VOL. LXVIII. No. 2 JUNE, 1954

THE ROYAL ENGINEERS JOURNAL

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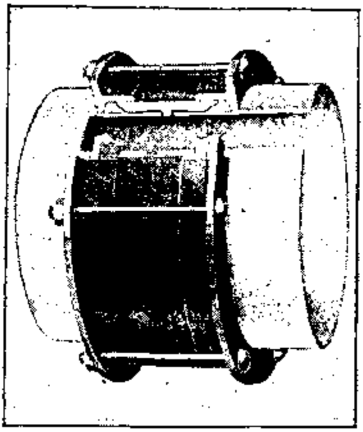
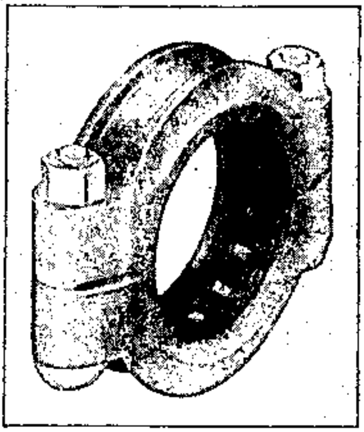
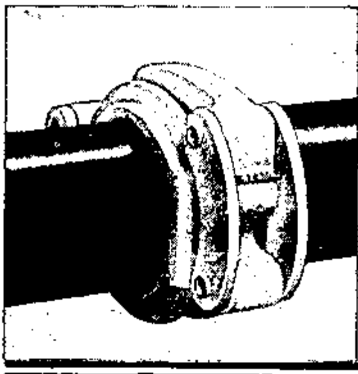
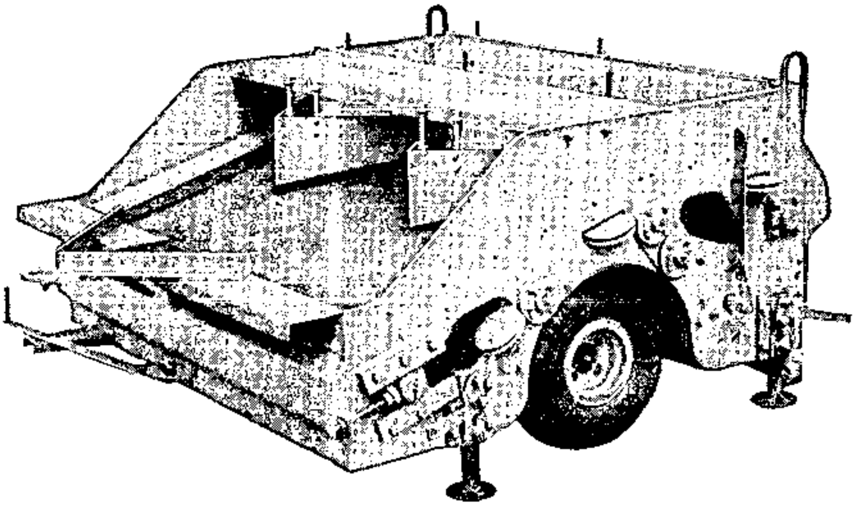
THE ROYAL ENGINEERS JOURNAL—JUNE, 1954 VOL. LXVIII. No. 2









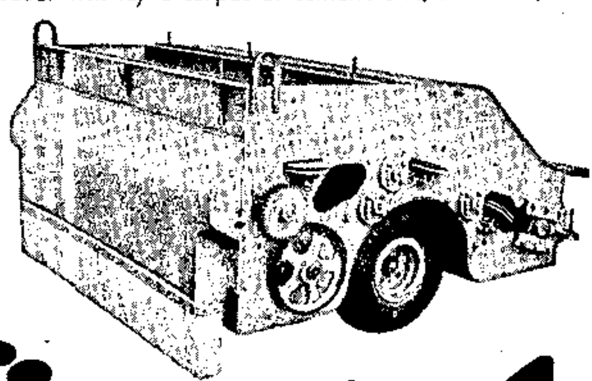


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Photo 1.—Aerial view of Fort Henry

Photo 2.—Lieut.-General. Sir Archibald Nye with memorial plaque—
Fort Henry Guard Sentry.

Unveiling of Plaque At Fort Henry,Kingston,Canada 1 , 2

UNVEILING OF PLAQUE AT FORT HENRY, KINGSTON, CANADA

ON 8th September, 1953, a ceremony took place at Fort Henry, Kingston, Canada, when a plaque was unveiled to commemorate the names of the various corps and regiments which had been stationed there since its original construction in 1813.

At the start of the American War of Independence in 1812 Kingston was a naval dockyard and had no defences except for a small garrison in barracks and two coast defence batteries. This local garrison hurriedly started to prepare field fortifications, mainly to protect the western approaches to Kingston. Early in 1813 a start was made on clearing a site to build a fort to protect the eastern approaches and by the end of the year Captain B. Marlowe of the Royal Engineers had completed substantial fortifications with demi-bastions, redans, a circular battery and a ravelin, the whole surrounded by a ditch revetted with logs. During the next six years these defences were gradually increased and timber works were replaced by brick and masonry, including magazines, offices and barracks, and Fort Henry became one of the strongest defence positions in Canada.

After the war with America, plans were prepared for building a larger defence work with its main front arranged for protection against a land attack, but with defences on the seaward side as well. In 1832 the old Fort Henry was razed and work started on the new fort.

Imperial troops were stationed there from 1813 to 1870 and Canadian units from 1870 to 1890. In 1885 the fort was declared obsolete and shortly afterwards the troops were stationed in Kingston.

Altogether thirty-three British units were stationed at the Fort and six Canadian units.

The plaque, with the names of all the units concerned, was unveiled by Lieut.-General Sir Archibald Nye, G.C.S.I., G.C.M.G., G.C.I.E., K.C.B., K.B.E., M.C., the United Kingdom High Commissioner in Canada. Representatives of all the units concerned were present and Major R. E. Thompstone, D.S.O., represented the Corps of Royal Engineers, who were stationed in the Fort throughout the whole of the time while Imperial troops were there from 1813 to 1870.

After the Inspection of the Guard and the unveiling ceremony there was a *feu de joie* by the Fort Guard, followed by a display of infantry drill and battle tactics of the mid-nineteenth century, including the "thin red line" immortalized by the 93rd Highlanders at the battle of Balaclava and the "British Squares" employed against the French cavalry at the Battle of Waterloo.

The Fort Guard fired a salute of thirty-nine "Congreve war rockets" to honour the thirty-nine units mentioned on the plaque and the guns of the East Battery fired a salute at ten-second intervals. These guns formed part of the original armament of the Fort, having been cast at the Carron Foundry in Scotland between 1796 and 1806.

THE ENGINEER TASK IN FUTURE WARS*

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

(The following report of the discussion which followed the Paper read by Major-General G. N. Tuck at the Institution of Civil Engineers on 19th January, 1954, and published in the March, 1954, issue of the R.E. Journal, is published by permission of the Institution of Civil Engineers and the Controller of H.M. Stationery Office.)

Discussion

Mr. R. M. WYNNE-EDWARDS said that perhaps the most useful contribution the civil engineer could make to the military engineer might be in the training of the Sapper officer. The Author was hoping that the civil engineer who was fully conversant with a continuously up-to-date knowledge of civil engineering practice, would apply his mind to military problems in peace-time. Mr. Wynne-Edwards did not think that that was likely to be very productive because the civil engineer, as the Author had described, was busy fulfilling very utilitarian civil purposes. He was not paid to think about military matters ; he was paid to do civil things.

Perhaps the best contribution which civil engineering could make would be to help the Army (whose daily job was to be conversant with military problems) by making available to the military engineer information about all the latest civil engineering practice ; but only the Army could ensure that that information was assimilated and the Sapper officer hoping for promotion would be required to be just as *au fait* with design or construction techniques as his opposite number in the civilian world must be, who was ambitious to advance in his profession. It was indeed absolutely vital for the military engineer to acquire that knowledge somehow.

Any war would obviously present a number of new problems, and no doubt if it went on long enough new devices would be designed and manufactured to cope with some of them ; but when war broke out the Sapper had to make the best use of existing plant and techniques, because they and the civilian engineers who knew how to use them were the only resources he had immediately to hand. As a rider to that, of course, the Army had to know exactly where to find those resources.

One could well believe that all that was more easily said than done. Some members might remember that in a discussion many years ago at the Institution a Sapper officer had said that the Sapper started off with a very good academic grounding, but by the time he was thirty he found that it was more important to keep his Company accounts right than it was to know about engineering. That was a real problem which had to be faced in the Army, and it was only the Army who could solve it.

The long course was obviously a very good start and he wondered whether the idea was used to its limit. For example Singapore and other ports were busy mechanizing their cargo handling ; he wondered whether Sapper officers were collaborating in those studies or learning from them. Again Sapper officers ought to take a great deal of trouble to discover how contractors maintained the efficiency of their equipment.

He felt quite certain that the civil engineering profession and industry would be pleased to help the Army in every way by bringing Sappers in touch with what was going on. If the Army could ensure that its knowledge was sufficiently up to date to know how to make use of that which was available, it would have gone a long way to solving all the problems that could be satisfactorily solved in peacetime.

Brigadier C. E. A. Browning said that, as Commandant of the School of Military Engineering, he was intimately concerned, under the Engineer-in-Chief, with the training of the young regular Royal Engineer officer. National Service officers, who also attended the School, were expected to complete their training as civil engineers in the profession after their National Service.

It was quite obvious that the young regular subaltern had to be ready and trained to undertake a very wide range of tasks in war. He had to do the job which was in front of his nose at the critical time and place, and he had to be prepared to take on tasks at very short notice and frequently work from first principles. There was no doubt that the War Office's policy that he should be trained on broad lines was right. The curriculum had to be sound and in accordance with professional standards and experience ; it should include sound teaching of the application, operation, and maintenance of earth-moving equipment—quite a big task in present times.

The young regular Royal Engineer officer broadly speaking received five years' training initially in his profession, and it was conveniently broken up into four phases. The first phase was the eighteen-month period which he spent with the Royal Military Academy at Sandhurst where, in addition to receiving his basic military training, he also received academic training designed to fit him to take Part I of the Joint Paper, and for those officers educationally capable of doing so, to be ready to pass the Cambridge University qualifying examination for the Mechanical Science Tripos. On leaving Sandhurst, after eighteen months, he went to the School of Military Engineering at Chatham for four months. That was his first training after receiving Her Majesty's Commission. Those four months were spent mainly on field engineering and tactics. The subjects included fixed and floating "equipment" bridges, field works and field defences generally, demolitions, and mine warfare. There was also some regimental training, tactics, and man-management. That involved four months of hard work. Then the young regular officer, before proceeding to phase three, was sent over to Germany to the British Army of the Rhine where he served two months with a field engineer regiment, in order to give him practical experience of the job on manœuvres. After phase three he would either proceed to Cambridge University, where he took a two-year mechanical science tripos course, or to the Royal Military College of Science. There he took the three-year B.Sc. engineering course, London University External, or a two-year general science degree. In addition the Royal Military College of Science had started an advanced two-year diploma course, which, with some adjustments on the teaching of civil engineering subjects, and, taken in conjunction with the training at the School of Military Engineering, might lead to exemption from Parts I and II of the examination for Associate Membership of the Institution. That was not yet quite firm on the military side, but everything was working satisfactorily in that direction and it was the firm policy of the Engineer-in-Chief.

Phase four began when the young officer had completed his two or three years at Cambridge University or at the Royal Military College of Science. He then came back to the School of Military Engineering at Chatham for forty-eight weeks for continuation training in civil engineering, electrical, and mechanical subjects. There he was given practice in the application of those engineering theories which he had learned at the Universities, with particular reference to their military engineering application. The subjects covered were: the design and construction of timber, steel, and reinforced-concrete structures; electrical generation, transmission, and distribution ; plant operation and application ; the construction of roads and airfields ; building and workshop practice ; and engineering survey. It was a fairly large field to cover but it simply had to be covered if the young Sapper officer was to have a sufficiently flexible mind to take on the task facing his Corps in war.

At the end of the forty-eight weeks' period he took an examination which consisted of a series of three-hour papers and several practical projects. The Sappers present at the meeting would remember the old " F " project in pre-war days ; they were similar projects in a more up-to-date form. It was hoped that that examination, monitored by the Institution, would be accepted as giving exemption from Parts I and II of the Institution's examination for Associate Membership. Those young officers who had achieved honours degrees were already exempt.

At the end of that period the young officer went out into the field engineer regiments of the Corps, the Engineer-in-Chief's policy being that the young officer should go to regiments, mostly overseas in Germany, the Middle East, or the Far East, for practical experience as a troop commander in the Royal Engineers. He would probably remain there until reaching the rank of captain.

Some time between the ages of 27 and 32 (depending on his availability), the slightly more senior engineer officer came back to the School of Military Engineering for the long engineering course. Those courses had been mentioned by Mr. Wynne-Edwards and they were undoubtedly of great value. They lasted for just over two years and were divided into three phases. The first phase of seven months was spent in the civil, electrical, and mechanical engineering departments of the School of Military Engineering ; engineering theory and practice were again studied, in retrospect, so as to make quite sure that the young officer had not forgotten what he had been taught in the past and to bring him up to date. At the end of seven months he joined (with the generous co-operation of the profession) a firm as a junior executive engineer for eleven months, in order to gain practical experience and understanding of the civil side of the profession. At the end of that period he spent a further seven months attached to a consulting engineer where he had to learn as much as possible of the planning of large projects. It was invaluable experience and at the end of that time he was in a position to write his thesis. Then if he were fortunate, and had sufficient ability, he obtained Associate Membership of the Institution of Civil Engineers or of some other professional Institution.

It might be added that it was the Engineer-in-Chief's policy to send on that course only those officers who had already achieved exemption from Parts I and II of the professional examination.

Of about 1,600 serving regular officers, 530 (or 32 per cent) had obtained an honours degree at Cambridge University or the B.Sc. (Eng.) at London University. Thirty-five officers (2.2 per cent) were either Members or Associate Members of the Institution. Twenty-five officers (1.5 per cent) were Members or Associate Members of the Institution of Mechanical Engineers ; and twenty-two officers (a little more than 1 per cent) were either Members or Associate Members of the Institution of Electrical Engineers. So that eighty-three regular officers in the Corps (5 per cent) were either Members or Associate Members of professional Institutions, the majority being Members or Associate Members of the Institution of Civil Engineers.

Mr. P. St. L. Lloyd said that the Author had quite properly taken as his underlying theme the importance of close liaison between the Sapper and the civil engineer, and it appeared that everyone was using the latter term on the present occasion in its original sense. Mr. Wynne-Edwards had already pointed out some of the difficulties ; but Mr. Lloyd's personal view was that that liaison, which was of fundamental importance, should be built up immediately, because as had already been stated, it would not be possible to rely, in the next war, upon the initial period of comparative inactivity during the autumn and winter of 1939–40.

The 1914–18 war had seen the beginning of a realization that the civil engineer and the military engineer were inextricably mixed. The 1939–45 war had proved that beyond doubt, and any future war would have to take account of it right from the beginning. So far as the individual civil engineer was concerned, part-time liaison should be comparatively easy, because most of the civil engineers would either have had war service, or would have undertaken their National Service probably with the Sappers or with some similar Corps and would therefore have some knowledge of the problems. But in peace the fundamental difficulty was that the engineer had to earn his living in civil life as an employee. It was difficult even for a chief engineer to facilitate liaison with the Sappers. It was certainly much more difficult for less senior engineers.

In the 1930's some of the younger engineers who expressed views that there might be a military application of the work they were doing were usually told to apply their minds to what they were paid to do. Therefore it would seem that effective liaison would remain in the realms of pious hope unless there was some officially recognized channel or machinery set up for the purpose. In that event, the engineer in civil life, encountering a development which he felt should be discussed with the Sappers, would have a means of initiating discussion.

The Author expressed the opinion that, in a future war, it would be easier to repair installations than to start afresh. Most civil engineers would probably agree with that, especially those who had had experience in the Royal Engineers, because the major part of the time, labour, and material was concerned with the services required for the installations—drainage, roads, water-supply, power-supply, and so on. It occurred to Mr. Lloyd that there was one problem to which the civil engineer in consultation with the Sapper might address his mind. That was the question of the hutted camp or base installation.

Atomic weapons would have far more widespread blast effect than the ordinary bomb, and in his view it was desirable to have quickly erected hut and workshop buildings ; easily assembled from prefabricated parts which could be replaced quickly. What shape would these buildings take ? In World War II there was a shortage of timber, and square concrete structures were used ; but was it not perhaps necessary to alter the shape ? Would a blister shape avoid blast effect, and should it be set partly below ground level ? That, of course, would raise problems of drainage. These were matters which should be investigated because the base installation was very expensive, and he felt certain that one could not abandon all the underground services which would have been provided.

A borough engineer who had recently visited the New York port authority had been given the use of a helicopter. It was reported that in company with the Engineer to the authority he dropped down and inspected drainage work in progress from the machine. How long would it be before every C.R.E. had a helicopter for reconnaissance purposes ?

Finally, Mr. Lloyd said he hoped that General Tuck would use his influence to ensure that on mobilization for a future war a suitable site is chosen for the R.E.O.C.T.U. He recalled that in 1939 when training started at Shorncliffe, there had been no bridging gap and one had had to be dug in the cliff-side ; there had been no suitable demolition ground and no field works ground, except a share in one occupied by a number of other units. Eventually enemy activity had made it necessary to move. Mr. Lloyd hoped that the next time a site was chosen it would be such that engineer training could be accomplished with less difficulty.

Mr. H. R. Lupton warmly welcomed the *rapprochement* between the military and civil engineer, of which this provocative Paper was an outward and visible sign. It had not always been like that. He well remembered as a junior Territorial infantry officer fixing up a mirror signalling system between battalion headquarters and the front line. It was invisible to the enemy and would have saved a great deal of trouble in mending wires broken by shell fire if the discovery had not immediately been made that he had one more heliograph mirror than was the proper ration of the battalion ; although it was not wanted for any other purpose the system had been dismantled and the extra mirror returned to stores !

The situation was now very different and the fighting cock of war was effectively mated with the productive barn-door hen of civilian industry. " Productive " was the operative word—it was not the brain and the initiative of the hen to which he was referring. But in fairness to the barn-door hen it should be remembered that before she had been domesticated she had had to forage about for herself and for her chicks and to protect them against her enemies ; but now she was hopper-fed. Could a moral be drawn from that ? Engineers a century ago were certainly not hopper-fed. They relied upon their own efforts and initiative for the knowledge they gained. Now there was, and must be, community-run research, and the works undertaken were of such magnitude that facilities for carrying them out had to be provided by the community. That did tend, perhaps, slightly to lessen initiative and willingness to take risks, and that, said Mr. Lupton, must be watched.

The Author had claimed that the Royal Engineers would pioneer any new idea. The fighting cock was prepared to deal with any hen without troubling himself to decide beforehand exactly what colour the chicks would be ! What an advantage for civilian engineers, to have the spur of the collaboration of an organization having so progressive an outlook !

As an illustration, Mr. Lupton remarked upon the rate of development of new ideas during a war as compared with their progress in peace-time. That was surely attributable to the collaboration then enjoyed with people whose chicks could not be of a predetermined colour, but who had to have interests and training wide enough to cope with their pioneer policy.

Colonel T. I. Lloyd referred to the Army's minor excavations termed " Field Defences " or, more fully, " Field Atomic Defences." They presented of course no abstruse engineering problem, but there would be so many of them throughout a theatre of war, during both offensive and defensive phases, that their aggregate volume entitled them to some professional consideration.

The Engineer-in-Chief had emphasized the importance of excavating field defences quickly, but there remained the problem of preventing their collapse. The weather and enemy artillery fire had always been catered for, but now atomic bursts had to be faced as well. It seemed that within certain ranges of an atomic burst the very field works which protected a man from conventional weapons, and from the heat and nuclear radiation of an atomic burst, would be likely to cause his death by collapsing upon him under blast or earth shock. Accordingly stronger field works were needed. Approximately, all excavations, even those in firm soil, ought to be revetted or shored as if they were in running sand. Against the air burst it was expected that it would be necessary to set the limited aim of countering an instantaneous pressure of $1\frac{1}{2}$ ton per sq. in. Against the ground burst, trenches and shelters had virtually to be earthquake proof.

Unfortunately, there was still great dependence on the 1918 methods of trench revetment and shelter construction, which required excessive time, skill and weight of stores for present-day conditions. There was, therefore, very considerable scope for the profession to solve that elementary but very extensive military problem by means of new techniques, which should be characterized by speed, simplicity, and use of minimum weight of stores.

The Author had referred to the resemblance between military engineering and the temporary work, using expendable stores, which occurred in the preliminary stages of a large civil engineering project, and Colonel Lloyd thought that that resemblance was nowhere stronger than in connexion with the branch of military engineering termed "field defences," but which should be thought of more as "field atomic defences."

Mr. E. H. Lewis-Dale suggested to the Author one additional factor in his distinction between the civil engineer's peace-time task and the military engineer's war-time task. It was the factor of cost. The civil engineer in peace-time did not necessarily make the cheapest job but his works had to be economically possible ; the military engineer in war-time had an almost free hand in terms of money, although he had to consider the cost in manpower (particularly in skilled manpower), scarce materials, and valuable plant. For example, a possible method of constructing airfields in time of war might be apt. It was known that research had been carried out into the use of metallic acrylates for soil stabilization, but as yet it would appear to be quite impossible in peace-time on account of cost. Research and development in the chemical industry might change that situation. In war-time it could probably be said that if those materials were not required for other purposes they could be used to build airfields.

In connexion with airstrips for modern and future aircraft, the present forecast must anticipate a strong surface extending over long distances. He suggested that when high-speed fighter aircraft were being considered it was also necessary to consider the question of very smooth surfaces. Bulldozers and graders were very versatile machines, but the actual surface of the strip itself had to be very smooth or else high-speed aircraft would run into severe trouble.

Mr. Lewis-Dale had amused himself a short time ago by making what he thought to be an ingenious schedule of the things he would look for in a prefabricated pavement for airfields. The result was a very long list, but it seemed that most of the items should be considered by any one designing prefabricated pavement for use in war-time. The list was as follows :—

(1) A smooth surface.
(2) Suitability for use on difficult sites (clay, bad sand, etc.).
(3) Ease of transport of prefabricated units—compactness in terms of shipping space and lightness in terms of air transport.
(4) Ease of handling at site.
(5) Speed of assembly and laying.
(6) Economy in manpower.
(7) Strength.
(8) Minimum site preparation before laying.
(9) Minimum of ancillary stores. (For instance, prefabricated bituminous surfacing, known as P.B.S., required drums of bitumen, which were difficult and unpleasant to handle.)
(10) Cost and relative availability of material.
(11) Ease of maintenance when laid.
(12) Suitability for taking up and re-using.

Checking the characteristics of the various prefabricated tracks used during the 1939–45 war against the list, Mr. Lewis-Dale had found that P.B.S. and Square Mesh Track could be labelled "fair"; Sommerfeld track was bad; bar-and-rod was indifferent; and Pierced Steel Plank (P.S.P.) was very good. Channel Track had not been used sufficiently in the war for it to be judged.

Mr. H. J. B. Harding observed that the situation in a future war would appear to depend on whether atom bombs were dropped or whether the warring nations would refrain from their use in the same way that gas was not used in the 1939–45 war. If atom bombs were dropped then it would seem that most of the Paper became academic. It was difficult to think of troops building little shelters against atomic missiles. The civilian population was a much more profitable target for atom bombs, and that would raise a considerable problem of devastation, the overcoming of which would absorb a great deal of manpower.

What was most noticeable in a war was the greatness of the human spirit and the comparative smallness of the human mind, especially when wrapped in officialdom. When faced with a crisis ordinary human beings rose to the occasion and were demoralized when nothing happened. The apparent inactivity of the autumn and winter of 1939–40 might have been a respite for the Allies, but it did the enemy a great deal of good by simply leaving Britain alone and doing nothing, although Germany had the power. It was comparable with the position which obtained at the present time.

If the horrors of another war had to be faced, then some Members of the Institution would be Royal Engineers and others would have to work in the civilian field. There were organizations which had plant and executive labour at their disposal. There were other organizations which had highly technical men who planned. The organizations which executed the work were those which had sources of direct labour and were members of various bodies such as that represented by the Federation of Civil Engineering Contractors. The planning element was represented by the consulting engineers and Ministry departments.

In the 1939–45 war the Federation did a considerable amount of work in conjunction with the Director of Fortifications and Works, and various firms formed companies or sent men to the Royal Engineers. At the same time they were responsible for civic duties. In Mr. Harding's own firm the members had been asked by various bodies whether they would look after this or that, and he personally had had five conflicting responsibilities, of which, fortunately, only two had materialized.

It was necessary to think ahead and consider the two possibilities—atom bomb or no atom bomb. Mr. Harding had spent a long time during the 1939–45 war in the East End of London repairing bomb damage, and during the first two years of ordinary raids he was repairing deep sewers, involving the excavation of tunnels, mains, and other services up to 30 or 40 ft. deep. Every major incident took five months to repair, but they were all repaired in a permanent way. In those conditions permanent repair was wise, because they had not had to be disturbed since.

The effect of atom bombs was difficult to envisage. The picture would be frightening and very different. It was likely to be a question of abandoning areas rather than attempting to do anything about them at the time. That was an aspect on which there should be some information. If it were likely to happen, what was it necessary to provide ? How was it going to be possible to get men to stay at war ? It would be a great strain on the discipline of everyone.

In war it had always been necessary to try and keep the whole function of the city going by shopkeepers maintaining distribution, men being paid wages, and even in the worst times endeavouring to keep everything going on the same standards. Even now there was a Committee sitting trying to agree on terms of universal contract for the repair of war damage in the next war.

Lieutenant-Colonel J. B. Brown said he was speaking from two viewpoints—as a regular Royal Engineer officer and as a Member of the Institution.

The Author had stated in his introductory remarks that the regular officer of the Corps suffered from the fact that he tended to get snowed under with paperwork as he grew older and consequently became more and more an administrator and less and less an engineer. The Commandant of the School of Military Engineering had also described what was being done to teach the young Royal Engineer officer his job as a professional engineer. What was being done at present, with variations and with rather more intensity, was that which had been done by Lieutenant-Colonel Brown and people of his seniority when they were young officers.

When reading one of the journals of the British Section of the International Society of Soil Engineers, he had been struck by one Paper which referred to the work done by regular Royal Engineer officers in the field of soil mechanics in the middle of the nineteenth century. Some of the examples were very interesting, including one on retaining walls. It was interesting to note, apart from the technical aspect, that the Treasury allowed the officers to build experimental walls and knock them down again !

In that connexion, there was room for comparison between the Corps of Royal Engineers in the United Kingdom and the United States Corps of Engineers. The latter were much more fortunate in that they had a more expansive and less developed country in which to work, and had more opportunities of carrying out big engineering projects than the Royal Engineers ; the American senior officers were fortunate in that respect.

Engineering in present times was becoming more and more specialized. There were engineers who had specialized in roads and bridges, water-supply, and drainage, to name but a few. In civil life the civil engineer tended to specialize in one or possibly more of those subjects and had only a nodding acquaintance with some of the others. If Royal Engineer officers were allowed to specialize in one subject only, it would be found that in war the specialist in roads could only be sent to a place where there were roads to build, and he would not be of much use anywhere else. Therefore, it was probably dangerous to encourage engineer officers to specialize. A great deal of their job, he felt convinced, was in acquiring the actual experience needed to be able to judge the merits of the advice put over by the expert on his particular subject.

One of the points stressed in a book by Lewis and Maude* was that there were insufficient professional people with administrative experience or, to put it in another way, insufficient administrators with technical experience. Professional men tended to confine themselves to the professional aspect and to pay insufficient regard to the administrative aspect. He was not at all sure that was not part of the job of the engineer officer—to be able to administer a number of younger people who were experts in their own line. If the senior engineer officer was to do that, then he must be up to date and have a fairly reasonable acquaintance with all the more important lines of engineering which he was liable to have to handle in time of war.

* R. Lewis and A. Maude, "Professional People," Phœnix House, London, 1952.

That was the problem—to give the more senior engineer officers, possibly from the rank of major upwards, more general experience.

How could that be done ? Possibly senior officers in some theatres abroad, where there was a considerable amount of work in progress, might be able to visit more jobs being carried out by civil engineers. Another possibility was for the various Engineering Divisions of the Institution to invite some of the more senior engineer officers in their own areas to visit them when they were to hold their discussions.

Those were some of the lines along which it would be necessary to think if the two points of view from which he was speaking were to be co-ordinated.

Mr. A. A. Osborne believed that all ideas, no matter how apparently fantastic, should be investigated. It had happened during the 1939–45 war that suggestions which had at first appeared ridiculous had turned out to be feasible and were sometimes excellent solutions of unprecedented problems.

The Institution had a vast membership, and in his view that membership could be used in exploring the fund of apparently fantastic ideas. In a Royal Engineers publication called the *Royal Engineers Training Memorandum*, there had appeared in an issue some time ago a list of problems which it was desirable to solve, and officers were asked to submit their ideas. Mr. Osborne suggested that the Institution could co-operate with the Corps of Royal Engineers on similar lines. He appreciated that there was, of course, a question of security, but if the Corps of Royal Engineers could list for circulation to all members, some of those problems to which there did not appear to be any immediate solutions, there might be some members who would come forward with usable ideas. If the Institution adopted Mr. Osborne's suggestion, there might be a germ of an idea originated by a Member of the Institution, which with Institution's closer co-operation with the Royal Engineers, who had all the resources of the Government at their disposal, could result in a difficult problem being solved.

Mr. A. S. Quartermaine referred to the work that was carried out by the United States Army Corps of Engineers in peace-time on flood control, and similar work, and said that it was not done in Britain in peace-time except in an emergency. When the flood disaster occurred in January and February of 1953, not only the Royal Engineers but all the Services were very busy helping in the emergency. It would be of interest to learn whether the Author felt that there was a case for the use in the United Kingdom of Royal Engineers on civil work of a suitable character. By that he meant such work as the further improvement of sea defences, which would be desirable if it could be done without quite the same expense as would be incurred if all the work were done by civilian labour.

The benefit would be that the Corps of Royal Engineers would get experience in that class of work.

***Mr. A. C. Paterson** observed that the active defence forces maintained in peace, to which the Author had referred, would be called upon, together with such Reserve and Territorial Forces as would be mobilized with sufficient speed, to bear the brunt of the aggressor's attack and their lack of numbers could be compensated only by superior technique and superior equipment. In addition, however, there would have to be made available to the field engineers the maximum possible amount of controlled power. That power would take the form either of high explosives for demolitions or of civil engineering and other specially developed plant. Since too much plant would affect mobility, a balance would have to be struck and advantage taken of all possible power sources. There had been, in the 1939–45 war, a limited number of vehicles with power-driven winches and they had proved themselves invaluable. Mr. Paterson suggested that all vehicles in a Field Army should be fitted as a matter of course not only with such a winch but also with a power take-off which could be used either directly to drive such plant as concrete-mixers, pumps, circular saws, etc., or to drive a compressor which would, in turn, provide power for pneumatic tools.

The Author had stated that the Services had far too many small power plants and had suggested that it might be possible to deliver electric power by grid to forward areas. The difficulties of establishing and maintaining such a grid supply would indeed be formidable. To be of value it would have to offer a reliable supply with the minimum number of outages. To avoid risk of damage to the generators and transformers, a degree of electrical protection would be required little less stringent than in civil practice. The effect of a single shell or bomb might be widespread and the time required for repair considerable. The small power plants offered the advantages of dispersal and enabled units to operate anywhere irrespective of whether a grid supply was available. It might well be, however, that within the unit there were too many small power plants which could be replaced by one or two larger units, their size being limited by considerations of mobility. In such cases the development of the gas turbine might be of assistance. At the Engineering and Shipbuilding Exhibition at Olympia in 1953 the electricity-supply was provided by a gas-turbine set, simply placed upon a reinforced concrete floor-slab, below which was a basement, and it had not been bolted down in any way. It had had a working rating of 750–900 kilowatts with a maximum output of 1,000 kilowatts and could take full load within 30 seconds of starting. These sets could be supplied

* This contribution was submitted in writing upon the closure of the oral discussion.—SEC. I.C.E.

to larger workshops and supply depots where the demand would justify their use and they could also be used for the small mobile power stations mentioned by the Author. The advantages of being able to dispense with the heavy foundations and elaborate cooling arrangements required for compression ignition engines of comparable power were obvious, particularly under active service conditions. As had been announced in the Technical Press, such sets were now in series production and a number had been ordered by the Air Ministry.

The Author, in reply, referred first to the question of how much experience Royal Engineer officers received in their profession. To begin with there was more construction going on than was perhaps realized outside the D.F.W.s. office. For instance, there was a new township being built in Germany for the new headquarters ; it was a complete town with all services and it was built on what had been virgin forest. That was one example of new work in permanent construction. The Army moved about the world so much in the cold war that there was a good deal of new construction going on overseas on roads and on semi-permanent buildings. The trouble was that it was difficult to obtain permission for permanent buildings when the treaty terms with the country concerned were not very permanent.

The second point was in connexion with how prospective war-time chief engineers were trained in peace. Thanks to the co-operation of Members of the Institution, an annual course had been started in which one senior officer, who had already reached the rank of lieutenant-colonel would spend a year with a firm of civil engineers to visit big projects all over the world, and to learn how a project was tackled right from the start in the office of the firm to execution on the site. If one officer a year were trained like that, there would always be in the Corps eight or nine senior officers who should be capable by selection and by training of taking on the kind of £250-million job that Generals Hughes and Tickell had taken on in constructing the Egypt Base in 1940–42.

It was fervently to be hoped that an Engineer-in-Chief should never have to do what the Chief of the United States Corps of Engineers had to do, namely, to give evidence to Congress Committees and to wheedle money from the Government. The Author's impression was that although the American Army's waterways responsibilities were based on old traditions and gave invaluable engineering experience to their officers, they also involved the U.S. Engineers in seeking political support—Municipal, State, and Federal—for their projects. If the Royal Engineers became tangled up in politics, in spending public money, and in competition with private interests, the Army's constitutional integrity and status would be compromised. However, there was one job that he would dearly love to take on with the Corps, that was the development of the road system in Great Britain.

Reference had been made to the use of helicopters. They were remarkable vehicles and the Author had flown some distance in them. They were invaluable for engineer reconnaissance and much time was saved by their use. The technique of soil reconnaissance from the air by photography was being developed and for both inspection and photography the helicopter was ideal. It was also well suited to reconnaissance after an atomic explosion. So there were many advantages in the helicopter, except from the point of view of cost and maintenance. Helicopters were very expensive and it was possible to buy many light aircraft for the outlay on one helicopter. Unless they were made much more cheaply they would not become as universal as could be wished. The American Army had them in considerable numbers, but for every helicopter in the air there were about four on the ground being maintained. The Army would get some helicopters, but there did not appear to be much chance of having them in large numbers in the near future.

The suggestion concerning airfields was gratefully received, and he desired to mention again the point made by Colonel Brown, namely, that Royal Engineer officers could not afford, much as they would like to, to specialize too much. However, they did specialize a little. They specialized in survey, transportation, and construction, but if there were more specialization the Corps would lack flexibility. In war it was seldom possible to have the right man at the right place. The Royal Engineer must have a broad engineering education, and it was the Corps' tradition to be able to tackle any job anywhere.

Mr. Wynne Edwards had suggested that one of the most valuable ways in which Civil Engineers could collaborate with the Royal Engineers in peace-time was by assisting them to keep up to date in the latest types of plant and in modern techniques. Although the civil engineer was not paid to think about military matters, the possibility of a major war in which he would certainly be personally involved was not a matter to be ignored. The Author hoped that the initiative of the Institution, and the attention drawn by this Paper to various aspects of engineering in war-time, would encourage civil engineers to pass on their information and experience to the Royal Engineers. Mr. Lloyd had recommended some officially recognized channel or machinery for liaison of that nature. The Author hoped that the recently formed Engineer Advisory Board would provide a solution to that problem.

The Author appreciated that the Sapper officer spent some years at the age of about 25 to 30 in field engineering and soldiering rather than in gaining engineering experience on large projects. Many officers were now involved in track making through forest in Mount Kenya and the Aberdares, and in Malaya. They were also making field defences, dirt roads, equipment bridges, and jeep tracks in Korea. He doubted if much more could be done in the way of long courses, simply because the Army had a " cold-war " job to do and could not spare more officers for courses of technical training. However, the existing arrangements for executive appointments in construction, transportation, resources, and survey as lieutenant-colonels and majors, taken in conjunction with civil attachments and with the young officers' academic training, should give the majority of Sapper officers an opportunity of reaching a fair standard of technical efficiency. The main difference between the Sapper and the civil engineer was that the latter specialized and that difference was unavoidable.

Finally, the Author was not altogether prepared to accept the notion put forward by Mr. Harding that, because of atom bombs, the Paper became academic. Civil Defence in the United Kingdom was not discussed in the Paper, though the Royal Engineers in the United Kingdom would take their share with the civil engineers in dealing with such a disaster. There were two problems, first to defend the country against atomic attack and the second to survive the atom bombs which reached their target.

The solution to the first depended on military operations and on engineer tasks overseas. Indeed it could not be assumed that attacks on civil populations would necessarily take the place of sea, land, and air battles. The best way to win a war might still be to destroy the enemy's armed forces. Also, because of the range of modern weapons, the geographical limitation of invasion by an aggressor might be vital to the survival of Britain.

Nevertheless the problems of home defence mentioned by Mr. Harding were of immense importance to engineers.

The Author wished to assure Mr. Paterson that power take-off was specified for a wide range of vehicles and to thank him for mentioning the military application of the gas turbine, which was being studied by one of the panels of the Engineer Advisory Board.

In conclusion, the Author wished to take the opportunity of thanking the members of the Engineer Advisory Board for the valuable service they were so generously giving to the Army.

SPEED AND SURPRISE IN AN ATOMIC WAR

By MAJOR M. L. CROSTHWAIT, M.B.E., R.E.

INTRODUCTION

THIS article is concerned with the need for a specialist Engineer unit in an Atomic War. The trend since the end of the last war has been to avoid specialist units. It has been rightly said that engineers will be so short, that we cannot afford to tie up units in specialist rôles. Despite these facts—and they apply to both field and L. of C. units—the following paragraphs attempt to show that with the advent of atomic warfare at least one (there may be others) specialist engineer unit may be required.

ATOMIC WARFARE

It is unwise to hope that atomic weapons will not be used in a future war. The basis of all United States defence plans, according to published reports, is that they will be used. Field-Marshal Montgomery has given his personal opinion that in the event of war, both sides will use their atomic capability. Every major Army in the world must be re-examining its organization and doctrine to see what changes an atomic age makes necessary.

What about our own Corps ? Does it appear that any major changes are indicated (in the light of the facts at present publicly known) to meet the demands of atomic warfare ? Before considering this problem further, a brief discussion on what these demands are likely to be, is necessary.

ATOMIC WEAPONS

The background knowledge of atomic weapons that has been made available to the general public to date, is limited. Without more knowledge it is difficult to assess the extent of the damaged area in any future atomic strike. Many service audiences must by now be familiar with the stock in trade of the average " atomic lecturer "—a map of London showing the effect of detonating a nominal 20kt. bomb over Piccadilly. But the 20kt. bomb from all accounts is a thing of the past, and it seems more likely that bombs or missiles of the order of 80 or 100kt. must now be taken into consideration. The hydrogen bomb—the equivalent of millions of tons of T.N.T. to quote President Eisenhower—is in a further class still. Concentric circles, based on damage caused by a 20kt. bomb over Piccadilly may not mean very much.

Tactically the effect of atomic artillery will also be of prime importance. This again is a closely guarded secret. It has been publicly stated that "for the same amount of fissionable material the shell is about one-tenth as efficient as a bomb." Without further information this does not mean much, but even an explosion giving one-tenth of the effect (say) of the relatively primitive bombs dropped over Japan in 1945, will still be an awe inspiring occurrence.

However little may be known of the exact nature of all these effects, one basic lesson can certainly be drawn. Every effort must be made to avoid providing an enemy with a target he could consider worth while bombing. Any time or effort expended for this purpose will be amply repaid.

Atomic Effects

To consider, very briefly, the three main effects of an atomic explosion (air burst only).

(*a*) *Blast.* Very great material damage must be expected. Damage to human life, even by direct exposure to blast, is not as great as might be expected, and casualties will be caused mostly by secondary effects—being trapped in buildings etc. In the field, slit trenches of normal design should generally give reasonable protection, except in the immediate vicinity of the explosion.

(*b*) *Heat.* The heat given out at the instant of explosion is very great indeed, and heat will be the major cause of casualties to personnel caught in the open. Assuming an air burst at optimum height, third degree burns can be expected within a mile radius of ground zero for a 20kt. bomb, and within some one and a half miles for an 80kt. bomb. These distances can be increased by about 50 per cent for second degree burns. The figures assume a visibility of about four miles. If the visibility is greater, the damage area will be materially increased, as fog or haze, anything which restricts visibility, has a considerable effect on heat penetration. Indeed any physical screening—a slit trench, a lightly constructed wall, even, in certain instances clothing can all give reasonable immunity.

Apart from the casualty hazard, the fire hazard in the field must not be forgotten. Fires in dry underbrush or woods can occur 7–10,000 ft. from ground zero for a 20kt. bomb. This risk might cause serious embarrassment, to say the least, to units concealed in such areas, and counter-attack routes which might be blocked by flame or smoke just when they are needed—after an enemy atomic strike—would not be very effective.

(*c*) *Nuclear Radiation.* Although the danger areas are not quite so great compared with thermal effects, protection from nuclear radiation is far more difficult to achieve. From a 20kt. air burst, of those caught in the open, 100 per cent eventually fatal casualties can be expected within 3,500 ft. or so of ground zero. Nuclear effects on the human body take some time to develop and the dose is not instantaneously delivered. It takes over a minute to receive a full dose, although about 50 per cent of the damage is done in the first second.

Protection can be achieved by sheltering behind the appropriate thickness of material. For instance 50 per cent protection can be obtained from 1 in. of steel, 3 in. of concrete or 5 in. of earth. Ideally slit trenches should be sufficiently deep so that a line drawn from the body to the explosion passes through about four feet of earth.

What does all this add up to ? In the combat zone, if properly designed slit trenches are conscientiously dug (no doubt they will be !) and defensive positions are given suitable overhead cover, reasonable protection can be achieved except in the vicinity of the explosion, say to within half a mile of ground zero. But soldiers cannot be in trenches all the time ; equipment must of necessity be exposed ; the fire hazard is always present ; the possibility of nuclear effects, being intangible in themselves, may have a bad effect on morale. The lesson again seems clear. Avoid offering the enemy an atomic target and take every step possible, if a good target is offered, to see that the target is there for the very minimum time before its components are once again dispersed.

Engineer Tasks

The time honoured rôle of the Engineers is to enable the Army to live, to move and to fight. To examine each of these in turn in the light of the foregoing.

(*a*) *To live.* Dispersion, camouflage, protective construction in so far as that is possible and quick repair if an attack should come, will all be necessary if an army is to maintain itself logistically in a theatre of war. The extra load thrown on the Engineers will primarily mean extra units—or austerity scales if engineer units cannot be increased, as the available effort will have to go farther. Qualitative changes in organization seem unlikely to be required.

(*b*) *To move.* The opening up, keeping open and repair of communications again will be reflected in numbers rather than in specialists. Training, use of machines and the maximum exploitation of indigenous labour will all play an important part.

(*c*) *To fight.* Here the constant aim of the Commander in the Combat Zones must be so to disperse his formations and units that a good target is not offered. In defence this will be easier than in the attack. In the attack the ability to avoid becoming a target will depend on speed—quick concentration, quick movement to the objective and quick dispersion. Also the enemy must find it difficult to discover where concentrations are taking place, and the target must already have dispersed before he can make an atomic strike.

It is the ability of the Field Engineers to enable a Commander to make use of speed and surprise in the attack that requires special examination.

Speed

What should be the reply of a C.R.E. who is asked by his Commander if the Engineers can, or in the near future will be able to, put his division across a major water obstacle in a very much quicker time than in the past ? The C.R.E., whether he is thinking of his own regiment or of the back-up which will be forthcoming from Corps Troops, might find it difficult to give the Divisional Commander the answer he wants. It must be remembered, too, that the Divisional Commander will be primarily interested in organizing an anti-tank defence in a very short time on the far side of the obstacle —and that probably means heavy tanks and heavy rafting and bridging.

The C.R.E. could think of the standard of training that he knows can be found in both Divisional and Corps Engineers. But even a good average training standard may not necessarily mean a particularly high standard in rafting or bridging. In war, especially, too much can depend on the type of work that units have been doing up to that period of the battle. He could think of the advances in equipment design—not in themselves a guarantee of quicker work on a dark rainy night, over indifferent approach routes. He could think of the relatively few items of plant available in field units, and hence the lack of experience in using it. He could assess the possibility of obtaining more plant (making mental reservations about the provision of operators and their " bridging " training). He could hope, if there had recently been casualties, that the experience in units as a whole would compensate for any lack of skill in newly arrived officers and men.

If the major crossing involved minor approach crossings he could perhaps count on Assault Engineers to help out with their more varied techniques. To enable the division to cross where the approaches were bad—to obtain surprise—he could hope again for the loan of plant, track material and labour from Corps.

But in the end he might well have to admit that he could not promise any startling improvement in times or performance. If conventional weapons only were involved, he could very reasonably assure his Commander that with the immensely improved equipment likely to be available and the traditional competence of the Engineers, there need be little worry on the score of timing. But atomic weapons call for a fresh assessment as to what is a satisfactory time and what is not. The Divisional Commander might well view the answer his C.R.E. is likely to give him with concern.

The problem can be crystallized as follows. If it is acknowledged that speed and surprise in attack will be of the utmost importance in the face of an atomic threat—so important that they may spell success or disaster to an operation, is everything possible being done to enable the Engineers to play their part in achieving these two goals.

Specialization

Which unit is likely to produce the quickest and most efficient work. A unit trained and equipped for the task in question, or a unit which is given general all-round training, and which contains only a proportion of the equipment required for the task and must rely on obtaining more, as best it can, from some pool or other ?

In the future, as in the past, there will never be enough plant, cranes, dozers, fork lifts, etc., to equip all field units with the plant they will want for a major obstacle crossing operation—let alone to provide for reserves in case of casualties. Although pools of plant may be available, there will seldom, if ever, be an opportunity to train the plant-field engineer team (including the reserves) so as to exploit fully the potential of such a team. This potential can only be fully exploited if in fact the team is permanently together and is fully practised and fully equipped for the task in question. This fact has of course always been known, but it has neither been a military necessity nor an economical proposition to make use of it in the past. In a future war, military necessity, as reflected in the demands of Field Commanders for speed and yet more speed, may force a degree of specialization on us. Specialization may be a small price to pay to lessen the chance of annihilation.

The Type of Unit Required

The characteristics of the unit required would be briefly as follows:—

(*a*) Its rôles would be :—

(i) To carry out all types of bridging and rafting—particularly for heavy loads.

(ii) To have a great capability in route opening and cross country track construction.

(*b*) It would contain plant of each and every description required for the performance of its rôles. This plant would be held on a luxurious scale.

(*c*) It would contain the proper balance of field engineer labour, so that under average conditions it could operate without outside help. If extra manual help was required, it would be obtained from the Engineers being supported.

(*d*) It would have a considerable all-round engineer capability as by-products from its main rôles—especially in protective construction and in assistance in organizing a defensive position.

Primarily the unit would be included under G.H.Q. Troops. It would be handled similarly to Assault Regiments, with whom it might well be grouped, the two together forming parts of a larger and more comprehensive team. It would be so practised by night and day and in all weathers, that every opportunity afforded by organization, training and mechanical handling is exploited to obtain speed and reliability in performing its two primary rôles.

Conclusion

The main purpose of this article has been to see whether the principle of specialization has any application to a future atomic war, or whether the extra load on the Engineers is likely to call for Engineer units with an all-round capability. It has been suggested that although atomic warfare will certainly call for an increase in engineer output, which will have quantitative rather than qualitative effects on the Corps organization, there is a case for a specialist unit in the Combat Zones. Without such a specialist unit, the necessary speed required in an attack across a major obstacle may not be achieved.

RIVER BATTLES, 1939–45

By Colonel T. I. Lloyd, D.S.O., M.C.

(A lecture delivered at the School of Military Engineering)

On studying the river battles of World War II, one can hardly fail to be impressed by the proficiency which the British Forces attained in the tactics and technics of assault river crossings. There was developed what might be called a varied routine, which finally worked with such precision that rising generations of officers will perhaps be misled into imagining that river crossings can be undertaken lightly. They should recall that, as Lord Vansittart has said, a process can be simple without being easy : to get a college lawn, you only have to roll it—for ages. Prolonged experience and training at all levels went into that successful routine. It has been preserved in training manuals, which show again and again how very much an assault river crossing is a matter of attention to detail. If for a while we relegate all details to the background, it is only in order that we may go on from where the manuals leave off and look at the whole subject more broadly.

So our aim for the moment is to review the place of river crossings in the wide panorama of war, more particularly in the British operations of the later stages of the last war. It cheers one up sometimes to look back. Let us reflect that in addition to defeating the Italians, the Germans and the Japanese, we also defeated such world-famous, mighty rivers as the Seine, the Rhine, the Elbe, the Po and the Irrawaddy. In Italy we advanced the full length of the country, against the grain, which meant that every single river was deployed against us. In north-west Europe we were on the seaward flank of the advance, and so met all the rivers at their widest, often incredibly swollen by the flood waters of the vast spaces and high Alps of inner Europe. Were not these river crossings unique and historic feats of soldiering and engineering?

Well, no, they weren't. It was merely history repeating itself. Rivers never have been any handicap to the side with the upper hand in war, and really it is rather amazing that after all these centuries of disproof we still talk and think of them as obstacles. By and large, when prehistoric man invented the boat, rivers ceased to be an obstacle ; one can argue that intrinsically they became just the opposite.

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In taking a closer look at our assault crossings, let us consider first their outstanding characteristic, which was their success. It was, moreover, success at the first attempt. The truth of this can best be assessed by looking at the exceptions : the failures—the disasters in which our assaulting troops either failed to reach the far bank, or, having reached it, were liquidated.

You will note that this definition of a disaster does not include instances where we crossed, and then later evacuated our bridgeheads in good order. Which is fair enough, for wherever troops were ferried out of a bridgehead, reinforcements could equally well have been ferried in. It was change of plan rather than failure, and for all we know the commander always intended that particular crossing as a feint.

There seem to have been six disasters—if you decide to call them so. They were, in brief :—

No. 1—Out of the five divisions which took part in the forcing of the Volturno, one failed. This was 56th Division. They had a very difficult stretch of river in front of them, and the Germans were firmly dug into the far bank along the few reaches suitable for assault boats. Accordingly the division didn't stake much on the attempt—only one brigade, and of that brigade only one battalion. It is a measure of their complete ill-success that by " H " plus only two hours Corps Headquarters had intervened and called the attempt off.

No. 2 was at 15th Division's crossing of the Seine. The 2nd Gordons launched their assault wave in broad daylight in five assault boats manned by Royal Engineers. When they were well afloat they were raked in enfilade by some well-concealed light automatics dug into the far bank a little way upstream. Only one boat completed the crossing and the few survivors in it were taken prisoner. Casualties were about a hundred.

No. 3 also was a 15th Division affair, on the Meuse-Escaut canal. Their 44th Infantry Brigade staged two separate crossings simultaneously by night. One was entrusted to the 6th Battalion King's Own Scottish Borderers. Reconnaissance had led them to believe the Germans were not present, and the assault seems to have been on a one-section front. The Germans held their fire only until the leading section was across. The remainder of the battalion were pinned to the ground still on the home side. Then the canal overflowed. The attack was never resumed and none of that leading section got back.

No. 4 was at Arnhem Bridge. They got there by air, and there were no friendly troops on the home bank, but 2nd Parachute Battalion's position at the north end of the bridge was in effect a bridgehead that met disaster.

No. 5 was in Italy. The 4th British Division reached the River Ronco late one October afternoon, and their 10th Infantry Brigade were ordered to cross that very night. Two battalions each put two companies across at widely separated places, and these companies advanced well inland, making for certain very deep objectives they had been given. But it was raining hard, and the river began to flood, so that ferrying soon ceased to be possible with the few sappers and little equipment that had been brought up. The Germans were lying back in fair strength, and when day came their artillery fire ended all hope of our regaining touch with the far bank. The four companies were mopped up, the Germans claiming 280 prisoners.

No. 6 was an incident in 7th Indian Division's otherwise successful crossing of the Irrawaddy. A battalion that should have reached the far bank during the night was late in starting, and was still at sea when day broke. It came under fire from the far bank, and put about.

Those are the only outright failures that have been unearthed : the disasters. To discover them scores of contested crossings had to be analysed and filtered, even down to section level. If ever exceptions prove a rule these must. Success was indeed the outstanding characteristic of our river crossings.

* * * * *

Now let us start searching for some explanation of our almost infallible success in river crossing attacks. Here are four ideas, founded on facts :—

Firstly, as a commander you never attack at all unless you fancy your chances. And when you have to put your troops into the attack across a river, you are somehow even less inclined to gamble.

Secondly, the presence of a river seems to induce the commander to plan and organize his attack extra carefully. And he pays more heed to his engineer adviser than perhaps he does ordinarily.

Thirdly, often a river crossing attack can be foretold and foreseen weeks or months ahead, so that planning, preparation and even rehearsal can be done at leisure.

Fourthly, when an advancing force reaches a river it can safely pause to mount its attack. The enemy is unlikely to riposte across a river. Moreover the attackers have the advantage of knowing how long the pause will be, whereas the defenders have to treat every day as " D minus one," almost every hour as " H minus one."

You will doubtless weigh these four ideas against your own experience or studies, and will perhaps decide that they throw light on why river crossing attacks have scored a higher percentage of success than plain attacks. But they relate only to the preliminaries, and no one maintains that planning is more than half the battle. So let us now consider the battle itself, starting with the " break in," which is the initial waterborne assault.

* * * * *

To be at the very sharpest end of things, advancing in a flimsy craft on an unfamiliar element, exposed nakedly to the fire of the enemy, must be a testing situation for even the bravest soldiery. But let us see exactly how dangerous it was in the last war. How often did the assault wave suffer casualties while waterborne ?

Two instances have already been quoted : 2nd Gordons on the Seine, and that battalion of the 7th Indian Division on the Irrawaddy. Research has produced three more instances :—

One was at 43rd Division's crossing of the Seine. Two storm boats of the 5th Battalion Wiltshire Regiment ran aground on a shoal in mid-stream. It was a daylight attack with smoke. The smoke lifted and a German post some distance upstream dealt with the storm boats at leisure.

The second was at the taking of Nijmegen Bridge over the lower Rhine where it is named the Waal. To come at the bridge from the rear, while Guards Armoured Division rushed it frontally, 504 Regimental Combat Team of 82nd U.S. Airborne Division crossed the river about a mile downstream of the bridge, in thirty borrowed British assault boats—craft they had never seen before. It was daylight, and Guards' tanks lined the home bank to give covering fire. The boats came under small arms fire when about halfway across the quarter-mile river. An eye witness reported " when a boat was hit, the survivors unhesitatingly struck out for the far bank." The whole operation was a most gallant and successful one, but the river crossing was not inexpensive.

The third was part of the Arnhem battle. 4th Dorsets' somewhat sacrificial crossing of the Nederijn, to the west of 1st Airborne Division, seems to have involved casualities at all stages of the operation.

That makes a total of only five occasions when the first flight was shot up, and even though other instances may come to light, we have once more exceptions proving the existence of a rule, which is that one of the safest places in battle is in the assault wave while it is on the water. We'll now search for an explanation of that.

* * * * *

To examine this immunity of the first flight it is necessary to turn and consider the defence. Behind a river the near bank is the extreme forward limit permissible for the siting of the foremost posts of the foremost defended localities. But, time and again, particularly where the river meanders away from the defenders, the commander of a foremost defended locality finds it disadvantageous to place even a single post so far forward as the river bank. The outcome is that except for the odd section post on the bank, or two (seldom more, even on a divisional front), the foremost defenders lie back from the river. Whereupon, since a river always runs in a ditch, *the surface of the water becomes dead ground to them.* At the best they may get long range observation of it, but that is of no avail by night, and, in any event, long range fire is plunging fire, which is not the sort of fire that is required. The quoted examples show that it is only grazing fire by small arms from or about water level that has ever proved deadly to the assault.

Thus against defence in depth the assault waves are masked from the defenders' flat trajectory weapons ; these weapons are virtually " left out of battle " until the assault landing has matured, and the fact that it does normally mature is hardly surprising.

Let us summarize what really happens when the defender puts himself behind a river. He accepts the river as an obstacle to his own forward movement, he even sends his boats away, so that the river is in fact an obstacle to him. But the enemy comes up with boats, lots of boats, of one sort and another : the river is no obstacle to him. For the purposes of the battle at large—certainly the night battle—the river is thus no more than a curtain, and only the attackers have the means and the intention of rending it. The defender has voluntarily hung a veil in front of himself, and gained the feeling of security, but, as history has always shown, not the reality.

If we can agree that the opening phase of an assault river crossing is no more than bursting one's way through a curtain, much that has happened on river lines in military history becomes explicable.

* * * * *

Now for the next stage of the battle. The first troops are across, and more are slowly being ferried into the bridgehead, but it will be hours or even a day before there can be a bridge. Meanwhile the entire enemy mass can swoop down and eliminate the bridgehead—in theory. In practice it has never happened. Throughout the last war the Germans scarcely ever failed to employ the conventional recipe, and counter-attack our bridgeheads. But our bridgeheads were invincible. Let us look for exceptions to this rule. It is difficult to find any. The nearest approaches are :—

That little airborne bridgehead at the north end of Arnhem Bridge, and this, of course, had no rearward link to sustain it. Even so, the Germans took three-and-a-half days to eliminate it.

That section of the K.O.S.B. who were mopped up on the far bank of the Meuse-Escaut canal ; and, if you like, the one assault boat-load of wounded Gordons who reached the far bank of the Seine and were captured.

There was the Ronco. But on that occasion the assaulting infantry were given deep objectives and never really formed a bridgehead.

Possibly Mareth provides the best instance of a defeated bridgehead, but even there 50th Division withdrew back across the Wadi Zigzaou in reasonably good order. And it can be called a change in plan, for meanwhile the battle was being won elsewhere.

Indeed, exceptions are hard to find, and it is no overstatement that our bridgeheads were invincible.

We'll search once more, this time for an explanation of the invincibility of our bridgeheads. It is interesting to recall that beachheads also were invincible. Neither ourselves nor the Americans lost a single one. You may perhaps be satisfied with the explanation that one never attacks unless one fancies one's chances. But there were many grim beachhead and bridgehead battles, and often it was touch and go. The whole explanation can scarcely be that the chances were calculated to a nicety. Can we not hope to find some underlying reason why a bridgehead, when it is thrown on the defensive, proves too tough a nut to crack ?

* * * * *

First, however, we must not overlook a major lesson for the attacker. It is that this dogfight period, between the break-in and the break-out, when the bridgehead is liable to be counter-attacked, must be as brief as possible. You break-in through the curtain by *surprise* ; thereupon *speed* becomes the prime requirement, so that you pass on to the break-out and pursuit phase with the utmost rapidity, trying to give the enemy no pause in which to mount a major counter-attack. Unfortunately he gets some pause almost inevitably, because during this phase the engineers must build the bridges without which no breakout or pursuit can be sustained. The engineers have to keep on ferrying, too. And by this time the river is being mortared, and shelled, and attacked from the air. Thus the engineering slows things down, and your bridgeheads do get counter-attacked almost invariably. Note in passing how vital it is to have plenty of engineers, with plenty of high efficiency equipment, so that you do not have to rely too much on this invincibility of bridgeheads which we'll now look into.

Since one easy way of losing a battle is to run out of ammunition and supplies, the first aspect of the defence of a bridgehead we'll take will be the administrative one. You will realize that at this stage the bridgehead is no more than the infantry zone during a purely defensive phase of the battle. All the artillery supporting it, and many of the mortars and machine guns, are still on the home bank. Accordingly the daily tonnage to be taken across the river is slight. And so long as any ferrying at all is feasible the administrative needs of the bridgehead will surely be met. World War II confirmed that night ferrying cannot be stopped by the enemy, and our bridgeheads only very seldom had any anxiety over their supplies. Certainly none was starved out—except perhaps Arnhem. Having a ferry behind you, instead of a road, has been shown to be no serious administrative handicap when it is a matter of hanging on to a bridgehead.

Next consider the tactical setting : picture the bridgehead, a semicircle based on the river. The river prevents it from being outflanked, surrounded, or cut off ; so no variation of tactics whatsoever is left open to the enemy counter-attack force. They can only bludgeon it with frontal attacks. And since they cannot venture very near the river, in view from the other bank, their front of attack is limited to the apex of the bridgehead, too narrow for the deployment of large forces. It becomes a siege, in which defence shows once more as the stronger form of war.

Finally, and perhaps most important of all, there is the morale factor. There are many aspects of it, but perhaps we need merely reflect that a battalion or brigade which has the honour of leading its division, or even corps, or army in a river crossing, is in no mood to throw its hand in. Taking all in all, would it not be surprising if bridgeheads and beachheads were *not* invincible ?

* * * * *

To recapitulate ; rivers were in 1939–45 as little handicap to the side with the upper hand as they always have been down the centuries. Indeed, river crossing attacks have had a better record of success than plain attacks, showing that a river between opposing forces may strengthen the attack and weaken the defence. How does this come about ? As regards the preliminaries and the actual assault, it is explained at once by the thesis that, with conventional defence-in-depth, the river is *not* an obstacle, only a curtain. The attacker is able to mount his attack carefully and secretly, and he can hardly fail to achieve surprise when he finally rends the curtain and bursts through it.

At the next stage, with bridgeheads established, the attacker is poised in what is possibly the strongest tactical posture devisable on the field of battle. That is : with his spearhead just across the river ; its supporting arms in action, deployed in complete security on the home side, where also lie the reserve formations and all the soft tail.

The next thing to happen is that bridge building is completed, whereupon the river immediately loses its significance. The bridges might equally well be solid road so far as the ensuing operations are concerned. We have, therefore, exhausted the subject of crossing rivers. Let us now join the other camp.

* * * * *

The question arises can we, being now the defenders, devise some form of river defence that does not play into the hands of the attackers. Let us assume, not without justification, that the lesson from all this experience is that the ground vital to the defence is the water's edge at the near bank of the river. And let us consider for a moment an instance where we held this ground and the wet gap did stop the enemy : namely, the English Channel in 1940. It would be truer to say that Hitler stopped at it ; he stopped, of course, because our Navy and Air Force dominated the Channel. That is how water (or for that matter, ground) becomes an obstacle : by being dominated. But neither the Navy nor the R.A.F. can dominate a river ; amongst other considerations there isn't enough space and the night is too long. Soldiers can, however, shoot right across a river, and along it in enfilade, sweeping the entire water surface and far bank. That would be domination and no mistake. But to achieve it you must occupy positions on or actually in your own bank ; you then very soon use up all your troops and so end up with purely linear defence —a thin red streak. On the other hand you have very definitely turned the river into an obstacle. If there is a curtain it now hangs well inland of the enemy bank.

It may be argued that a battalion cannot fight in a thin red line, and that fire positions dug into a river bank would never be tenable.

Those are difficulties. But consider the enemy's difficulties. He will first have to make his way up to his bank in the face of the thin red firing line. He will then have to win a fire fight against defenders already dug in and concealed. Note in passing that a line is the most difficult shape of artillery or atomic target, so the fire fight must be largely a short range affair over open sights. On winning the fire fight the attacker may still not be able to launch his assault wave at once, for the defending engineers may have fouled the banks and the stream itself in a variety of ways.

These processes must in any event take time. Accordingly if we cover the waterfront we at least counter one potential enemy's favourite tactic of rushing his rivers. " Cover the waterfront " is a precept worth pondering over. To a certain extent it has the blessing of current British tactical doctrine which does sanction sacrifice of depth in a delaying position in order to make the most of an obstacle.

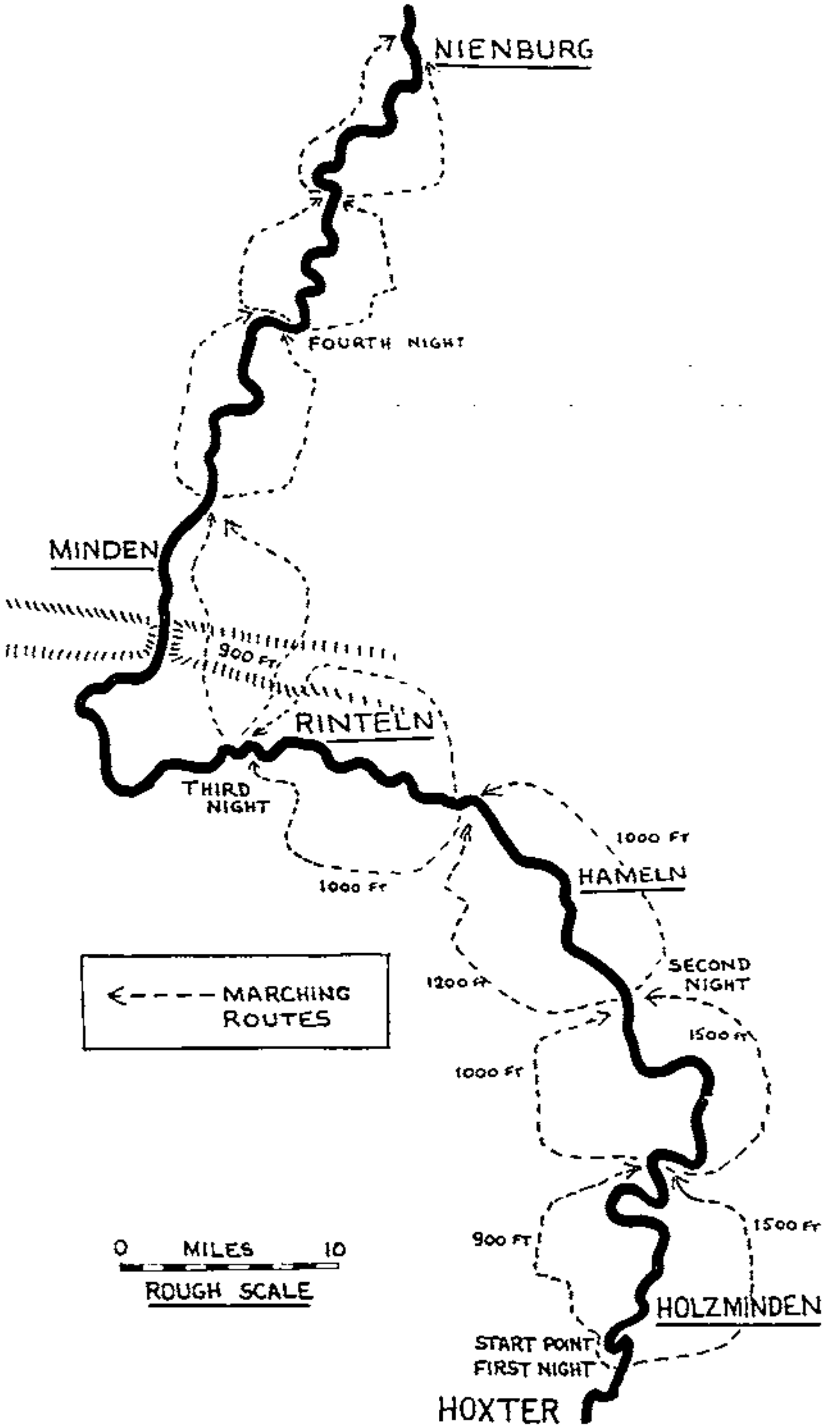
* * * * *

Let us turn finally to a possible way of using a river in defence *à outrance* : the decisive battle, possibly the final battle of the war. Picture, would you, a defensive position in which a broad deep river, perhaps hundreds of yards wide, flows across our front—surprisingly—between our infantry zone and our gun areas. Our infantry are forward of the river in a string of shallow bridgeheads. Guns, armour, reserves, headquarters and everything else of that sort are deployed safely behind the river. There are no bridges, but ferries run all through the night, supplying the infantry, evacuating the wounded, taking across reliefs and bringing out units to rest, sometimes reinforcing one bridgehead from another.

The slogging match goes on for days, weeks, or months. Meanwhile we are secretly building up our counter offensive force. When the time is ripe we bridge the river overnight, clandestinely, behind certain selected bridgeheads, and launch our counter offensive—the when and where of it being totally unsuspected by the enemy.

Lest you think this too fanciful a picture : you should know that it is merely an abbreviated account of the Battle of Stalingrad, where for once in all history the tide of war was forcibly turned at a river.

Reputations fluctuate in that part of the world, and perhaps in time we shall be expected to talk of the Battle of Malenkovograd; but, without waiting for that, should we not do well to rename it straightaway in our own minds the Battle of the Volga ? Then, if ever the conversation runs on River Battles, we shall perhaps not forget the most decisive of them all.


NIENBURG
FOURTH NIGHT
MINDEN
900 FT
RINTELN
THIRD NIGHT
1000 FT
1000 FT
HAMELN
1200 FT
SECOND NIGHT
MARCHING ROUTES
1500 FT
1000 FT
900 FT
1500 FT
0 MILES 10
ROUGH SCALE
HOLZMINDEN
START POINT FIRST NIGHT
HOXTER

EXERCISE "WATER-RAT"

By Lieut.-Colonel R. L. Clutterbuck, R.E.

THIS article tells the story of a 150-mile trip down the River Weser, by a field squadron on rafts and on foot. It also includes a digression on a technique for handling rafts in a current, which was invented and proved by a distinguished Sapper officer in the war, and which I can only wish may one day be taught as standard practice in the Corps.

Background

The field squadron was in an armoured division in B.A.O.R., where the training cycle was roughly as follows :—

3 months Administrative period } overlapping
3 months Individual training }
3 months Troop and Squadron training
3 months Regimental and formation training

The squadron was below strength. The troop leaders were all young regulars fresh from Sandhurst, very keen and good leaders, but with little experience. The W.Os. and sergeants were all battle experienced. The junior N.C.Os. and sappers were 75 per cent National Servicemen. The first two periods of the training cycle were completed, N.C.Os. and specialists were coming back from a winter of cadre and trade courses, and everyone had had leave. Basic training had been brought up to date. It was April. The snow had just melted in the valleys. Spring was in the air and it was time for field troops to find their souls.

In Praise of Watermanship

We chose to base our first collective exercise on marching and watermanship. This may seem a strange choice, since with the few troops we had in B.A.O.R. at that time, mining, demolitions and fieldworks would seem to be a more urgent training need.

We did, of course, train in these subjects also, but we made it our declared aim that the squadron should be primarily efficient at shooting, marching and watermanship. The first two need no advocacy. But why watermanship ?

First, because it is unrivalled as a means of fostering team spirit. Failures are usually public, decisive, and without alibis, not only for the individual but for his whole troop or section.

Secondly, and concurrently, because the stakes are high. Slow reaction or incompetence by one sapper can cause a raft to be wrecked—not just "umpired out", but really smashed or stranded.

There is no room for passengers, and every soldier gets ingrained into his system that finest of military parables :—

> "For want of a nail a shoe was lost,
> For want of a shoe a horse was lost,
> For want of a horse a rider was lost,
> For want of a rider a message was lost,
> For want of a message a battle was lost."

How easy to start an alternative version with "For want of a breastline . . ."

Thirdly, because, in becoming watermen, men become handy at many other sapper crafts, particularly knotting, lashing and splicing, the application of power, and quick makeshift repairs to engines, canvas and woodwork.

Fourthly, because watermanship training, like marching, acts as a sieve, through which the best N.C.Os. and sappers emerge and the weak, indecisive, clumsy and plausible are unmasked.

These advantages apply to watermanship and NOT to the practice of constructing and dismantling rafts. I think that it is a common error in the Corps to devote most of the time allotted to "watermanship" to training teams of expert constructors of meccano, who will save ten minutes in building time, only to sacrifice them in the first two crossings by unskilled watermanship —if they do not wreck their craft altogether.

Outline of Exercise "Water-Rat"

We named it Exercise "Water-Rat." We could only spare a week, and, allowing time to collect and construct and then to dismantle and return equipment, this left only four days on the water. We decided to launch a series of miscellaneous craft near Hoxter, and propel them 150 miles down the River Weser which would bring them to our door at Nienburg. Each man would spend half each day afloat, and the other half marching. He would thus navigate for 75 miles and march 60 miles through the hills (allowing for the many bends in the river). The journey would be completed in four days, during which every man would crew each type of craft once. We would do no night work—that could come later.

Our Troops had a marching strength of twenty to thirty each. Squadron H.Q. was slightly weaker (several specialists were still on courses). The squadron was organized for the exercise into two halves as follows :—

2nd Lieut. Hunt's party—	1 Troop (his own)
	H.Q. Troop (S.S.M. Look)
Lieut. Garrick's party—	2 Troop (2nd Lieut. Noel)
	3 Troop (his own)

They were initially allotted the following equipment :—

Hunt.—One bay F.B.E. with two Seagull engines. Two folding boats each with one Seagull engine.

Garrick.—One close support raft with four Petter engines. Two bipartite pontoon piers each with one Petter engine.

(All craft, of course, had oars. We carried one extra engine of each type and plenty of spare parts.)

They were told to navigate these craft in two days to the half-way point, near Rinteln, where they would exchange equipment and navigate the other craft to Nienburg in the following two days. The marching parties were to march on opposite sides of the river, to avoid racing.

From that outline, the planning and execution was done by Garrick and Hunt. Each was allowed one vehicle to carry cooks, rations and petrol, which met him on the river bank at the point he chose each day to change over his rafting and marching parties, or to harbour for the night.

Launching the Expedition

In a meadow opposite an attractive river-side village between Hoxter and Holzminden, a dozen army vehicles drew up on an April evening and began to unload. We had been joined by a German river pilot, Otto, who appeared like Dick Whittington with a bundle over his shoulder, apparently delighted at the prospect of four nights under the stars.

It was a beautiful evening. When all the boats were launched, the rafts assembled and the engines tested, we sat back and chatted, and watched the wildfowl against the setting sun. Even the most philistine of soldiers could hardly fail to be content.

We were asleep before dark. We carried no bivouacs, and the dew drenched our hair, promising a glorious day. The camp was alive at 0400 hrs., and 0545 hrs. saw the meadow clear, with the raft engines warming up and the marching troops adjusting their packs, impatient to start before the heat of the day developed.

H.Q. Troop were ferried across in folding boats to start their march from the village. Hunt was a mountaineer, and had given S.S.M. Look an arduous cross-country route through the hills. He was to take his own troop on a similar route that afternoon in the heat of the day.

The Close Support Raft put out first, under Garrick. It was to lead the flotilla, with Otto the pilot. For a few minutes it stemmed the 3½-knot current while the crew settled down. Then, gently at first, it began its journey downstream. The other five craft followed.

For the first few miles we did nothing ambitious. We concentrated on steering a steady course on whichever side of the river Otto told us to. This varied at every bend, and was further complicated

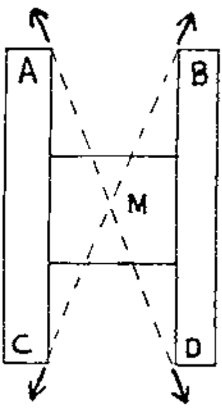


Fig. 1. "Neutral."

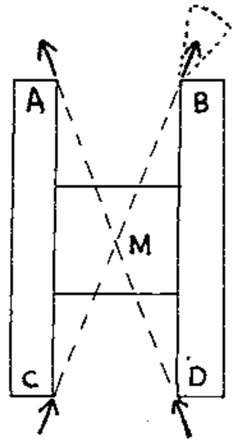


Fig. 2. Ahead.

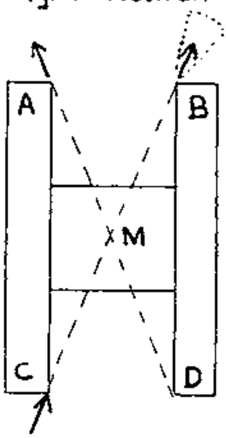


Fig. 3 Engine D fails.

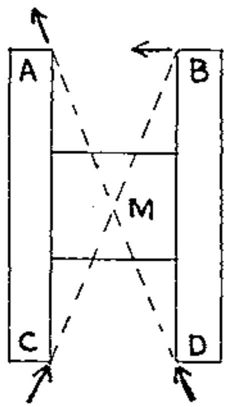


Fig. 4. Turn to Port.

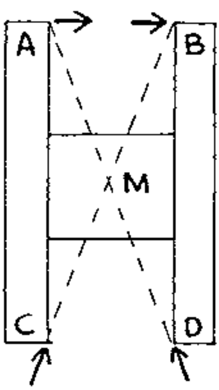


Fig. 5. Reinforced Turn to Starboard.

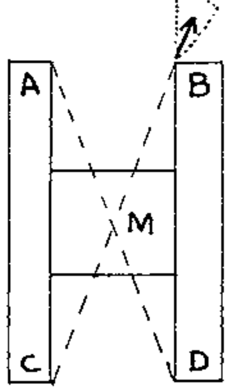


Fig. 6. Single Engine.

by shoals and groynes. These were all just covered in April (the snows were still melting in the mountains), and were hard to spot until one was almost on top of them. The groynes were stoutly built of granite blocks, and the current racing over them would have been enough to hole any of our craft beyond local repair. All ranks were clearly briefed that the " aim " of the exercise was to get all our craft to Nienburg undamaged.

We shot Holzminden Bridge in style, and Otto cheerfully survived the battery of comments from the waterfront of his home town as he piloted his strange flotilla through. In fact they were so astonished that they sent out a river police boat to shadow us, and it never let us out of its sight all the way home.

After an hour or so we brought our flotilla alongside the bank between groynes, and started to practise a few ferry crossings.

Method of Free Ranging Rafts in a Current

This is a good moment to digress on the method we used for controlling our rafts. The method was taught to me by Brigadier L. R. E. Fayle, D.S.O., O.B.E., soon after the war, " since when I have used no other." He described it in March, 1950, in his article " Rafting and Boating " in this *Journal*. The version I shall describe (which I hope Brigadier Fayle will not disown) is the method in its simplest form, with steering confined to one engine, which I have found most suitable for inexperienced crews. In his article, Brigadier Fayle describes a more advanced version, which he used with his highly trained formation in the war, in which all four engines assisted in the steering.

The basic principle is that all engines are aimed along their neutral axis, i.e., either *directly towards* or *directly away from* the centre of the raft, instead of straight fore-and-aft. The only engine allowed to drive in any other direction is the one detailed to steer.

When all engines point directly away from the centre of the raft (Fig. 1), the raft is in " neutral "—i.e., the engines are ticking over ready for instant action, but the raft has no way. This is used during loading and off-loading if there is little current at the bank (e.g., in a bay between groynes).

To drive " ahead " (Fig. 2), the two stern engines are turned through 180 deg.—i.e., towards the centre of the raft. Engine " *B* " alone is permitted to waver to keep the raft on course. The raft has, therefore, a resolved forward drive, perhaps only 10 or 15 per cent less than the drive if all engines pointed fore and aft.

What do we gain from this sacrifice of 10 or 15 per cent of power ? The answer is :—

Greatly increased stability.

Less reliance on individual sappers manning engines or propulsion units.

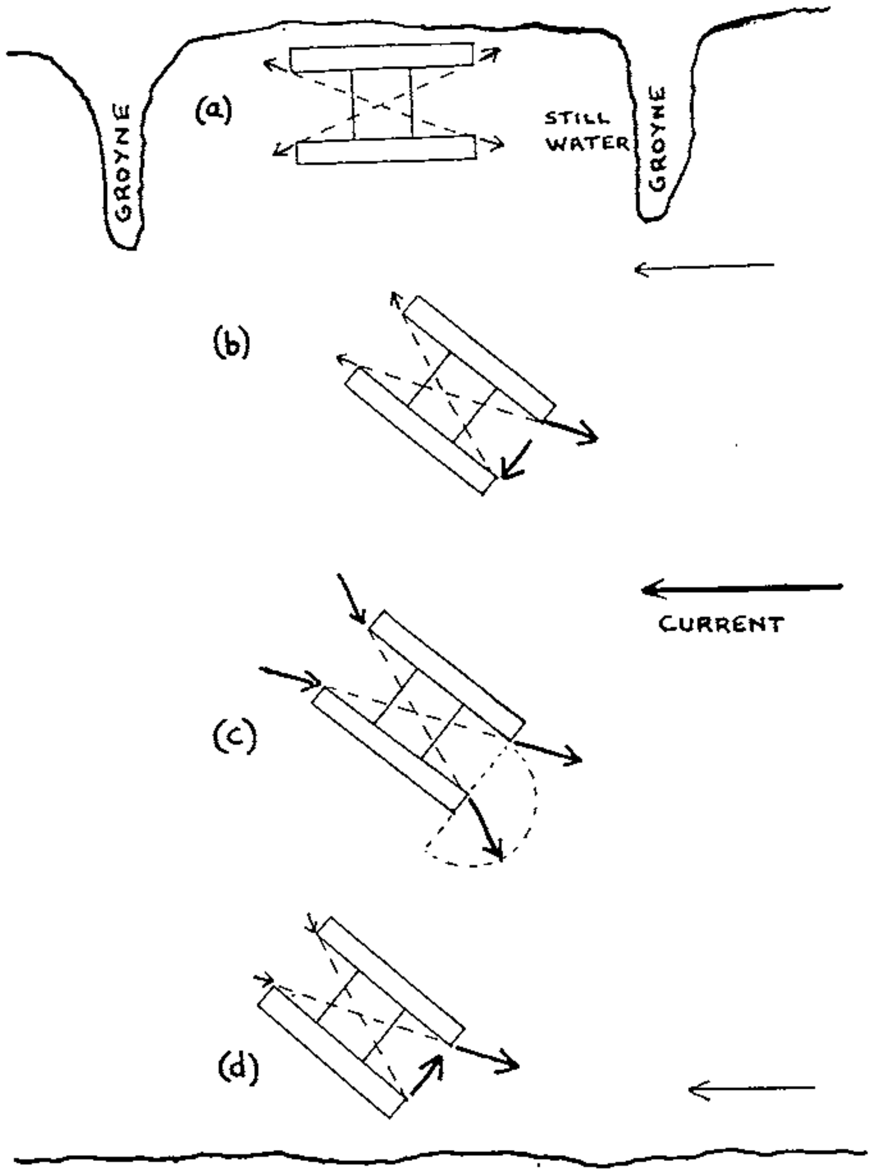


Fig. 7. Example of Crossing a River with a Current.

The increased stability is illustrated in Fig. 3. Suppose one engine suddenly fails (common enough). A raft with engines driving fore and aft would immediately start to swing, as there would be two to port against one to starboard. In the moment of coming alongside or avoiding an obstruction in a strong current, even the beginning of such a swing might be disastrous—certainly with a not too experienced raft commander. In a raft using the neutral axis drill (Fig. 3), there will, on the other hand, be no torque whatever—simply a small tendency to make leeway to starboard ; this tendency is in practice almost imperceptible.

Similarly, should one engine " rev " faster than another, there is no torque. This may often occur, particularly at night, due to misunderstandings, or to inexperienced men fumbling with the throttle.

Only two men need to be really good watermen—the commander and the steersman (B). Even the steersman's task can be simplified, for if the raft is loaded, its reactions are slow. The steersman, therefore, can be restricted to two applications of helm—hard to port (Fig. 4) or hard to starboard. The commander can judge when to reverse him to check the swing, and then return him to centre.

In a strong wind or exceptionally strong current, single engine steering may not be enough. In these conditions the other upstream engine can be warned ready to apply full starboard or full port helm to reinforce the steersman (Fig. 5).

This neutral axis drive applies equally to a raft driven by two engines or even one engine (Fig. 6). In gentle currents, a single waterman can handle a loaded raft with one engine, with only one mate to help him with breastlines, etc. (Single engine handling can also be used in bringing bays into a floating bridge, with considerable economy in manpower.)

The normal application of this method to river crossings is illustrated in Fig. 7. (*a*) Shows the raft ticking over in " neutral " while loading in still water between two groynes. (*b*) Shows the first stage of pulling out if there is slack water—the rear engines continue ticking over astern (small arrows) while the forward ones rev up (large arrows) and give the raft some way, the steersman applying starboard helm. (*c*) Shows the raft in mid-stream, with all engines ahead, angling to the current on the course needed to keep her steady on the land. During the crossing, the commander can either order full port or starboard helm to swing the raft as required, or leave the steersman (if he is experienced) to keep her steady. (*d*) Shows the steersman swinging the raft into its berth as the bow almost touches the bank. Whilst unloading at this bank, which has no groynes, all engines will be kept ticking over in the ahead position to balance the current.

At this point a critic may ask why free ranging need be given all this attention, when the flying ferry or the captive ferry are so much more reliable in a current. There are two reasons. First, many rivers are too wide for a standing cable, or tactical considerations may make it undesirable to commit a raft to a single site. Secondly, only a crew who can free-range a raft can handle it with complete confidence on a standing cable. On a narrow river, the most efficient method is to use a captive ferry, with a single engine to angle the raft correctly on the cable, and to swing it in and out of the bank. Men do this best when they have been trained in the neutral axis drive principle, because they know that the engine, when not in use, can always be left idling on the neutral axis where it will do no harm.

My contention is that this centre of resistance drive (or neutral axis) principle should be taught as standard to all sappers. Almost every military assault raft is, and always will be, driven by one or more eccentric engines, and to drive through the centre of the raft should be as instinctive to a sapper as it has always been to a Red Indian paddling a canoe.

Through Hameln Lock

We left 1 and 3 Troops free ranging the C.S.R. and the Bay of F.B.E. to and fro across the river. The less skilful sappers in the troops were practising on the separate pontoons and the single folding boats, with some rowing thrown in. There were enough craft for every man to have a full-time job on an engine or prop unit, with only an occasional turn on boathook or breastlines. There were no passengers, and H.Q. Troop in particular was to be hard pressed to man the C.S.R. and pontoons when their turn came. The officers and N.C.Os. took turns in commanding the rafts, and in coaching the beginners in steering. Every minute was worth its guinea. After the exercise, the worst of our crews could ferry at an average of twelve and the best at sixteen round trips an hour, including loading and unloading.

Just before noon we rounded the bend into the stretch of sheer rock by which both troop leaders had arranged to meet their marching parties and halt for a brew. In fact, although they were free to halt and harbour where they chose up to the half-way point, they elected to halt together every time. I was slightly disappointed in this from two officers of such notably independent outlook, but it had the advantage of every troop having an audience of rivals for its rafting. I'm sure that the ribald and derisive comments from soldiers at ease which echoed over the Weser did much to raise the standard. It was also pleasant to relax together at noon and in the evenings, and cool our blisters in the Weser while we discussed how narrowly so-and-so (never ourselves) missed hitting a tug and five barges.

We waited under the rocky cliff for H.Q. and 2 Troops to emerge from the hills. We heard their marching songs from far away, and they came down in style after a six- or seven-hour march.

The sun was intensely hot as 1 and 3 Troops buckled on their packs and set off through the rolling hills for the night harbour a few miles south of Hameln. We kept well away from main roads, and followed forest and hill tracks, occasionally cutting across country. In each half-day march on the first two days, every man climbed and descended 1,000 to 1,500 feet. We quickly learned to set a steady pace and not to try to race the clock.

As we licked our sores in the evening, we learned how any spot on the river, however remote from villages, could muster at least one hundred children within half an hour. They converged on bicycles, on foot, swimming, and in every type of boat. German children instinctively flock to soldiers of every nationality, not only in the hope of chocolate, but because it seems to be in their blood. We were glad to see the ones who came by boat, as their skill was a challenge to us.

The weather was kind, and once again we awoke with nothing worse than dew in our hair. We were away by 0600 hrs., and the crews, with a day's navigation behind them, were gaily confident. As the C.S.R. sped round a bend with the current under it, we saw the C.R.E. on the bank. The crew reversed engines and brought her up to the bank with faultless ease, much to the relief of their officers. The C.R.E. was a distinguished ocean racing skipper, so we were anxious to justify the value of our exercise as we took him with us over the next fifteen miles. We edged our six craft into Hameln lock, and an hour later we were coursing through the Hameln bridging camp. The banks were lined with parties of sappers from a rival division, and they seemed to our salt-encrusted sea-dogs to be doing very elementary things.

The marching parties, having no currents to help them and many muddy hills to climb, gave plenty of time for the rafts to practise coming alongside and doing ferry crossings. Another halt for a brew, and an afternoon in the gloriously spacious valley of the Weser below Hameln, brought us to our half-way halt near Rinteln. Here we sat down in ranks on the grass in the evening sun, with our feet bared ready for a half-way check by the doctor.

The M.O. arrived exactly on time, and started his inspection. He and his wife were themselves great walkers, and he scoffed at the paltry distance we had marched. We nearly all had blisters of sorts, and a few of the weaker brethren were gazing wistfully at beautiful rainbow-coloured specimens in the hope of "rafting only" for the remainder of the trip. Their plaintive bleats and pleading eyes were rudely swept aside by the doctor, and not a man was excused anything.

Next day we passed through the hills around Vlotho, and through the magnificent Minden Gap, where the river cuts cleanly through a steep-sided breach in a 900-ft. razor-backed ridge. We pictured the French armies with their guns and baggage trains crammed in confusion on the narrow river bank in their precipitate retreat after the Battle of Minden in 1759.

A Busy Water-Way

Minden is a great inland port, where the Ems-Weser and Weser-Elbe canals join, and are carried over the Weser by an enormous aqueduct. A complex system of locks, docks and basins disgorges most of their traffic on to the Weser, for its journey to Bremen and the sea. So from Minden homewards we could look forward to great trains of tugs and barges passing each way along the 150-200 foot channel. Some of the bends are so sharp that the streams of river traffic have to cross each other to get round. But Otto the pilot knew the rules, and the crews were now so confident that he had few anxious moments. As the C.S.R. approached each bend he would ask the skipper to slow down. He would pick his moment, and then, snatching a comic horn from his pocket he would give a gay little toot and signal the flotilla across with a flourish of the arm, cutting between a pair of barge trains. The $3\frac{1}{2}$ knot current left little time for fumbling. We had a day and a half on this busy 50-mile stretch before we made fast, tired but unscathed, at Nienburg.

Was Water-Rat worth while ? Ask any officer or N.C.O. who took part and he will tell you that it built more spirit in his troop than any other week of training he ever did with them. Listen to the talk of the young soldiers as they sat on the banks on the last evening, and you would be left in no doubt that they were nearer to being men, and that they had enjoyed becoming so.

Every man had marched 60 miles and had been up and down the equivalent of Snowdon. A 150-mile journey down a busy river breeds more confident watermen than a fortnight of training in camp. A great adventure ? A superb physical achievement ? No. But enough of an incident in the life of a 19-year-old boy from Hoxton or Birmingham to be worth a letter home.

Conclusion

Should anyone be tempted to try something similar, I would highlight the following points. Make friends with a workshop which repairs the types of engine you are using. Borrow from them an ample stock of spares—you can always return the 98 per cent you do not use. Attach your engine fitters to them for a week or so in advance, to learn the form. And finally, train your men in the neutral axis drive principle—a brand-new crew can learn it in a couple of hours !

Photo 1.—Close Support Raft with four Petter engines.

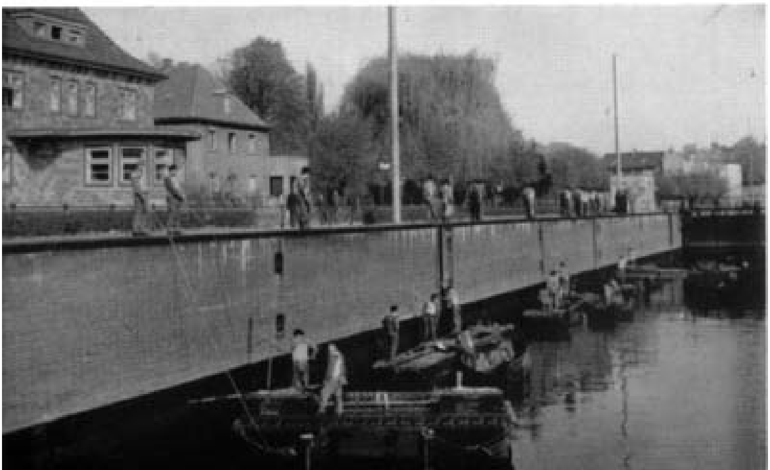


Photo 2.—The flotilla in Hameln Lock (The C.S.R. being without its ramps in order to fit in.)

Exercise Water-Rat 1 , 2

Photo 1.—L.C.I(S). disembarking troops on No. 5 Causeway on Mike (Green) Beach.

Photo 2.—L.C.T.4 discharging tanks of 11 Armd. Division on to No. 5 Causeway on Mike Beach.

The Causeaway Story 1 , 2

THE CAUSEWAY STORY

By Brigadier L. R. E. Fayle, D.S.O., O.B.E.

General

THE causeways on the Normandy beaches formed a small and unnoticed part of a great organization. Though over 100,000 troops and nearly 14,000 vehicles landed on them it is probable that few who did so paid much attention to these queer devices—their minds were taken up with other thoughts—and those who noticed them have probably forgotten them. They were almost a last minute conception, and as their construction and operation was confined to one field engineer formation, the circle of those who knew and understood them was necessarily limited. For the formation concerned, however, they proved to be a vitally interesting job which claimed their undivided energies and attention from March to July, 1944. Before memories fade, the story of the causeways is, therefore, committed to print. Here I must mention, in passing, that they had nothing whatever to do with Rhino ferries, with which they were often confused, as they happened to be constructed of similar material.

Conception

The Chief Engineer, 21 Army Group, was responsible for their conception. The problems to be overcome were :—

1. In case the beaches contained clay patches between high and low water mark (as seemed probable from air photos), beach roadways would be required running from low to high water mark which would allow vehicles to cross the bad patches without bogging.
2. As it seemed probable that insufficient material would be available for waterproofing all build-up vehicles, some means of landing these dryshod was required.

A promising method of overcoming both these problems by one device seemed to lie in the use of either floating piers or sunken causeways of American Naval Lighterage (N-L) Pontoons. These were steel boxes or tanks, 5 ft. long, 7 ft. wide and 5 ft. deep, which could be connected together by steel angles into strings up to thirty pontoons long, while the strings could be connected side by side by means of tie rods to form rafts or barges up to six or more strings wide. The decks of these pontoons were reinforced and could be used as a roadway for vehicles—at least Class 40.

PLATE I.

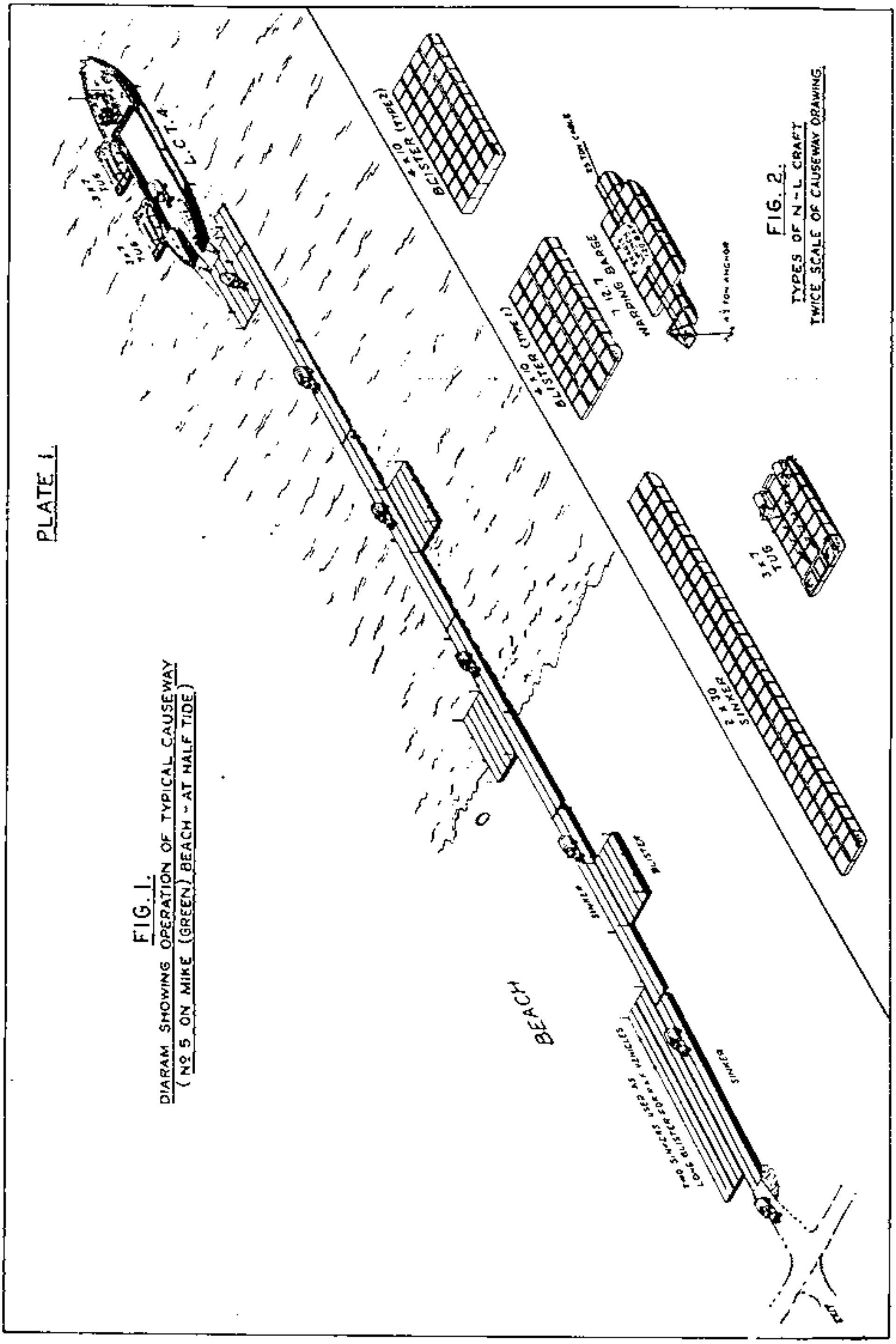


FIG. 1.
DIARAM SHOWING OPERATION OF TYPICAL CAUSEWAY
(No 5 ON MIKE (GREEN) BEACH - AT HALF TIDE)

FIG. 2.
TYPES OF N-L CRAFT
TWICE SCALE OF CAUSEWAY DRAWING

The Chief Engineer considered that by placing a number of these rafts end to end the gap from high to low water could be covered—a distance varying in the various beaches from a quarter to half mile. If the pier were floating, the L.C.T. could drop its ramp on the outer end and the vehicles could then drive off the craft, up the long pier and on to the beach, thus overcoming both problems. Alternatively, if the pier were sunken the craft could proceed inshore to a spot where the deck of the pier was just exposed and lower its ramp on to the pier there. Since the pontoons were 5 ft. deep, there would be plenty of water to float L.C.Ts. 4, 5, and 6, and in some cases enough water to float L.C.T. 3. This again would overcome both problems; moreover both alternatives would produce another advantage—L.C.Ts. would be able to disembark vehicles on a falling tide without fear of drying out and consequently of being stuck and useless for periods up to twelve hours. A further advantage of the scheme—only appreciated later—was that L.C.Is. could use the causeways and thus land personnel dryshod, or practically so, whereas by the normal process of beaching the unfortunates on board had to plunge into four feet or so of water, consequently arriving in France with morale somewhat damped.

DESIGN

Only one field engineer formation—15 (Kent) G.H.Q. Troops Engineers of which I was C.R.E.—was available for the job, but fortunately we had already had extensive training in watermanship in tidal waters in Northern Ireland and at Goole. O.C., 582 Field Company and I were ordered to accompany C.E. 21 Army Group to Falmouth, late in January, 1944. During the journey the whole matter was discussed and at the U.S. Navy Base at Falmouth various types of N-L pontoon equipment were seen, then under construction or being used for training by the Construction Battalions, U.S. Navy. Arising out of this visit the following decisions were made as to the composition of each causeway set-up, it having previously been decided that six causeways would be required on the British beaches and four on the American, the latter to be operated by the "C.Bs." of the U.S. Navy.

(1) The causeways should be sunken, owing to the difficulty of securely mooring a long floating pier on an exposed beach.

(2) The causeway proper should consist of a number of 2×30 "sinkers," placed end to end. It should here be mentioned that N-L pontoon equipment is described by the number of pontoons contained in the particular piece. Thus a 2×30 consists of sixty pontoons made up in two strings each thirty pontoons long, close coupled side by side. In the same way, a 3×7 consists of twenty-one pontoons made up in three strings side by side, each seven pontoons

long. The 2×30 "sinkers" were 176 ft. long over all by 14 ft. beam, drawing 1 ft. 8 in. of water when light and displacing 90 tons. When filled with water the all-up weight was 390 tons. It was anticipated that the average causeway would be 14 "sinkers" in length—i.e., nearly half a mile long. (See Photo No. 1.)

The difference between 176 ft. (total length) and 30 × 5 ft. (length of pontoon) was accounted for by a space of about nine inches left between each pontoon. In the width the pontoons were coupled close together.

(3) Landing craft should lower their doors on a "floater" 4×30, 176 ft. by 28 ft. This floater should be drawn up and down the causeway with the tide, close alongside it. Vehicles should drive from the floater on to the causeway by means of a landing mat or other device. To anticipate, floaters were found to be unsatisfactory owing to the difficulty of controlling them alongside the sunken causeway. Instead, three "blisters," each 4×10, were cut from each floater, and these blisters were sunk close alongside the causeway proper, on alternate sides, at various points up the beach, arranged so that the L.C.T. would lower her door on to the blister which at the particular state of the tide was approximately awash. (See Photo No. 2.) Each blister would cover about two feet rise and fall of tide, and by stationing enough blisters practically the whole range of tide could be catered for.

A spare floater had been planned for each causeway, and thus six blisters became available for each, a number later increased to eight.

(4) For each causeway, three tugs (including one spare)—later increased to a total of four tugs—would be used. These tugs were to be manned by personnel of the formation, and would have the job of bringing in the sinkers and blisters, beaching them and sinking them in position, and later of assisting the landing craft to berth. They would also be N-L type craft, 3×7, 43 ft. long by 21 ft. beam, displacing about thirty-eight tons and each fitted with two Murray & Tregurtha 120 B.H.P. heavy duty outboard engines (see photo No. 3). Outboards were chosen in preference to the inboard type, as the propeller arm could be raised vertically above the water, and so would come to no harm when the craft was beached (see photo No. 4) : manœuvrability was also thereby increased.

(5) Two dozers Class 2 (including one armoured) would be provided for each causeway. These dozers were to be fitted with Hyster winches, their object being to assist in beaching the sinkers, to provide mobile anchorages, and to be available for general beach use when not being used for the causeways. For this reason a Mechanized Equipment Platoon was added to the formation.

A causeway set-up is shown in Plate 1, Fig. 1, while Fig. 2 of the same plate shows the component parts, which are described in detail in Table I (on page 167).

Photo 3.—3 × 7 tug, T.29 *Tullybody*, in Osborne Bay.

Photo 4.—The gale of 20th June. A 3 × 7 tug safely beached on Mike Beach. Note propellers raised out of harm's way.

Photo 5.—Seaweed Hut " Shipyard " in its earlier stages.

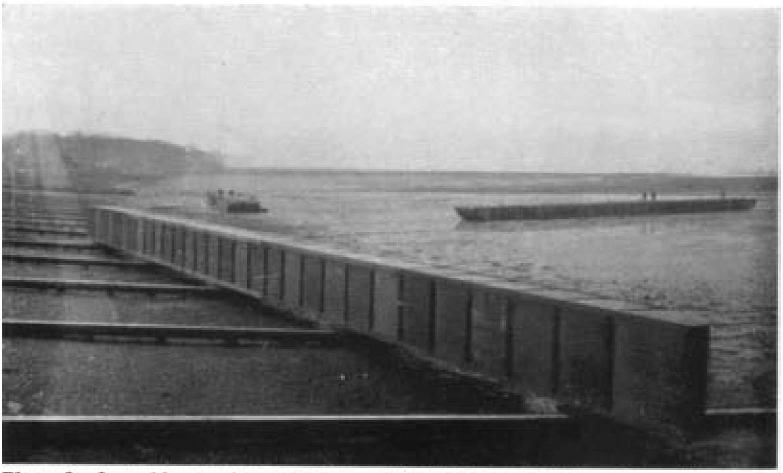


Photo 6.—Launching a string at the Seaweed Hut " Shipyard." The craft travelling down the ways on its side. Two sinkers lying on the mud nearby.

Initial Training

A Cadre of officers and N.C.Os. from each Field Company, approximately thirty all ranks, were sent to Falmouth at the beginning of February, 1944, for a month's training with the U.S. Navy C.Bs. and to develop techniques. During this training much work was done on the beaches outside Falmouth Harbour. One of the main results of this was to discover the clumsiness of the 4×30 floaters, and the difficulty of handling them in a seaway. Another result was to find how rapidly sappers already trained in rafting mastered the control of the much larger craft powered with big outboard motors.

Planning the Construction

It was originally thought that the finished sinkers, floaters and tugs would be provided "ready made" by U.S. Navy, but early in February I was summoned by C.E. 21 Army Group and told to carry out a recce at Southampton for building sites, as 15 G.H.Q. Troops were to do the construction of the material for the British causeways. The normal method of construction was to build the strings of the required length, on their sides, on a quay wall, and to topple them over the edge into the water, where they would float the right way up and could be connected in the water to other strings, thus forming craft of the required width.

An exhaustive search of the Southampton area gave us only one *available* quay wall, about fifty feet long, at Eling Quay, near Totton. This was chosen as the tug building site, but was useless for sinker and floater strings 176 ft. long: time was short and I reckoned that at least ten berths for the long strings would be necessary in order to complete construction in time: allowing 250 ft. per berth, a frontage of nearly half a mile would be necessary. Thus some entirely new technique for launching would be necessary, and I turned at once to the normal method of launching ships sideways as used in narrow waters, with the one difference—that the strings would be built on their sides and would have to turn through ninety degrees on floating.

The choice, therefore, was a long section of flat, shingly beach near Seaweed Hut, between Woolston and Netley, backed by Woolston promenade, where there was ample room for ten berths. Each berth was to have five 12 × 12 in. timber launching ways, each with a launching cradle. The strings were to be built on the cradles with wedged packing between the cradles. When ready to launch, the wedges were to be knocked out of the packing, leaving the string free to travel down the ways by gravity, on its cradles. The top of the ways had to be above high water highest springs, while the bottom had to be 2 ft. below high water lowest neaps to allow the strings to be floated away on any high water. (See Photo No. 5.)

At this time the formation was in Scotland and I was, therefore, on my own in the south of England, without a staff to work out the plan. However, as the whole idea was new, my guess was as good as another's, and oddly enough it worked out very well. 21 Army Group arranged for the delivery of all stores and, except for some delay over cranes and welding sets, all turned up in good time. The following points in planning the construction of the craft may here be of interest :—

1. The material was expected to arrive by ship from U.S.A. in Southampton Docks, starting about 10th March.

2. The formation, less 65 and 584 Field Companies was to arrive in the Southampton area at the beginning of March and prepare the building sites. The two remaining companies were to arrive two weeks and one week later respectively.

3. The plan was to give each company (65, 582, 583 and 584 Field Companies and 297 Field Park Company) two building berths at Seaweed Hut, while 583 Field Company was also to build the tugs at Eling with one platoon. We hoped to be able to launch one long string per berth per day at Seaweed Hut, and three 1×7 strings per day at Eling. The connexion of the strings in the water was to be done by the companies building them.

4. The Mechanical Equipment Platoon allotted to us was to join at Southampton to assist in the construction of the craft when necessary and to get familiar with the gear.

5. A General Transport Company R.A.S.C. (equipped with 10-tonners) was to join at Southampton for collecting stores initially and later to collect the pontoon material from the ships in Southampton Docks.

6. A Naval Liaison Officer was to work with the formation.

7. At Seaweed Hut, a Decauville track was to run the full length of the berths. Sommerfeld track roadways over the shingle were also to be provided to allow access for lorries, and a number of dumpers (to be operated by the Mechanical Equipment Platoon) were also laid on.

8. A total of thirty-two crawler cranes (19 R.B.), were asked for, allowing two per building berth at Seaweed Hut, plus one additional per berth for stacking the material in rear of the berths, allowing two for the Eling tug site.

9. Crane operators (as well as the cranes themselves) were to be provided by Transportation.

10. We asked for two welding sets per berth, plus a few spare. The additional welders required were provided from 21 Army Group sources. This dismisses the problem somewhat lightly, but it is worth noting that in the construction of the causeways no less than 40 miles of welding rods were used !

Construction

The first three companies of the formation arrived in the Southampton area at the beginning of March and moved into a tented camp at Sarisbury Green near Bursledon, except the platoon for Eling which moved into billets at Totton. Our rather draughty quarters were left later in the month when, to our great relief, we all moved into billets in Southampton.

Stores started to arrive steadily and by the middle of March we were almost ready with the berths, but terribly short of cranes as only two or three had arrived ; worse still, there was no sign of the material arriving from America. Work was nearly at a standstill apart from a good deal of " chasing " of stores. A good liaison had been made with Messrs. Thornycrofts, the Woolston shipbuilders, who advised us over special launching grease.

By the end of the month we still had no material, and Transportation had taken back some of their cranes, leaving us only one.

On 2nd April, S.S. *Benjamin Contee* arrived at Southampton, followed within the next four days by three more Liberty ships—*Hellas*, *Webb Miller* and *Binger Herman*. The crane situation was desperate—only five had been received, while only 50 per cent of the welding sets had arrived, but offloading of material went on at full speed. It was, in fact, impossible, even with our fleet of 10-tonners, to keep pace with the offloading of the ships. The distribution of material to the berths was arranged on a day-to-day basis, and a good check was kept on stores.

Building commenced on 4th April at Eling and on 7th April at Seaweed Hut. A rush of crawler cranes brought our complement up to twenty-six, so work started in earnest. Launching the long strings at low water proved successful beyond our dreams. They rushed down to the end of the ways where the cradles stuck in the beach and the strings toppled off them right side up, clear of the cradles, which could then be hauled back (see photo No. 6). Launching at high water was not a success. The strings went too slowly and floated on their sides, sometimes even turning bottom up. This meant turning them over in the water : we tried bulldozers for this—but not very successfully—and generally resorted to parbuckling.

At Eling the platoon of 583 Field Company under Lieutenant Williams put up a splendid show. Tugs were turned out at the rate of one per day, including fitting out. Each tug from start to finish took about four days to complete, so there were always three or four under construction at a time. In all, twenty-two tugs were built, all numbered and named somewhat ridiculously with names beginning with T. The first tug T.21 *Topgallant* went from Eling to the Seaweed Hut site on 6th April, and I confess I took a childish delight in taking the first horrible ship of my nightmare fleet to sea. I may add here that other tugs included T.24 *Thermopylae*, T.26 *Titania*, T.27 *Trenchemer*, T.34 *Taiping* and T. 38 *Thessalus*. I fear this was an insult to the beautiful tea and wool clippers (and one ocean racer) after which they were named, and Captains Kemball, Burgoyne and M'Kinnon must have turned in their graves at the thought.

But ugly as they were, these tugs, with their big outboard motors, did grand jobs from the start, towing the strings away from the beach to anchorages off-shore where the " tie rod parties " connected them into sinkers and floaters, and later towing the assembled craft over to Osborne Bay. Early in the proceedings T.21 *Topgallant* went over to Cowes to take the N.L.O. and myself on a liaison visit. While she lay at the quay wall a small naval craft came alongside her to disembark ratings ; as one of these walked across the deck he was heard to say to his companion, " Lumme, Bill, it's just a lot of floating tins!" Tug crews were soon very skilful and they quickly assimilated the rule of the road at sea, (a vital subject with Southampton Water and the Solent as crowded as Piccadilly Circus), learning the ground-work from a lecture or two which I gave on the subject.

Meanwhile building at Seaweed Hut went on rapidly. In the middle of April 582 Field Company left to carry out training with the equipment in Osborne Bay. An achievement was their method of taking the equipment to the island. They tied two sinkers together, and with two tugs (*Torchbearer* and *Tullybody*) made fast to the pair, set off from Netley to Cowes, the sinkers laden with a pile of company baggage. This remarkable composite craft, 176 ft. long by 70 ft. beam, made the passage to Cowes at 4½ knots, and, escorted by my own tug *Topgallant*, ran up the Medina river a mile above Cowes, turned in the narrow stream and moored, all without mishap. 582 were replaced at the building site by 55 Field Company—obtained " on loan " from another formation.

Our N.L.O. has been mentioned, but indeed he was the key member of the team. We had been most fortunate in getting Commander E. W. Middleton, R.N.V.R., a former P. & O. Officer, a prime seaman whose word carried weight in naval circles, and who could also quickly grasp the problems of the soldier. We could not have had a better N.L.O. : but for his work we should never have got to the post, and throughout he was a real friend to us. He was assisted by Lieutenant Law, R.N.R., his able A.N.L.O., and later by a number of skipper Lieutenants R.N.R. who were to act later with great success as " Causeway Pilots " on the beaches and bring the L.C.Ts. alongside to berth. The girth of one of these pilots—a Grimsby trawler skipper in peace time—was such that when fitted with Army battledress, two suits had to be cannibalized before he could get a fit.

By the end of April the bulk of the building had been done : the remaining three Field Companies joined 582 Company training on the island, and 24 Field Company was loaned to us to help 55 Company and the Field Park to complete work on the mainland. The little party at Eling remained to finish off a few additional craft. At the height of the work, in mid-April, the Seaweed Hut shipyard (see photo No. 5) had been a remarkable sight and output had been terrific. Late in April, S.S. *John D. Ross* arrived in Southampton with the balance of the material, but by 1st May N-L craft were dispersing to the Isle of Wight and work in the " shipyards " was easing down. Nevertheless, much was still to be done :—

(1) A decision was made late in April that sunken blisters 4×10 would be used instead of floaters 4×30. This meant much cutting of strings already launched.

(2) Four " warping barges " were ordered. These were queer craft three strings wide, the two outer strings being seven pontoons long and the centre one twelve long. Amidships was a 120 h.p. Skagit winch operating two drums on which were coiled special 30-ton cables. One lead went to the stern and the other to the bow on which was mounted a 4½-ton anchor (see plate 1, Fig. 2). The object of the device was, by anchoring the barge and passing the other wire to a stranded craft, the latter could be refloated by taking in on the winch. The construction of these meant more work for the Eling party.

(3) Plastic armour had to be fitted round the petrol tanks and steering wheels of all tugs.

(4) All craft had to be " flashed," against magnetic mines. This gave us a further headache as we had to take N-L craft here and there, wherever and whenever the demagnetizing vessel called for them.

(5) Towing bridles and gear had to be prepared and fitted, to enable the craft to be towed across the Channel.

(6) Dinghies (one per causeway) had to be collected. In addition, our N.L.O. provided one 22-ft. and two 18-ft. dories, one of which he used himself, giving the other two to me. These were excellent 6-knot craft and saved using a tug for inspection journeys.

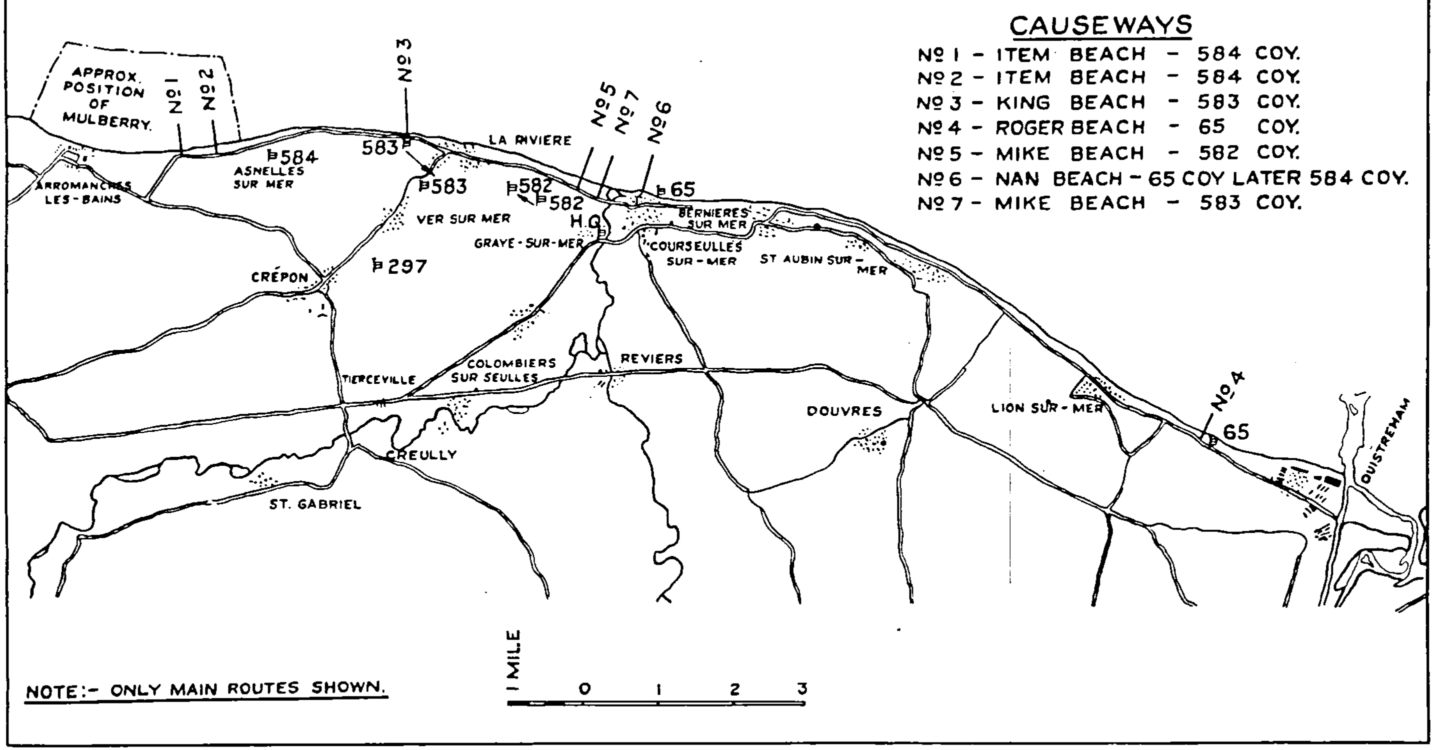
(7) Tugs were all fitted to carry 120 gallons of reserve petrol in jerricans : these were stowed below decks between the pontoons.

(8) The first eighteen sinkers scheduled to arrive on the other side were each loaded with 10 tons of P.S.P.—this was merely a method used by C.E. Second Army for obtaining additional engineer stores early in the proceedings.

(9) Four tugs (one per Field Company) were fitted with a welding set each. We felt we might need these early.

While all these tasks and many others were going on, companies were training in bringing the causeways in to the beach and sinking

POSITION OF CAUSEWAYS & COMPANIES WORKING THEM. PLATE 2.



them, and also in manœuvring L.C.Ts. alongside by means of tugs. All this was done in Osborne Bay in April and May and at the end of it the sunken sinkers had to be raised and moored. By the end of May we had the whole fleet on moorings in Osborne Bay, prepared for sea—eighty-one sinkers, forty-eight blisters, twenty-two tugs and four warping barges, some 13,000 tons of material, all unloaded, assembled and fitted out in a period of eight weeks. It had been, perhaps, the most fascinating job an engineer formation with a penchant for water could be called on to do.

Having got our craft nearly to the start line, it is now ripe to turn to the planning of the actual operation.

Planning

The planning of the operation had been going ahead since early February, when I had been "Bigoted"—i.e. told the place and approximate date of the landings. I remained the only "Bigoted" member of the formation until late April, a fact which resulted in my having to type Top Secret letters myself for over two months!

As already mentioned, the Americans were to build four causeways and ourselves six. Ours were to be as follows (see Plate 2):—

Gold Sector—50 Division—XXX Corps

Two on Jig Beach (Asnelles-sur-Mer) to be operated by 584 Field Company plus one platoon 583 Field Company.

One on King Beach (Ver-sur-Mer) to be operated by 583 Field Company less one platoon.

Juno Sector—3 Canadian Division—I Corps

Two on Mike Beach (Graye-sur-Mer) to be operated by 582 Field Company plus one platoon 65 Field Company.

Sword Sector—3 British Division—I Corps

One on Roger Beach (Ouistreham) to be operated by 65 Field Company less one platoon.

This last causeway was planned to be started on about "D+10" as, being on the left flank of the beachhead, it would be too exposed at the outset. A temporary causeway would, therefore, be built by 65 Field Company on Nan Beach (Courseulles)—in 3 Canadian Division Sector—but removed to Roger Beach later.

The four Field Companies would be allowed only ten vehicles each, so each had to leave behind a rear party including one officer to bring over the remaining vehicles. These would arrive after "D+21."

297 Field Park Company was to produce a detachment of tradesmen who would assist the Field Companies in welding and overhaul of craft. The bulk of the company was to follow after "D+21."

I was to arrive with a skeleton H.Q. at the outset, followed by the remainder of my H.Q. on "D+7." As Field Companies would be working in different sectors they would be placed under command of C.R.E. Beach Group concerned, and I would act only as chief technical adviser on causeways. In point of fact this worked differently in practice. I had an excellent liaison with the Cs.R.E of Beach Groups and was virtually in command of the formation throughout, officially taking over on about " D+10."

The N-L craft were to be towed across the Channel by various naval vessels, but the Navy were unable to make a definite programme beyond " D+2." It was left to the Naval Liaison officer—who was to remain in England until all the craft had gone across—to arrange with L.S.Ts. to pick up the craft after the definite programme of the first two days.

The leading parties were to be in France on " D+1," and causeway construction was to start the following day. We felt it was vital that two tugs per Field Company, complete with crews, should be over on " D+1 " and the third tug per company the following day. It was arranged, therefore, that eighteen tugs, each with a crew of one section, should be towed over first, the towing vessels towing a tug each and, in addition, a sinker each. Of these, ten tugs and ten sinkers were to go first, the crews being taken on board the towing vessels, and with this party were to travel the second in command of each Field Company, F.E.1, Mechanical Equipment Platoon Commander and myself. The second batch of eight tugs and eight sinkers and eight tug crews were to follow one tide later.

All the rest of the formation involved in the causeway party had to go through the ordinary sausage machine of concentration areas and marshalling camps followed by embarkation in L.C.Ts. and other craft. The Field Company Commanders travelled by this method and were scheduled to arrive in Normandy at second tide on " D " day, to decide on causeway sites with their C.R.E. Beach Group and be ready for the leading tug and sinker parties arriving on first tide " D+1."

Final Departure

The story of the parties who went through the ordinary sausage machine is like that of thousands of others, but the leading tug parties' experience was out of the common. By 1st June I was still in Southampton with F.E.1, Mechanical Equipment Platoon Officer and a skeleton staff. The equipment was by now all moored in Osborne Bay and the tug parties all in the Isle of Wight. The ten leading tugs with their sinkers had to join their towing vessels (a Boom carrier and nine Boom Defence Vessels or converted trawlers) by 10 a.m. on "D" day in St. Helen's Roads, outside the Spithead Boom. We, therefore, had to get through the boom and into Bembridge early on " D−1 ", before the entrance became crowded with " D " day assault craft. This no doubt was an excellent plan, but unfortunately I could not find out exactly when "D" day was to be! H.Q. Second Army could not, or perhaps would not, help, so the N.L.O. was asked to find it out on the "old boy net" from naval circles. On Friday, 2nd June he told me the date was Tuesday, 6th June. We, therefore, planned to leave Southampton by dory after lunch on Saturday, 3rd June, join the tug crews on the Isle of Wight, spend Sunday making final preparations on the craft, and move to Bembridge on Monday, ready to hitch on to the towing craft outside, on the following morning.

On Saturday morning the N.L.O. told me that his "net" had let him down. "D" day would be Monday, 5th June. This meant we should have to dispense with Sunday's preparations and move to Bembridge a day earlier.

On Saturday afternoon the party left Southampton Docks for Osborne; I was at the helm of the 18-ft. dory *Dunlin* and the Mechanical Equipment Platoon Officer (Captain McNab, another keen yachtsman) at the helm of *Tern*, the older 22-footer. We had painted the R.E.Y.C. burgee on the bows of each of these as I thought that the Yacht Club should be represented in Normandy. The evening at Osborne was busy; new orders had to be issued and tug crews briefed as well as some further preparations on the N-L craft. On Sunday morning at 5.30 a.m., we were on the beach, ferrying kit and gear out to the craft, and at 9 a.m. the flotilla set off, each of the ten tugs towing a sinker alongside, the whole in line ahead, with a skipper lieutenant (causeway pilot) on each of the two leading tugs. *Tern* and *Dunlin*, the dories, forged along ahead to warn the boom trawlers to let the strange flotilla through. There was a moderate southerly wind and we were very wet in the dories and glad to be invited on board a boom trawler for a cup of tea. From the deck of the trawler we saw the nightmare flotilla pass through, line ahead, going well, though their station-keeping was hardly up to R.N. standards. From the boom a very wet passage (during which *Dunlin*'s engine broke down and I had to accept a tow from *Tern*) brought us into Brading Haven, Bembridge.

That afternoon (Sunday) the N.L.O. arrived and told me that "D" day was postponed till Tuesday, 6th June, so for the next twenty-four hours we were able to check and overhaul all gear, and ensure that everything on board the tugs and sinkers was securely lashed. We bivouacked on the beach and at 10 p.m. on Monday evening we ferried the crews on board again and set off at midnight, to anchor a mile or two outside, where there would be no fear of drying out at low water. Just before dawn a tug crew, brewing up, allowed a petrol cooker to flare up, which brought a naval trawler alongside to inquire if we were making distress signals! At 8 a.m. we set off for the towing vessels, scattered over several square miles of sea. The N.L.O. (in his L.C.V.(P)) and I, now in *Tern* (I had found *Dunlin* too unreliable and presented her to the Mechanical Equipment Officer!), contacted the towing vessels and directed the tugs to them. By 10 a.m. all were ready for towing and the dories had been hoisted on board the boom carrier *Fernmoor*. We sailed at 4 p.m. As we cleared the land there was a moderate cross sea and in our wakes the sinkers and tugs wallowed uneasily. Soon afterwards the L.S.Is. from the assault wave were seen returning: they appeared unscathed and it did us good to see these gallant cross-Channel steamers which four years before had done such great work at Dunkirk, coming back safely from their biggest assault operation.

Dawn found us nearing the French coast, but with it came a nasty shock. The sinker was still wallowing astern of *Fernmoor*, but the tug *Tullybody* had disappeared. We looked around and saw that four other tugs in tow of other craft had gone the same way, leaving us only five tugs and ten sinkers. As it turned out, all but one of these craft were picked up and reached us some days later, but at the time it was depressing.

We anchored off Arromanches and at about 9 a.m. *Tern* was lowered into the water and I went round to the other towing vessels to assemble the craft and direct them in. Some of the tugs took two sinkers apiece, but in spite of moderately rough water they managed it and we set off eastward. I had also to recognize landmarks from the map and direct the various craft to their causeway beaches. Some of us had 10 miles to cover, but by about 2 p.m. all were at their destinations, and I ran *Tern* on to the beach at Graye-sur-Mer to see O.C. 582 Field Company (Major Keeble) standing waiting for me—a good omen.

The leading shore parties had mostly arrived on shore that morning, but one party of 65 Field Company, under Lieutenant Mansell, had landed at Courseulles at "H+4." After exchanging salutes with a German officer who was burying his dead, he had done much work on mine clearance round Courseulles harbour to fill in time till the causeways arrived.

By the evening of "D+1" all companies had been contacted, as well as Cs.R.E. Beach Groups, and we were ready to start work.

Operations

The units of the formation established themselves near their work, as follows:—

H.Q. Graye-sur-Mer

65 Field Company Courseulles

582 Field Company (with det. 297 Field Park Company) Graye-sur-Mer

583 Field Company Ver-sur-Mer

584 Field Company Asnelles-sur-Mer

A certain amount of mine clearance had to be done in most of the bivouac areas, but luckily it was done without mishap. As to the causeways themselves, the original plan was modified somewhat and the first five were built as follows (see Plate 2) :—

No. 1 and No. 2 on Item Beach (Le Hamel) by 584 Field Company
No. 3 on King Beach (Ver-sur-Mer) by 583 Field Company
No. 5 on Mike Beach (Graye-sur-Mer) by 582 Field Company
No. 6 on Nan Beach (Courseulles) by 65 Field Company

This fitted in with the requirements of the Beach Groups (see Plate 2 and Table II).

I assumed wrongly that the equipment would come over more or less to schedule, and, therefore, all five causeways were started simultaneously. This was a great mistake, for by "D+8" (14th June) when all equipment should have arrived, we had only received :—

thirty-two out of eighty-one sinkers
thirteen out of forty-eight blisters
thirteen out of twenty-two tugs
Nil out of four warping barges.

The result was that the causeways were all short and, therefore, could not be operated at low tide. It would have been better if we had concentrated on completing one or two causeways first.

Our Naval Liaison Officer remained in the Isle of Wight and he had the thankless task of arranging for L.S.Ts. and other craft to tow our queer beasts across the Channel. They were unpopular tows, and frequently broke adrift, to be picked up later by Naval craft and generally towed back to the Wight for a second attempt. On our side too, our task was not easy. Sometimes craft signalled the Naval Beach staff that they had causeway equipment in tow, in which case we sent out one of our tugs to collect it, but generally no such signal was made—the craft were just cast adrift, or at the best anchored well off shore. Every day each company sent out a tug to patrol and look for tows, while I usually managed to do at least one search daily in my dory : slowly and painfully the equipment came in, and it was not until "D+29" (5th July) that we reached finality. By then we had received :—

sixty-eight out of eighty-one sinkers
forty out of forty-eight blisters
twenty-one out of twenty-two tugs
four out of four warping barges

We found one or two of the craft hopelessly wrecked on the cliffs near Arromanches, but the others disappeared into the unknown, including the tug T.26 *Titania* : whether they foundered or reached German held beaches we shall never know.

During one of the early search patrols the tug T.23 *Titmouse*, under

Lieutenant Bellamy of 583 Field Company, lost her bearings in the smoke screen which was usually put up at dusk and ran on a teller-mine attached to an under-water obstacle. One of the pontoons was destroyed and four others were holed. Part of the plastic armour was blown overboard and one helmsman, blown down by the blast, was lucky to escape injury. Finding that the tug would still just float and run on one engine, Lieutenant Bellamy moved off-shore and anchored till dawn when he brought her in for repair.

There was no enemy interference affecting our work, apart from a little very wild sniping till "D+2" or so (from small German pockets which were soon eliminated) and from nightly attention by the Luftwaffe which was more notable as a spectacle than as a source of danger.

The actual building and sinking of the causeways was put in hand on "D+2" (8th June). The first sinker was run ashore by a couple of tugs at high tide, water being admitted to the inshore tanks on grounding: the offshore end was left floating until the next sinker had been brought in and shackled to the first, end to end, when water was admitted to the rest of the first sinker and the inshore end of the second and so on. Once each sinker had sunk in position the water was retained in the tanks by a simple device, and this applied also to the blisters. We found it was possible to get three or four sinkers in position on each causeway in one tide, but speed of construction was always limited by the slow supply of material.

By "D+5" (11th June) Nos. 3, 5 and 6 causeways were in operation, followed by No. 2 causeway the next day. Trade started modestly: each causeway had been designed to handle 400 vehicles in twenty-four hours, but actual figures fell very short, not because the causeways could not handle the traffic, but because the Navy preferred to beach at high water: L.C.Is., however, were regular users, sixteen of them being handled on 12th June. (See photo No. 1). On 17th June, thirty-eight L.C.Ts. and 294 vehicles were handled at the causeways (see photo No. 2) and this remained the record for some time.

On 19th June the weather worsened, and only ten major landing craft were dealt with. Next day it was a heavy gale: traffic was at a standstill, and we worked hard to save our tugs from damage. Most of them we beached in safe places (see photo No. 4), but some suffered damage through other craft driving ashore on top of them. One stout hearted N-L tug skipper (a Lance-Sergeant who had formerly been mate of a Thames tug) had fitted his craft with a deck-house, and with adequate rations on board he put to sea and rode the gale out for nearly two days, lying to two anchors. Finally both his cables parted, so he got under way and neatly ran his craft ashore in a safe place, without damage.

On 23rd June the gale had died down sufficiently to let us operate the causeways again. Nos. 2 and 6 had been silted, scoured and shifted by the gale, but hard work and some re-aligning got them working again. Several sinkers and tugs had been holed and the Field Park Company detachment repaired these by welding.

Meanwhile, as expected, a causeway (No. 4) was ordered for Roger Beach near Ouistreham, and 65 Field Company moved there on 20th June, leaving behind a platoon to complete No. 6 causeway on Nan Beach under 582 Field Company. Owing to the gale, work was not started till 26th June and by 28th June the causeway was four sinkers long. On that day the Navy decided to abandon Roger as a working beach as it had always been shelled spasmodically from east of the Orne and showed no signs of improving, so 65 Field Company abandoned No. 4 causeway, which was never used, and returned to Nan Beach.

After the gale, the causeways, which were still growing in length, were also growing in popularity. On 29th June, twenty-four L.C.Is. and over 8,000 personnel were handled by them, No. 3 causeway on King Beach taking most of this type of traffic. On 30th June, eighty-one L.C.Ts. used the causeways and 879 vehicles were landed, 454 of them coming ashore on No. 2 causeway on Item Beach, while for the first three weeks of July a daily average of thirty-six major landing craft were handled, averaging 329 vehicles and 1,800 troops per day. This, of course, was far below capacity and we felt it was time we moved inland to do a more normal R.E. task. However, there was still much work to be done. 65 Field Company left the formation permanently on 12th July and 582 Company took over their causeway on Nan Beach, which, as a matter of fact, had so far only been used as a landing pier for small naval craft. Then on 16th July all work on Gold Beaches came to an end, so 584 Field Company took over No. 6 causeway and 583 Field Company were ordered to build a new one—No. 7—on Mike Beach (Red Sector). 582 remained operating No. 5 on Mike Beach (Green Sector). In order to build the new causeway the sinkers and blisters were lifted from the disused ones, including No. 4 on Roger, and used again.

Our N.L.O., Commander Middleton, had come over at the end of June when all the equipment had been dispatched, and he was instrumental in helping our liaison with the Navy and smoothing out difficulties. A sunken causeway can never be popular with those who have to operate craft on beaches, as it is only one more submerged obstacle ! One L.C.T. got stranded across No. 1, but was luckily refloated without damage. A worse incident occurred on No. 5 where a great L.S.T. sat squarely across the causeway, squashing a sinker flat and damaging her own bottom. The sinker was replaced and our welders repaired the L.S.T's. leaks between tides.

There was occasional light relief. A senior naval officer holding an important beach appointment had adopted an unorthodox type of dress, including army boots and socks, khaki shorts and a blue beret. He was very irritated over the slowness of one L.C.T. in coming alongside a causeway, and the moment the door was down he strode on board, waving a blackthorn cudgel, and expressed himself forcibly to the skipper-lieutenant R.N.R. who was acting as the causeway pilot : the latter, a former Fleetwood trawler skipper, did not improve the situation by replying :—" If you were a seaman you would understand the difficulty of the operation." As the pilot explained to me afterwards : " I thought he was some cavalry colonel ! "

On another occasion we overheard a conversation between a Beachmaster and an L.C.T. on R/T. It went something like this :—

L.C.T. : " I am damaged. Request permission to land my vehicles on causeway."

B.M. : " No, come in and beach."

L.C.T. : " I cannot beach ; flooded aft."

B.M. (angrily) : " I am NOT b— daft ! "

On 25th July our new causeway No. 7 on Mike (Red), was opened for traffic : it was double width over most of its length and proved a great success. An enterprising American L.C.T. flotilla commander had taken a liking to the causeways and with his co-operation the two causeways on Mike did a roaring trade, each taking over 300 vehicles per day.

But the rear parties of the formation had now joined us and we were glad to be away from the beaches, which now seemed very much out of the war, and on the evening of 29th July we handed over our causeways and tugs to No. 3 I.W.T. Group, who had been operating Rhino ferries.

It is worth noting that the tugs, with Murray & Tregurtha heavy duty outboard engines, were kept in good running order in very adverse conditions. Three of the twenty-two became total losses—T.26 *Titania* missing in the Channel, T. 42 *Trocadero* wrecked in the gale, T.23 *Titmouse* damaged by mine and later a total loss in the gale. One, T.33 *Torridon*, lost her engines, which were not replaced, and the remainder, eighteen in all, were handed over in serviceable condition to No. 3 I.W.T. Group. Of these eighteen, three had been re-engined, so that after four months gruelling use, maintained only by our own fitters, fifteen of the tugs were kept in service with their original engines, a fact which says much for their reliability. The four warping barges had hardly paid a dividend, though they succeeded in refloating four or five neaped and stranded L.C.Ts. after all naval efforts to refloat them had failed.

In all, the causeways had handled 1,606 major landing craft. 13,947 vehicles and 115,000 troops had been landed across them, so perhaps they justified their existence. Had the beaches been muddy and impassable they would have been a real asset, and could have handled at least 50,000 vehicles, but as it was they were merely a luxury, and an awkward luxury at that. The formation left the beaches feeling that they had not really justified their existence : but now, looking back at it all, no doubt they feel, as I do, that the causeway party was sufficiently unique to be worth while.

TABLE I. TYPES OF N-L CRAFT USED FOR CAUSEWAYS

Name	Length	Beam	Depth	Draught	Displacement	Remarks
Sinker 2 × 30	175.7 ft.	14.1 ft.	5.0 ft.	1 ft. 8 in.	90 tons	All converted to blisters.
Floater 4 × 30	175.7 ft.	28.3 ft.	5.0 ft.	1 ft. 8 in.	180 tons	
Blister 4 × 10 (Type 1)	58.7 ft.	28.3 ft.	5.0 ft.	1 ft. 8 in.	60 tons	
Blister 4 × 10 (Type 2)	56.7 ft.	28.3 ft.	5.0 ft.	1 ft. 8 in.	59 tons	
Tug 3 × 7	43.5 ft.	21.2 ft.	5.0 ft.	6 ft. 11 in.	39 tons	Two 120 B.H.P. engines, Twin Screws, 7 knots, static pull 3 tons. Draught given is for propellers fully lowered. Minimum draught 3 ft. 4 in.
Warping Barge 7 : 12 : 7	72.2 ft.	21.2 ft.	5.0 ft.	2 ft. 9 in.	67 tons	Fitted with 120 B.H.P. Skagit Winch, 4½-ton anchor and 25-ton anchor cable

TABLE II DETAILS OF CAUSEWAYS ACTUALLY BUILT

Causeway No.	Beach	Place	Length yds.	No of Sinkers	No. of Blisters	Tidal range of Operation	Date opened	Date closed
1	Item	Le Hamel	469	8	7	15 ft.	26 June	15 July
2	Item	Le Hamel	411	7	5	11.5 ft.	12 June	8 July
3	King	Ver-sur-Mer	939	16	7	19.5 ft.	11 June	17 July
4	Roger	Ouistreham	236	4	—	—	Never	Opened
5	Mike (Green)	Graye-sur-Mer	763	15*	8	19.0 ft.	11 June	After July, 1944
6	Nan	Courseulles	880	15	8	12.8 ft.	11 June	
7	Mike (Red)	Graye-sur-Mer	694	19†	8‡	19.5 ft.	25 July	

* Two sinkers used side by side to form long blister as in Plate 1.
† Seven pairs of sinkers used to form double width causeway for part of the length.
‡ Blisters used together in pairs end to end to form four long blisters.

B.R. or B.M.?

An Imaginative Solution of the Transport Problem

By "MONSTROVIAM"

THE voice of the scientist is heeded increasingly in national affairs, and a plea has recently been made for adding to it the voice of the engineer.* But within that plea there lay the imputation —almost an admonition—that engineers have tended to become docile servitors, content to wait for, and in due course translate into reality, the visions *of other people*: in fine, that engineers are reluctant themselves to point the way. Here, then, is an example of reluctance overcome.

* *R.E. Journal* Vol. LXVIII, No. 1, March 1954, pp. 2, 3.

PART 1

A recent casual reference in the press to a bus service scheduled to cover 88 miles in 78 minutes and "never been late yet" brings home to us how much we are missing in not having motor-ways. That bus service runs on one, in the U.S.A., between Tulsa and Oklahoma City ; motorways are nicely termed turnpikes over there.

Imagine Britain laced with roads safe for speeds of that order: Gloucester 8 a.m.—Bedford 9.18—Norwich 10.36. How we should get about ! It may not be a prospect of immediate appeal to quite everyone, and a first reaction may be to say that the difficulty of finding land and effort for new motorways in this busy, crowded island prevents it from being a prospect at all. But a British motorways system would be entirely beneficial and is strangely practicable, as will be shown at first in this Part in lay manner and then, in Part 2, a little more technically.

To simplify the arithmetic of it let us take the average speed of that bus service as 60 m.p.h. instead of its actual 68 m.p.h.

First we'll think of a number : 20,000 M(million) passenger-miles a year, and work out how many 60 m.p.h. 30-seater buses can produce them, employing perpetual motion. It comes to 1,250 ; but perpetual motion is theoretical ; to be practical we'll multiply the figure by 20, and say that a fleet of 25,000 buses, working to capacity for one-twentieth of their time, will yield 20,000 M passenger-miles annually.

Now let us think of just one more : 22,400 M ton-miles of freight traffic per year. The number of 60 m.p.h. 10-ton lorries required for them comes to 4,250 theoretically, or 85,000 practically—allowing the same pessimistic 5 per cent employment factor as with the buses.

The interesting thing about the numbers we first thought of is that they happen to be British Railways' annual traffic, in the handling of which there are engaged the following vehicles :—

Locomotives	19,000
Passenger coaches	42,000
Powered coaches	2,000
Other coaches	15,000
Motor vehicles	36,000
Horsed vehicles	8,000
Freight wagons	1,120,000

That makes a total of 1,242,000, so there is no need for anyone to look aghast at the total of 110,000 buses and lorries required by British Motorways to do all that British Railways do. Indeed, having regard to the sheer weight of fabricated material that goes into the respective vehicles, does not this comparison reveal at once a case for *converting British Railways into British Motorways*?

At any rate the comparison surely disposes of any argument that the present railway traffic could not be handled. Nor will the motorways be crowded by it. There are some 20,000 route-miles of railway waiting to be turned into 20,000 miles of motorway, yielding 320 yards per vehicle of the 110,000 fleet. It has been worked out that there are only sixty yards of public road for each of the 5 million vehicles in this country, and we are not chock-a-block. If we are nearly so, it is only a further argument for providing the extra 20,000 miles which would, of course, be available to private and commercial vehicles (of tested roadworthiness) on payment of toll to British Motorways.

We must not underestimate the magnitude of the task of converting the railways. It may amount to fully one-tenth of what our great-great-grandfathers accomplished in constructing them initially. In return for this tremendous outlay of effort, however, we can expect to be rewarded with motorways as superior to our present roads as railways were to the rough, dusty and muddy roads of a hundred years ago.

It is not merely that the converted railways will be devoid of slow traffic, and free from hills, corners, cross-roads and accident "black spots" generally. We can expect the chief contrast with the roads we know to-day to be in the quality of the surface. In the main the road foundation is ready-made, in the form of permanent way consolidated by more than a century of rail traffic. On this the Civil Engineering profession, guided by the Road Research Laboratory, will certainly be able to produce roadways of such evenness that, in retrospect, railway travel will seem to have been unbearably jolting and noisy. And this is not just a matter of comfort. Perfection of surface minimizes not only discomfort, but also tractive effort and wear and tear of both road and vehicle—which brings us to the economics of the proposition.

Road transport, even as we know it to-day on crowded, ill-designed roads, is so healthy an institution that it not only pays for itself and for road upkeep, but also produces about £200 million for the Treasury yearly. The passenger and freight services of British Motorways will be operating under infinitely better conditions, and being nationalized will hardly be expected to support the Exchequer to the same extent, so there can be no question of their financial health. In addition B.M. will draw gratuitous toll revenue which, on American turnpike experience, or even on our own Mersey Tunnel experience, will more than cover motorway upkeep and interest charges. Briefly, since public-road transport pays, motorway transport must pay—better. Through it we can hope for lower fares and lower freight charges, which we can never hope for otherwise.

Before leaving the subject of costs let us consider just two aspects of railway costs *vis-à-vis* motorway costs. First : the manning and maintaining of 20,000 miles of intricate railway signalling equipment. B.R. intend spending £17 million merely on modernizing it. B.M. will need virtually none. Secondly, B.R. pride themselves—rightly, for a railway—on their freight trains averaging 605 ton-miles per engine-hour : the motorway equivalent can be a single 10-ton lorry running at 60½ m.p.h.

Now for passenger traffic, which is very much *our* subject, for are we not the experts—expert passengers ? Let us imagine that all our lives we have been catching the 8.21 a.m. from A to B, and we refuse to be broken of the habit. Very well : B.M. can arrange for a number of buses to be lined up, just like the original train, in station A, ready to set off for B at 8.21. We could hardly object to being required to fill the front buses first ; indeed we should do so voluntarily. Nor could we object to the front bus moving off when full, even though the time were only 8.18. And if we were late that morning and reached the station at 8.22, we should be aggrieved to learn that the last of the string had been sent off empty at 8.21. The principles emerge : no timetables, buses employed as required, all full, hence a load factor of 100 per cent—which is sufficient to make a passenger traffic manager's mouth water, without contemplating variants such as trailers, first-class taxis, sleepers, or epicurean dining cars. Small units of pneumatic-tyred transport give us the continuous flow or magic carpet effect. And why, in this atomic age, should not something magical be introduced into our daily transport ?

There will be a mischief in freight traffic, however. British Motorways will never play free warehouseman to industry as British Railways do, holding their customers' goods for days and weeks in shunting yards and sidings. Goods handed in at one end may come out at the other too soon for pilfering even ; consignor and consignee may need to be much quicker at filling in their forms ; it will all be very strange at first but one can detect certain compensations.

For the present only one other aspect of the metamorphosis will be considered : that of the railwayman become motorwayman. His staple job will consist in driving the finest and fastest public service vehicles on earth. At last the common run of waymen will play a direct part in conveying people and things along the ways. A driver's daily output might amount to 10,000 passenger-miles or 3,000 ton-miles. Others may care to work out what his income tax or super tax might be under a fair system of payment by results ; we'll conclude this Part on the subject of his morale, with which is bound up the important and (for B.R.) difficult business of recruiting.

Do you remember how you wanted to be an engine driver ? The youngsters of the next generation—or next but one ?—when they are sizing up the big outside world ; deciding what is a real man's life ; watching the sleek, streamlined, turbined vehicles glide by ; will surely be extraordinary little fellows if they don't sometimes end their " I want to be " with " a British Motorwayman," *and* in due course compete for entry into this new aristocracy of the transport world.

PART 2

If, despite Part 1, the reader's mind remains shut against the conversion of railways into motorways it may not be due altogether to conservatism, nor to awe at the magnitude of the task. But it may be due partially to certain optical illusions whereby railways nearly always look narrower than they in fact are, and roads wider.

This article must not be overloaded with known and knowable facts, but we should perhaps remind ourselves at the outset that the normal formation width of a double-track railway is between twenty-seven and thirty feet—single-track sixteen to eighteen feet. These measurements relate merely to the levelled formation, of course, not to the total width of real estate owned by the railway. Even bridges and tunnels may not be quite the bottlenecks they look. However, it is not proposed to make play with the fact that two motor-cars could pass in a single-track tunnel or bridge, or that double-decker buses are not entirely ruled out. Many of the most interesting engineering problems will arise at these points.

It is proposed, though, to establish that the private motorways of a concern such as British Motorways need bear no close resemblance to the public autobahns or turnpikes of other countries. In the first place, having been laid out as railways, they will not have hills to engender overtaking, nor corners or humpbacks to unsight the driver. Then they are fenced throughout, so that there can be no unauthorized access to them, and B.M. will be under no obligation to accept any traffic that does not conform to their own standards. These standards will be high in respect of roadworthiness and speed capability of vehicle, and in respect of driver proficiency. The sum of it is that whereas elsewhere vehicles perpetually get in one another's way, so that fast roads have to be extremely wide or dual-carriageway, on our motorways the phenomena that call for great breadth of roadway will be absent, and, except within towns, it would merely be extravagant and wasteful to build them wide. Within towns the railways are already multi-track, readily convertible into multi-lane motorways of width appropriate to the density of traffic.

Exactly how wide the motorways should be is a topic without precedent, for nowhere does there exist at present the uniform, well-disciplined type of traffic that will use them. We get a pale reflection of it in, say, the Mersey Tunnel. There the main tunnel is 36 ft. wide between kerbs, marked off into four 9-ft. lanes; the branch tunnels, for two-lane traffic, are 19 ft. wide. Since these dimensions prove satisfactory (for close on 8 million vehicles a year), under imperfect conditions, they certainly need not be exceeded for an open-air motorway. Greater speed is no reason for widening the standard lane; rather the reverse, for the faster you go the more difficult does it become to depart from a straight course, and a curve can be virtually straightened out by well-designed banking. Accordingly it seems that the basic two-lane motorway can safely be 18 ft. wide; the three-lane 27 ft., corresponding to a double-track railway formation unwidened.

The discipline envisaged need not be harsh. Only a few simple rules will be required, such as :—

(*a*) No dawdling—a standard minimum speed of perhaps 60 m.p.h.

(*b*) No halting except in an authorized lay-by or shunt lane in a station, leaving the through lane clear.

(*c*) No overtaking at all on a two-lane motorway.

(*d*) Only uni-directional overtaking allowed on a three-lane motorway, e.g., for 5 miles in one direction, then for the next 5 miles in the other, and so on, possibly varied throughout the day to suit "rush hour" traffic.

(*e*) On all multi-lane motorways a strict "keep in lane" rule except at clearly marked places where transfer to the adjacent lane is specially permitted.

It is perhaps as well to touch on the carrying capacity of motorways; here and there the extraordinary notion lingers on (from horse-and-cart days ?) that railway capacity exceeds road capacity. The basic consideration is that each lane of a motorway—or of any comparable stretch of road—is worth 1,000 vehicles per hour. They may be twenty-five yards apart at 15 m.p.h., or fifty yards apart at 30 m.p.h., or one hundred yards apart at 60 m.p.h.: speed scarcely matters. Accordingly a mere three-lane motorway being used by 30-seater buses can pass 90,000 passengers an hour, or, being used by 10-ton lorries, 30,000 tons an hour. And if the motorway were formed from a double-track railway probably no very great engineering problem would be met in adding a fourth lane which would send the figures up by one-third. The reader can himself complete the comparison from any railway treatise, and will beyond doubt satisfy himself that, great as were the achievements of railway trains in the nineteenth century, they are, in this mid-twentieth century, only an encumbrance, monopolizing "ways" that could be put to far better use.

A metropolitan passenger terminus become bus station, possibly with platforms removed and turntables where the buffers were, will present a fine field for organization. Extending the example from Part 1 into the evening rush hour, and equating, say, a ten-coach train to twenty buses : the basic problem is to dispatch the old trainload of passengers from Platform 17 (now Lane 17) once every twenty minutes. Railway operation proves that the necessary twenty buses could be so dispatched if coupled together. How very much simpler it will be to send them off one at a time, spread over the twenty minutes. Actually, with good organization, a hundred or more could be so dispatched, if necessary, in that one lane within that same time, indicating the greatly increased passenger dispatching capacity of the terminus. It would all be done smoothly, too, in a steady flow.

Could toll traffic be allowed to use a city terminus ? It is an interesting question. City authorities always wish to minimize private car traffic in their central streets, so there will be pressure on B.M. to allow *outward* bound traffic through a terminus, but not *inward*. Inward bound cars might be compelled to quit the motorways on the outskirts of the city, though in some instances they might be allowed deeper in, to vast car parks on the redundant portions of the marshalling yards. A very considerable acreage of railway land will come free, mainly because road vehicles can manœuvre—a simple characteristic though beyond price.

A good place to continue these ruminations—if you felt so inclined—would be alongside a road bridge over a railway, at the same time comparing the traffic on the poor, curly roadway with what passes along the beautifully engineered way below. And when at length some 400-ton train comes flashing by, do not be mesmerized by it. It is a fine sight, but, for all you know, it is carrying only a couple of buses' worth of passengers and a few boxes of fish. It is travelling more slowly than it used to ; it is burning, in locomotive or power station, tons of exportable coal to do what a few gallons of petrol could do ; it is the instrument of vested interests trading on the fact that in tractive effort and many other respects it is a better proposition than a four-in-hand stage coach.

Before the next train comes along you will have plenty of time to turn over in your mind many of the fascinating problems some engineer will eventually meet in putting that train-way to modern use as a motorway. The pavement—concrete, or what ? If concrete, prefabricated, prestressed, or neither ? The lighting. Possibly the heating (anti-frost). The sequence of work. The plant. The salvaging of rails and sleepers. The time—ten years, or twenty, for the entire country ? The cost—forget that. It is something we cannot afford *not* to do.

PAST AND PRESENT AT THE SCHOOL OF MILITARY ENGINEERING, CHATHAM

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

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LIKE many other institutions in the army, the School of Military Engineering has its origins in the Peninsular War. "The Sieges carried on by the British in Spain," writes Napier, "were a succession of butcheries, because the commonest means and materials necessary to their art were denied to the engineers." It was not only lack of materials. At that time the proper function of engineer troops in operations was only beginning to be perceived. The Royal Engineers was a Corps of Officers ; the rank and file required for an operation were scratched together from the Royal Military Artificers and, to a larger extent, from "carpenters and miners" detailed from the Infantry. Led by R.E. officers, these improvised parties of almost untrained men formed the spearhead of the assault on heavily defended fortresses. In numbers, too, they were utterly inadequate. The Engineer order of battle for the first assault on Badajoz for instance, was thirty-three R.E. officers, twenty-seven N.C.Os. and men of the Royal Military Artificers, and eighty-four carpenters and miners attached from the infantry.

The heavy casualties and frequent failures of these gallant little parties led to lack of confidence and a loss-cutting policy ; Field-Marshal Sir John Burgoyne, himself a Sapper, called it "that miserable doubting policy of small storming parties—on the grounds that if we fail we can't lose many men—which causes more mischief, loss and disgrace than any other proceeding in war."

One of Sir John Moore's aides-de-camp, during the retreat to Corunna was a young Sapper officer named Charles Pasley. The bitter events of the campaign had convinced him, and some others of his brother officers, that a far-reaching reorganization of their corps was needed. They had, in fact, arrived at what was then a new conception of the function of engineers with an army in the field—one that demanded a rank and file, trained individually as sappers and collectively, under their own officers, as units of a fighting arm. Pasley (later General Sir Charles Pasley, K.C.B.) was destined, not only to have his ideas accepted but, by becoming the founder and first Commandant of the S.M.E., to be the chief instrument in effecting them.

In 1808, on leave in England, he wrote the first two chapters of his famous *Essay on the military policy and institutions of the British Empire.* That same year he was in Spain, and in the following one he accompanied Lord Chatham on the Walcheren expedition. There, whilst leading the assault on Flushing, he was smitten, literally hip and thigh ; in the former by a bullet and in the latter by a bayonet. He was got back to England and in two years had recovered ; though he was never fit for active service again.

By this time Captain Charles Pasley, R.E., was a man whose views commanded respect—though they do not seem to have helped his promotion—and he could give them forcible expression. In 1812 the Royal Engineer Establishment at Chatham was authorized. Pasley, with a brevet-majority, was appointed to organize it ; and he remained in charge for twenty-nine years. The first batch to pass out was formed into a Company of Sappers and sent out to the Peninsula, where, with the soubriquet of " Pasley's Cadets," they earned fame at the siege of San Sebastian and subsequent actions.

We get a characteristic glimpse of Pasley and of his devotion to his Corps in the first standing orders for the school. " Officers of the Royal Engineers," he wrote " are always to consider themselves on duty. Even if no positive task should be assigned to them, they ought to feel so much the importance of their situation and the character that they have to support in the Army, that they ought voluntarily to occupy themselves in the study of their profession and of military affairs in general."

The school, so largely the creation of a junior officer, was to become the fount of engineer doctrine and training, not only for Sappers but to some extent for the army as a whole. For it was soon realized that much of the elementary engineering required in war could, with a certain amount of training, be done by troops of all arms. Thus, at a later date, the name of the R.E. Establishment was changed to the more appropriate one of The School of Military Engineering ; and under this name it became recognized as the leading scientific military school in Europe.

In the early years of the nineteenth century the barracks at Chatham were shared with the Royal Artillery. Some pieces of silver, now in the R.E. Headquarter Mess, date from the days of the combined Gunner-Sapper Mess. The association was broken—one hopes with no hard feelings—owing to a difference of opinion about the hour of dinner in the Officers' Mess. The Sapper officers wanted their dinner-time to be altered, on some occasions to conform with the tides ; and on others with the position of the stars. Without this, they maintained, their training in bridging and survey respectively would suffer irreparably. The Gunner officers, who were unaffected by these matters, wanted their dinner at the proper time—the

Prince Regent would no doubt have sympathized. And so, eventually the Gunners, who by this time had become a small minority, moved out and a few years later the Headquarters Royal Engineers, which had up to that time been at Woolwich, moved in.

This association of the S.M.E. with the headquarters of the Corps has existed, to some extent, ever since. It became more complete with the disappearance of the mounted branch of the Corps, which until 1938 had its headquarters at Aldershot. The eclipse of " the galloping bricklayers " was a sad break with tradition ; but it has made for unity within the Corps and has focused loyalties more strongly on Chatham, where the S.M.E., the Corps Headquarter Mess and the Institution of Royal Engineers, with its library and museum, are all situated.

At Chatham, under the aegis of the S.M.E., the majority of the Corps' social and sporting activities are concentrated. The R.E. Yacht Club, the oldest in the Service, has its headquarters on the River Medway: so also has the Rowing Club. The Sappers, as in pre-war days, keep a pack of hounds in Brompton Barracks, and hunt a drag in country borrowed from the West Kent and Tickham Hunts. The R.E. Draghounds Point-to-Point has again become a well known fixture in the county. Riding is made easier for the young officer at the S.M.E. by the R.E. Saddle Club which, though it has branches in other parts of the world, has its headquarters at Chatham. So also has the R.E. Flying Club, which keeps its aircraft at Rochester Airport ; and the R.E. Gliding Club whose headquarters are at Detling, near Maidstone.

The Medway towns—Rochester, Chatham and Gillingham—nowadays form an immense, and expanding, built-up area. Anyone driving his car down " A2 " in summer is made painfully aware of this fact. It produces obvious difficulties for the S.M.E.—both for training and for many forms of recreation. But the difficulties are surmounted ; or in some cases ignored, as in the S.M.E. Shoot, at which visiting guns may be surprised to find themselves facing a row of suburban houses ; and, on a good day, further surprised at the number of partridges which—driven out of allotments and even back-gardens—come scudding past the chimney pots.

In 1941 the greater part of the S.M.E., though not its training workshops, left Chatham ; the Navy became tenants of Brompton Barracks for " the duration," and most excellent tenants they were. In Yorkshire the School found a war-time home in a large modern camp on the outskirts of Ripon. Here were good quarters ; and good training grounds on the doorstep. Many Sappers have happy memories of the lovely West Riding countryside ; and of the courtesy and friendliness of its residents, of which an expression was the grant of the Freedom of the City of Ripon to the Corps.

At the end of the war the possibility of a permanent move was once more considered (it had been mooted as long ago as 1903). Sites in Hampshire or Wiltshire were proposed as being nearer the Army's centre of gravity in peace-time. Of the many suggestions, Blandford and Poole Harbour were the most heavily tipped. Neither of them entirely filled the bill, and the Treasury shied violently at the cost. So, in 1948, the S.M.E. returned to Chatham and, with some spreading here and there, settled down very happily again in the place of its birth.

To-day, the School has expanded far beyond Pasley's original foundation. He would doubtless recognize the lineal descendant of his establishment in the present Field Engineer School. This, since the war, has moved out to Gordon Barracks on the outskirts of Gillingham, where, together with the National Service Cadet Squadron, it forms part of the 11 S.M.E. Regiment. Here the main subjects studied, and taught to other arms as well as R.E., are bridging, demolitions and field-defences.

In Chatham itself the former infantry barracks, now Kitchener Barracks, is occupied by another regiment of the S.M.E. This is the Trades Training Regiment, responsible for the individual training of the rank and file in trades mostly undreamed of in the days of the Royal Military Artificers. The nearby S.M.E. Park (officially Workshops) is the scene of most of this training, but the regiment also has a large area for operating its earth-moving plant at Wainscott, beyond the Medway.

Though the S.M.E. is thus widely spread about the environs of Chatham, its heart remains at the barracks on Brompton Hill, where Pasley originally founded it. This hilltop must always have been an important site in the defences of the Medway estuary. Many of the old fortifications remain: massive brick affairs with fine resounding names—demi-bastion and triple redan, blunted lunettes and counter-scarp galleries—terms of common parlance to eighteenth century military engineers, but nowadays only to antiquaries and the makers of crossword puzzles. One of the larger forts is now the United Services Lawn Tennis Club—a surprising and successful adaptation ; there can be few tennis clubs set in more delightful surroundings. A network of underground passages connects these old defence-works. Late one guest-night a party of young officers lowered themselves through a hole in the floor of the mess basement and vanished. They surfaced, according to their story, half a mile away in the married quarters of the Royal Marines Barracks. After that, to the vexation of subalterns, the passage was bricked up.

Among these examples of the art of former military engineers, Brompton Barracks were built at the turn of the eighteenth century. There are later additions : for instance the somewhat oriental

Electrical and Mechanical School. (Whenever the services try a little originality in their architecture some unkind story develops ; this particular building, originally a Naval Signals School, was—we are sure—never intended as the Royal Naval Hospital, Bombay.) For better or worse it is out of sight from the barracks proper. In full view, however, facing the barracks, of agreeably weathered brick-work with terra cotta ornamentation, there stands the Headquarters of the S.M.E.

This building, which dates from the 1870's, houses, besides the S.M.E. main offices, the Tactical School, the Civil Engineering School and the offices of the Institution of Royal Engineers. Until the war it also contained the Survey School (now in Berkshire), and that odd appendage to its establishment—a spider farm. The spiders were of a variety producing the very fine but strong web used for the grid lines of survey instruments. They occupied a dark and secluded room in the basement ; it was a macabre little establishment.

Also in the headquarters' building was an impressive, but singularly ill-ventilated, semi-circular lecture theatre. In it, many generations of young officers have been able to sleep or doze, in spite of the extreme discomfort of the seats. It is now being converted into a library, its place as a lecture theatre having been taken by an up-to-date study centre.

In front of the headquarters building stands the well-known bronze statue of Gordon on his camel. He looks across, through two memorial archways and past the obelisk commemorating the two Great Wars, to the parade ground of the sedate and dignified Georgian barracks. Outwardly these have changed little in 150 years (nor until comparatively lately had there been much change inwardly). " The old place doesn't alter much does it ? " say the old Sappers on Veterans' Day—and they at any rate seem happy to find it so.

Until the late war every dismounted Sapper of the rank and file did his recruit training from Brompton Barracks. The training lasted ten months, of which eight weeks were " on the square." It was a hard school, but it turned a boy into a man—" a man " in Kipling's words, " who does something all round, with the rank and the pay of a Sapper." So Brompton Square, to old Sappers, is a place of sentiment and legend ; and, once a year, it is a place of pilgrimage where, for a week-end in the summer, R.E. Veterans assemble for their annual reunion. Each year they come in their hundreds, and on Sunday morning they put on their medals and march (officers with billy-cock hats and rolled umbrellas) to the Garrison Church near by. After the parade service they give an eyes-right to the Chief Royal Engineer and then, to the strains of " The Boys of the Old Brigade," march on to Brompton Square to be addressed. On the previous evening if it is fine, tables are set round the parade ground and here, after an indispensable visit to their former barrack room (and sometimes a scornful comment on its curtains and bedside tables), the veterans sit under the old lime trees and meet old comrades ; whilst the R.E. Band, last survival of scarlet, plays the sort of music that goes with the slow consumption of pints. And when the sun sets, Retreat is sounded and the guard-room flag is hauled down. It is all very pleasant and not a little moving. It has the flavour of a school speech day, with the same unexpressed but unmistakable affection for the " old School."

The Barracks are now occupied by the 12th S.M.E. Regiment—the third of the three regiments in which the S.M.E. is organized. It holds staff and students of the Civil Engineer School and the Electrical and Mechanical School ; and as the majority of these are destined for non-commissioned rank, mainly in the Engineer Services, it has a considerable N.C.O. training commitment. The unit also functions as the Headquarter Regiment of the S.M.E., the Commanding officer having anything up to a hundred young officers in his care.

Brompton Barracks still remains a traditional and ceremonial centre of the Corps. In the past it was the scene of reviews of the Corps by its Colonel-in-Chief ; and doubtless will be again. On its parade ground the passing off parades of the National Service Cadet Squadron R.E. are now regularly held, and watched by a good muster of parents. Here, in 1953, took place the ceremony—recorded on television—when the Freedom of the Borough of Gillingham was conferred on the Corps.

From the rows of old lime trees which so pleasantly margin the parade ground, one tree, on the north side, is missing. This marks a brave effort of a Royal Air Force pilot—shot down and killed in September, 1940, during the Battle of Britain. Unable to reach open country and knowing that if he baled out his Spitfire would crash in the crowded streets, he chose to stick to it, and to put it down on Brompton Square, where the chances were it would not do much harm. He can hardly have hoped to save his own life, but he almost certainly saved the lives of many others. One night a week later a stick of bombs fell across the barracks, hitting two buildings, with a sad toll of Sapper casualties.

On the north side of the square is the former chapel with its surprisingly elegant Regency interior. It is now the R.E. Museum which, together with the Corps Library, is under the management of the Institution of Royal Engineers. It contains a remarkable and varied collection—from Gordon's " Yellow Jacket " to a working model of the Mulberry Harbour.

From the terrace of the H.Q. Mess garden there is a fine view of river, town and countryside. Chatham, with its river and dockyard, lies below, usually veiled in mist, above which rise the towers of Rochester's Cathedral and Castle. Both of these were the work of Gundulph, Bishop of Rochester in the reign of William Rufus. He was a great builder, not only of cathedrals but of fortresses—one of the latter being the White Tower of the Tower of London. As the first holder of the title " King's Engineer," he may be regarded as the predecessor of the present line of Engineers-in-Chief. So it is fitting that the Royal Engineers annual memorial service is by tradition held in Rochester Cathedral ; and that the large artificial lake constructed recently for bridging training should be named Gundulph Pool.

Immediately below Brompton Barracks is the oldest part of the R.N. Dockyard, with the 300-year-old covered slipway (now a store) in which H.M.S. *Victory* was built. Beyond it the Medway flows through Upnor Reach, where generations of Sappers have learned their watermanship and pontooning. One of the former parsons of Upnor, in the sixteenth century, was a Mr. Drake, whose boy, Francis, must here have learned his watermanship, and perhaps his love of a seafaring life. It was in Upnor Reach that, on a black day in 1667, the Dutch set fire to a number of H.M. Ships at anchor there, and towed away as a prize H.M.S. *Royal Charles* (the *Vanguard* of her day)—an incident that greatly shocked Mr. Pepys, and indeed the whole country. Pepys as Charles II's Secretary of the Navy was a frequent guest of the Dockyard Superintendent at his quarters " The House on the Hill." This house, long since swept away, must have been not far from where the R.E. Mess now stands. But Pepys, running true to form, tells us more of his host's daughter than of his house.

To-day, Upnor Reach, and the Gundulph Pool which adjoins it, play a large part in the activities of the S.M.E. In the tide-way men get their training in handling boats, pontoons and rafts in a current. Once a year the Sappers and the Navy compete here for the Warren shield—a whaler race over a course of 1½ miles. In the fifty-five years since it was instituted the trophy has been won an almost equal number of times by each. Under the walls of Upnor Castle, the R.E. yachts are moored, and from the boathouse on Upnor Hard the clinker fours come out on summer evenings to practise for Henley.

The R.E. Headquarter Mess is still in the building that housed the combined Mess of 1812. It has been greatly enlarged and improved over the years, but keeps something of the air of those spacious days. It owns a fine collecton of pictures and silver, and at least two pieces of furniture which, in very different ways, are of historical interest. At one end of the dining-room is " Gordon's Throne "—so called because acquired by Gordon (then a Captain R.E.) at the Sack of

Pekin in 1860. It is recorded that when the Summer Palace was ablaze permission was given to the troops to keep " such objects as they could rescue from the flames." The throne, which is magnificent and almost certainly unique, is in the form of a heavy and intricately carved sofa. It must have taken a deal of rescuing.

At the opposite end of the dining-room from Gordon's throne stands " The Gauge." This is a piece of furniture of the species—seldom seen nowadays except in auction rooms—known as a " dumb waiter," with three open shelves. It is of no intrinsic value but is of sentimental interest to all regular Sapper officers—for all have been through it. Normally the Gauge stands unobtrusively against the end wall, beneath the portraits of Burgoyne, Gordon and Kitchener. On it, during dinner, Wallace the Mess butler, keeps such items as decanters of port and boxes of cigars. (Wallace having served the Mess continuously for forty years, has himself become something of a tradition). But on " Batch Nights," when the officers of a newly joined batch from Sandhurst are introduced to the Mess, the old Gauge comes to life and is the centre of a curious and traditional ceremony. Towards the end of dinner, when the tablecloths have been whipped off the long mahogany tables, the Gauge is wheeled out into the ante-room. Each newly joined subaltern is then initiated into the Corps by being " gauged." This consists in swinging him to and fro between the two bottom shelves of the Gauge : his brother officers assist by beating him to the necessary degree of flatness with rolled-up newspapers. The space between the two upper shelves is rather larger, and is used sometimes for gauging field-officers on promotion. There is no record of anyone being irretrievably stuck in either gauge, though some field officers in the past must have been glad of the extra inch or so allowed them. The top of the Gauge is reserved for Generals who may, on special occasions, be hoisted on to it ; and are then expected, if unable to sing a song, at least to make a speech.

The young officer who emerges from the lower shelf of the gauge has a long period of academic training in front of him. It may be as much as three years before the S.M.E. sends him out into the world to gain the indispensable, and enjoyable, experience of working with, and for, the other arms. Three years is a large bite in the career of a young officer ; but an engineering training, particularly for the Sapper, must take time. The regular Sapper officer still must master almost every branch of an increasingly complex subject. Any descent into specialization, by the young officer, would reverse the traditions of the Corps and completely alter its character. The Army has always expected the Sapper—even a young one !—to produce the answer, particularly to anything new or unexpected, over a very wide field. This is a great tradition of the Corps ; but to maintain it in this atomic and jet-propelled age presents an increasingly difficult problem. In providing the broad scientific education which is indispensable for the young Sapper officer, other seats of learning, besides the S.M.E., play a valuable part. The young officer may go on to Cambridge University, or the Royal Military College of Science, and get a degree in engineering. Or he may take a shorter course at the latter, return to the S.M.E., and then take a final examination ; he will in this way gain the same exemptions as conferred by a degree, from the examinations for associate membership of the Institution of Civil Engineers. For the National Service officer an academic training of such length is obviously out of the question ; but he gets a grounding at the S.M.E.

In the Headquarters Mess at Chatham there is much coming and going of these young officers on their courses ; among them there are frequently officers from the Commonwealth. In addition, there will be other R.E. officers back on visits or courses, and officers from friendly powers : from the N.A.T.O. countries ; from Burma and Jordan, Iraq and Israel ; and instructors on exchange from the U.S. Corps of Engineers and the Arme du Génie of France.

In peace-time, no arm of the service is more widely dispersed than are the Royal Engineers. For them, the motto " Ubique " has an even wider sense than " Wherever the Army is to be found." They are to be met in the oddest and most remote places ; on survey duty with colonial or international boundary commissions ; as navigators or surveyors on explorations or arctic expeditions ; on duty with civil firms building bridges, roads, railways, dams, in any quarter of the globe. For Sappers, the S.M.E. is the hub of a wheel whose spokes reach a long way across the world. The Mess is a great meeting place, and one seldom goes into it without finding there a traveller returned.

JORDAN HOLIDAY

By " BATTLEDRESS "

IF you look at a map of that part of the world known as Middle East, you will see, where Africa marches with Asia, a Churchillian " V " sign at the northern end of the Red Sea. The right-hand finger of the " V " represents the Gulf of Akaba. That, and the fact that the summer temperature in the region bids fair to rival a crematorium, was the sum total of my knowledge of the locality, when I found myself involved in a party whose primary destination was Akaba.

At first the prospect filled me with trepidation, but when I learned that the duration of our stay was to be limited to four days, I consoled myself with the thought that we might be blest with a north wind to keep the temperature down during that short time. I discovered, too, that we were going to fly in, which would avoid any protracted sea journey under unpleasant conditions of climate and latitude.

By the time preparations were completed, I was almost looking forward to the trip. Bathing, I had heard, was superb, provided one kept within one's depth, where the sharks were loath to make a pass at a land-lubber and where coral reefs could be seen in the clear water, entrancing in their colours and conformation.

We took off at early dawn, climbing steadily to 8,000 ft. in still atmosphere, till we were droning over the arid wastes of Sinai. I wondered how any considerable body of people like the Israelites could have survived their journeyings in such a terrain. Standing out in relief below us were the hills and wadis of a country apparently naked of any vegetation and obviously permanently devoid of water. That pilgrimage must have been a miracle indeed.

Presently we were losing height and starting to buck about in the changing air currents flowing upwards from the hills below, brown and red in colour, serrated and cracked as though the combination of heat and cold had tortured them down the ages, as indeed it had. We came swaying through a gap with the jagged peaks level with the wing tips and the incredible blue of the Gulf of Akaba ahead of us. Then, in a gentle sweep we were round heading up the gulf, each coast clearly visible to port and starboard. Near the shore the deep ultramarine of the sea gave way to turquoise as the water shallowed and the coral reefs became outlined in the transparent depths. There was a wild grandeur in the contrasting loveliness of this strip of sea lying placidly between coasts of barren rock. Here was a small inlet, Kah harbour, and there an islet, Faraun, supporting the ruins of a castle built centuries before by some crusading army. Soon we were skimming the northern shore to bump gently down on the airfield from a straight run in.

I stepped out of the plane and filled my lungs with cool air which came whispering in a gentle breeze from the north.

Westwards, the Sinai escarpment looked less formidable. Underneath nestled the "tents of Elath," where Israel had established a frontier garrison.

Eastwards, towering crags tended to crowd the little township of Akaba into the sea. A fringe of palm trees ran along the shore to provide a contrast in colour to the browns and buffs of the desert.

Northwards, stretched the waste of the Wadi Araba, losing itself in the distance where it falls away to join the Dead Sea more than 1,000 feet below sea level. A jeep had been placed at our disposal and soon we were bumping our way towards the little mud-brick town, past the Arab Legion fort, built in P. C. Wren style and flying the flag of Jordan over one of its turrets. The main street was lined with shops, a barber was snipping hair, a vegetable vendor was unloading a donkey, a fisherman peddled two enormous fish which looked like bass, children played in the dust and a dog snapped at flies and shook its ears.

We had no time to linger, but by afternoon we had completed our tasks for the day and set out for a bathe. Sea bathing varies the world over from the shivering misery endured by some in northern climes to the luxurious pastime of Hawaii or the West Indies. Here, it rivalled the latter; clear sparkling water, calm in spite of the breeze with a sun hot enough to dispel any tendency to chill. I plunged in and swam delightedly out to a raft moored off shore near the coral reef, whose shape danced and elongated under the ripple of the surface. Others had brought strange masks with a "snorkel" tube on either side which made them look like sea serpents as they prowled about on the surface, with only their backs and the "snorts" visible.

I had seen these contraptions before and privately wondered at the oddness of those who wore them. When offered the loan of a mask, I set out with some fear that I might drown by getting the "snort" under water. But in a moment all such fears were forgotten. Viewed through the window all the wonders of the ocean were unfolded beneath my gaze. The coral reef stood out clear cut like a stereoscopic picture, its colours glistening like some fairyland garden. Fish of wonderful hue, swam in and out of the crevices. One nuzzled and pulled at a piece of weed, a garfish slid by, and a host of little harlequins flashed their bodies like a troupe of circus performers. A giant clam lurked with its jaws apart waiting to snap hold of the unwary, the dark spines of some horror protruded from a niche and I propelled myself hastily away. Round the corner squatted a chicken fish, puffed out like a broody hen, but far more dangerous to touch, with its feathery poisonous spines.

Fronds of coral appeared in front of me and I put out a hand to feel them. My hand looked half as big again and I began to feel like "Alice through the looking glass," but the coral was real enough and I broke off a frond and stuffed it into my belt only to whip it out again. It had stung me like a handful of nettles and I plunged for the raft smarting across my middle. By the time I got ashore I had a rash as big as a pancake which continued to irritate for days.

As I crept into my tent that night with a chill wind blowing, Akaba seemed a more exciting and kindlier place than could possibly have been imagined.

Next day we took ship to Kah harbour some dozen miles down the coast of Sinai. As the fringe of palm trees fell away astern there was time to ponder on the obscure history of the region. Had the Queen of Sheba sailed up this gulf to visit King Solomon, bringing gifts from Ophir ? That King is reputed to have maintained a fleet in southern waters. A later monarch, Jehoshaphat is said to have lost his ships in a southerly gale, and, to this day, there is no safe anchorage in which to shelter from the tempests that sweep up between the flanking mountains like the blast from a wind tunnel. The explanation lies in the conformation of the sea bed. The coral reef is close inshore where the water shallows. Outside, the bottom falls away so steeply that the construction of a suitable harbour has never been practicable.

At the beginning of the present century, the Turks made efforts to develop Akaba, but the British lion growled and they desisted. Since then there has been little change, and a sleepy fishing village is all that can describe the place.

The wind followed us as we chugged down the coast, surrounding us with a breathless haze of exhaust smoke. The sun beat down from above and bounced up from the dancing sea. It was blisteringly hot. Presently we could see Faraun Island on the starboard bow and as we drew abeam, the ruins of the crusader castle became clearer, a pathetic remnant of an age of bygone chivalry. The white tents of an Egyptian outpost squatted incongruously within its tumbled ramparts and we kept at a respectful distance. Life for the garrison must have been excessively dull, for the sentries had been known to enliven the tedium by taking pot shots at passing craft.

The engine-room telegraph tinkled and we slowed down to nose our way through the coral reef into Kah harbour, a natural inlet in an otherwise even coastline. Harbour is a misnomer. There is no port but, for small ships, it would provide a safe anchorage in dirty weather.

Inside the reef the water was clear and calm, and without more ado we let go the anchor and to a man plunged over the side, more than thankful for the cool depths below after the scorching heat of the passage. " Snorkels " could be seen on every side, their fortunate owners enjoying the wonders of the world beneath the surface, to the envy of the rest. One fellow stalked fish with a hand harpoon, a fascinating pastime requiring considerable skill and patience. A giant clam was levered out of its niche, and coral of wonderful hue and shape was retrieved and placed on board.

All too soon we were summoned to return and the deck became a scene of laughing dripping bodies, jostling each other to struggle half dry into clothes which would not slide into place.

We turned for home and I sat against a thwart, with a head wind flinging the spray in my face. The westering sun had lost its sting, and a sense of well-being crept over me, which even the faint, nauseating smell of living coral freshly culled from the sea could not mar.

When we eventually stepped ashore, the sun had dipped behind the western ridge, throwing its sharp battlements into stark relief. To the east, the mountains were lit with a roseate glow and the harsh colours of high noon were softened to pastel shades as twilight deepened imperceptibly into night. It was a time of silence and contemplation and, as if in answer to my thoughts, the call of the Muezzin rang out over the stillness summoning the faithful to prayer.

Akaba could not claim our attention for ever and we made preparations to move northwards to Ma'an, 80 miles away. We set off early one morning, our jeeps piled high with baggage, emergency rations, water and all the paraphernalia which must be taken when travelling in a sparsely populated and desert country. The sun had just topped the eastern ridges, but there was a nip in the air which made the blood tingle, enhancing the sense of adventure as we sped along the first few miles of our journey.

Before long we were entering the Wadi Yutm, where the road gave way to a track marked in the dry shingle of the wadi bed. The mountains closed in on either side, terrible in their naked steepness, till the blue sky seemed to recede, leaving us to the mercy of these threatening crags. Mile after mile we bumped and jolted, gradually gaining height till the road regained some sense of conformation, as we debouched on to the uplands. The hills fell back as though thwarted in their endeavour to destroy us, and the country between undulated gently in an ever-widening plain. Stunted scrub appeared, wild sage, camel thorn, wild melon that is bitter as gall to taste and reputedly poisonous. My mind went back ten years to another country ; the aromatic scent of sage, the rocky uplands, the reddish colour of the hills, all were the same. This was Baluchistan again. We came upon a road gang repairing the track but they wore burnouses and not the pyjamas and safa of the Baluchi Pathan.

The road improved and we sped along for half an hour or more through the same scenery, to cross a watershed and drop down gradually into a region the like of which I have never seen elsewhere. It was fantastic, unbelievable. My mind sought for comparisons and found none.

The plain had broadened out into a vast amphitheatre, the borders of which were dim in the shimmering haze. Like giant players on some unearthly stage, great masses of volcanic rock reared their weird shapes in a ghostly, macabre tableau. Wind and sand had weathered their conformation. Here a gigantic swan floated immovable in a petrified sea, there a cathedral stood silent, a flying buttress supporting one angle. An unearthly organ sounded from unseen pipes as the wind moaned round its turrets, and a raven croaked somewhere from a crevice high above. Over to the south a monstrous " Christmas cake " rose 500 feet in the air, its sides notched with colossal plums, and crowned with a grey coating of sugar. I looked at the sun. It was high noon. Yet I could not dispel the impression that I was gazing at some silent city seen at dead of night with a full moon painting the shadows black and shedding a ghostly radiance on the upper surfaces.

In silence I got out my map and searched for the cartographer's description. It was named " The Valley of the Moon."

Making a detour we crept stealthily on, feeling like trespassers, and passed into the head of the Wadi Rum which took off from one side of the valley. Great towers of rock flanked the route, running up in sheer walls to over 400 feet, their bases shrouded in stunted foliage where hidden springs seeped through the strata. Over us one such wall displayed a great " Crusader's Cross " etched in the living rock. What intrepid sculptor had achieved the impossible feat of climbing that smooth wall ? We stared in wonder till our binoculars revealed the truth. A vertical discoloration cleft a horizontal fault in such perfect symmetry that the crucifix stood out twixt earth and heaven to arrest the attention of any who might pass by.

Continuing on our way, faster now, with the comfort of that cross to dispel any forebodings, we passed Lawrence's spring, where the water oozes from the mountain foot, and regained the main road with some thankfulness.

The Valley of the Moon now lay behind us and the ground rose in front to the steep ascent of the Naqb Ashtar feature, the road zigzagging up the escarpment in easy gradation. From there the route lay for over twenty miles, first through downland with scattered herds of goats grazing on the sparse vegetation, to drop away later to a barren stony plain over which the track took on the nature of the surrounding country.

Ma'an stands on a slight rise and a white-washed building came into sight on the horizon when we were still some miles away. The city claims no urban boundary. The desert just gives way to the houses, extending its fingers between them to serve as streets. We made our way through the town, past the lock-up outside where a policeman lounged, and fetched up at the railway station three miles farther on. Seldom has hot strong tea been so welcome to such weary and dust cloaked travellers !

The main shopping centre in Ma'an consists of a twin carriage-way boulevard, boasting a tarmac surface for a few yards. On the north side of the street, the booths that served as shops were in the shade. There, it would be expected that the butchers would ply their trade. Not so, the cloth merchants seemed to have staked their claim on the cool side, while the carcases of goats and sheep hung, sometimes swathed in calico, in the full glare of the sun. We made our way slowly up the shady side and swung round to halt at the post office, an impressive building neatly sign-posted and decked out in white. Inside we bought stamps and I asked the postmaster if they were printed locally.

" No, sir ! " he replied blandly. " They came from London. Everything comes from London ! "

That may have been so in the post office, but it certainly did not apply to our next port of call, which was a general merchant's.

" Come in, my dears. Have a sweet." And we were offered a tin of well-wrapped toffees. The owner was a cheery fellow with a terrible squint, but he obviously knew his stuff, and we were bidden behind the counter to view his stock in trade. His wares covered a wide range to cater for a varied clientele. There were sacks of dried peas, lentils and potatoes ; oranges illicitly traded from Israel, tea from Ceylon, a tin of *ghee* (clarified butter) from Holland, biscuits from Beyreut (we bought some of these) Arabian bread, bottles of scent claiming to render Sudanese ladies irresistible, and a collection of cheap Arabic novels. But what struck me most was the gallant way " Mr. Grits," the grocer, had festooned his remaining wall space with pictures, culled from illustrated magazines, of our own Royal Family.

Having completed our purchases we mounted our jeep, and bumped and swayed out of the town greeted by cries of delight from the children.

" *Zaida, zaida,*" " Hallo, hallo," accompanied by the thumbs-up sign and an occasional " V."

The road to Wadi Musa was execrable. We followed the track to Akaba and then swung off to the west across the same barren, stony plain. Soon we began to climb and stunted scrub appeared, wild sage as before, and many other plants nameless to my ignorant eye. Wheatears bobbed across our front and an occasional lark sang in the sky. One pintailed sandgrouse whirred away, but on the whole these downlands were devoid of life.

Higher up as the track mounted there were signs of water in the valleys and stunted crops appeared. On one side there was a spring trampled and muddy from the feet of many herds of goats.

Over the watershed the road dropped away between the hills and presently the distant heights of Israel came into view across the wide expanse of the Wadi Araba, dim in the haze of distance. The track broadened and a herd of fat-tailed sheep barred further progress.

We stopped and got out. Water was gushing from the rocks in a satisfying stream, and I felt little wonder that local tradition should claim this as the place where Moses struck the rock. The Biblical account of the episode gives the impression that it took place over a hundred miles away, but tradition is not infrequently founded on fact.

Down below, the village of Wadi Musa nestled in a gully, amidst groves of figs, pomegranates, grapes and apricots, all fed by the water from above. We parked our jeep in the police post and bargained for horses on which to continue our journey. Mine was a black, with a very upright saddle and stirrups which were not a pair. My companion had a mare with a skittish little foal at heel. Horses and followers fell into line and we picked our way down the pathway through the village. It was eleven o'clock and school was finishing. A knot of boys barred our way.

"Good morning, sir!" ventured the boldest.

"*Salaam ali-akum,*" I returned.

"Can you speak Arabic?"

Before I had time to deny any such proficiency, he continued "Swear!"

I left this astounding injunction unanswered. He was obviously one of the brighter boys. The dunces, I could see over the wall, were still at their letters inside the school. Down the path we went, their shouts and laughter ringing in our ears, past a large building with the Jordan flag flying bravely overhead. Our guide informed us that it was the mayor's parlour. Unlike His Worship in England, the local dignitary cannot have been held in very high esteem, for his doors were scrawled with rude pictures of dogs and cats, possibly by the very scamps we had just passed coming out of school.

Our little party fell silent as we entered a ravine whose sides of solid rock rose vertically on either hand. To the left there was a 12-in. conduit hacked out of the wall, the chisel marks still clearly visible. This ran on in an even gradient down the valley, a masterpiece of labour and engineering. The ravine continued to narrow till the sky above showed only as a thin blue ribbon. Here and there ferns clung to a crevice, a few wild fig trees reared their twisted stems from unseen rootholds while the crunch of horses' feet in the shingle echoed dully upwards. It was a wierd and awe inspiring introduction to the wonders which lay beyond.

Turning a corner, we were suddenly confronted by the majestic columns of the great Treasury of Petra. I have heard it said that these and other carvings show a decadence of the arts when compared to the glories of ancient Greece and Rome. I cannot argue on that score, but the sight filled me with a wonder which no words can describe.

The Corinthian colonnades, the finely chiselled capitals, the arrow and egg motif, the bunches of grapes and shocks of corn, all held me spellbound. The style and architecture have been copied down the centuries, but here, cut out of the living rock, in perfect symmetry was a masterpiece that had withstood the ravages of time. Some of the carving was as clear cut as the day it was completed, other had suffered from wind and water, while Turkish marksmen had at some time perpertrated their vandalism by sniping at the figure of a goddess in the middle.

Inside the Treasury was a vast cubicle cavern—nothing more. But visitors can never, it seems, refrain from desecration, and its walls were scrawled with the names of all and sundry. One party of five, including two women, claimed to have paid a visit in 1836, no mean undertaking, if the date was not a forgery.

The ravine contracted again, and the water supply system changed from open conduit to an earthenware pipe cemented into a channel cut in the rock. In places the original piping, interlocking-jointed, was still visible. What engineers those ancients must have been, and it appeared that our present-day sanitary engineers could have taught them nothing about their trade, while the design of earthenware piping seems to have changed little through twenty centuries or more.

We sat over against the amphitheatre and ate our lunch, discussing what is known of the history of this remarkable place. The origin of Petra is shrouded in the mists of antiquity, giving much opportunity for speculation. Questions came bubbling up to burst and evaporate unanswered. Did the children of Israel pass through Petra on their journey to the Promised Land ? If there is anything in the Wadi Musa tradition they probably did. Who were the Nabateans who once ruled from this, their capital, as far north as Damascus ? How did the Romans capture the apparently impregnable fortress? What was the end of the civilizations which had left behind them such evidence of their art and culture ? Perhaps the answers are known to some, but we were unlearned and ignorant men, groping our way back up the ladder of time.

The ruined remains of a Roman city lies below the amphitheatre, blocks of hewn stone peeped forlornly through the scrub. A herd of kids nibbled at the foliage, ignorant of the history lying beneath their little feet. The sun had dipped behind the ridges to the west, and we reluctantly turned our faces homewards, pausing on our way to take one last look at the Treasury, before entering the darkening ravine which lay between us and the village of Wadi Musa.

The country we had traversed was the ancient land of Moab. What peoples had gone that way in past ages ! Israelites, Nabateans, Romans, Crusaders and now the followers of the Prophet. Each in their turn had left their mark upon the countryside. The Crusaders built a line of castles along the mountains guarding the entries to the Wadi Araba and, farther north, the routes down to the Jordan valley. Many still stand but time permitted us to visit only Shobek. The castle stands on a pinnacle of rock, separated from the main hillside by a causeway. In perspective it looked like a fairy tale castle, lifted high above the surrounding country, impregnable to all comers. It commanded a magnificent view down a valley, now dotted with olive groves and other fruit trees. That was the finer aspect of the castle. Alas, inside was a squalid rabble of Arab huts and the debris of the living had transformed the once elegant courts, turrets and keeps, into a midden. The one point of interest which we found inside, was the rock hewn passage leading precipitously down for 300 feet or so to two large underground cisterns of water. With such a supply any garrison might have withstood a siege for years.

From Shobek we drove southwards down the range of mountains by unfrequented tracks. The mountains rose on either side of us in gradual undulations to over 5,000 feet. Green crops stood in the fields and stunted bushes grew in some profusion. These we discovered to be dwarf holly and there was one mountain ash of immense girth, a remarkable sight in a country, where trees are almost unknown.

Presently we overtook two gentlemen riding their grey Arab horses. They pulled aside saluting us as we passed, but shortly after we heard a thunder of hoofbeats and these gentlemen came galloping up pacing our jeep, their cloaks flying in the wind. This race continued for over a quarter of a mile until one fellow lost his stirrups and swerved off while his companion's burnous flew off his head. We left them shouting with laughter and waving gaily at us as we went. A happy breed.

We struck across a track and followed it over the crest, to be met by a panorama of hills and crags dwindling downwards to the plain thousands of feet below. The wind had changed and now blew from the south-west, warm in our faces even at that height. We thought of the plain dwellers and the heat they must be enduring.

Great towering mountains of rock barred the way to an easy descent into the plain and we scanned these ridges out of curiosity. On the topmost point of the highest rock glistened an Islamic tomb. We were debating this curious fact when a police lorry came by and stopped to pass the time of day.

"Is there anything you want ?" queried the spokesman in the best police tradition.

"Just looking," I replied, "but what is that tomb over there, right on top of the rock ?"

"That is Harun."

"Harun al Raschid ?" I queried jocularly.

"Oh no, long before that, long before Christ," came the unexpected reply.

We were puzzled and continued our way, ruminating. Harun ? . . . Harun ? . . . Long before Christ ? . . . At last we tumbled to it. Harun is the Arabic for Aaron. We had stumbled on the traditional site of Aaron's tomb on the top of Mount Hor. It may have been recorded in some guide book, but to us it was far more satisfying to have come upon it in that manner. Jebel Harun is but a stone's throw from Petra thereby lending some support to the Wadi Musa tradition.

Time was up and once more we piled our jeep with baggage and rattled our way southwards.

From the top of the Naqb Ashtar escarpment I gazed out over the Valley of the Moon. Dust, blown up from the plains was heavy in the air, creating an even stronger impression of moonlight suffusing the darkness of a giant city asleep.

We dropped down the escarpment and sped over the plain, stopping but once to "brew up" in the shadow of an overhanging cliff. Down the Wadi Yutm the air came at us like puffs from a furnace door. We opened the windscreen and let the wind, hot as it was, blow right through. The temperature seemed to rise with every yard we gained towards the coast. Akaba was living up to its reputation. We drove straight on to the beach, threw off our clothes and went for a swim.

At noon the thermometer registered 115° F. By 3 p.m. it was close on 120° F. There was no shade on the airfield and we clustered under the great wing of the plane while the sweat evaporated as quickly as it came. At last we clambered in. The cabin was like an oven and my clothes stuck to me under my safety belt. With a roar and a shudder we were off, the wheels came up and we climbed rapidly, banking round in an 180 deg. turn to head south-westwards over the sea.

As the plane rose, the land below fell into perspective and once more the thin strip of sea, that is the Gulf of Akaba became but the finger of a Churchillian "V" sign.

TEMPORARY REPAIR OF THE LIBERTY SHIP S.S. SAM CLYDE

By Lieut.-Colonel E. G. H. Jeffery, R.E., T.A.

IN March, 1945, a Liberty Ship, the S.S. *Sam Clyde*, struck a mine in the approach to Salonika Bay and although the damage to the vessel was considerable she was able to proceed at reduced speed into Salonika Bay, where she dropped anchor about half a mile from the shore.

A large gaping hole had been blown in the port side in No. 1 hold, about thirty feet square, of which ten feet were below the water line. The ship was carrying a load of grain in five holds, two forward and three aft.

An emergency meeting of the Port Committee was called to consider what action should be taken. The C.R.E., Lieut.-Colonel R. A. Turner, D.S.O., M.C., who was a very prominent member of the committee offered to assist in carrying out any possible temporary repairs.

It is admitted that work of this nature did not come within the scope of the Engineer plan, but in the interests of general rehabilitation and to assist in the quick turn-round of shipping, the work was put in hand without delay.

Following a visit to the ship by the C.R.E. and O.C. 110 (East Lancs) Army Troops Company, R.E., who were accompanied by the B.N.C.N.A. and the S.S.T.O., unloading of Nos. 1 and 2 holds proceeded apace. This raised the bows of the vessel to such an extent that the bottom of the hole was now at water level, which made it possible to pump out No. 1 hold. It was decided that if the bulkhead between Nos. 1 and 2 holds was stiffened up it would be possible for the ship to proceed at reduced speed to a base in the Mediterranean, where permanent repairs could be carried out.

The following day a party of electric welders from No. 110 (East Lancs) Army Troops Company, R.E. went aboard. Their mobile petrol-electric welding set was temporarily installed in a small floating craft and brought alongside the *Sam Clyde*. This welding set, needless to say, was surplus to G.1098, it somehow found its way from Italy to Greece where it proved invaluable.

Heavy section channels were placed vertically against the bulkhead inside No. 2 hold and were stretch welded to the bulkhead plates. Against these vertical members channels were used to form angular bracings, which were taken back and welded to the floor plate supporting joists. The task was completed in about thirty hours, and the master of the ship was then able to obtain a certificate of seaworthiness signed by three ship's masters, and he put to sea as soon as steam had been raised.

A letter was subsequently received from the Admiralty, congratulating the formation on the very efficient way in which the temporary repairs had been carried out, and that due to these repairs the ship had been able to proceed to Alexandria where permanent repairs were effected.

The absence of technical data is regretted, the article is simply intended to illustrate another of the many and varied tasks undertaken by the R.E. in World War II.

An interesting point is the discovery by Captain Geoffery Rawlings D.S.O., D.S.C., R.N. (who was in command of the minesweepers which swept the H.M.S. *Sirius* and the S.S. *Worcestershire* into Salonika Bay in November, 1944) of an entirely new type of mine. Captain Rawlings is, however, of the opinion that the *Sam Clyde* was struck by an 850-lb. moored magnetic mine, this type of mine being found in the approaches to Salonika Bay, and not by one of the ground magnetic type found in the Bay itself.

Captain Rawlings swept a channel into Salonika Bay and proceeded to sweep a channel towards No. 1 Power Station, on completion of this task he went ashore to contact the senior Greek naval officer, who took him to his H.Q. where numerous bogus and useless German mine charts were produced. He then questioned the Greek officer about the type of mines which were laid, and was casually informed that there was nothing to worry about, as the Germans left in such a hurry, they did not have time to take the mines out of their packing cases before they were laid. This immediately raised Captain Rawlings's suspicion and he was determined to find one of these packing-case mines. After several hours of questioning and searching he was taken to a small dump of these mines on the Khalkhadihi shore south of Salonika Bay.

On examination, the mine proved to be of a type hitherto unknown, housed in a waterproofed rectangular wooden box, containing a charge of 1,700lb. of H.E. and fitted with magnetic and acoustic initiated detonators, a deadly weapon, extremely difficult to locate and sweep.

During the three weeks following the arrival of British troops in Salonika early in November, 1944, about 300 of these mines were swept and detonated in Salonika Bay alone.

BOOK REVIEWS

HISTORY OF THE SECOND WORLD WAR
THE MEDITERRANEAN AND MIDDLE EAST, Volume I

By Major-General I. S. O. Playfair and a small team of assistants

(Published by H.M. Stationery Office. Price 35s.)

This is the first of six projected volumes dealing with operations in the Mediterranean area and in the rest of the Middle East, in the widest sense of that term. The history deals with the activities of all three services. To write of the second World War in any other way would be misleading, particularly so in the case of the Mediterranean and Middle East. On the other hand, this is perhaps the first serious attempt to record without bias the strategy and tactics of sea, land and air forces on a grand scale in one continuous story, and thus to bring out the complications, interactions and difficulties of modern, and therefore nearly always three-service operations. In this new historical task General Playfair has had the assistance of a sailor and an airman, and it adds no small part to the reader's interest to notice how these authors have succeeded in balancing and knitting together their often (apparently) disconnected stories.

This was by no means their only difficulty, for, as they mention at one stage, the three Middle East Commanders-in-Chief were not confronted by " one damned thing after another," but by everything in all directions at once. The problem of these historians was thus akin to that of a B.B.C. commentator if called upon to make a simultaneous broadcast from Ascot, Henley and Wimbledon and also from several local horse shows and cricket grounds. The wonder is that they have succeeded. Their story is one story, though it is the story of things that happened, often at the same moment but thousands of miles apart, to men in ships, tanks and aircraft, and to those at General Headquarters responsible for handling and maintaining them. To those of us who served in the Middle East in the early days (we are rather few in comparison with the huge numbers involved later in the war) it is this feeling of having to juggle with just too many balls at once that we perhaps remember most clearly, and this is certainly the feeling that General Playfair brings home to the reader.

He apologizes for the number of pages " before the first shot is fired " and for the stress he lays upon " administration," but surely no picture of these campaings could be a true one without a record of that time of ever-changing strategic outlook and of ill-defined objective that preceded the moment when Middle East suddenly found themselves to be the only allied forces confronting the enemy on land. Surely also it would have been a crime indeed to neglect the administrative side of these campaigns, fought as they were from bases, at first merely desert wastes, separated by vast tracts of ocean from the sources of all the necessities of modern war. They taught many lessons to those who fought and to those who watched from afar, but we must not forget that slow awakening to the horrid fact that modern weapons must carry a vast but so vital tail, and that this is true for all three services.

This, the first of the six volumes, deals with the events up to early 1941, and includes the period of no enemy and no fixed policy, to be followed so suddenly (when Italy entered the war) by one of great activity with very few resources and very few disasters, but no Germans. It was a very complicated period of trial and error, excitingly described, a period when bold and brilliant decisions were so often rewarded by startling victory. It makes a very readable book in spite of its being almost entirely factual. We are given the tale of exactly what occurred, but there is no praise and no blame and above all no wisdom by the authors after the event and after they had perused the documents of both friend and foe. One is told, for instance, how the Greek venture gradually came to pass, but is left to decide whether the decisions that led to it were wise or rash, and whether they could, in fact, at any stage have been reversed. This is a volume of facts, but of facts excellently marshalled and presented in lavish style. The printing and paper are first class, the maps "just right" and very well arranged, and the literary style above reproach. What more can one ask, but how seldom in a military history does one get it ?—E.F.T.

THE WAR IN KOREA 1950–53

By Major R. C. W. Thomas, O.B.E.

(Published by Messrs. Gale & Polden. Price 10s. 6d.)

The hot war in Korea has become cold and its events stand out in better perspective. The remarkable speed with which the United States, starting from scratch, reacted to the North Korean invasion lives in the memory. This liveliness off the mark has, let us hope, been noted by all concerned. North Korea and China have, each in their turn, been grievously surprised. Neither the sudden attack of the one nor the mass onslaughts of the other succeeded in ejecting the United Nations from the peninsula. The 38th parallel has become an Iron Curtain again and peace still seems far off. Indeed tension in Korea is likely to persist for a long time.

No soldier, therefore, can afford to be ignorant about the war in Korea. To those few, who may be, this small book of 119 pages with 5 sketch maps will be a useful introduction to the subject. It rarely strays from the narrow path of sober and accurate narrative, which perhaps makes it rather unsatisfying. A chapter on casualties would have been useful. Few people realize that the war in Korea cost the United States more casualties than the defeat of Japan in the Pacific. What a pity we have acquired the bad habit of fighting in a big way on the Continent ! Sea power was so satisfactory. B.T.W.

THE RECAPTURE OF GUAM

(Published by the Historical Branch—H.Q. U.S. Marine Corps)

This monograph is the twelfth of a series of detailed studies of the operations of the U.S. Marine Corps in the Pacific. The three previous ones to this have already been reviewed in the *R.E. Journal.* The monographs are to be the basis of a general history of the Marine Corps in World War II. It should be a notable work on the use of air/sea power.

The Recapture of Guam more than maintains the high standard of its predecessors. Chapter II on "Planning and Preparation" is of particular interest. The insistence of Admiral King, C.-in-C. U.S. Fleet, and General Arnold, Commander U.S. Army Air Forces, secured that the advance on Japan should be made on the Mariannas through the Central Pacific and not through the S.W. Pacific, with main air bases on the mainland of

China. It is astonishing, now, to think that there could have been argument about the matter. But argument there was and the U.S.A. was fortunate in having sea and air commanders at the top who saw so clearly how to use their dominant air/sea power to the best advantage. The capture of Saipan, Tinian and Guam brought the war to the climax. From these islands B.29 bombers flew off in hundreds to devastate the homelands of the enemy. Finally during August, 1945, two of them from Tinian dropped the atom bombs, which convinced the Japanese leaders that the game was up.

All these monographs are packed with important details on landing operations. The use of pallets for handling ship to shore supplies is of special interest to sappers. The excellent maps, now fixed at the end of the book, can be read with greater ease. B.T.W.

CARNOT 1753–1823

By S. J. Watson

(Published by The Bodley Head. Price 18s.)

The author of this book is an officer of the Royal Engineers, now serving in Korea. Having read history at Oxford he found that no biography of Carnot existed in the English language and determined to fill the gap himself. What is more, he has carried out his ambitious task extremely well and rather in the manner of Guedalla and Arthur Bryant. He is not, therefore, one of your "muck-raking" biographers, who are discontented unless they can blacken and defame. To him Carnot is a man of unassailable worth. A lofty contrary opinion of Lord Acton and a flippant aside of Castlereagh are quoted in the preface, so that in the course of the story they can be proved to be wrong. The picture of Carnot, which emerges, more than confirms the correctness of Major Watson's judgement.

Starting his devoted service to France in the "Corps Royal du Génie," Carnot held high office at the very crisis of the Revolution. No man of ordinary ability could have done so. Without a doubt, he lacked the devouring ambition and the urge to control events, which must animate the leaders of a revolution. But when general confusion was widespread, as often happened, no one could sort out the mess better than Carnot. Slow to change his views and proudly honest at a time of almost universal corruption, he was a soldier-statesman, who became indispensable to the successive ruling Committees of the Revolution. Whilst they were busy, under the shadow of the guillotine, struggling for power, Carnot was recovering the "natural frontiers" of France. Later on, when his organization of victory became rather pedestrian, the dynamic impact of Napoleon made it decisive.

The real quality of Carnot is revealed both by his opposition to Napoleon being made Emperor of the French and by the respect which Napoleon always had for him.

Major Watson, with his wealth of historical knowledge and a most pleasing style, has produced a book of unusual merit. Nowadays when all know something about everything and biographies interest the reading public almost as much as novels, he will be well rewarded for his industry. He has obviously enjoyed writing about such an honourable man.

B.T.W.

ELECTRICAL INSTALLATION WORK (2nd Edition)

By T. G. Francis, M.I.E.E.

(Published by Longmans, Green & Co. Ltd. Price 12s. 6d.)

This book has been written with a view to assisting those engaged in electrical installation work, who desire to learn something of the technical side of their profession. It is well suited as a text-book for those studying for City and Guilds examinations in "Electrical Installations" and a number of examination questions and answers are included in this edition.

About two-thirds of the book is devoted to the electrical installations found in the average house, the remainder dealing with A.C. and D.C. machines, common instruments and cables. An excellent feature of this book is the numerous references to I.E.E. Regulations and the explanations of some of the Regulations.

The author has presented his material in a logical manner, commencing with a short introduction on the generation, transmission and distribution of electricity at different voltages. He then goes on to deal with the actual control of supply and circuits in the consumers' premises.

The chapters dealing with the different wiring systems and accessories are excellent. Not only is the text well written, but the illustrations and diagrams are exceptionally clear and concise.

The important subjects of earthing and testing wiring installations are well covered and the author has not only explained the various techniques involved, but, equally important, he has set out the reasons for their development.

Illumination and electric heating is dealt with both from the theoretical and practical aspect, and a number of useful diagrams and tables are included.

A short, but useful, chapter is included to cover tariffs and power factor correction. The section on P.F. correction may be rather difficult to understand, but that on tariffs is well written and should be most useful to those who have to choose between two or more tariffs.

In general, this is a practical book and may be recommended for its simple and logical approach to the subject and the clarity of its illustrations. It might well be of use to the constructional engineer with little or no knowledge of electrical engineering, who has small electrical installation jobs under his control. P.C.

ELEMENTARY ELECTRICAL ENGINEERING

By A. E. Clayton and H. J. Shelley

(Published by Longmans, Green & Co. Price 14s.)

This text-book is now in its fourth edition, having been first published in 1927 to meet the requirements of the syllabus for the Ordinary National Certificate in Electrical Engineering.

With succeeding editions the subject matter has been kept up to date and the scope of the book increased without recourse to higher mathematics. This fourth edition is notable for the introduction of the m.k.s. system of units which is now superseding the c.g.s. system in the treatment of magnetism and electromagnetism. In introducing the new system each unit is first defined and compared with the c.g.s. unit and finally two examples are worked out side by side in each system of units. Subsequently all e.m.f. equations are based on the m.k.s. unit of flux.

The character of the book remains elementary. It is very well illustrated, employs the normal symbols, has many worked examples and there are plenty of examples, with answers, for the serious student.

W.J.J.

CHARACTERISTICS AND APPLICATIONS OF RESISTANCE STRAIN GAUGES

(Published by U.S. Department of Commerce, National Bureau of Standards Circular 528, 140 pages. Price $1.50)

This book contains the eleven papers, presented at the N.B.S. Semicentennial Symposium on Resistance Strain Gauges, which deal with the latest practical and theoretical results in the study of this method of strain measurement. It will be of great interest to those engaged in the development and testing of military equipment.

Direct strain measurement is dealt with in great detail and reference is made to modern methods of cementing and water-proofing conventional paper-backed gauges, the measurement of large strains and the particular techniques for strain measurement in concrete. New devices include an unbonded resistance-wire gauge which is clamped to the specimen, the new G-H plastic mounted gauge and preliminary tests are described of a gauge in which wire is replaced by a vaporized-metal deposit.

The strain gauge may also be used as a basis for many instrumentation devices and among those described are, load cells, accelerometers, pressure gauges, torque measurers and impact testers.

Although this book does not give complete practical details of all the techniques described, it should provide useful pointers to the best method of tackling many problems. J.N.B.

DUODECIMAL TABLES

(Published by Pembroke Publishing Co. Price 8s. 6d., plus 9d. post)

Duodecimal Tables is a ready reckoner designed for builders, civil engineers and quantity surveyors who deal in superficial and cube dimensions.

The tables give direct answers in superficial feet, and to the second place of duodecimals of dimensions in 1-in. steps ranging from 1 in. × 1 in. to 11 ft. 11 in. × 12 ft.

In addition, results are given in each table for dimensions of 20 ft., 30 ft., 50 ft. and 100 ft., also for useful fractions such as $\frac{1}{3}$, $\frac{1}{8}$, etc. These results can be added to results in the main tables to obtain the squared result for any normally used dimensions.

The squared result of two dimensions can be "cubed" by the third dimension by a second reference to another page of the book.

The tables are in bold, clear type and are claimed to have been meticulously checked. There is no doubt that *Duodecimal Tables* would be useful to anyone uncertain of his capacity accurately to multiply dimensions by duodecimals. Even such people will still have to be careful to read off the right figures and add correctly. W.B.C.

TECHNICAL NOTES

Notes from *Civil Engineering*, January, 1954

Effect of Detergents on Concrete Strength

In this month's edition an article appears on the " Effect of Detergents on Concrete Strength," the particular detergent under discussion being " Stergene."

It is well known that the mixing water in concrete batching has two distinct functions ; some is used up in hydrating the cement content, and the excess lubricates all the constituents and aids their compaction into a dense mass. The water-cement ratio at which cement hydrates is about 0.30, but at this value the mix is so dry that expulsion of entrapped air is difficult. In recent years artificial lubricants have been introduced in order to minimize the amounts of excess water and to increase workability at low water-cement ratios. The most promising are wood-resin air-entraining agents and wetting agents including some detergents. With the help of comprehensive graphs and tables, showing results of tests, the following conclusions are drawn :—

(1) The use of a detergent may provide a useful aid to the compaction of concrete.

(2) For this particular detergent, the loss of strength in fully compacted concrete due to air-entraining is not serious in the useful range of concentration, and its effect is more than outweighed by gain in workability.

The author tenders his thanks to the Commandant and staff of the Royal Military College of Science for the facilities and help provided by them in the investigation.

Reinforced Concrete Garage

A description and photographs appear of the new large reinforced concrete garage built for the L.P.T.B. at Stockwell. It is considered to be one of the finest contemporary examples of the use of reinforced concrete as a structural medium. The dominating influence on the design was the need for the maximum unrestricted floor space to house the requisite number of large vehicles.

The main building is 392 ft. long and the main structural members consist of two-hinged reinforced concrete arched portal frames with 27-ft. radius, barrel vault roofing spanning the 42-ft. bay between each frame.

The comparatively small section of the main frames made it essential to weld the main reinforcement instead of providing the customary laps, and some 1,200 " V " butt welds were made in the arch ribs.

Shear and Torsion in Prestressed Concrete

The second serial on the " Design of Prestressed Concrete Beams Subject to Secondary Shear and Torsion " is included in this edition. The author works through five practical examples of this theory and gives a very clear picture of the calculations involved when dealing with this type of stress.

Accelerating Fill Settlement By Blasting

There is a most interesting account on "Accelerating Fill Settlement with Explosives" carried out in Massachusetts, U.S.A. Often referred to as "bog blasting" this method of dealing with useless organic sub-soils, such as peat, is becoming increasingly popular with highway contractors. On this site the spongy peat varied in depth between twenty and forty feet and the tenders envisaged two methods of construction, (*a*) excavation with plant, (*b*) blasting with explosives; the eventual contractors selected the latter method, from which it may be concluded that in certain cases this method is the more economical.

Calculations For Shell Roofs

The final article on the "Design Calculations for Cylindrical Shell Roofs" appears in this edition and in conclusion the author points out that whilst no attempt has been made to compare the results derived basically from the Schorer approximation, with those of the more rigorous analytical theory, it may be stated that values derived from the Schorer approximation by calculating machine are to within 3 per cent of those derived by the more analytical method. Thus the accuracy of the slide rule calculation, which is seldom more than 10 per cent in error of the calculating machine results, and in some cases much less, is in the author's opinion sufficient for design purposes. Should, however, the reader feel that such inaccuracy is too large for design purposes, then he has no alternative than to compute by calculating machine.

"Wolf" ⅜ Cu. Yd. Excavator

In the *Contractors Plant Review* the latest model of the Priestman "Wolf" ⅜ cu. yd. excavator is described; this is the Mark III B. For digging speed, mobility and ease of operation, the "Wolf" has always stood out foremost amongst excavators of ⅜ cu. yd. capacity. The Mark III B is an even better machine and a typical example of Priestman workmanship. In addition to all the standard front end equipment, this machine carries a side drag-line attachment, which is extremely useful for drainage maintenance on roads as the machine can work whilst standing on the carriageway. It also has a "Teredo" narrow type bucket.

Notes from *Civil Engineering and Public Works Review*, February, 1954

Timber Sheds

Timber storage sheds for the docks at Hull described in this monthly edition illustrate the increasing interest being paid to the use of timber in structures now that restrictions on its purchase has been removed. Up-to-date methods of design have provided very light spans of 55 ft. with ample working space in a shed covering nearly two acres of ground.

Prestressed Concrete in U.S.A.

The U.S.A. has been rather backward in adopting prestressed concrete as a material, but since 1951 it has begun to find application in a variety of structures, and methods of stressing the concrete have been developed which are entirely of American design. The author describes the growth of interest in prestressing and the background on which it developed, in addition to the methods now considered standard procedure.

Tunnelling

The Swedish tunnellers have developed tunnelling methods in their own country which have become world famous and an article in this edition describes the equipment which they use and the reasons for their choice of methods.

Bailey Parts for Floor Girders

The ubiquitous Bailey parts are shown here being used as girders supporting the floor of a garage which was being built over an old quarry, the floor of the garage is of concrete.

Mobile Cranes

The review of contractors plant describes two very useful cranes, the Ardelt Mobile crane and the Coles Convertible crane. This latter crane would seem to have application as a dockside crane in time of war in that it can be converted to have a 60-ft. tower in less than an hour.

Notes from *Civil Engineering*, March, 1954

Analysis and Design of Beams under Given End Restraint

Since the publication of the "Final Report of the Steel Structures Research Committee" in 1936, various proposals have been made regarding the design of beams with partially restrained ends. The author expresses the opinion that none can claim to be a major improvement over the method originally proposed by Professor Batho* and known as the "Beam-line Method."

Moreover, many of them tend to be extremely rough approximations which do not yield good results or bear any more than a vague relation to the true conditions.

The theoretical basis of the "Beam-line Method" is briefly as follows :—

If a beam AB is loaded symmetrically and has end rotations of θ and end moments M, then the relationship between θ and the remaining criteria is given by :—

$$\theta = (MF - M)/2EK$$

where MF is the fixing moment, and EK a flexural constant, K being equal to I/L = (Moment of Inertia)/(Effective Length), and E equal to Young's Modulus.

The author then explains the graphical representation of the above equation with moments as ordinates and angles as abscissae. The main body of the article is then devoted to considering the effect of adjoining members, the over-all restraint values at the beam ends, the general "Beam-line equation," and a most convincing worked example, from which it is proved that a saving of 20 per cent in the beam bending moment may be made, provided the appropriate additions are made to the stanchion moments. Whether or not this constitutes an over-all saving in steel is by no means sure since increases in the stanchion sections may be necessary to cope with increased moments in them.

Economic Aspects of R.C. Retaining Wall Design

The object of this article is to show how economy could be effected by suitable proportioning of walls retaining earth at their backs, and also

* Civil Engineering Department, University of Birmingham.

how the prices of various items such as concrete, steel and shuttering affect these proportions. As the author points out, this aspect of design does not receive much help from the existing codes or practice.

The study has been based on Rankine's theory, as it offers more handy expressions without affecting economic proportions appreciably. As in all such cases of design, it has been necessary to make certain assumptions, namely that (i) the soil is granular, homogeneous, isotropic and unlimited in extent ; (ii) the surface of the earth is plane ; (iii) the pressure of filling on the toe side is negligible ; (iv) the pressure acts normally to the wall at one-third the height above base ; and (v) the distribution of reaction of the soil on the base varies uniformly. The reinforced concrete part of the work is based on the elastic theory and other standard assumptions regarding elastic modulus and adhesion, etc. In the article, the following aspects of the problem have been investigated :—

1. Determination of economic ratio of length of toe to the base in a T-shaped wall with counterforts. Two cases have been examined, one in which the entire base length has to be in contact with the soil for fear of water entering the underside, and the other when such a risk is not present.

2. Determination of the height above which counterforting a wall is economical and how this height is affected by soil properties and prices.

3. Economic spacing of counterforts.

Careful consideration has been given to T-shaped cantilever walls and an examination of the economical Toe, Heel and Stem design to suit the two particular cases, firstly with base in contact with the soil at all points and secondly with base partially in contact with the soil. The author arrives eventually at five important conclusions :—

1. Economic ratio of the length of toe to base (r) can be shown graphically and increases with the value of B (where B is the product of the retained soil density and the height of stem divided by the safe bearing value of the soil). Approximately, $r = 0.31 (1 + B)$ when B is less than 1.15.

2. When full base is in contact with soil, the value of r should be between 0.38 and 0.43, provided that pressure on the soil under the toe is not excessive. If it is, the ratio should be equal to $1 - 1/2.42 B$.

3. It is more economical to permit a release of compression under the heel when B is less than 0.8. Above this value there is no difference.

4. The variations in the cost of the base with change in r is shown graphically in the article. It will be seen from this graph that a variation of 15 per cent in the value of r, increases the cost by 1 per cent, whilst for a variation of 30 per cent the cost increase is 5 per cent. Considerable adjustment is therefore possible to suit local conditions, but the excessive cost of adopting " no heel " or " no toe " designs is emphasized.

5. Prices and angle of soil repose have little effect on the economic ratio r.

(*The article is to be concluded.*)

Heavy Loads on Concrete Pavements

The U.S. Highway Research Board Special Report 14, described a study made with a heavy tank-transporter consisting of a tractor and semi-trailer combination. There was a total of 5 axles in the tractor-trailer combination, the unloaded and loaded weights being 83,000 lb. and 198,800 lb. respectively.

The investigation shows that, where concrete pavements rest on soils which are susceptible to pumping, the most serious damage develops in the vicinity of the outside corners when the vehicles are tracking near the outside edges of the pavements. This damage increases progressively with an increase in soil consolidation or an undermining of the pavement by pumping. By positioning vehicles some distance away from the outside or free edges of the pavement, the critical conditions existing at the outside corners are relieved and damage in their vicinity is minimized. When vehicles of greater than conventional width are positioned (say) thirty inches away from the outside edge of the pavement the offside wheels may track very near the *longitudinal joint edge*. The point to note here, is that the majority of thickened edge concrete pavements are not designed with edge thickening at the longitudinal joint. As a result, the stresses that develop in that region when the wheels of a heavy vehicle track near the joint, may be very critical.

The article then goes on to describe the influence of temperature variations on stress conditions in pavement slabs. For example, it is interesting to note that the magnitudes of the critical stresses and deflections caused by such loads acting near the edges during the *daytime*, when the slab edges are warped downwards, are considerably less than those caused by the same loads acting during the night when the slab edges are warped upwards.

The whole article makes interesting and instructive reading.

High Discharge Loader

In this month's review, a new type of high level discharge loader, known as the Merton Over-Loader, is described and a photograph is included.

This machine discharges its load over-head at a height of 12 ft. 6 in. above ground level and the digging bucket is 14 cu. ft. capacity. The complete cycle of digging, hoisting, discharging and return is claimed to take between fifteen and twenty seconds. The machine itself has an optimum efficiency range of 12 yds. from the stockpile. There is also a standard model made by the same firm with a ⅝ cu. yd. bucket capacity and a discharge height of 8 ft. 6 in. The Merton Engineering Co. state the following output figures achieved under normal working conditions: ash, coal or rock, 60 tons/hour; aggregate 80 tons/hour; sand, 100 tons/hour; for the standard model. They claim that those for the new 12 ft. 6 in. model when available will be very slightly inferior.

If these figures are correct, then it should be noted that the output of this machine compares favourably with any other type of plant used for this purpose. The output figure given for rock should be regarded with some suspicion, even more so since it is classed in the same group as ash, coal, etc., and is in fact a much more difficult material to handle mechanically.

Materials Handling

We have recently published in the *R.E. Journal* a number of articles on "Mechanical Handling of Stores and Equipment." Messrs. Tubewrights Ltd., of Buckingham Gate, London, S.W.1, have issued an interesting illustrated pamphlet showing pictures and giving details of a very large variety of handling equipment, including several different types of pallets, crates, stillages and trolleys. The pamphlet shows very clearly how the most suitable shape and size of equipment can be designed for any particular purpose or material.

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

Concrete Shell Roofs

Shell construction in reinforced concrete has become an established method of design, and it is estimated that upwards of 200 papers on this subject have been published since 1945. This paper contains no revolutionary ideas, but it sets out an interesting general review of the history of arched shells and includes a much simplified discussion of design methods and calculations. The author forecasts the increased use of prestressing and precasting, and offers valuable practical remarks on standards of workmanship and on costs. A method of construction is outlined, in which all the members are precast and are precompressed by post-tensioning wires or bars after the shell elements are assembled. By this method the need for scaffolding is eliminated, and the cost of formwork and weight of reinforcement are considerably reduced.

The Plastic Theory of Structural Design

Although new materials and new structural methods are in the limelight there is little likelihood that the steel-framed building will become obsolete, as conventional methods combine lightness and stiffness with adaptability and ease of erection. Furthermore, the increased use of welding makes construction easier and more efficient. On the other hand, rising prices demand the greatest possible economy in design and in erection costs.

By using " limit " or " plastic " design methods in preference to the conventional " elastic " method a considerable saving of steel can be effected, and the engineer can apply a load factor against collapse as opposed to a factor of safety on the yield stress of the material. This paper gives an admirably simple outline of the elements of the plastic design method which, though not yet applicable to columns, undoubtedly simplifies the economical design of beams.

Prestressed Concrete Buildings

In recent months there has been a spate of literature dealing with the design and erection of prestressed concrete structures. This paper does not add anything to theoretical knowledge but it is a valuable record of the practical construction methods used in erecting the roof structures of two large ordnance depots, a naval armament depot and a memorial arena and auditorium. The feasibility of precasting by production line methods is well exemplified and the practical solutions of some of the erection problems are ingenious and interesting. The author sounds a warning that the large forces applied to develop precompression induce stresses in both concrete and steel which cause important deformations, but adds that the consequent need for good workmanship and skilled supervision is the best guarantee of quality in construction.

Notes from *The Engineering Journal of Canada*, January, 1954

The Stabilization of Suspension Bridges

Suspension bridges have many advantages, especially for long spans, and would probably be more widely used where obstruction is undesirable if excessive deflection and undulation could be reduced. Most failures and troubles are attributable to wind blowing diagonally against the bridge, the longitudinal force being translated into dangerous vertical oscillations and vibrations. In most suspension bridges the suspended weight, although itself stiffened, is braced longitudinally only by some auxiliary connexion to the cables at the centre of the span, and resistance to longitudinal thrust tends to straighten the cables at the windward end and to sag them at the leeward end.

This paper suggests a change in the stiffening system, using diagonal instead of vertical hangers, on the lines of the Warren girder, to produce a complete trussing system between the final reaction points. Despite the obvious disadvantages of variation of stress in the hangers and the greater adhesion required between the cable bands and the cable, this system would offer many advantages besides the prevention of longitudinal movement and local distortion of the cable, with consequent undulations in the floor. Though not fully developed, the arguments put forward offer an interesting and perhaps worth-while exercise for the mathematically inclined.

Economics of the Diesel-Electric Locomotive in Railway Service

This paper is, perhaps, of more interest to the economist than to the engineer, since the problem discussed is to what extent existing serviceable steam locomotives, whose disposal value is virtually that of scrap metal, should be replaced by diesel locomotives of high capital cost but comparatively low operating cost. In discussing the problem, however, the author compares the characteristics and performance of steam and diesel locomotives, and also examines the suitability of the diesel for various classes of railway operating. In so doing he states a number of factors of considerable interest. Those concerned with service transportation can deduce additional military factors for themselves, and will probably agree with the author that the diesel locomotive represents one of the most important technological advances in railway history.

Notes from *The Engineering Journal of Canada*, February, 1954

Recent Studies of Foundation Behaviour

For many years it has been the practice to base the design of shallow foundations upon somewhat arbitrary permissible bearing pressures and to estimate the bearing capacity of piles from pile-driving formulae. The design of structures has normally been based upon the assumption that an equal bearing pressure all over a site caused uniform settlement over the loaded area. In fact, foundations are often subjected to a horizontal thrust and a bending moment as well as to a vertical load. Improved knowledge of soil mechanics has made possible a more rational approach to this problem.

Total settlement is relatively unimportant compared with differential settlement, which depends not only upon variation of the compressibility of the soil beneath different parts of the foundation, but also upon the layout and rigidity of the superstructure. Methods recently developed make it possible to estimate the stiffness of a structure and to relate it to the deformation characteristics of the soil. While differential settlement decreases as the stiffness of the structure increases relative to that of the soil, greater bending moments and shearing forces are induced in the framework. This paper describes very clearly the results of recent analysis and indicates how theory may be applied to practice.

THE MILITARY ENGINEER

(Journal of the Society of American Military Engineers)

January–February, 1954

"A Strategic Study of Indo-China," Colonel Wright Hiatt, Corps of Engineers.

An excellent article of topical interest, well illustrated with photographs and a good map. The author deals concisely and briefly with the political, geographical, climatic, and topographical background of that association of three independent, self-governing countries in the French Union which form Indo-China : the Kingdoms of Laos and Cambodia and the Republic of Viet Nam. He describes the natural resources, transportation systems, and conditions of health and sanitation to complete the background for events taking place there to-day which may decide the fate of some 30 million inhabitants and a country about one-third larger than France.

Military supplies furnished by the United States to French and native forces to July, 1953 are summarized as : 170 million rounds of S.A.A., 16,000 transport vehicles and trailers, 850 combat vehicles, 350 military aircraft, 250 naval craft, 10,500 radio sets, 90,000 small arms and automatics. In addition there have been large quantities of hospital supplies, engineering and technical equipment, and $71,330,000 granted in aid for the three years ending in 1953.

While no Chinese communist forces have been identified in the fighting so far, the close association of the Viet Minh with the Red Chinese neighbours to the north is obvious. If Red Chinese military units do move in, what will the United States do about it ? In the face of this question the writer has little doubt that it is a wise precaution for Americans to know more about this far away place. His article, written while attending the Army War College, is a valuable contribution to such a study.

"The Jet or Rocket Flame Drill—New Tool for Industry," L. L. Kelly.

In the jet or rocket type flame drill, a low viscosity fuel oil or kerosene is combined in the burner with a high-purity oxygen to produce a flame having a temperature in excess of 4,000°F., with a gas velocity of the flame of 6,000 ft. per sec. This type of burner is thermodynamically similar to rockets and has ten times the velocity of a normal industrial flame burner. This higher concentration of energy opens up a new field for flame utilization including the jet piercing process for the rapid production of blast holes in those rocks or ores which spall under heat. The velocity of the jet blows away the spalled particles. In the low grade iron ore, known as taconite, records of 175 ft. of 7½ in. diameter blast hole have been obtained in a single shift, which is some ten times the speed attained by the best mechanical drills, which also have an average bit life of only 75 ft., compared with a jet-piercing burner life of 3,000 ft. of hole. Sustained jet drilling speeds in granite have been as high as 40 ft. per hour. For holes of 6 to 7 in. diameter present estimates indicate a saving in cost of $1.00 per ft. for jet-pierced holes as compared with mechanical drilling methods in spallable rock ; of course in broken rock the jet piercing flame does not drill as fast as in solid rock. As one jet piercing blowpipe usually replaces six or seven mechanical drills, its application for service use should be worth consideration.

Notes from *Roads and Road Construction*, January, 1954.

Snow Fences

A most interesting and useful article prepared by the Road Research Laboratory on Snow Fencing appears this month. The author points out, that in Great Britain, the roads in some districts become blocked by snow drifts in most winters and very considerable sums are spent by highway authorities in removing snow.

The mechanics of snow drifting have been carefully examined, and have found to be similar to those of drifting sand, hence the question develops into a straightforward aerodynamic problem. In siting snow fences near a critical area of roadway, the important factor becomes the control of the leeward drift, the length of which, will determine the correct distance of snow fence from the carriageway.

The type of snow fences recommended is mainly of timber construction and easily made up. One of the cheapest forms is the chestnut pale fencing which has a "density ratio" of 42 per cent (i.e., per cent ratio of the frontal area of the *material* to the total frontal area of the fence, including the apertures). Both the height of the fence and the "density ratio" determine the length of the leeward drift and tests carried out in this country for a 4-ft. high fence give an approximate expression in the form of an equation :—

$$L = 42 + \frac{1,300}{r}$$

where L is the distance from the road in feet and r the "density ratio" of the particular fencing. For chestnut paling 4 ft. high with an $r = 42$, it will be seen that the value of L becomes 73 ft. The article goes into the whole question very thoroughly with excellent illustrations and is well worth reading.

Prestressed Concrete

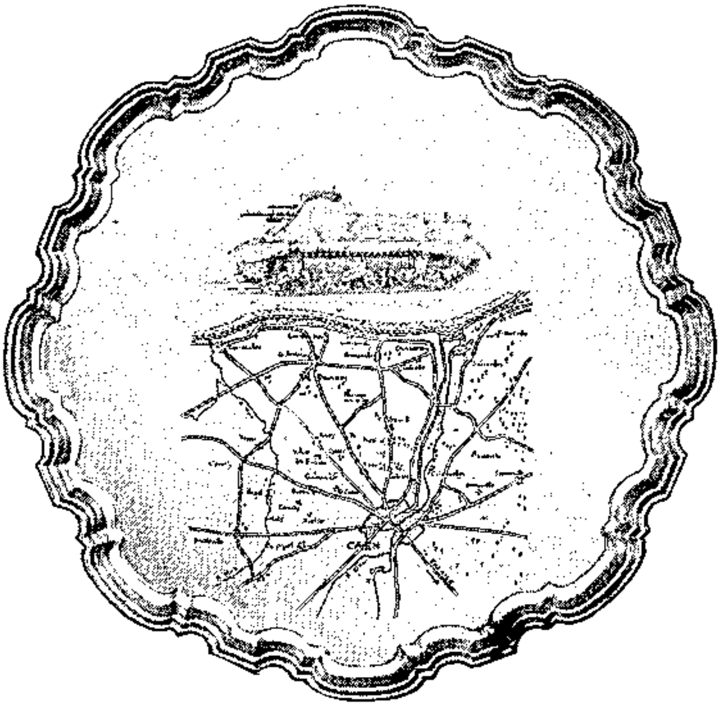
Two filmstrips entitled "Equipment and Methods" and "Development and Application" respectively are available together with lecture notes by A. J. Harris, B.Sc., A.M.I.C.E.

They are designed to demonstrate in detail the technique of the Freyssinet method of prestressing concrete and to illustrate its simpler forms of application in building. They provide both essential practical "know-how" and background information for those interested in prestressed concrete and the advantages it offers as a building material.

Filmstrip No. 1 shows all the stages of prestressing using the Freyssinet equipment.

Filmstrip No. 2 illustrates the structural forms which are most usual in prestressed concrete—the solid slab, the hollow box beam and the I-beam, which are seen in a wide range of different uses—in floors, columns, beams, bridges, reservoirs and shell roofs.

They can be obtained from Diana Wylie Filmstrip Production, 18 Pont Street, London, S.W.1, at a cost of £1 1s. each.



Mess Presentations

THE special gift which shall be a tribute to the recipient and an enduring record of the occasion requires more than ordinary care in its selection. We at '112' are proud of the service we are able to offer for Mess Presentations and Wedding Gifts. A Mess Presentation Catalogue is now available and will be sent upon request.

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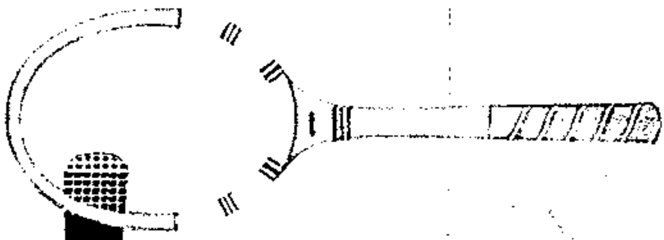
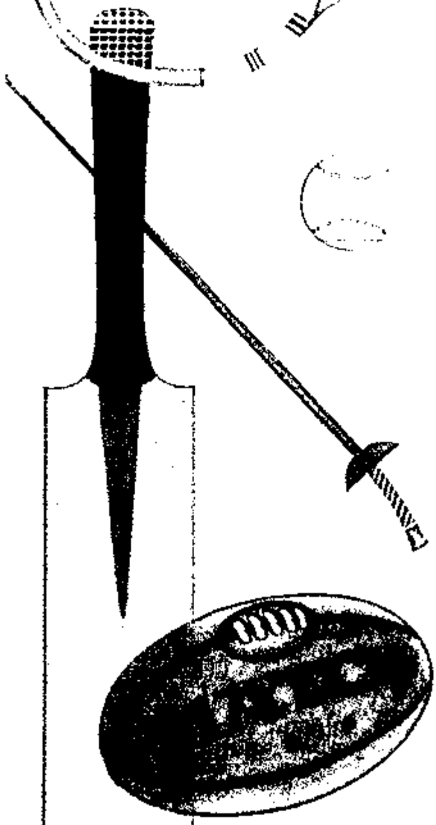
Here's the answer to your Catering problems

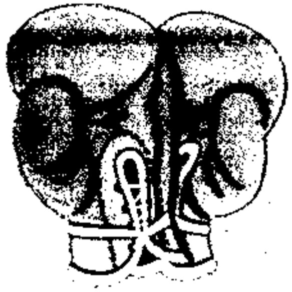
Special occasions within the Forces, at home and overseas, call for meticulous preparation.
Re-unions, Corps Weeks, Sports Days, Gymkhanas, At Homes, Service Weddings... all demand careful planning, and all involve "an eye to detail" which cannot be left to chance.
The problem of catering for numbers great and small is one which can be solved with the minimum of concern and the maximum of confidence by the appointment of Naafi, the Services' own catering specialists.
Enquiries are invited, and Naafi's District Managers will be glad to call by appointment to discuss your special requirements.
A selection of exceptionally attractive menus will be provided by Naafi, without obligation, from which choice may be made. And the prices are as moderate as the catering is faultless.

NAAFI

The official canteen organisation for H.M.Forces
RUXLEY TOWERS · ESHER · SURREY



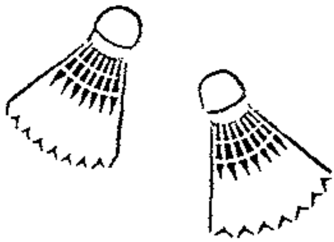


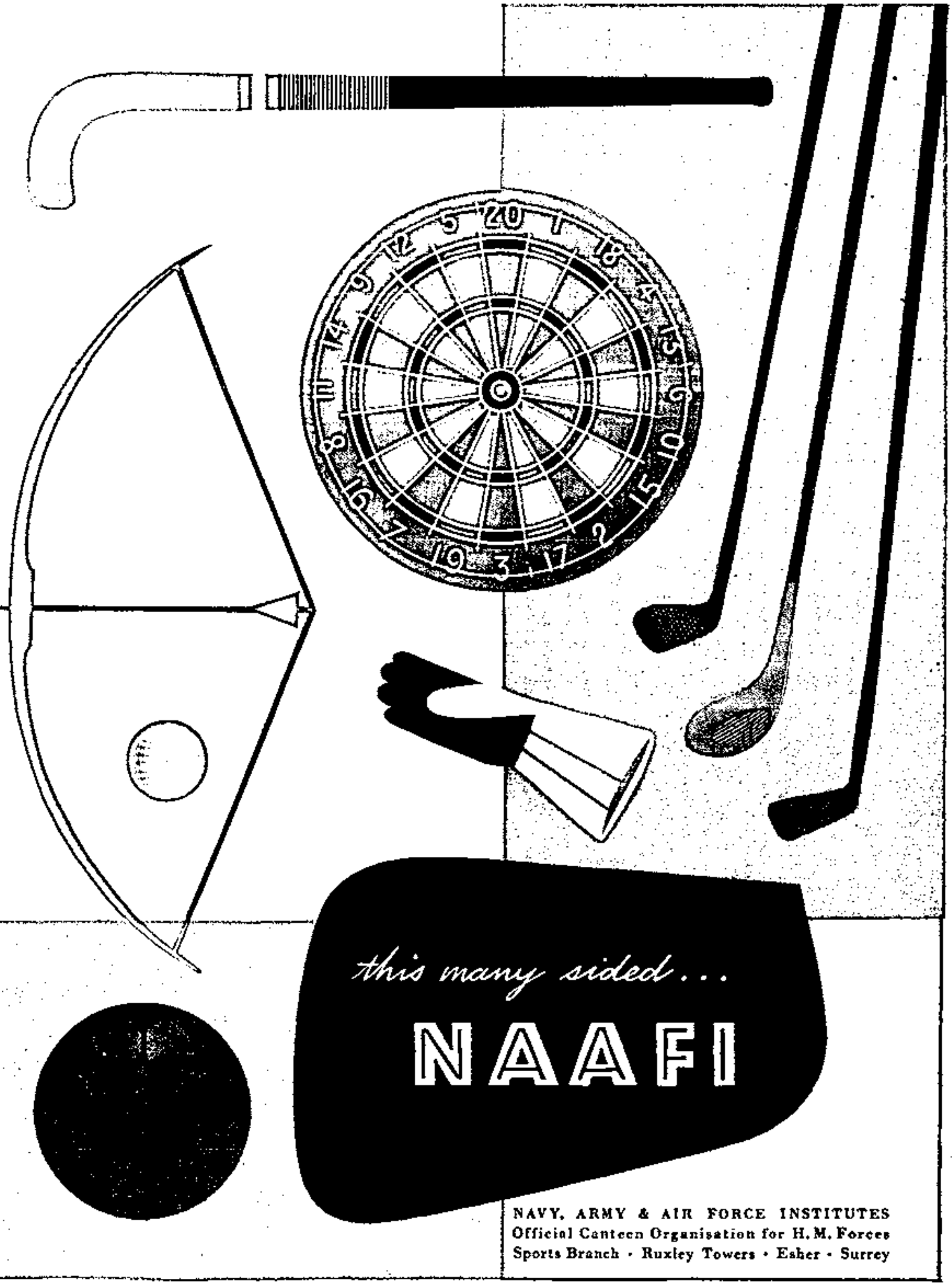


Steel shafts for Badminton rackets?
Yes.
Steel shafts for Squash rackets?
No.

Naafi's sports representatives, specialists at the service of the Services everywhere, know the answers to *all* questions concerning games and recreations. They are always available to advise (from practical experience) on matters relating to sports and their organisation, and their advice is backed by a service of kit and equipment second to none.

Naafi's sports goods are manufactured by the leading makers, and Naafi—the Serviceman's and Servicewoman's own business—allows a discount of 10% on sales to Units, Messes and Welfare Committees of the Royal Navy, the Army, the Royal Air Force, the Territorial Army, Auxiliary Forces of the R.A.F., the Sea Cadets, the Army Cadet Force and the Air Training Corps.




this many sided...
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NAVY, ARMY & AIR FORCE INSTITUTES
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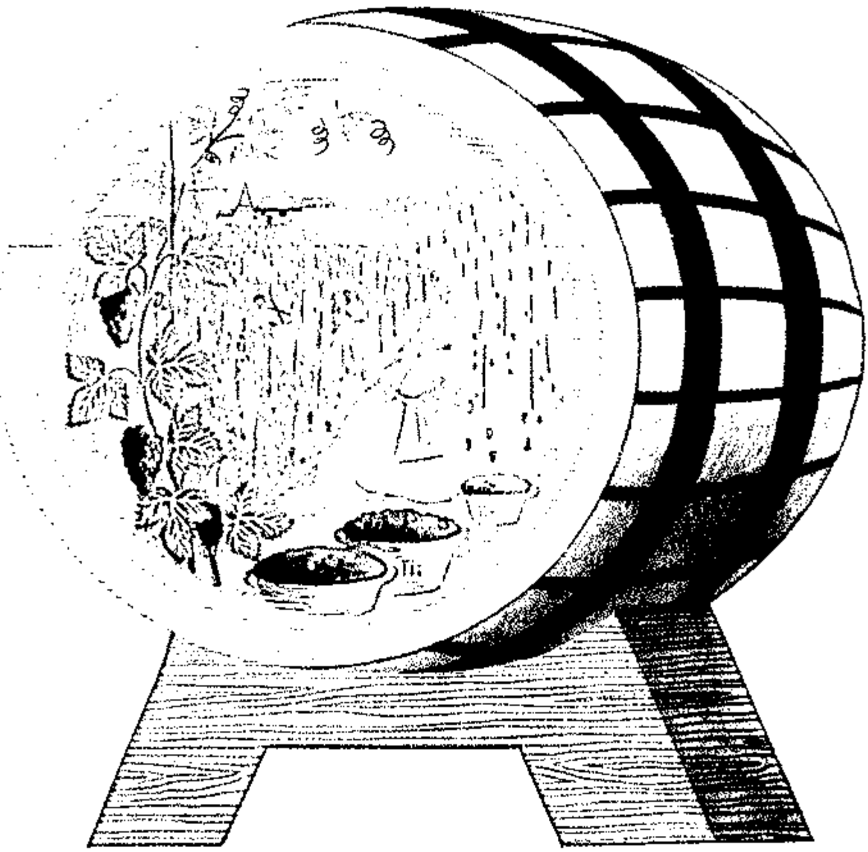
WINES AND SPIRITS



The connoisseur of wines knows his vintage years when, from the sun-drenched vineyards, comes fruit of the vine that has the promise of an especial excellence.
The Navy, Army and Air Force Institutes employ experts to choose wines and spirits of this finer quality. Carefully stored in modern cellars and perfected in maturity, Naafi stocks pay tribute to all occasions that call for wine. In Wardroom and Mess, make this year a vintage year with wines and spirits from Naafi. Write for wine list, or visit your Naafi shop for all your requirements.

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