work on the approaches, but it would provide some cover where it would be needed. There was a risk, which had to be taken, that the enemy had added a "vertical" or cross minefield between "January" and "February" immediately opposite Point A.* The width of the minefield at this point as originally laid was 300 yards.

The intention briefly was as follows :—

The enemy's protective minefields were to be breached at or about the 256 Northing (Point A on plan). 7th Armoured Division on the left would make two 12-ft. lanes (later to be increased to four) using Scorpions.† 44th Infantry Division on the right would make one 12-ft. lane (later to be increased to two) by hand. Direction of advance—due west. Zero hour—2200 hrs., 23rd October, 1942. As an entirely independent operation, the Free French Brigade would capture Himeimat.

The operation was planned on a Corps basis. 44th Division would, in effect, provide a flank-guard on the north of 7th Armoured Division. The latter division would clear a pair of lanes about a hundred yards apart, whilst 44th Division would clear one lane about 300 yards to the northward. The existence of the "scattered minefield" in front of "January" had complicated matters, and the plans for dealing with it, which differed in the two divisions, were as follows :—

In the 7th Armoured Division each of the two advanced guards (as the leading detachments were called) was to be led by a pilot vehicle, with a Scorpion and R.E. mine-clearing party immediately in rear. As soon as the pilot vehicle struck a mine it would be assumed that the edge of the mined area had been reached and gapping drill would commence. This would consist of the Scorpion flailing, and Sappers with detectors widening and marking the cleared lane. For each of the two lanes there would be a duplicate party and Scorpion in rear, for leap-frogging, replacements or extra gaps.

In 44th Division the plan was as follows : The advance would be led by a party of Sappers on foot who would spot mines by eye on a 12-ft. front. Their job was not to find mines but to avoid them, and thus find a safe, though probably not straight, way through the

* The 9th Royal Australian Engineers were, I believe, unlucky enough to strike such a situation in the northern sector. They continued to lift mines for many hours before it was realized that they were advancing *along* a minefield, and not across one.

† The "Scorpion" was a Matilda tank fitted with a flailing device. It was the original flail-tank and was developed specially for "Lightfoot." The flails were driven by an auxiliary engine (Ford V-8) which was housed, with a Sapper driver, in an armoured box outside the hull of the tank. The speed of the tank when flailing was about one mile per hour.

scattered mine belt. Immediately behind them the trail was to be blazed by three " snail " lorries with infantry protection. These were twin-tyred 30-cwt. trucks of the Divisional Field Park Company. They had been specially fitted with tanks over the rear wheels and from these tanks diesel oil flowed through drip-feeds on to the tyres. Diesel oil leaves an unmistakable mark on the desert ; it can be seen even on a moonless night by a man driving a truck. These trucks, besides marking the safe lane would also " prove " it ; for when driven in echelon, their tyres covered the width of the lane. These trucks would also carry the gap-marking stores. The drivers' cabs were well sand-bagged. Along the oiled path made by the " snails " would come the minefield gapping party and the carriers of the assaulting battalion. As soon as a gap had been made in "January," the infantry, headed by their carrier platoon, would pass through the gap and form a bridge-head. From this, the assault on " February " or any intervening minefield would be launched.

The whole operation was to be done under an artillery barrage—firstly on the enemy positions behind "January" and then lifting on to those immediately in rear of " February." Machine guns in rear would fire red tracer continuously as an aid to keeping direction.

EVENTS OF NIGHT, 23RD/24TH OCTOBER

The following verbatim account is from XIII Corps Engineer Operations Report dated 26th November, 1942.

"The advanced guard for 7th Armoured Division consisted of 44th Reconnaissance Regiment (under 22nd Armoured Brigade) who advanced in two columns, each of which included a Scorpion, and detachments of 4th Field Squadron sufficient to provide three detector parties with lifters and markers. Local escort was provided by a tank and carrier troop. The R.E. detachments had duplicate reserves (from 210th Field Company), and there were three spare Scorpions. The first encounter of mines was by a vehicle striking one. The Scorpions started thrashing, the detector parties sweeping on their right rear, to produce a gap 12 yds. wide. It was subsequently evident that the first mine was one of a very scattered mine marsh, and clearing went on for about 900 yards before the main belt (300 yards wide) was met. Meanwhile the Scorpions had had many troubles, mostly from the tank engine and from hits by enemy shells. Bringing up new Scorpions caused delay. Progress was in fact so slow that the Scorpion engines did not overheat as had been feared.

As a result of this slowness and the difficulty of re-forming the Reconnaissance Regiment into column after it had deployed to form bridge-head, it was not possible to start clearing the second (" February ") minefield, about 2,000 yards ahead, as had been intended.

Meanwhile, on the right flank of 44th Reconnaissance Regiment 1/7th Queens and one Section of 11th Field Company had advanced as flank protective force. The same scattered mines were encountered and were dealt with by " Snail " which had been devised to meet this case. The lorries were preceded by a party of sappers using their eyes to pick out mines. This they did successfully and the " snails " got up to the main minefield. There were three others in reserve in case any were hit, in which case a detachment was ready to clear a detour round the struck vehicle.

The main belt was then lifted, prodders and eye being used for locating mines. No detectors were used. 11th Field Company had practised these methods very carefully as a result of some disappointments in the use of detectors in a previous minor operation. The breaching was completed some hours before 7th Armoured Division had completed their task."

* * * * *

It would be wrong to draw any conclusions from this account, as to the respective merits of the methods employed. For a vehicle to strike a mine 900 yards from the minefield was a piece of incredible bad luck—no mine had been previously found more than about 300 yards out. It was probably a chance in a million and it was, I believe, the only mine encountered by that column in its advance to the minefield. The premature start of flailing, besides causing delay, drew the enemy's fire over a long period. As there was no wind, each Scorpion advanced (at 1 m.p.h.) in a cloud of dust which rose to some height and could be seen by the light of moon and flares from a considerable distance, though the Scorpion itself was invisible. Prisoners said they were less frightened by the barrage than by this strange phenomenon—a slowly advancing pillar of dust, out of which came dreadful noises of clanking, grinding, and rattling chains. They had no idea what it was. But it made a good " Aunt Sally " for them. Most of the Scorpions were hit and only one I think reached the main minefield ; it got about half-way through before being hit ; and the gap was then completed by hand by Sappers of 4th Field Squadron.

All this, by drawing the enemy fire, naturally helped the 44th Division's assault party, 300 yards away to the right. Not that they had a comfortable time. The " snail " lorries of 211th Field Park Company, though they had a rough trip, completed their task (leading the division into battle was a new rôle for a Field Park Company!). The Carrier Platoon of 1/7th Queens came up the oiled track and lay up in the broken ground short of the minefield. The Sappers of 11th Field Company went into "January," spotted the mines by eye and pulled them out by hand. When the further fence had been reached, the Section Commander went through the gap. He came back again and said to the Carrier Platoon Commander " It's all right now—you can go through." When, later the Carrier Platoon Commander was telling me about this, he added " To tell you the truth there was so much mortaring and other stuff flying about that I didn't think it was on to take the carriers through—but after that I had to ! " The Sapper subaltern, who was wounded later that night, got an M.C.

The enemy behind "January " fought stoutly ; there were many killed and many captured. The remainder withdrew to behind " February," but by now there was not enough darkness left to launch an assault on " February " that night.

When daylight came, our infantry were digging in between "January " and " February." Three lanes had been made through "January," the centre one widened to 24 yds. and its approaches improved. "January One," as this gap was named, was not a good place to hang about in that morning. In a small hole near the entrance stood a military policeman ; his face, surmounted by a red-banded tin-hat, appeared just above ground level. At the approach of a vehicle he sprang out, and directed it through in the best point-duty style. The vehicle would scuttle through the gap at top speed, cover the red-cap with dust and, as often as not, bring down " one round battery fire " from the enemy. In his spare moments the M.P. could watch a burial party going imperturbably about its task near by. Gilbert's song "The policeman's lot is not a happy one " seemed more than usually applicable.

Meanwhile, the Free French Brigade, after occupying Himeimat for a few hours, had been driven off by a tank counter attack. So this magnificent O.P. instead of being ours was still the enemy's, and it had become not unlike a stage box in the wings of a theatre.

It has since been revealed that the enemy was purposely allowed to retain Himeimat up to the time of the Battle of Alamein, in order that he might observe our deception plan. This no doubt he did, and reacted by heavily reinforcing his southern flank. But the possession of Himeimat by the enemy at this particular juncture weighed heavily against our operations carried out below it.

Events of 24th/25th October

In particular, the assault on " February," now planned for the following night, was bound to be more difficult. This minefield was now closely watched by a thoroughly alerted enemy ; a daylight recce was hardly feasible. Furthermore the enemy knew within fairly narrow limits whereabouts the assault would be made. He was not slow in making suitable arrangements to receive it. Among these arrangements (though we did not know it at the time) was the laying of a dense anti-tank minefield on the further side of " February" ; though possibly it already existed.

There were two Scorpions (out of seven) still functioning, and it was decided to use them to break through " February" that night. It was assumed, correctly, that there were no scattered mines in front of the minefield, for our leading infantry, who were not far short of it, had found none. On the further side of " February," according to our intelligence reports, there was only one more minefield and that was eight to ten miles away. It seemed that the 300-yd. width of " February" was all that lay between us and a complete break-through.

That evening the enemy asked for a truce to bury his dead—which was refused. Soon after dark 1/5th and 1/6th Queens assaulted through " February" and dug in precariously on the far side. There were very heavy casualties in this attack including many from the " S" mines with which " February" was now liberally studded. The two Scorpions flailed up to the further fence and made two narrow lanes.

At first light the tanks went through. In the half light some tanks missed the openings and blew up in the minefield. Those that got through met very heavy fire from eighty-eights, and some also ran on to the scattered mines beyond. C.R.E., 7th Armoured Division got into a Grant tank and went through the gap. His tank was knocked out by an eighty-eight and he had to bale out and run for it to another one. The losses in tanks were heavy and the attack was stopped. That night our infantry were withdrawn to behind " February" again.

The following night, at a point about one and a half miles to the south, a gap was lifted by stealth. This operation (of which a description appeared in R.E.T.M. No. 5 of June, 1943) was carried out by an officer and eight sappers of 209th Field Company, R.E., during the two hours of darkness before moonrise. The gap, however, was never used, for at this time the 7th Armoured Division and two brigades of 44th Division were switched to reinforce the attack in the northern sector. It is possible that there were scattered mines beyond this gap as well.

It was not until five days later that, against diminishing resistance, what was left of 44th Division finally broke through " February," the scattered mines beyond it, and the further minefield eight miles on. Then we were really through—and the chase was on.

THE EMERGENCY IN KENYA

By Major J. N. Holmes, M.B.E., R.E.

Introduction

THIS brief description of the emergency is intended to give the reader a broad idea of the causes of Mau Mau and of the course of the emergency. To those who wish to delve deeper the following books are recommended :—

Mau Mau and the Kikuyu by Leakey
Mau Mau by Stoneham
Before the Dawn in Kenya by Christopher Wilson
Red Strangers by Elspeth Huxley
Last Chance in Africa by Negley Farson
Facing Mt. Kenya by Jomo Kenyatta

To those whose reading time is limited, *Mau Mau and the Kikuyu* is particularly recommended.

The Country

Two immense features run the length of East Africa—the Rift Valley which starts at the Dead Sea and ends in Lake Nyasa ; and the East African Plateau, anything between 4,000 and 7,000 feet high, which has for its northern and southern bastions the Abyssinian Highlands and the South African Drakensberg Mountains. In Kenya the Rift Valley divides the plateau in two, and the two combine to form what is known as the Kenya Highlands. The longitudinal boundaries of the troubled areas are the western edge of the Rift and the eastern edge of the plateau where it starts to fall gradually towards the coast. The northern limit is the Northern Frontier Province boundary running east and west north of Mount Kenya ; Nairobi marks the southern limit. The whole area approximates to a square of 130-mile sides.

Superimposed on the continental features are local ones, which in a land less huge than Africa, would themselves be the chief features. The Aberdare Mountains run north-north-west from Nairobi along the eastern edge of the Rift into the Northern Frontier District, rising to peaks 12,000 feet high. They rise abruptly from the Rift Valley but fall away more gradually to the east. Ninety miles to the north-north-east of Nairobi is Mount Kenya, 17,000 feet high. The lower slopes of both the Aberdares and Kenya are thickly forested ; higher up, the forest gives way to moorland and later to rock.

The Kikuyu live in the very fertile and well-watered area east of the Aberdares ; the Embu in a similar area south of Mount Kenya and the Meru in a less fertile area east of the same mountain. The more important of these areas are enclosed by an inverted triangle with its apex at Nairobi and its base running westwards from Mount Kenya to the Aberdares.

The white settled areas lie between the base of this triangle and the Northern Frontier District boundary to the north and also in the Rift Valley. The country is more open than the native reserves, and therefore more suitable for European methods of farming, but is less well watered.

The Climate

The climate is temperate. There are heavy rains in March and April and again in October and November. From May to September the weather is generally overcast with intermittent periods of clear skies. From December to February there are few clouds.

At normal altitudes the temperature is about forty degrees at night and rises to a maximum of ninety degrees in the day at the hotter times of the year. Above the 9,000 feet contours there are night frosts, and the top of Mount Kenya is snow-capped and shares with Mount Kilimanjaro the distinction of possessing one of the two glaciers in Africa.

The Kikuyu

The lands which the Kikuyu now own have already been described. The tribe probably originated about the sixteenth century in the central part of their present reserve. It gradually increased in size despite the depredations of disease and of marauding tribes until it outgrew its lands. The Kikuyu gradually acquired by negotiation with other tribes, the country to the north and south of its birthplace, until in the middle of the last century it occupied its present area and certain other land in and around Nairobi, of which more will be said later.

During the greater part of their development, the Kikuyu were entirely cut off from the influences of other current civilizations. The skins of animals were their clothes ; the tinderbox was unknown, and when by some misadventure a community allowed its last fire to go out, resort had to be made to the fire stick ; the wheel did not exist. These facts give some idea of Kikuyu civilization before contact with the outside world was established.

The first outsiders who penetrated far enough inland to meet the Kikuyu were the Arab slave traders in the first half of the last century. They were followed by explorers and missionaries about 1850, and later by the first settlers. However, the flow of foreigners into the Highlands remained a trickle until the railway reached Nairobi in 1901. To-day it remains the chief means of communication with the coast.

Many of the present troubles are due to the sharp impact of British colonization on the Kikuyu. The country was opened up almost overnight by the construction of the railway, which brought in Europeans, who in their early dealings with the Kikuyu had to be guided by their colonial experiences elsewhere. Their greatest handicap was ignorance of the Kikuyu, and particularly of his intelligence and potential for rapid development. The tribe was apparently little different from many others ; there was no written word to give any hint of the complex legal and administrative systems which operated. To add to the difficulties, Kikuyu is not an easy language to learn. Every step by the Europeans had to be made in the dark.

To understand the causes of present-day ill discipline amongst the Kikuyu, it is necessary to know something of the system by which they originally governed themselves. The life of a Kikuyu was marked with ritualistic graduation from one age group to another, and it was from the age group system that the collective machinery for family and governmental control sprang. As a man rose to the more senior age groups he not only acquired a share in dictating family matters, but might also represent his family on the tribal organizations.

The Kikuyu family was distinguished by its size, latterly families as large as 1,000 were not uncommon, by its cohesion and by the sense of obligation which its members felt towards each other. The family generally owned one or a number of large plots of land which were divided amongst its members in an ever-increasing degree as a father bequeathed his land to his sons. The senior age group controlled the family and was concerned primarily with social matters including the ever important question of land. There was a strict moral code which, although peculiar and indeed in some respects abhorrent to the European, represented for the Kikuyu the standards which he had to observe in his life. This code was rigorously enforced by punishment if it was not observed ; the offender was shunned by the rest of the family, and to people for whom a community life is important, this was a powerful deterrent.

Tribal government was exercised by councils of elders at various levels, forming a pyramid-like structure of control, which was responsible for administering the law and for questions to do with tribal warfare, religion and much else. Most important of these, when examining the present situation, was the law. It was a complex case law passed on from generation to generation by men whose whole lives were devoted to its study and later to its administration. It relied normally on the judgment of these men, but when they could not reach agreement, or in a case between two appellants which could not be settled, the following method was used. The parties concerned were told that at a specified later date they would be called to the court to take an oath swearing that they had not perjured themselves. The belief was that if a perjurer took the oath, some calamity would subsequently befall him, or more probably his family. The natural hazards of life were such that this generally happened, and the catastrophe was naturally attributed to the oath. At all events the belief in the latter was so great that the family of a perjurer would very seldom, if ever, allow him to return to the court, to invite disaster by taking the oath. This description has been given because it shows how deeply the oath system, which is now a major factor in the emergency, is ingrained in the Kikuyu.

Religion was the third disciplinary factor in the life of Kikuyu. His beliefs numbered three—Ngai or God, an all pervading, invisible but ubiquitous being ; ancestral spirits and inanimate spirits. In any new venture all three had to be consulted and their blessings sought. For example if a Kikuyu were about to buy and cultivate a plot of land, he would at the outset seek by ritualistic means the agreement of the family spirits. Having bought the land he would clear it, but he would leave the largest and tallest tree standing, believing that it contained a spirit, the destruction of which would result in drought and infertility of the soil.

From what has been said, it is clear the Kikuyu discipline had three sources—the family, tribal government and religion. But the incentives towards high standards were in a sense negative ones, the fear of family ostracism, of tribal law and of the malign influences of various spirits. There is little mention of less material motives, for example, the voluntary observance of ideals. On the whole Kikuyu standards depended on their enforcement.

What was the impact of the European on this Kikuyu civilization? The newcomers were of three types ; they were either missionaries, settlers or administrators.

The missionaries were anxious to convert the Kikuyu to Christianity. They built their missions and schools in the reserve and quickly attracted many followers. But the attraction lay more in the education that was offered, than in Christianity. In retrospect it is a pity that this education was a scholastic one, elementary though it was, rather than the teaching of manual skills. It is possible, of course, that had it been the latter, it would have held little attraction for the Kikuyu. But as it was, the Kikuyu acquired book learning which, having left school, he was generally unable to employ in an economically under-developed country. This situation, even if the Kikuyu were not a natural intriguer, provided fertile ground for unrest. It was aggravated by the fact that his new learning revealed to him the fallacies of his own crude religion. Only occasionally was the vacuum left by this revelation filled by Christianity, for most Kikuyu, in their own minds, did not go to the missions to learn a new religion.

The settlers' first need was for native farm labour. The chief source was the Kikuyu, many of whom migrated to the white settled areas. Although they seldom lost all connexion with their reserves and often retained their native land holdings, they were removed from the family environment and tribal custom, and consequently lost many of the disciplinary ties which restrained the native in the reserve. These conditions were even more marked in the towns which sprang up in the wake of the settler.

The administrator came to give the Kikuyu the benefits of British Government. He brought with him a number of preconceived ideas, amongst which was the notion that all African tribes were ruled by chiefs. He imposed this system on the Kikuyu to whom individual leadership was quite foreign, with the result that power was concentrated in the hands of men who were not fit to wield it, and who not infrequently did, and still do, use it for their own corrupt ends. The new system also had the effect of weakening the authority of the councils of elders. British rule brought the Pax Britannica and medicine, both of which increased the expansion rate of a naturally fecund tribe, with a consequent growing demand for more land.

Of all the effects which the coming of the European had on the Kikuyu and which have contributed to the present emergency, the most profound has been the undermining of discipline. This resulted from the destruction of their religious beliefs, from the removal of many of them from their reserves, and from the breaking up of the indigenous machinery of government.

Before ending this description of the Kikuyu, it is worth noting how seldom the tribe throws up an outstanding leader ; and this despite the fact that they are intelligent and natural politicians. It has also been remarkable during the emergency that Mau Mau co-ordination has been poor and the tribal reaction to any event of importance generally slow. Both may result from the habit of collective decision and the endless debate which is the consequence of such a system.

The Embu and Meru

The Embu and Meru live to the south and east of Mount Kenya. They are in character and tribal custom system akin to the Kikuyu, and have subscribed to Mau Mau in the same way as the Kikuyu, but to a lesser extent. The reader can consider the three tribes as identical.

The Origins of Mau Mau

There is no recognized meaning of the words Mau Mau in the Kikuyu language, but they often use a code name to hide the meaning. " Uma " means " quit " and Mau Mau is probably a code name based on this.

The basic causes of Mau Mau are Kikuyu ill discipline, political consciousness and ambition which has outrun the development of

Kenya, and which in the end it may be difficult to satisfy within the economic resources of the territory.

A dissident movement frequently gathers its strength from the exploitation of some grievance, real or imaginary. Mau Mau has exploited the land problem. Just before the arrival of the British the southern part of the Kikuyu reserve suffered in succession from a famine and then from an epidemic of smallpox. Many of the survivors returned temporarily to relatives in the north, and much of the land was left unoccupied, although in Kikuyu eyes it remained their property.

When the British arrived they supposed that the vacated land was free for settlement, and alienated some of it for this purpose. The appropriated part is between a fifth and a sixth of the land now occupied by the Kikuyu. It is the least well watered country and was originally only of limited use to the Kikuyu because it was exposed to attack by neighbouring tribes. Mau Mau has won the support of most Kikuyu by claiming the return of this land ; each year its case became stronger as the population increased.

Kikuyu politics, in the modern sense of the word, started in 1922 with the formation of the Kikuyu Central Association. It barely concealed its subversive intent and quickly got itself into trouble. Its leader was arrested and replaced by a group which included Kenyatta. The new leaders adopted more subtle methods and the Association skipped warily just out of reach of the law until 1939 when the emergency regulations allowed its proscription. During the war Kikuyu politics were in the doldrums.

At the end of the war, Kenyatta, who is a Kikuyu-Masai half-breed, spent several years in London and Moscow. He returned to Kenya in 1947 determined to rid the country of the European. His motive may have been a genuine desire to better the lot of the African, or merely lust for power. The latter, judging from his behaviour, probably influenced him to at least some extent. His stay in Moscow does not seem to have made a Communist of him. He probably realized that in a country so remote from Russia, and with no organized worker proletariat, Communism could help him little, and would only attract unwelcome attention. At all events there has been no evidence that Communism has played any significant part in the present troubles, although Kenyatta undoubtedly improved his technique as an organizer of subversion while he was abroad. His methods for achieving European evacuation were in the first place to use political pressure, and then, if that failed, to resort to violence. For both methods he needed the backing of a large body of Africans. The Kikuyu were the obvious people. They were already a discontented tribe, and the land problem was an issue, which if championed by Kenyatta, would guarantee him a large following. Unification of the Kikuyu was the immediate task, to be followed by pressure on the European.

Soon after his return, Kenyatta founded the Kenya African Union. It was a political organization which operated legally, and was intended to bring the pressure of massed Kikuyu opinion to bear on the Government. At the outset, it attempted to be a pan-African body, but it quickly became dominated by Kikuyu. The latter's unpopularity prevented the union gaining the support of other tribes to any appreciable extent.

Concurrently with the formation of the union, Kenyatta organized its militant counterpart, Mau Mau. This organization was set the task of uniting the Kikuyu, and thereafter, if the need arose, of applying physical pressure to the European. Its method of unification was to administer an oath committing the person to support the aims of the movement and to keep its secrets. At first this oath was voluntary, but the need for speed increased and as the less co-operative Kikuyu were encountered, compulsion was used.

Both the Kenya African Union and Mau Mau were organized in parallel to the Government's administration. There were committees at colonial, district, locational and sub-locational level. At the top some of the office bearers belonged only to one organization—the moderates to the Kenya African Union and the extremists to Mau Mau. The important leaders combined both, being on the one hand leading members of the Kenya African Union and on the other the covert organizers of Mau Mau. The latter connexion was extremely difficult to prove because of the organization's excellent security and the Government's poor intelligence. At the lower levels the office bearers of the Kenya African Union and Mau Mau were generally the same people.

The Emergency

During the early months of 1952, the tempo of the oathing campaign was increased. Some resistance was met, and as a result about forty Africans were murdered, culminating in the murder of a senior chief. At the same time the oath itself started to include promises to take up arms "when the war horn is sounded" and to murder Europeans. By August it was calculated that 90 per cent of adult Kikuyu men and women had taken the oath. In October the Government decided to declare a state of emergency.

It was planned that the declaration should coincide with the arrest of the more important Mau Mau leaders who at that time had been identified. Opinion varied as to what the Kikuyu reaction would be to these arrests. At the worst, open rebellion was forecast, and it is perhaps a measure of European ignorance of the Kikuyu that the slow reaction which developed was not foreseen. The emergency and the arrests started on the night of 20th/21st October.

During the following seventy-two hours, 104 of the 138 known leaders were arrested, including the great majority of the important ones.

The security precautions involved the reinforcement of the police in the affected areas ; half of the colony's police force was concentrated within a thirtieth of the colony's total area. At that time there were in Kenya three K.A.R. battalions. These were reinforced on the day the emergency started, or soon afterwards, by the equivalent of two further battalions from the other East African territories and by a British battalion from Egypt. There were then between 6,000 and 7,000 regular police and troops in the Central and Rift Valley Provinces, mostly the former. They were deployed in small groups, generally of platoon size to prevent the outbreak of any major violence.

During the period up to Christmas, to the casual observer there was no apparent deterioration in the situation. The murders of loyal Africans continued, but not on a greatly increased scale. About a dozen Europeans were killed, which was a new, although not unexpected development. But there was no major outbreak of violence, and the tempo of incidents was much as it had been in the months immediately preceding the emergency. It was the sullen and uncooperative attitude of the Kikuyu tribe as a whole, and the continued heavy rate of oathing and re-oathing which were the serious omens. The gradual elimination of the few loyal Kikuyu cores was also most discouraging. Effective action by the Government was made almost impossible by lack of information, which was due to the infection of the vast majority of all Kikuyu and to the lack of means for the passage of information between the few loyal Kikuyu and the security forces. Before the emergency there were no police in the reserves, and the administration involved very remote European supervision by officers, some of whom had never been able to visit the more remote parts of their areas. The police special branch existed only as an office in Nairobi. The main feature of the Government's first plan was to administer and police the reserves more closely, and thereby not only apply closer supervision but also encourage the flow of information by reducing intimidation. The police force was so extended that to implement this plan it was necessary to continue the dispersion of army units and to use them as police.

In retrospect the period until Christmas was one of preparation by both sides, with Government sensing that things were not going very well, but unable to detect what was going to happen.

At Christmas a number of particularly brutal murders introduced a period of increased Mau Mau activity. It is possible that this action was caused by the threat of the small loyal groups who, thanks to the local efforts of certain administrative police and military officers, were becoming an embarrassment to the security of Mau Mau by giving information. The protection of these groups became vital, and, whereas it had been planned to concentrate military units, their continued dispersion became necessary. By February, when the Chief of the Imperial General Staff visited Kenya, it was clear that the forces available were not going to be able to stop the trouble and plans were made for the arrival of 39 Infantry Brigade from England.

From the early days of the emergency, it had been appreciated that, unless Kikuyu violence and non-co-operation were to become permanent features of Kenya, the battle had to be won by rehabilitating the whole tribe. The problem of rehabilitation is an immense one and its process will continue long after the emergency is over. The most immediate need is to convert the tribe to a law-abiding way of life. To do so directly, using European institutions as a foci, is impossible, because the Kikuyu dislikes, if not hates the European. The foci must be Kikuyu. It was on this conception that the development of the Kikuyu Guard, planned at about the time of the Chief of the Imperial General Staff's visit, was based.

Its organization was started soon afterwards, and its early members included the various loyal groups which survived. Its development is not yet complete. When it is, there will be large numbers of small units scattered throughout the reserve and sufficiently well armed to protect themselves. These Guard units, which are run by the administration under military supervision, have already supplied the security forces with much information, and are more and more becoming the means of demonstrating to the Kikuyu that co-operation with Government is more profitable than subjugation under Mau Mau.

By April, the Kikuyu Guard had developed to the stage when, in many areas, the Mau Mau thug could no longer live at home, farming by day and killing by night. The result was the precipitation of the Mau Mau gangs. At first these roamed the reserves freely, but having become identifiable groups they became easier to locate, and had to retreat to the more remote parts of the reserves, within or close to the forest slopes of the East Aberdares and South Mount Kenya.

39 Infantry Brigade arrived in May and was located in the Rift Valley. After a few weeks, during which time the situation there improved considerably (largely because the ground and local resources, such as food, did not favour Mau Mau), it became the first military striking force available since the start of the emergency. By this time the great majority of the gangs were operating from forest bases, and since early June, 39 Infantry Brigade, and latterly

70 (E.A.) Infantry Brigade, composed of the K.A.R. battalions, have been employed in a series of operations against those gangs. There have been no dramatic successes. The country and the terrorists' tactics of avoiding contact and their excellent security, make it unlikely that a whole gang will ever be accounted for in one operation. Casualties are nevertheless being steadily inflicted and, more important, the gangs are being continually kept on the move and faced with the recurrent problem of finding food and shelter. The war against the gangs may be won more by making life in the forests unbearable than by the infliction of casualties. Nature alone makes these areas uncomfortable enough ; the nights are cold, there is little food and one's bed companion can be anything from a tick to a rhinoceros.

Conclusion

This description may have given the reader an idea of what is happening in Kenya. It has inevitably only skimmed the surface of a situation, which owes its origins to causes, some of which are not understood by people who have spent all their lives in Kenya.

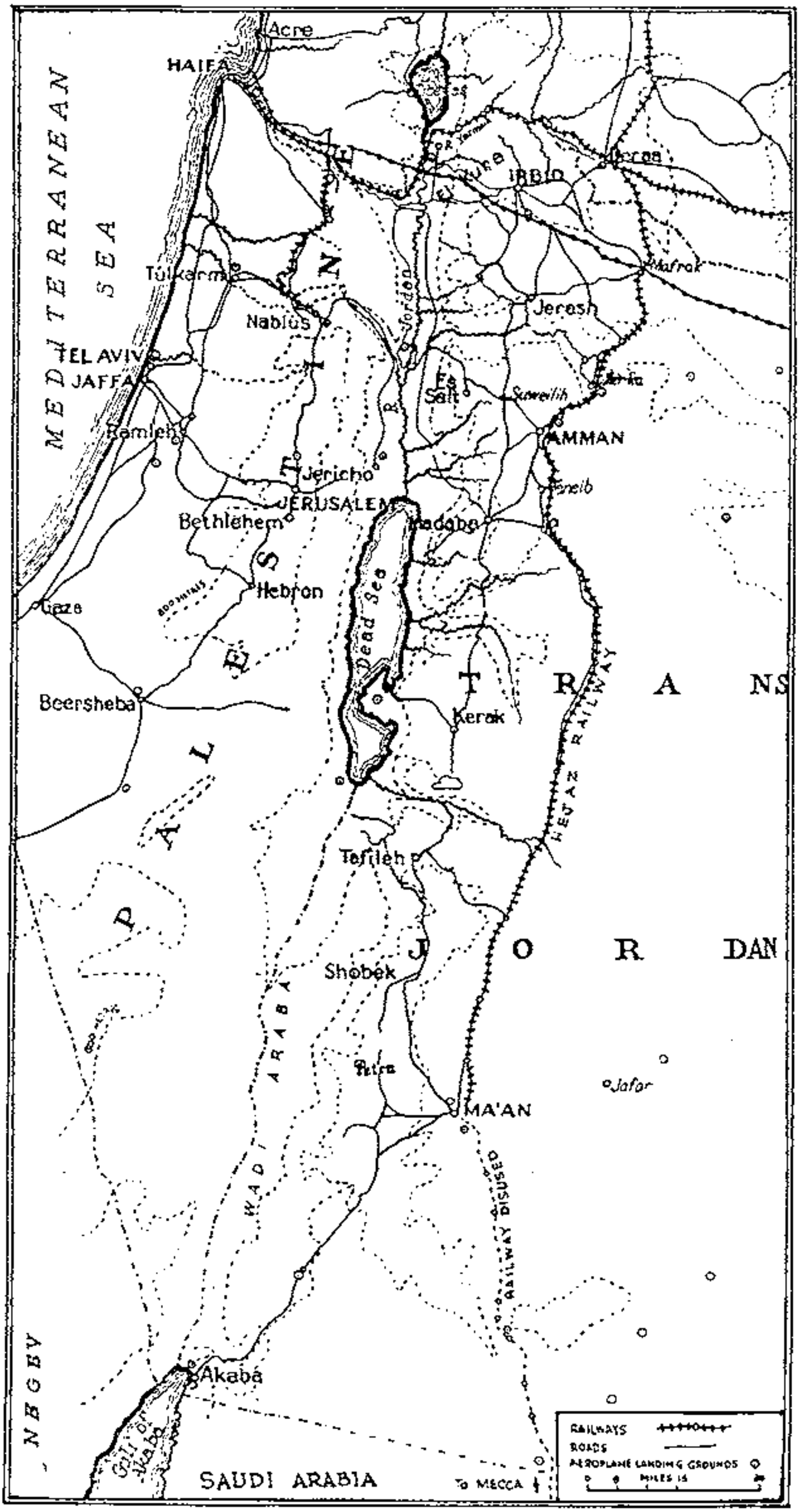
To conclude, the tasks that face the authorities in Kenya are to :—

(*a*) Destroy the gangs.
(*b*) Destroy the Mau Mau organization within the Kikuyu tribe.
(*c*) Rehabilitate the tribe.

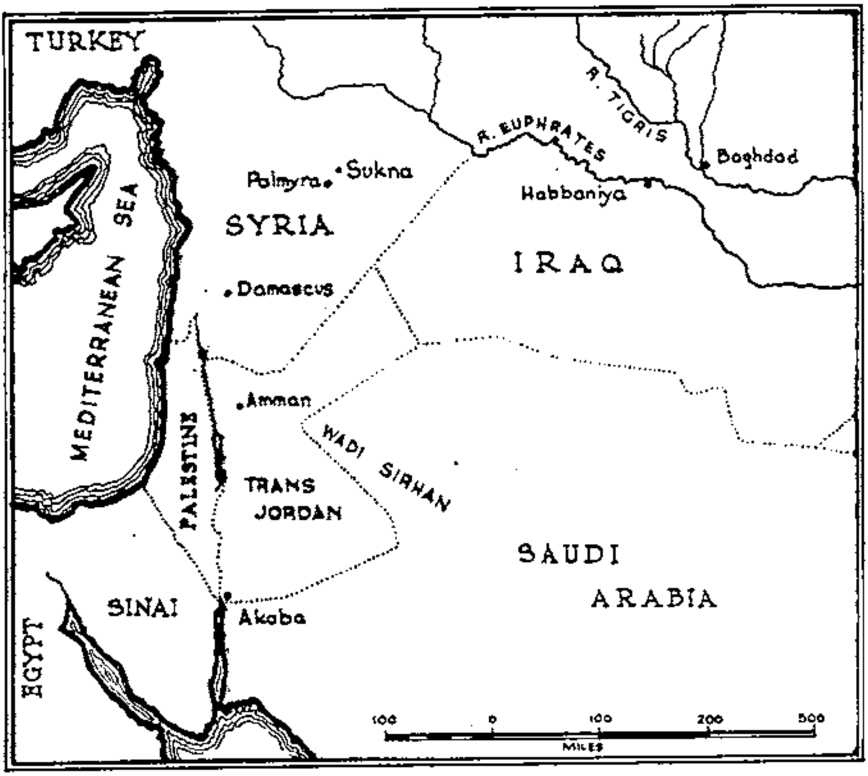
THE ARAB LEGION

By Major G. Horne, A.M.I.C.E., R.E.

JORDAN, until recently known as Transjordan, is situated in an area whose history goes back to very early times. In 650 B.C. a people known as the Nabataeans were paying tribute to the Assyrians ; later they prospered and from their hidden " Rose-red City of Petra " controlled the main trade routes of the East. Caravans from Syria, Persia, India and Egypt, and camel routes of the Negev and Akaba itself all came under their sway. The galleys of the Queen of Sheba once swung at anchor in Akaba bay. Uriah the Hittite was " slain in the forefront of the battle " at Philadelphia, now Amman. The area knew its most prosperous days under the Romans, who cultivated the hill country. North of Amman, at Jerash, is the finest and most complete specimen of a Roman town in existence to-day. To the south is Shobek, once a Crusader keep, and Kerak, the fortified town of Renaud de Chatillon, Prince of Transjordan in the days after the first Crusade. Such, in brief, is the fascinating historical background of this area.



Note:—The boundaries shown on this map are those between Palestine and Transjordan and not the present boundaries between Israel and Jordan.



Transjordan came into being as a separate state immediately after the 1914–18 war, being carved by the British Government out of an area lately subject to Turkish rule. With the passing of Turkish suzerainty went the maintenance of law and order and had not the British stepped into Transjordan and the French into Syria, the traditional practice of the desert nomad preying on the cultivator would soon have reduced both countries to poverty. Immediately after the war, military occupation kept the peace, but by 1920, nearly all troops had been withdrawn and the policing of the country was in the hands of a small force of gendarmerie. An officer of the newly formed Palestine Police was sent from Jerusalem to inspect this gendarmerie and found it most inefficient. He saw that no semblance of order could be maintained by such a force, so obtained permission from the High Commissioner of Palestine, Sir Herbert Samuel, to enlist five officers and one hundred other ranks to form a force to be known as the Arab Legion.

This officer was Lieut.-Colonel Peake, later to become Peake Pasha. Commissioned into the Duke of Wellington's, he served in India from 1906 to 1913, when he managed to get seconded to Kitchener's Egyptian Army, in those days a *Corps d'élite*. After service in the Sudan and Salonica he took over a detachment of the newly-formed Egyptian Army Camel Corps and joined Lawrence and the Arab Army. After the war the disbandment of the Camel Corps saw Peake transferred to the Palestine Police.

In October, 1920, when the Arab Legion was raised it consisted of five officers, seventy-five cavalry and twenty-five mounted machine gunners. During the first six years, the Legion was increased in size until it contained about 1,600 men and included cavalry, infantry, a machine-gun company, mountain guns, a signal section and a small camel corps for use in the desert districts around Maan. Most of the men were enlisted from the towns and villages, and there were few nomad Bedouin in the force in the early days. Some Circassians and Turcomans were enlisted from the village settlements of these peoples, which the Turks had encouraged years previously in order to form small colonies of these mountain folk to act in case of trouble as a barrier against the Arabs. The first officers were mainly ex-officers of Arab birth from the Turkish regular army, but later young recruits were obtained from the better-educated youth of the country.

One purpose of the newly formed Arab Legion was to show the flag in the various outlying parts of the country, thus demonstrating the existence of an armed and disciplined force capable of dealing with any disturbances. This was very necessary in areas where there were literally no police and no attempts made to enforce law and order. In some of these areas, like Kerak, more men were enlisted for service in the immediate vicinity. During his constant patrols through the country to inspect detachments, Peake came in close contact with both the nomad tribes and the villagers, who came to regard him as the embodiment of law, and laid before him all their complaints and difficulties. Thus he found himself an administrator as well as a soldier. Peake was wise and courageous and by his able handling of problems and settling of quarrels without resort to bloodshed, no mean task in this area, he steadily enhanced the prestige of his force.

Then came a severe setback. Whilst Peake was away in Jerusalem, the people of El Kura, which lies in hilly country to the north-west, rose against the Government and refused to pay taxes. The officials in Amman, without reference to Peake, dispatched the whole of the Legion to El Kura under an Arab officer. He marched the whole force into an ambush, losing eighteen killed, many wounded and nearly all the horses. The remainder broke and fled and upon returning to Amman went straight back to their homes, having no further wish to serve. Peake had returned whilst the Legion was still away, only to find a tribal war imminent much nearer to Amman between the people of Es Salt and Suweilih. He set out to prevent this tribal clash, and called a meeting of the local sheikhs which began on an angry note with much shouting. However, under the threat of attack by R.A.F. planes and armoured cars, tempers cooled and the meeting ended with everyone, including Peake, sitting down to a large feast, after which the two " armies " quietly returned to their villages. Though he had prevented this " war " Peake now had no Legion, which had become a laughing stock. The people of El Kura had won the day.

With difficulty he pursuaded some of his best men to rejoin, but found it very difficult to get his force up to strength, as hostility to the Legion was very marked, especially by a considerable section, who had no desire to see law maintained. Some Egyptians and Sudanese were brought over from Palestine and training was carried out clear of the town. When the new force was ready, it showed the flag in Amman and this sudden appearance of a large body of armed and uniformed men had a salutary effect on the sedition-mongers who were congratulating themselves that they had prevented the re-forming of an army. Good local recruits increased in numbers and eventually the Egyptians and Sudanese were discharged. Some difficulties were encountered in getting arms. Old German weapons collected from the dumps of enemy equipment were used. Some of the cavalry sabres obtained from Cairo were part of the equipment of Napoleon's ill-fated army which had come to Egypt in 1798. In spite of several setbacks, the force grew, trouble was quelled at Kerak and the people of El Kura were taught a lesson. This time Peake commanded the expedition. An ambush again awaited them but Peake sent a small force as a decoy into the ambush and by a night march he outflanked the ambushers. They, realizing they had been outmanœuvred, surrendered.

Thus the Legion grew, bringing law and order to the country and quelling small uprisings and tribal feuds. During these years there was friction with the French who were having trouble in Syria and accused, not without some justification, the people of Transjordan of giving sanctuary and help to the Syrian rebels. In 1921, Emir Abdulla became the first ruler of the territory to be known as Transjordan and later his father, King Hussein of Arabia, was driven from Mecca by Ibn Saud and his Wahabis. Since 1920, the power of the Wahabis of Riyadh had grown under the leadership of Abdul Aziz Ibn Saud, later King of Saudi-Arabia. His family had established themselves in central Arabia in the middle of the eighteenth century by the usual Arabian method of a revival of religion, in this case in an ultra-Puritan form. The Wahabis were religious fanatics and their raids into Transjordan territory were not the usual light-hearted affairs to steal a few camels, but ruthless attacks in which everyone they met was slain. Some of them were caught and publicly executed in Amman. In 1925 came the great Wahabi invasion which might have been the end of Transjordan. Thousands of tribesmen mounted on camels swarmed out of the Wadi Sirhan, sacked the village of Teneib, and advanced on Amman. R.A.F. planes and armoured cars went out and dealt them a crushing defeat on the plains south of the town, whilst Arab Legion cavalry rounded up scores of prisoners and wounded. The invaders retreated into the vastness of Saudi-Arabia, having failed to spread the " true faith " by putting everyone in Amman to the sword. To guard against the possibility of further invasions by the Wahabi Arabs, in 1927 the Transjordan Frontier Force (late the Palestine Gendarmerie and an Imperial force) was transferred from Palestine to Transjordan and the Arab Legion was reduced to 1,000 men, the machine-gun companies, artillery and signals being disbanded. The British officered T.J.F.F. contained many nationalities including a number of Transjordanian Arabs as well as Arabs and Jews from Palestine. Though there were no further attempts at invasion, raiding continued. To check this and to act as peace-maker and law-giver to the frontier tribes east of the Hejaz railway, a Bedouin force was recruited and put in charge of another British officer who had arrived in 1930 to act as second-in-command of the Legion. This officer was Major Glubb.

Major Glubb was a Sapper who had served in France and Belgium. After four years of war he found " the barrack square at Chatham was more than monotonous " and in 1920 volunteered for service in Iraq where the Arabs were in revolt. After the revolt he served in the Iraq political service and achieved great success in making peace between Bedouin tribes along the western borders of that country. From 1930 his talent as a peace-maker was directed to the tribal areas of Transjordan. His great knowledge of Arabic and Bedouin law, and his capacity for living as an Arab, soon made him most popular amongst the Bedouin tribes who gave him the affectionate nickname of *Abu Henaik*. This means the " father of the little chin," and refers to one of his war-time wounds. No Bedouin likes being policed by *felaheen* or town Arabs, so 150 Bedouin were recruited to the Arab Legion to form the famous desert patrol or *Badia*. They were dressed in a long *abaya* or cloak under which was a white calico shirt with very long sleeves, a mark of social eminence in the Arab world. With their Arab head-dress, ammunition bandoliers and decorated dagger they were, and still are, most imposing figures. This force operated on camels, with a few armoured cars, from small " Beau Geste " forts in the desert. Soon their fame was such that small detachments kept the peace amongst the great tribes, one of the secrets of their success being that they themselves were some of the finest men from those tribes. The Legion now had

Photo 1.—Arab Legion Sappers with some of the Badia or Desert Patrol.

Photo 2.—A camel patrol of the "Badia" returns to its fort.

The Arab Legion 1 , 2

Photo 3.—Officers and an N.C.O. of the Arab Legion Engineers.

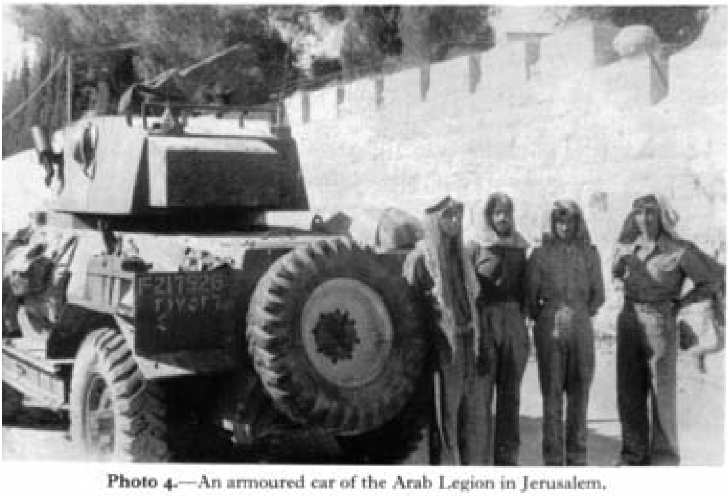


Photo 4.—An armoured car of the Arab Legion in Jerusalem.

The Arab Legion 3 , 4

three British officers: Peake its commander, who was kept busy in training and maintaining peace in the villages and settled areas and who, having learnt to fly, visited his various detachments by light aircraft; Glubb who kept the peace in the desert areas; and Major Northfield who was at the time in charge of the depot and prison service.

The 1936 Arab rebellion in Palestine resulted in an increase in the Legion to strengthen the frontier posts. Bands of rebels attempted to cross the frontier when pursued by Palestine police and British troops. Insidious attempts were made by the Arab party in Palestine to spread the rising across the Jordan, but the inhabitants of Transjordan remained loyal throughout this protracted struggle, though their sympathies were, quite naturally, with their countrymen across the river. Forces of rebels did in fact establish themselves in the broken country on the northern border. These were dislodged by the combined efforts of the R.A.F., the T.J.F.F. and the Arab Legion. At the time, the Legion had been given another British officer, Lieutenant Macadam of the Palestine Police. Unfortunately he was killed in these operations.

In March, 1939, Peake, now Lieut.-Colonel Peake Pasha, C.M.G., C.B.E., left Transjordan on his retirement from Government service. He had commanded the Arab Legion ever since it was first raised in 1921 and was such an established institution in the minds of the people that few realized that Transjordan had ever been without him. His going marked the end of an epoch. Major Glubb was now the sole British officer in the Legion.

The disturbances in Palestine prior to the outbreak of the Great War in 1939, and the series of allied disasters in 1940 brought British prestige to a low ebb. Our chances of survival seemed scant indeed. Nevertheless the people of Transjordan retained their faith in Britain and the Emir Abdulla offered his army and his country to the British cause. The British Army supplied the Legion with arms and equipment, the Desert Mechanized Force was doubled and formed into a Mechanized Regiment, whilst the 1st Infantry Company moved into Palestine on guard duties. In 1941 Rashid Ali rebelled in Iraq and the Iraqi Army besieged the R.A.F. cantonment at Habbaniya. "Habforce," a hastily organized relief column, made its famous dash from Palestine and ahead of it went the Arab Legion Mechanized Regiment, carried in Ford trucks, armed with rifles, Vickers and Lewis machine-guns and taking with them several home-made armoured cars. The successful conclusion of the Iraqi campaign was followed by the attack on Syria against the Vichy French. Again the Legion fought with "Habforce." They came under frequent air attack, operated against Palmyra, and at Sukna charged the enemy in their trucks, capturing eighty men and six armoured cars.

Fighting with the Legion in these operations were many tribal volunteers who welcomed the chance of attacking the French and also enjoyed a good scrap.

The Arab Legion had won its spurs in modern war, and with the help of the British Army it commenced a period of expansion. More British officers arrived, the mechanized regiment became a brigade, and when armoured cars were not available the Legion manufactured their own on Ford chassis.

If the Germans had broken through Anatolia the scant British forces would have been forced to retire, their lines of retreat being down through Syria and Palestine and down the Tigris and Euphrates. The 500 miles of nearly waterless Syrian desert between these two lines of withdrawal would have been the responsibility of the Mechanized Brigade of the Legion, and to this end they trained. The German break-through never came. Glubb was keen to get some of his men with the Long Range Desert Group in the Western Desert, where they would have been invaluable. However, due to rapid expansion most of the veterans were busy training new recruits ; that, together with the Syrian commitment, prevented a force going to North Africa. Then came Rommel's break-through and the Legion moved to Sinai to cover Egypt. After Alamein followed the pursuit and though the Legion were ready and keen to go they were not required and were given the tedious, but very necessary, task of mounting guards over the dumps and communications of the Middle East. This dull monotonous job made no appeal to the dashing Arab soldiers. Nevertheless they carried it out with great efficiency and many were the brushes with raiding tribesmen and gangs of thieves.

There was one more hope of action. This was that the Mechanized Brigade might be employed in the Balkans in the event of an allied landing. The country was mountainous and covered in places with forests. The Brigade carried out training in mountain warfare and was re-equipped, but the landing did not take place and the war ended. The Legion had fought in the early campaigns, tried hard to get into later ones and carried out a large and valuable rôle in the maintenance of internal security ; Transjordan itself being the only country in the Middle East where Allied commanders were not obliged to retain combat troops in order to ensure stability and order. Transjordan not only looked after herself without outside assistance, but she gave the whole of her army to serve beyond her frontiers without a moment's anxiety as to her own security.

After the war came the troubles in Palestine when Jewish thugs fell to murdering the army which had protected them in 1936 and the Arabs saw the fears that had caused that rebellion come true, namely the Jewish infiltration into Palestine. During these troubled times, the Arab Legion did its full share of duty and helped to keep the peace, even though its sympathies were obviously with the Arab cause. In 1946, Britain ceased to govern Transjordan as a mandated territory and a treaty was negotiated between the two countries. On 25th May, Emir Abdulla became King Abdulla and Transjordan became a kingdom. On Amman airfield the new king reviewed the Arab Legion, a very different Legion from that of the early days. Now it was becoming a full-scale army, with an increased number of British officers and some supporting arms. The Arab soldiers were learning to handle their armoured cars with the dash and spirit of the cavalry and camelry.

In May, 1948, the British Mandate in troubled Palestine was ended and the Transjordan Frontier Force disbanded. Prior to that date all Arab Legion units had been moved out and on the eve of the ending of the Mandate, the Legion assembled in the Jordan valley, east of the river. British Spitfires patrolled the river line to see that no crossings were made that day. The following day the Legion, together with the armies of the other Arab countries, moved in. Not, as is sometimes thought, to push the Jews out, but to garrison the Arab areas of the country and thus prevent the Jews seizing them. The original plan was for the Legion to hold part of the line in central Palestine and the local Arabs to hold Jerusalem. However, brave and gallant fighter though he is, the Arab, unless carefully disciplined, does not worry himself about sordid matters like digging-in, conserving ammunition, getting up his supplies, etc. Very soon the Legion had to move regiments into Jerusalem to prevent the local Arabs being pushed out. By the first truce, the Arab armies were fairly well established. During the truce, when the United Nations were expected to prevent rearming, the Jews built up their strength, and when hostilities recommenced were able to push forward in several places. During the second truce, by the process of keeping the U.N.O. observers away from vital areas and moving their forces about, the Jewish Army retook a lot of ground, mainly from the Egyptians. During these incidents the Arab Legion stood firm, even though their line became longer and longer. They had to plug the gap south of Jerusalem when the Egyptians pulled out; forces were needed in the Irbid area when there was fear of a Jewish thrust into Transjordan, and until the British moved in under the terms of the new treaty, Legion forces were required in Akaba, as the Jewish Army had reached the coast.

When the war turned into an uneasy truce, the Arab Legion was strung out along the frontiers of the Arab areas of Palestine. In the Jordan valley were camps containing thousands of Arab refugees whose land and homes had been seized by the Jews. The area of Palestine saved from the Jews, which included the Old City of

Jerusalem, became West Jordan and the whole country Jordan, or to give it its full name the Hashimite Kingdom of Jordan.

The Arab Legion went into the Palestine war under a division in strength with artillery, signals, armoured cars, mortars, workshops, a field hospital, a supply organization, a works section and with base installations back at Amman and Zerka. During the war these supporting arms increased in numbers and efficiency and field sappers were recruited and trained. For a time the Legion ran the railway, a branch of the old Palestine Railways, in its vital task of bringing in supplies from Akaba and Damascus.

To-day the Arab Legion has a well-equipped, well-trained division containing Bedouin and Felaheen regiments. Supporting arms include an Engineer Regiment and aircraft for liaison duties. Base installations for keeping a division in the field are now well established. In West Jordan are locally recruited home guard units to meet the threat of expansion by the new state of Israel. Lieut.-General Glubb commands the Legion, in which serve seconded British officers and N.C.Os. of many arms, including Sappers.

In spite of its great expansion, the Legion also continues to carry out its traditional rôle of policing the country by means of the town police, who wear the spiked *Khuza* based on the Saracen helmets, and by the country police or cavalry in the rural areas. In the desert the law is still maintained by the *Badia* or camel patrols.

Finally a word about the men who make up the Legion. Born soldiers they have acquitted themselves under modern conditions as well as their forefathers did in the early days with Peake. Their valour is never in doubt though at times they have to be " chased " in the more mundane tasks such as trench digging, wiring, etc. Bedouin and Felaheen make very well behaved troops and all have the fine manners and confidence of their race. The lowliest private soldier will politely invite any passing officer, however exalted in rank, to take coffee with him and discuss the problems of the day, for are they not both soldiers of the Arab Legion ?

The author wishes to acknowledge two books which have been of great assistance in the writing of this article.
They are :—

Arab Command by Major C. S. Jarvis, C.M.G., O.B.E., published by Hutchinson & Co., Ltd., and *The Story of the Arab Legion* by Brigadier John Bagot Glubb, C.M.G., D.S.O., O.B.E., M.C., published by Hodder & Stoughton, Ltd.

Photo 5.—An N.C.O. of the Desert Patrol or Badia.

Photo 6.—The late King Abdulla presenting medals. The then Crown Prince, Emir Talal, looks on.

The Arab Legion 5,6

Photo 1.—Ceremonial Parade in Berlin.

Photo 2.—On training with a T 34 tank.

A Russian Soldier 1,2

A RUSSIAN SOLDIER

By Colonel J. V. Davidson-Houston, M.B.E.

IVAN PAVLOVITCH KRYLOV was born in 1932 in a small village near Kharkov. From the age of six he had attended the village school and learnt to read, write and praise Stalin. On leaving school he had gone to work in the fields with the other members of the local collective farm.

Ivan first registered at his local recruiting centre in 1950 at the age of 18. He knew that under the universal conscription law all Soviet male citizens were required to serve for two years. He also knew that, although called up in the summer or autumn, his service would only count from 1st January of the following year; that he would then be required to serve a full two years before becoming eligible for demobilization and that this would probably not take place until the autumn following that. Ivan therefore prepared himself for at least three years with the forces. During that winter he was instructed to do his 110 hours pre-military training. This was carried out in the near-by town's "club" under the auspices of DOSAAF (the Voluntary Society for Co-operation with the Army, Air Force and Fleet) and as this was some way off from his village he was billeted in a near-by house. The training was carried out in civilian clothes and included basic drill, weapon training and marching.

It was with no great surprise, therefore, when on the 15th July, 1951, a letter arrived instructing him to report to the recruiting centre a week later. Here he found a number of other youths from the surrounding districts. They were given a detailed medical examination and sent off by train to a large camp about a hundred miles away.

On arrival, the recruits were given a shower bath, inoculated (with some protest) and had their hair close-cropped, as it would remain until their third year of service. They were issued with uniform: first, a *gymnastyorka* or long loose-fitting blouse of traditional Russian pattern with a stand-up collar, which was worn outside the breeches and pulled together at the waist by a leather belt with a large metal buckle incorporating the Red Star; next, khaki-coloured breeches, a pair of jackboots and a greatcoat, which was rolled up and slung round the shoulders; finally, a side-hat and some foot-bindings which wound round the foot in lieu of socks.

Ivan spent his first ten days in the camp in quarantine with the rest of his draft. When this quarantine period was completed, Ivan began his elementary training and from early morning to late at night he learnt how to march, drill and use his rifle.

After ten weeks of this training, the day came for the recruits to "take the oath." The whole company was paraded and the Colonel appeared.

"Hail Comrades," he shouted.

"We wish you health," chanted the recruits.

"I compliment the company on its bearing."

"Hurrah!" roared the company.

"Thank you, Comrades," replied the Colonel.

"We serve the Soviet Union," shouted the recruits in parrot fashion.

This ceremony is laid down in detail in Soviet Army Regulations as also is the lengthy military oath, which each man now recites in front of the assembled troops.

The next day Ivan and many of his draft were issued with better quality uniform and jackboots, and from this they gathered that they would be going to Germany. True enough, on the following morning all were marched off to the station behind a regimental band and herded on to a train. The conditions were far from comfortable. The recruits were crowded into covered wagons in which wooden tiers had been erected, and these hard boards acted as beds; not that there was room enough for them all to lie down at the same time. While some slept, the remainder stood or sat around singing or talking. Meals were cooked in a special box car attached to the train and eaten during halts at wayside stations. The journey across Poland and East Germany continued much the same as before but the most stringent security precautions were taken. The doors were locked, the windows covered and the train only stopped in deep forest. At last after about ten days they arrived at their destination. Ivan found himself lined up with many others whilst officers sitting at tables divided up the draft to various units.

A few hours later Ivan and some fifty others were on the way to their new unit, a motor rifle battalion of a tank regiment. Ivan's new home was a big *kaserne* on the outskirts of a German town not far from Berlin. The barracks built by Hitler were more spacious than anything which Ivan had known in Russia. He soon found, however, that the barrack area was more like a prison, being cut off from the outside world by a high wooden fence. No one was allowed out of barracks, except on duty, and the only glimpses of the outside world were through the chinks in the fence or when moving by truck to the local training area. Ivan found that there were many other restrictions too—no fraternization with the local population, no alcoholic drinks and no girls ; even the few Soviet women in the barracks were officially authorized to associate only with the officers.

Ivan was given little chance to brood over his sorry lot, and, anyhow, from as early as he could remember he had been taught that the state was always right. The days were long. Reveille was sounded at 0600 hours and five minutes later Ivan had to be outside dressed in P.T. kit. Breakfast consisted of soup with bits of meat in it, black bread and tea with sugar. The morning training period lasted until two o'clock when there was a break for dinner. Dinner was somewhat more ample than breakfast ; Ivan had *borshch* (vegetable and meat soup), fried meat and *kashà* (porridge made from millet). Tea and black bread were also issued. Coming from a collective farm, however, Ivan felt that he was not getting enough to eat. This was because, as a civilian, he had eaten an unbalanced diet of potatoes and bread and had not as yet adjusted himself to the more balanced army diet. In fact, he was probably eating better than he did before, either on the farm or whilst serving in the U.S.S.R. He knew that he was entitled to a butter ration and was rather rankled because it did not appear to be issued to him, not realizing that it had already been used in the preparation of the food. After dinner he had a rest period followed by three more hours of training and weapon cleaning. At last came supper : mashed potatoes, cabbage, bread and tea. This was followed by political instruction or " hobbies," which lasted until the time came for roll-call followed by the " evening walk," when the various platoons marched round the parade ground, each singing at the top of their voices a different patriotic song—a strange and incredibly noisy performance.

Through the winter months, one day followed the next with little to break the monotony until April came and a fresh impetus was given to the training by the arrival of an inspecting team from Moscow consisting of several well-known generals.

The regiment was drawn up on parade and the inspectors went around asking each man if he had any complaints. Later, standards of political training, drill, shooting and physical fitness were tested. In one of the tank battalions of the regiment there was a C.S.M. who was an excellent shot with both the tank gun and the machine gun. During the inspection, this C.S.M. was changed from tank to tank so that the battalion got excellent results in marksmanship. Ivan had heard that during a previous inspection his C.O. had been reprimanded for the large number of entries on the men's conduct sheets. This is not surprising in view of the fact that practically all crimes, whether serious or insignificant, are dealt with summarily by officers at all levels. The C.O., however, had learnt his lesson and had recently taken to punishing the men with extra fatigues or severe reprimands which were not entered on the cards. As a result, the inspectors found only "ten punishments and fifty-two commendations" had been given during the year.

Shortly after this the whole division left winter quarters and moved out by night to a large training area near the River Elbe. Once more they were isolated from prying eyes, as entry to the area was forbidden to all Germans. Here Ivan lived in a tent and saw for the first time all the vehicles, tanks and S.P. guns of his regiment.

Training in the summer camp from April to July was fairly similar to winter training, but as autumn approached more and more troops were involved in the exercises until in early October the whole division moved to a concentration area and was joined there by other Soviet units. The main manœuvre of the year was about to begin. Ivan did not really know what it was all about, but for seven days and nights he slept in the open or did not sleep at all, sometimes carrying out mock attacks (with tanks and artillery laying down real covering fire), at other times wading, swimming, or rafting across rivers with the assistance of local materials, whilst Soviet engineers built pontoon bridges for the tanks and trucks. He got used to the whine of the MIG15 passing low overhead and the roar of the tanks as they moved across the countryside. He also got used to food at irregular intervals and the continual need to dig in and camouflage.

It was with great relief that the end of the exercise signalled the return to the comparative comfort of winter barracks, where immediately Ivan found himself in the midst of cleaning up and preparing for the Soviet "Holy Day," the anniversary of the October Revolution—celebrated, as it happens, on 7th November.

It was now about a year since Ivan had come from Russia ; the class due for release was being sent back and new recruits were arriving. Ivan's second year would have been much the same as his first, but suddenly in March, 1953, a tenseness fell on the Soviet Army ; Stalin was dead ; leave was stopped—not that this affected Ivan because as a conscript he didn't get any—but perhaps here at last was something to change the dullness of their lives. New names appeared : Malenkov, Khrushchev and others ; but after a time life drifted back to the weary old ways and the date for summer camp came round again.

Eight weeks later the regiment was suddenly alerted and moved out almost immediately for Berlin—the date was 17th June, 1953. On arrival an incredible sight met their eyes : crowds milled round the street, Communist posters had been obliterated and Communist headquarters stoned. The "impossible" had happened ; here was a spontaneous public revolt against a Communist dictatorship. Ivan was given strict instructions not to open fire and remained unperturbed when a few stones were flung at him and when he saw two youths haul down the " Hammer and Sickle " from the Brandenburg Gate and run up the West German flag. The tanks, however, soon cleared the streets by advancing steadily on the crowds.

Later on the Political Officers informed their classes that the riots had been sponsored by enemy agents, but Ivan was used to their themes and had his doubts. Two or three times a week he and his platoon were assembled in a lecture room and harangued by the *Zampolit* (the company Political Officer) or one of his " agitators." The subject matter varied but little ; the history of the Party, the benefits of Communism, the life of Stalin or the war-mongering of the West. Ivan was bored ; the references made to agriculture in Russia were to his own knowledge crude distortions, but there was little he could do. He had nowhere else to turn for the true facts and fear of " informers " effectively sealed his lips when with his comrades. While the *Zampolit* droned on, Ivan dreamt of home, Mother Russia, girls and Vodka, and wished they were not so unobtainable.

Little did he realize that at that very moment Lieutenant Dmitriev was reading the latest orders issued by the army commander, which authorized fraternization with the German public for the first time since 1945. Troops were now free to leave barracks and visit cafés and dance-halls in off-duty hours, and there were several other minor concessions on the burdensome restrictions which, until then, had been " essential to the security of the Soviet State."

Ivan and a few friends took advantage of the new rules at the first opportunity ; they got drunk, were involved in a fight with Germans over some women, and ended up with ten days in the guardroom. Other similar incidents occurred daily and it was rumoured that only organized parties would be allowed out. Fatalistically Ivan thought that his pay of thirty roubles a month (1s. 9d. a day) would never have lasted very long anyhow. He thought of Lieutenant Dmitriev, who received about 1,000 roubles a month, but didn't feel envious : after all an officer had to remain in the army for life ! He calculated that he only had another year to do, unless he were made an N.C.O. in which case he would have to serve for an additional twelve months. Ivan turned over and went to sleep.

THE AGHIRDA RIFT

By CAPTAIN B. H. MARTIN, R.E.

WHEN we first arrived in Cyprus our offices looked out on to a typical Mediterranean range of limestone hills, which appeared to hang over our heads, but were, in fact, some twelve miles away. My particular companions at the time were two newly commissioned officers, 2nd Lieutenants Rigden and Barker, and a certain amount of three-cornered speculation went on between us as to whether there was any chance of finding a few " potholes," when we had an opportunity of making a closer inspection of the range. Chris Barker knew a little about such things, coming from Yorkshire. I had done a little in the south, and " Rig " knew only what he had read on the subject, so that our discussions tended to fade a little, due to lack of enthusiasm. Then we were split up and scattered over the island and had little time or opportunity to discuss matters further, and none at all to arrange the reconnaissance which we had been planning.

During the next three months we made no advance whatever, and were beginning to think that we would have to bury our hopes, work out a suitable epigram and forget our precious limestone hills, when Christmas suddenly dawned, taking me completely unawares. I woke up one morning to discover that it was Christmas Eve, a glorious day, and that I had an afternoon off duty. This was obviously the chance of a lifetime, and having finished an early lunch, I made for the hills to the east of Aghirda Village, which had recently become a part of my area.

For weeks I had been examining, from a distance, several fairly obvious openings in the limestone, and I headed directly for them as fast as I could. The openings were on a shallow escarpment on the lower side of a range of smaller hills which ran, in places, up to the 1,000-ft. contour, and had the appearance of having fallen away from the parent range, which reaches the 3,000-ft. contour for most of its length. We later verified the fact that this falling away almost certainly did take place, probably between 3,000 and 4,000 years ago. The openings I had seen, however, proved to be a big disappointment, each one being simply a soft spot in the face of the rock, which had been washed away by the flow of surface water down the escarpment. I had heard local stories of springs in the neighbourhood, which dried up at the end of summer, but this proved equally useless, since on arriving at the spot indicated, I discovered that the springs had been taken over by the irrigation engineers, and all that remained of them were several concrete catchment tanks built into the rock face, and connected by 6-in. tubing to a main pump house.

After Christmas, Chris Barker returned to the fold, complete with a Morris, and things began to look very much happier. We knew of the existence of a spring further to the west, which produced several million gallons of very hard limestone water a day, serving a village, an irrigation system, and the immediate needs of the Army in the vicinity. Although the set-up generally was very similar to the other, catchment tanks and pump house, we were very curious to examine the ground for an entrance at the level of the original water table. We made our first discovery fairly quickly, a very small gallery containing a few rather delicate looking stalactites and stalagmites, and something that looked very much like a petrified tree trunk. This proved, on closer examination, to be a broken section of a fairly big stalactite, which had been smashed up during an upheaval, probably during the earthquakes that occurred here some 3,000 years ago. The same upheaval had cut off any further progress in that particular gallery, denying the sight of what might have been a considerable amount of Nature's subterranean magnificence until, perhaps, another upheaval occurs to open this particular section of the mountain once more.

In February I was given a certain amount of work to perform in this particular area, and the policy was that, as far as unskilled labour was concerned, it should be recruited from the nearest villages. The clerk responsible for recruiting such labour also acted, when necessary, as my interpreter, and he was bred in these very hills. He was aware of my passion for caves, but was quite unable to understand it, and the only caves of which he knew, were the openings I had examined on Christmas Eve. He was, however, quite prepared to humour my apparent insanity, and was always very careful to question each new labourer as to the whereabouts of caves in the neighbourhood of his village. This usually raised a cheap laugh from the labourer, but eventually brought forth the information that one of the newly aquired hands knew of such a cave. If we would care to meet him in the village coffee shop, equivalent of an English pub, on Saturday afternoon, he would show us the very spot. The necessary arrangements were quickly made, and Saturday afternoon found us drinking coffee and discussing the cave through the medium of our extremely useful interpreter.

The old man gave us all the information he could before we set off. There was a climb of 1,000 ft.—he had never been to the bottom of the cave—no, he did not think anybody had—he did not think our lights were good enough—he thought we would need ropes—but at least he would show us the cave. He was as good as his word, and after climbing for nearly an hour, we arrived at the entrance, and realized that without his aid we would have passed within a yard of it without noticing it. It was a typical limestone gallery, the roof of the opening extending only just above ground level, large enough inside to walk bent double, containing vertical walls, an arched roof, and a very slippery form of clay covering the rock floor. All the gloomy predictions proved well founded. Our lights were most inadequate and we had only gone a matter of yards before we discovered a pitch, of which we could not see the bottom. We thought it most unwise to attempt to negotiate this without the assistance of ropes, and with such poor lights. However, the formations on the walls convinced us, from the outset, that this was what we had searched for, and a council of war was called immediately we reached daylight.

We had previously acquainted Major Paxton, our D.C.R.E., with our activities, and he expressed himself very keen to help us as much as he could. His views were very sound.

"After all," he used to say, "even if you never get far, it keeps you out of bed during afternoons off, and you get some fresh air and exercise."

It had been arranged that, should our preliminary reconnaissance prove successful, a more probing expedition would be arranged. This would include the original three officers, and as many of our sappers as could be extracted from their normal Sunday activities with a winkle pin. On this organization we based our council of war.

Our guide would be glad to accompany us on the Sunday, we were told, and although we were of the opinion that he would almost certainly be no real asset, we weighed this against the fact that he could produce, if we wished, a donkey to carry our ropes up to the entrance. He was also sufficiently friendly with the owner of the coffee shop to borrow two large tilley lamps. We came to the conclusion that it was a borderline case, and decided that the donkey would probably be a help, with the result that on the Sunday morning the coffee shop proprietor thanked God for speleologists, when eight thirsty sappers descended on his establishment for coffee and bottles of beer.

When we had arranged our tilley lamps on the pitch which had barred our progress the previous day, we saw that it had been, in some past age, a very attractive water shute, and consisted of rows of tiny limestone formations which resembled rows of mouth organs, one beneath the other. We took a belay around a solid piece of rock, and made a rapid descent of some thirty feet to what seemed to be a mound of earth, with a large gallery going down in each direction at an angle of about forty-five degrees. We decided to split up, and Rigden took a small party off to the right, while the main party took the gallery on the left. Almost immediately we discovered a small chimney, about ten feet deep, in the floor of the gallery, causing the main party to split—Barker going straight ahead, while I, with two sappers, disappeared quietly down the chimney. At the bottom of this chimney we found that the gallery was still descending quite rapidly, and that the wall on our left was formed by the base of an enormous stalactite, of a peculiar " honey-pot " formation. Since our lights were too poor to examine this miracle closely, we noted it for further investigation and continued our descent. After negotiating two further chimneys, we could see a very solid-looking rock wall in front of us, with nothing in the nature of an exit, apart from a very narrow " staircase " in the rock floor. This dropped at roughly sixty degrees, and appeared to end abruptly some few feet below where we stood. A large rock, which we judged to weigh about two tons was wedged precariously in the opening of the staircase, and the whole thing looked a little dangerous from above. We failed to realize, until we arrived, that it looked considerably more so when one was crouching directly below the loose rock !

At the bottom of the staircase was an opening in the floor. It was rather small, with a narrow ledge some four feet below, formed by two rocks which were cantilevered from the walls on each side of a small rift and had wedged themselves into a flat arch. I managed to get my feet through the opening, and after an effort, the lower half of my body and there I stuck. I calculated that my feet were about eighteen inches above the ledge, and the only answer was to remove all clothing above the waist, put my arms above my head so that the people above could push, and go through like a cork. I was quite thankful when I felt the ledge underfoot, and realized that, apart from the odd scratch, I was none the worse, and I jammed myself into a crevice to enjoy a rather peculiar shaped cigarette, and have a look around.

I was in the top of a rift, and I could see the opposite wall to a depth of about thirty feet, ending in what looked like a black ironstone floor, which was what we were half expecting, but were rather surprised to find so soon. By this time Barker's party had caught up with us, having come to the end of their gallery, and we soon had a rope firmly belayed and tested. The thirty feet I had seen from my perch proved an easy climb, narrow enough to " chimney," with the feet against one wall and the back against the other, but when I arrived at the " floor " it was simply a turn in the rift, and for the next fifteen feet I was very glad to use the rope to help out the few poor footholds. My light was too bad to enable me to see whilst climbing, and being hooked to my belt, was very difficult to direct in the line of descent. I leaned against a fairly solid-looking stalagmite for a rest, and unhooked my light to get my bearings. I was on the edge of an " overhead," and could get only a very vague idea of where the rock face finished and floor began, but it seemed to be another thirty feet below, so that once again I was glad of the fact that there was ample rope, and that we had tested it so thoroughly. Excitement was mounting steadily by this time, as I was still in communication with the others, and supplying a commentary, although all they could see of me was a vague glow. I was very mystified, at this stage, to see other lights below me, and to hear voices, until I remembered our third party, and cursed at the thought that they had apparently found a very much easier entrance to this terrific cavern.

I touched solid ground very much sooner than I had expected, and found myself perched on the top of a heap of loose boulders about fifteen feet high, I soon reached the floor of the cavern, which I judged to be some 200 feet high in most spots. The lights I had seen now made themselves apparent, and I no longer cursed. They emanated from a small entrance hole almost in the roof, and I felt quite pleased with life as a rope snaked down in the darkness, and Rigden began his eighty-foot climb! I began to realize that it was highly probable that I was the first human being ever to have stood on that particular floor—a feeling which amply repaid all the effort of the climb, and made up completely for the few rather nasty moments on the rock face, I wasn't alone for long and, leaving two men on the top of each pitch, we formed two small parties and pressed on into the extremities of the cavern.

We chose the right end, and disappeared into a gallery under an enormous arch, almost perfect in shape, which gave the whole rift the appearance of an enormous cathedral. We were still in the rift, however, which narrowed down until it became impassable, but before we returned we had discovered a further pitch, if the exit holes were large enough to permit the passage of a body. A further discovery was that of a tree root growing in the shape of an ordinary plant, but with a complete lack of light and water, which proved that we had been working our way towards the side of the hill instead of into it. The air at this spot was very fresh, and moving noticeably, presumably from a blowhole which we later discovered on the hillside. By this time the other party had joined us, and we traced our way back to the main rift to discuss prospects.

Our new pitch seemed to be the only really promising find of the day, and it was painfully obvious that we could entertain no thought of tackling it without ropes and better lights. We agreed, also, that next week would involve cameras, flash powder, and photographic paraphernalia generally, and that our ropes should be made into 25-ft. lengths, with a thimble on one end and a hook on the other, knotted at 6-ft. intervals, for easy carrying and simpler climbing. By this time it was three o'clock, and no one had had lunch as yet. Both exits looked fairly terrifying on an empty stomach, but a

Photo 1.—Myself in a "chimney," with Barker.

Photo 2.—Rigden emerging from a "pothole."

The Aghirda Rift 1,2

Photo 3.—The lower part of the 80-ft. climb, showing limestone formations on main cavern wall.

Photo 4.—Honey-pot stalactite.

Photo 5.—The "cathedral arch."

The Aghirda Rift 3 ,4, 5

decision was made to use the hole I had discovered, the climb being an easier one, and to use both ropes, one as a safety line. This was all quickly organized by the party above, and the ascent began.

We watched the first man go up, giving him what assistance we could with our light, and saw him disappear around the turn, but were mystified by the fact that the safety line failed to reappear—the signal for the next man up. The exit hole, which had been so tricky to negotiate on the descent, was proving even more difficult on the ascent! It was almost four o'clock before I discovered the reason for the time-lag, which was simple enough to appreciate. The climb to the exit proved easy enough, although the psychological effect of a safety line around the waist might have been a considerable factor in making it appear so, but on arrival at the ledge, some four feet below the opening, all clothing was once again removed, and from there on it was every man for himself—and the realization that we were not as fit as we might be !

Outside, the day was very cold, with a slight drizzle, and a tardy lunch of cold beer and sandwiches made us resolve that in future all our food would go down with us, even if it did mean eating a little dirt with it. At least we could eat when we felt like it, instead of three hours later !

During the following seven days there were raw fingers, bleeding hands and plenty of bad language, as we set about preparing ropes in 25-ft. lengths, for easy carrying, and spliced thimbles and hooks on alternate ends, with knots every 6 ft., for a better grip. By the following Sunday, we had a couple of hundred feet ready, slightly improved lights, and the knowledge that we were " on to something." With as little preparatory work as possible, we made a very rapid descent to our first really big stalactite, where we produced cameras and flashes, and set to work.

It took us, I suppose, about half an hour to prepare that first photograph. The formation was in an extremely awkward position, having just the narrow gallery, some six feet wide, around its base, and being about twenty feet high itself. There was only one position for a camera and this involved the stuffing of an ex-miner, and a six-footer at that, into a position to be able to reach the trigger. It cost us about three flashes, and a lot of valuable time, but we were lucky enough to hit on an exposure which was near enough correct, and the result was very well worth it.

After this, we were in a hurry, and we were very soon down what we now termed the main pitch, and into the rift cavern. The new pitch that we had discovered the previous week now looked very much less inviting, and we imagined that some sort of fall had taken place during our absence. Indeed, there were now two very narrow-looking openings, side by side, one ending with a ceiling about nine inches high, and the other in a small opening about two feet square, both pitches being in the region of sixty degrees. Chris Barker and I won the toss, I took the pitch with the low ceiling, and he took the small opening. As I crawled down the loose scree slope, I could hear the small pebbles landing some thirty or forty feet below, but I failed miserably to pass the rock ceiling, and was forced to return. Barker had fared even worse, for when I reached the gallery, he was very firmly wedged, slim as he is, in the narrow opening. Fortunately we had roped him up, and were able to hold the rope taut while he heaved himself out, a process which took nearly half an hour! Looking decidedly crestfallen, we made our way back into the main cavern where we ate our sandwiches, swore a little at nothing in particular, and told each other how stupid this "pot-holing" was.

We had already decided that the rift we were in must continue below us, and that the floor we were sitting on was simply the old roof which had fallen, and jammed in what had been the waist of the cavern. If this were so, of course, there must be some way through the floor somewhere, even though we had failed to find it yet. After lunch we started poking around one of the bigger boulders and eventually I discovered a hole which looked more or less passable, if one breathed out first. Barker got a rope around me, "just in case," and I dropped in, feet first, while the remainder of the party carried on the search. In a very short time I was wedged tight, but I could feel nothing with my feet in any direction, and I knew that I was through the floor, if only I could make it! All my efforts to force my body downwards had the effect of jamming it completely, and rather painfully, with nothing below for a foothold, and only sheer, smooth, rock faces above for a handhold. We tried the rope. It was not easy to breath now, and all efforts had failed to move me at all, when I heard sounds below me somewhere. Rigden had found a somewhat easier entrance on the far side of the rock, large enough to get through sideways, and was sitting on a ledge at the top of a rock chimney, asking silly questions about the pair of disconnected legs emerging from a tiny opening in the opposite vertical rock face, and thrashing the void in an effort to find a purchase. He was eventually convinced that he had not been overtaken by D.Ts., that the legs were real, that they belonged to me, and that he was required to do something about getting them back through the opening from which they had emerged. He chimneyed up to meet them, and by getting his shins under my heels, gave me sufficient purchase to emerge; somewhat painfully I think, for us both.

I was soon on the ledge beside him, and we decided that, although it was rather late, we would tackle this first chimney, and get our ropes down for an assault on any pitch we might find below us. It was very easy climbing, and we had soon negotiated the chimney we were in, and the one immediately below it. Here we finished up in a small, muddy cave, and decided to call a halt. We hadn't realized, until we called for the remainder of the ropes, that we had used up 100 ft. of it getting to our present position, and that we would need even more rope the following Sunday.

There was very nearly no following Sunday for quite a number of our party. Two of us had reached the open gallery at the top of the main pitch and, as was our normal custom, were waiting, clear of the exit hole, for the last man up and the two safety-line men. One of the party was climbing the stone staircase to our small assembly area, when he slipped, and automatically reached for the nearest support. This was the large, unsafe boulder above the hole, which turned a complete revolution on its very unsafe axis, slipped towards the hole a few inches, and a couple of tons of rock teetered above our two linesmen, as they struggled to help the last man through. By the time they joined us, all three were looking about the colour of cigar ash, and rather shaken. It was a case of getting our ropes out while we could, and making a firm mental note to use the other entrance in future.

This was an unfortunate business, since the alternative pitch involved an absolutely vertical rope climb of some eighty feet, with only a couple of rests each way. By the time we tackled it, I had managed to find a few miner's helmets, and fixed one up with a good light, which proved to be a boon on a climb where both hands were necessary the whole time, and a fairly good light was essential. The descent was nothing like as difficult as it had looked from the floor of the cavern, although on arrival at basement level I had to rest against the wall to recover my breath. The second down was a new face to me, and informed me that he was a rock-climber, having his first experience underground. Feeling rather proud of my newly acquired light, I was able to point out to him the massive limestone formations on the walls, the height of the bedding place which formed the roof of our cavern, and the whole breathtaking beauty of this subterranean world. It was quite ten minutes before I realized that the poor devil was suffering rather badly from a dose of claustrophobia and we had to stop all descents while we got him out into the open air.

We moused all our hooks and thimbles on our way down the chimneys, until we were safely huddled in the tiny cave where our ropes were housed. Here there was a rock bridge across the chimney, forming two narrower funnels which both emerged in the same cave some thirty feet below, and a further rather tight-looking entrance to yet a further chimney. It proved very muddy indeed, and we began to imagine that, at this depth of some 500 feet below the sunshine outside, we were going to find the water which would mean so much to us. We were doomed to disappointment, for what we had taken to be a chimney proved to be an entrance in the roof of the lower portion of the rift which was soon negotiated, and quick inspection showed that not only was there no possibility of continuing toward our water supply, but that the sooner we left the place, the better. It was quite obvious that one small slip here would bury us all, and it wasn't the most pleasant thought in the world on which to dwell. Getting out, however, proved rather more tricky than getting in. After a fifteen-foot vertical rope climb, it was found that the best way out was to wedge the body in the roof opening, adopt a diving position, hands directly above the head, pulling up with the arms and wriggling violently with the body. The feet played no part at all, and we regained the main cavern with aching arms and chests, and decided to rest for at least an hour before starting up the now very formidable-looking pitch ahead. However, with a little panting, a fair amount of assistance from above, and an awful lot of hard swearing, we eventually reached the fresh air, and within a couple of hours, were enjoying the finest hot bath ever—even if there was a limestone deposit on the sides! We had come to a temporary halt, but we had been "on to something"; we had been disappointed in our main object of finding water. We had done a fantastic amount of hard labour; we had learned, and are continuing to learn, a lot about nature underground, and how to photograph it. We are kept out of our beds, we have developed a team, and formed a fine spirit amongst ourselves. We have achieved something, and had enormous fun doing it.

CHEVALIER ISLAND SHIPYARD

By Brigadier J. H. D. Bennett, C.B.E.

Inception and " Z " Craft

IN the early days of the war it was considered by G.H.Q., Middle East, that some form of landing craft capable of putting ashore stores and vehicles, both wheeled and tracked, on an open beach, after the beachhead had been secured, would be required in the Middle East theatre. These craft were not to be armoured in any way as it was not the intention that they should either supplement or replace the various types of naval landing craft to be used in the original assault on the beaches. Major-General E. F. Tickell, the then Director of Works, Middle East, caused preliminary designs of such a craft to be prepared, the main points of such a craft to be that it should be self-propelled and capable of landing vehicles up to twenty tons in weight.

It was obvious that the Middle East, from its own resources, could supply neither the steel required nor the propelling machinery. On the other hand the size and weight of the craft precluded them from being shipped as deck cargo to Middle East, nor had Middle East the shipbuilding capacity to undertake the complete construction of the craft if materials only were supplied. Again, the type of craft required was not such as to allow of them proceeding under their own power from the U.K. or India if built there. It was, therefore, decided that the craft should be prefabricated elsewhere and shipped " knocked down " to Middle East for assembly there

After negotiation, India undertook to prefabricate the craft, ship the components to Middle East, and provide the supervisory staff and labour for assembly and fitting out in Middle East. Propelling machinery, together with tail shafts and propellers, was ordered in U.S.A. for direct shipment to Middle East.

The immediate problem confronting Middle East at the end of 1940, therefore, was the provision of the necessary shipyard and facilities for this assembly and fitting out work. The initial order for these craft, known as " Z " craft, in India was for forty, together with a further four to allow 10 per cent of craft to be out of commission in dockyard hands for refit and repair at any one time. The delivery of craft components in Middle East was expected to commence in May, 1941.

On 31st December, 1940, the Director of Works instructed the writer to carry out a reconnaissance for a suitable site for the proposed shipyard and to prepare the necessary plans for its construction.

The only information then available as to the design of the craft was contained in a plan showing the longitudinal section and deck plan. Displacement tonnage, launching tonnage, launching draft, etc., were not known exactly and could only be approximated.

A possible site having been located at Chevalier Island in Lake Timsah, preliminary survey work, both land and marine, was put in hand at once and negotiations opened with the Canal Company for the hire of the necessary land. Plans were drawn up for fifteen building berths with a side loading slipway between the sixth and seventh berths from the north end. This slight out of balance was dictated by the physical characteristics of the proposed site and, although it slightly complicated the production line, to attempt to overcome it would not have been justifiable on the grounds of cost, time and labour. The understanding with India being that all components should be sent to Middle East fully fabricated and marked for assembly, except for certain naval stores to be dispatched from U.K. and propelling machinery from U.S.A., workshop facilities were planned on only a very limited scale initially. The theory that assembly work would be purely in the nature of " Meccano " was not borne out in practice ; for that reason and consequent on subsequent expansion of the yard, it was necessary gradually to expand the workshop capacity of the yard until ultimately approximately 2,000 h.p. of plant was installed at the island.

The layout of the yard as it ultimately existed is shown on Plan No. 1 and Photo 1. This plan shows the yards as fully expanded. The original plan only provided for the fifteen " Z " craft building berths and slipway, together with a building 100 × 80 ft. as offices and stores, and a 5-ton travelling derrick at the off-loading quay. The design of the slipway and layout of the " Z " craft yard generally were governed by two factors :—

(*a*) the launching draft of the craft, and

(*b*) whether end or sideways launching was to be adopted.

After full consideration end launching by means of a horizontal top cradle was decided on, to be workable at all states of the tide. The building sites, which also formed the ways on which the craft were side-slipped from their building berths to the launching cradle comprised eleven parallel ways. These extended for 216 ft. on the north and 324 ft. on the south side of the cradle, and on them the keels were laid at 36-ft. centres. After riveting and caulking between the ways, the craft were transferred to blocks, to allow of riveting where not possible on the ways, and subsequently transferred to the sliding ways for side-slipping on to the cradle, for which purpose six (and later eight) 25 : 1 hand winches were used.

The slipway itself was built at a grade of 1 in 18.4 and in it laid six parallel sets of 60-cm. Decauville track at 5 ft. centres, on which a wedge-shaped horizontal topped steel lattice cradle running on seventy-eight Decauville bogies was constructed. This cradle was operated by four 25 : 1 hand winches, with 2½-in. S.W.R. through snatch blocks on equalizing springs.

An office and store block, together with a very small workshop and a discharge quay for incoming components were also provided. This quay and the slipway were provided by contract. All other works were executed by Egyptian D.E.L., supervised by a detachment of an officer and nine O.R. from No. 2 E.B.W. which the writer then commanded. The target date for the completion of the yard on 31st May, 1941, was achieved, work having started on site on 20th February, 1941, despite the fact that the only mechanical equipment or tools available were three concrete mixers, all steelwork being cut and drilled by hand and all timber being hand sawn, including the squaring of 5,000 ft. of 12 × 12 in. for the ways.

Type "A" Craft Design

The first type of "Z" craft, Type "A," were designed on the Isherwood system, leading dimensions being L.B.P. 135 ft., beam 30 ft., moulded depth 4 ft. 6 in., frame spacing 24 in. Plating varied from 12½ lb. for the keel strake to 7½ lb. for the sheer strake, intermediate strakes being 10 lb. Longitudinal and transverse bulkheads divided the hull into seventeen watertight compartments. The deck house aft provided accommodation for an Indian crew of fourteen with galley and latrines. The craft were powered by Grey Marine, four-cylinder two-stroke diesels developing 96 h.p. at 1,500 r.p.m. and driving outward turning 30 × 20-in. propellers through 2 : 1 reduction gears giving a speed of 7 knots. Diesel fuel carried in tanks in the wing compartments to the engine-room gave a cruising radius of 400 miles. The original auxiliary engine not only drove the bilge pump, but also the degaussing generator. These were, however, handed over to R.N. for use in merchant ships and a locally designed arrangement, using a Southern Cross engine, provided in lieu for the bilge pump drive, protection against magnetic mines being provided by having the craft wiped by R.N. A ramp of 15-ton capacity operated by a gallows on the bows provided the connexion with the shore for vehicles loading and landing.

Labour

India undertook to provide the technical officers for supervision, as well as a riveting battalion for erection and fitting out of the craft. The majority of the officers provided by India proved themselves to be unsuitable, as did most of the labour, being largely inexperienced in riveting and being entirely deficient of the personnel required for installation of machinery and fitting out. In consequence a British unit—No. 1 R.E. Workshops Special—was raised for supervision of the works and carrying out of some of the more skilled tasks. Gradually the Indian labour was replaced by Egyptian artisans and unskilled labour. The maximum numbers employed when the yards were in full production amounted to 200 British and 4,000 Indian and Egyptian.

Equipment

Initially all that was available were hand blown field forges and a few hammers, together with very limited numbers of carpenters' and other tradesmen's sets of tools. No pneumatic equipment or welding plant was available. Spanners, hammers, dollies, reamers, etc., were made up in the yard workshops to allow of work getting under way. Gradually pneumatic tools were collected, originally operated off portable compressors. These were later replaced by two large static compressors, the portable ones then being used to provide air for the rivet fires. In addition welding plant and machine tools, lathes, milling machines, radial drills, punching and shearing machines, woodworking machinery, etc., were installed to allow of production of items short shipped, or unduly delayed from India, and for rectification of damaged components, until finally over 2,000 h.p. of plant was installed at the yard, together with the necessary generating plant for its operation.

General Organization

In the early days there was not much organization, and a good deal of friction existed between the riveting companies and the technical officers, largely due to the low standard of workmanship of the Indian riveters. Consequently, in December, 1941, the appointment of C.R.E. Special Duties was created and the writer sent as such to Chevalier Island to take charge of the shipyard and to have both No. 1 R.E. Workshops Special and the Indian units under his direct control. The work in the yard was then divided up as follows :—

Head Office.—General organization and control.

Stores.—Receipt, custody, issue and provision of tools, stores and plant.

Construction Department.—Loft, plate and angle shops. Construction of craft on stocks.

Riveting and Sailors.—All riveting and water testing of craft, movement of ships afloat, rigging of craft.

Boring out and pipe work.—All plumbing work, boring out, erection of tail shafts and rudders.

Woodwork.—All carpentry and joinery work, preparation of building berths, launching, all painting work.

Workshops.—Machine, fitters, smiths, welders and electricians shops and maintenance of all plant.

Time Office.—Timekeeping of all civilian labour, muster rolls, and wages check list, payment of civilians.

Each department was under the direct control of an officer, except the woodwork department, which was so efficiently run by the N.C.O. in charge that an officer in charge was unnecessary.

Later, when the yard was extended by the construction of the R.C.L. yard, a modified organization was introduced and is outlined at Appendix " A."

" Z " Craft Type " A " Construction and Trials

(*Photos* 2, 3, *and* 5)

The first components for the first three craft arrived in Middle East on 25th July, 1941, and from then on until the end of January, 1942, components arrived spasmodically. All engine deliveries ex-U.S.A. were completed during September–December, 1941. Throughout, the main difficulties at Chevalier Island were that no one craft ever arrived complete in all its parts and that, in many instances, components were badly damaged or distorted en route. Delays, damages and short deliveries were not, however, allowed to delay production. Rectification work and manufacture of replacement parts were undertaken locally, as the building of the yard workshops permitted, so that production could proceed.

The keel of the first craft was laid in the berth adjacent to the slipway on the north side on 6th August, 1941, further keels following as stocks of components permitted. The first craft was successfully launched on 3rd October, 1941. After water-testing of the bulkheads, engines were lowered and lined up, bridge superstructure erected, decks closed up, and by 28th October fitting out had been completed.

Initial trials took place on 2nd November. These and subsequent trials disclosed the following facts :—

1. The contract speed of 7 knots was achieved.

2. The craft was capable of handling both wheeled and tracked vehicles with ease.

3. The ramp was quite satisfactory and easy to handle. The gallows, however, possessed too much windage and, with the shallow draft of the craft, made manœuvring difficult in a strong wind.

4. The absence of any deadwood between the twin screws led to such violent interruption of the propeller slip-streams that steering was most difficult.

5. The single centre rudder was not entirely satisfactory and that twin balanced rudders would be very much more effective.

6. Some form of winch or capstan was necessary for operation of the stern anchor for hauling off a beach.

The main objection, that of the difficulty of steering, was overcome by the fitting of a ⅜-in. deadwood plate on the centre line between the hull and the centre rudder post and by fitting twin balanced rudders, the first ten sets of which were made by 81 E.B.W. S.A.E.C. and subsequent sets by India.

As receipt of components ex India and local production permitted, further keels were laid, the last on 14th April, 1942. C.R.E. Special Duties took over the yard on 19th December, 1941, and on his arrival a tentative time schedule for various sections of the work was drawn up and in addition, a programme of taking back the earlier craft for modification was prepared and executed. The time schedule was based initially on an output of four craft per month. This forecast was realized in January and February, 1942. As the year wore on the improved organization, coupled with the gradual, but still very meagre additions to pneumatic and other tools and extra items of plant began to bear fruit, the rate of production was increased until in June, 1942, when the last of the 42 Type "A" "Z" craft was almost completed, the output had been stepped up to eight craft per month.

The whole contract for the Type "A" craft was completed on 8th July, 1942, exactly forty-eight weeks after the keel of Z.1 was laid. The fastest time for any one craft was sixty-three days for Z.40, and the average time 109 days, which still left considerable room for improvement.

"Z" Craft Type "B"

(*Photos 4 and* 6)

In November, 1941, an order for a further forty-four "Z" craft was placed by Middle East on India. As a result of our limited experience with Type "A," and in consultation with the naval architect from India, various modifications in the specification and design were made, in addition to the two major changes, that the ramp capacity was to be 40 tons and the accommodation to be for white and not native crews.

The hull was appreciably strengthened. A centre keelson and longitudinal central stiffening girder were added, all bulkheads were provided with double boundary bars and the shell plating increased to 12½ lb. throughout. Engine power was also increased, the propulsion units being two six-cylinder Grey Marine diesels, developing 165 h.p. at 1,950 crankshaft r.p.m., and driving, through 3 : 1 reduction gears, 36 × 34 in. outward turning propellers, with a contract speed of 10 knots. Fuel for 400 mile radius of action was carried in two 750 gallon tanks, in the wing compartments to the engine room and 400 gallons of fresh water in a tank in No. 2 cofferdam, access to all three being provided by water-tight doors in the engine-room bulkheads.

In February, 1942, it was estimated that the yard would be ready to receive the second batch of " Z " craft by early June, but the best delivery that India could then offer was October. In actual fact the north stocks were emptied of Type " A " on 18th June. In consequence of the delay that would occur, other work, to be discussed later, was undertaken in the interval, which gradually became longer, and it was not until March, 1943, that the first components for six Type " B " craft arrived in Middle East, these components being sufficient for hulls only, but excluding all under-water fittings. In addition main engines ex U.S.A. were delayed.

In the interval of nine months between Types " A " and " B " there was plenty of time to consider means of speeding up production. Revised methods of receiving, sorting, checking, stacking and handling of components were worked out, the entire construction was time analysed, methods of mechanical handling of all heavy and bulky components devised and an operation schedule prepared which gave thirty-two days from keel laying to launching and a further twenty-six days for engine installation and fitting out afloat, this schedule being based on one keel being laid each four days.

The first six Type " B " keels were laid during April, 1943, but the next delivery of components ex India did not arrive for two months and it was not until September, 1943, that sufficient material had been received to allow of production getting into its stride. By this time the Far East requirement had come to the fore and eleven craft were retained in India for erection there for use in Burma, our allotment being reduced to thirty-three.

Despite the shortage of components we struggled ahead. The first six craft were delivered with skin apertures blanked off, and without superstructure, for use as dumb barges pending arrival of engines, etc., being recalled later to the yard for completion. Delivery of engined craft commenced in October, 1943, and the last of thirty-three Type " B " craft was delivered on 11th February, 1944. The average time from keel laying to delivery for all craft, including all delays outside our control, was ninety days, the average time once production was in full swing being fifty days. The record time was forty-five days for four consecutive craft, the delivery rate then being eight craft per month. The average labour employed during this period on " Z " craft was twenty-two riveting gangs, 750 Egyptian artisans and 650 coolies. Of the artisans, 150 were employed in Workshops, which number gives an indication of the work involved in repairs to damaged components and fabrication of those deficient. In addition to our own production both 2 E.B.W. and 81 E.B.W.

S.A.E.C. undertook a large amount of production work for us, chiefly castings and heavy forgings, for which work we were not equipped.

Employment of "Z" Craft

"Z" craft were used extensively in the Egyptian ports for the transfer of vehicles, both armoured and unarmoured, as well as general freight from ship to shore and through the Canal. Two were specially fitted out for R.N. to lay the anti-aerial torpedo net defences at Fanara, and a further two for landing main-line locomotives in Syria. They were also used on a large scale during the advance of Eighth Army, keeping pace with the advance on land as far as Sousse and Sfax, as well as taking part in the invasion of Sicily and working at Anzio and Bari. Out of the total fleet of seventy-five, the casualty list numbered six.

"Z" Craft Type "C."

Early in 1943 it was estimated that if India kept to her then promised delivery dates all Type "B" craft would be completed by November, 1943. In view of delays ex India and our knowledge of the heavy load on their shipyards we proposed that if further "Z" craft were required in Middle East they should be produced *ab initio* at Chevalier Island. It was evident that hole-making would be the limiting factor. Based on the punching and drilling capacity likely to be available it was computed that the yard capacity was 21,000 holes per day, thirty days per month. On this, production of three craft per month was offered. In due course War Office agreed to these proposals and steel was ordered, 50 per cent on India, 50 per cent on U.S.A. American engines not being available, War Office ordered 130 h.p. Thornycrofts in lieu. This change involved redesign of the engine-room and stern gear, which work was undertaken by C.R.E. Special Duties.

Delays in delivery of steel prevented full production of Type "C" being undertaken as yard capacity became available from Type "B." However, by using material collected locally, a start was made on the smaller components and, by the end of 1943, deep floors, bulwark plates, beam knees, etc., sufficient for eighteen craft had been worked out. In addition, 2 and 81 E.B.Ws. were busy on castings, rudders and other work beyond the capacity of our shops.

Early in 1944 it became evident that further "Z" craft would not be required in Middle East, but that any we could produce would be a valuable addition to India's own production for use in the Far East. The order on Middle East was therefore raised to fifty-four craft, all to be shipped knocked down for re-erection in India. About the same time we learnt that 130 h.p. Thornycroft engines would not be available for all fifty-four craft. In the event, each batch of

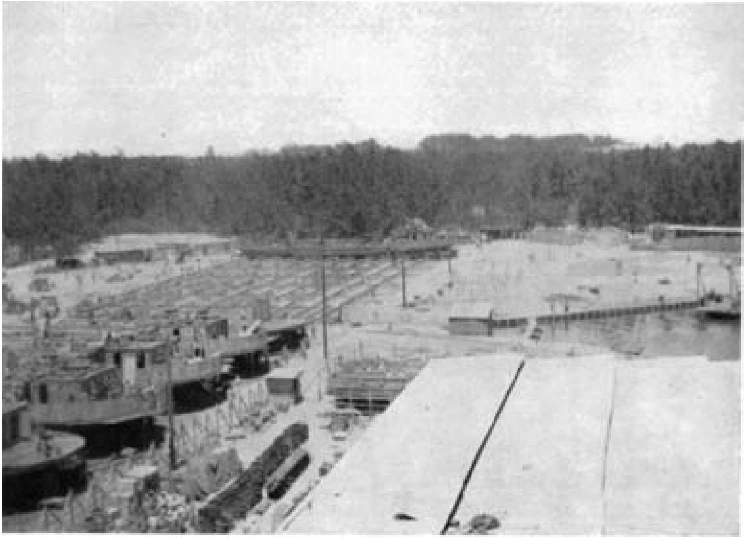


Photo 1.—Z Craft, Type A, under construction.

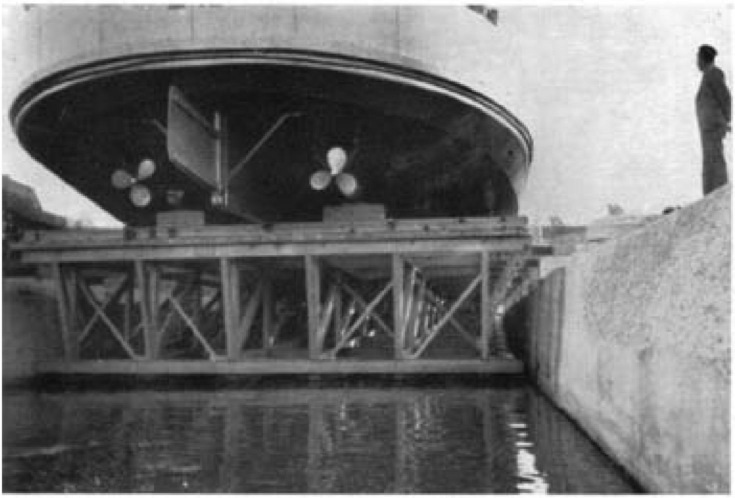


Photo 2.—Z 16 (Type A) on cradle ready for launching.

Chevalier Island Shipyard 1 , 2

Photo 3.—Z Craft (Type A) on cradle and dumb barges on stocks.

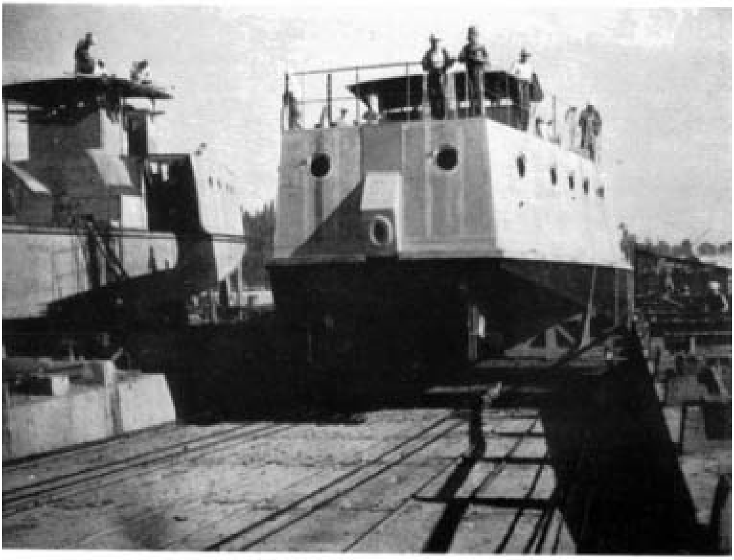


Photo 4.—Z Craft (Type B) on cradle. Note difference between sterns of Type A and Type B.

Chevalier Island Shipyard 3 , 4

Photo 5.—"Z" Craft (Type A) fitting out.

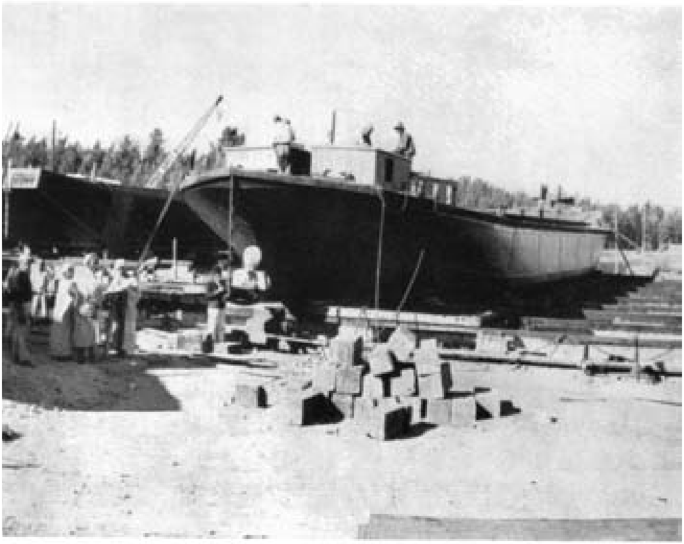


Photo 6.—I.W.T River class barge installing engine and stern gear.

Chevalier Island Shipyard 5 , 6

Photo 7.—"Z" Craft (Type "B") proceeding on trials.

Photo 8.—Caique immediately after launching (not at Chevalier Island).

Chevalier Island Shipyard 7 , 8

eighteen craft had different propulsion units and auxiliaries so that engine-room design had to be modified again twice. By October, 1944, production at three craft per month was in full swing. The first hull of each batch of eighteen was erected and tight bolted ready for riveting on the stocks to prove the fabrication, and only when we were satisfied that there were no errors of any consequence was batch production permitted.

As craft were completed at Chevalier Island they were transferred to a Transportation dump at El Shatt to await shipment to India. At the same time marking and shipping lists, case contents lists, and re-erection lists, together with plans of revised engine-room layouts, were forwarded to India. By the time the writer left Middle East shortly before the end of the Far East war, some thirty craft were still awaiting shipment to India. He still wonders what was their fate.

Dumb Barges

(*Photo* 3)

Although the shipyard was originally provided for the assembly and fitting out of " Z " craft, many other tasks were undertaken by the yard. The spare capacity of the yard, which became available initially due to the interval between the completion of " Z " craft Type " A " programme and the receipt of components for Type "B," was used for the construction of a fleet of dumb barges to augment the limited number already available in the Canal Zone. A simple design of barge of 80 tons carrying capacity involving no curved plates or bent frames was evolved. The necessary template loft and plating shops, equipped with punching machines, radial drills and home-made countersinking machines were erected. A varied assortment of plates and angles was collected from E.S.B.Ds. and S.N.S.O., shell expansion drawings were adjusted to suit these materials and production commenced in June, 1942. Five weeks were required for the construction of each barge and from mid-August a steady delivery of two per week was maintained. In all fifty-eight such barges were produced, as well as four for petrol and four for diesel oil.

Other Works

Dumb barge work in itself was not sufficient to keep the yard capacity fully employed, and a variety of other works were undertaken. These included eight 100-ton swim-ended, open hatch barges for R.N., as well as four of equal capacity but of different design and flush decked for Ministry of War Transport, a small compressor barge for R.N., a 4,000-gallon fuel-oil barge for our own yard use, sixty-five Orlikon gun platforms for Ministry of War Transport for arming merchant ships, as well as the steelwork for twenty-six 10-ton and 5-ton overhead gantries. In addition regular servicing and refitting of all "Z" craft in commission was undertaken until the Indian I.W.T. Workshop Company slipway came into commission in December, 1942; a total of twenty-seven "Z" craft passing through our hands. Yard maintenance was continuous, two 600 c.f.m. static compressors were installed, providing air through a 4-in. line for all building berths for the gradually increasing number of pneumatic tools. A second discharge quay equipped with a 2-ton steam crane was also provided.

Floating Dock

Early in 1943, the Royal Navy requested us to construct for them a 200-ton floating dock from two bow and one centre section of old L.C.Ts. R.N. delivered these sections to Chevalier Island in March, 1943, where they were hauled out and side-slipped to the most northerly berth on the stocks. The work comprised the joining together of the three sections, removal of various structures on the bow-sections, removal of the tank top, raising the floors by 2 ft. 6 in., providing water-tight compartments in the double bottom by longitudinal and transverse bulkheads, replacing the tank top on the raised floors, and providing 10 ft. high side walls as ballast tanks. R.N. undertook to provide all pipe work and pumping machinery. Work ashore was completed by the end of June, when the dock was launched. After launching and water-testing to a head of 18 ft., side wall erection was commenced. By the end of July, "Z" craft work was again in hand, and as this higher priority work was being delayed by the dock, R.N. volunteered to undertake completion of the latter. On 20th July, therefore, the dock, with side walls completely fabricated and about 50 per cent erected, left the yard under tow for Port Said for completion there by R.N.

Invasion of Sicily

When the invasion of Sicily was being planned we were approached by M.W.T. to assist in fitting out merchant ships for use as troopships. Five Liberty ships and one other 10,000-ton merchantman were anchored in Lake Timsah at intervals during April and May, 1943, for us to do this work, which comprised partitioning No. 1 hold to provide fire-proof stowage for 1,000 tons of petrol, mess deck accommodation in the after holds, cooking, latrine, and ablution accommodation on deck, officers cabins and a special signal cabin on the bridge, arrangement for the securing of vehicles and numerous other minor works, none of which presented any peculiar difficulties, but which took longer than they should have as the depth of water at our yard prevented these ships being brought alongside, and in consequence all labour, material, etc., had to be ferried out to them.

The Ramped Cargo Lighter Yard

In the autumn of 1942, instructions were received that the assembly of one ramped cargo lighter daily would be required at Chevalier Island. Details of the craft from the only single line drawings available were that these craft would be of timber construction, length 55 ft., beam 18 ft., estimated draught (light) 2 ft., general construction being of 3 × 3 in. framing with five-ply skin, the main hull being divided into six water-tight sections and an engine room, two side buoyancy pontoons and a ramp. The craft was twin screw, powered by 100 h.p., six cylinder, Chrysler petrol engines.

As this work could not be overlaid on the " Z " craft yard without interfering with production there, a new yard was necessary. A site was selected at the north end of the island (see Plan I), dredging would be necessary to provide access to this site, the dredged spoil being used to increase the area of land available. The layout initially provided for a stores compound and storehouse, 192 ft. of steel shedding for use as machine, fitting, electrical, welding and plumbers shops, a fitting-out and discharge quay, with 4 ft. 6 in. depth of water at low tide, equipped with a 5-ton American Hoist derrick, paint and P.O.L. stores, and thirty-two building berths all served by a 5-ton travelling Butters derrick. Space was left for sawmills and carpenters shops should they be required later.

Side launching was decided upon, as giving the more economical layout, each berth of 66 ft. frontage being provided with three ways at 14 ft. centres. The slipway grade (1 in 8) was such that if continued back over the building berths a fill of over twelve feet would be necessary at the inshore side. To avoid this excessive fill, the building berths were made level and connected to the slipway by means of tipping beams on to which the craft were side slipped after erection and then tipped to the slipway grade prior to launching.

The slipways were constructed inside a sheet pile cofferdam, driven by contract, which contract included the sheet pile frontage of the fitting-out quay and certain concrete beams. The Suez Canal Company undertook the dredging, whilst all other works were executed by military labour and D.E.L. under the direction of C.R.E. Special Duties.

Whilst constructional work was in progress, information was received that the numbers of R.C.L. and the rate of delivery was likely to be reduced. In consequence the two most westerly slipways were omitted, reducing the yard capacity by eight building berths. In addition, the two most easterly slipways were combined and deepened to give docking capacity for craft up to 120 ft. in length, 150–200 tons displacement and with 6 ft. depth of water over the cradle. The approach channel dredging programme was suitably increased. No major difficulties were encountered during the building of the yard and it came into full commission in June, 1943.

R.C.L. Type " A "

Of the estimated total of 200 of these craft, only nineteen of the first shipment of twenty-five ex U.S.A. reached Egypt. Assembly proved to be relatively simple, the work required being the bolting of the prefabricated sections together, fitting of tail shaft and propeller, lining up of engines, fitting the ramp and fitting of rudders and steering gear.

R.C.L. Type " B "

Based on our and other theatres' experiences of Type " A," a modified and improved type of R.C.L., Type " B," was produced in 1944. In principle they were the same, but were shipped in smaller, and hence more numerous, sections. Assembly and fitting out presented no difficulties. Two days were required for this work and, during the period June/September, 1944, seventy " B " Type R.C.L. were delivered from the yard.

R.C.L. Type " ZZ "

Thirty " B " type craft were retained on our hands and converted to non-magnetic river minesweeping craft for the Royal Navy, providing two flotillas each of thirteen sweepers, one petrol craft and one stores craft. The R.N. design called for the following modifications :—

(*a*) replacement of all ferrous fittings and fastenings in the hull by non-ferrous ones ;

(*b*) removal of all magnetic material to 15 ft. above the waterline.

The latter requirement necessitated the construction of a brass-fastened timber superstructure on which the engines were mounted and from which the drives were taken down to the bronze propeller shafts by endless cotton ropes running over seven grooved brass pulleys and tensioned by brass jockey pulleys. On the engine platform was mounted also a 22 K.W. Lister generating set and the necessary batteries which provided current for the degaussing cables encircling the craft at main deck level. This conversion work presented no difficulties, except that of obtaining a splice in the cotton rope which would stand up to the speed of running for any really appreciable period.

Other Works in R.C.L. Yard

During the latter part of 1943 and in 1944 and 1945, various other works were undertaken in the R.C.L. yard, and are briefly described in the following paragraphs :

Minus Barges

These were scow ended, open hatch, hard chine, timber barges 78 ft. L.O.A., 18 ft. beam at chine, 22 ft. at deck and 11 ft. moulded depth. General construction of 9 × 4 in. frames with 9 × 9 in. transverse floors spaced at 20 in. and sheeted with double 2-in. planking with a layer of canvas in between. All components were shipped cut to length and shaped from U.S.A. Assembly proved to be simple and, being of timber, rectification of damaged parts or replacement of those deficient was a straightforward matter. The only difficulty was in obtaining a water-tight skin, but this was overcome by treating the canvas with a mixture of lampblack and glue applied hot and by caulking both skins. A total of thirty-six of these barges were produced by the joint yards.

I.W.T. River Class Barges (*Photo* 7)

These 250-ton open-hatch barges built for I.W.T. by Egyptian contractors for use on the Nile Valley route were originally delivered without engines, owing to their non-availability at the time of construction. Towards the end of 1943, however, 140 h.p. caterpillar diesels became available and we undertook their installation. The work required included the provision of engine seatings (in some cases complete framing was required), boring out, provision of and fitting of stern bearings and fuel tanks, as well as all fuel, water and exhaust lines. In addition, accommodation for the crew in two cabins was provided. Twenty-seven craft were so fitted out without undue difficulty between November, 1943, and May, 1944.

Other Minor Works

Amongst the other minor works undertaken were the refitting of a 60-ton floating sheer legs which had been accidentally sunk at Suez and the overhaul of the Kilo 74, Suez Canal, Class 24, floating bridge.

Caique Construction (*Photo* 8)

The most interesting of the other tasks undertaken by the R.C.L. yard in 1944/5 was the production of sailing schooners. In late 1943, Middle East decided that a fleet of small craft would be required for work amongst the Greek Islands when they had been recaptured. The shortage of powered craft led to the decision that this fleet would be provided by sailing schooners. C.R.E. Special Duties undertook the construction of the pilot model, which the fleet constructor at Alexandria would design. Unfortunately he was transferred before the design was complete, but from the body lines and water lines C.R.E. finalized the design and added the sail plan. Leading dimensions were L.B.P. 66 ft. 1 in., beam 20 ft., moulded depth 11 ft.—capacity 100 tons, the schooner being provided with auxiliary power from an 85 h.p. Leyland engine from old Valentine tanks and converted to marine use by R.E.M.E. Designs for spars, rigging, blocks, anchor gear, etc., were also prepared by C.R.E. in conjunction with M.W.T.

Timber construction was adopted, but the only timber available for frames was from the reserve stock of railway sleepers, from which 6 × 6 in. frames were built up in three laminations, and bolted together. The keel of the pilot model was laid in mid-February, 1944, and all frames erected by 1st March, on which date M.W.T. and R.N. visited the yard to inspect the hull form. Although we were anxious to lengthen the hull fore and aft and to provide a counter stern, with the rudder in a trunk, to ease the bends and twists in the shell planking, it was decided, in view of the delay redesign would involve and the additional materials that would be required, to retain the original hull form. By this time the requirement by new construction had been fixed at fifty, in addition to the pilot model. C.R.E. Special Duties was allotted fifteen, M.W.T. undertook a further fifteen, and twenty were put out to contract. It was estimated that if timber framing was adopted, some 450,000 ft. of 10 in. width timber would be required, of which 60 per cent would be cut to waste, as well as an extremely large number of 7-in. bolts, all of which would have to be manufactured locally. C.R.E. Special Duties therefore proposed that the craft should be of composite construction. Agreement to this was received in a few weeks. C.R.E. then prepared fresh designs in conjunction with M.T.W. using 2½ × 2½ × ¼ in. angle bars for all frames except fore-peak and after-peak frames, and providing a steel keelson, steel floors, and steel stringers.

Production of fittings such as anchors, winches, fuel tanks and stern bearings was undertaken by R.E. Base Workshops, blocks and propellers were put out to contract, whilst M.W.T. opened a riggers shop at Port Said, where all standing and running rigging was made up and where the rigging and fitting out of all fifty caiques was ultimately undertaken.

The pilot model craft was launched on Sunday, 18th June, 1944, and four weeks later, after the engines had been installed and work on accommodation completed, delivered to Port Said for masts to be stepped and for general fitting out. The contract for the remaining fifteen was completed by the end of November, 1944, deliveries being two craft in September, seven in October, and six in November.

In addition to the provision of schooners by new construction, M.W.T. purchased several from the Delta ports and the Levant coast. C.R.E. Special Duties undertook his share of the refitting of these craft as well as the installation of auxiliaries in them. This work was largely a case of "new wine in old bottles." Moreover the installation of engines necessitated, on occasion, reconstruction of the after end of the hull and each case was a separate and interesting problem.

General

The writer wishes to place on record his appreciation of the assistance and co-operation he received from the Suez Canal Company, on whose land the yard was built, and in particular to the British pilots of the Canal Company who piloted our "Z" craft on their trial trips in the Canal free of all fees. He also wishes to record his appreciation of the assistance he received from the Royal Navy who frequently supplied a variety of stores and undertook work in their shops which was beyond the limited shop capacity of Chevalier Island. In particular he received immense assistance and technical advice from the Repair Officer Canal Area and his staff.

Plan I shows the yards as they were finally developed. They occupied an area of forty-six acres in all, covered areas being 48,300 f.s. in the "Z" craft yard and 43,300 f.s. in the R.C.L. yard. Nearly one hundred machine tools were installed, power and air provided by six generating sets and eight compressors of varying sizes and the yards were served by ten cranes varying in capacity from 2 to 5 tons.

Throughout, the work of the yards was of unusual interest and outside a normal Sapper task. It was beset with the usual difficulties of shortage of skilled labour, plant and equipment, and also of materials. These, however, were difficulties only to be overcome by training, organization, improvision and modification of designs, all of which added materially to the interest of the tasks in hand.

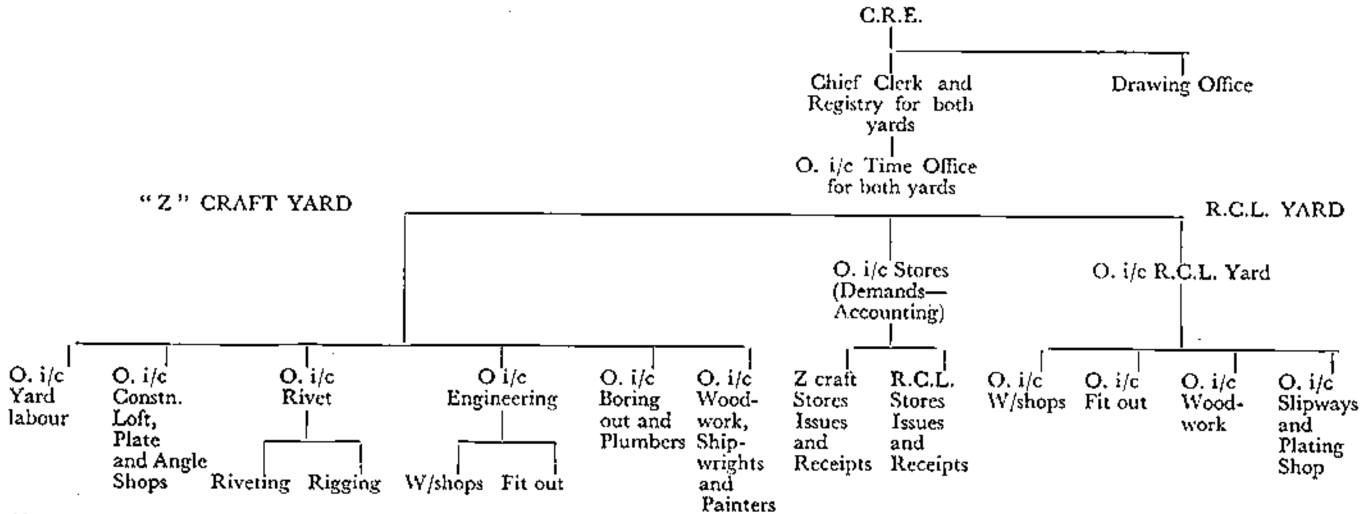
Of the Special Unit raised (No. 1 R.E. Workshop Special) to supervise the working of the yards under C.R.E. Special Duties, only two individuals had had previous experience of work in a shipyard. Despite the strangeness of their work, all ranks rapidly became efficient in their duties and worked long hours, seven days a week, under relatively trying climatic conditions with a will rarely exceeded. Discipline was excellent and the sickness rate extremely low. The writer considers himself fortunate to have had a task of such unusual and varying interest, although far from the heat of the battle, and to have been privileged to be served by such a unit as No. 1 R.E. Workshop Special.

Note.—A more comprehensive report of the work, together with plans of craft, schedules and additional photographs is filed in the office of The Secretary, Institution of Royal Engineers, Chatham.

APPENDIX "A"

C.R.E. SPECIAL DUTIES-SUB-DIVISION BY DEPARTMENTS.

ORGANISATION OF YARDS W.E.F. 12TH APRIL, 1942.



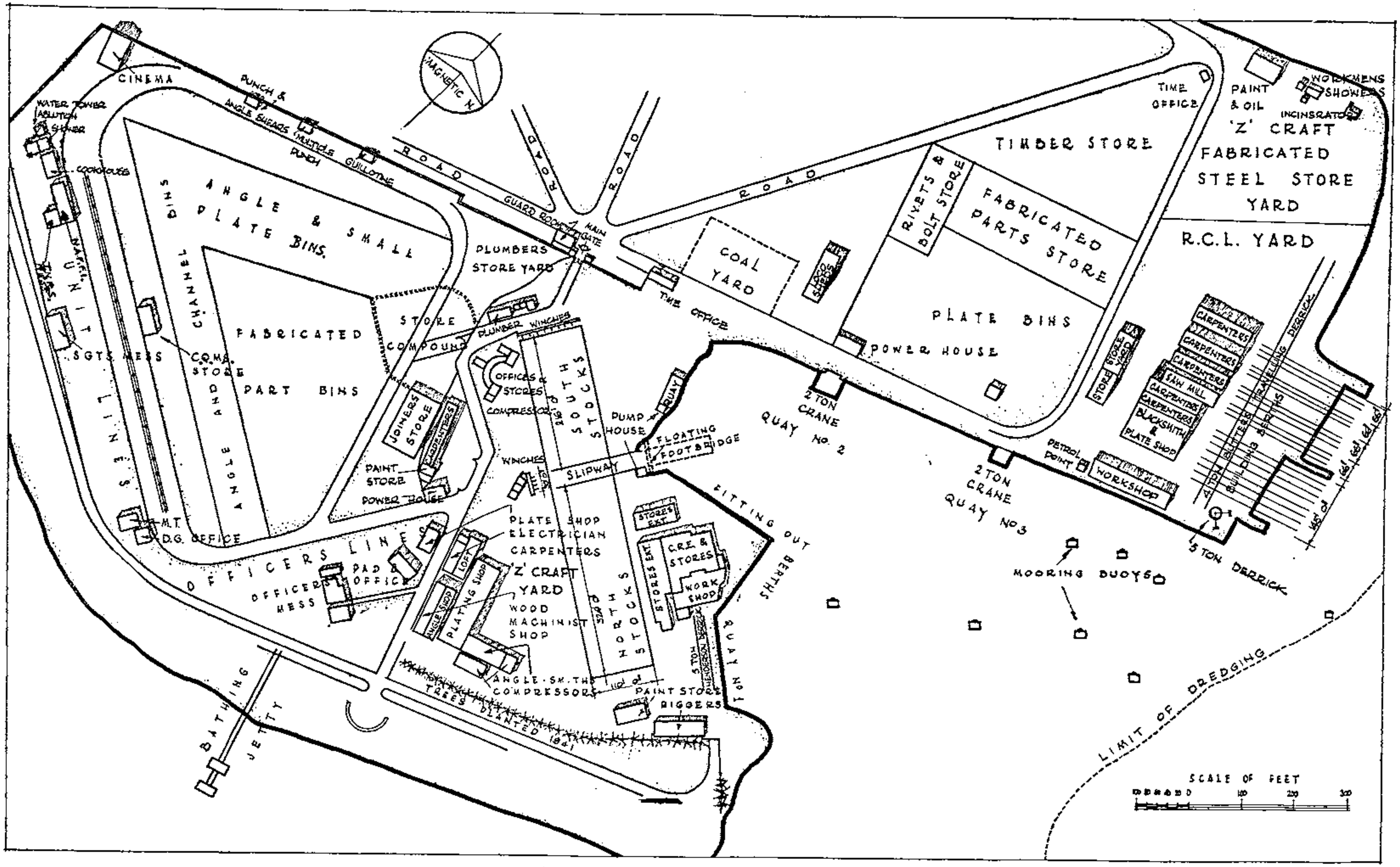
Notes

1. All correspondence will be registered into and dispatched from the Central Office on a Central Registry.

2. All correspondence will be kept in main office where a Central Registry and Post Book will be maintained. All typing will be done in Central Office.

3. Separate Time Office for each yard, O. i/c Time Office supervising both Time Offices.

4. All store demands to be issued from Central Office. Each yard will notify O. i/c Stores of store requirements to permit of demands being prepared. Yard stores will confine their activities to detailed issue and receipt of stores to their own yards, passing documents to Central Office, where all stores accounts will be dealt with.



CINEMA
WATER TOWER
ABLUTION
SHOWER
COOKHOUSE
PUNCH & ANGLE SHEARS
MULTIPLE PUNCH
GUILLOTINE
MAGNETIC N.
ROAD
ROAD
ROAD
ROAD
GUARD ROOM
MAIN GATE
TIME OFFICE
PAINT & OIL
WORKMENS SHOWERS
INCINERATOR
TIMBER STORE
'Z' CRAFT FABRICATED STEEL STORE YARD
RIVETS & BOLT STORE
FABRICATED PARTS STORE
R.C.L. YARD
COAL YARD
LOCO SHED
PLATE BINS
POWER HOUSE
THE OFFICE
ANGLE & SMALL PLATE BINS.
CHANNEL BINS
FABRICATED PART BINS
ANGLE AND ANGLE
C.Q.M.S. STORE
N.A.A.F.I.
UNIT LINES
SGTS MESS
PLUMBERS STORE YARD
STORE COMPOUND
PLUMBER
WINCHES
OFFICES & STORES
COMPRESSOR
SOUTH STOCKS
JOINERS STORE
CARPENTERS
PAINT STORE
POWER HOUSE
M.T. D.G. OFFICE
OFFICERS LINES
OFFICERS MESS
PAD & OFFICE
QUAY
PUMP HOUSE
FLOATING FOOTBRIDGE
SLIPWAY
WINCHES
2 TON CRANE
QUAY No. 2
2 TON CRANE
QUAY No 3
STORE YARD
STORE
CARPENTERS
CARPENTERS
CARPENTERS
SAW MILL
CARPENTERS
BLACKSMITH & PLATE SHOP
PETROL POINT
WORKSHOP
BUILDING BERTHS
TRAVELLING DERRICK
5 TON DERRICK
PLATE SHOP
ELECTRICIAN
CARPENTERS
'Z' CRAFT YARD
WOOD MACHINIST SHOP
LOFT
PLATING SHOP
ANGLE SHOP
ANGLE-SM.THS
COMPRESSORS
NORTH STOCKS
STORES EXT.
STORES EXT.
C.R.E. & STORES
WORK SHOP
FITTING OUT BERTHS
MOORING BUOYS
5 TON HENDERSON DERRICK
QUAY No 1
PAINT STORE
RIGGERS
TREES PLANTED 1941
BATHING JETTY
LIMIT OF DREDGING
SCALE OF FEET
100
200
300

MAINTAINING THE ALASKA HIGHWAY

By MAJOR A. B. YATES, R.E.

THE maintenance of the Alaska Highway and its associated airfields and access roads is probably the biggest peace-time commitment ever undertaken by military engineers, and as such is deserving of our interest. In an article of this length it is not possible to do more than outline the nature of this task and a few of its peculiar difficulties. The many engineering problems that must inevitably arise on a project of this size are left to the imagination of the reader, who may be assured that they are solved almost daily by those invaluable assets of the sapper, in this case the Canadian sapper, the ability to improvise and compromise.

In order to understand the magnitude of the task confronting the Canadian Army, it is necessary to review briefly the history of the Alaska Highway and to quote a few of its " vital statistics."

As far back as 1930 the strategic importance of an overland route to Alaska had been realized by the United States Government. It required, however, the impetus of war in the Pacific to translate this thought into action, and in February, 1942, the decision was taken by the United States and Canadian Governments to construct an all-weather highway to Alaska, linking up the established airfields on the North-west Staging Air Route (shown on the accompanying sketch map).

Work was commenced by the U.S. Army in that month and a rough pioneer road completed by November, 1942, truly a stupendous achievement.

Contractors followed this pioneer road to correct alignment and grade and to build permanent bridges.

The specifications called for a 36-ft. road bed, with 28 ft. of gravel surface, class 70 bridges, ruling grades under 7 per cent, easy curves and good sight distances. Construction was, however, called off in October, 1943, with these standards drastically reduced.

A few of the statistics of the construction are noted below to give some indication of the scope of the construction, which may be compared with the more well-known Ledo Road.

Estimated cost of the highway $139 million, or $97,000 per mile.

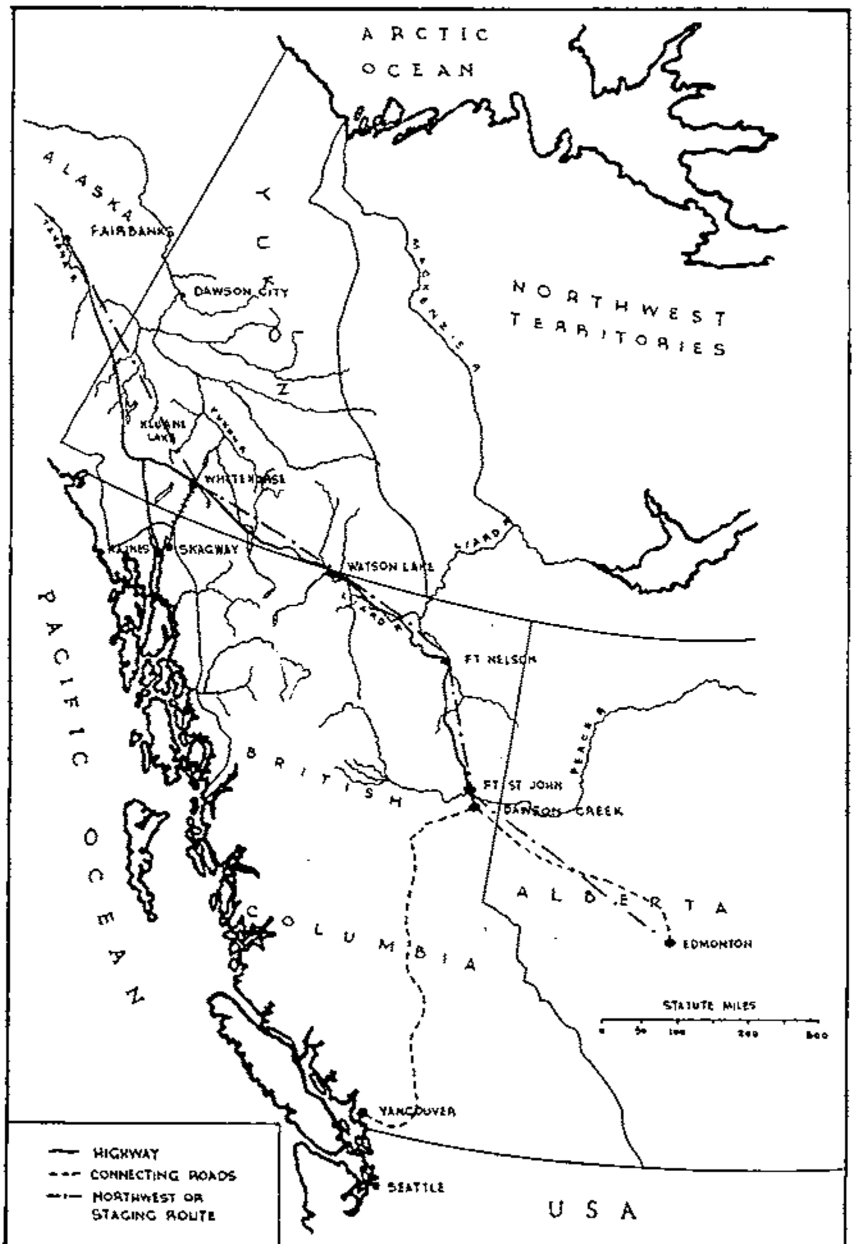
At one time seventy-seven contractors were employed, who in turn employed 14,000 men.

11,000 pieces of construction equipment were used.

Sixteen major bridges, over 500 feet, were constructed.

Total length of bridging 29,000 ft., of which 15,000 ft. was permanent and the remainder temporary timber pile bridges.

8,000 culverts placed.


ARCTIC OCEAN
ALASKA
FAIRBANKS
YUKON
DAWSON CITY
NORTHWEST TERRITORIES
KLUANE LAKE
WHITEHORSE
HAINES
SKAGWAY
WATSON LAKE
FT NELSON
PACIFIC OCEAN
BRITISH COLUMBIA
FT ST JOHN
DAWSON CREEK
ALBERTA
EDMONTON
STATUTE MILES
VANCOUVER
SEATTLE
USA
HIGHWAY
CONNECTING ROADS
NORTHWEST OR STAGING ROUTE

The highway is a gravel road ; that is, it consists of a rock base with a surface of gravel (crushed or pit run), mixed with selected binder. All materials are drawn from pits along the highway and in some cases the gravel or binder had to be and still is hauled up to twenty miles where local material is not available. In some sections over muskeg, a corduroy base has been used. The depth of base and thickness of the surface is subject to a wide variation all along the highway, dependent on the foundation to some extent, and also on the speed with which that section was originally constructed.

On 1st April, 1946, the Canadian Army took over the maintenance of the North-west Highway System from the U.S. Army.

The engineering task undertaken, in addition to defence and training commitments, was the year-round maintenance of 1,221 miles of the Alaska Highway from Dawson Creek, B.C., to the Alaskan border, a distance equal to that between Edinburgh and Rome, the year round maintenance of 472 miles of airbase access roads for D.R.C.A.F. and D.O.T. airfields, the maintenance and operation of seven emergency airstrips situated along the highway and the summer maintenance of 117 miles of the Haines cut-off.

To appreciate fully the extent of this task it must be remembered that the highway was by no means completed when construction was called off. The original survey had been hasty due to the urgency of the project, and the pioneer and subsequent final road very often followed an existing winding track which was by no means the best location. Many sections built over unstable ground required years of annual maintenance to eliminate sagging, frostboils, slides and icing areas, and are still giving trouble. The majority of the bridges were of temporary native timber construction and culverts were built of native unpeeled poles. All of the buildings and utilities were of temporary construction and the majority of the road equipment taken over had been in use since the original construction.

It would be well at this stage, before going into the mechanics of the task itself, to describe the geographical and climatic factors which enter into every aspect of the work.

The highway commences at Dawson Creek B.C., which lies in fertile wheat-farming country. It is linked to Edmonton by a rather poor provincial road and to Vancouver by the newly-opened Hart Highway, which also is a gravel road. Dawson Creek is also a railhead.

From Dawson Creek the highway runs through Fort St. John, now a booming oil town, to Fort Nelson at Mile 300, where the first of the staging airfields lies. The country to this point is hilly, well covered with timber and watered by many rivers, the largest of which is the famous mighty Peace River which flows under a $4 million suspension bridge at Mile 20.

After Fort Nelson the highway rises rapidly up through the foothills of the Rocky Mountains to reach the summit, at Mile 392, which is 4,156 ft. above sea level. From there it falls down through mountainous country to the Liard River valley to reach Watson Lake at Mile 635, the second of the main airfields on the staging route. This section of the highway is often considered the most beautiful.

From Watson Lake to Whitehorse, at Mile 917, lies rather dull and comparatively flat country. Along this stretch is Nisutlin Bay and the longest bridge on the highway, a timber pile bridge of 2,326 ft., rather fragile and the subject of frequent heart searchings. It is being replaced by a permanent bridge.

Whitehorse, the capital of the Yukon, is a thriving community and the centre of all communications in north-western Canada. It is linked to Skagway by rail and pipe line and most supplies are brought in by that route, being transported to Skagway by ship from Vancouver. It also lies on the banks of the Yukon, one of the main lines of communication for the 1898 gold rush. Paddle steamers still ply their way to Dawson City from here in the summer. It is here that the H.Q. of the North-west Highway System is situated and also the third, and last in Canada, of the main airfields of the North-west Staging Air Route.

On to the north-west again, the highway passes alongside the Dezadeash and St. Elias mountain ranges, through barer and more rugged glacial country to reach the Canadian–Alaskan border at Mile 1221, where the Canadian Army responsibility ceases. From the border it is a comparatively easy 300-mile drive to Fairbanks, the end of the Alaska Highway.

At Mile 1016, the Haines cut-off leaves the highway for the port of Haines in Alaska. This road is at present only maintained during the summer months owing to the very heavy snowfalls and drifting conditions existing in the famous Chilkoot Pass.

The climate along the 1,200 miles of highway naturally varies considerably. On the whole the winters are predominantly clear and cold, with temperatures commonly as low as $-60°$ F., but averaging about $-10°$ F. throughout the winter. The coldest weather occurs at the N.W. end of the highway, where at Snaga Y.T., a record low of $-83°$ F. has been recorded, and in the Liard River Valley in the central section. Temperatures are, however, very variable and while the S.E. end of the highway may be experiencing temperatures of $-60°$ F., Whitehorse may be basking in the sunshine at $+10°$ F. Snowfall is, however, on the whole, light, the average around Whitehorse being only about three feet. Hence drifting is not a problem except in a few exposed sections.

The summers are of about four to five months' duration, and can be quite warm with temperatures up to 80° F. Rainfall is very variable. The hours of darkness at Whitehorse vary from approximately one hour in mid-June to eighteen hours in mid-December.

The organization set up by the Canadian Army to carry out the maintenance and improvement of the North-west Highway System consists entirely of Engineer and Service units. These units are also responsible for the local defence of a very large area, and training has to be carried out for this rôle at the expense of work on the road.

The system is commanded by a brigadier, with a small A/Q staff, and an operational staff consisting of a senior highway engineer (lieut.-colonel), a bridge engineer, and a recent addition, a soils engineer.

The operational engineer units consist of the North-west Highway Maintenance Establishment, 1 Road Maintenance Company R.C.E. and the N.W.H.S. Park. The only other engineer unit is a Works Company R.C.E. responsible for all accommodation, utilities and other works services along the entire length of the highway.

Besides the engineer units there are units of R.C.A.S.C., R.C.O.C., R.C.E.M.E. and R.C.A.M.C., whose primary rôle is to support the operational units, but who also have responsibility for services to many Command exercises taking place along the highway, and in the case of R.C.A.M.C. for service to the R.C.A.F. and dependants.

The Highway Maintenance Establishment is responsible for the day-to-day maintenance of the highway, bridges, flight strips and access roads, and for surface and drainage improvements. To accomplish this task it has a small military headquarters in Whitehorse and 175 civilian maintenance men, most of whom are experienced equipment operators. The necessity for the civilian element is easily appreciated since the R.C.E. is too small a corps to hold such a large number of equipment operators in peace-time, even if it were possible to get sufficient recruits.

These maintenance men are directly controlled by three area superintendents, each of whom is responsible for 400–500 miles of highway with its associated access roads and flight strips. The area superintendents are at present civil servants, but it has been proposed that they be replaced by Captains R.C.E.

Each area is further subdivided into fifty to seventy-mile stretches, each of which is looked after by a maintenance camp of about five operators, a mechanic and a working foreman. These camps are completely self-contained, and the men, the majority of whom are married, live in married quarters provided by the Army, and only have to supply their own rations. For single men certain camps have accommodation and kitchens. Each camp has its own power unit and water supply, and a walk-in refrigerator and cooler are supplied for food storage.

The amount of equipment held in each camp varies, but in the average consists of three heavy duty motor graders, one underblade, two 5-ton 4 × 4 trucks fitted with wing snow ploughs, a steam generator, and two or three administrative vehicles. An underblade is a hydraulically controlled grader blade mounted on a 5 ton 4 × 4 truck. It is invaluable for light blading work, owing to its comparative cheapness and speed. The equipment is withdrawn for overhaul during the off-season, i.e., the snow ploughs are overhauled in summer and the graders in winter.

The remainder of the maintenance men, beyond those employed in camps, are used on bridge and culvert crews, as roving mechanics, transporter drivers, storemen, and on a multitude of miscellaneous jobs.

During the construction season, these men are supplemented by about 200 operators and truck drivers on temporary employment for resurfacing, ditching, culvert replacement and other improvement work.

1 Road Maintenance Company, R.C.E., is a purely military unit and is employed on new bridge construction, relocation work, and as a mobile "crash crew" in case of an emergency, such as extensive washouts. The unit has recently completed the 1,600-ft. steel truss Donjek River bridge, after considerable difficulties had been overcome. A few of the problems encountered were: permafrost existing four feet below the stream bed in some places, pouring of concrete and steel erection at — 40° F. and — 50° F., and an extensive flash flood which destroyed much previous work and ruined much equipment. Overlying all these problems were the ever-present factors of time and distance. The bridge is 214 miles from Whitehorse and nearly 2,000 miles from Edmonton or Vancouver, from where most supplies had to be brought.

The North-west Highway System Park R.C.E. has only recently been formed and was not in operation at the time this article was written. However, it takes the place of an *ad hoc* organization within the Highway Maintenance Establishment and its functions will be the same. The park will be divided into two troops, a bridging stores troop and a mechanical equipment troop.

The bridging stores held consist of timber and hardware for the many bridges, culvert material (box, wood stave and steel circular) cement, structural steel, traffic signs and paint. All items are purchased from civilian concerns out of funds provided in the annual estimates. Most of the bridging timber is Douglas fir, which is brought in from Vancouver B.C. The local timber is only suitable for piling and concrete forms. Nearly $1 million worth of bridging stores are held in stock.

The mechanical equipment troop is responsible for holding all

Photo 1.—A typical section of the Alaska Highway in winter.

Photo 2.—Temporary fill over a washed-out culvert.

The Alaska Highway 1,2

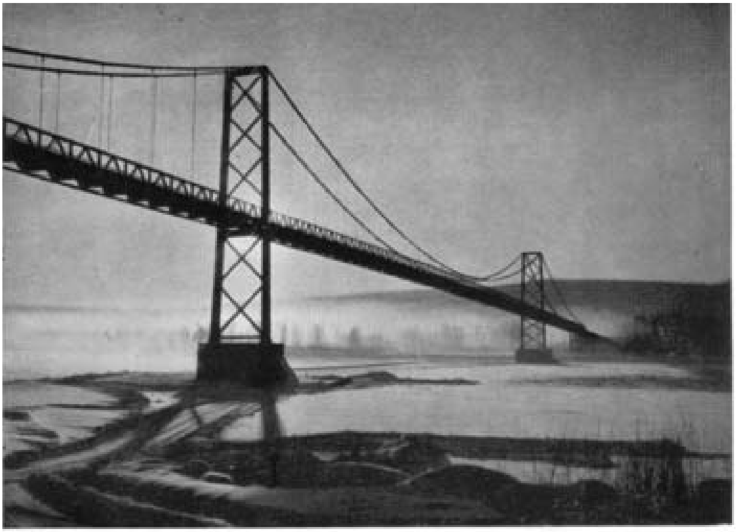


Photo 3.—The Peace River bridge. Bagged concrete is being dumped through the ice around the pier to prevent further scour.

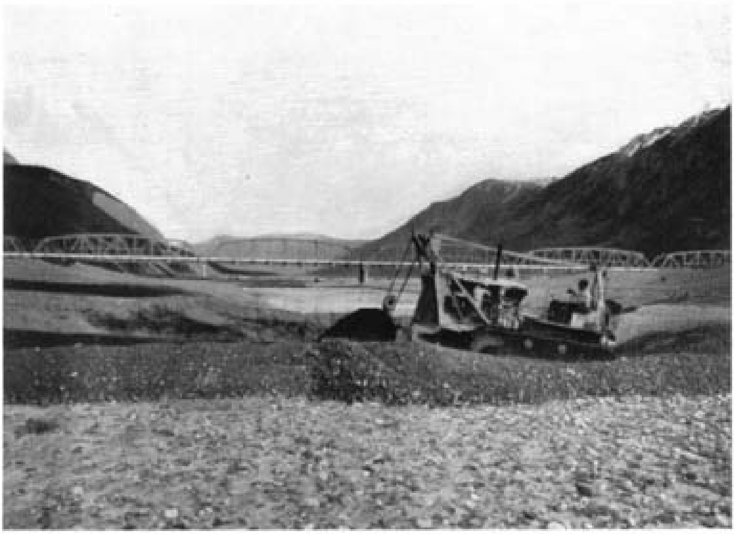


Photo 4.—The Donjek River bridge constructed by 1 Road Maintenance Coy R.C.E.

seasonal equipment not in use and for arranging with R.C.E.M.E. for its repair and overhaul on a planned programme. It is also responsible for the movement of all equipment to sites of work along the highway. There are over 600 pieces of major equipment held between the Highway Maintenance Establishment and the Equipment Troop, the repair and movement of which is a major administrative task. A factor which increases the difficulties of the task is the many different makes of equipment which are held.

In order to give some idea of the day-to-day operations, the following are a few of the tasks carried out during each of the four seasons.

Commencing with the spring, a short season of about five weeks, beginning in late March or April, the maintenance crews are employed in getting the first run-off away. This run-off is from the melting snow at the lower levels, and is usually a mild run-off with no floods. The snow banks are cut back, ditches cleaned out and culverts steamed with trailer type steam generators. The graders and underblades are fully occupied blading the surface and scarifying any ice formed by the rapidly fluctuating temperatures. Blasting ice or removing driftwood pushed up against the pile bridges is another task for the maintenance camps. In the event of a bridge washout a bridge crew or a section of 1 Road Maintenance Company, R.C.E. is rushed to the site to effect repairs. The type of washout which occurs during this season is the knocking out of two or three bents of a pile bridge by blocks of ice coming down the river. The highway is seldom closed for more than twelve hours for these repairs.

During the summer the maintenance camps are mainly employed on blading the surface. The complete highway is bladed from end to end continuously and covered as many as three times a week if necessary. Coupled with this the airbase access roads are bladed about once in three weeks, and the Haines Cut-off opened up in May and bladed frequently. The maintenance camps also carry out minor local improvements in their sections, such as ditching, construction of ice prevention measures, correction of frost boils, erection of traffic signs, and so on. For these purposes extra equipment in the way of bulldozers, scrapers and towed graders is allotted out of the park.

Also in the summer, as soon as the frost has gone out of the ground, which may not be until late May, casual labour is hired and formed into roving crews for resurfacing, culvert replacement, relocations and other improvement work. It is usual to have at least three 150 ton/hr. crushers operating along the highway producing surface materials for resurfacing and for stock-piles. There are also usually about six dump truck crews, consisting of ten or more 5-yd. dump trucks, together with shovels and graders, resurfacing sections of the highway with selected binder and crushed gravel. Because of the heavy, in weight rather than in numbers, and fast traffic, resurfacing is necessary about once every four years. Other crews and 1 Road Maintenance Company, R.C.E., are employed on major and minor relocations to eliminate winding or difficult sections and on new bridge construction. On relocation work many difficulties are encountered due to muskeg and permafrost.

The bridge maintenance crews are reinforced with casual labour from their skeleton strength maintained throughout the winter, and one crew operates in each area redecking, driving new bents, tightening bolts, etc., under guidance from the Bridge Engineer.

All roving crews are completely self-contained with their own power plants and cook-house trailers, and are accommodated either in some of the many unoccupied buildings along the highway or in tented accommodation.

The shortage of qualified engineers becomes apparent during the summer, since there are only about nine R.C.E. officers in the operational staff and units. This discrepancy is partly made up by the summer employment of officer cadets from the service colleges and from the university C.O.T.C. contingents.

A late spring run-off occurs in July or August caused by the melting of the upper snow and mountain glaciers, usually initiated by heavy rain or warm winds. These run-offs can be most destructive and in 1951 a flash flood resulted in about sixty grade washouts of twenty feet or more in length, as well as the loss of a number of bridges, over a fifty-mile stretch in the Kluane Lake area. In two days the face of the country was much altered and the highway closed to traffic. However, the North-west Highway System prides itself on the rapidity with which it can go into action and within four and a half days of the first washout, the highway was once more open to traffic. This, bearing in mind the considerable distances involved in moving men and materials, was a very creditable achievement. In 1952 extensive washouts occurred 400 miles from those in 1951, but on identically the same date, 1st July, ironically enough a public holiday in Canada! These flash floods spring up overnight and cannot be anticipated accurately, either as to the time when they will occur or as to the place.

As the autumn approaches in September, the main attention is directed towards producing a smooth surface on the highway before freeze-up, as this is the secret of trouble-free winter maintenance. By mid-November the surface is usually frozen and set for the winter for better or for worse. It is possible to remove washboard in winter with saw tooth blades, but this is very hard on equipment and is not normally attempted. Considerable sanding and scarifying of ice on hills is carried out during this season.

All winter equipment is arcticized during the autumn with lighter lubricants and oils, and summer equipment is surveyed and withdrawn for overhaul. It is at this time too that the following year's work programme is drawn up.

Once winter has taken hold, the maintenance camp's task can be comparatively light, depending on how well they have succeeded in leaving their surface at freeze-up and how well their ice prevention measures were carried out during the summer. Heavy snowfall is unusual, but when it does occur, the equipment is operated continuously day and night until the highway is clear. Earth dykes and snow fencing are used in areas where drifting may occur.

The road surface is kept with a thin snow covering over the crown and the shoulders slightly built up so as to give a flat surface. It has been found that this keeps the traffic from driving down the centre of the road, which increases safety and reduces maintenance. Small evergreen trees are placed in snow banks on dangerous corners. Contrary to what might be expected, the surface is very seldom slippery unless the temperature rises above about 10° F. Snow provides as good a grip as concrete when sufficiently cold.

One of the biggest tasks confronting a maintenance camp in winter is likely to be the control of an active "glacier." These are not, of course, true glaciers, but are formed by the continual freezing of slow-moving water on the surface of the ground from seeping springs or small streams. Sidehill cuts are likely spots for glaciers. Some spots will ice up every winter, others are dependent on the snow and freezing conditions. If active glaciers are not promptly dealt with they will build up over the road to a depth of several feet within the space of a few days.

Prevention of a known glacier is carried out in summer by deep narrow ditching to carry the water down through a culvert, by inducing icing further back off the road, or by raising the grade. Many glaciers previously active on the highway have been brought under control by these methods. If, however, the glacier appears during the winter for the first time, it may sometimes be prevented from reaching the road by using hessian or sacking to form ice dams. These dams can be built up into terraces by erecting another fence when the previous one is filled. In extreme cases blasting and scarifying is resorted to.

In the case of small streams freezing up in culverts, oil burners or calcium chloride are sometimes used, but it is more usual to steam the culverts out regularly, using the camp's steam generator.

Except in an emergency no equipment is operated at temperatures below − 30° F. Below these temperatures experience has shown that not only does a great deal of effort produce very little result, but also equipment is very easily damaged. This is mainly due to the human element, although the metal does become slightly more brittle at these low temperatures. All equipment is kept in heated storage when not in use, and when working is run continuously until returned once more to heated storage. A bulldozer left in the open will take about four hours to start when covered with a tarpaulin and heat applied with a hot-air heater.

This, briefly, is what the maintenance of the highway involves. There are many other diverse tasks which come up from time to time, such as in the winter of 1951, when 2,000 cu. yds. of bagged concrete was manufactured in an aircraft hanger and placed, through the ice, around one of the Peace River bridge piers to prevent scour which was endangering the bridge. These all prevent life from becoming monotonous.

The main factors which affect all work on the highway are time and distance. All supplies have to be brought in either by sea to Skagway and rail to Whitehorse, or up the 917 miles of highway from the railhead at Dawson Creek, or in the case of light or urgently required articles, by air. Haulage costs are about ten cents a ton-mile or $90 (about £30) a ton, from Dawson Creek to Whitehorse. Equipment for projects seldom has to be hauled less than 200 miles. Labour is mostly hired in Edmonton or Vancouver and brought in by air.

For the future there is a programme of housing improvement, bridge replacement, correction of slide areas and relocations. Hard surfacing is not contemplated at present, although experiments are being carried out. Some of the permanent bridges are in danger of structural damage by pier or abutment movement due to unstable ground, and this problem, too, is undergoing study.

Life on the highway is, on the whole, very pleasant for those who enjoy an open air life. There is very good fishing, big-game hunting and bird shooting in summer and autumn, and during the winter there is some ski-ing, without, however, the modern comforts, such as ski lifts, expected by many. Whitehorse has an active ice hockey league and a very good radio station, owned and operated by the Army.

All in all, the Alaska Highway is a very good gravel highway, carrying heavy and fast traffic. It is not only of great strategic importance to Canada and the United States, but also of great economic importance in opening up the vast latent resources of Northern British Columbia and the Yukon. It is also an invaluable training ground for the military engineer.

CORRESPONDENCE

THE PALLETIZATION OF MILITARY CARGOES

To The Editor,
R.E. Journal.

Dear Sir,

I have read with great interest in the latest *R.E. Journal*, Captain P. K. A. Todd's very valuable article "The Palletization of Military Cargoes." Although I agree with much that Captain Todd says, there are a number of points on which I should like to comment.

1. Apart from the confusion over my initials in the first line of his paper, I feel that the author does less than justice to my articles in stating that they refer only to problems of handling and storage in the field. Their scope is clearly wider than that.

2. Palletization or Parcelling

Captain Todd concentrates on the merits and demerits of palletization. These are fairly well known. If he had dealt more generally with the handling by sea of "unit" loads, including in this term parcelled as well as palletized loads, he would have been on more interesting and far less well-trodden ground. Parcelling, by which I mean the making up of unit ½ to 1½-ton loads without pallets, is an extremely important alternative to palletization. Very valuable results have been obtained recently through the parcelling of bridging and other engineer stores. The bulk reduction of 40 per cent which can be obtained by the correct parcelling of barbed wire contrasts sharply with the 30 per cent bulk loss for general stores which the author says can be incurred through palletization. An interesting current example of "parcelling" in the civilian field is the shipment of cotton baling hoops in 1-ton parcels to U.S.A. through Barrow docks. These parcels are handled and stacked eight to nine feet high by Coventry Climax forklift trucks working in holds and between decks. The cost of pallets has in the past killed many proposals for mechanical handling. Parcelling without pallets would often have saved the day.

I believe that a great deal of progress would be made if more effort were put into developing the potentialities of parcelling than in bemoaning the difficulties of palletization. I think that the Americans and the pallet manufacturers between them have made us all a little too pallet conscious.

One step in the right direction would be the coining of a better name than "unit load" to cover in general the making up of stores into large units to ease mechanical handling problems.

3. Size of Unit Load

The author arrives at 1½ tons as the best normal maximum size of unit load. This is my second mechanical level, of which I said "Uses—Loading of bridging equipment and general engineering stores, particularly for maritime shipment."

I should like to draw attention, however, to the ½-ton unit load, my first mechanical level, of which I said "units convenient for rapid handling in ships holds and landing craft . . . Uses—assault landings, airborne operations . . ."

Thus although the 1½-ton unit is excellent for normal maintenance there is a strong case for ½-ton units in the early stages of build-up.

4. Terminal Palletization or Local Palletization

The author's "terminal palletization" is a special case of the "local palletization" of my articles. Of this I said "The flexibility of local palletization may make it in many ways a more efficient method for service purposes than through palletization."

I prefer my term "local palletization" to Captain Todd's "terminal palletization." A port is a terminus for ships, *not* for stores; and it is, after all, the stores, and not the ships, which really matter. An alternative phrase might be "transit palletization."

5. Loading ex Quay or Shed Floor

It is a somewhat sweeping statement to say that forklift trucks can load only flat topped or drop-sided vehicles. It was shown conclusively at Exercise "King Kong" last October that rear loading of covered vehicles can be carried out by forklift trucks in at least two ways. One simply involves using roller runway on the floors of ordinary trucks. The other depends on vehicles with moving floors. The latter, though more expensive in first cost, may well be the economical answer to this important problem.

6. Conclusion

Although the author advocates palletization for war, he reaches the conclusion that it is not essential or worth while for peace. On the other hand many officers with experience of the last war feel that if mechanical handling depends on pallets, the Services would be better without it.

Captain Todd's article suggests that mechanical handling without palletization would be like Hamlet without the Prince. Fortunately, however, it is becoming increasingly clear that this is not so, and that there are alternative and more important methods of making up through unit loads. Local or transit palletization, however, should certainly be retained.

It is clear from such differences of opinion that the urgent need at present is not academic discussion, but properly co-ordinated practical trials on sound general principles.

Yours faithfully,

Salisbury. J. E. L. CARTER,
15th December, 1953. *Major, R.E.*

ARE YOU PLANT MINDED?

To The Editor,
The R.E. Journal.

Dear Sir,

"The Duffer's" excellent article in your last issue "Are you Plant Minded?" ought to provoke searching thought among Sapper officers. But there is an even more fundamental question which few officers can answer satisfactorily: "Are you Labour Minded?"

By labour is meant man-hours.

I was once a regular Sapper officer; now I am a farmer. The farmer's personal income is directly affected by the efficiency with which he organizes his labour. Meticulous thoroughness in this respect, coupled with the farmer's willingness to lose even more sweat himself, can result in the reduction of an already tiny labour force by one man and a consequent saving of £300 a year. If the farmer wastes only one minute of one man's time each day, it costs him £1 a year with agricultural wages at their present level (£6 a week).

How many Sapper officers regard the efficient employment of their men with this care? A great deal of rubbish is written about time wasted in the services, but I confess I find it better not to look back . . .

It is a regrettable truth that farmers, whose world is one of narrow profit margins, hard work, and long hours, are very chary of taking on ex-servicemen: too often it merely depends on the fellow's rank whether he is good at wasting other people's time, or his own.

I am,

Yours faithfully,

Argyll, Scotland P. KEELAN,
2nd January, 1954. *Major R.E. (Retd.)*

MEMOIRS

MAJOR-GENERAL SIR HENRY F. THUILLIER, K.C.B., C.M.G., D.L.

HENRY FLEETWOOD THUILLIER was born at Meerut on the 30th March, 1868, the eldest son of Colonel Sir Henry R. Thuillier, K.C.I.E., Surveyor-General of India, 1887–95, and grandson of General Sir Henry E. L. Thuillier, C.S.I., Surveyor-General of India, 1861–78. His mother was Emmeline Williams, daughter of Fleetwood Williams, C.S.I., Bengal Civil Service. On the paternal side he was of French (probably Huguenot) descent, a forebear having left France for Switzerland about 1700, whose son Jean Pierre Thuillier left Switzerland for England about 1780.

Educated at his father's old school at Wimbledon and the Royal Military Academy, Woolwich, Thuillier was commissioned 2nd Lieutenant in the Royal Engineers on 23rd July, 1887. After forty-three years of remarkably varied service he retired in 1930, having held the rank of Major-General for no less than thirteen years. On the outbreak of war in 1939 he responded, at the age of seventy-one, with typical self-effacement and devotion to duty, to a further call to service, made on account of his unique knowledge of gas warfare, both defensive and offensive. From April, 1940, to November, 1946, he served, in the rank of Major, in the Chemical Defence Research Department of the Ministry of Supply.

A very just appreciation by " H.H." in *The Times* of 19th June, 1953, read : " Thuillier was a remarkable man, with both imagination and a first-class analytical mind which might have made him a successful scientist or a great lawyer, but he had too the military qualities that made him such a shrewd, decisive and fearless leader." It is considered to be of special interest to follow the career of so versatile a soldier—a keen sapper, a military engineer of wide experience and marked capacity, a good linguist and writer, a resourceful and successful commander of all arms in battle, an effective organizer and administrator of technical services. He was also a man of wide humanity and engaging personality—frank, friendly, humorous and resolute. As such he quickly won and imparted confidence, and was able to inspire men of all ranks, and of many races—civilians as well as soldiers—with a spirit of high endeavour.

After two years at the School of Military Engineering, Chatham (October, 1887–July, 1889), he joined the Military Works Department in India in November, 1889, doing routine work till September, 1890, when he spent a year on the Zhob Valley Railway Survey, a most interesting work requiring initiative and resource and one which made him familiar with trans-border districts, tribesmen and languages. From September, 1891, till April, 1895, he was employed on the important Rawalpindi defensive position. In 1894 he married Miss Helen Shakespear, daughter of Major-General S. R. Shakespear, Indian Army.

A period of active service with the Chitral Relief Expedition (April to October, 1895) ensued, during which Thuillier as Assistant Field Engineer was in control of military and civilian labour working in co-operation with Sapper and Miner Companies on road-making and notable bridge building between the Malakand and Chitral. He was awarded the Indian Frontier Medal with Clasp. Promoted Captain in 1898, he won in 1900 the Prize Essay Gold Medal of the United Services Institution of India, and in 1902 published *The Principles of Land Defence*, an important work of 384 pages remarkable for its clarity and wealth of historical illustration. He then served at home as D.O.R.E. Harwich (1900–2) and in the office of I.G.F. and W. (1902–4). The next ten years (1904–14) were spent in India in military works services, including nine months as Assistant Secretary to the Government of India Military Supply Department. He was promoted Major in 1906.

In October, 1914, he returned to England, was promoted Lieut.-Colonel in November and employed for six months on the defences of South London. Appointed C.R.E. 1st Division B.E.F. in May, 1915, he took part in the battle of Aubers Ridge, the attack on Rue de Bois and the battle of Loos. His selection in October to command the 2nd Brigade was clear recognition of his military capacity and must have afforded him keen satisfaction. The Brigade, under his command, took part in the actions of the Hohenzollern Redoubt. He was created C.M.G. in January and C.B. in June, 1916.

In March, 1916, a combatant officer with technical knowledge being required as Director of Gas Services, G.H.Q., to co-ordinate and control the activities of the offensive and defensive organizations, which had hitherto grown up somewhat independently, Brigadier-General Thuillier was appointed, with Colonel Cummins, R.A.M.C., remaining as Assistant Director for the control of anti-gas measures and Colonel Foulkes, R.E., remaining in command of the Special Brigade, R.E., in charge of offensive operations. How the Germans were gradually overhauled and mastered in gas-warfare is briefly told in Chapter XX Vol. V of the *History of the Corps of R.E.*, which chapter was written by him, and in *Gas, the Story of the Special Brigade*, by Major-General Foulkes, and elsewhere. The magnitude of the scientific, administrative and other difficulties successfully overcome and of the operations, totalling 768, of the Special Brigade may not be generally realized. In this achievement Thuillier played a prominent part both in the field and later at home.

In June, 1917, he was appointed, with temporary rank of Major-General, to command the 15th Scottish Division, which was soon engaged in "Third Ypres"—battles of Ypres, Pilckem, Langemarck and St. Julien—during which he "proved his powers of leadership" (*The Times*, 13th June, 1953). An unwelcome call was made however, in October, for his services at home as Controller of the Chemical Warfare Department, Ministry of Munitions, and President of the Chemical Warfare Committee, which appointment he held for one year, during which he was closely associated with the Minister, Mr. Churchill. His second son, Captain George Fleetwood Thuillier, M.C., was killed in action in France on the 26th March, 1918, when commanding a company of the Devonshire Regiment.

In October, 1918, Thuillier was released to command the 23rd Division forming part of the XIV British Corps under Lord Cavan in Italy. The division figured prominently in the battle of Vittorio Veneto, when the success of the operations depended on forcing the passage of the River Piave at Papadopoli, on the 23rd Division's front, where the river ran in many channels with a bed about a mile wide and was in flood. This formidable obstacle was successfully surmounted in the face of the enemy by the Field Companies, R.E., of the British 7th, 23rd and 48th Divisions, greatly assisted by a well-equipped company of Italian Pontieri, all under the executive control of Lieut.-Colonel Kerrich, C.R.E., 7th Division. Extracts from the *History of the 23rd Division* read: "To take over command of an unknown division with an unknown staff immediately before a large operation must have been a severe ordeal to a new commander. General Thuillier's immediate grasp of the details of the operation, and the entire absence of friction which characterized his command from the outset, were proof of his qualities as a commander. He placed his trust in the division and immediately received their confidence." (Page 301.) . . . "The spirit of comradeship, confidence and determination was fostered by General Thuillier during his short and successful tenure of command." (Page 345.) He was awarded the Italian Order of Savoy and the Order of St. Maurice and St. Lazarus.

On return from Italy in March, 1919, Thuillier was appointed D.D.F.W. War Office and made a member of the "Rawlinson Committee on Organization of the R.E." In November he was appointed Commandant School of Military Engineering and R.E. Depot and G.O.C. Thames and Medway Area, which appointment he held till October, 1923. His work at Chatham was of peculiar importance as it involved not only dealing with the immediate problems connected with R.E. demobilization, the reorganization of the R.E. Depot, the resuscitation, and in some cases expansion, of the S.M.E. schools, but also the completion of the engineer training of some 250 R.E. officers commissioned during the war. Thanks to the cordial co-operation of the late Sir Charles E. Inglis, O.B.E., F.R.S., then Professor of Engineering at Cambridge University, and of the various college authorities—despite severe post-war overcrowding—it was found possible to send the majority of these officers to that university for a special one-year course in engineering. This measure was coupled with that of sending all newly commissioned R.E. officers to Cambridge for two years to take an Honours Degree in Engineering as part of their full training. The wisdom of sending R.E. officers to Cambridge—incidentally wearing cap and gown and under certain college as well as military discipline—was at the time much doubted on many grounds. But Thuillier was confident and, judged by its fruits, the success of the step can now hardly be questioned. Sir Eustace Tickell, peculiarly well qualified to judge, both from pre-war, war and post-war experience, writes: "The Cambridge scheme was an unqualified success . . . I myself, though in a strong position to see the weaknesses of the scheme, am still a firm believer in it."

It was also particularly necessary at this time to secure—both in all service manuals and schools of instruction—that the lessons of the recent war were not lost as regards sound methods of employment and tactical handling of divisional engineers, namely, in brief, their direct command, normally, by the C.R.E., with due provision made by him for meeting quickly the tactical requirements, as arising, of the infantry brigades, in contradistinction to the attachment of engineer units, in whole or part, normally, to such brigades. Thuillier with his wide experience and influence was able, in the face of some opposition, to secure the final recognition of this principle and its essential concomitant, namely, the allotment, both to C.R.E. and the Field Companies, R.E., of sufficient mechanical transport and means of communication to make such system of direct command operable. Other features of his work at Chatham were the stress he laid in the schools on "education" rather than "instruction," and the need to reduce problems quickly to their essentials. Also the full use he made of his staff, both instructional and administrative, by letting them know his mind fully, giving wide instructions, devolving executive responsibility and, withal, giving much general encouragement. The death of Mrs. Thuillier which occurred in 1923, shortly before he left Chatham, was a grievous blow.

His next appointment was that of Director of Fortifications and Works, War Office, which he held from April, 1924, to June, 1927, during which years he reorganized the staff of officers engaged on works services at home and abroad—formerly all in one grade of Division Officer, R.E.—to form a graded staff of D.C.R.Es., G.Es., and A.G.Es., which reorganization is said to have worked well and on which was later built the war-time organization in both Middle East and N.W. Europe. He also organized the "Surveyors of Works, R.E." branch recruited from qualified R.E. non-commissioned officers (Foremen of Works) to replace the former "Staff for Royal Engineers Services" recruited from civilian sources. The scheme was later amended so as to broaden the source of entry and give the improved status of the present Quantity Surveyor.

His last command before retiring was that of the Scottish 52nd (Lowland) Division, Territorial Army, and Lowland Area, which, it is thought, came as a welcome change after years of high-pressure administrative and departmental work. He was always happiest with troops and enjoyed renewing acquaintance with many former friends of the Scottish Division. He was created K.C.B. in 1930.

On retirement on the 30th March, 1930, he settled at Cheltenham where, amongst other activities he was Chairman of the British Legion from 1933 to 1939. He was appointed Deputy Lieutenant of the County of Gloucester in 1936 and Colonel Commandant R.E. (1935–40). A lecture on "Gas Warfare" at the R.U.S.I. in 1936, followed in the spring of 1939 by the publication of his book *Gas in the Next War*, served to arouse public attention and to increase preparedness. It is significant that the Germans did not have recourse to gas in that war. As already recorded Thuillier was, at the age of 71, again called to active service in September, 1939. A photograph of three generations—himself, his surviving son Lieut.-Colonel H. S. Thuillier, D.S.O., R.A., and grandson Lieutenant (now Major) H. W. Thuillier, R.A.—in uniform "on active service" gave him much pleasure.

A man of wide religious sympathy, he never hesitated to express his Christian conviction. He died at Cheltenham, after a short illness, on 11th June, 1953. Many relatives, friends and representatives of the services and civic bodies attended the burial service at the near-by old Parish Church of Leckhampton.

J.A.McQ.

Major-General Sir Henry F Thuillier KCB CMG DL

WM Roberts Esq,OBE MA

W. M. ROBERTS, ESQ., O.B.E., M.A.

Professor of Mathematics, R.M.A., Woolwich, 1904–39

W. M. ROBERTS, who died on the 16th October, 1953, at the age of 77, was elected an Honorary Member of the Institution of Royal Engineers in 1930 "in recognition of his great help in teaching Mathematics to many hundreds of Gentlemen Cadets who were commissioned into the Royal Engineers." He is remembered as an instructor by some 1,500 serving and retired officers of the Corps. Most of these officers were in his class as cadets and knew him as a gifted teacher with an abundance of interests outside the class room.

It is fitting to couple "Bill Roberts" with the "Shop" in our memory, for he dedicated his career to the Royal Military Academy. The Shop was a small closely knit team in which Bill was not only a full partner but also for many years the experienced "oldest member." He was interested in every aspect of the training of Gentlemen Cadets and his contribution to their education, in its broadest sense, stems as much from his influence on the staff as from his individual responsibilities as a professor. His loyal and devoted service was recognised by the award of the O.B.E. in 1930.

His thirty-five years' tenure on the staff is in itself a record of his affection and loyalty to the "Shop." He took the greatest pride in its achievements and maintained that the Royal Military Academy provided a training and education for Army officers which was unequalled elsewhere in the world. Its high academic reputation with schools and universities owes much to his teaching and enthusiasm.

He was involved, more than once, with projects to combine the R.M.A. and R.M.C. into one academy. When the decision was taken in 1939 to effect the union in 1940 he took a major part in the planning. It was a great disappointment to him that the outbreak of war in 1939 prevented the move of the "Shop" to Sandhurst as a live concern and as a formed body taking its staff, cadets and traditions with it. It is sad that after all his long service to the "Shop" he never had any send-off; his life's work just disappeared into nothing with Hitler's war.

However, as in the 1914–18 war, Bill put on uniform to serve with the Royal Artillery. In the 1914–18 war, after continued refusals to his requests to serve, he enlisted as a gunner at the age of 40. He saw active service in France and ended the war at an officer cadet school. In 1939, a major, he was an instructor at an O.C.T.U. until he retired at the age of 65; he then joined the Home Guard.

Bill's hobby was mountain climbing. He loved the Alps and excelled in guideless climbing, his delight was to find the best way up a mountain. He disliked new-fangled "aids," pitons, etc. He abhorred anything sensational or needlessly risky as much as he hated publicity.

He was unselfish and unassuming, though he held strong views and was decisive. He set very high standards and could not do with anything slipshod or with small mindedness. Although intellectually outstanding and well informed on many subjects, he was chiefly remarkable for his abundant common sense. Above all, he was a keen student of people and was seldom at fault in his judgments. He had a wonderful memory for faces and an almost uncanny facility for connecting together names, dates and incidents. He would recognize and place senior officers whom he had not seen since they were cadets. He was a delightful companion in every way and a wise friend and guide at all times.

In 1926 he married Kathleen King, who joined wholeheartedly with him in the spirit of " Shop " life. They were devoted to each other and during his crippling illness, which lasted through three sad years, she was always by his side. She has the deepest sympathy of all the many friends who loved them both.

G.N.T.

BRIGADIER-GENERAL R. F. A. HOBBS, C.B., C.M.G., D.S.O.

The following memoir was published in *The Times* of 14th July, 1953, and is reprinted by permission.

REGINALD FRANCIS ARTHUR HOBBS was born on 30th January, 1878, the son of the late Captain S. H. Hobbs, 89th Foot. He was educated at Wellington and the Royal Military Academy, Woolwich, and was gazetted to the Royal Engineers in 1898. He served in the South African war and was awarded the D.S.O. for his conduct while in the rearguard of von Donop's column when it was cut off at Kleinfontein in 1901. The two guns in the rearguard were put out of action ; Hobbs rode back, got one of the guns into action and fired it himself. Finally he fetched a team of horses and helped to drive both guns away to join the main column. He served in East Africa in 1903, taking part in the operations in Somaliland, and in 1904–05 he was on survey duty on the Gold Coast. In 1907 he was appointed to supervise the technical side of the School of Musketry at Hythe and remained there until 1911.

Soon after the outbreak of war in 1914 he was appointed a divisional D.A.A. and Q.M.G., and was promoted to A.A. and Q.M.G. in the summer of 1915. He served in this appointment in France and Italy until February, 1918, when he was appointed D.A. and Q.M.G., XVII Corps. His services were mentioned five times in dispatches and he was created C.M.G. in 1915. He was given the brevet of colonel in 1919 and from 1924 to 1927 was

A.Q.M.G. of Southern Command. He then took up the appointment of Brigadier in charge of Administration, Western Command, and held it until his retirement from the Army in 1931. He died at his home near Warminster on 10th July, 1953, at the age of 75.

He married in 1906 Frances Graham, the youngest daughter of the late General Sir William Graham Stirling, K.C.B., who survives him together with one son of the marriage. His two other sons were killed in action, one in 1942 and the other in 1943.

BOOK REVIEWS

KOREA—LAND OF THE MORNING CALM

By Colonel Donald Portway, T.D., M.A., J.P., A.M.I.C.E.

(Published by George G. Harrap & Co. Ltd. Price 15s.)

Lewis Carroll's "Alice" thought badly of books which were "without pictures and conversation." She liked her reading to be vivid and direct. Even grown-up people prefer first-hand to second-hand information. Colonel Portway rather errs in this respect. He provides us, indeed, with some excellent pictures, which are mostly photographs taken by himself. But much of the book is compiled from works of reference, some of which seem to contain errors. This is a pity, for when he embarks on his own, as in the chapter on "Korea as a battlefield," his narrative immediately becomes more lively.

The fact is that the author did not decide to write about Korea until after his return home, by which time he had destroyed his notes and had to rely on what he calls the fickle jade of memory. So the book is uneven and at times contradictory.

It is not true, for instance, to say that "no Koreans were allowed to bear arms" (by the Japanese). A Korean division assaulted Hong-Kong in 1941 and although Koreans could not rise above the rank of Colonel in the Japanese army, they were amongst their best troops. It is also quite wrong to suggest, as on page 105, that the Koreans are purely a peace-loving people. They are, on the contrary, a warlike race.

The "thriving forests" of Korea are said to have benefited much from the enforced absence of the usual "Korean wood-scroungers." It is believed, however, that the field armies of both sides have felled timber with a rapacity, which has done far more damage than the normal day-to-day depredations of the peasantry.

In political matters, Korea is a free-for-all battleground. It is, however, permissible to question the statement on page 177 that "the United States and her allies could destroy the Communist armies facing them, if they were prepared to pay the price in casualties." The forces of the United Nations were at full stretch when they succeeded in holding up the Chinese offensive just before the cease fire. Apart from other weighty considerations, destroying Communist armies on the mainland of China is quite a big job, for which the United Nations would have required large reinforcements of every kind.

The author's criticisms of the U.S.A. and the U.S. Army are not unfriendly, but expressions like "Pentagon pundits" and "God's Own

Country" seem out of place in such a context. Other colloquialisms of a similar kind are here and there also rather irritating.

But the defects of the book will stimulate rather than dismay the reader because Colonel Portway writes with a purpose. He wishes to attract the sympathy of the British public to the immense sufferings of the Korean people. *Korea, Land of the Morning Calm* is well designed to do so.

B.T.W.

HOW TO DOWSE

Experimental and practical radiesthesia

By MARGUERITE MAURY

(Published by G. Bell & Son. Price 11s. 6d.)

Madame Maury is a trained nurse, married to a doctor, who has spent some time of her life studying physics in Vienna. Her interest in dowsing was first aroused through following up a medical diagnosis of M. Louis Turenne, a French radiesthetist of great repute. This interest was soon extended to many other fields of radiesthesia in which she clearly obtained a very considerable proficiency. In association with others, she founded a College of Radiesthesia in France which operated, in the main, by giving instruction through correspondence courses.

The first and greater part of this book consists of the lessons compiled for this work, the remainder of the book is devoted to some chapters on medical radiesthesia.

The lessons in Part I are well set out and cover a very wide field in dowsing, and include much useful information on the use of samples and colours, the effect of parasitic images, dowsing from a map, the interaction of bodies, the effect of telluric emissions, and perception for water, minerals and oil.

Elementary instruction on the use of the rod and pendulum, together with some notes on amplifiers is also included.

In Part I, Madame Maury mentions an apparatus she has designed, termed a "Compensator," which she has used successfully to help her arrive at solutions in much of her work on radiesthesia. Practical uses of the compensator are further developed in Part II of the book in a chapter on the breeding of animals. It would have been helpful if a simple constructional diagram of this apparatus could have been included in the book in addition to the illustration on page 124. I understand, however, that the instrument will be obtainable from Electro Medical Hire Ltd., 74 New Cavendish Street, London, W.1.

Much of Part II, on medical radiesthesia, is more a matter of interest than use to the layman. I do not doubt, however, that an experienced dowser will obtain results in line with the author's teaching. The chapter on choice of diet certainly gives a basis for some interesting and perhaps rewarding experiments.

Each lesson in Part I ends with a number of exercises which should assist the reader to understand more clearly the explanations given in the lessons themselves, the more particularly since parts of the book are lacking in detailed exposition, which is inevitable when such a wide field is covered in a comparatively small book.

Madame Maury believes in a purely physical origin of radiesthetic phenomena, but as Colonel Bell remarks in the foreword it is difficult to connect this with dowsing from a map or diagram. It might be suggested that the author really bases herself on the results she has obtained from her own methods and experiments.

This book should serve as a useful introduction to anyone who is interested in dowsing and would like to know more about it. It is recommended that such a person should, after reading the book, seek demonstrations from a skilled dowser before embarking too seriously on many of the experiments given. For those already possessing dowsing experience, the book can be commended for its suggestions for study and experiment in aspects of dowsing perhaps hitherto neglected. A.J.E.

GEOLOGY AND SCENERY IN BRITAIN

By T. G. Miller

(Published by B. T. Batsford Ltd. Price 18s.)

The author states that his object in writing this book is " to strike a balance between the purely geological regional survey and the more ramifying ' country book '." The result is a pleasant and readable study of the geological fabric of England and Wales (for despite the title Scotland is barely mentioned) and its influence upon the countryside.

The author's style shows a very beautiful economy, the matter is well arranged and the book stands as a whole and complete. There is little " text book " material and no apparent " teaching." Because of these facts, the reader must persevere, for terms are often introduced without immediate explanation, but as the end of the book is reached the pieces of the jigsaw fall into place and the picture stands clear.

The book is divided into three parts. Part I is a general introduction to remind the reader of the basic facts and general machinery of rock formation. Part II deals with the highlands and includes chapters on Old Wales, the South-West and the Greater Pennines. Part III deals with lowlands, with chapters on the Red Midlands, the Surassic Belt and the East and South.

The book is lavishly illustrated with clear diagrams and excellent well-selected photographs. The camera both on the ground and in the air is shown to be a powerful tool in the hands of the teacher of simple geology.

The book can be recommended to the ordinary reader who has country interests and wishes to understand the background of the land in which he lives and also to all who appreciate a well set out and well presented scientific study. H.C.G.C-T.

CORONATION AND COMMEMORATIVE MEDALS 1887–1953

By Lieut.-Colonel Howard N. Cole, O.B.E., T.D., F.R.Hist.S.

(Published by Gale & Polden. Price 5s. in paper cover or 7s. 6d. bound in cloth.)

This little book of 52 pages gives details of all commemorative medals issued since the first for Queen Victoria's Golden Jubilee in 1887 up to the latest Coronation Medal.

The book gives full details and pictures of the obverse and reverse of each medal and also coloured illustrations of all the ribbons, of which there are fifteen different types.

Besides giving details of the medals and ribbons, the book also gives a brief account of the occasions for which the medals were issued. It is therefore a comprehensive account of this type of medal. C.C.P.

TECHNICAL NOTES

Notes from *Civil Engineering*, August, 1953

Grouting Clay Embankments

An interesting article in this month's edition describes the experiments made in grouting clay embankments under railways. The object of the experiments was to find some way of reducing slips in the fissured clay of which the embankments are constructed. The alternative to grouting is the construction of counterforts in open masonry, which is an expensive task. The development of a suitable grouting point was necessary to overcome the blocking of grout holes by clay during driving and the back flushing of the grout up the sides of the tube. Colcrete grout was accepted for the task after some experiment. Experiments were also carried out with aerated mortar, but an expected saving in cement was not achieved.

Vibratory Soil Compactor

In the review of contractors plant the performance of a vibratory soil compactor is described. This machine would seem to have application in the rapid construction of airfields, being able to compact soils 20 in. to 40 in. below itself depending on the type of soil. It will cover the ground at about 2,000 square feet per hour and the soil never requires more than two passes for optimum compaction.

Notes from *Civil Engineering*, November, 1953

Hydraulic Power for Civil Engineering Plant

An interesting and comprehensive paper appears on hydraulic power, as applied to civil engineering plant. The article discusses the use of fluid transmission of power, from heavy compression ignition engines to the main drive shaft of machines, such as excavators. It is well known that the ideal excavator drives are provided either by steam or diesel electric power, by means of which heavy digging efforts are obtained at slow speeds without imposing shock loads on the machinery, conversely, high speeds are obtained quickly when in light digging. In view of this, fluid couplings have been fitted to excavators of various sizes and the results obtained in the field proved that this form of coupling gives the flexibility of operation and many of the advantages obtained by steam or diesel-electric machines.

Power transmission by hydraulic fluids for engineer plant may well have important military application as the following factors are noteworthy :—

(*a*) Operator fatigue is reduced, and there is no danger of stalling the engine.

(*b*) Wear and tear on the whole equipment, especially clutches, ropes and gears, is reduced ; hence longer service between overhauls.

(*c*) Higher average effort can be applied to bucket under heavy digging conditions.

Blast Furnace Cement

Another article brings news of the use of blast furnace cement by the North of Scotland Hydro-Electric Board on one of their major projects. This is known as the Trief process and has proved to be satisfactory. The Trief process consists of using blast furnace slag (which is at present virtually a waste product) by grinding it wet at the site in a rotary grinder. The slurry so produced is passed direct into the concrete mixers to be mixed with aggregate and sand and a small proportion of Portland cement to produce a concrete equal in strength to a similar mix using wholly ordinary Portland cement.

From the military engineer's point of view the Trief system may well have important application, especially overseas.

Engineer Plant

In the review of engineer plant there are two items of equipment worthy of note. Firstly, a new 3 cu. yd. capacity scraper which is operated entirely hydraulically, hence no power control unit is necessary. It is known as the "Conder," and is possibly a suitable "toy" for the airborne engineer, faced with hasty construction of dropping zones or air landing grounds. Secondly, a new prestressing jack for prestressed concrete work. The weight of the jack and pump together is only 56 lb. and it is, therefore, eminently suitable for work in the field.

Notes from *Civil Engineering*, December 1953

Submersible Bridges

A most interesting article appears on submersible road bridges, and the author points out, that with the need for an extensive road construction programme in the colonies and in other undeveloped countries, the subject of submersible bridges or causeways, merits greater attention by road engineers in this country than it has received in the past.

Within its limitations, this type of bridge provides a cheaper means of crossing than a normal bridge, the cost of which may be such that no river crossing at all is provided.

The article draws attention to the special problems involved in the design which do not normally occur with a bridge of conventional type. The submersible type of bridge construction is specially suited to sites having (*a*) a straight reach of river, (*b*) well defined and fairly high banks, (*c*) good foundation possibilities, and it must be designed for two conditions, namely, when passing a discharge under the bridge, it may be treated as a conventional bridge structure, but when submerged, it must be treated as an anicut or weir with under sluices.

Shear and Torsion in Prestressed Concrete Beams

The first part of a paper on secondary shear and torsion in prestressed concrete beams, although a complex subject, is well presented. If a beam is loaded eccentrically, or curved in plan, the transverse loads set up torsional moments in addition to the bending moments and shear forces.

In rectangular beams and most I- and box-sections of the type used in prestressed concrete, the torsional shear stresses have their maximum at the same point as the transverse shear stresses. The total shear stress at any point may be combined with the direct stresses at the same point to obtain the principal stress. In a prestressed beam the direct stress at the centroid of a section is always compressive, and the principal tensile stress is therefore much smaller than the shear stress. In normal reinforced concrete beams, the direct stress at the neutral axis is *nil*, and the principal tensile stress is therefore numerically equal to the shear stress. The author goes on to describe shear stress distribution due to prestressing and maximum principal tensile stress due to combined prestress and shear.

Concrete Vibrator

In the *Plant Review* this month a new type of concrete vibrator known as the "Johnson Model III" appears. This is an immersion type vibrator and is powered by either a 4 h.p. petrol engine or a 3 h.p. squirrel cage electric motor. The drive is transmitted by flexible shafting in standard 12 ft. lengths, of which three may be used with any one unit, giving a maximum operational length of 36 ft.

Notes from *The Engineering Journal of Canada*, October, 1953

Reconstruction of the N.R.X. Reactor at Chalk River

In December, 1952, the nuclear reactor at Chalk River, which had been in operation for over five years, broke down owing to a mechanical failure which resulted in a power surge. Some of the uranium rods overheated, uranium fuel and aluminium in the rod assemblies melted and sheathing was ruptured. Cooling water became heavily contaminated with highly radioactive fission products, the flow to delay tanks ceased, and contaminated water poured into the reactor basement. The basic structure of the reactor, the decontamination procedure and the methods adopted for dismantling are well described in this paper, which demonstrates triumphantly what can be achieved by meticulous planning, organization and the training and rehearsal of personnel, even in the most difficult working conditions.

Development of a Pulpwood Shipping Harbour

The development of a harbour at a remote and previously unsurveyed site is an engineering problem of some complexity and considerable interest. The author of this paper was concerned in the project described from the first reconnaissance in 1937 until five years after the first coastal steamer used the wharf, and he presents an admirable summary of the preliminary planning and of the sometimes novel construction methods used. The most interesting feature, perhaps, is the remarkable co-operation achieved in the planning stage, in which practical loading foremen and ships' captains, among others, were encouraged to criticize the proposals of the engineers. The value of preliminary observations of tide, wind, current, sea-bed, littoral drift and navigational factors is clearly proved by the performance of the harbour structures over a period of ten years.

Modern Developments in Prestressed Concrete

It is common knowledge that prestressed concrete, using high strength concrete and high tensile steel, makes possible more slender members and longer spans than can be achieved with ordinary reinforced concrete. *The Engineering Journal* for October, 1953, contains two papers on this subject, the first of which provides a valuable summary of the systems used both in pre-tensioning and in post-tensioning, and gives practical details of some comparatively unusual applications of prestressed construction. These include caissons built up of precast sections, underpinning, dam construction, and tubular and box-shaped poles for power-line use.

The second paper discusses the use of prestressed concrete in roof-joists, and gives a detailed description of one particular job which has several interesting features. The author also advances a theory, as yet unconfirmed experimentally, to explain some of the discrepancies between theory and practice in prestressed concrete design and construction. This is based on an apparent inter-relation between the symmetrical ratio of a beam and its margin of safety, and seeks to explain why designs calculated for the same maximum working stresses do not necessarily have the same ultimate capacity.

Notes from *The Engineering Journal of Canada*, November, 1953

THE CRACKING PROBLEM IN REINFORCED CONCRETE BUILDINGS

Stresses caused by gravity loading are comparatively easy to calculate and to provide for, but those due to shrinkage and temperature change are less well understood. The most complex and unpredictable stresses probably occur where an outside wall and a floor are homogeneous, as the external surface has a greater temperature range than the internal floor. This paper first considers theoretically the formation of cracks and fissures, and then deduces practical rules for the limitation of cracking by reinforcement design and properly located contraction joints. Successful design is instanced by two examples of actual construction in severe climates. The need for co-operation between the architect and the structural engineer is convincingly expounded and the use of " architectural concrete " roundly condemned.

SMOKE PREVENTION AN ENGINEERING PROBLEM

The word " smog " bids fair to achieve inclusion in the English dictionary. For those interested in smoke abatement, this paper provides a comprehensive summary of types of fuel, and of boilers, furnaces and burners, with succinct comments on their capacity for smoke production and the means of control. Enhancement of the powers of local authority is not the whole answer to the problem.

THE MILITARY ENGINEER

(*Journal of the Society of American Military Engineers*)

September–October, 1953

" Dud Atomic Bombs," Jack De Ment.

The author, a research chemist and director of the De Ment Laboratories at Portland, Oregon, was present at the Bikini atomic bomb tests and is interested in the design and development of atomic weapons and counter measures. In a short article he deplores the fact that while the number and variety of atomic missiles are steadily growing, the problem of dealing with dud or unexploded weapons seems to have been completely neglected. Even the difficulty of recognition is acute, close security has resulted in only a few experts knowing what an unexploded atomic missile looks like and still fewer knowing how to deal with one. Even these cannot guarantee to have the same detailed knowledge of foreign made atomic weapons. What is wanted is a more widespread knowledge of foreign atomic bombs rather than our own. One has only to recall the recent reward offered by the United States for an undamaged M.I.G. to appreciate this point. Atomic Bomb Disposal units will have a serious problem to face in the next war, as not only are there not nearly enough trained experts to go round, but also such units would require the highest order of training and their personnel would need to be of very exceptional intelligence, stability, courage, and good judgement. Considerable time would be required to train such personnel and as bomb disposal units offer the only effective counter measures once an atomic dud has reached its target, a nation without them would be highly vulnerable to dud warfare. In this connexion it must be remembered that with atomic warfare we have to deal not only with the real dud, caused by faults arising in mass production and storage, but also with the deliberately simulated dud used to exploit radiophobia or fear and panic with a view to neutralizing or evacuating an area at least comparable with that which would have been destroyed by a live bomb. A Director of Atomic Bomb Disposal of the future—if a belated war appointment—seems to be faced with either failing in his task through lack of adequately trained staff or seriously prejudicing the war effort by diverting from their essential work the few specialists employed in the production and development of atomic weapons. The author strikes an interesting, and incidentally warning note, which should not be ignored.

November–December, 1953

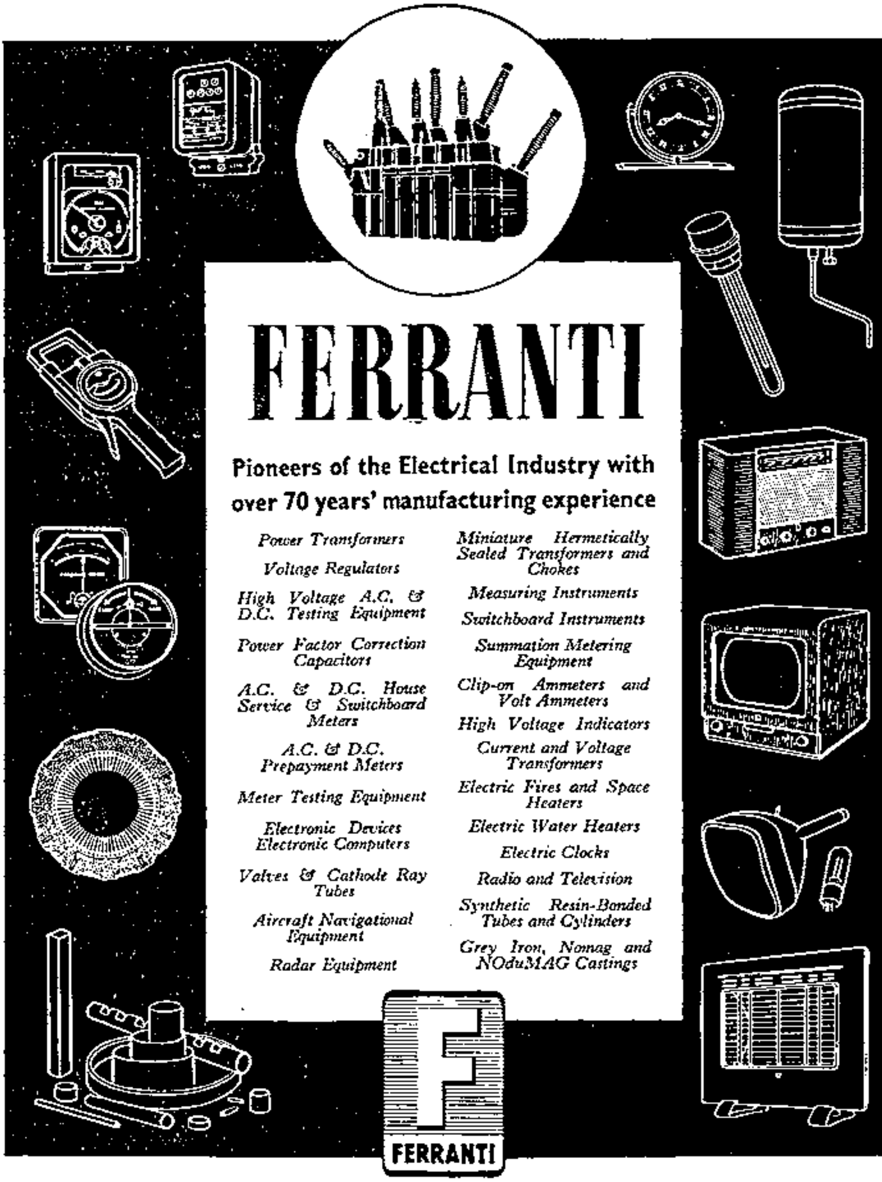
"Plastic Laminates for Structures," Arthur C. Bushey, jun., Commander, U.S. Navy.

In an interesting and well illustrated article, the author describes the successful use of laminated glass, polyester resin construction for boats, and forecasts that the time is now ripe for the extension of this technique to the mass production of many other objects, structural and non-structural.

While specially suitable for boat construction, owing to its high specific strength, the new material has many other advantages. Rapid repairs are simple and it is not subject to rot, destruction by fungi, or the corrosion of the common building metals. Neither the polyester resin nor the glass laminated material should ever be in short supply in war. Indefinite storage without deterioration makes it particularly suitable for mobilization equipment, or alternatively moulds can be made and stored for mass production in an emergency.

This new method of construction was made possible by the introduction in 1942 of "contact" or "low pressure" thermosetting polyester resins. The recent advent of thixotropic resins has been a boon to the manufacturers of moulds, the construction of prototypes, and production on a limited basis as opposed to mass production work.

Among the large number of uses envisaged for laminated glass plastics are, a 40-ton Navy ship 57 ft. long, a substitute for metal pipes, flasks for oxygen and carbon-dioxide, bathroom fixtures and furniture, fuel tanks, refrigerators, pressure tanks for water, military containers, segmented quonset huts using resin adhesives in place of metal fasteners used in present construction, bearing or non-bearing partition walls, with the added possibility in the near future of complete rot-proof and weather-resistant houses in which the architectural designs would be both utilitarian and aesthetic.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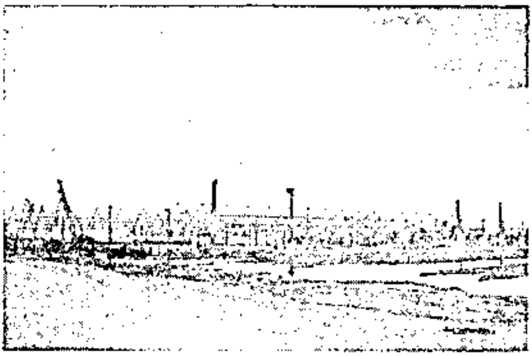

The contract illustrated involved the supply and erection of 1,750 tons of Structural Steelwork to provide covered storage accommodation over an area of 17 acres. Associated contracts called for covering a further 31 acres.

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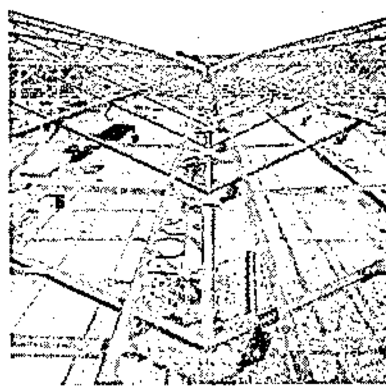

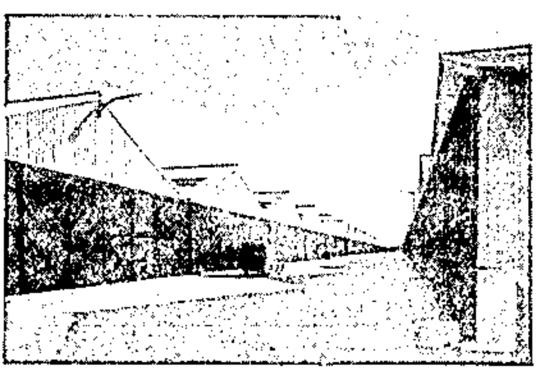

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