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CONTENTS

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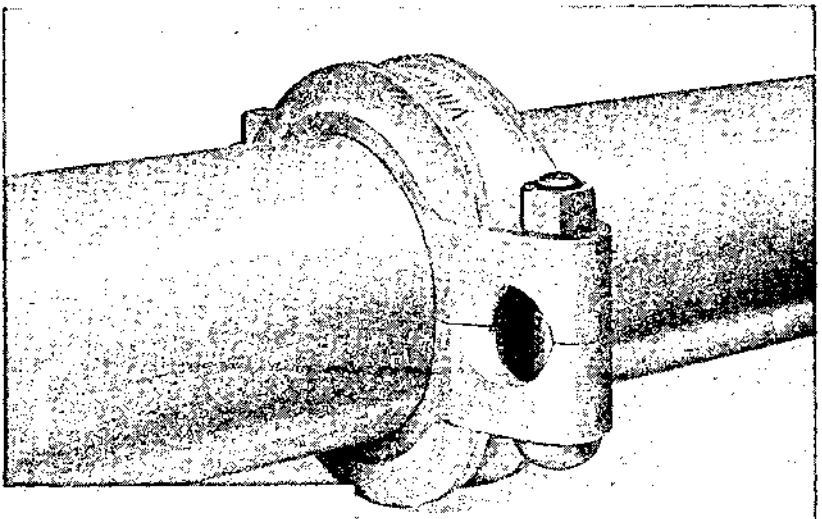

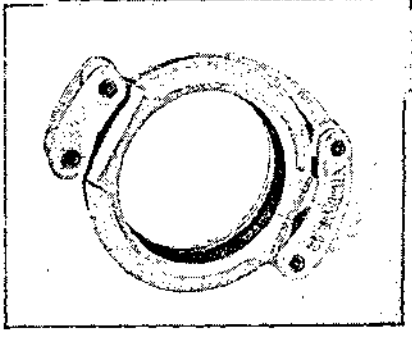

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VOL. LXXIX **CONTENTS** MARCH, 1965

Silver Candelabra for the HQ Mess

Silver Candelabra for the HQ Mess

By Major F. Dufton, RE

A set of six magnificent candelabra was presented to the Headquarters Mess, Chatham at the Territorial Army Guest Night on 16 October 1964, attended by over eighty RE Territorial Army Officers.

Designed by Atholl Hill, one of Britain's finest young silversmith designers, and made for Reid & Sons Ltd of Newcastle-upon-Tyne by Wakely & Wheeler, this set of six 10-branched candelabra embodies the best of modern design with finest craftsmanship and technical skill. Each candelabra uses 85 ounces of silver and is composed of seventy different pieces, all beautifully integrated into one whole.

Standing on a circular base bearing the Royal Engineer's Corps monogram on one side and that of the Territorial Army on the other, each candelabra has a central tapering pillar surmounted by the Royal Engineer grenade in silver-gilt. From this central pillar ten straight arms branch out, each terminating in a circular candle holder. These are fitted with very slim candles, slightly off-white in colour. The classically beautiful engraving on the candelabra—their only decoration—was carried out by Mr Theodore Wise whose work is known throughout the world.

The idea for this generous presentation by the Royal Engineers of the Territorial Army came from Major-General K. C. Appleyard, CBE, TD, DL, Honorary Colonel of the 50th (Northumbrian) Divisional Engineers since 1937.

After the Loyal Toast had been drunk the nine candelabra, which had been in place on the dining tables during dinner, were removed leaving only the two Kitchener candelabra on the top table to light the room. The doors behind the Vice-President, Lieutenant D. G. Knott, RE (TA), were then thrown open and the Mess Steward handed him one of the new candelabra. Lieutenant Knott made a most eloquent speech of presentation and, during the applause which followed, the remaining five candelabra were brought in to complete an impressive presentation ceremony.

Major-General A. J. H. Dove, CB, CBE, Representative Colonel Commandant at the time, deputised at the dinner for General Sir Frank Simpson, GBE, KCB, DSO, DL, Chief Royal Engineer, who was unable to be present. In accepting the candelabra he said that in the Corps the links between the Territorial and Regular Army officers had always been very close. It was through the officers of the Territorial Army that we were able, in time of war, to tap the expert engineering skill and knowledge of the nation. In fact the education of a Regular Sapper Officer was not really complete unless he had spent a period with the Territorial Army. It was for such reasons that the Corps so greatly appreciated receiving such a magnificent gift from the officers of the Territorial Army. It would be an ever-present reminder of our mutual comradeship. He concluded by commenting on the outstanding service of Major-General Appleyard as Honorary Colonel of the 50th Divisional Engineers, and expressed the Corps' great appreciation of his initiative in arranging this most generous and imaginative presentation.

In a letter to Major-General Appleyard the Chief Royal Engineer wrote: "I know that all those Regular Royal Engineers who were privileged to be present at the presentation were most impressed. The unanimous opinion of the Regular Officers of the Corps is that this has been a most imaginative and generous gesture on the part of the Royal Engineers of the Territorial Army."

Silver Candelabra for the HQ Mess 2

Presentation from the Officers Royal New Zealand Engineers

By Lieut-Colonel E. E. Peel, RE

On 23 September 1964 Colonel Andrew Murray, OBE, AMICE, AMNZIE, MNZIS, Colonel Commandant, Royal New Zealand Engineers, and an Honorary Member of the Institution of Royal Engineers, presented a coffee table to the officers of the Corps of Royal Engineers on behalf of the officers of the Corps of Royal New Zealand Engineers.

The presentation was made in the Headquarters Mess, Chatham. The Chief Royal Engineer, General Sir Frank Simpson, GBE, KCB, DSO, DL, JP accepted the table on behalf of the Corps, a delightful gift gratefully accepted.

3

Presenation from the Officers Royal New Zealand Engineer

The table is made of inlaid New Zealand woods; the photograph of the table illustrates its perfect proportions, but it does not fully reveal the truly magnificent craftsmanship of its construction nor the delicate graining and artistic merit of the patterned inlay. It bears two silver plates inscribed "Presented to the Officers of the Corps of Royal Engineers from the Officers of the Corps of Royal New Zealand Engineers" and "A token of admiration, esteem and goodwill in recognition of glorious achievements". It now stands in a place of honour in the main Ante-Room of the Mess.

The luncheon that followed the presentation was attended by Colonel and Mrs Murray, General Sir Frank and Lady Simpson, Major-General G. W. Duke, CB, CBE, DSO, Engineer-in-Chief and Mrs Duke, Brigadier J. G. Carr, ADC, Commandant Royal School of Military Engineering, and Mrs Carr and some seventy other officers of the Corps and their wives.

Preparation for a Defence Force 1964-69

GOLD MEDAL AND TRENCH GASCOIGNE
PRIZE ESSAY COMPETITION 1963

The 1963 Gold Medal of the Royal United Service Institution, together with the Trench Gascoigne Prize was awarded by the Council of the Royal United Service Institution to Major J. N. Elderkin, RE.

His prize-winning essay was first published in the November 1964 *RUSI Journal*, and it is reprinted here by permission of the Council of the Royal United Service Institution.

"Any idiot can go on doing what has been done before, but it takes real courage, intelligence, and character to assess the needs of the future, to devise a sound programme, and carry it into effect. This is particularly true of the armed Services, which become merely an expensive luxury unless the process of improvement, modernization, forward thinking, and planning goes on continuously." (*His Royal Highness The Duke of Edinburgh at the Royal School of Military Engineering, 20 July 1962.*)

What improvements in organization and administration jointly affecting all three Services do you consider could and should be made during the next five years?.

INTRODUCTION

THE five year period dealt with in this paper follows immediately upon the greatest single administrative upheaval affecting the higher direction of the British Services since the Haldane reforms brought the General Staff into being nearly 60 years ago. Because Service officers have an inbred, if often understandable, reluctance to depart from proven paths, there is a real danger that the radical changes being made in the organization of the Defence Departments in Whitehall will not be allowed to permeate downwards as rapidly and as deeply as they should. Also, during the next ten years, it is possible, if not probable, that political circumstances allied to

economic necessity will compel the United Kingdom government to confine its strategic interest to Europe and the North Atlantic. Unpalatable to the traditionalists as such a development may be, nothing is to be gained by pretending that it is so remote as to be of no consequence; on the contrary it should be seen as a spur to recasting the armed Services so that they will enter the new era unhampered by the consequences of historical accidents and by clinging to ways of life which really belong to another age. Moreover, although much has been done since 1945 to modernize and to liberalize the forces, the creation of a favourable public image has been frustrated by the cumulative effects of 20 years of conscription. The impression that the armed Services are a somewhat ponderous and reactionary body is still abroad.

In this paper it is taken as axiomatic that by 1970 the Services should be moving rapidly towards a Defence Force within which the relationship between sailor, soldier, and airman is comparable to that which exists in the Army to-day between gunner, sapper, and infantryman. The argument is not concerned with matters of strategy, with the pros and cons of Polaris, whether or not the aircraft carriers should be replaced or the future of the manned interceptor. Rather it is concerned with the steps which the author considers should be taken now if eventual integration is to be made easier and less painful than it will otherwise be. In this context it is salutary to remember that the total strength of the U.S. Marine Corps is more than 50 per cent of the planned peacetime strength of the U.K. armed Services. Not only has this country got to build forces whose cost can be reconciled with their efficiency, but they have also to be organized in such a way that they will attract adventurous young men who have known of the doings of astronauts for as long as they can remember; for them the events and lessons of the last war are no less remote than the Somme and Passchendaele. In brief, the time has come to lay the foundation for a Defence Force which is not only strictly professional, but which is also a byword for enterprise and efficiency.

This review is concerned only with matters which will affect all three Services jointly. Because the efficiency of any Service depends ultimately upon the quality of its officers, the paper opens with a consideration of methods of officer training and the spreading of scientific knowledge and understanding. This will be followed by a review of organizations which appear to have outlived their original purpose and which seem likely to obstruct logical progress. Lastly, a view will be taken of administrative problems and in particular of those associated with the provision of a satisfactory career structure in the armed Services of the future.

The Education of Officers

The most pressing need in the realm of Service education is to produce leaders who enjoy a common set of values and who have absolute mutual trust in each other. It would be wrong to suggest that these essentials are entirely absent to-day, but because the three Services have grown up almost independently, each has sought to establish its own loyalties and its own traditions; inevitably this has led to the inculcation of pride and of prejudices and all too frequently to the adoption of isolationalist policies. So deeply ingrained are these loyalties that they can, and do, lead to the clouding of otherwise intelligent judgments. Support for a policy may be influenced not by military expediency but by a desire to maintain the power and authority of a particular Service.

Rather in the way that the Cyprus tragedy was made almost inevitable by the fact that the professional leaders of the communities had spent their formative years in the universities of Athens and Ankara, so the root of the problem of producing a British Defence Force unified in spirit lies in the training of officer cadets. A central Defence Academy on the lines of that established by India (on British advice) at Khadakvasala or by Canada at Kingston, would base the careers of all officers on a common foundation. If time permitted only the first year of the course to be spent in a common establishment before beginning specialist training, it would still be worthwhile. Much of the curriculum at the present Service colleges is academic and does not demand specialized facilities. The unification of Cranwell, Dartmouth, and Sandhurst has been seriously discussed on more than one occasion in the last 15 years; each time it has been rejected on the grounds of cost. Judging by the size of the building funds of the new universities, £10 million would be a generous provision, and yet such a sum is no more than the cost of three or four TSR.2 aircraft. The impact of such a change on the public should not be ignored; the schoolboy and careers master are likely to see in it a sign that the Services really are determined to forget past jealousies and to blend themselves into a versatile and modern force. No other single change is likely to produce such far-reaching and beneficial results.

The three Services lay very different emphasis upon technical training and the importance of scientific understanding. The Royal Air Force is essentially a modern technical Service. So complex are modern aircraft and weapon systems that every pilot and air commander has to some extent to be a technician; he has to be familiar with the physical laws of aerodynamics and cannot escape contact with the world of electronics. Although the naval engineer largely trains apart from the executive officer (and has still to achieve representation on the Board of Admiralty)[1] the organization of shipboard life is such that contact between specialist and executive officers is closer than in the Army. A scientific approach is also fostered by the practice of specialization by seamen, whether it be in submarines, navigation, or communications, as well as by the existence of the Fleet Air Arm as an integral part of the Navy. In the Army the technical services have never been accorded the same status as the so-called "teeth" arms. Apart from the officers of the Royal Engineers, who significantly have often been able to enjoy the best of both worlds, the technically trained officer has usually been denied any real opportunity effectively to influence Army doctrines. The post-war creation of the Technical Staff might be thought to have raised the level of scientific awareness in the Army, but it has, in fact, tended to aggravate rather than to relieve the position. The TSO has almost invariably been employed in specialist appointments far removed from troops. Meanwhile, although the General Staff Officer has tended to regard things even faintly technical as being outside his scope, he has continued to monopolise appointments concerned with all types of policy. The shortcomings of the system are not fully apparent until the Army's requirements come into conflict with those of the other Services. In such circumstances the scientifically-minded sailor or airman is likely to confound the soldier who still prefers to look upon war as an art.

All three Services have some officers who have been trained in the universities and, in addition, they run their own colleges to train specialists to degree standards. One Army officer in ten is a university graduate. In spite of these

[1] Such an appointment has since been made.

arrangements, civilian scientists are increasingly being co-opted to direct operational research and development and to advise on defence problems at the highest level. The elevation of the Chief Scientists to the Service Boards is but one example of this development. While there is abundant evidence that the analytical and critical approach of the trained scientific mind is invaluable, there is an increasing danger that very important military decisions will be taken without a proper understanding of Service needs and operational realities. This danger will persist and will grow until such time as the armed forces can produce from their number a succession of high calibre officers with sound scientific training. In addition to the need to recruit more graduates and to make scientific interest more fashionable, there is a strong case for bringing together the R.N.C. Manadon, R.M.C.S. Shrivenham, and the Technical College at Henlow. If a Defence University could be established it might then be possible to give applied military science a much higher academic standing than it enjoys to-day. Moreover, while such a move might involve an initial rise in costs, it would cut out the triplication of expensive laboratory facilities and make better use of the available academic staff. It could also provide a much-needed bridge between the Scientific Civil Service and the armed Services.

Experiences of the last war left no doubt as to the need for a body of officers trained for service on joint staffs. Since 1948 the Joint Services Staff College has been running courses for officers who have had about 18 years service. At a lower level, there has in recent years been increasing emphasis on joint training at the single Service colleges and on the cross-posting of students. The success of these moves makes the establishment of a single college which could undertake all staff training the next logical step. Some of the training in such a college would still have to be specialist, particularly with regard to naval operations, but the syllabi of the Army and R.A.F. colleges already have much in common. Staff procedures are now being standardized. No rebuilding would be necessary. Andover, Bracknell, and Camberley could between them accommodate students from all three Services. The colleges would cease to be single Service in outlook or composition and would become divisions of the Junior Defence Staff College. While the present colleges retain their independence their positions inevitably become more deeply entrenched and they will continue to vie with each other over capital facilities and accommodation, to say nothing of doctrine.

Rationalization

The deep reluctance of the Services to change established patterns has led to the survival of a host of quaint and often illogical organizations; occasionally, too, it leads to the perpetration of new anomalies. Too often the value of tradition is overstated when changes in Service matters are proposed, the ability of strong leaders to foster *esprit de corps* in a very short time is ignored. Few who have encountered it would underrate the corporate spirit of a ship three months after commissioning, or of a recently formed squadron in either the Army or the Air Force. In recent years some steps have been taken and are being taken to cut out duplication of effort by the device of one Service assuming responsibility for a particular requirement in a particular area. Unfortunately the contentious issues have been sidestepped and changes have so far been of a minor nature. For example, the Army has assumed responsibility for baking bread in Hong Kong and the Air Force is

providing medical services in Aden, but no attempt has been made to reconsider the place of the Fleet Air Arm, the Royal Marines, the R.A.F. Regiment, and the Army Air Corps. These will be discussed before attention is drawn to other fields which merit independent and critical analysis.

The advent of VTOL aircraft does much to demolish the somewhat specious argument that the operation of seaborne aircraft is so specialized that it should be reserved to seamen. The search for a common aircraft to meet the requirements of naval and air Staffs has taken place on both sides of the Atlantic. In both this country and in the U.S.A. it was bedevilled by sectional interests. Were naval aircraft to be manned by the R.A.F., there would be a much greater incentive to make land and carrier-based squadrons interchangeable. Above all, airmen would acquire a closer insight into the problems of the fleet, and no longer would there be so much talk of "we" and "they".

The Army Air Corps operates aircraft used for liaison and unarmed reconnaissance. The value placed on the aircraft by Brigade Commanders illustrates in a minor way the importance of linking air and ground operations. However, because these aircraft are manned by Army officers, R.A.F. pilots miss a great opportunity of working in close contact with Army formations in the field. If responsibility for light aircraft were taken over by the R.A.F., not only would the Air Force gain additional manned aircraft to operate (albeit of very different performance to the 'V' bomber and supersonic fighter but not to the communications aircraft), but a constant flow of young pilots would gain first-hand knowledge of the Army at brigade level. The way would also be made easier for the eventual introduction of the closer air logistical support which is becoming both technically possible and operationally essential. The present upper weight limit imposed on Army aircraft is all too likely to inhibit progress. The insidious belief that the Army will not get the support it needs unless it controls its own aircraft must not be allowed to linger any longer.

Transference to the R.A.F. of the responsibility for all air operations, including that of helicopters, is likely to result in economies in training establishments, better use of technical manpower, and considerably greater operational flexibility and efficiency. Above all, because operations are so entwined, demarcation between the Services would be blurred and the Air Force would regain the close contact with land and sea operations which was evident in the early days of aviation.

The Royal Marines are the outstanding example in the British forces of the merits of true integration, but their very success has led to the creation of a private empire which is not always in the best interests of the Services as a whole. The amphibious skills of the Marine, which are essential at least for so long as we retain our world-wide commitments, are no more than the very skills which should be common to the whole Army; their dissemination will never take place properly until berths aboard *Albion* and *Bulwark* are open to any battalion in the Army. It is therefore suggested that control of the Royal Marines should pass to the Army and that R.M. officers should cease to have a career structure of their own.

The R.A.F. Regiment grew from the wartime need to provide for the close defence of airfields. Post-war developments and, above all, the shrinkage in the size of the Services, have made the Regiment an anachronism. The Air Ministry is saddled with a body of men who are essentially soldiers.

Quite understandably, the R.A.F. Regiment has sought to expand its activities in order that it may offer its recruits (officers and men) a more interesting career. While the assumption of responsibility for fire fighting on R.A.F. stations has a certain logic, the tendency for the field squadrons to be regarded as first-line internal security reserves has none. This is a role far better catered for by the Army. A better solution to the important fire-fighting problem may well be the amalgamation of the Army and R.A.F. fire services. Nothing can justify the recent move to train men of the Regiment to parachute so that they may follow up the Parachute Brigade in any attack on a defended airfield; in the planning of any assault such a development could well lead to embarrassing competition for a strictly limited dropping capacity —a capacity which is hardly ever likely to be big enough to satisfy the operational commander. It therefore seems logical for the Regiment to disband and for those men whose training has been primarily military to be absorbed by the Army. In a minor key, for the numbers involved are small, it is uneconomical for the R.A.F. to maintain airfield construction units when at the same time the Army has its own corps of engineers equipped to do the same job.[1]

The prime importance of communications is well recognized. In Whitehall joint signal committees of many kinds are in constant session. Even so, operating techniques used by signallers in the different Services still differ widely. Current guides to the planning of joint operations emphasize the need to ensure that both ends of any communication link are operated by men who wear the same coloured uniforms. This is a state of affairs which imposes unnecessary handicaps and also one which could be rectified comparatively easily and rapidly. The prospect of the establishment of a British satellite communication system should provide the incentive to draw all Service signal interests together and establish a joint signals school. Such a school would not only achieve practical standardization at the lower levels, but also lead to the wider acceptance of standard equipment and broaden the horizons of all signal officers.

Administration

There are many undramatic ways in which Service administration can be improved. The adoption of a common code of law and disciplinary regulations has at last been put in hand. A common legal service is a logical consequence, as would be an integrated provost corps. The unification of the medical and dental services is seen by some not only as the best way to make sensible use of the scarce qualified manpower but also of offering a career with the sort of pyramid which will continue to draw enthusiastic men unattracted by the National Health Service. The arguments that the need for Service specializations, such as aviation medicine, make closer association impossible, are unconvincing and, indeed, were quoted with open scepticism by the Parliamentary Sub-Committee which examined the problem in 1959[2] few professions have more specializations than the medical. In the domestic field there can be no sound reason for each Service having its own regulations for the furnishing and allocation of married quarters, or for the payment of travelling allowances. This sort of situation continues because there is no

[1] It was announced in November 1964 that over the next five years the functions of the RAF Airfield Construction Branch would be transferred to the Royal Engineers.

[2] 4th Report of the Sub-Committee on Estimates—Session 1958/59.

real pressure to reform it, and the resultant work provides employment which those involved naturally seek to perpetuate.

The manning of armed forces is always likely to be a compromise between a need for youth and vigour and a desire to offer potential officers and men both worthwhile careers and security for their families. Years of comparative peace have led to such slogans as the Army's "Careers to Fifty-five"—a concept which is almost impossible to reconcile with a businesslike fighting force. In modern war, whether it be in Brunei or in Europe, there can be no place for the airman whose responses have ceased to be in tune with supersonic flight, or for the officer who is not as fit as the men he commands. Too frequently commanders are forced to concern themselves more with the welfare of women and children than with training and efficiency. Now that the working lives of most of the population extend to the age of 65, it must be accepted that the majority of officers and men in the Services must plan two careers and that the second of these ought to begin before the age of 40. It must be recognized that to pay substantial gratuities and pensions which will make it possible to change careers without hardship is likely to be more economical than to fill administrative posts with men who have no prospects of promotion and no incentive to eliminate themselves from the administrative machine. There is also a need to establish much closer links between the Services and public civilian authorities than at present exist; further examination of this problem is beyond the scope of this paper but it merits the closest attention, for a guarantee of attractive employment on retirement could do much to boost both morale and recruiting.

Since 1945 the standard of education of boys leaving school has risen steadily and an increasing proportion of young men have enjoyed the benefits of secondary and grammar schools. The contrast with conditions ruling before the last war is already great and will become even more marked when the school leaving age is raised to 16. Simultaneously with these changes, the standard of living throughout the country has advanced rapidly and much levelling of incomes has taken place. Up to now the Services have not done enough to adjust themselves to the situation which has come about. Particularly in the Army, but also in the Navy and the R.A.F., the Sergeants' Mess and its equivalent imposes a virtual ceiling on the prospects of men enlisting in the ranks. This arbitrary limitation of careers is out of tune with civil practice and, undoubtedly, serves to deter men of zeal and ability from a Service career. Particularly in a period when recruiting is likely to grow more and more difficult, opportunities must be created which will make the Services once again the natural outlet for the boy who is both adventurous and ambitious.

If worthwhile opportunities are to be created, command (in Army terms) of at least platoons and companies, if not of battalions, must be put within reach of the man enlisting in the ranks. This could be achieved by progressively reducing the size of the intake to cadet colleges and simultaneously training and promoting suitable N.C.O.s and men to fill executive and combatant appointments, which in the past have been reserved for officers with permanent regular commissions. A system of this kind has operated for many years in the Gurkha units of the British Army. Queen's Gurkha officers have held junior commands alongside both British and Gurkha officers commissioned from the Royal Military Academy. The adoption of a similar system in the United Kingdom armed forces would both meet the need for new openings

and have the added result of automatically making it possible to apply more stringent standards to potential entrants to the Cadet Colleges; in turn the cadets would themselves enjoy enhanced prospects of promotion to the higher ranks, both in command and on the staff. An incidental effect of any reduction in the number of cadets would be to simplify the amalgamation of the Cadet Colleges. Changes of this sort could revitalize the Services and be a force in the creation of a new and much needed professionalism. In the past radical changes have always been resisted because they would inevitably result in the disappearance of much of the familiar order, but only by making such changes will the Services get into step with the social ideas which have now become established in the wider civilian world.

In order to make the intermingling of the three Services as simple and as free of friction as possible, it is important that the present differences in rank structure be eliminated as a matter of priority. The most serious divergence occurs at the commander/lieut.-colonel level; on joint staffs of equal rank, the Army member is likely to be four or five years older than his naval and air opposite numbers. Furthermore, with the advent of a common promotion roll for all "two star" officers and above, it is essential, if only in the interests of equity, to ensure that officers reach this level at approximately the same age; at present the R.A.F. have a lead of about two years over the other two Services. The solution to the problem is complicated by well-established Army policy concerning appointments to the command of battalion-sized units. Success in such an appointment is made essential for an officer aspiring to further promotion, but in peacetime command is not normally given to officers before they reach their 42nd year. There would appear to be no practical alternative but for the Army to bring about a progressive reduction in the age at which command appointments are made. While such a reduction would involve the declaration of limited redundancy, it would undoubtedly be welcomed by the Army. Because it would take some years for the change to become fully effective, some adjustment to rates of pay is necessary in order to bring all officers more nearly into line, on an age-for-age basis, than they are to-day.

Conclusion

The period 1964 to 1969 must be used to lay the foundations of a unified United Kingdom Defence Force. Powerful and valuable as tradition may be, it must not be allowed to deter logical steps in the evolution of the armed Services. *Esprit de corps* grows quickly when strong leadership is at hand. In order to set common standards and ideals throughout the Services the initial training of all officers must be done in one institution. Whenever possible training establishments, including staff colleges, must become functional rather than Service in character. An understanding of technology must no longer be reserved to the specialist; it must become as essential a requirement of the staff officer as the ability to write English. All officers must study war on land, at sea, in the air, and in space. Attempts must be made to increase the academic standing of applied military science and, to this end, the Service technical colleges should operate to a common plan.

The position of the component parts of all three Services must be subjected to critical and impartial examination; each arm or branch must be judged not on past performance but in the light of circumstances prevailing to-day and in the probable future. Nothing must be allowed to prevent the

Royal Navy, the Army, and the Royal Air Force dovetailing in every possible way; in particular, the position of the Fleet Air Arm, the Royal Marines, the R.A.F. Regiment, and the Army Air Corps must be rationalized.

The career structures of the Navy, Army, and Air Force must be adjusted to bring them into reasonable balance with each other. The organization of the Services, and in particular of the Army, should be reviewed and altered to take account of the rise in the general standard of living and education which has occurred in the last 15 years. Opportunities must be created which will encourage the able and ambitious recruit by offering him a career that is not limited, for all practicable purposes, to non-commissioned rank. At the same time the qualifications demanded of candidates for regular commissions must be raised, in order to ensure that the all-round intellectual ability of the average regular officer is comparable with that of the university graduate.

The changes and developments outlined in this paper could and should take place in the next five years. Their sole object is to make possible a supremely vigorous and efficient Defence Force, which will not only uphold the best of past traditions, but set standards which will be envied the world over.

Motorways in England and Wales

By LIEUT-COLONEL J. D. TOWNSEND-ROSE, MC, RE

INTRODUCTION

The aim of this paper is to show some of the work behind a finished motorway, discussing some of the problems and their solutions.

It is based on a twenty-one-month ESSE attachment in 1962–4, which was divided, like Gaul, into three parts; the first with Marley Concrete, where the product was precast reinforced concrete; the second with a consortium of contractors (Marples Ridgway, Keir, and Christiani & Nielsen) which was engaged on that part of the M4 carried above the Great West Road west of Chiswick; and the third with G. Maunsell and Partners, working on the design of another section of the M4 where it passes through Monmouthshire.

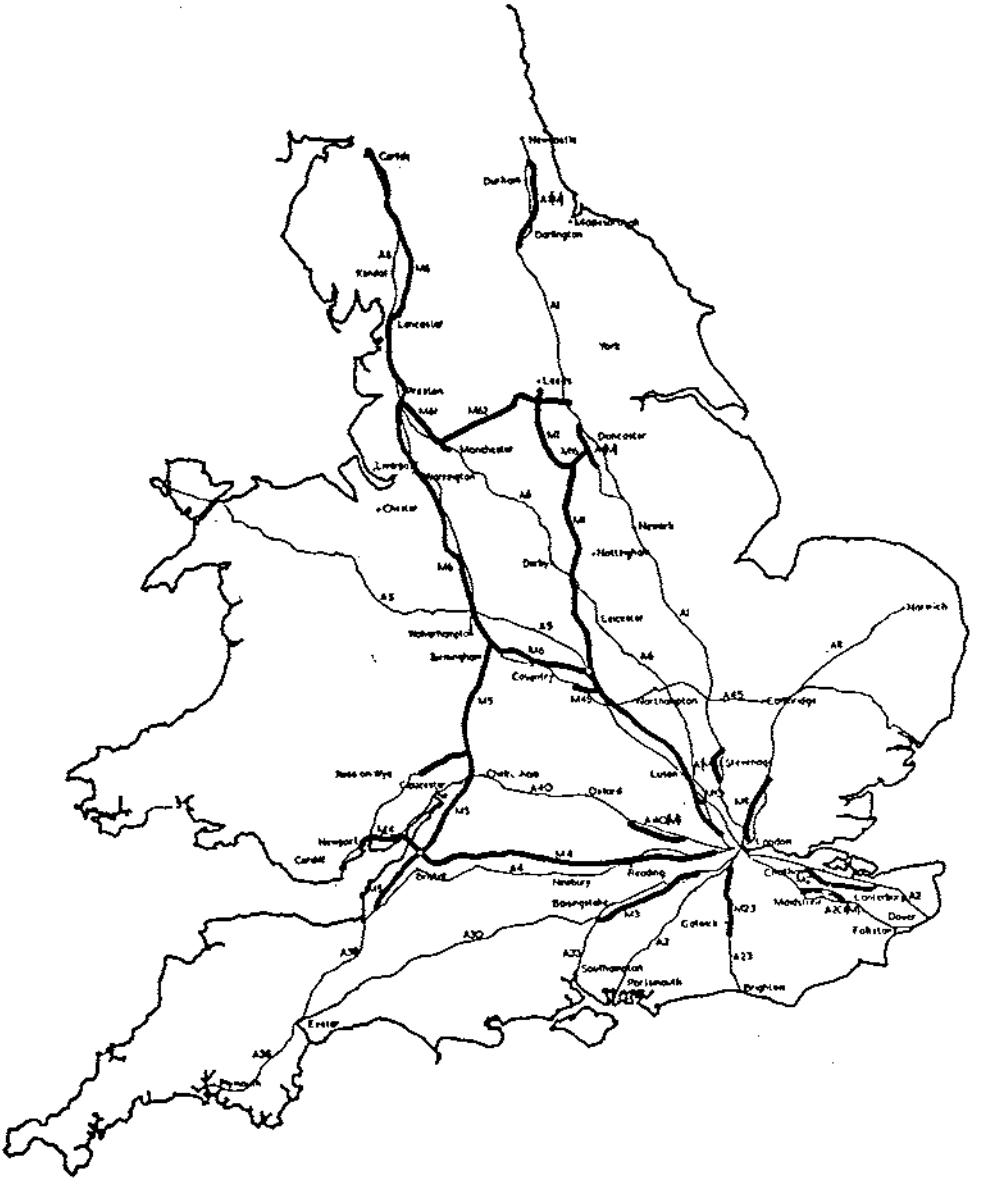
The paper deals with motorways in general, but I have drawn on actual experience to illustrate particular points.

THE PROGRAMME

A map showing motorways of England and Wales planned, under construction and completed, is shown at Drawing No 1.

Outline Planning. The outline network of rural motorways required is not difficult to determine, nor does it take long to plan. As a result of traffic surveys, the Ministry of Transport has produced this outline of what motorways are needed, both now and in the future, and on these conclusions is based the desirable programme of completed roads, taking into account not only the traffic picture of the future, but also funds likely to be available for the various projects—this latter in very round terms, since at this stage the detailed route has not yet been determined.

DRAWING No. 1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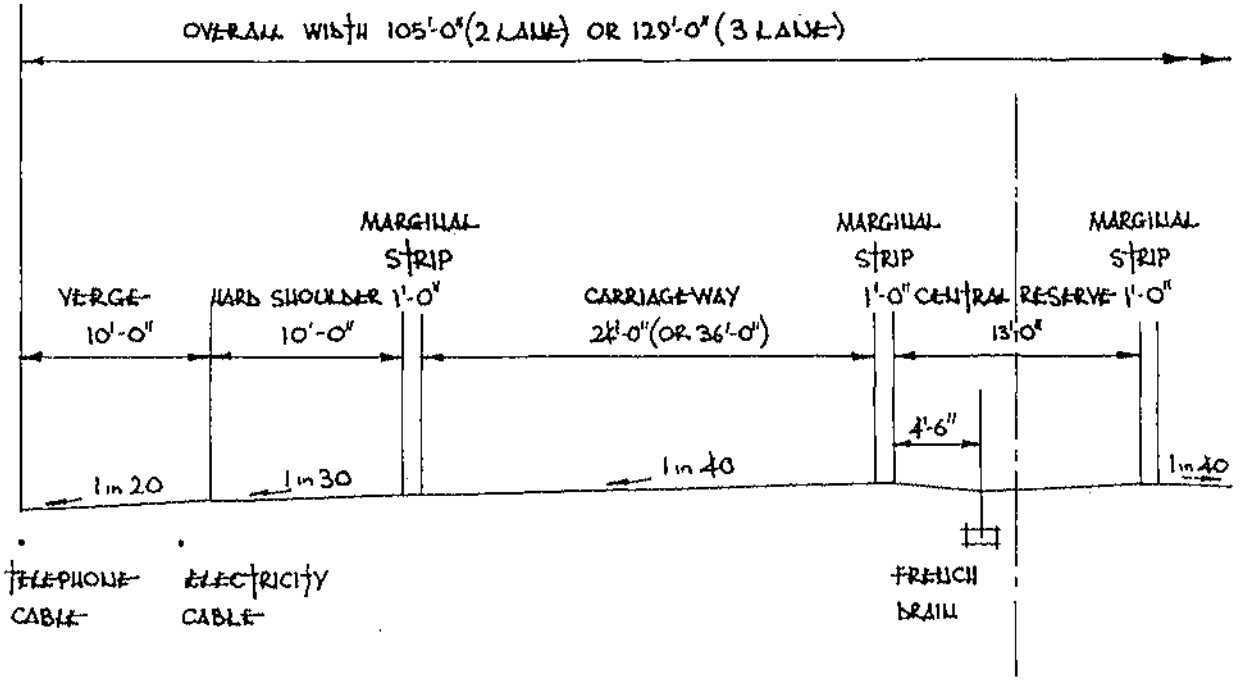


DRAWING No. 2

HALF CROSS SECTION OF TYPICAL MOTORWAY

SCALE: 1/10" to 1'-0"

Plan and Profile. Three years are needed for the preliminary stages before the first dozer is loosed on the project. A firm of consultants is appointed which will carry out a survey between the terminal points and recommend a detailed route to the Ministry who will then, if they approve the route, consult with local authorities and institute proceedings for land acquisition. The report to the Ministry will include large-scale plans showing not only the proposed alignment, but a profile of the road showing gradients and curves, and the results of a soil survey throughout its length. This will enable the Ministry to check that their specifications with regard to gradients, curves, landscaping and junctions are being met, and the soil survey will give some indication of probable cost of foundations to bridges, excavations and so on.

At this stage, while the local authorities are acquiring land, the Consulting Engineer will continue with more work in preparation for putting the project out to tender, and will have many details to discuss with other organizations. These may include:—

County Council	diversion of local roads, sewers, etc.
Waterboard	diversion of water mains
GPO	diversion of telephones and television cables
British Railways	work in connexion with railway crossings
River Board	work in connexion with river crossings
Fine Arts Commission	design of major bridges
Electricity Boards	diversion of power supplies.

Such a list can be continued almost indefinitely, and can easily be duplicated where the route passes through more than one County or region; and the discussions may well take a long time.

Eventually the tender documents will be produced, which will include the standard specification, additional clauses, bills of quantities, general drawings and financial arrangements. By this time, outline design of the motorway and its associated works is complete, but detailed drawings have not yet been done, and indeed much of the detailed design has not yet been started.

The tender document will probably give a starting and finishing date, and a reasonable time for the Contractor to carry out the work is two years, the target date for completion usually being at the end of the summer.

At any stage in the first three years, financial or other considerations may postpone the date by which completion is required, and the fact that the Ministry has appointed a firm to design a motorway is no guarantee to the motoring public that, in five years time, they will be able to travel on it; nor indeed can the start of work guarantee an opening date. Such projects are normally very large and the pitfalls, ranging from adverse weather to contractors bankruptcy (not to mention Parliamentary denial of funds) are legion. However, an initial target of 1,000 miles of motorway by the early seventies has been announced and although progress to date is not at a rate sufficient to achieve this figure, there is no reason, other than financial, why this rate should not be increased, since the design and execution potentials already exist.

Motorway Specification

Source. The facts and figures given below are extracted from the Ministry of Transport Motorway Design Memorandum dated August 1962, with subsequent additions and amendments. Space does not permit a full transcript, but as much information as possible is included, in an abbreviated form.

Carriageway capacity. Traffic likely to be attracted to a new motorway, including an allowance for growth of population density, future traffic demands, and traffic actually generated by the existence of the motorway, is calculated from origin and destination surveys. The figures thus obtained are converted into Passenger Car Units (pcu).

For design purposes it is assumed that each lane has a capacity of 1,000 pcu per hour, and provision must be made for peak hour traffic, particularly at intersections.

The pcu conversion factors vary according to gradient, curvature, lane width, and design speed of the road, but the Ministry of Transport uses the following table for motorways:—

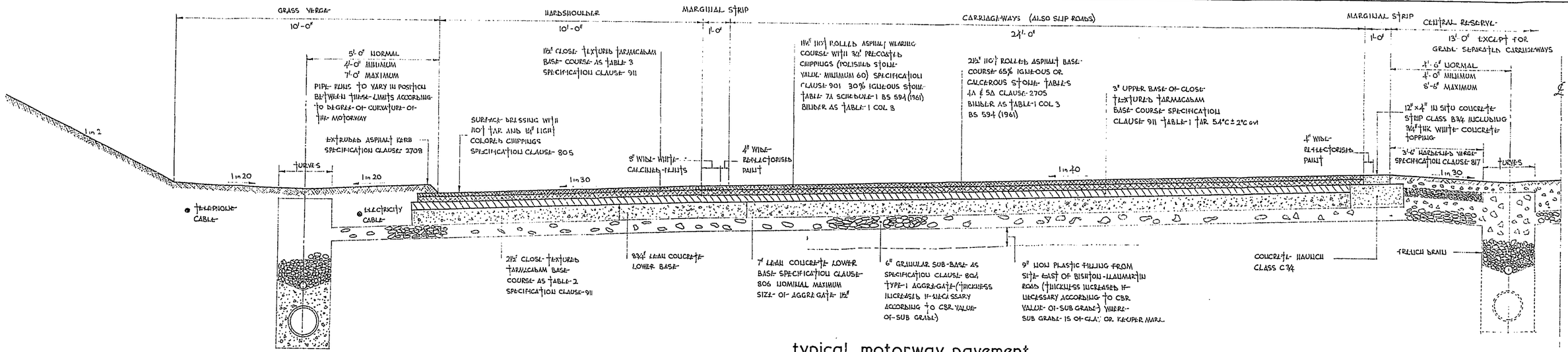
Motorcycle	1.0 pcu
Private car	1.0 pcu
Bus or coach	3.0 pcu
Light goods vehicle	1.0 pcu
Heavy goods vehicle	3.0 pcu

Cross section. Drawing No 2 shows the standard cross section, which is increased by 12 ft for each carriageway when three lanes are required. The central reservation is normally 13 ft, but may be reduced to 8 ft to save expense on viaducts (some motorways designed before 1962 have a central reserve as little as 4 ft). Hard shoulders need not be designed for continuous heavy use, but must be capable of carrying heavy loads in emergency. The crossfall of 1 in 40 is required for drainage and does not normally affect the driver, though when reversed for central drainage, as on the Hammersmith Flyover, it is quite noticeable. Where superelevation is required, the carriageway and hardshoulder portion of the cross-section is tilted about the edge of the central reserve either increasing the normal crossfall, or reversing it; if a split level road is required, such as may be desirable when it traverses a fairly steep slope, then the central reserve may be widened and two profiles provided; these profiles still represent the levels at the edge of the central reserve, and ensure that traffic in the fast lane has the benefit of the smoother line round horizontal curves.

Gradients and curves. The normal maximum gradient is 3 per cent; an extra lane on the up-gradient may be provided where the slope exceeds 1,500 ft in length; abnormally, in hilly country, maximum gradient may be 4 per cent, with an extra lane if over 1,000 ft long.

Horizontal curves are to a normal minimum radius of 2,800 ft, abnormally 1,500 ft. For curves of less than 11,000 ft radius, transition curves are required, and the adverse crossfall must be eliminated. In this case, favourable crossfall is provided to a slope of 1 in $\frac{37r}{V^2}$ where r is the radius in feet, and V is the design speed in miles per hour (normally 70 mph). The maximum permitted superelevation thus obtained is 1 in 14½, which represents a radius of 1,920 ft for a 70 mph design speed, or 62 mph for the minimum radius of 1,500 ft. One of the bends on the elevated road at Chiswick has a radius of only 520 ft; the superelevation is the maximum permitted, ie 1 in 14½, and this represents a calculated speed of less than 37 mph; it would be reasonable to impose a 40 mph speed limit at this point.

Vertical curves should not normally be of a radius less than 60,000 ft for crests, 30,000 ft for valleys; to allow continuity, a long curve of large radius



typical motorway pavement
cross section in cutting

DRAWING Nº 3

is preferred to a short curve of small radius and the length of a vertical curve should not be less than 1,000 ft.

Sight distance is an important factor in designing curves. At all times, two points each 3 ft 9 in above the road level, at the centre of any lane and 950 ft apart, must be intervisible, and this sight distance of 950 ft must not be reduced, either by excessive vertical curve, or by horizontal curves in conjunction with bushes, trees, bridge piers or sign boards.

Bridges. When another road passes over the motorway (referred to as an overbridge) it must have certain features incorporated in its design. Minimum headroom is 16 ft 6 in; ideally there should be no central pier, and the abutments should be clear of the hard shoulders. The bridge itself should be designed to carry 50 per cent of the Ministry of Transport HA loading as a minimum, though many such bridges may well require a higher capacity. Footbridges must be designed for a loading of not less than 100 lb per sq ft. The piers and abutments of all such bridges must also be designed to withstand the impact from a heavy vehicle which has left the carriageway, though guard rails are also installed as an extra precautionary measure.

Underbridges should normally be to the full width of central reserve, carriageways and hard shoulders, though a reduction in verge width is permitted. This normally means a width of about 100 ft, which may be more if there are extra lanes, and a light well between the carriageways (especially if they are at different levels) can be provided, but must be gridded to take HA loading. For long bridges and viaducts, the central reserve may be reduced.

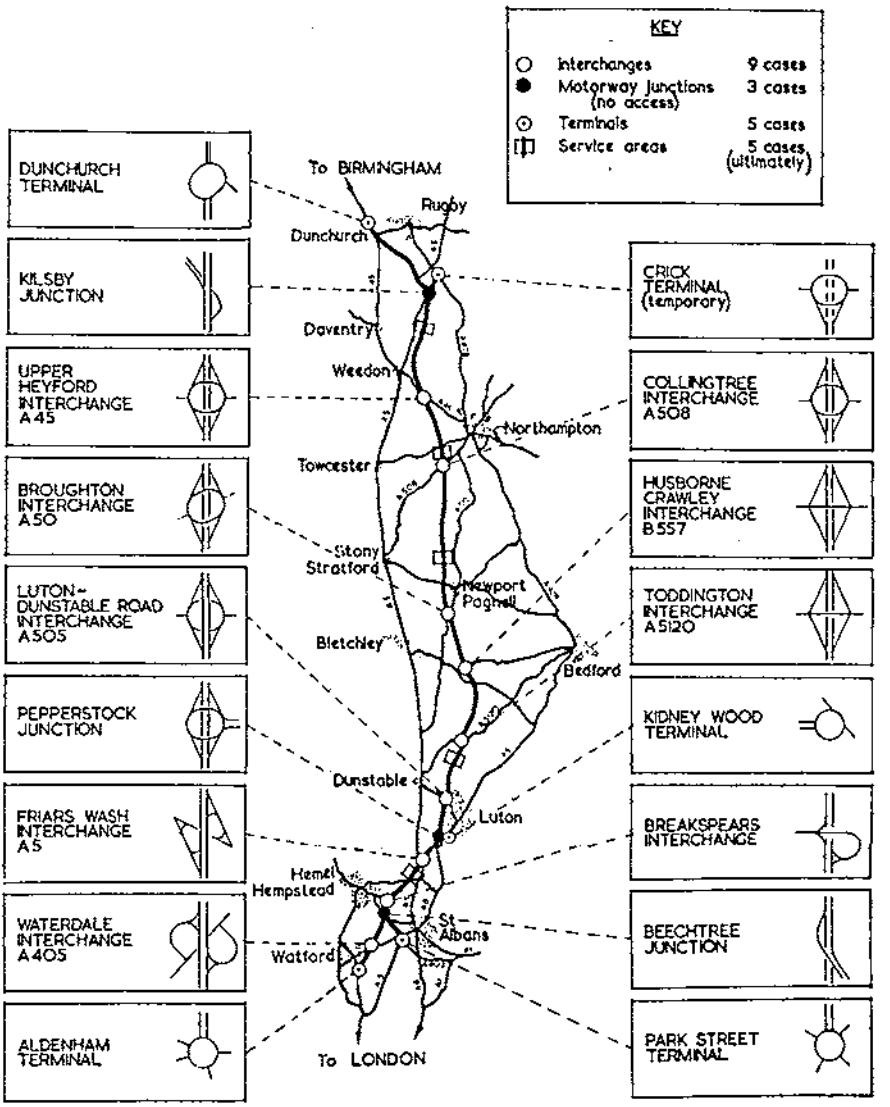
Surface. The running surface, or pavement, may be of rigid, flexible or composite design and the Ministry usually asks for two alternative tenders. A typical specification for a composite pavement is shown in Drawing No 3. A rigid concrete pavement for a motorway would be of the order of 10 in thick, with 14 lb of reinforcement per sq yd; a base course up to 6 in thick, depending on local conditions of subgrade, may also be necessary.

Colouring is important so that there is a contrast between the road and the hard shoulders, and so that lane markings may be plainly visible. The smoothness of the surface is regulated by the tolerance of plus or minus an eighth of an inch over a 10 ft length in any direction; the surface is also tested by means of a "bump integrator" which is a machine towed behind a vehicle at a constant speed and which measures the aggregate deviation from profile, both plus and minus, over a given length of roadway.

Road heating is employed under certain circumstances. Its use is still in the development stage, but at present it consists of cables laid in sand or asphalt just below the surface; these must be clear of the wearing course, and normally require between 10 and 20 watts per sq ft of surface. The control gear is designed to switch the system on automatically when there is snow on the road, or when there are conditions of temperature and humidity which may cause ice to form.

Heating is expensive both to install and to run (that on Hammersmith Flyover cost of the order of £4,000 to run during the winter of 1962–3; it is just over half a mile long) so it is only provided where ice and snow will provide a serious hazard to traffic, such as on steep slopes; but it may be argued that £4,000 is a small price to pay for avoiding only one serious accident. Heating is being installed on the elevated road at Chiswick and on its sliproads.

DRAWING Nº 4



ACCESS POINTS ON THE LONDON–BIRMINGHAM MOTORWAY

Signs. To prevent the motorist from being distracted, signs are kept to a minimum and advertising is prohibited. The customary county boundary and river signs are also prohibited, and only those necessary for directing the motorist are allowed. Such signs are made from reflective material, and are illuminated only at junctions. They are placed at least 5 ft clear of hard shoulders, and are angled to prevent headlamps being reflected off a glossy surface into the eyes of drivers (specular reflection). Advance direction signs are normally 440 yds ahead of a junction (300 yds ahead of a terminal) and "reduce speed now" signs are 550 yds ahead on the off-side, 500 yds on the near side. The design and dimensions of all signs are standardized.

Junctions. The minimum spacing of junctions along a motorway is normally 3 miles, though up to 12 miles may be adequate in sparsely-populated areas. At these junctions, the sliproads form part of the motorway, and their specification is controlled by the MOT memorandum. Slip road width is 20 ft (increased slightly for tight curves), horizontal curve desirable minimum radius is 750 ft, the absolute minimum 150 ft; vertical curve minimum 6,000 ft radius for crests, 3,000 ft for valleys; gradient maximum 5 per cent for slip roads rising above the motorway, and 4 per cent for those falling below it. Sight distance minimum is 425 ft.

Junctions between motorways and the existing road network—access points—take up a rather large area of land, and since they may be in developed areas, they may be costly; an example is the crossing by the M2 of the Chatham–Maidstone road, where buildings and building sites were affected. A junction between two motorways, however, occupies much more land, and is likely for that reason to be in open country. That near Almondsbury, in Gloucestershire, on which work was due to start in 1964, will occupy about 100 acres (one-sixth of a square mile); it will form the crossing point of the London–South Wales M4 and the Birmingham–Bristol M5, and will incorporate a four-level bridge. The slip roads will have a design speed of 45 mph, and it will be the first motorway "crossroads" to be built; reference to Drawing No 1 will show that only one more such cross roads, that near Leeds, is planned. Some typical junctions, as used on the M1, are illustrated in Drawing No 4.

Fencing and services. Fences are required to be stockproof, and are usually timber post-and-rail, supplemented by quick hedge, barbed wire or woven wire; the risk of stray animals on the motorway must be eliminated. In urban areas, pedestrians must also be kept out and a close-boarded wooden palisade fence is recommended. Fences are installed in smooth flowing lines to avoid motorist distraction. Such fences are boundaries of the motorway, as defined by Act of Parliament, but in addition safety fences are required to reduce damage if a vehicle leaves the carriageway. These are installed as far back from the edge of the carriageway as possible, under the following circumstances:—

(*a*) At both verges where an embarkment is over 20 ft high.
(*b*) At the outer verge where an embankment is over 10 ft high on bends of radius 2,800 ft or less.
(*c*) Where there is a road, rail or river at the foot of an embankment.
(*d*) At the top of retaining walls.
(*e*) To protect bridge piers.

Considerable research into the best form of safety fence has been carried

out both in Europe and in America, much of it using real vehicles, the aim being to deflect an errant vehicle back on to the road without overturning it and without endangering other traffic. An alternative form is installed at Hammersmith Flyover, where a continuous steel top rail, 6 sq in in total cross section, transmits the impact load to successive stanchions which are firmly anchored to the deck. It is said to be able to stop a 15 ton vehicle moving at 28 mph, both at right angles and at 45 deg to the fence.

Services are not, in general, permitted to run the length of a motorway since their maintenance will inevitably impede traffic; exceptions are those that serve the motorway itself, such as heating and lighting cables, emergency telephone lines, and advance warning systems such as that on the M5. Under certain conditions, the Pipelines Act of 1962 exempts pipelines from this restriction.

Services running across the motorway must be replaceable without interruption of traffic, and such services are carried in sleeves or culverts designed for the purpose, with all manholes outside the motorway boundary.

Landscaping. This is a subject which is commanding more and more attention as the years go by, and as experience of motorways increases. Its aims are various and include not only avoiding "desecration" of the countryside, but also pleasure for the motorist and, indeed his safety. For example, artificial curves, which might otherwise be unnecessary, may be introduced to provide an attractive view; to avoid severance of property; to swing round a spur and avoid the scar made by a cutting; or to increase what would otherwise be a very small change of direction which gives a false perspective impression.

Short curves and straights are normally avoided for safety reasons, and straights between intervisible curves are also inclined to make for more difficult driving. Great care must be taken to apply superelevation at curves gradually, to avoid giving a wrong impression of gradient to the driver, and small radius curves are avoided at junctions to give the maximum sight distance.

Tree planting must be undertaken with care, not only in location (they must be well clear of traffic) but in type; one hazard is the slippery properties of broad leaves when carpeting the roadway in the autumn, and another is the ability of quick-growing trees to dry out a clay subsoil and cause subsidence. Hedges are desirable in the central reservation to prevent dazzle, but must be well clear of the traffic, and must not interfere with sight distance; they must be such that they only need trimming once a year, and thorn, beech and hornbeam have been found to be the most satisfactory.

Grass is sown on embankments, cuttings, verges and central reservation to prevent erosion and to preserve the natural countryside.

Such then are some of the requirements written into the Ministry of Transport's motorway specification. They are by no means comprehensive, but serve to show some of the problems associated with motorway design.

Costs

General. It is impossible to say that the cost of a motorway is £*X* per mile. Costs can vary enormously—for example, the 9-mile Monmouthshire section of the M4 works out at about £½ million per mile, including seventeen bridges and over 1,500 ft of viaduct, whereas the elevated section at Chiswick will cost more than £3 million per mile. These are figures relating to the contrac-

tor's tender, and do not include the cost of land, costs of re-routing sewage, water, telephone and other mains services and so on; the relaying of the GPO television land lines is, incidentally, quite an expensive item, where it is experienced.

Land. The over-all width of a dual lane, dual carriageway motorway is 105 ft; if the average height of cutting or embankment is 10 ft, at a slope of 1 in 2 then the over-all width of the earthworks, allowing for ditch and fence on each side will be some 150 ft. This works out at just over 18 acres per mile of road; it will be more for a three-lane motorway and more in hilly country where cuttings and embankments are higher, but where land prices are usually lower. However, even with the inflated land values of today, the property element of the total cost of a rural motorway is comparatively small, but will increase considerably if demolition of houses and industrial or commercial buildings is necessary, and attracts compensation to the owner.

Contract costs. The project is normally allotted to a contractor by competitive tender, which serves to keep the cost down; but other devices are also employed. As mentioned earlier, the tenderer may be asked to submit prices for alternative types of pavement (the M1 is constructed partly in concrete, partly in flexible pavement), and this principle can be extended; for example, he may be asked to price the abutments of a bridge designed in mass concrete, reinforced concrete, or piled foundations, and alternative bridge designs in concrete and steel may be offered to him.

If a contract exceeds a certain figure, it is probable that only the largest firms will be able to undertake it but, on the other hand, a short length of motorway is likely to be uneconomical, since there is so much repetitive work involved. As a result, there has been an increasing tendency for smaller firms to combine together, forming a partnership, consortium or joint venture—the choice of names is ever expanding—to tender for the contract. This partnership can be managed in a variety of ways, but the principle remains, namely to combine the resources of two or more firms which would be unable, as individual contractors, to undertake the project.

Design Loads

General. The military load classification system, as applied to vehicles and bridges, depends for its success on a disciplined control of vehicle spacing, which is necessary to limit the strength (and consequently expense, time for erection and logistic effort) which would otherwise be required for military bridges. No such control is possible on civil highways, and provision has to be made for a number of different circumstances.

The Ministry of Transport employs two standard loading systems, which are described in BS 153, for all highway bridges, and the same loadings are used for pavement design, though here the maximum axle load will be of greater importance than the total loading.

HA loading. The first system is Type HA, which is an equivalent lane loading. It represents, approximately, the effect of three vehicles, each 22 tons in weight closely spaced, in each of two carriageway lanes, followed by 10-ton and 5-ton vehicles. Tables are provided in BS 153 giving equivalent UDL for bridges of all spans up to 3,000 ft.

Though on a motorway the lanes are 12 ft wide, allowance must be made for vehicles using the hard shoulders and central reserve, with a whole number of lanes of width from 8 to 12 ft; thus it is assumed that three lanes

of traffic may be found on any carriageway (including hard shoulder) between 24 and 36 ft in width; above 36 ft up to 48 ft may take four lanes, and so on. In addition to the UDL, a knife-edge load of 27,000 lb per lane width must be allowed for. Any structure must be designed for any two lanes to be occupied by full HA loading, including knife-edge load, with all other lanes occupied by one-third of the HA load.

HB loading. Type HB load, the second system, is a unit loading representing a single abnormally heavy vehicle. For design purposes the hypothetical vehicles has four axles at 6, 20, and 6 ft centres, each with four wheels at 3 ft centres, and "one unit of HB loading" implies a load of one ton on each axle; rural motorways are designed for forty-five units of HB loading (ie 180 tons), in one single vehicle at any point on the carriageway. Since abnormal loads are subject to police escort and control, spacing between such loads can be controlled.

Other considerations. In addition to the static effect of live loads imposed by HA and HB loading there are a number of other factors to be taken into account. In summary, these are:—

(*a*) Impact. An allowance of 20 per cent is added to the axle load (or adjacent wheel loads) for short bridges; but where a loaded length of 100 ft is required to produce maximum stress, impact may be ignored.

(*b*) Centrifugal force. This is more appropriate to railway bridges, but must be considered on curved motorway bridges and viaducts; it was certainly a design factor on the sharper curves of the elevated road at Chiswick.

(*c*) Longitudinal force. Braking on a motorway, where speeds are high, imposes a reckonable force on bridge bearings. The force is assumed to act horizontally at the surface of the carriageway; for HA loading it is taken as 10 tons + $\frac{1}{2}$ *L* tons where *L* is the span in ft (up to a maximum of 25 tons), and for HB loading, 45 tons for all spans.

(*d*) Wind pressure. Normally a pressure of 30 lb per sq ft (equivalent to a 90 mph wind) on all surfaces exposed to the wind is allowed for on unloaded structures; but the structure must also be designed to resist 15 lb per sq ft on all surfaces including any load it is likely to be carrying; such a load is taken to be represented, on motorways, by a single continuous vertical plane surface, 8 ft high. The overturning effect of wind, amounting to 5 lb per sq ft of the plan area, must also be allowed for.

(*e*) Temperature effect. The thermal range is taken, in Great Britain, as being a minimum of 20°F, and a maximum of between 80°F and 120°F, depending on the location. Due to the effects of sun and shade, individual parts of the structure must withstand a differential of 15°F.

(*f*) Frictional resistance of expansion bearings. This must be provided for, and the coefficient of friction is taken as being between 0.01 and 0.25, depending on the type of bearing.

(*g*) Forces on parapets. This will depend on the incidence or otherwise of crowd loading, and will be from 25 to 100 lb per lineal ft, depending on conditions.

(*h*) Erection forces. Provision must be made for erection of the structure, and it may well be that more strength is required during erection than when the member is in use. As an example, more concrete is required in the bottom flange of a prestressed beam to take compressive stresses at transfer than is required when the beam is in position supporting the deck.

Some Design Problems

General. The specification for a motorway is so precise as to line and level, that great care is needed in the setting out of the work, and the top corner of an underbridge abutment, for example, must be built in space to an accuracy of $\frac{1}{8}$ in; the somewhat haphazard manner in which the roads of this country grew in the past is dead and gone, and very careful planning and design is vital if the new roads are to give the service expected of them.

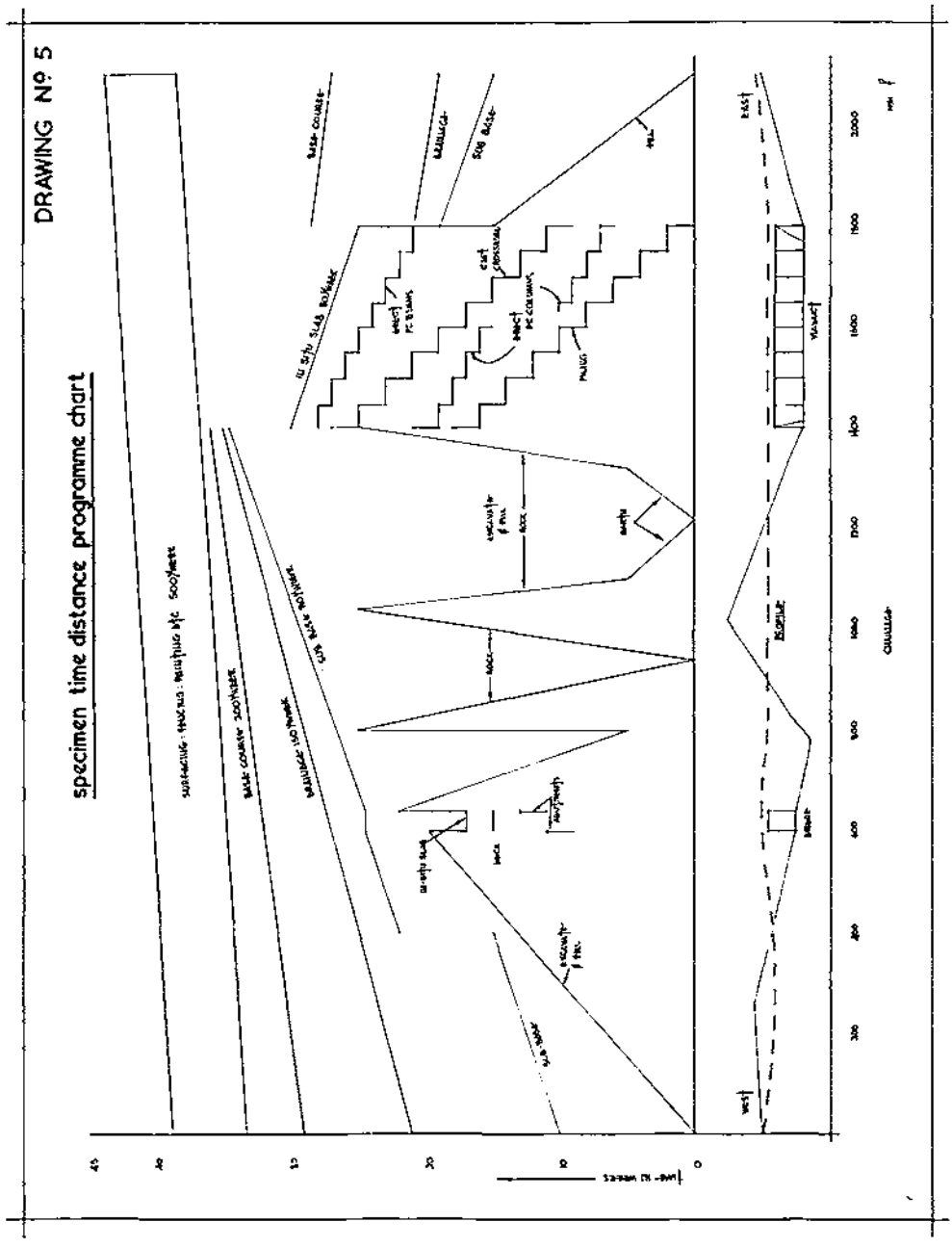
Subsidence. This is one of the serious difficulties, and there are many ways in which it may occur. In structures, the disturbance of the ground, and excavation for foundations, may cause drying out of the subsoil; penetration of a previously impermeable layer may permit surface water to penetrate into a silty layer beneath and wash out the fines, with a consequent reduction in bearing strength. The effect of quick-growing trees and the need for careful compaction of fill are well known. The weight of an embankment may well compress the existing soil unless all such material is first removed from the site, and old mine workings presented problems on the M6.

In order to overcome these unknowns, the geological survey mentioned earlier is necessary, with boreholes at intervals throughout the length of the project, with particular attention being paid to the sites of bridges. From an analysis of the cores, suitable foundations to bridges can be designed, and the probable depth to which piles must be driven, or bored, to achieve the designed bearing strength can be determined.

The boreholes will also establish the nature of the material to be excavated from cuttings, and its suitability for use in embankment fill. In Monmouthshire, borings on the route of the M4 revealed a 10 ft thick layer of compressible peat in a valley, which would have to be excavated before placing an embankment fill, and it was calculated that it would be cheaper to build a 700 ft long viaduct on piled foundations; at Chiswick, the elevated road is carried on central columns at 60 ft centres, and 4 ft diameter pile shafts had to be bored through an apparently sound gravel layer to reach the underlying London clay, which was in some cases over 50 ft below ground level. Each column is carried by four such piles, belled out at the base to 12 ft diameter; this bearing area of 450 sq ft does not seem so great when it is realized that at this point each 60 ft bay, including the piles themselves, consists of over 1,000 tons of concrete.

Economy. The specifications described earlier present the designer with a number of conflicting problems, when it is remembered that he is required to keep costs as low as practicable. A long, high embankment may be reduced by increasing the gradient, which may mean providing an extra lane; or by making an adjacent cutting deeper which may prove to be in rock; or by introducing a curve which would increase the length of carriageway to be built; he must in any case determine the point at which a viaduct becomes cheaper than an embankment, or a tunnel cheaper than a cutting, and he must gauge whether, from a landscaping point of view, the formation of, say, a cutting on the skyline (which makes an ugly feature) justifies the saving in cost against circling the hill.

Up-to-date outlook. Once the outline design has received approval from the Ministry further questions, more connected with detailed design, require resolution. Engineering techniques are progressing all the time, and new methods have to be tried out. For example, the driving of sheet steel piling


DRAWING Nº 5
specimen time distance programme chart

near a hospital would have been avoided a few years ago, on account of the noise; but silent hydraulic driving is now possible, and could be specified for such a project. It is just as important, therefore, that the consultant should keep up to date with modern construction techniques as he should with design techniques.

Prestressed concrete was rare in this country before the war, and it was not until 1959 that the relevant British Standard Code of Practice, CP115, was published, but now most large projects incorporate prestressed members. There must always be an element of risk attached to the use of new designs and techniques (witness the collapse of a prefabricated building in the new Aldershot Barracks reconstruction scheme), but at the same time, experience in their use is essential if development is to proceed smoothly. Such a risk was also taken in using a low-quality shale for the foundations of the Preston By-pass; had it been successful, that section of motorway would have proved cheaper than if all risk had been eliminated. One hears nothing of the risks taken which have proved successful.

Design Programme. It is most unlikely that all design work will be completed before the contractor starts work, and it is therefore essential that the consultant knows the contractors programme, so that he can provide working drawings in the right order and in time to meet this programme—he must in fact, have his own timed programme and must not fall behind or the contractor will probably put in a claim on the grounds that he was held up by lack of detailed drawings. This problem is particularly acute when the starting date follows closely on the award of the contract; at this stage the contractor himself scarcely knows what drawings he will need first and the consultant, who has been working on the project for two or three years, must either be sufficiently ahead with his design work to meet all eventualities, or must be able to make an inspired guess at the task the contractor will tackle first. Conditions can, however, be written into the contract which will keep the contractor off those parts of the project for which drawings cannot be made available for some time.

Some Contractors Problems

Planning the work. An outline plan of how the project might be tackled will have been made at the time of tender, and more detailed planning will start as soon as the contractor has been awarded the contract and will continue throughout right up to the actual date of completion. Programmes will initially be worked out on a "block chart" which is the basis of all further calculations and progress checks; this chart may be altered as time goes on and the pattern of progress becomes more clear.

The time–distance programme chart. For a linear project, a form of programme can be developed which will clearly show what operations are falling behind programme, and whether they will affect any subsequent operation. Drawing No 5 shows an imaginary section of road, represented by the horizontal ordinate, and time (in weeks) as the vertical ordinate; for convenience, the horizontal ordinate need not be to a constant arithmetical scale but in this case, since the operations can be plotted on a "chainage per week" basis, care must be taken to plot the correct slope if the horizontal scale is varied.

The chart represents a 2,100 ft section of road which has to be completed in forty-five weeks. It includes a small bridge, an eight-span, 400 ft viaduct

which can only be approached from the east end, and a quantity of excavation and fill. The contractor has plenty of earth-moving plant, only one heavy crane, and would find it convenient to do most of his work from the west end of the project.

All rates of progress for the various operations are first calculated—for example, piling is estimated at two weeks per pier, erecting columns at one week per pier, and drainage (both sides) at 150 ft per week—and these operations are plotted on the chart, so that a short period, say a week, is left between each operation; in some cases, a longer time may be necessary to allow for concrete curing.

The chart shows work on excavation and fill starting at four separate points, one of which is in rock (and consequently proceeds at a slower pace, resulting in a steeper line on the chart). The heavy crane is used for erecting columns for four piers on the viaduct, then spends five weeks at the bridge (since it has caught up with piling) and then returns, in week 15, to complete the erection of columns.

It also reveals what are the critical points in the project. Clearly a delay of, say, three weeks in consolidating the fill at chainage 800 is going to affect the whole of the road work and thus the completion date of the whole contract, but a similar delay in piling at chainage 1,400 will only delay the erection of the columns by a similar amount (and tie up the crane for that period)—there is sufficient "float" at that point between column erection and casting the crosshead to accommodate the three weeks delay.

The rate of progress in laying the sub-base—80 ft per week—requires that work shall start at the west end, continue until it has caught up with the filling, and then move for four weeks to the east end; having reached the viaduct, work recommences at chainage 400, by which time the fill up to the bridge is complete, and fills and cuttings on the other side of the bridge (chainage 640, 800 and 1020) are planned to be complete by the time work reaches those points.

This method of programming is in many ways similar to a Critical Path analysis but has two main differences; firstly, it presents the programme in a graphical form which can be readily understood, with the implications of delays apparent at a glance, and secondly, it shows the critical operations at particular points of a linear project. The critical path method would involve, for repetitive operations, breaking each of these operations down into say 100 ft sections, and there would be an additional requirement for as many of these sections as possible to be consecutive, to allow for ease of working.

Another merit of this method is that it shows at a glance what operations are likely to be going on at any one time; for example, in the chart shown, in week 12, concrete will be required for sub base at chainage 200, a bridge abutment, piling at chainage 1500 and crosshead at chainage 1750. This will assist in planning the ordering of materials, the size of the labour force and the amount of transport and plant required at any given time throughout the contract.

Such a system, though much more complex than that in Drawing No 5, was originally devised by the author for work on the elevated road at Chiswick, when it became apparent that it was not going to be possible to work a continuous series of operations at deck level. It is not known if the system has been used elsewhere, but it provided a most useful guide to future operations in a readily-assimilated graphical form.

Communications. Motorway contracts may consist of anything from two to twenty miles but inevitably they will present problems of communications. Telephones or radio will provide great savings in time, and a helicopter was used during the construction of M1, largely for bringing spare parts to keep plant working; it must be remembered that a motorway normally runs across country, independent of the existing road network, and access to it in the early stages of construction may be severely limited. At Chiswick, the Great West Road was so congested that it was frequently quicker to walk the length of the project than to drive; it was only possible to cross the road when traffic lights were against the main east-west traffic, and if the road had been blocked for a few minutes during the rush hour, traffic would have been at a standstill from Hyde Park Corner in the east and from London Airport in the west; such closures were carefully controlled by the Police, and were only allowed for a few minutes at a time, at night.

For the elevated roadway itself a vertical interchange provided the only point of access, until the road was connected at the east end to the Chiswick Flyover and at the west end to the next section of M4, which in any case had not by then been built; this restriction determined the sequence of construction and also affected the choice of method for certain operations.

A working drill. Linear projects of this nature—pipelines and railways are two other examples—seem at first sight to be merely repetitive work, for which a drill, once established, will provide the best solution. This is so for the final stages of the work, once the grade level has been established, but in order to achieve this level, the tasks are many and various. Piling, excavations for bridge foundations, the bridges themselves, cuttings and embankments, are distributed haphazardly along the length of the contract, and when the motorway crosses the existing road network, alternative routes and diversions will be required.

However, once the grade level has been achieved, even only in part, there are a number of operations which can be geared to follow each other in sequence, each covering a daily linear yardage of the motorway—these include laying and compacting the various base courses, surfacing, fencing, drainage (where this has not already been done) lane marking, lighting, signing and seeding—at this stage, work should proceed apace if it has been carefully planned so that no one operation is allowed to overtake another.

In the case of the elevated road, the repetitive work started much earlier. Work had to start in the middle of the section near the interchange, for various reasons, and move eastwards; thereafter, work started again at the centre and moved westwards. The sequence of main operations could not conveniently be geared to the completion of so many linear yards per week, and in the early stages of the contract, it took the following form:—

Operation	*No of bays per week*
Piling	3 increasing to 5
Pile caps	2 increasing to 6
Columns	2 increasing to 6
Crossheads	1 increasing to 2
Placing precast deck beams	1 increasing to 2

It would have been more convenient if all these operations could have gone forward at the same rate, since each is dependent on the completion of the previous one; but even on a project as repetitive as this one, many factors

prevented such an even flow. Site limitations, plant availability, bad weather, labour availability, sub-contractor's planning, traffic flow and failure by suppliers to meet delivery dates all took their toll from smooth planning.

Site organization. In the early stages the project will probably be divided geographically into sections, with a section engineer being responsible for, say, two miles of roadway in open country, or half a mile where there are several bridges. But it is for consideration whether even at this stage, and certainly at a later stage, responsibilities should be allotted "Horizontally", thus primary excavation and fill, largely an exercise in plant control, becomes one man's task, bridge foundations another, abutments yet another; in due course, as the earlier tasks are completed, the first engineer might supervise secondary excavation for drainage channels, the next would deal with the pavement sub-base and so on. Such horizontal division of tasks gives each construction team the opportunity to benefit from its experience and to cut time and costs on subsequent operations of a similar nature; it also enables sub-contractors, whether they be undertaking piling at the beginning of the contract or fencing at the end, to be responsible to one engineer only. A Contractor's previous experience, however, will probably dictate which method he will employ to start with, but he must be sufficiently flexible to change his organization as work progresses.

Conclusions

It is obviously impossible, in this short paper, to produce more than an outline of some of the ways in which the country sets about improving its road communications system. The problems are widespread and in many cases conflicting, and there are many departments and authorities whose views must be considered. If I have shown that the task of the Minister of Transport is not one which can be lightly undertaken, and that the construction of a motorway involves rather more than the unrolling of an asphalt carpet, then perhaps this paper has been of some value.

Mutual Aid in Southern Europe

By Lieut-Colonel C. W. R. Story, RE

The NATO Common Funded Infrastructure Programme

"Through NATO we ally ourselves in a common peaceful purpose fully aware that the burdens of our goals rest heavily upon the shoulders of our nations. The sacrifices are great, the obstacles are many, but from the energies of our peoples shall come the treasures of peace and progress—an atmosphere which we shall rightfully share with all nations of the free world.

The people of Italy, Greece and Turkey are making these heroic sacrifices daily. Their efforts, invested in NATO, have ensured its success and guaranteed its future.

Indeed, there are no walls to be built around Southern Europe, except those that assure man's natural dignity—the bricks are those of peace, and the mortar is the enthusiastic sacrifices of every man who knows and loves freedom."

Admiral James S. Russell, USN
Commander in Chief
Allied Forces Southern Europe

FOR two years the writer held a NATO appointment unique in the Corps, and indeed in the British Army. It was concerned with the day to day initiation, supervision and administration of that part of a very large NATO works programme which concerns the Southern Region of Allied Command Europe. The views expressed and the conclusions drawn in the article are personal and do not necessarily express the official policy either of any part of the NATO organization or of any of the individual member governments.

An outline of the relevant parts of the NATO organization, giving titles and abbreviations of the principal committees and commands referred to is shown at Annex A.

The Southern Region came into being in 1952, three years after the original establishment of NATO, when Greece and Turkey became signatories to the pact. The problems which exist within the theatre are dissimilar to those of the other regions for a number of reasons.

Geographically the Command becomes a complete entity only by reason of the sea and air components. The land areas comprise three mountainous peninsulas almost entirely separated from each other without good land connexions with allies. Mutual support is difficult and a continuous land line of defence is impossible. Turkey has the longest common border with Russia (some 120 miles) of all the NATO Nations.

The three Nations of the Southern Region (Greece, Italy and Turkey) occupy 42 per cent of the land area of NATO Europe and contain 31 per cent of its population. The integrated NATO Air Defense system obliges the AFSOUTH theatre of air operations to cover the entire Mediterranean Sea—an area larger than that of the combined land masses of NATO Europe.

Limitations of wealth, industrial capacity and skilled manpower severely restrict the ability of all three countries to meet fully their NATO commitments. The Italian economy has shown great improvement since 1947 and much of the equipment and supplies required for modern forces can be provided from national resources; but Greece and Turkey have insufficient industrial capacity to furnish more than rudimentary war material.

The average *per capita* income in all three countries is well below that of the other NATO Nations and the burden of taxation is therefore correspondingly heavier. It is worth noting that Greece has by proportion 33 per cent more of her population in the armed forces than does Britain—Turkey can claim 16 per cent more.

Against this background one is forced to the conclusion that the task of continuing to strengthen the NATO alliance will depend upon assistance to the countries in the Southern Region, particularly Greece and Turkey, by those countries which have greater resources. This is primarily a political problem but it is not generally known that assistance of this nature is in fact being given as part of a military programme—the NATO Common Funded Infrastructure Programme (probably unique in the sense that it is not known by a series of initials or a mnemonic).

The purpose of the infrastructure programme is to provide, from NATO funds, fixed facilities for common (NATO) use. The rules governing the eligibility of projects for common funding are somewhat complicated; but in broad terms an infrastructure facility can be wholly or partly paid for by NATO if it is to be used by:—

More than one NATO nation.

A NATO nation other than the "host" nation (the nation within whose boundaries the facility is to be set up).

A NATO headquarters or organization.

Nations are expected to provide all logistic facilities and utilities for their own forces assigned to NATO, eg barracks, training areas, railways, roads, water and electricity systems etc. The host nation is also required to provide normal utilities up to the boundary of a NATO infrastructure facility and provides at no cost to NATO the ground upon which the facility stands.

General categories of works upon which NATO funds are spent include:—

Airfields.
Naval depots and facilities.
POL pipelines, depots and distribution systems.
Communications.
Surface to Air Missile sites.
Special categories.

The establishment of the common financial fund and the allocation of monies from it, compared with a national system, is inevitably rather complicated. The basis upon which it is founded is the outline military plan for manning and equipping NATO forces at some future date (the Force Goal). To support this outline plan a long range forecast of infrastructure requirements, giving justification and rough estimate costs, is made—this is very much a crystal ball affair. The works plan so calculated is injected as part of the financial programme for a Cost Sharing Fund to which individual nations contribute according to their means.

The works programme itself is initiated in annual increments (Infrastructure Slices) which are processed as follows:—

Stage 1. MOD, as advised by the local NATO Commander, proposes a project giving detailed justification and rough cost. This is submitted through the Principal Subordinate Commander.

Stage 2. The projects received at MSC are co-ordinated and screened to ensure that the justification is valid, the project supports the operational and equipment plan, the scope is not in excess of the minimum military requirement, and the project is a feasible engineering possibility within the price quoted. Priorities within the command are allotted.

Stage 3. Takes the form of a continuous review of individual projects by SHAPE culminating in the publication of a *Recommended* Slice.

Stage 4. The Recommended Slice is reviewed at SHAPE by staffs of SACEUR, theatre Commanders and MODs.

Stage 5. The International Staff make recommendations on the Recommended Slice for consideration by the NATO Council. Finally, the NATO Council publishes the ". . . Slice NATO Common Infrastructure Programme".

From start to finish, the publication of a given slice takes some $1\frac{1}{2}$ years and in the process up to 30 per cent of the projects originally put forward fall by the wayside.

Inclusion of a project in a particular slice does not permit work on the ground to start immediately but is in the nature of approval in principle (A in P). In order to get work under way the MOD concerned will submit to SACEUR, through the PSC and MSC, a formal request for funds giving detailed justification, outline engineer drawings and cost estimates. This

request is processed in a similar way to the original slice proposal but as A in P has already been granted, the process is reduced to a matter of three or four months (in urgent cases this may be reduced to as little as one month). These fund requests do not necessarily cover a complete project which will often be dealt with piecemeal, eg in the case of an air base separate requests for funds may be made for runways, hangars, administrative buildings and fuel storage.

When a project has been approved in a slice, there is an automatic carry-over of funds until the work is finished—unexpired portions of the slice do not lapse or need to be rejustified in a new programme.

Upon release of funds all executive action concerned with the contract and work on site devolves upon the nation, which prepares tenders (international competitive bidding among NATO nations is the general rule); accepts bids (International Staff are consulted if the lowest bid is, for any reason, unacceptable); supervises construction work; accepts the work on completion; pays the contractor; and, finally, hands the facility over to NATO.

The military staffs in SHAPE, MSCs and PSCs are responsible, according to their various delegated authorites, for monitoring the progress of work to ensure that estimated completion dates are achieved and suit the operational plan for ensuring that NATO criteria and standards are met, advising when requested upon any aspects of the work, and scrutinizing the military justification for requests for funds.

NATO International Staff represent to the various NATO committees the technical and financial justification, screen in detail the technical designs, advise upon design and execution as requested and finally recommend to the NATO Council that the facility be accepted and the construction account closed.

The NATO infrastructure programme is very expensive—some £120 million has been or is being spent in Italy alone since 1949. The programme includes major engineering works which, in Greece and Turkey particularly, have a considerable impact beyond that of satisfying a military requirement.

Nations contribute to the NATO common fund according to their ability; but money for infrastructure is spent in any country according to its military need: Some countries receive more than they contribute in this way. The US, Britain and Canada for example, by fortunate geographic accident, are not suitable locations for many infrastructure projects and therefore, contribute more than they receive in return. The contributions of those nations, Greece and Turkey, despite being a large proportion of their national economy, do not meet the cost of the programme in their own countries. There is, therefore, an injection of NATO money to boost their own economy.

Technically, many of the projects being carried out involve advanced design and construction techniques requiring the most up-to-date skills available within the NATO partnership. These offer excellent experience to young engineers (who may have been trained overseas) who would otherwise either lose their skill through lack of practice or leave their native country in the search for apportunity and practical experience.

Contractors are enabled not only to work on advanced designs based on the latest technological experiences or research; but also to acquire practice in handling plant and equipment, and, indeed, even to find it worthwhile to purchase their own equipment.

All of these factors are contributing to the establishment of a capability to undertake the type of engineering work which is so necessary for the development of the country.

Other advantages are more immediately felt. Access roads to NATO facilities open up new routes to isolated localities and villages, water and electricity systems can be tapped to provide local resources, and POL pipelines can be used for civilian purposes. Some of these services are obtained by lease from NATO, others by a pro-rata sharing of original installation cost; but however it may be done, the host nation will get a useful service which it might not otherwise have had, and will do it more cheaply and get it earlier than if it had to be part of a purely national programme.

All that has been considered so far is in the past, the present or the immediate future. In the long term the main part of the military construction programme will come to an end and emphasis will shift to maintenance, repair and modernization—a relatively inexpensive programme compared with what goes on at the present time. This will certainly affect adversely the Greek and Turkish economy; it will leave high and dry a construction potential which has been slowly and painstakingly built up over the years and which represents a considerable, although hidden, NATO investment.

Reference has already been made to the national responsibility for providing logistic resources for indigenous troops in regard to construction of public utilities such as roads, railways, etc. Clearly, the less developed nations, such as Greece and Turkey, do not offer today the sort of road and railway networks required to support operations of much more than guerrilla type. Improvement of these networks will permit more effective use of troops and equipment, increase flexibility and lead to economy in stockpiling and logistics; but implementation of the sort of programme necessary to carry out such improvement is too much for these nations to undertake for some years.

The extension of the present infrastructure programme to include the provision of assistance for work of this nature would protect NATO's present investments, would ensure that the organizations built up over the years do not become dissipated and would enable nations to meet their full commitment to NATO sooner than they would otherwise be able to do so.

To summarize:—

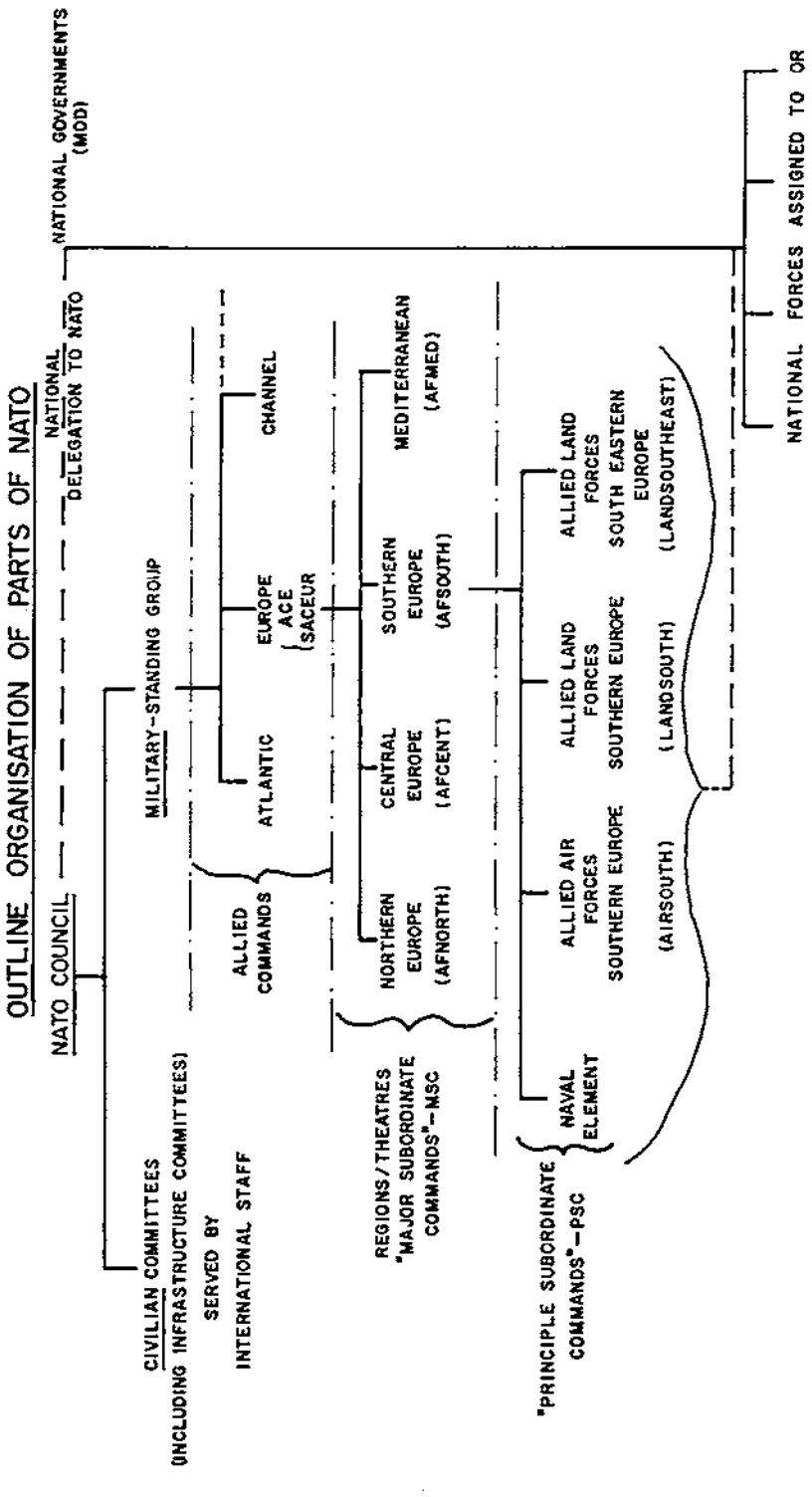
An effective and expensive infrastructure programme within NATO has existed for some fifteen years; it will continue with less impact in future as it achieves the purpose for which it was originally initiated.

Considerable economic benefit has been derived from the programme by Greece and Turkey.

The programme has helped to set up a construction capability which would be of value to Greece and Turkey if it could be kept employed.

National utilities, particularly road networks, are inadequate to support major complicated military operations and their rapid improvement is beyond the financial capability of Greece and Turkey.

The extension of the NATO Common Funded Infrastructure programme to include such work as improvement to road and rail systems, coastal shipping facilities, etc. would strengthen the NATO military position and improve the economies of the less developed NATO nations.


OUTLINE ORGANISATION OF PARTS OF NATO
NATO COUNCIL
NATIONAL DELEGATION TO NATO
NATIONAL GOVERNMENTS (MOD)
CIVILIAN COMMITTEES (INCLUDING INFRASTRUCTURE COMMITTEES) SERVED BY INTERNATIONAL STAFF
MILITARY-STANDING GROUP
ALLIED COMMANDS
ATLANTIC
EUROPE ACE (SACEUR)
CHANNEL
REGIONS / THEATRES "MAJOR SUBORDINATE COMMANDS"-MSC
NORTHERN EUROPE (AFNORTH)
CENTRAL EUROPE (AFCENT)
SOUTHERN EUROPE (AFSOUTH)
MEDITERRANEAN (AFMED)
"PRINCIPLE SUBORDINATE COMMANDS"-PSC
NAVAL ELEMENT
ALLIED AIR FORCES SOUTHERN EUROPE (AIRSOUTH)
ALLIED LAND FORCES SOUTHERN EUROPE (LANDSOUTH)
ALLIED LAND FORCES SOUTH EASTERN EUROPE (LANDSOUTHEAST)
NATIONAL FORCES ASSIGNED TO OR EARMARKED FOR NATO

Military Applications of Nuclear Power

By Major D. R. Whitaker, MA, MINucE, RE

Introduction

The *Journal* has previously published papers by Majors A. Hiscock[1] and J. D. Isaac[2] on the subject of American military reactors and on the idea of the nuclear energy depot. The aim of this article is to bring readers up to date with the development of these reactors, also, to introduce them to the idea of the direct conversion reactor and the radioisotope generator and to mention recently announced developments in all these fields by the USSR.

The Army Nuclear Power Programme (ANPP)

The responsible agency for the development of land-based nuclear power plants for all three services in the USA is the ANPP. The Department of Defense (DOD) and the Atomic Energy Commission (AEC) are jointly responsible for this programme and in April 1964 they published the results of a study they have been making for some time on its progress. The conclusions they came to on the future development of the equipments described in this paper have had the effect of curtailing rather than expanding the programme.

Portable reactors. Maintainability and reliability of the portable or package reactors built until now have not reached a satisfactory level and improved component development is recommended. Accordingly, the AEC is to pursue a follow-up programme to develop improved components for these projects in order to demonstrate that portable nuclear power can be made reliable. The previous plan, however, to produce a second generation portable reactor has been cancelled. Such units, it has been found, simply cannot compete economically with conventional diesel generators, and even if major cost reductions of up to, say, 50 per cent were realized, only in one region (Antarctica) are conventional fuel costs so high that nuclear power could be economically advantageous. Before the cancellation, fifteen firms had submitted designs for the second generation plants, so that their production in the future is possible, if improbable. Two portable reactors, the PM3A at McMurdo Sound in Antarctica and the PM1 at Sundance, Wyoming, continue to operate, but the third at Camp Century, Greenland, has been closed down and is currently being moved to the Idaho AEC testing grounds for an undisclosed use. The next PM1 core will have an additional 50 per cent life (three years) and the one after that will increase reactor output from 10 to 40 MW(t)[3].

Mobile reactors. The ANPP mobile low power reactor ML1 appears to have been operating satisfactorily under test. It completed a 664 hour run in June 1964 with only five shutdowns, all due to minor, quickly remedied faults.[4] The ML1A, a true field model of the ML1, now seems certain to be

[1] "More About Reactors" by Major A. A. T. Hiscock, RE, *The Royal Engineers Journal*, March 1962.

[2] "Army Reactors" by Major J. D. Isaac, RE, *The Royal Engineers Journal*, March, 1964.

[3] "Nuclear Science Abstracts," Vol 18 No. 14 *Abstract* 24899.

[4] "The Aerojet Booster" (House Journal of Aerojet General, the makers of the ML 1) June 5, 1964.

built, since without it military doctrine on the use of mobile reactors could not be established and the $45 million already spent on the project would be wasted. The DOD admits, however, that it sees few possibilities for ML equipments. Power would cost about ten times that from diesels over a ten-year operating period, and, since the US Army uses only about 2 per cent of its diesel fuel for electricity generation, replacement of this fraction by nuclear fuel would be unhelpful.

High powered mobile reactors. The DOD and AEC study has shown that a survey of remote military sites has pinpointed only Thule (Greenland) and Guam as locations where mobile high-powered plant might be economical owing to added transportation costs for conventional fuel. Procurement of additional MH1A type barge-mounted plants will, however, be dependent on a full evaluation of the operation of the first MH1A. The MH1A project is now well under way, the reactor is at present being installed in the ex-Liberty ship *Charles H. Cugle.*

The Nuclear Energy Depot. Development of the Military Compact Reactor (MCR) is to continue but has been slowed down to phase more closely with the technology for producing hydrogen from water and nitrogen from the atmosphere and ammonia from these two products. The Nuclear Energy Depot is to consist of an MCR coupled to apparatus producing either liquid hydrogen or ammonia; these are to be used as fuels in conventional internal combustion engines or fuel cells. An alternative is to use the MCR to charge batteries which drive vehicles. Comparison of the alternatives is lengthy and obstruse and all that can be certain at the moment is that such a system is a long way off and will be expensive. Nevertheless, there is just a possibility that it could be the answer to the problem of providing fuel on the battlefield and the AEC continue to pursue it, although they have had several changes of mind before finally deciding to go ahead.

USSR Small Reactors

At the recent Third United Nations International Conference on the Peaceful Uses of Atomic Energy in Geneva, the USSR released more details of two reactors comparable in size and use to the American ANPP reactors. These are called by them The Small Gabarit Atomic Power Plant TES3 and the APBYC (ARBUS) Nuclear Power Station.

The TES3[1] has been in experimental operation in Obninsk since 1961 but its reliability and actual power output since then have not been revealed. It is a light water moderated and cooled reactor with an output of 1.5 MW(e), mounted in four wheeled trucks. These move by road or rail (but evidently not by air) to their operating site where the engines and other running gear are removed to make more space in the vehicles. The reactor truck and one other have to be put into a trench 2.8 metres deep, although the main shielding is apparently a lead tank which is filled on arrival with boronated water. The total weight of the equipment is 310 tons, so the trucks are quite large! The present core life is 250 days but it is hoped to increase this to two to three years. The equipment is designed so that it can be moved to a new site when required, but there is no evidence that such a move has been tried. No military applications are claimed for the reactor.

[1] "Small-Gabarit Atomic Power Plant TES-3." Paper A/28/P/310 of the proceedings of the Third United Nations International Conference on the Peaceful Uses of Atomic Energy (The Geneva Conference).

The ARBUS[1] utilizes an organic cooled and moderated reactor to produce .75 MW(e). It comprises nineteen units each weighing not more than 20 tons, and can be moved to a building site by "water or by land". Erection time is two to three months and the total operating crew is seventeen. The Russians claim to have overcome the main objection to the use of any organic moderator by regenerating, without removal from the circuit, the "hydrostabilized gas oil" from the substances into which it has been broken down by radiation. Economically, their claim is that an organic moderated reactor will have a lower capital cost than any other kind because it allows the use of cheap structural materials (in this case they hope eventually to be able to use standard petroleum pipes and fittings), simple instrumentation, and much less biological shielding. Such a reactor may be "advantageous even today in a number of remote areas of the USSR". Again no military use is claimed for what is clearly what the ANPP would classify as a Static Low Power Reactor.

Large Reactor Economics

There has been a great deal of argument recently as to whether or not recently designed reactor systems have reached cost parity with fossil fuel systems for producing electricity on a large scale. One company in the USA has gone so far as to issue a fixed price list for a range of complete reactor power stations.[2] These range from M$ 15 for a 50 MW(e) station to M$ 103 for a 1,000 MW(e) station. Price of the electricity they produce, it is claimed, will be 3.8 mills per KWH from the larger plant, rising to 5.8 mills from a 300 KW(e) plant but with no forecast for the smallest of the plants. Extrapolation and conversion to units more easily understood indicates a figure of around $\frac{3}{4}d$ per KWH for a 50 KW(e) station. Here, at any rate, are some reasonably firm figures on which one might produce an argument for building a reactor at any new, large, remote overseas military base with an unusually high demand for power for, say, water de-salination.

Radioisotope Thermoelectric Generators

As a radioisotope decays it emits heat which can be converted into electricity. The AEC Systems for Nuclear Auxiliary Power (SNAP) Programme which began in 1956 has led, along with other techniques, to the fabrication of a number of devices employing this principle which are at the moment supplying power to satellites, terrestial weather stations and navigation buoys at sea. Such radioisotope generators have the advantage that they require no-refuelling or other maintenance for periods of years, and at first sight would appear to have numerous military applications. It must be said straight away, however, that for a variety of reasons which will be explained such promise is not likely to be fulfilled.

Proper selection of the fuel for these devices is basic to their design; half life must be compatible with the required life of the device, including of course shelf life since isotope decay cannot be switched on and off. High power density (in watts per gram) may be necessary to minimize size and weight. If the device is to be handled, then only certain sources can be used or heavy shielding is necessary. The chemical properties of the fuel must also satisfy safety requirements, and, last but not least, cost and availability must

[1] "The APBYC Organic Cooled and Moderated Nuclear Power Station. Paper A/28/P/307 of the Geneva Conference.

[2] *Applied Atomics*, 30 September, 1964.

be reasonable. Suitable fuels are obtained either by purifying fission products from spent reactor fuel, or by irradiating suitable target materials. Each method provides, out of the many hundreds possible, four radionuclides reasonably suitable for power generation. These are shown with their properties in Table 1.

TABLE 1

Nuclide	*How produced*	*Type of decay*	*Half life*	*Thermal activity*	*Availability by 1970*
				Curies/watt	Megacuries/year
Sr^{90}	Fission purification	β	27.7 years	154	25
Cs^{197}		β, γ	27 years	210	25
Pa^{197}		β	2.6 years	2,700	50
Ce^{144}		β, γ	285 days	128	200
Po^{210}	Irradiation	α	138 days	31.6	3
Cm^{242}		α	162 days	27.6	0.3
Cm^{244}		α	18 years	28.6	0.2
Pu^{238}		α	90 years	29.0	0.6

The β emitters which are relatively cheap (Sr^{90} is about \$1–\$1.5 per curie but such an estimate could be out by a factor of four depending on circumstances) require heavy shielding, while the α emitters which cost tens of dollars per curie require none. Terrestial applications have so far all used Sr^{90} while space systems have used α emitters. The use of a mixture of isotopes, to save costly separation, is a possibility.

Thermoelectric conversion is so far the only principle which has been tried in SNAP systems. A temperature difference imposed across a junction of two dissimilar metals will generate an electric potential, and recent intensive investigations have developed semiconductors which can do this with a reasonable efficiency. Various pairs of semiconductors can be used each of which has an acceptable efficiency over a small temperature bandwidth only, and this bandwidth varies for the N and the P doping conditions of the pairs. The thermal output from a radioisotope reduces as the source decays; it is therefore necessary not only to select the correct thermoelectric device for any particular source, but also, in some cases, to have a thermal bypass which wastes heat during the early life of the source so that a reasonably consistent temperature difference is maintained. A significant advantage will be obtained when elements can be made of a composite material and thus operate over a wider temperature range. The thermoelectric elements are normally encapsulated, connected in series to give a higher voltage, and may trickle charge batteries to provide a higher, intermittent, power supply.

It was in 1959 that President Eisenhower produced the first working SNAP device on his desk at a White House press conference. This had a life of six months and an output of 3.5 watts. Since then, two SNAP systems have been launched with satellites, one of which failed because of an ancillary device after six months in orbit, while the other (SNAP 3 in *Transit 4A*) is still producing 2.7 watts after over three years in orbit. The first operational terrestial system to use radioisotope power (SNAP 7C) sensed and transmitted weather data at three hourly intervals in an unattended, remote Arctic weather station for more than two years. After exceeding its design life by several months a failure in the electronics system necessitated its renewal. It is at the moment being reinstalled, unchanged in design but with

better electronic equipment. This device gave 10 watts and was similar to another in a navigation buoy used by the US Navy. SNAPs 7B and D are respectively in a fixed navigation light and an unmanned barge weather station, both producing 60 watts. The Balitmore light in Chesapeake Bay is shortly to be moved to a more remote location, having proved itself where it is. *Nomad*, operated by the Navy, is moored about 350 miles south of New Orleans and radios air temperature, barometric pressure, wind speed and direction and water temperature every three hours. A storm sensor triggers hourly transmission during severe weather. The generator, fuelled with 20 lb of strontium titanate, is designed to withstand ramming by a 20,000 ton ship travelling at 20 knots. Power not used in its two and a half minute transmissions is stored in batteries and used to light a navigational beacon. It should not require refuelling for ten years.

The SNAP 7 series of generators each cost about $100,000, excluding development costs, which were very much more and the cost of fuel, and they were never seriously considered for commercial use. The next official generation of SNAP devices, SNAPs 21 and 23, which are still some years away show such promise, however, that two firms in the US are producing their own interim devices for sale to industry throughout the world, and they estimate that they may well sell between six and seven hundred of these by 1967.[1] All of these are likely to be Sr^{90} fuelled, their outputs ranging between 20 and 40 watts(e), and they will weigh about 750 lb. The cost of them has not yet been announced, although it has been estimated at $25,000 for the larger devices; add to this the cost of fuel, and a 40-watt generator will cost a minimum of $85,000.

USSR Radioisotope Generators

Unless they have a separate, classified programme, the Russians are clearly well behind the Americans in this field. They openly claim only two such devices for terrestial use. The first is fuelled by PO^{210} and has not been put to specific use; the second is fuelled by Ce^{144} and has been powering an automatic weather station somewhere in the Soviet Union. Semi-conductor thermocouples are used for direct conversion.[2]

Reactor Direct Conversion Units[3]

Electrical power requirements of satellites have until now been limited to a few hundred watts at the most and have been supplied by batteries, solar systems or radioisotope generators. To solve the power requirements of more advanced missions, the SNAP programme is investigating fission heat sources, and SNAP 10A is a 500 watt(e) reactor direct conversion unit which is scheduled to be sent into space in 1965. The briefest description of the device would call it an homogeneous, U^{235} fuelled, zirconium-hydride moderated, Be reflected, reflector-controlled, liquid metal-cooled reactor with thermoelectric power conversion. There is no need to describe the system further in this paper but the following points are worth noting. First, it is not a fast

[1] *Nucleonics*, August, 1964.

[2] "Radio Isotope Fuelled Thermoelectric Generators". Paper A/28/P/318 of the Geneva Conference.

[3] Details of this programme are given in a series of reports issued by Automatics International under the reference NAA-SR which are available from the Office of Technical Services Department of Commerce, Washington. Numerous other papers and articles are available on the subject.

reactor; second, it is virtually unshielded, criticality being achieved after launching; third, it has few moving parts, the reactor heat being controlled by the negative temperature coefficient of reactivity inherent in a hydride system (which also makes it exceptionally safe), and fourth, it has a design lifetime in space of one year. The reactor itself will weigh under 250 lb but the thermoelectric conversion gear for space, where cooling has to be by radiation, makes the whole system weigh about 1,000 lb.

Here, then, is a miniature reactor which could be used terrestially provided it were sited in a remote spot or were shielded. It is the forerunner of a range which will produce up to megawatts of electricity, but, of course, its cost at the moment is very, very high.

Possible Uses for These Devices

This is the point at which readers must start to think for themselves, and the author would be very grateful if anyone who is visited by any bright ideas would pass them on to him. Some suggestions for the use to which the power from the devices described could be put are that they could be used for unmanned surveillance devices, telephone repeaters or radio relaying stations in inaccessible places such as jungle; for navigation beacons for jungle or desert patrols, as unattended counter-bombardment acquisition devices or as radio sondes.

Even so, none of these possible uses seems to be of such pressing importance that the high cost involved can be ignored. The answer does seem to be at the moment, that the British Army has no practicable use for them.

Conclusion

The United States ANPP has now developed portable and mobile electricity producing reactors for use in remote locations and on the battlefield. At the same time it has proved that only under the most exceptional circumstances are the former economical, and it has said virtually that there seems little use for the latter. There would, therefore, be little point in the British Army becoming too interested in this type of equipment. It seems likely that shortly the very largest reactors will be able to compete with fossil fuels economically but the lower limit of power at which they will do this has yet to be determined. It has been suggested that any new British base overseas would in the future be built on an island, and in this case, starting with no local facilities available, a reactor to provide power, space heating and to desalinate water would have to be considered. Larger reactors may therefore still be of interest to us. Radioisotope and similar generators are novel devices and there will be many suggestions in the near future of the uses to which they should be put: it will have to be a good one that will be worth developing. Nevertheless, as Sappers, it is important that we understand the principle behind such devices and their limitations, so that, should a real opportunity to use them arise, it is acted upon quickly.

Army Aviation

The Air Troop RE

(The information given below is not yet final or approved. It represents present intentions only and should be read in this sense.)

DCI 251 of 11 November 1964 outlines the expansion of Army Aviation which is now in progress and it is of interest to know what the Sapper slice of this is likely to be and the type and capabilities of the aircraft we are likely to get.

The Air Troop, RE is to be based on the Agusta-Bell 47G–3B1 (known also as the Sioux) with a possible establishment as follows:—

Pilots RE	
OC Air Troop (captain)	1
Pilots (WO/S/Sgt/Sgt)	2
Other Ranks RE	
Driver operators	2
Other Ranks (REME)	
Artificer aircraft (S/Sgt)	1
Technicians aircraft	4
Vehicles	
Truck, FFR, ¼ ton, 4 × 4	1
Truck, cargo, 3 ton, 4 × 4 (REME G1098)	1
Trailers, cargo, ½ ton	2

It is planned that Air Troops, RE, shall be attached to Headquarters of Divisional Engineers and Corps Engineer Regiments in UK and BAOR, plus a further troop each in Middle East and Far East Commands. They will be phased in over a period of eight years with the majority appearing during the period up to March 1968. This calls for a substantial increase in the number of volunteers for pilot training particularly from among the other rank element, where volunteers in the rank of corporal are urgently required, and may present a difficulty since the standards are very high and individuals of the calibre called for are often already holding a higher acting rank. Commanding officers may be, not unnaturally, loath to lose this type of NCO material, but since Air Troops have to be found from within our over-all manpower allocation a long term attitude will have to be taken to the problem of the provision of other rank pilots.

The Sioux helicopter can operate world wide and poses less maintenance problems than the Skeeter. Principal data are as follows:—

Gross weight	lb	2,350	2,650	2,950
Maximum speed at SL	mph	105	105	105
Cruising speed at 5,000 ft	mph	93	90	86
Service ceiling	ft	20,000 +	19,600	17,200
Hovering ceiling in ground effect	ft	20,000 +	18,500	16,100
Hovering ceiling out of ground effect	ft	18,600	15,900	10,600
Maximum rate of climb at sea level	fpm	1,320	1,100	880
Maximum rate of climb at 13,600 ft	fpm	1,320	1,100	880
[1]Maximum range at 5,000 ft no reserve	St. Mi	315	292	273
[1]Maximum endurance at 5,000 ft no reserve	hrs	5.3	4.8	4.3

[1] With standard tanks.

A number of attachments can be fitted to the Sioux to make it suitable for a variety of roles. These consist of floats in place of skids to permit operations from water, marsh or snow, cargo containers, enclosed litters for stretcher casualties, a weapons platform for guided missiles, machine guns or rockets, extra fuel tanks which will permit double range to be attained and a cargo hook and sling with a capacity of some 8 cwt.

In all the Sioux would appear to be an aircraft which will go a long way to meet Sapper requirement and the Air Troops, when implemented, should prove an invaluable adjunct to the Headquarters they serve.

The Army Apprentices' School Chepstow

By Lieut-Colonel F. W. L. Shepard, MBE, BSc, AMICE, RE
Chief Instructor 1962–65

Introduction

During 1964 a Working Party under the chairmanship of the Director of Army Training has reviewed the organization of Army Apprentices Schools. As a result of this review it is probable that AAS Chepstow will very shortly be controlled by the Engineer-in-Chief. It therefore seems appropriate that the attention of the Corps should be drawn to this School, which although it has always been an All Arms establishment, has rendered long and useful service to the Royal Engineers by producing many able officers and a large number of high class Warrant Officers and Senior NCOs. It is worth noting that the Convention held in October 1964, twenty-three out of the fifty-two RSMs present had been apprentices at Chepstow.

History

After the 1914–18 War there was an acute national shortage of skilled tradesmen and an increased demand for them by the technical corps of the Army. General Sir Robert Whigham, KCB, KCMG, DSO, who was then Adjutant-General, founded the Central Training School for Boys to make good the deficiency. It was originally intended to form the School at Blandford, in Dorsetshire, but it was found necessary to change the site of the School to Beachley, near Chepstow, where a new camp was being constructed. Tradition has it that the Army Council met at the inn by the Beachley ferry in 1923 to approve the site.

The School was formed on 20 November 1923 under Army Order No 185 of that year and, because Beachley Camp was still not completed, it initially occupied the RASC Buller Barracks at Aldershot with a staff of twenty and 105 Boys of No 1 Group. The first Commandant was Lieut-Colonel V. T. R. Ford, DSO, The York and Lancaster Regiment, whose widow laid the foundation stone for the new School Chapel in 1963. The first Chief In-

Photograph by Gloucester Equipment Lt

Photo 1. Aerial view of Beachley Peninsula looking north. The River Severn, a ferry boat, and part of the new Severn Bridge can be seen on the right; the River Wye is on the left. The school playing fields and married quarters are in the foreground with barrack blocks and parade ground beyond the viaduct under construction to the left; classrooms, workshops and more playing fields are in the neck of the peninsula.

The Army Apprentices School Chepstow 1

structor was Major F. P. Barnes, DSO, OBE, RASC, the Trade Instructor Captain E. A. Robinson, MC, RE, whilst the Chief Clerk and RQMS were also RE. The trades taught were—Carpenter and Joiner, Fitter, Blacksmith and Electrician.

In February 1924 the School, now increased to 200 Boys, moved to Beachley Camp at the junction of the Rivers Severn and Wye, four miles from Chepstow—"a bleak yet healthy spot"—where it has remained ever since. Incidentally the Apprentice Tradesman of today owes his designation to Army Order No 306 of 1924, which directed that those who enlisted for training as tradesmen would in future be known as "Apprentice Tradesmen", and no longer as "Boys". The name of the School was changed to the Boys' Technical School in 1924, to the Army Technical School (Boys) in 1930, and to the Army Apprentices School, Chepstow in 1947. Presently it may became an Army Apprentices College. However, its task of producing soldier tradesmen with capacity for leadership has remained the same for forty years.

Training continued without interruption during the Second World War although the School was bombed and straffed in 1940 and one Apprentice was killed. Ex-Chepstow "boys" served in the RAC, RA, RE, R Sigs, Infantry, RASC, RAMC, RAOC, REME during the Second World War and in subsequent operations, and amply rewarded the Army Authorities for the care they had taken to ensure that the Apprentices had received a good solid military and technical education. A large number of them, having taken advantage of subsequent upgrading technical and military courses on man service, served with distinction and successfully filled officer appointments on Directorates of Works, etc. Several commanded units and many were decorated for gallantry.

From 1948 to 1961 the Chepstow trades were predominently REME, but since then 90 per cent of the School's output has gone to RE.

Other similar Apprentices Schools include—AAS Arborfield (REME) founded in 1948, AAS Harrogate (R Sigs and Building Trades and Electricians RE 1948–61) founded in 1948, AAS Carlisle (REME and RE Vehicle Mechanics) founded in 1960. There are also smaller Army Apprentices Schools at Worthy Down (RAPC), Crookham (RAMC) and Aldershot (ACC). Junior Tradesmens' Regiments at Rhyl and Troon produce Drivers, Driver Operators and Clerks. There are in addition nine Junior Leaders' Regiments serving exclusively particular Arms and Services, while the Infantry Brigade Depots have Junior Soldiers' Wings training bandsmen, drummers, buglers and pipers.

Organization

The School year is divided into three terms each of fourteen weeks, commencing early in January, May and September. A group of about 120 Apprentices joins the School at the beginning of each term and stays for three years, making a total strength over any three years of 1,000 Apprentices, allowing for wastage. At present the School has a staff of 202 Military and 280 Civilians; of these eighty-one Military are RE and seventy-nine Civilians are trade instructors, mainly ex-RE WOs and NCOs.

The School is commanded by a Colonel, assisted by an RE Lieut-Colonel as Deputy Commandant and Chief Instructor with responsibility for the general direction of training. There is an Adjutant, Quartermaster, Medical

Officer, Dental Officer, Chaplain, Paymaster, Messing Officer, and HQ Company Commander with the usual administrative staff. The Brigade of Guards furnishes the RSM.

On the trade side, controlled directly by the Chief Instructor, are the following departments each commanded by an Officer: Survey, Construction, Mechanical and Metal Working, Electrical, Ammunition Technicians (RAOC). These departments are staffed by RE and RAOC WOs, NCOs and Civilians. A Technical Stores Officer deals with training stores and equipment.

The Education Department is commanded by a Lieut-Colonel RAEC with thirteen Military and fourteen Civilian Lecturers. There is a Military training officer (Major RE) who has a Weapon Training and PT staff, he is also responsible for controlling sports, games and extra mural activities.

There are three Senior Companies organized by trades and one Junior Company in which all Apprentices spend their first year. Company Commanders are responsible for welfare, administration and general military training. One Company Commander and all CQMSs are RE; all CSMs are from the Brigade of Guards. Selected Apprentices are appointed as Apprentice NCOs and Warrant Officers while at the School and share the responsibility for maintaining discipline. Some Sappers may think it a pity that the School is not entirely staffed by Royal Engineers; in fact the present mixture has worked so well during the last forty years that it has been adopted as a model for the establishments of other Apprentices Schools.

Apprentices' Terms of Service

Apprentice Tradesmen join between the ages of 15 and 17 and are signed on for a three year apprenticeship with nine years subsequent man's service reckoned from the age of 18, and a further three years in the Regular Reserve. They can purchase discharge for £20 up to three months after joining; after this the rate increases up to £150 in three years and discharge is subject to Ministry of Defence (Army) approval. Apprentices enlist into the General Service Corps and are subject to Military Law, but discipline at Army Apprentices Schools is suited to the age of the boys.

Pay is 7*s* 6*d* a day for the first year, 14*s* a day for the second year and 18*s* a day for the third year, with additional increments of 2*s* 6*d* a day at 17 and 3*s* a day at 18. Extra pay is given to Apprentice NCOs and Warrant Officers. All boys wear uniform and march to and from work, but outside duty hours they may wear civilian clothes. There are no bounds at Chepstow, and the Senior boys are allowed out till midnight. There is a carefully graded series of privileges depending on seniority, good conduct and satisfactory progress; at present only A/T Sgts and above may keep motor vehicles at the School. Apprentices may not marry while on Boy service.

The School gets ten weeks leave a year, usually two weeks at Easter, five weeks in Summer and three weeks at Christmas, but there is normally no week-end leave during term time.

Royal Engineer Apprentices start their man's service at 1 Training Regiment RE, where they do fourteen weeks Combat Engineering and Military Training before going to Units. AG7's policy is that ex-Apprentices should be sent to a trade appointment on first posting, but this aim cannot be fully achieved at present.

As regards career prospects, the following figures for ex-Apprentices serving in the Royal Engineers on 31 July 1964 speak for themselves:

Brigadier	1	Warrant Officer Class I	76
Colonel	2	Warrant Officer Class II	193
Lieut-Colonel	8	Staff Sergeant	208
Major	52	Sergeant	249
Captain	12	Corporal	375
Lieutenant	1	Lance-Corporal	333
		Sapper	806
	76		2,240

Career prospects do not finish with retirement from the Corps. Many ex-Apprentices are now holding important technical and other types of appointment in civil life, where a blend of practical and theoretical ability, mixed with an inborn sense of discipline and loyalty is sought.

Training Programme

An Apprentice normally completes nine terms at the School, totalling about 5,000 training periods of forty minutes each. During this time his training follows three main channels:

Trade Training for about half the time available,

Education for one quarter of the time,

Military and leadership training for the remaining quarter.

The working day starts with Reveille at 0630 hrs, breakfast at 0700 hrs and a Company Muster Parade at 0800 hrs, followed by School prayers or a School parade. Training begins at 0830 hrs and continues till 1635 hrs with breaks for mid-day dinner and at mid-morning and mid-afternoon; milk and cakes are served at the mid-morning break. After tea from 1740 hrs to 1900 hrs there are "prep" periods on Mondays and Tuesdays, Clubs and Hobbies activities on Thursdays and "Interior economy" on Fridays. Supper is at 1930 hrs and "lights out" at 2230 hrs.

A full range of sporting facilities are provided. School and Company matches are played on Wednesday and Saturday afternoons, and there are other games periods staggered throughout the week. All Apprentices attend Church Service on Sundays and Morning Prayers twice a week, in addition to Religious Instruction periods.

Trade Training

The trades taught, and present annual outputs, are as follows:

Survey Trades	46	Engine Fitter (Plant)	52
Ammunition Technician RAOC	20	Welder	12
Electrician RE	46	Plumber and Pipe Fitter	12
Fitter Machinist	16	Draughtsman Civil and Structural	12
Engine Fitter (I C & P) (incl 6 for Marine Engineer)	52	Bricklayer	12
		Carpenter and Joiner	40
		Painter and Decorator	12

Training is designed to provide a broad technical education going beyond the basic requirements of Army trades so that Apprentices are fitted for future employment as Clerks of Works or technical NCOs. The minimum final standard aimed at is Class III Practical and Class II Theory in the

Army Trade Test. Nearly all Apprentices achieve this and many now pass a full Class II Trade Test before leaving; they are paid for it after six month's satisfactory man's service. Those in appropriate trades are entered for the Craft or Technicians Certificates of the City and Guilds of London Institute, and in 1964 a pass rate of 90 per cent was achieved.

One of the advantages of Chepstow is that it covers a wide spread of trade types ranging from Technicians to B Tradesmen. However, increasing importance is being given to Technician trades in the Army; at present there are no Technicians in the RE apart from the Survey Trades and Clerks of Works. For this reason we do not get the most intelligent recruits as Apprentices for the Corps, which I think is a pity. Each term a batch of RAOC Ammunition Technicians leave the School as full Corporals, the minimum rank for their trade. At present we have nothing to offer to compare with this, nor with the R Sigs and REME Technician Trades. There is also a cause for concern at the lack of trade employment within the Corps. Tradesmen lose their skills in a few years unless they are able to practice them and, if this is allowed to happen, the elaborate training we give the Apprentice is largely wasted.

Education

The minimum standard aimed at is the Army Senior Test, giving exemption from the First Class Certificate of Education. About 80 per cent now achieve this aim, and almost all the remainder obtain exemption from the Second Class Certificate. Subjects are chosen to match Apprentices' trades, and special classes are run for City and Guilds Candidates. Many boys have some GCE subjects on arrival, these and others continue with this higher level of education at Chepstow and take further GCE subjects at O and A levels; in addition about 10 per cent are currently taking their Ordinary National Certificate. The School is approved by the Ministry of Education as a Technical College for Ordinary National Certificate and for City and Guilds courses. It is not an Approved School—although we sometimes get letters inadvertently addressed as though we were!

Military and Leadership Training

Military Training is based on the Army Recruit Training Syllabus and includes elementary drill, PT, field craft and first aid. All Apprentices fire a recruit's range course and take the Soldiers' PE Tests. Results compare favourably with Junior Leaders Regiments, but this training is necessarily limited by lack of time. In addition each Apprentice attends three ten day camps which include map reading, field craft, simple tactical exercises and elementary combat engineering of the "Sticks and String" type designed to develop the boy's initiative and powers of leadership. Selected Apprentices attend courses at the Army Outward Bound School and a number qualify for the Duke of Edinburgh's awards.

Games are regarded as part of leadership training. All Apprentices take part in them at least twice a week, and all the usual games are played on our fifteen sports' fields. There is also a cinder running track built by the School with provision for a full range of field events. We have recently completed our own open air swimming pool and an indoor pool is due to be built shortly. All these facilities are well used and the School has a very good athletic record with numerous successes in Army Youth and Junior com-

petitions. In 1964 we won the Quadrangular Tournament between the four major Army Apprentices Schools.

Bands

The School has a Military Band, Corps of drums and a Pipe band. The total strength of these is 130, all volunteers who practice out of training hours. We also have a School Mascot, a Welsh mountain pony called "Apprentice Beachley". He has a decidedly Celtic temperament, and we have to surround his field with notices saying "Beware the Pony".

Sports and Hobbies

There are at present over thirty active clubs in the School covering just about everything from angling to weight lifting. A number of courses and expeditions are run during the leave periods including parachuting and gliding, sailing in the Baltic, ski-ing in Norway, canoeing in France and climbing in Corsica.

Social Clubs and Entertainments

We have the usual Junior Ranks Club, run by NAAFI, and a WVS Club for the younger boys. A new development is the "Keymer Club" run by the Senior boys and their girl friends with some indirect supervision. This includes a coffee bar serving soft drinks and a room for dancing; it is very popular and goes well.

The School has an extensive library, and a cinema giving six shows a week. All barrack blocks are equipped with television sets and every Apprentice appears to own a transistor radio so special provision has to be made for private study.

Visits, Parades and Prize Giving

The Junior Company holds a "Passing In Parade" at the end of the first six weeks, to which parents are invited. At the end of each term a "Passing Out Parade" is held for the Senior Group and prizes are awarded to outstanding Apprentices in their first, second and third years. The "Passing Out Parade" is commanded by the A/T RSM and A/T NCOs; last term the reviewing officer was General Sir Richard Hull, GCB, DSO, ADC, then CGS, who created a popular, but dangerous, precedent by granting the School an extra day's leave. Visitors are always welcome in term time and we are glad to show them round the School, which I think all Sappers will find well worth seeing.

Beachley Old Boys' Association

The School has been in existence for over forty years and we have a very flourishing Old Boys' Association with over 3,000 members. There is an annual re-union on the week-end nearest to 20 September, the Foundation Day, when old boys are invited to stay at the School. In 1964 over 250 came, ranging from No 1 Group who joined in 1923 to No 61 C Group who had passed out the preceding term. The number included several old boys who now have sons at the School.

Copies of the School magazine "The Robot", which has been continuously published since 1924, are sent all over the world and we get many letters from old boys overseas.

School Buildings and the Severn Bridge

Originally the School was partly housed in the buildings erected for the Admiralty Shipyard during the first World War; some of these still remain, mostly huts with concrete block walls and asbestos roofs, but all are now scheduled for demolition. About 1958 it was decided to re-build the Camp on the same site in spite of the intention of the Ministry of Transport to construct the Severn Bridge and M4 Motorway through the middle of it. This decision should prove a wise one; the motorway is carried on an open viaduct which does not restrict access between the two halves of the camp and will provide useful overhead cover for training and games.

All Apprentices now live, feed and work in new buildings designed for the purpose. A striking new Chapel was completed in 1964; the Junior Ranks Club is under construction, and plans have been approved for an impressive Amenities Centre incorporating Gymnasia, Assembly Hall, Indoor Swimming Pool, Miniature Ranges, Squash Courts and Club Rooms. The new buildings are generally reckoned to be good to look at, well lit and well heated. There are already indications that they are far from being "boy proof" but it must be admitted that this requirement is not easily met.

Eventually the only "old" School building to remain unchanged will be the Administrative Block built by the Apprentices and completed in 1935. The main workshops retain their original steel framework but have been completely re-clad and are now as well equipped as any in the country.

The Future

It is intended that the Army Apprentices School, Chepstow, should continue to train mainly RE tradesmen, although the small number of Transportation trades that we now produce will no doubt go to the new Royal Corps of Transport.

It is proposed that Apprentice training for all A & B Trades should be reduced to two years by 1971. This scheme is expected to start at Chepstow in about 1967. The main reason for it is the intended rise in the School leaving age to 16 years which should produce a higher educational standard but will further reduce the gap between Boys' Service and Mans' Service. It will provide a challenge for us as we will have to try and do the same job in two thirds of the time.

The Technicians course is planned to stay at three years, so we will have Apprentices at Chepstow on both two and three year courses. By then Senior Apprentices will probably be on almost adult terms of service to get over the anomally of twenty year old "boys" and seventeen year old "men". Apprentices are likely in the future to enlist direct into the Corps for which they are selected, and it is proposed that Army Apprentices Schools should come under the control of Arms Directors while remaining under the general direction of the Inspector of Boys Training, so Chepstow would be controlled principally by the Engineer-in-Chief. This will no doubt strengthen the ties between the School and the Corps to the benefit of both.

Photograph by E. J. Rumball

Photo 2. Passing out parade, July 1964. The Senior Group being inspected by General Sir Charles James, KCB, CBE, MC

Photograph by W.O. Reproduction Service

Photo 3. Apprentices leaving the new classroom block

The Army Apprentices School Chepstow 2 & 3

Photograph by E. J. Rumball

Photo 4. Dedication Service in the new school chapel

Photograph by E. J. Rumball

Photo 5. Open air swimming pool built by the School. The WO's and Sgts Mess is in the background.

The Army Apprentices School Chepstow 4 & 5

The Reredos

The Army apprentices School Chepstow 6

History of St Martin's Garrison Church, Longmoor, and its Memorials

By Brigadier C. A. Langley, CB, CBE, MC

Introduction

Longmoor has been the home of the Transportation Branch of the Royal Engineers since 1906, and St Martin's has been its centre of worship since 1931. The church has been the scene of many memorable services, and it has given strength and inspiration to countless members of the Regular and Supplementary Reserve (now AER) Units.

The time is fast approaching when a new Corps—the Royal Corps of Transport—will be formed by an amalgamation of the Movements and Transportation Branches of the Sappers with the Transport component of the Royal Army Service Corps. It is appropriate, therefore, to present an up-to-date history of the church and the memorials which the new Corps will inherit. This church, despite its unprepossessing exterior, is a building of unique associations and beauty. It contains a magnificent reredos and a series of memorial windows and commemorative tablets to Transportation men of all branches and classes who served their country in two World Wars.

During the first World War, Longmoor was the Depot for the vast number of railwaymen who served on the Western Front and other theatres of operations. At the conclusion of hostilities, Longmoor went through a short period of quiescence once the rush of demobilization was over, but with the revival of interest in transportation and the initiation of plans for the formation of Supplementary Reserve Units in 1923, Longmoor began a fresh and active phase of its history. The regular Royal Engineers contingent comprised the Railway Training Centre, with its administrative and training staff, and the 8th Railway Company, reinforced in 1928 by the re-formation of the 10th Railway Company which took over the running of the Depot and the Woolmer Instructional (now Longmoor) Military Railway. The first of the new Supplementary Reserve Units came to camp in 1925 and they were raised exclusively from personnel of the four great Railway Companies—the Great Western, the London Midland and Scottish, the London and North Eastern, and the Southern. The operation of railways in war was their chief concern, but docks working was also included in their activities and the LNER raised a Docks Unit. It was not, however, until the late 1930s that other transportation undertakings, such as the Port of London Authority and the Mersey Harbour Board, were asked to co-operate.

During the years between the wars, close bonds of friendship and co-operation were forged between the Regular and the Supplementary Reserve Units who came each year for a fortnight's training. During this period they were visited regularly by the Chief Officers of the Railways and Docks undertakings, who took a great interest in the military activities of their men. The Sunday Church Parade was an outstanding feature of each camp, and was attended not only by Regular and Supplementary Reserve officers and men, but by their families and friends and later by their "Old Comrades".

During these years Longmoor was also the home of Royal Artillery Units, first the Mountain Artillery Brigade and later the 2nd Medium Artillery

Brigade. The officers and men of these units gave their full support to the church and co-operated with the Sappers in beautifying it.

The Early Church

When the Supplementary Reserve Units were first formed in 1925, church services were held in the Seymour Hall, a large hut that was used as a cinema and recreational centre on weekdays, and converted into an extempore church on Sundays. With the increase in the Royal Engineers regular establishment and the growth of the Supplementary Reserve, the need for a permanent Garrison Church became more and more pressing, but it was not until Palm Sunday, 29 March 1931, that the present building was dedicated by the Reverend A. C. E. Jarvis, CB, CMG, MC, DD, Chaplain to the King, the Chaplain General to the Forces.

The church was originally a forage barn, built for the Mounted Infantry who occupied Longmoor on their return from the Boer War. It was furnished by the Government in plain deal with strict regard to economy, and an old harmonium supplied the music. The appearance was marred by the low steel roof-trusses, which were constant reminders of the church's humble origin. Even so, it was much more suitable than the old hall and was much appreciated, especially by the Supplementary Reserve. Before long a series of improvements were initiated. A fine two-manual organ which came from the Curragh Camp in Ireland was installed on perpetual loan from the Church of England Sailors', Soldiers' and Airmen's Institution, and the local Garrison and Supplementary Reserve Units subscribed for new oak pew fronts, choir stalls, pulpit and lectern, and oak panelling in the chancel. These additions transformed the appearance of the chancel, but were of no particular artistic merit.

The Reredos

The history of the memorials began in 1935 when I was commanding the 8th Railway Company and received a letter from a Petersfield bank manager who held our Regimental Funds. He asked me to call and examine some documents deposited with the bank during the first World War by Longmoor Units. On looking through the Register I noticed that a packet sent by the Railway Depot in 1918 was still uncollected. It was soon brought from the vaults and out of it came hundreds of War Savings Certificates, the balance of the Depot Garden Fund—proceeds from the Longmoor allotments which had been cultivated so assiduously and so successfully by railwaymen during the first World War.

On my return to Longmoor I hastened to the Commandant, Lieut-Colonel (later Brigadier) Lionel Manton, CBE, DSO, and told him the good news. He decided that part of this unexpected treasure trove should be allotted towards a memorial to the many railwaymen who fell in the 1914–18 war. I was a churchwarden at the time, and suggested that we should present a reredos to replace the oak and tapestry screen behind the altar which did little to conceal the bare brick wall. Colonel Manton agreed and asked me to prepare a plan. My thoughts turned to Liss Parish Church, where a beautiful reredos had recently been dedicated. It had been designed by Martin Travers, ARCA, one of the leading men of his profession, and I decided to get in touch with him. Thus began an association which lasted until his untimely death on the 25th July 1946.

The limitations set by the low unsightly roof trusses did not disturb him unduly and he designed a striking reredos in the form of a triptych which focuses attention immediately. The centre panel contains a life-size figure of the Risen Christ with hand upraised in blessing; the Figure, surrounded with rays of gold, stands out from a fiery red background and is encircled by the inscription "Greater love hath no man than this, that a man lay down his life for his friends". The side panels contain the words "I am He that liveth and was dead and behold I am alive for evermore" set in gold on an ivory-coloured background. Each corner is enriched with the RE grenade and the Corps' motto "Ubique" embossed in gold—a symbolic idea, not only representing the Corps of Royal Engineers but also the flaming torch of Christ spreading light throughout the world. The whole scheme was completed with a carved red and gold altar frontal, tall silvered wood candlesticks and a silver cross.

This beautiful memorial was dedicated by the Reverend E. A. Fitch, OBE, KHC, the Assistant Chaplain General, Aldershot Command, on Sunday, 26 April 1936, in the presence of General the Hon Sir J. Francis Gathorne-Hardy, GCB, GCVO, CMG, DSO, ADC, General Officer Commanding-in-Chief Aldershot Command, and a distinguished gathering of Regular, Retired and Supplementary Reserve officers and men, and senior officers of the four great Railway Companies. At a luncheon after the ceremony I explained how the reredos was intended to be a striking feature in the church, and how we hoped to further enhance its beauty by removing the chancel roof-trusses which obscured it. I also suggested that memorial windows would be much appreciated.

This idea appealed to the Railway officers present, and after the luncheon Mr (now Major-General) Gilbert Szlumper of the Southern, backed up by Mr (now Sir) Michael Barrington-Ward of the London and North Eastern and Mr R. Carpmael of the Great Western asked me to put forward proposals for memorial windows to commemorate the men of these Railway Companies who had died in the Great War. Sir Josiah (later Lord) Stamp, President of the London Midland and Scottish Railway, also approved the plan which received strong support from J. A. Kay, Editor of the *Railway Gazette*. I had no hesitation in asking Martin Travers to take on the work.

The Railway and London Transport Windows

The problem of producing suitable church windows to represent the Railway Companies gave us much food for thought, but finally we decided to include in each window the patron saints of two cathedrals on each railway system, and to incorporate the coats of arms of representative cities and towns. This solution was not so simple as appeared at first sight, because we had to eliminate those cities served by rival companies, and we found that our choice was much restricted, owing to many cathedrals being dedicated to the same saints. We also wished to represent Scotland adequately in the windows of the two companies serving that country.

For the Southern Railway window, the Blessed Virgin Mary, the patroness of Salisbury, and St Augustine, the founder of Canterbury, were obvious choices. As regards Scotland, we decided that the London Midland and Scottish Railway should be represented by Glasgow, and the London and North Eastern Railway by Edinburgh. Unfortunately, as we were sassenachs, we spent many hours looking for a Glasgow saint, until my wife, who was

reading *In Search of Scotland* found St Mungo for us. No doubt we could have saved ourselves much trouble if we had asked any Glaswegian! St Alban, the soldier, was the second LM & SR saint. For the LNER our first choice for Edinburgh was St Margaret of Scotland, but we changed later to St Andrew; St Peter of York was a most appropriate second saint. For the Great Western Railway we selected St David of Wales, but we could not find a second suitable saint—all the cathedrals in this area seemed to be dedicated either to the Holy Trinity or to one or other of the saints we had already chosen; we though of St Frideswide of Christchurch, Oxford, but felt she would not be suitably appreciated, as her fame was unknown outside a limited number of scholars. In the end we changed the theme slightly and coupled St George with St David, to indicate the Great Western link between England and Wales.

In each window the appropriate cathedral is included, either carried by the saint or shown in the background and a dozen coats of arms of towns and cities served by the respective Railway Companies add interest and beauty; London, the headquarters of each Company, appears in each window. The coats of arms offered a wide choice and selection was influenced to some extent by artistic requirements, but we endeavoured to represent Learning, Industry, Railways, Ports and the Services. Diagrams of the windows showing the position and names of the coats of arms are illustrated at the end of this article.

The designs of the four Railway windows were nearly completed when, by chance, I met Mr (now Colonel) V. A. M. Robertson, the first commander of the LNER Construction Company and then Chief Engineer of the London Passenger Transport Board. As a result we were offered a fifth window by Frank Pick, General Manager of the Board, and gladly accepted it. For this window, St Paul and St Edward the Confessor of Westminster were chosen and they are surrounded by the coats of arms of London and the London County Council and of the counties served by the Board.

Much time was spent with Martin Travers and the railway officers discussing details, and meanwhile the three disfiguring trusses in the church were cut away and the roof supported by steel columns, encased in oak. The organ was similarly encased, and other improvements were made. These alterations further transformed the chancel and enabled a clear view of the reredos to be seen from the main body of the church.

Eventually the windows, which were made in Mr Travers' own workshops, were dedicated on 7 May 1939 by the Reverend E. H. Thorold, CB, CBE, MA, DD, KHC, the Chaplain General to the Forces, in the presence of a large and representative gathering, including Chairmen and Members of the Railway Boards, Chief Officers of the Railway Companies, the GOC Aldershot Command, the Representative Colonel Commandant, Royal Engineers, and a host of RE and Railway Officers.

The Canadian Railway Window

During the Second World War, many thousands of Transportation Troops from all over the world served at Longmoor or in one of the many camps in the vicinity, and much interest was taken in the church memorials, so much so that on the completion of hostilities the Canadian National and Canadian Pacific Railways offered another window in memory of those members of their staff who had fallen in the Second World War. Once again

I got in touch with Martin Travers, and at a meeting with the European General Managers of the two Companies we decided to adhere to the general style of the other memorials, but to incorporate the Royal Coat of Arms of Canada, in place of a saint, in the lower half of the window. We selected St Lawrence as the most appropriate ecclesiastical representative of the Dominion and he is shown standing by the river which leads into the heart of that great country. Each Canadian province (except Newfoundland, which was then still a colony) is represented by its coat of arms, and the completed window is one of the most beautiful in the church. It was unveiled by the High Commissioner for Canada and dedicated by the Bishop of Portsmouth on 11 April 1948.

Two more windows were designed by Martin Travers before his death, but unfortunately he did not live to see them completed. The first, presented by the Port of London Authority, was in memory of their men who had died in the Second World War; the second, subscribed by all ranks, commemorates the sacrifice made by the officers and men of the Transportation and Movements Branches of the Royal Engineers.

The Port of London Window

In the Port of London window, the figure of St Nicholas, the patron saint of sailors, stands above the coat of arms of the Port Authority. The inclusion of the arms of a number of riverside boroughs of London illustrates in some small measure the area covered by the greatest port in the world. This window was unveiled by Sir John Anderson and dedicated by the Bishop of London on 12 July 1949.

The Transportation and Movements Window

The Transportation and Movements window, the last of the Martin Travers' memorials, was unveiled by Major-Generals Sir Donald McMullen, KBE, CB, DSO, and W. D. A. Williams, CB, CBE, on 4 September 1949 and was dedicated by the Reverend Canon F. Llewelyn Hughes, CB, CBE, MC, Chaplain to HM The King and Chaplain General to the Forces.

St Christopher, the patron saint of travellers, had long been reserved for this memorial and he is shown as the giant in the legend carrying the Child Christ across a fast flowing river. The Royal Coat of Arms with golden lion and ivory unicorn standing rampant on either side present a striking display of heraldry, whilst the Corps' mottoes "Ubique" and "Quo fas et gloria ducunt" adequately express the widespread activities of the two branches of the Royal Engineers which are commemorated.

Railways are represented by the coats of arms of the four Railway Companies, and the London Passenger Transport Board and the Docks undertakings by the coats of arms of the ports of London, Bristol, Mersey and Clyde. Southampton, the South Wales ports, Hull and other East Coast ports are already covered by the respective Railway Companies who originally operated them. For the Inland Water Transport we added the arms of the Watermen and Lightermen's Company and the RE blue ensign, which was worn by every IWT vessel throughout the war, whether in France, the Mediterranean, the Middle East, Iraq, India or Burma. This flag carries a hand issuing from a mural crown and grasping a thunderbolt. It was granted to the Corps in 1886 in the days of submarine mining before that work was handed over to the Royal Navy.

Mr Travers unfortunately died before he had completed the work on these last two windows, but this was undertaken by Mr Lawrence Lee, ARC, his partner, who since then has taken a great interest in the church.

The Inland Water Transport Window

With the dedication of the Transportation and Movements windows, all eight openings in the nave had been completed, but long before work on these had been completed, plans were being discussed for another window to be presented by the IWT Old Comrades Association. Accordingly, two more openings were made in the nave and filled with plain glass pending the completion of the new memorial. This followed the same general theme as the others. The Soldier Saint, St Martin, to whom the church is dedicated, fills the top half and below is a roundel containing a medieval ship with the central figure of Christ blessing the fishermen disciples, St Peter, St John and St James on the shore of the Sea of Galilee. In the surrounding scroll are the well-known words "They that go down to the sea in ships, these see the works of the Lord". The roundel and scroll are intended to emphasise the part played by Inland Water Transport in ports and on inland waters. The badges of the various formations and armies where IWT played a prominent role are spaced throughout the window in a manner similar to the coats of arms in the other windows. This fine window was dedicated on 20 August 1950 by the Reverend H. Vaughan-Jones, KHC, Assistant Chaplain General, Southern Command, who had been Chaplain at Longmoor when the reredos was planned and who had always taken a great interest in the church.

The Rose Window

The rose window over the south (ecclesiastical west) door facing the reredos was still of plain glass, and as its replacement by stained glass would further enhance the beauty of the church, an appeal was made in 1958 to the Regular officers, serving and retired, who had ties with Longmoor. This appeal met with immediate response and Lawrence Lee was asked to prepare a design incorporating the coat of arms of the Corps. This lovely window looked like a jewel when it was unveiled on 30 September 1956 by Brigadier G. J. Bryan, CBE, Director of Transportation, and dedicated by the Reverend H. Vaughan-Jones.

The Royal Corps of Transport Window

One window in the Nave remained to be filled, and when I heard that the new Royal Corps of Transport was to be formed, I suggested to Major-General Duke, the Engineer-in-Chief, that a window representing the new Corps should be presented by the Royal Engineers and the Royal Army Service Corps. This idea has been approved by both Corps Committees, and Lawrence Lee has been asked to undertake the work.

My chief problem was to find a suitable saint to represent the new Corps, since St Christopher, the Patron Saint of Travellers, St Nicholas, the Patron Saint of Sailors, and St Martin, the Patron Saint of the Garrison Church, are already represented in the post-War windows.

Having visited Santiago de Compostela in north-west Spain in 1963, I was reminded of St James the Great, who has all the qualifications to be a Transport Saint! Before being called by Christ to be a Disciple he was a fisherman of the Sea of Galilee and so is associated with ships and inland

waters. Legend has it that he journeyed to Spain where he travelled widely preaching the Gospel, and ultimately he returned to Palestine where he was put to death. A band of his disciples took his body back to Spain by sea, and during a storm off the coast of Portugal St James rose from his marble sarcophagus and rescued a horseman who had been carried away by the high seas. St James' body was eventually enshrined in a tomb near Santiago and lost sight of until the Moors invaded that part of Spain. Then he arose once again from his tomb and, mounted on a white horse, charged the invaders at the head of the Spanish Cavalry. He so inspired them that they drove the Infidel from their country.

Following this feat of arms, St James' shrine became, after Rome, the most holy place of pilgrimage in the Christian world. A main road was built across northern Spain for the pilgrims who flocked there from the rest of Europe, whilst a fleet of ships carried thousands of English men and women to Corunna where they joined other pilgrims to the shrine. This Saint had the reputation of cherishing his pilgrims, both at his shrine and on their journeys.

Thus St James the Great, who was so closely associated with transport by land and by sea, and who has all the qualities of a valiant Christian Soldier, is undoubtedly a most suitable Saint to represent the new Corps.

His figure will appear in the top half of the new window, mounted on his white charger, rampant. The bottom half will contain the crests of the three Corps, within the compass of a wagon wheel. The supporters will be a Sapper and RASC Driver, each in full dress uniform and holding his Corps flag.

The coats of arms of the following cities and towns will be placed suitably throughout the window: London, the capital of the Commonwealth; Salisbury, Chester, York and Edinburgh, headquarters of Army Commands; Chatham, and Aldershot, the homes of the Royal Engineers and the Royal Army Service Corps respectively; Darlington, the birthplace of railways; Southampton, to represent the IWT and the seafaring connexions of both Corps.

Other Memorials

In addition to the windows, there are a number of other memorials. On 5 December 1937 a stone font, designed by Martin Travers, was placed near the south end of the church and dedicated to the memory of Sister Ann Phillips who for many years had devoted her talents and abounding energies to the Longmoor Garrison Infant Welfare Centre.

A carved and coloured Portland stone tablet commemorates all ranks of the three Great Western Supplementary Reserve Companies—Nos 151 and 152 (GW) Construction Companies and No 154 (GW) Operating Company. The inscription is embellished with the RE cap badge at the top and the Great Western coat of arms at the bottom, both in colour. On 5 December 1948 this tablet was unveiled by Master Richard Illingworth, young son of the late Lieut-Colonel V. R. Illingworth, OBE, who gave his life in Italy. The memorial was dedicated by the Reverend A. Jones, BA, KHC, the Assistant Chaplain General, Southern Command.

A tablet, similarly embellished with the RE cap badge, but of diamond shape and with the Southern Railway coat of arms at the bottom, commemorates all ranks of the Southern Railway Units—No 1 (SR) Tn Stores Group

and No 156 (SR) Tn Stores Company. This tablet was unveiled on 18 September 1949 by Mrs Chester, the widow of the late Colonel A. B. Chester, who had commanded the units during the war. It was dedicated by the Reverend G. H. Davies, MA, the Longmoor Chaplain.

A third memorial in Portland stone was unveiled on 27 May 1951 by George Rollason, Deputy Chairman of Tothill Press Limited, in memory of J. A. Kay, for many years the Editor of the Railway Gazette, who used his wide influence to encourage the work of RE Transportation and did much to stimulate interest in the church and its memorials. This is a unique memorial in a Garrison Church, and it was the result of a joint appeal by the Commandant and all the ex-Commandants of the Transportation Centre and the Railway Training Centre who had been associated with the Supplementary and Army Emergency Reserve units since 1923.

Other memorials are two bronze tablets mounted in a gilded frame to the memory of the officers and men of the 755 and 763 Railway Shop Battalions of the Transportation Corps, United States Army. Each tablet is emblazoned with the US Transportation Corps badge flanked by the Union Jack and the Stars and Stripes.

Memorial windows and tablets have not been the only gifts to the church. In recent years the chairs in the nave have gradually been replaced by oak pews made in the Longmoor Workshops and presented by units, organizations and individuals who have shown their interest and love of St Martin's Church in this practical way. A list of the donors is given at the end of this article. Noteworthy amongst them are the Royal Artillery, who presented a pew with their crest carved on it, as a reminder of their close association with the church during the years between the two World Wars. The Guild of St Helena has presented a number of pews, and another was presented by Mrs Hill in memory of her husband, Mr W. Hill, who was for many years the chief draughtsman at the Railway Training Centre HQ, and who took a great interest in the church and its memorials.

The Rededication

The 25 April 1964 saw the culmination of another stage in the transformation of the church from its humble origin. On that day a service was held to dedicate further improvements, renovations and gifts. The north side of the chancel has been enclosed to match the south side, but the chief feature is the beautiful effect created by the new lighting.

The designs were prepared by a team of Sappers, both serving and retired, at Southern Command Headquarters. The architectural alterations were designed by Major (retd) P. Haine, MBE, ARIBA, assisted by Captain (retd) C. O'Farrell, ARIBA, and the lighting by Lieut-Colonel J. C. Court, RE, the M & E Planning Engineer, assisted by Mr A. Ibbitt, an old Longmoor Sapper who had taken a personal interest in the church during the war. The lighting is of particular interest. A honeycomb ceiling has been placed over the chancel with fluorescent tubes above it, whilst floodlights illuminate the reredos. The lights in the nave have been replaced by others carried on wooden replicas of locomotive driving wheels, made in the Railway Workshops. The whole church has been redecorated in cream and pale blue, and the parquet floor has been sanded and polished so that it is a joy to see, and emphasises the loving care bestowed on this church.

The gifts included a pew presented by Lieut-Colonel D. C. Merry,

Officer Commanding the 16th Railway Regiment, RE, from 1956 to 1958, and Mrs Merry; a pair of silver altar candlesticks, presented by Brigadier F. H. Lowman, DSO, MBE, the Commandant, and Mrs Lowman; a new altar cloth and frontal, and a Priest's prayer book.

The Venerable Archdeacon I. D. Neill, CB, OBE, the Chaplain General to the Forces, performed the dedication ceremony in the presence of Major-General G. W. Duke, CBE, DSO, the Engineer-in-Chief, and a large congregation, including past and present Commandants and Commanding Officers of RE Transportation Units, and retired Regular and Reserve officers.

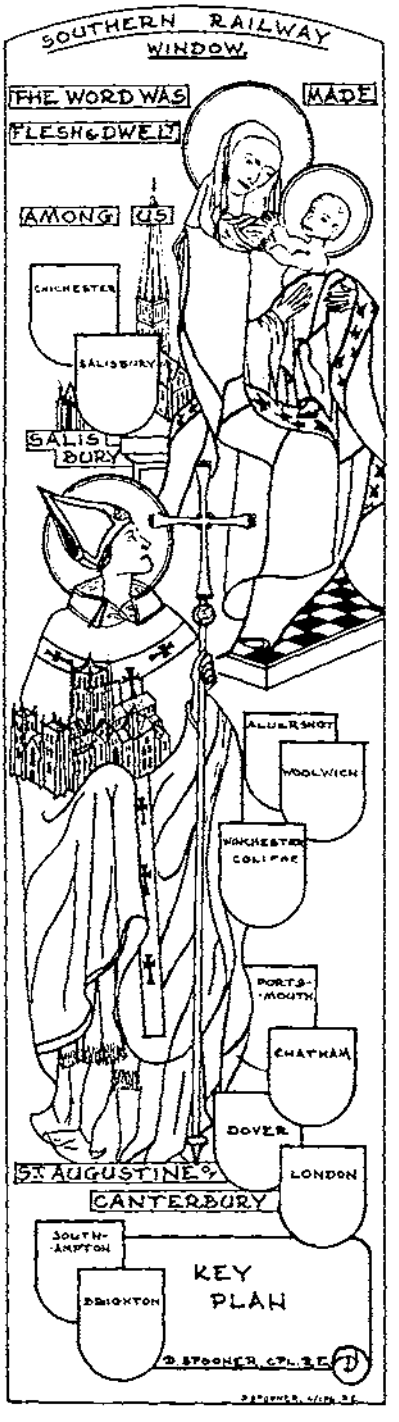
Conclusion

This account of the Longmoor memorials is no substitute for a visit to the church. Although no claim is made for ancient lineage or striking architecture, the reredos is an outstanding example of ecclesiastical art, and there can be few collections of modern stained glass to equal the memorial windows, and none with such unique associations.

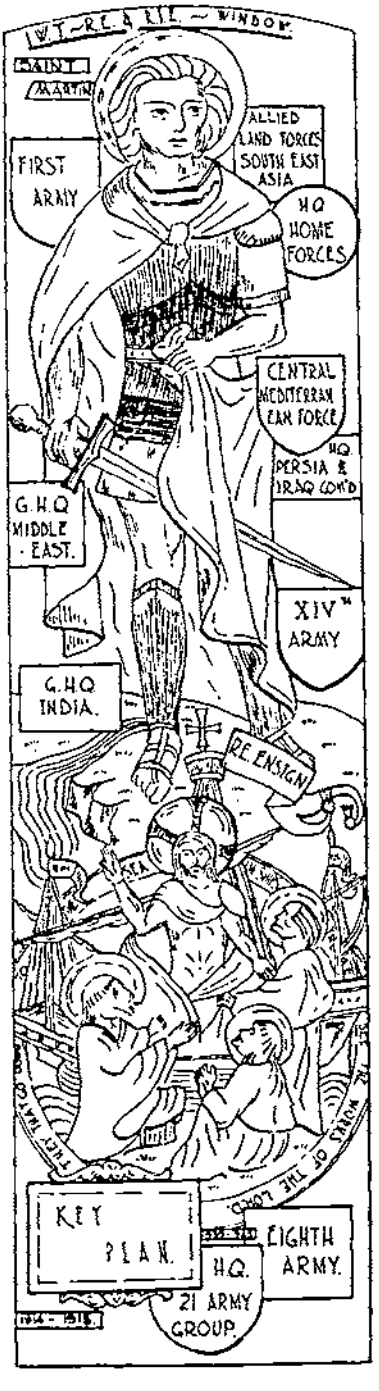
Over one hundred crests and coats of arms present a notable heraldic display; the linking of Saints with military and technical Services will interest alike soldier and civilian, artist and layman, whilst the reredos with its arresting figure of the Risen Christ is a challenge to all who worship at St Martin's Garrison Church.

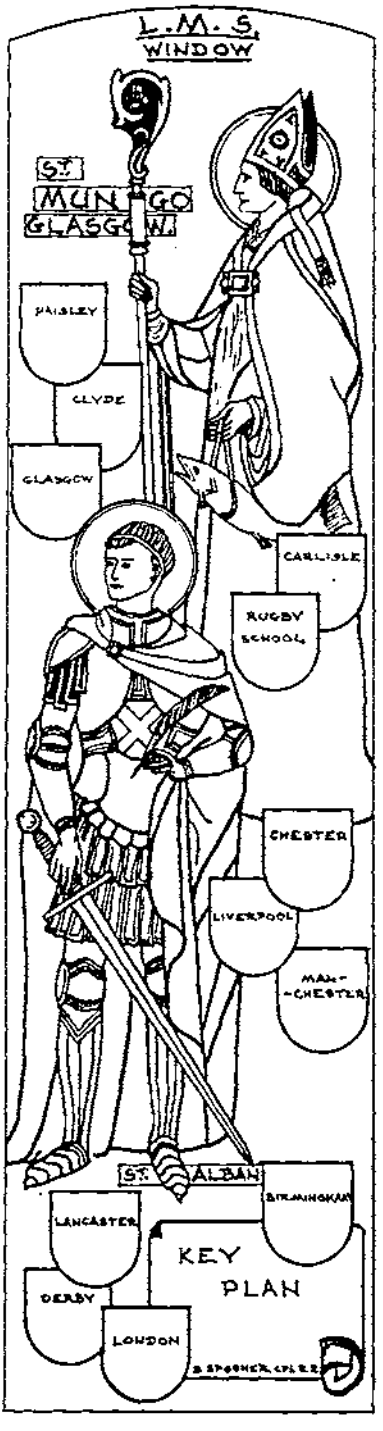
List of Donors of Oak Pews to St Martin's Garrison Church, Longmoor

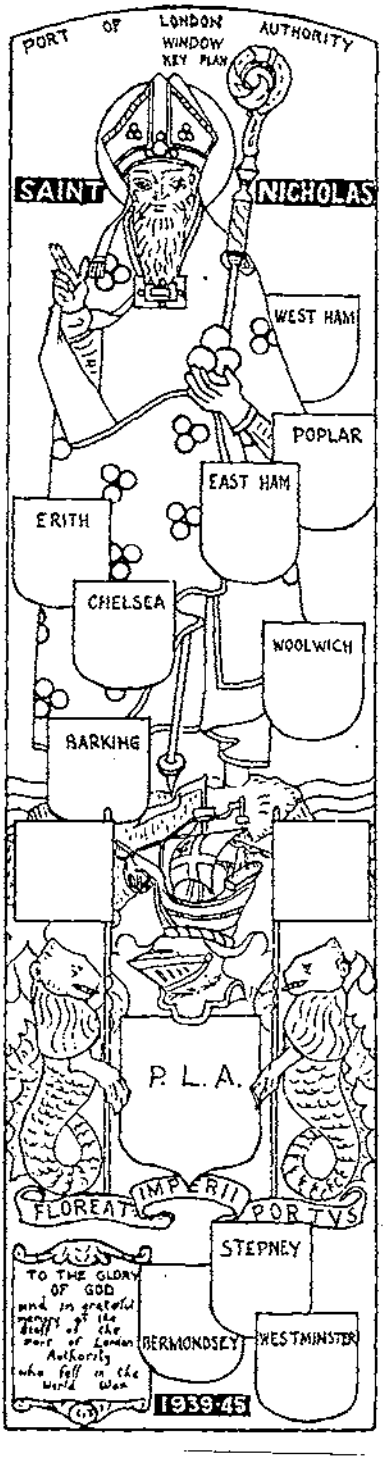
Name	*Year of Presentation*
No 2 Engineer Stores Depot and Workshops and No 5 Engineer Stores Depot	1957
Army Emergency Reserve (Engineer Resources)	1957
No 16 Railway Training Regiment	1958
Lieut-Colonel and Mrs E. Woodhouse	1958
Major and Mrs E. D. Sheppard	1958
No 2, No 9, and No 15 MC Groups RE (AER)	1959
"Southern" Friends of Longmoor	1959
"Southern" Friends of Longmoor	1960
Brigadier and Mrs L. Manton	1959
Guild of St Helena	1959
Guild of St Helena	1960
Guild of St Helena (2 pews)	1961
Lieut-Colonel R. C. Gabriel, RE	1959
No 155 Railway Sqn RE (AER)	1960
No 155 Railway Sqn RE (AER)	1961
Mrs A. Hill in memory of Mr W. Hill	1960
No 152 Railway Construction Company RE (SR) in memory of W. J. Scott and R. G. M. Matthews (Brother Officers)	1960
No 15 and No 18 MC Groups RE (AER)	1960
Longmoor Branch of Royal Engineers Association	1960
Royal Artillery 1920–39	1960
No 136 Construction Regiment RE (AER)	1961
No 1 Railway Group RE	1961
Lieut-Colonel and Mrs D. C. Merry	1962
Lieut-Colonel and Mrs B. G. Jones	1964

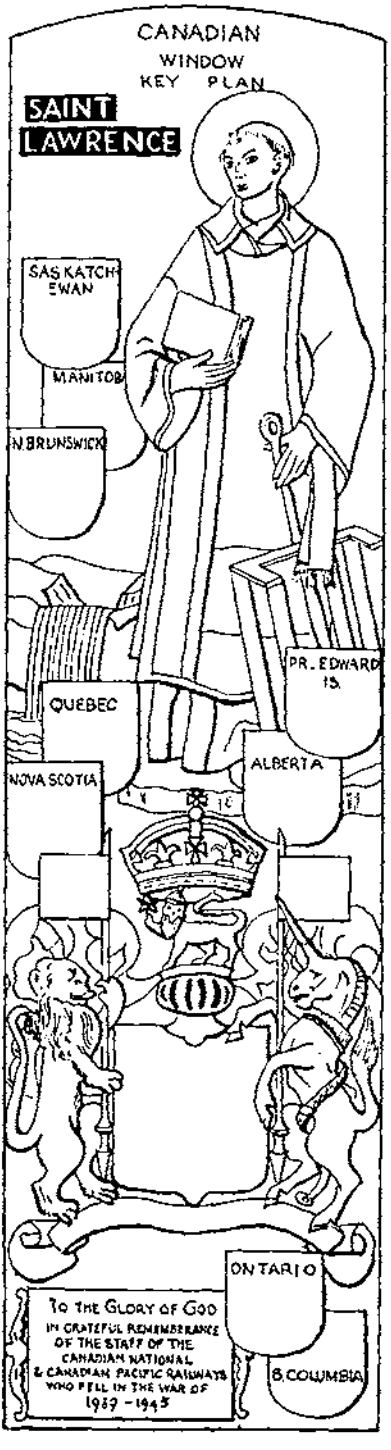

SOUTHERN RAILWAY
WINDOW
THE WORD WAS
MADE
FLESH & DWELT
AMONG
US
CHICHESTER
SALISBURY
SALIS
BURY
ALDERSHOT
WOOLWICH
WINCHESTER
COLLEGE
PORTS-
MOUTH
CHATHAM
DOVER
LONDON
ST AUGUSTINE'S
CANTERBURY
SOUTH-
AMPTON
BRIGHTON
KEY
PLAN
D. SPOONER, CPL. R.E.

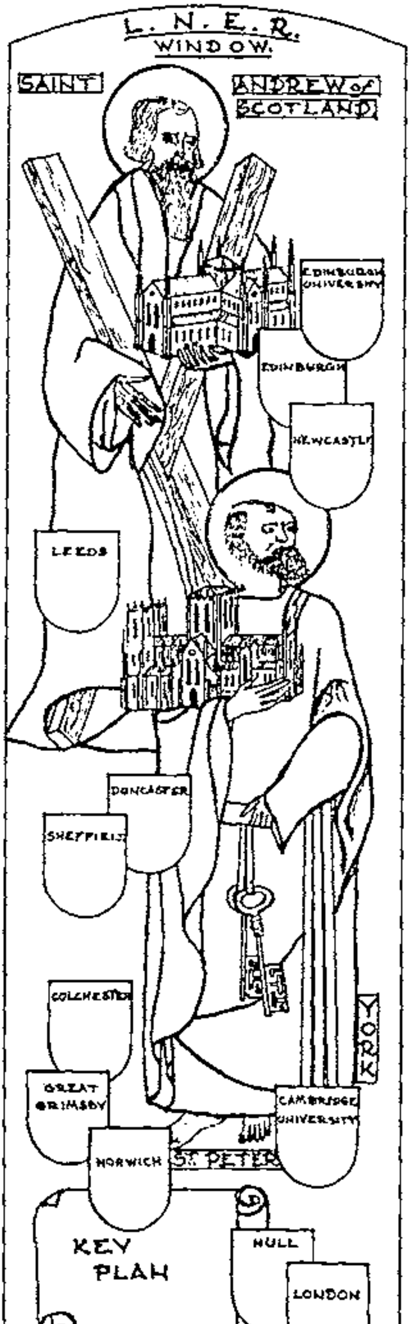

G.W.R.
WINDOW
ST DAVID OF
WALES
EXETER
MERTHYR
TYDFIL
CARDIFF
SHREWSBURY
PLYMOUTH
ABINGDON
DEVONPORT
BRISTOL
OXFORD
UNIVER-
SITY
ST
GEORGE
GLOUCESTER
LONDON
SWINDON
KEY
PLAN
D. SPOONER. CPL. R.E.

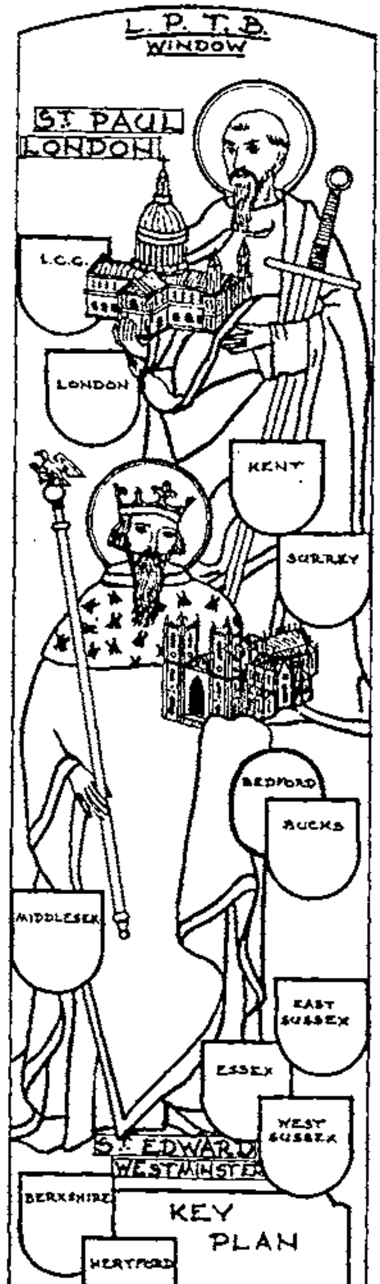

W.T.-R.C. & R.E. — WINDOW
SAINT MARTIN
FIRST ARMY
ALLIED LAND FORCES SOUTH EAST ASIA
H.Q. HOME FORCES
CENTRAL MEDITERRANEAN FORCE
H.Q. PERSIA & IRAQ COM'D
G.H.Q. MIDDLE EAST.
XIV TH ARMY
G.H.Q. INDIA.
RE ENSIGN
KEY PLAN
EIGHTH ARMY.
H.Q. 21 ARMY GROUP.


L.M.S. WINDOW
ST. MUNGO GLASGOW
PAISLEY
CLYDE
GLASGOW
CARLISLE
RUGBY SCHOOL
CHESTER
LIVERPOOL
MANCHESTER
ST. ALBAN
BIRMINGHAM
LANCASTER
DERBY
LONDON
KEY PLAN


PORT OF LONDON AUTHORITY
WINDOW KEY PLAN
SAINT NICHOLAS
WEST HAM
POPLAR
EAST HAM
ERITH
CHELSEA
WOOLWICH
BARKING
P. L. A.
FLOREAT IMPERII PORTVS
STEPNEY
TO THE GLORY OF GOD and in grateful memory of the Staff of the Port of London Authority who fell in the World War
BERMONDSEY
WESTMINSTER
1939 45


CANADIAN
WINDOW
KEY PLAN
SAINT LAWRENCE
SAS KATCH EWAN
MANITOB
N BRUNSWICK
PR. EDWARD IS.
QUEBEC
ALBERTA
NOVA SCOTIA
ONTARIO
B COLUMBIA
TO THE GLORY OF GOD
IN GRATEFUL REMEMBERANCE OF THE STAFF OF THE CANADIAN NATIONAL & CANADIAN PACIFIC RAILWAYS WHO FELL IN THE WAR OF 1939 - 1945


L. N. E. R.
WINDOW.
SAINT
ANDREW of
SCOTLAND
EDINBURGH UNIVERSITY
EDINBURGH
NEWCASTLE
LEEDS
DONCASTER
SHEFFIEL
COLCHESTER
YORK
GREAT GRIMSBY
CAMBRIDGE UNIVERSITY
NORWICH
ST PETER
KEY PLAN
HULL
LONDON
D. SPOONER. CPL. R.E.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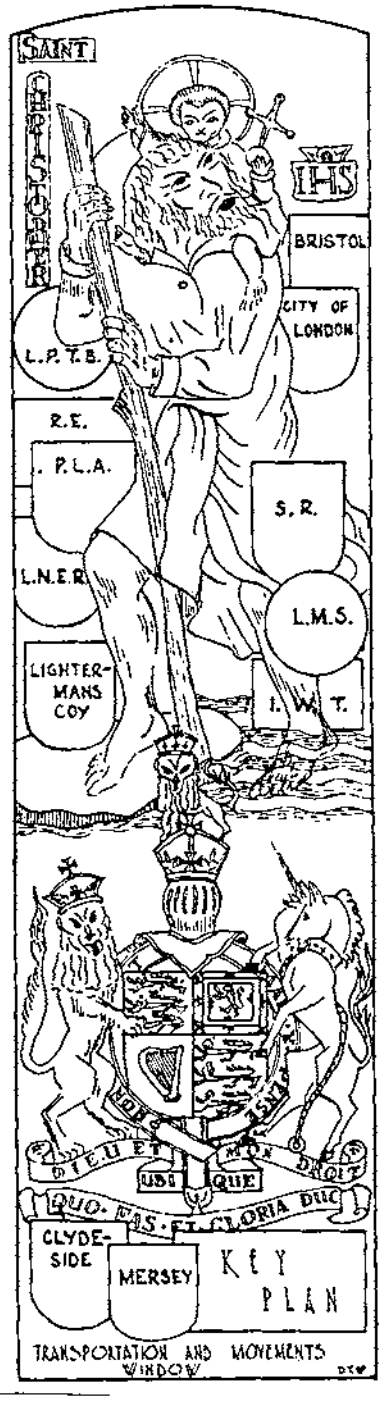
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DIEU ET MON DROIT
QUO FAS ET GLORIA DUC
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MERSEY
KEY PLAN
TRANSPORTATION AND MOVEMENTS WINDOW

Correspondence

Brigadier Sir Mark Henniker, BC, CBE, DSO, MC, DL
Pistyll,
Began Road,
St Mellons,
Near Cardiff.

The Editor,
RE Journal

2 January 1965

MAN MANAGEMENT

Dear Sir,

Many readers must have been interested in the two excellent articles on Man-Management that appeared in recent editions of the *Journal*.

Having always been fascinated by the subject, I once discussed it with an elderly Chinaman, a banker by profession but a philosopher by inclination. "If you wish to learn about managing your fellow men," he said, "you must first learn to manage yourself, and your wife, and your family; and gradually extend your orbit till it encompasses all mankind. You will be much assisted by studying the works of Confucious. If you are diligent you may make some progress in a lifetime."

Had the banker been a Jew he might have recommended the Old Testament; for that is a tale of leaderships, telling how the people were led from the land of Egypt and how the leaders coped with frightful difficulties. It tells of the works and the sayings of judges, Kings and prophets over many centuries. The Old Testament is laden with wisdom; dealing, as it does, almost entirely with the management of men and their affairs.

The Ten Commandments are a guide to life. Six of them deal with man's dealings with his fellow men; one is a guide to work and leisure; only three deal with man's relation to God. The application of these rules is continually illustrated by picturesque historical examples. It is a great book on man management.

Similarly, The New Testament is a tale of leadership: how a carpenter's son so influenced men that His name will never be forgotten. He epitomised man's relation to man in one famous sentence and illustrated it abundantly.

In the best British "way of life" much of this doctrine has become enshrined in what we call "Good Manners". Schools and colleges have been founded since ancient days to teach their pupils—amongst other things—good manners. They inculcated good manners in many ways; but academically they founded the work on two pillars: a study of the Bible and a study of the writings of ancient Greece and Rome. The Bible, as we have seen, is full of teaching on manners and the management of men; and the classics abound in accounts of human affairs. Neither offers much advice upon *things*. (Xenophon, a popular scourge for Middle School dunces, is particularly suitable for military cadets; for he was an accomplished regimental officer and a fine leader.)

Perhaps our fathers did not always practice what they were taught; but those who aspaired to even elementary education were bound to receive instruction from these two prime sources of wisdom. Though much may have been forgotten, a lot must have struck—both consciously and sub-consciously.

Today, however, you can win the highest honours without opening the Bible and without two words of Greek or Latin. This, I submit, is dangerous in the education of military leaders; for man is a principal weapon of war; and it ill become the leaders of men to neglect the best text-books. They should be studied still; and if the teachers say "Sorry, old boy. There's no time for that sort of thing today", I refer them to Deuteronomy V, verse 13. "Six days shalt thou labour . . ." No mention of a five day week.

Yours sincerely
Mark Henniker,
Brigadier (retired)

Redesdale,
Broomleaf Corner,
Farnham,
Surrey.

The Editor
RE JOURNAL

15 January 1965

MAN MANAGEMENT

Dear Sir,

After the publication last February of "The Art of Leadership" by Captain Roskill of the Royal Navy it was fitting that the Army should respond, and I pay tribute to Colonel G. H. Pannett for his article in the December edition of *The Royal Engineers Journal*.

May I suggest that squadron morale is maintained by attention to the following points:-

(*a*) Discipline. The state of discipline as between NCO and man is, in my experience decisive. Where NCO's are well supported, and guided as necessary, discipline is good.

(*b*) Confidence in the leaders. Good leadership is good bearing, general effectiveness, and fairmindedness in officers and senior NCO's, together with planning and initiative within the squadron's general programme of activities. These qualities easily rule the men and bring out the best in them.

(*c*) Team spirit. For strength and vitality in a squdron, as in a football team, self-effacement (or modesty) is a quality to be marked down, encouraged, and made use of. Sportsmanlike competition is needful, but jealousy is poison to morale.

(*d*) Good training. This is the squadron's approach to war, and morale requires that it should be well prepared, with sustained interest and even a little entertainment for everyone.

(*e*) Plenty of work is good for the sapper, and most of them like it. This too makes for morale.

Yours faithfully,
K. B. S. CRAWFORD, Brigadier (retd)

Major N. R. STURT, RE,
Engineer Planning School,
RSME Chatham.

The Editor
RE Journal

15 January 1965

THE CRITICAL PATH METHOD

Dear Sir,

The latest—and longest—of the series of articles on the Critical Path Method, contributed by Lieut-Colonel Hasildon and published in the December 1964 issue, prompts me to add a few words of correction and amplification. The need for me to do this arises more from the passage of time than from any shortcomings in this very interesting article.

At the same time that Lieut-Colonel Hasildon was writing his article, the RSME pamphlet was being completely re-written; the new edition, 'Engineer Planning and Organization of Work 1964' appeared in September complete with a red cover to distinguish it from its senoir colleagues the Blue, Green and Orange Books. The party line has now developed into a fairly middle-of-the-road position, which I think Lieut-Colonel Hasildon will find an improvement. The author of the previous CPM article, Colonel Baines, has been kind enough to give the new Red Book his blessing.

To take Lieut-Colonel Hasildon's first point: the nomenclature is still rather confused, although most of the terms are self evident. We now do not use the word 'job', but say 'activity', for the reasons he puts forward. But we do still say 'event' rather than 'node'; general usage seems to be heading the same way. Interfering and independent float, admittedly of limited use but occasionally relevant, have been relegated to an annex.

Of more importance is the matter of the bar chart versus the arrow diagram drawn to a time scale. We think that each has its uses, and the Red Book suggests that for civil engineering and large construction projects the plan is best transferred from the arrow diagram to a bar chart for controlling and progressing the project. However, by using mainly horizontal arrows and by zoning geographically or by areas of responsibility, the arrow diagram drawn to a time scale can be made very much more understandable than the example in Major Johnson's article was. The use of colours and abbreviated activity title further improve the clarity and usefulness of this method, which is still the one we recommend for most purposes.

Issue is taken with Lieut-Colonel Hasildon over the comparative merits of calculation by tabulation or on the diagram. The critical path can be identified, and all the necessary information for drawing to a time scale can be gained, by calculating only the earliest time that each event can occur. This can be done accurately for networks of several hundred activities with little difficulty on the diagram itself. It is indeed a very much easier step than drawing the diagram in the first place, and is done to a simple drill. As soon as these earliest event times have been calculated (if done by the method given in the Red Book) the Critical Path can be identified, again by a simple drill. It is at this stage that the critical activities should first be considered for shortening, as they and the project duration are now known; there does not seem to be any point in first drawing a bar chart and then changing it.

One other point that is worth raising is that the palaver of numbering events of nodes is entirely unnecessary unless the planner is then going to resort to tabulation, matrix solutions, computers or the type of bar chart given in the article. This means that if the calculations are done on the diagram, and the result given as a simple bar chart or an arrow diagram to a time scale, many dummies, all event numbers and the node circles can be omitted. In any case, I believe that all the computers now on the market can deal with networks that have random numbering; it is merely a matter of having the appropriate computer programme.

It is very encouraging to see the *Journal* publishing these interesting articles. The wide variety of methods of using CPM will have struck every reader; which one is adopted is less important than that a real effort is made to plan in a systematic way to suit the individual planner and project.

Yours faithfully,

N. R. STURT

Colonel R. F. Pratt (Retd),
Ministry of Public Building & Works,
Western Mediterranean Region,
New Mole Parade,
Gibraltar.

The Editor,
RE Journal

26 October 1964

GIBRALTAR

Dear Sir,

"Engineer House", for so long a symbol of the Sapper connection with the Rock, will soon pass out of MOD (Army) ownership. It may well be pulled down to make way for some of the re-building of the City of Gibraltar.

As a retired Sapper, I was priveleged to be the last "Head of Establishment" in this rather quaint office block. Tradition presumably kept us there till the bitter end although by modern standards it was far from ideal.

In 1959 the RE Works Services were "Civilianised" in Gibraltar and I was posted as Command Works Officer in March 1963, as a relief to Mr McInnes, the first CWO.

On 1 April 1963 the MPBW took over and for a time I called myself Chief Works Officer (Army Works).

In November 1963 we moved out so that the Command Land Agent could prepare the old place for disposal.

Only recently, however, have we managed to remove the "Foundation Stone" of the building. I formally handed it over to Major Quentin Bowker RE, as the senior serving RE officer on the Rock at the time. I enclose some last photographs of this occasion.

The stone is now in the safe keeping of 1st Fortress Squadron RE who are all that are left of a once numerous Sapper element in the Garrison.

Yours faithfully,

R. F. PRATT

P.S.

At the request of the Secretary of the Institution, I am adding this postscript to my letter of 26 October, referring to the Rock Model which has been in Engineer House for a very long time.

The model is now regarded as the property of Fortress Headquarters, but is kept up to date on the strength of 1st Fortress Squadron RE. The accompanying photograph shows the present incumbent of the post, L/Cpl Clarke, with elbow steadied by "Mediterranean Road" and "Fire Control South", putting the finishing touches to "Windmill Hill Barracks". Unfortunately the contractor has not made nearly such good progress. The radio masts on Windmill Hill do not exist either. They were "erected" on orders of the Deputy Fortress Commander to illustrate proposals under discussion at the time. They have evidently not been "dismantled".

The above two examples show that the model is kept as the progress chart of the Rock and is used a great deal for briefing visiting VIPs.

The model will remain in the stable block of Engineer House until the new Fortress Headquarters is built on top of Rosia Casemates. A model room is planned in this new building and the transport of the model to its new abode will be an interesting operation. No doubt this will be reported in due course. The model is constructed to a scale of 50 ft to 1 inch from a survey made by Lieut Warren RE in 1865 (later General Sir Charles Warren, GCMG, KCB, FRS, Colonel Commandant, RE). It measures 30′ × 12′ × 2′ 6″ at "sea level" and its substructive is something like a billiard table. We think it splits into ten sections but there has been quite a lot of recent "building" over the joints. Even so the parts will be heavy and awkward to handle. The end wall of the building, one window of which is seen in the photograph, may have to have a large hole made in it and the pieces lowered some fifteen feet on to a vehicle in Engineer Lane, one of the narrowest thoroughfares in the City.

R. F. PRATT

Photo 1. The Foundation Stone in its original position

Photo 2. Handing over the Foundation Stone

Correspondence 1,2

Photo 3. The Rock Model

Correspondence 3

The following letter has been received from Havildar Clerk Ghulam Sarwar, late Royal Bombay Sappers and Miners.

He has been sent a copy of Colonel Sandes' History of the Indian Engineers 1939–45.

Village Darwish,
Haripur District,
West Pakistan.
13 December 1964

RE Journal

Sir,

I am sending you this letter with the request that kindly convey my Christmas and New Year's Greetings to all RE Officers serving and retired generally and those who served in the Royal Bombay Sappers and Miners Kirkee, Poona, India especially. I am an ex-Service man and served in the above Corps between 1923 and 1946 as a Clerk. During last World War I was serving in the 21st Fd Coy RBS & M under Major G. E. H. Philbrick but unfortunately when this unit proceeded overseas I could not accompany it. Later on I went to Far East in the 9th Ind Div Engineers with the following officers:- Major T. H. Lindesay, Captain A. P. Smith, Captain H. W. Hamilton, Lt Pyne and Lt Carter-Clout D. G. If the addresses of any of these officers are known to you kindly convey my greetings of Christmas and the New Year to them by name. I am now 59 and employed in a civil job and pass my time alright. However I remember the days spent with British Officers in my service. During long nights of winter when I am with my family members I tell to my grand-children the stories of love and kindness the British Officers and their wives extended to soldiers. I also know too H. P. Cavendish, P. L. Kirwan and P. G. Hatch. They were Adjutants. At present I am not in touch with English literature. I like if I could get some books written by some generals on World War II and Malay War especially as I was prisoner of war in the hands of Japs, from 15/2/41 to 17/8/45. I was in Thai Land when I heard that the Japs had surrendered. One day a major and a sergeant landed in Thai Land by parachute. We were very glad to see two white faces there in the jungle. With best wishes,

Yours sincerely,
10418 Hav Clerk Ghulam Sarwar

Memoirs

BRIGADIER A. T. SHAKESPEAR, DSO, MC

ALBERT TALBOT SHAKESPEAR was born on 15 September 1884, the son of Lieut-Colonel A. B. Shakespear, Royal Marine Artillery. He was educated at Cheltenham and the Royal Military Academy, Woolwich. He was commissioned into the Royal Engineers in December 1903.

After his young officer training at Chatham he served in Ireland with a field company in the Curragh. His first overseas tour was spent as a company officer in the 24th (Fortress) Company in Malta. On returning to the home establishment in 1911 he became an instructor at the Royal Military Academy, Woolwich where he remained until the outbreak of war in August 1914 when he was posted to the British Expeditionary Force.

Except for five months in 1915, recovering from wounds, he served continuously throughout the entire war on the Western Front. He was a subaltern officer in the 2nd Divisional RE during the retreat from Mons. In November 1914, during the First Battle of Ypres, when his unit was engaged in fighting in an infantry role, he assumed the temporary command of the 11th Field Company—all officers of the company senior to him having become casualties. Shortly afterwards he was transferred to take temporary command of the 5th Field Company which had also sustained heavy losses. During the Battle of the Somme he commanded the 142nd Army Troops Company, and later the 126th Field Company. During the latter part of 1917 and the early months of 1918 he served on the staff of the Chief Engineer Corps. He then became successively CRE 42nd Division and CRE 12th Division during the final advance to victory.

For his war service he was awarded the DSO and the MC, and he was mentioned in despatches. The authors of Volume V of the History of the Corps of Royal Engineers, which deals with operations on the Western Front, sought his help in the compilation of the volume and drew on his wide experiences of the fighting in France and Flanders, ranging from those of a Field Company Subaltern to those of a Divisional CRE, together with those of an Engineer Staff Officer.

After a tour of duty as a Grade I Staff Officer dealing with the disposal of surplus military stores in France he returned home in July 1920 and reverted to his substantive rank of captain. After completing two staff appointments at the SME, as Assistant to the Brigade Major and as Staff Captain A, he qualified for the Staff College.

On graduating from Camberley he became Staff Captain at Fortress Headquarters Gibraltar and two years later a second staff appointment followed—that of DAA and QMG 46th (North Midland) Division TA at Derby. In April 1926 he was given command of the 9th Field Company, then stationed at Shornecliffe.

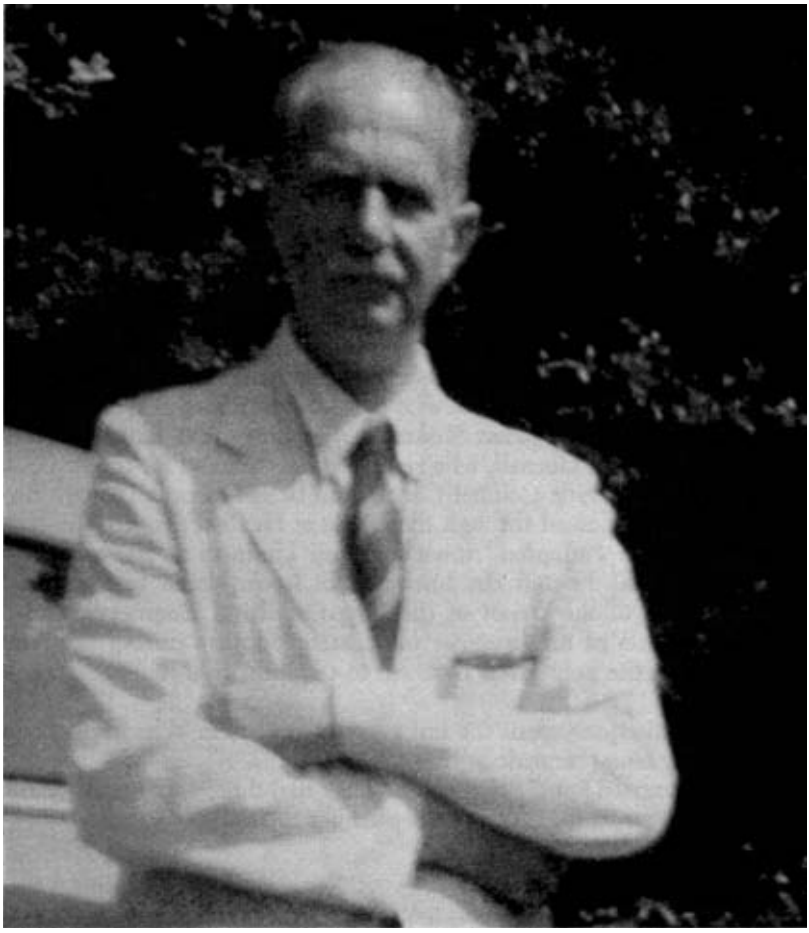
Posted overseas in the second half of the 1929 trooping season he became CRE Changi, Singapore and the following year he was posted from Malaya to Egypt where he became CRE Cairo with his headquarters at Abbassia. He returned to the home establishments towards the end of 1933 and the following year he attended the Senior Officers' War Course at the Royal Naval College, Greenwich before returning once more to Malaya where he became AA and QMG, at that time a Brigadier's appointment. He retired on 23 October 1937.

After retirement he became the Air Raid Precaution Organizer for Richmond (Surrey) and on the outbreak of war in September 1939 he was re-employed firstly as AA and QMG at Fortress Headquarters, Gibraltar and then as Commandant the RE Depot. This unit had expanded greatly on the outbreak of war and, due to lack of serious battle casualties during the early months of hostilities, men were held there for a considerable time. As a result the depot had built up to a headquarters and two battalions. The heavy bombing of the Medway area during the latter part of 1940 necessitated a move from Chatham and Brigadier Shakespear was ordered by the War Office to find accommodation at Halifax and move the depot there. The move was made in February 1941 and, despite many initial administrative problems, the Depot was eventually happily installed and a warm friendship established with the people of the town, so much so that at Christmas 1942 there was hardly a man in the depot who was not entertained at a private house.

The following year Brigadier Shakespear, then aged 60, handed over the Depot to Colonel J. M. Gornall, who remained in command for the rest of the war. At a VE Day Parade Colonel Gornall, on behalf of over 100,000 Royal Engineers who had passed through the Depot at Halifax, thanked the Mayor and people of their "adopted" town for their kindness and help, and the Major expressed the honour the town felt in having been selected as the war-time location of the Depot of the Corps of Royal Engineers, and the town's appreciation of the presence of so many Sappers during the fateful years of war and the help given by them to the local civil defence organizations.

Brigadier Shakespear spent the last years of his life in Winchester, bowls and bee-keeping being his main hobbies.

In 1909 he married Sophie Eyndoven. They had three daughters. He died, in his eightieth year, at his home on 5 September 1964.



Brigadier KD Yearsley MC

BRIGADIER K. D. YEARSLEY, MC

BRIGADIER KENNETH DARLESTON YEARSLEY, one time Chief Engineer West Riding District, died on 8 January 1965. He was in his seventy-fourth year.

The son of The Rev R. Q. Yearsley of Sutton Bonnington, Loughborough, he was educated at Dover College and the RMA, Woolwich. He was commissioned into the Royal Engineers on 23 December 1910.

After his Chatham training he served in various Military Works Services appointments in India before being posted to Mesopotamia in 1915.

At the beginning of December 1915 he arrived in Kut el Amara where he was employed as an Assistant Field Engineer. As the siege of Kut developed the Indian Sapper and Miner Companies suffered heavy casualties and on 22 December Yearsley was placed in command of 17th Company 3rd (Bombay) Sappers and Miners in which unit only one British officer remained. His company was heavily engaged in the Turkish attack delivered on Christmas Eve.

After the fall of Kut Yearsley was sent to a Prisoner of War Camp at Changri where he was a leading figure in organizing the construction of a tunnel through which a mass escape was planned. He was, however, transferred to Yozgad before the escape attempt could be made. Refusing to give his word not to try to escape again, he suffered the deprivations and discomforts of that camp until the mass escape of 7 August 1918. He was a leading spirit in the organization and execution of the escape in which twenty-five officers got away and, after travelling overland for thirty-six days and using a stolen motor boat, eventually reached Cyprus. On returning to England Yearsley and some of his companions of the escape were received by the King. He was awarded the MC and mentioned in despatches for his work in the defence of Kut, and he was awarded a bar to his MC for "gallant conduct and determination displayed in escaping from captivity".

Together with Captain Johnston (now Brigadier M. A. B. Johnston, DSO, MC, late RA rtd), he wrote an account of the escape in a book entitled *450 miles to Freedom.*

After a period of sick leave he returned to India in 1920 and rejoined the Military Works Service. Two years later he was posted to the War Office where he served in the Department of the Director of Fortifications and Works.

After a four year tour at the War Office he was posted to Aldershot where, on being promoted substantive major, he was given command of the 38th Field Company. His next appointment was that of DCRE Malta, and when he completed that overseas tour he joined the 1st AA Battalion RE at Blackdown where he became officer commanding A Company.

He was promoted Lieut-Colonel in October 1934 and appointed CRE Salisbury Plain. In 1937 he was made CRE New Construction, Larkhill. In October 1938 he was awarded a brevet colonelcy, back dated one year, and, as a temporary Brigadier, he was placed in command of 43 AA Group TA whose headquarters were at Darlington. In 1941 he was given command of 57 AA Brigade. On the run down of AA Command after the Battle of Britain he became Deputy Chief Engineer, Southern Command. In 1944 he was made Chief Engineer, West Riding District, his last appointment. He retired in July 1946.

He married Norah Rose, daughter of H. P. H. Webb Esq, of Brighton in 1924. They had two sons and two daughters.

COLONEL C. F. BIRNEY, DSO

CHARLES FOLLIOTT BIRNEY, Director General of Transportation, British Army of the Rhine after the First World War died at his home Millfields House, Rusper on 27 December 1964 a few days after his eighty-sixth birthday.

The son of Colonel John Birney, also a Royal Engineer, he was educated at Marlborough and the RMA, Woolwich. He was commissioned into the Corps on 23 June 1898 and whilst at Chatham he won the Fowke Silver Medal, in those days a prize for architecture.

After his Young Officer courses he was posted to India where after a short time in the Military Works Service at Mhow he was posted to the 3rd Company Bombay Sapper and Miners at Quetta. He stayed with that unit until the end of 1901 when he was seconded to the Bengal State Railways at Calcutta —the start of a long and distinguished connexion with "Transportation". Early in 1903 he became an Assistant Engineer (Railways) at Sealdah.

He was later in the year recalled from the Bengal State Railways to join the 12th Company Madras Sappers and Miners which formed part of the military escort force, commanded by Brigadier J. R. L. Macdonald (late RE), that accompanied Younghusband on his celebrated Mission to Tibet through Sikkim. Birney was put in charge of one of the demolition parties for the attack on Gyantse Jong on 6 July 1904 during the opposed advance on Lhasa.

On the return of the Mission Birney went back to railway employment and was engaged on work connected with the Thall-Parachinar railway survey in the North West Provinces. Throughout 1905 he was employed with the North Western Railway at Lahore and after two other short appointments he became, in 1908, Assistant Secretary to the Railway Board at Simla. Further promotion and more varied appointments followed and in 1913 he was selected as Assistant General Manager, North Western Railways.

Recalled for military service on the outbreak of the 1914–18 War he accompanied the Indian Expeditionary Force to the Western Front where he took part in the costly fighting at Neuve Chapelle, commanding for a time the 20th Company Bombay Sappers and Miners which had suffered serious battle casualties. Shortly afterwards he was appointed DAQMG in the Directorate of Railway Transport. A year later he was made Deputy Director of Transportation, British Expeditionary Force and in March 1918 he became Deputy Director of Railway Traffic. For his war services he was five times mentioned in despatches and awarded the DSO. He was also made a Chevalier Legion d'Honneur.

At the conclusion of hostilities he was appointed Director-General of Transportation, British Army of the Rhine with the temporary rank of Brigadier-General.

In August 1919 he was seconded to the Rhodesian Railways as General Manager with his headquarters at Bulawayo. He retired from the active list on 18 October 1924.

After retirement he served for many years on the Horsham District Council. He also took a keen personal interest in the Boy Scout movement. He was District Commissioner for the Horsham and District Boy Scouts for several years. He was a holder of the Silver Wolf award in recognition of his services to scouting, and until his death he was a member of the Committee of the National Council of Boy Scouts Associations.

On 27 September 1910 he married Dorothy, elder daughter of Lieut-Colonel J. T. W. Leslie, CIE, IMS. They had two sons. The elder son, Lieut David Birney, served with the London Rifle Brigade and won the coveted King's Prize at Bisley. He was killed when serving with the Commandos at St Lazare.

Among the many who attended Colonel Birney's funeral at Rusper on 31 December was Lord Hawke, President of the Horsham and District Boy Scouts Association. The service was conducted by the Rev J. C. Waters, assisted by the Rev Dr Davies, former Dean of Worcester and Colonel Birney's brother-in-law.

Book Reviews

HISTORY OF THE SECOND WORLD WAR
GRAND STRATEGY VOLUME III, PART I AND PART II

By L. M. A. Gwyer and J. R. M. Butler

(Published by HMSO. Price £4 4s 0d)

This volume of the official history of the Second World War, divided into two parts, covers the crucial period from June 1941 to August 1942, the beginning of the end, when the initiative in the conduct of the war shifted decisively from the Axis to the Allies. Mr J. M. A. Gwyer is the author of Part I, covering 1941 and Sir James Butler, the general editor of the series, wrote Part II dealing with the grand strategy of 1942.

Although in their preface the authors state that the history covers the period of war when for the first time the means of victory in men and materials became assured to the Allies, many serious reverses were suffered in 1941 before the fortunes of war dramatically turned during the following year.

Hitler's invasion caught Russia quite unprepared, despite convincing British warnings. Its initial spectacular successes in June 1941 led to the general belief that the Wehrmacht would go through Russia like a dose of salts. By August 1942 the German Armies had been halted, the Stalingrad disaster was impending and they had failed to secure the South Russian oilfields. Stalin's incessant and obdurate demands for a Second Front posed the most contentious strategic problem.

The fighting in the Middle East, despite its fluctuating fortunes in 1941 and 1942, did in its way provide a Second Front in that it drew off numerous German divisions to the Mediterranean to face ultimate complete defeat, and the threat of an invasion at any point on the mainland of Europe led to the construction of the "Atlantic Wall" and a further drain on German resources to man these static defences.

Perhaps 7 December 1941 was the most significant date of the period covered by the History. The fire and destruction of Pearl Harbour brought onto the stage all the belligerents who were to fight out the war to the finish. Hong Kong fell on Christmas Day 1941, Singapore capitulated on 15 February 1942, Burma was lost, the East Indies were over-run and Australia menaced. The Japanese had become masters of the world's richest source of rubber and tin, valuable oil supplies and incalculable quantities of military raw material; they also controlled all communications between the Pacific and the Indian Oceans, except the long South Australia route. They had also established a popularly-held belief that they were invincible. By May 1942, however, the Japanese thrust on India had been held, and in the Pacific the Americans were establishing their command of the sea, and of the air.

On the home front the submarine threat to our shipping, vital to the prosecution of the war and indeed to our very existence, had not been mastered; the British bombing offensive was not yet seriously interfering with the German war effort, and a Joint Planning Paper of June 1941 hopefully envisaged the creation all over Europe of secret patriot armies, supplied by air drops, which would arise after "the vanguard of the Allied Armies had forced a landing".

Much of the Volume is understandably taken up with Churchill's remarkable influence on every aspect of British and Allied grand strategy, and the methods by which strategic decisions were reached through the Chiefs of Staff Committee and the Combined Chiefs of Staff are clearly explained. These methods have been described by Sir Alan Brooke as "the most efficient that had ever been evolved for co-ordinating and correlating the war strategy and efforts of Allies".

Decisions on the central direction of the war were only agreed after protracted controversy due to conflicting British and American outlook and indeed ideologies—Nevertheless the combined strategy formulated at the time was based on a joint resolve to take as the immediate aim the defeat of Germany, leaving the Japanese to be dealt with later, and the maintenance of the resistance of Russia whose early collapse was then believed to be highly probable. L.

HISTORY OF THE SECOND WORLD WAR
DESIGN AND DEVELOPMENT OF WEAPONS

By M. M. Postan, D. Day and J. D. Scott

(Published by HMSO, Price £3 3*s* 0*d*)

This volume of the official history of the Second World War comprises a series of studies of governmental and industrial organizations set up to deal with the design, development and production of military aircraft and army weapons and equipments. There are also sections dealing specifically with radar and with scientific establishments.

The chapter on Army Weapons will, no doubt, be the most interesting to the readers of this Journal. It covers firstly the long, lean period between the end of the First World War and 1936 when British foreign policy began to change and serious re-armament was decided upon, then the period of slow re-armament stretching from 1936 over the first year of the war itself, and finally the period starting some six months after Dunkirk when design development and production ran full bore reflecting the urgency and insistence of battle. In the case of the development of Armoured Fighting Vehicles the story starts with the design and operational use of the first tanks in the 1914–18 War stemming from the original idea of "Landships" and "Destroyers", developed in close conjunction with the Admiralty. This Royal Naval semi-parentage was to have a lasting effect on both the design of tanks and the tactical doctrine of armoured warfare on land; the "Cruiser Tank"—what the sailors would call a "well balanced ship"—persisted for many years, in addition to the Infantry Tank—the slower and more powerful capital "landship"—and the Light Tank or "Tankette" which developed into the Carrier. The many frustrating problems facing Major-General A. Brough and Major-General A. E. Davidson, who were Directors of Mechanization at the War Office from 1932 to 1936 and from 1936 to 1940 respectively, are fully described.

No detailed account is given of the development of anti-tank mines, except for references to the Hawkin's "grenade". The development of infantry anti-tank weapons by Major-General Sir Millis Jefferies—described by Mr Churchill as that "brilliant officer whose ingenious, inventive mind proved fruitful during the whole war", however, gets a special mention.

The inter-war activities of the RE and Signals Board, responsible for the development of equipments connected with the crossing of water obstacles, demolitions and field engineering generally, are described in a separate section. Full credit is given to the team at the Experimental Bridging Establishment (now MEXE) that developed the Bailey Bridge in such a short space of time—an equipment that proved to be a vital factor in preserving the mobility of the Allied Armies in every theatre of operations and made a substantial contribution to ultimate victory. L.

THE LOST GENERATION

By Reginald Pound

(Published by Messrs Constable & Co Ltd. Price 30*s*)

The Preface to the 1915 issue of Debretts solemnly stated : "In the terrible European War which broke out at the end of July, and at the beginning of August involved the British Empire, our Naval and Military Forces comprising the British Expedition-

ary Force (both from home and from overseas) have aquitted themselves with their traditional bravery, and day by day earn undying fame. Already sad toll has been taken from very many families whose names appear in 'Debrett', for both the titled and untitled aristocracy have given—and are giving—the best of their manhood to the service of the nation, a large number having one or more members on active service with the forces of the Crown, once again showing that they can always be depended upon to come forward and take their share at a time of national emergency; and HRH the Prince of Wales is now attached to the Headquarters Staff, as ADC to the Commander-in-Chief.

Among those killed in action have appeared, in addition to the untitled, the names of numerous bearers of hereditary, personal and courtesy distinctions, and the line of normal descent of many and many a hereditary dignity has been entirely changed, by reason of the death of either the actual holder or the immediate heir, while younger sons of Peers and Baronets have also frequently figured in the lists of the fallen, as well as many Companions of the various Orders."

Reginald Pound's book pays tribute, not only to those numbers of the Peerage, Baronetage, Knightage and Companionage who gave their lives in the first two years of Great War of 1914–18, but also to the host of others who "gave the best of their manhood to the service of the nation" voluntarily at Kitchener's compelling injunction: "Your country needs you". Scholars, Churchmen, sportsmen, athletes, writers, poets, musicians, young scientists, doctors and engineers, incipient diplomats and statesmen, leaders and teachers in all walks of life—the Citizen Soldiers of Kitchener's Armies—suffered the most devastating casualties. The book describes the gradual changes in attitude from the first enthusiastic rush to the Colours to the inevitable introduction of conscription, the social revolution caused by a Nation at War, and the thoughts of many splendid young men about to meet certain death. L.

GENERAL JACK'S DIARY 1914–1918

Edited and introduced by JOHN TERRAINE

(Published by Eyre & Spottiswood. Price 35*s*)

Reginald Pound's excellent book "The Lost Generation" tells how the flower of young British manhood—the Citizen Soldiers—were decimated on the battlefields of the Great War 1914–1918. Brigadier General Jack's Diary describes the fearful sufferings of those who fought in the trenches of the Western Front as seen through the eyes of a professional regular officer.

As a young Subaltern Jack had seen active service in the South African War and he served throughout the Great War of 1914–1918 with the Cameronians (Scottish Rifles) and the West Yorkshire Regiment and finally as Commander 28th Infantry Brigade. His diary covers the whole period of the bitter fighting in France and Flanders from Mons to the Armistice.

In his Introduction John Terraine, who edited the diaries, asks how the professional soldier, trained for war and brought up to expect war, differed from those of Britain's Citizen Army—the soldiers of the War who were only soldiers because of the War. Did their training make them different men? Were they dull fellows? Were they less sensitive to death and suffering than their Citizen comrades? Did they ever give way? Did they have doubts and regrets? What was it that sustained them? General Jack's diaries, without intending to do so, go a long way to answering these questions. They reveal a stern conception of duty, a keen attention to detail, a good eye for country sharpened by training, a sense of history and tradition instilled by the Regiment and, above all, a true knowledge of his men. The following extract reveals this latter point: "The weather remains raw and damp but, apart from colds the health of all ranks is very good. Games, mainly football in the afternoon, keep men fit and cheery . . . however tired the rascals are for parades they always have energy enough for foot-

ball." A renowned senior British Commander, more distantly removed from close contact with the soldiers, was writing almost simultaneously in his more famous Diary: "Men should rest during the day when they know they will be on sentry duty at night. Instead of resting they run about and play football."

Sidney Rogerson, who was Jack's Adjutant when he came to take command of the 2nd Battalion the West Yorkshire Regiment, sick and shaken after their terrible experience of July 1916, wrote the Foreword to these diaries. In it he refers to Jack's sympathetic nature which lay behind his martinet exterior and to the impressive evidence of the load of responsibility which rests on the shoulders of those who command men in battle, and of how this conscientious officer reacted to it. He concludes by saying that a great deal has been written about an officer's duty towards the men under him, and seldom has it been said more effectively than in General Jack's Diary. It should be read, marked and inwardly digested by those who aspire to command, and it might well benefit those who are commanded without realizing what is passing in the minds of those who command them. L.

RANK AND FILE

Compiled by T. H. McGuffie, MA, FRHistS

(Published by Hutchinson & Co (Publishers) Ltd, 178–202 Great Portland Street, London, W1. Price 35*s*)

This book is a collection of passages taken from books or documents written by men who served in the ranks of regular armies. The only exception is the chronicle of "Mother Ross" who enlisted as a man to follow her fugitive husband into the field.

The forty-three writers, with the exception of two French, two French Foreign Legion and three Americans, were all British regular soldiers and their accounts of the trials and tribulations they and their comrades-in-arms had to endure, in peace and in war, cover the period from 1642 to 1914.

It is often said that "it is a soldier's privilege to moan", but whilst many of the passages spare no details of the military and social hardships they had to endure, the theme of the writings is largely factual without the degree of "bellyaching" one might have expected. This is probably due to the selection made by Mr McGuffie who, as an historian, was naturally more interested in fact than the unreasoned meanderings of the grousers.

The writers range from a Bugler of the 71st Foot and a Sergt-Major of General Hopson's Grenadiers, to 2nd Lieut William Robertson of the 16th Lancers, later Field-Marshal Sir William Robertson, and their individual subject cover: recruits and recruiting, training and uniforms, barrack life, social conditions, NCOs, movements by road and sea, skirmishes, savage warfare, siege operations, and the whole gamut of battle in the advance and withdrawal, in victory and defeat, to the long anticipated, but often regretted, return to civil life.

The stories told are all slanted to the sight of the soldier in the ranks, nevertheless readers will probably be surprised to learn, for example, that the women who were saved from a terrible fate in Lucknow during the Indian Mutiny by Sir Colin Campbell's relieving force, had little time or attention for the dirty, exhausted British troops who fought so gallantly to save them. Only a few of the passages are so disparaging in tone, several give unstinted praise for acts of bravery and feats of physical endurance that, for example, enabled the British force in 1839 to reach Kandahar on the North West Frontier after a series of 20 miles a day forced marches, on rations that never exceeded a quarter of a pound of meat and the same quantity of flour per day. The chronicles often relate to events that took place in many of the well-known battles of the nineteenth-century, in places as far apart as Gibraltar and Bengal, and they leave little doubt about the courage and fortitude of "Tommy Atkins".

F.T.S.

LIEUTENANT KATIA

By CATHERINE DEVILLIERS

(Translated from the French by Charlotte Haldene and published by Constable, London. Price 25*s*)

When the Germans invaded Poland in 1939 they set in motion a remarkable chain of events that resulted in a French girl, Catherine Devilliers, becoming "Lieutenant Katia" of the 10th Engineers of the 5th Red Army.

Born in France of French and Russian parents, and brought up in Poland, she was sent to an aunt in Moscow to save her from the tragedy of Warsaw. Expelled from Moscow in 1940 after an innocent flirtation with the son of a British Embassy official she was sent to L'vor, a Polish city annexed by the Soviets, with an expedition to "bring help to the populations of White Russia and the Ukraine oppressed by Polish capitalism". There her natural mathematical ability obtained her a student place in the Institute of Roads and Bridges and Soviet Institute of Commerce. This lasted until the Germans invaded Russia and swept forward towards Moscow.

Like others she fled to Moscow and soon found herself and her slide rule attached to the 10th Engineers, where "her vast knowledge was necessary for the salvation of the Motherland". Up to that point the book is factual and throws a light on the conditions and reactions of the Russian people under the German onslaught; however, the subsequent references to the author's experiences in the Engineer Regiment whilst bridge building on the Russian line of retreat, her capture by the Germans, her escape and and eventual recovery from a war wound, are so emotionally tempered that they merely record, decorously to some modern standards, the sexual hazards she survived and the love interest that eventually overtook her.

The chronicle throws little light on the defence of Russia in 1941, nor the work done by the Engineer unit, but merely serves to illustrate the dangers that might encompass academic females in war-time Russia. F.T.S.

NEWARK-ON-TRENT—THE CIVIL WAR SIEGEWORKS

By THE ROYAL COMMISSION ON HISTORICAL MONUMENTS

(Published by HMSO. Price 17*s* 6*d*—by post 18*s* 5*d*)

Lieut-General Sir Charles King wrote a most interesting article in the June 1964 issue of the RE *Journal* on "Cromwell's River Crossings" which he hoped would "stimulate curiosity for proper research" into the military bridging operations of the great Civil War in the mid 17th Century.

This excellently illustrated and annotated book makes no specific references to river crossing operations, despite the fact that Newark stood on the River Trent over which a bridge of boats was built. It does, however, present to the Sapper officer a fascinating and detailed account of the defence works thrown up by the Cavaliers around and outside the city and the siege-works constructed by the Roundheads well worthy of the closest study. Newark was a communication centre of great tactical importance to the Royalist cause and its defences withstood all attempts by the Parliamentarians to take the place by storm. The city was eventually ordered to surrender by the King on 8 May 1642.

There was an accute shortage of skilled and experienced engineer and artillery officers during the Civil War. The most outstanding military engineer on either side was Bernard de Gomme—the King's Chief Engineer—who, like his predecessor of 600 years before Bishop Gundolphus, was "imported from the Continent". He was a young Walloon military engineer brought to England by Prince Rupert who also imported the French "fireworker" Bartholomew Los Roche as his CRA. de Gomme was knighted by King Charles I. He drew up the plans for the Battles of Naseby, Marston Moor and Newbury. He designed the defences of Liverpool Castle and he had a hand in planning the defences at Newark. In addition to his duties as the Kings Chief Engineer, he also acted as the Royalists' Quarter Master General. On the Restoration of

King Charles II he became in 1660 Surveyor General of Fortifications and the following year Engineer-in-Chief of all the King's Castles and Fortifications. In 1682 he was made Surveyor General of the Board of Ordnance. He was the outstanding military engineer of the Stuart era and among its most famous soldiers. L.

THE WORLDS' GREAT BRIDGES

By H. SHIRLEY-SMITH

(Published by Phoenix House, London. Price 25*s*)

The second and revised edition of this book has recently been published. It is a fascinating book which must be of interest to any Sapper or civil engineer. It is written in an easy style, and covers the subject in a general enough manner for it to be readable to non-engineers, yet it contains a mass of technical information.

The subject of bridges is covered from their very beginning by primitive men up to the present day with the new Forth road bridge, and the still unfinished Severn and Verrzano-Narrows bridges. Construction methods through the ages are described, as are also some notable failures and bridge disasters. The book is well illustrated with both drawings and photographs, and would make an excellent gift to any aspiring young civil engineer. J.C.P.

THE ORDNANCE SURVEY ANNUAL REPORT, 1963–4

(Published by HMSO. Price 6*s*)

When the 1939–45 War ended the Ordnance Survey was faced with the task of dealing with the consequences of the enforced neglect of mapping in the inter-war years and the virtual cessation of its normal activities during the war. Since 1945 successive Annual Reports have recorded the progress made towards the repair of this neglect.

The latest Report brings the story up to date. It sets out the year's achievments clearly and concisely, its content and style being designed to appeal to professional and laymen alike. For example, geodesists are told of the new cross-channel geodetic connexion and of plans for readjusting the retriangulation; all readers will find interest in the sections dealing with the progress of the survey and mapping programmes and the increasing part that air survey methods are playing; and those whose interests lie in the conversion of the surveyors' work into maps and plans can read of developments in cartography and printing.

The Report also records a new high peak in the public demand for the Ordnance Survey's publications. The promised continued production of new editions of the standard series of maps and plans, and of further tourist maps, should ensure that this high level of demand continues.

There is always much of interest in these annual reports of an organization with which the Corps has long been so closely connected. The 1963–4 Reports maintains the standard. C.W.F.

NETWORK ANALYSIS FOR PLANNING AND SCHEDULING

By A. BATTERSBY

(Published by Macmillan & Co. Ltd. Price 42*s*)

This is the second book to be published in 1964 on the subject of network analysis (or the Critical Path Method of planning as it is perhaps better known). The two books, by Lockyer and Battersby, were in preparation at the same time, and both adopt much the same rather conventional approach to the subject. The present volume is somewhat larger, and more expensive, but compensates for this by providing two extra features: there are many exercises for the reader to practise on, with solutions, and there are a number of case histories quoted in sufficient detail for the reader to see for

himself the degrees of success or improvement that these techniques have achieved in real situations.

Mr Batterby is a senior Lecturer at the Cranfield Work Study School. Although there are a number of mentions of network analysis being used to identify activities where work study techniques should be applied, and an example of a multiple activity chart is given, the author has avoided the pitfall of considering CPM primarily as a work study tool. In fact, he states clearly that although it forms a useful basis for choosing activities for method study, this is only one of many applications.

Apart from the exercises and case histories, this book is also useful for its clear and practical approach to arrow diagramming, although a certain rigidity of outlook here may jar on a reader who draws his diagrams differently. There is undue emphasis on the numbering of events, and even sequential numbering, without it being made clear that event numbering serves little purpose unless a computer or a matrix is to be used for doing the calculation. The use of computers, however, is not given as much attention as it warrants; in the introduction the author explains this by saying that computers are treated as a possible aid whose use depends entirely on relative costs. A book that covers, in some detail, such techniques as the matrix methods, statistical mathematics and even the French method of potentials, should surely provide more information on the effective use of computers with network analysis. Types of programme, input requirements, and (particularly) varieties of print-out orders with their different uses, should have been covered.

The short section on the French system, mentioned above, is not easy to understand; this may be the fault of the author or the fault of the system. In any case, the reviewer is one reader who is now convinced that the method of potential holds no real advantage over the more customary type of network analysis. The chapter on variable costs and durations is much clearer, and PERT is covered competently.

The chapter on allocation of resources, surprisingly, does not really say how the planner can level out the requirements for plant, equipment and labour when producing his final programme. This omission probably results from a failure to give proper weight to graphical methods. The accepted technique is to draw the arrow diagram to a time scale and tabulate the resources underneath: the activites can then be moved within the restraint of the diagram logic in order to even up the employment of resources. This is lengthy, but it is the only affective manual method of producing a good programme from the original network analysis. In the book, graphical methods are only touched on, and are strangely bracketted with their exact opposites, matrix and tabulation methods. The reviewer's antipathy to the latter is further reinforced by reading this section of the book.

The value of this volume would have been greater if it were not such a mixture of very elementary and much more advanced and specialized techniques. The middle ground, of practical application to ordinary jobs, has too little room in the painting; the foreground and the background predominate. Despite this, any serious student of planning and management techniques will want to read this book, and will find much food for thought in it.

There are, unfortunately, some errors and misprints (eg pages 38, 40 and 53), but this is to be expected in the first printing of a new text book. Apart from these, the volume is well produced and clearly printed. N.R.S.

CONSTRUCTION MANAGEMENT FOR CIVIL ENGINEERS

By J. H. W. Turner

(Published by C. R. Books Ltd. Price 45s)

In his foreword to this book, Sir Richard Costain writes that it is "a comprehensive and comprehensible civil engineer's view of the nature of management. In this respect it satisfies admirably the need for literature on the aspects which the author has chosen as being the most important for presentation to those who manage construction". These are carefully chosen words, which the reviewer whole-heartedly endorses.

Mr Turner has written a much-needed book; it is thoughtful and convincing, and will be very useful in helping those concerned with construction management to crystallize their own thoughts and experiences into a clear policy and a consistant outlook.

The author has not held back from stating his own strong opinions, and has reached firm conclusions from his analysis of the facts that he gives. Engineers and managers will find themselves agreeing more often than not with the conclusions made, even if they have not previously considered the problems from the same view point.

This book is not a comprehensive text book covering all aspects of the subject of construction management. But it does cover the principles and the nature of the subject thoroughly. It is readable and interesting, and does not adopt the over-theoretical and jargon-prone approach so commonly found in books on management subjects. There is no attempt to treat the elements of the subject as separate lessons, with pages full of sub-sub-paragraphs. One possible criticism is that the style is perhaps a little too discoursive, and the layout of the subject matter rather lacking in precision and logical order; it is not therefore a reference book, although it succeeds in covering all the important points in sufficient detail.

The seven chapters are entitled "The Nature of Civil Engineering", "The Nature of Management", "Types of Contract", "Planning", "Organising", "Controlling" and "Retrospect and Prospect". The rather unpredictable layout of the book is evident from the fact that the chapter on Organising includes such matters as recruitment, salary scales, interviewing technique, job satisfaction, pension rights, training, tendering, trades unionism and prevention of accidents. Programming and Critical Path techniques come under Controlling and not under Planning, although the text makes it clear that the Critical Path Method is primarily a planning tool and is of limited use in actually controlling the project.

This book is especially recommended to those readers who have connections with, or aspirations towards, the civil engineering industry. But any Sapper Officer would gain food for thought from this clear and straightforward treatment of the problems of construction management.

N.R.S.

HIGH TEMPERATURE STRUCTURES AND MATERIALS

Edited by A. M. Freudenthal, B. A. Boley and H. Liebowitz

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price £5)

This book consists of thirteen papers presented to the Third Symposium of Naval Structural Mechanics at Columbia University during 1963. The main theme is the exploration of the fatigue phenomena encountered by aircraft, missiles and certain structural members of nuclear reactors when subjected to very high temperatures. Most of the papers consist of a very short preamble followed by a detailed and highly technical discourse on the subject concerned; the paper dealing with the behaviour of materials, which is mainly descriptive, is the exception.

The technical range of the papers is large and embraces the elastic and anelastic properties of solids, the behaviour of ceramics, various aspects of "creep", thermal and mechanical fatigue and the re-entry problem. The book is intended for specialists interested in this field, but certain sections could be read and appreciated by technically trained officers. The latter would find that some of the laws of mechanics and physics do not apply when structures and materials are subjected to high speeds, temperatures of the order of 1000°C, and pressures in the region of 10^{-15}. mm Hg.

The papers were presented by scientists and technologists from America, Austria, Great Britain, Japan and Russia. Each paper is illustrated with photographs, diagrams, graphs and tables and documented with references for further reading. The general standard of the production is excellent.

L.J.B.

ELEMENTS OF EXPERIMENTAL STRESS ANALYSIS

By A. W. HENDRY, PhD, DSc, MICE, MIStructE, FRSE

Professor of Civil Engineering, University of Edinburgh

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 21*s*)

This book is Volume IV of the Structures and Solid Body Mechanics Division in the Commonwealth and International Library. Its purpose is to outline the basic theory of the subject and describe the more widely used techniques and pieces of test equipment used to determine the stress conditions in a structure or element subjected to some specific loading, either by observation of the physical changes brought about in it by the applied loads, or by measurements made on a model or analogue.

The author emphasises that a book of this size (188 pages) is much too small to deal in considerable detail with any particular topic, so the text is, therefore, more suited to the civil engineering undergraduate than qualified engineers employed on design work. For readers who may wish to study any particular subject in more detail a bibliography of further reading is given at each chapter end.

In practice it is usual to investigate the stress analysis of prototype structures, or machine parts, by loading reduced scale models, and the author deals adequately with the construction of the latter with particular reference to materials, scales, and the snags to avoid. One of the problems of stress analysis is to provide adequate means of loading and measurement, and the method of generating forces, either static, slowly varying, or dynamic, are summarized, together with the methods by which they can be applied and a brief description of the measuring apparatus in common use.

A chapter is devoted to mechanical, optical, and other gauges and this outlines the operating principles of dial gauges, telescopes, microscopes, moment indicators, and mechanical strain gauges, including those of Huggenberger, Jenkins and the De Leiris. The use of electrical resistance straining gauges was first introduced in the 1930s and since then they have been developed into one of the most useful tools in experimental analysis work. The operating principles of this type of gauge is given in some detail, including those employing the characteristics of capacity, inductance and vibrating wire. As these particular gauges all measure strain a complementary section is included to show how stress calculations can be deduced from them for elastic materials.

The completely different technique of ascertaining stress values from the optical behaviour of stressed transparent materials, a phenomenon discovered by Sir David Brewster in 1816 and since developed, is covered in a chapter titled Two-Dimensional Photo-Elasticity, which details the optical theory, the determination of the principal stresses, photo-elastic apparatus, materials, models, and test procedure. The developments of the photo-elastic method ie, the Frozen Stress Method and Surface Coating Techniques, are also explained.

The remaining chapters cover: Structural Model Analysis; The Direct and Indirect Methods of Measurement; Special Instruments for Dynamic Stress Analysis; Analogue Methods for Stress Problems; and The Selection of Method of Analysis.

The text with its photographs, diagrams, tables, and graphs is well worth the modest price of twenty-one shillings. F.T.S.

THE DYNAMIC BEHAVIOUR OF STRUCTURES

By G. B. WARBURTON

Professor of Applied Mechanics, University of Nottingham

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 21*s*)

This soft covered book is Volume V of the Structures and Solid Body Mechanics Division of the Commonwealth and International Library published by Pergamon Press Ltd. It deals with those aspects of vibration theory relevant to structural problems, and in particular with the approximate methods of analysis of complex systems and the determination of the response to transcient excitation.

It is only suitable for undergraduates in the later years of study as the author credits the reader with an elementary knowledge of strength of materials and theory of structures, a mathematical ability to solve elementary differential equations, and a knowledge of dynamics sufficient to apply Newton's second law of motion in order to derive the equations of motion of vibrating systems.

The seven chapters cover: Systems with One Degree of Freedom; Systems with Several Degrees of Freedom; Flexural Vibrations of Beams; Natural Frequencies of Frames; Vibration of Plates and Shells; and Wind-Induced Oscillations of Structures. Also included are two appendices giving some properties of matrices, and the orthogonality conditions of beams.

A number of problems are given with each chapter with the correct answers at the end of the book.

F.T.S.

DIGITAL CALCULATIONS OF ENGINE CYCLES

PREPARED UNDER THE AUSPICES OF THE SAE FUELS AND LUBRICANTS ACTIVITY COMMITTEE

(Published by the Society of Automotive Engineers Inc, 485 Lexington Avenue, New York 17 and distributed in the UK by Pergamon Press Ltd, Oxford. Price 70s)

This book, Volume VII of the Society's Progress in Technology Series is an edited collection of seven papers on the subject matter originally presented at the technical meetings of the Society during 1962 and 1963. Readers may recall that volume V, *The Application of Computers in Valve Gear Design* was reviewed in the June 1964 *Journal*.

Since the advent of rocket engines, and during the recent continuous development of jet and reciprocating piston engines, designers have carried out intensive researches to determine accurately the characteristics of working fluids, pressure-time cycle events, and the products of combustion in a never-ending search for greater efficiency. The papers published in this volume cover those subjects with particular reference to the application of modern high speed digital computers for calculation purposes. The authors are associates of American universities, automotive engine manufacturing concerns, and certain fuel supply companies whose trade names are well-known to motorists.

The specific subjects covered by the papers are:—

A Consideration of High Temperature Thermodynamics of Internal Combustion Engines.

Combustion Temperature, Pressure, and Products at Chemical Equilibrium.

Thermodynamic Properties of Octane and Air for Engine Performance Calculations.

The Influence of Compression Rates and Dissociation on Ideal Otto Cycle Engine Thermal Efficiency.

Limits of Engine Performance—Comparison of Actual and Theoretical Cycles.

A Digital Computer Simulation of Spark-Ignited Engine Cycles.

An Analysis of the Ideal Otto Cycle, Including the Effects of Heat Transfer, Finite Combustion Rates, Chemical Dissociation and Mechanical Losses.

Each paper is presented in considerable detail and the texts are quite advanced technically, but apart from being of considerable value to the designers of reciprocating and other engines the papers will enable interested and qualified mechanical engineers to keep abreast of modern development trends. The papers include a multiplicity of graphs and technical tables to illustrate the texts and an extensive bibliography of further reading is given. The index at the end of the volume will please seekers of specific information.

F.T.S.

MECHANICS OF AUTOMOBILES

By H. E. BARNACLE, BSc (ENG), AMIMECHE

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 35*s*)

Many text-books on automobile engineering have been published during the past fifty years. The earlier publications concentrated on the principles of the Otto Cycle and the conversion of engine power into road speed through the agencies of gear boxes and other parts of motor vehicle transmission systems. As time passed and the auxiliary systems and other individual parts were improved these, in turn, were made the subjects of specialized text-books. Very little information, however, was made available to students and engineers outside of the motor industry which dealt specifically with the dynamic problems arising from the motion of automobiles and the methods available to improve vehicle ride and stability.

The latter factors are now receiving the full attention of designers and it is appropriate that this book should now become available for study by those preparing for the examination of the Institution of Mechanical Engineering, and those studying vehicle design at the Royal Military College of Science.

The following subjects are covered and students should find the material presented adequate for examination purposes: Vehicle Performance—Linear and Angular Inertia: Vehicle Braking and Brakes: Dry Friction Clutches: Gear Box: Couplings between non-axial Shafts: Balance of Reciprocating Engines: Cams and Valve Gear: Suspension, Steering and Tyres: Gyroscopic Effects: and Vibrations. These subjects do not exhaust all the dynamic problems but the basic material for studying them are presented.

Many worked examples are included which have been taken from the Examinations of the University of London and the Institution of Mechanical Engineers, and the text is well illustrated by a number of graphs and diagrams.

The author is the Senior Lecturer in Mechanical Engineering, College of Technology, Oxford. F.T.S.

MAGNETOHYDRODYNAMICS WITH HYDRODYNAMICS

By P. C. KENDALL, PHD

University of Sheffield and High Altitude Observatory, Boulder, Colorado

and C. PLUMPTON, MA, PHD

Senior Lecturer in Mathematics, Queen Mary College, University of London

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 17*s* 6*d*)

This is the first of two paper-backed volumes designed to introduce the subject to students on advanced undergraduate courses. The two volumes form part of the Physics Division of The Commonwealth and International Library published by the Pergamon Press.

The reader is credited with a considerable knowledge of hydrodynamics, vector methods and a knowledge of mathematics.

With the aid of worked examples the authors formulate mathematical models to describe and explain the more important aspects of the problems involved. These are detailed in five chapters. The first recapitulates the mathematical techniques employed, whilst the second includes the equations of inviscid hydrodynamics, hydrostatics and the equilibrium of gases, the steady motion of incompressible inviscid liquids, viscous motion, compressible fluids and surface waves. Chapter 3 discusses electromagnetic effects with references to the Maxwell equations, the Lorentz force, the Poynting vector, and the simplification of the magnetohydrodynamic equations by dimensional analysis. The motion of a fluid in a uniform magnetic field is studied in Chapter 4 with an introduction to Alfven waves and magneto-acoustic waves. The final chapter deals with steady states and equilibrium configurations, including corpuscular flux problems.

Exercises are given at each chapter end and include questions set in examinations by the Senate of the University of London. F.T.S.

FATIGUE RESISTANCE OF MATERIALS AND METAL STRUCTURAL PARTS

Edited by ALFRED BUCH

Institute of Precision Mechanics, Warsaw

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 100s)

This book contains reports of the technical papers presented by a number of the engineers and scientists who attended a conference in fatigue effects held in the Mechanical Research Laboratory of the Instytut Lotnictva, Warsaw (now the Strength Research Laboratory of Instytut Mechaniki Precyzyjney) in May 1960. The Conference was an international one and nine representatives from East and West Germany attended, together with five from the USSR, four from Czechoslovakia, two from Hungary, and one each from Great Britain, Switzerland and Bulgaria. Also in attendance were Polish representatives of Research Institutes, Technical Colleges, Design Offices, Foundries, Shipyards and numerous factories.

The reports are presented in three sections :—

Section A—*Special Problems*—deals with a number of experimental fatigue works on the basic scientific problems including fatigue limit and UTS, damage accumulation, safety factors, strength at high temperatures, the fracture of plastic metals and constructional carbon steel, cracks in aluminium and mild steel, and the influence of fatigue on tensile strength, elongation, electric resistance, the micro-hardness of steel, and fatigue decohesion.

Section B—*Materials and Technological Problems*—which cover the influence of non-metallic inclusion lines, the fatigue strengths of sintered cermetallic materials, the effect of surface treatment and internal stress, the strength of elements made of carbon steel saturated with cathode hydrogen, the effects of electrolytic depositions, the comparative fatigue strengths of semi-finished products of AlZnMgCu and AlCuMg alloys, properties of P4-4 Alu alloys, the effects of low-temperature annealing, preliminary deformations, and the use of nickel in constructional steels.

Section C—*Constructional Problems*—in relation to jet-propulsion engine blades and resonance, tests of joints and welded elements, the strength of welded crankshafts subjected to torsional loading, and the dynamic graduation of the 50T-Schopper's Pulsator.

Readers are warned that six of the reports are printed in the German, although short summaries of these are given in English at each report end.

The book is well produced and the type is easy to read. Most of the reports are illustrated with diagrams, tables, graphs, and/or photographs. References for further reading are included.

The hitherto published material on fatigue resistance of materials and metal structural parts is still rather scanty and this collection of reports will enable designers and metallurgists to be aware of the trend of development in Central and Eastern Europe.

F.T.S.

STRUCTUAL CONCRETE

By J. D. DAVIES

(Published by Pergamon Press, Ltd, Headington Hill Hall, Oxford. Price 17*s* 6*d*)

The object of this book, as described in the preface, is to examine theoretically the behaviour of reinforced and prestressed concrete structures under both working and ultimate load conditions. The book is aimed at the civil engineering undergraduate rather than the practical designer, and for this reason there are only brief references to practical details, codes of practice, or empirical methods; nevertheless many designers would gain considerably from studying the book, for it contains clear explanations of the important principles necessary for an understanding of concrete design.

R.E.J.—D

The opening chapter on the properties of concrete is too elementary to be of much value, but the level thereafter is correctly aimed. Chapters on struts, beams and slabs are well explained and illustrated by a number of worked examples; several exercise questions are also included for the student. The final chapter gives an introduction to the use of models for the analysis of concrete structures, covering briefly both the scale relationships between models and prototypes, and the materials best suited for making the models.

The book is a paperback, but it is very well laid out with a good clear print and excellent figures; the symbols used are mostly traditional and obvious, but could well been listed, with their explanations, as an aid to the casual reader. J.C.P.

CONTROL SYSTEM FUNDAMENTALS

By HOWARD L. HARRISON

(Published by the International Textbook Company, Scranton, Pennsylvania. Price $2.75)

This soft-backed textbook provides an introduction to control-system fundamentals which, according to the author, can be presented to and absorbed by a class of mechanical engineering students in about two weeks, depending on the mathematical and engineering background of the pupils.

The text deals only with *linear* type systems of control, i.e. those systems whose behaviour can be adequately defined by linear differential equations, the linear system theory offering a satisfactory starting point for the study of the more complex systems.

Apart from Chapter 1, which defines the subject generally and describes the principles of the feedback control system by means of a home-heating application, the text is presented in mathematical form. Chapter 2 is devoted to the writing of differential equations to define the behaviour of dynamic systems from an understanding of the basic laws underlying the systems being considered. The examples and equations derived cover the more common damping parts of hydraulic and mechanical systems.

Chapter 3 deals with the problem of finding the solution of homogeneous equations in which the forcing function is zero, by giving examples of solutions for first, second and higher order equations, and the derivation of their constants. The solution of non-homogeneous equations, and the combination of a number of simultaneous equations into one differential equation, are also considered.

Chapter 4 studies certain aspects of dynamic-system response to varying inputs, based on the same example systems used for illustration in Chapter 2. The last section of the book deals with control actions, i.e. the manner in which system errors are utilized to make corrections, or, conversely, how the correction is related to the error, a liquid-level control application being used for this purpose.

A number of exercise questions are included at each chapter end and two appendices give: methods of determining the roots of an equation, or to factor a polynomial: and the application of Routh's criterion. F.T.S.

A TEXTBOOK OF ANALYTICAL GEOMETRY

By JOSEPH S. MAMELAK

(Applied Research, RCA, Camden, New Jersey)

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 42*s*)

This textbook has been written for students of engineering and science. Reference is made to the exposition of concepts not traditionally used in mathematics, but the author claims that much of the text has already been used with successful results.

The fifteen chapters of the book cover: Definitions and other basic concepts; Fundamental formulae; Sets, Algorithms; Functions; The problems of Analytic Geometry; The geometric content of algebraic manipulation is stressed in working

with lines, circles and conics; Transformation of axes; Parametric equations; Limits, Tangents, Normals; The elements of curve tracing; The graphs of some algebraic equations and transcendental loci; Polar co-ordinates and empirical equations.

A feature of the book is the unusually large number of exercise questions and problems set at each chapter end. These cover the various items of the text in detail and invite descriptive and mathematical solutions from students.

The general standard of the publication is first-class. F.T.S.

STRUCTURAL THEOREMS AND THEIR APPLICATION

By B. G. NEAL, MA, PhD, MICE, MIMechE, AMIStructE

Professor of Applied Science, Imperial College of Science and Technology, London

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 21*s*)

This soft covered book is Volume 6 of the Structures and Solid Body Mechanics Division of the Commonwealth and International Library published by Pergamon Press Ltd.

Its purpose is to provide a suitable connected account of the theorems of structural analysis for the second year, third year, or post-graduates taking courses on the theory of structures and strength of materials in universities and colleges of advanced technology. The theorems are explained by a number of applications which are generally limited to simple type structures such as plane trusses, continuous beams and frames.

The text shows how the theorems stem from the principle of virtual work and the eight chapters cover:- The Problems of Structural Analysis, The Principles of Superposition; Virtual Work and Energy Concepts; The Analysis of Indeterminate Structures by the Compatability Methods; Calculation of Deflections; The Analysis of Indeterminate Structures by the Equilibrium Method; Reciprocal Theorems; Theorems of Plastic Analysis for Plane Frames; The Proof of Principle of Virtual Work for Plane Frames. A bibliography and a list of books recommended for further reading are included. F.T.S.

FUNDAMENTALS OF GAS DYNAMICS

By JERZY A. OWCZAREK, AMIEE, ASME

(Associate Professor of the Dept of Mechanical Engineering, Lehigh University)

(Published by The International Textbook Company, Pawnee Avenue, Scranton, Pa. Price $11.50)

This book sets out the physical phenomena and the mathematical methods and techniques needed in a study of gas dynamics.

The contents cover—Fundamental concepts of gas dynamics; Kinematics of fluid flow; Equations of flow of compressible perfect (nonviscous and nonconducting) fluids; Topics from classical thermodynamics and statistical mechanics, speed of sound; Stationary shock waves in perfect fluids; Unsteady flow of a perfect fluid involving discontinuities; Spatial supersonic steady flows of perfect fluids; Equations of flow of viscous and heat-conducting compressible fluids, and the Two-dimensional laminar boundary layer.

In addition Appendices cover a review of Vector Algebra and Calculus, The Maxwell Equations and other Thermodynamics Relations, Hodograph Characteristics in Steady Two-Dimensional Homenergic and Irrotational Supersonic Flow as a Family of Epicycloids, Derivation of the Rule of Transformation of the Coefficients q_{ij} of a Dyadic and Tables for an Ideal Gas with Constant Specific Heats.

The easy-to-read type is printed on good quality paper and the standard of production is excellent. F.T.S.

ANALOG AND DIGITAL COMPUTOR METHODS IN ENGINEERING ANALYSIS

By M. L. JAMES, G. M. SMITH and J. C. WOLFORD

(Dept of Engineering Mechanics, University of Nebraska)

(Published by International Textbook Company, Scranton, Pennsylvania. Price $9.25)

The text of this book covers a greater range of information than its title suggests; for in addition to presenting the methods whereby the problems of engineering can be solved and analysed, the authors describe in considerable detail the basic components of the machines and their modes of operation. both individually and collectively, that enables them to perform their complex mathematical calculations. This descriptive detail is further amplified by a large number of explanatory mathematical examples, which illustrate the sequence of operation for both analog and digital machines.

The authors have presented their text on electronic analog computers without reference to any particular compiler, but most of the information provided in connexion with digital computers is referred specifically to the FORTRAN, a processor which has been developed from the IBM 704 computer of 1956, and now used extensively in the USA. This, however, does not detract from the instructional value of the text.

Whilst this is a useful book for engineers in all branches of the profession, it is also very suitable for graduate students who wish to get a detailed insight into the theory and operation of computers.

The printing standard of the publication is first-class. F.T.S.

FRICTION AND WEAR IN MACHINERY VOLUMES 15 and 16

Translations from the Russian edited by G. HERRMANN

(Published by the American Socity of Mechanical Engineers and distributed outside of the USA by Pergamon Press Ltd; Headington Hill Hall, Oxford. Price 70s each)

These paper-back volumes are in continuation of Vols 11 and 14 that were published in 1963 and reviewed in the RE Journal of September 1963. The translation and publication was undertaken on the initiative of the Research Committee on Lubrication of the ASME with the aid of a financial grant from the US National Science Foundation.

Each volume consists of a number of research papers written by Soviet scientists under the direction of Professor M. M. Krushchov, the Director of the Wear-Resistance Laboratory of the Institute of Science Machines, of the Academy of Sciences, USSR, to whom the papers of Volume 15 are dedicated in honour of his seventieth birthday. The latter volume also contains an interesting monograph which outlines his achievements as the Founder of the Soviet science of friction and wear, and names several of his written papers that have become standard references to Russian research workers. The remaining text of Volume 15 covers the following subjects in respect of friction and wear: The effects of extremes of pressure and temperature on certain metals and machine parts; Properties of lubricants and the effects of using antiscoring additives; Problems of elastorheology; The nature of white layers formed on friction surfaces; Use of metal additives to USSR steels and ferrous alloys; The use of radioactive tracers to determine the ability of bearing materials to absorb abrasive particles.

One third of Volume 16 (some 213 pages) consists of an extremely comprehensive bibliography of papers and books issued during 1957–59 on the subjects of friction wear and lubrication by authors of various nationalities, mostly Russian; but there are papers covering investigations of: The use of four-ball machines to determine degrees of pitting; Wear of diesel-fuel pumps, roller chain link components, and plastic materials, and the ways to increase their service life; Anisotropic friction; and The theory of hydrodynamic lubrication of porous bearings.

The papers in both volumes are extremely detailed technically and only suitable for metallurgists, machine designers, and chemists interested in the application of lubricants to industrial machinery and vehicles for all purposes. Most of the papers are well illustrated with photographs, tables, charts and diagrams in support of the text; and interested readers who lack the time to wade through the details will appreciate the clearly defined objects of the experiments and the final conclusions drawn by the researchers. F.T.S.

HYDRAULICS AND FLUID MECHANICS

Edited by RICHARD SILVESTER

(Department of Civil Engineering, University of Western Australia)

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price £5)

This book contains twenty-nine papers submitted to a Conference on Hydraulics and Fluid Mechanics, sponsored by the Faculty of Engineering in the University of Western Australia, and held during December 1962 at Nedlands near Perth.

The Conference was attended by over forty delegates from Australia and sixteen delegates from overseas countries, including America, India, New Zealand, the United Arab Republic and Thailand.

Apart from slight editorial work to achieve imformity of presentation, the papers are reproduced as written. The findings and views of the authors are not necessarily those of the University of Western Australia.

The papers cover a wide range of specialized subjects. Some describe installations and experiments that provide possible solutions to problems which have bothered engineers in the past, others cover experiments which have been progressed to expand the knowledge and theories of hydraulics and fluid mechanics. Typical of the former are: Hydraulic and Dirt Lock in Piston Type Control Valves, Analogue Computers for the Solution of Drainage Problems, and Pressure Surges in Fire Services of Tall Buildings. Whilst examples of the theoretical papers are: Analysis of Shallow Water Wave Patterns, Horizontal Diffusion over the Sea Surface, Influence of Entropy in One-Dimentional Nozzle Flows.

One unusual feature of the book is that many of the papers have a synopsis at the beginning which outlines the contents as regards the problems explored and the findings obtained.

The standard of printing and general production is first-class. F.T.S.

SUCCESSIVE APPROXIMATION

By N. YA VILENKIN

(Translated and adapted from the Russian by MICHAL B. P. SLATER and JOAN W. TELLER)

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price 15s)

This book, Volume 15 of the publishers *Popular Lectures in Mathematics Series*, was first published in Moscow in 1961. The text comprises a series of lectures which the author gives to ninth and tenth grade students in the mathematics circle of the Moscow State University.

The methods of successive approximation (iteration) are now widely used to solve the different problems of physics and engineering, including those presented by researches into space rocketry, the calculation of satellite orbits, the structure of the atom and the starting of atomic reactors. The author, however, has restricted his text to the solution of algebraic equations. The subject is presented in a precise manner. A set of students exercises is included and the answers provided.

Students at colleges of technology and engineers who need to solve equations in specialized fields of design will find this book informative and helpful. F.T.S.

DICTIONARY OF AUTOMATIVE ENGINEERING ENGLISH/GERMAN/FRENCH/RUSSIAN

By W. MULLER

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price £10)

This dictionary contains some 10,000 entries in each of four languages. It was compiled after an intensive study of automotive books and magazines, maker's instruction books and catalogues, etc. It covers the names of all parts of the engine, chassis, structure, electrics and other accessories, plus many terms used in design, production, testing and maintenance. As no universal standardized engineering terminology exists at present, this dictionary will serve a useful purpose in international commerce and military liaison.

The book comprises about 1,000 pages and its standard of production is very good.

F.T.S.

THE MECHANICAL AND PHYSICAL PROPERTIES OF THE BRITISH STANDARDS IN STEELS, VOLUME I

By J. WOOLMAN, MSC and R. A. MOTTRAM, AIM

(Published by Pergamon Press Ltd, Headington Hill Hall, Oxford. Price £7 7s 0d)

This is the first of three volumes to be published by the Steel User Section of the British Iron and Steel Research Association to satisfy the many enquiries constantly made by industry regarding the relative properties of British EN steels and their foreign equivalents. The task of compiling the information was aided by a grant from the Department of Scientific and Industrial Research under the Special Assistance to Industry Scheme.

The volume presents the most important properties of En 1 to En 20 inclusive. (BS 970–1955). Volumes II and III will, when published, be concerned with En 21 to En 50 and En 51 to En 363 respectively. The information was collected from a wide variety of literature, research records, and industrial knowledge, and contains information not previously published. In fact some laboratories actually carried out special tests to ascertain properties not previously determined.

To illustrate the wealth of information contained in individual specifications the charateristics detailed for En 8 ('40' Carbon Steel) are set out below:-

Chemical Composition, Mechanical Properties, Related Specifications UK, USA; France, Germany, Sweden, USSR, Applications, Welding, Machinability, Hot Working and Heat Treatment, Physical Properties, Transformation Characteristics, Hardenability, Mechanical Properties at Room Temperatures, Effect of Cold Work on the Mechanical Properties at Room Temperatures, Effect of Tempering on Mechanical Properties, Effect of Mass on Mechanical Properties, Mechanical Properties at Low Temperature, Impact Transition Temperature Data, Mechanical Properties at High Temperature, Mechanical Properties in Torsion, Fatigue Properties, Unnotched and Notched Fatigue Data.

The volume, which is excellently produced, will be a boon to designers and production engineers.

F.T.S.

Technical Notes

CIVIL ENGINEERING

Notes from *Civil Engineering and Public Works Review*, September 1964

The Shearing Resistance of Granular Soils. The pressure exerted by soils on retaining walls, the bearing capacity and settlement of foundations and piles, and the strength of the subgrade under a road or airfield pavement are all dependent upon the density and shearing capacity of the soil mass. This article, based on a series of experiments carried out at Leeds University, analyses the correlation of density and shearing resistance of granular soils. In particular, the effect of particle shape on density and shear strength is described, and various graphs illustrate clearly how the coefficient of friction influences the obtainable density, and how the density controls the shear strength.

PVC Pipe for a River Crossing. This short article is of interest in that it describes a method of laying a PVC water main across a river bed. PVC was chosen for this pipeline because of its resistance to seawater corrosion.

Anchorage Zone Reinforcement for Post-Tension Concrete. The design of end-blocks and anchorages is probably the most difficult part of post-tensioned pre-stressed beam design. This article describes a method of reinforcing end-blocks based on recent experimental work. Useful design curves are given covering a wide range of conditions and anchorage types. In general the stresses used are higher than those recommended for military work (See M.E. Vol XIV Part III), and the curves would therefore need amendment for military design. The advantageous reduction in reinforcement obtained by increasing the concrete strength in the end-block is shown and indicates that in a military design it might well be worth attempting to obtain a high concrete strength for the end-blocks whilst accepting a lower strength for the remainder of the beam.

Simplified Analysis of Cylindrical Shells and The Analysis of a Bridge Framework with Inclined Legs. These two articles complete papers which appeared in the August issue. The first gives a series of tables listing stress constants for cylindrical shells; the second shows by examples the application of the analytic approach described in the August issue. Both are specialist subjects and are not for the beginner.

Construction Equipment Digest. This Supplement to Civil Engineering and Public Works Review describes and illustrates an interesting range of current and new Construction plant and equipment. One machine of particular interest (and now marketed in the United Kingdom) is the CASE "530 Construction King". This compact American wheeled excavator is fitted with a front shovel and can dig a trench to a depth of 14 feet. Also illustrated is the silent pile driver introduced last year by Taylor Woodrow Construction Ltd. C.F.R.

Notes from *Civil Engineering and Public Works Review*, October 1964

New System of Constructing Marine Piers and Elevated Motorways over Water. This article claims to describe a new system, subject to British Patent, for constructing piled piers. Although of some general interest, it is very difficult to see what new ideas are involved to warrant the patent. It may be that, in order to protect the patent, a few important items have not been described but, overall, the system appears to be no different from current practice.

Test Results on Mild Steel Reinforced Glulam Timber Beams. In January 1964 an article was published describing tests being carried out on glued laminated beams with mild steel reinforcement. This article gives some of the test results and describes

the general progress of the tests. Although no firm conclusions can be drawn yet, valuable information has been obtained on the bond between steel and timber or glue and how this affects the mode of failure.

EARTHQUAKES AND EARTHQUAKE-RESISTANT BUILDINGS IN JAPAN (PART 3). Continues a series of articles on the design of structures with reference to earthquake conditions. This part deals with the composite construction of steel and concrete recommended by the Building Standard Law and also describes the special problems which were met in the design of the Atomic Power Station at Tokai Mura.

AN ULTIMATE FLEXURAL THEORY FOR UNBONDED PRE-STRESSED CONCRETE BEAMS (PART 1). This article compares the results of many tests on unbonded pre-stressed concrete beams with CP 115:1959: The Structural Use of Pre-stressed Concrete in Buildings. This part mainly introduces the notation and the basic theory and discusses the mode of failure.

MAMMOTH OPERATIONS FOR EARTHMOVING ON OROVILLE DAM CONTRACT. This article describes the construction of the Oroville Dam in the California State Water Project. The dam will be the highest embankment dam in the world when it is completed at 747 ft high and involving 78,000,000 cu yd of fill. A vast array of plant is being used including a specially designed wheeled excavator capable of handling about 3,000 cu yd/hr.

CONCRETE CONSTRUCTION IN CALIFORNIA—SOME RECENT APPLICATIONS OF SLIP-FORM TECHNIQUES. Describes a number of uses to which the slip-form technique have been put in America. These include the construction of long hollow pre-stressed piles and several examples of the cores of multi-storey buildings including one in light-weight concrete. The article also describes construction using hyperbolic paraboloids and the construction of a 210 ft diameter dome by casting it on a prepared mound of earth and then excavating the earth.

D.F.M.

Notes from *Civil Engineering and Public Works Review*, November 1964

THE CONTROLLED BLASTING OF BOULDERS. An interesting short article translated from a recent Russian technical journal. It describes an investigation, using very high-speed cameras, of the actual disintegration of a blasted boulder. Based on the investigation, a new method of blasting was developed, using small charges tamped with water. Recommendations for the size of drilling, charge, etc are given. The method would appear to be very suitable for rock blasting in general, especially in restricted or built-up areas.

RAPID TECHNIQUE FOR ESTIMATING SEEPAGE DISCHARGE. The estimation of seepage flow beneath a water-retaining structure founded on permeable soil is a difficult task. It is none the less a highly important factor in the design of dams, aquaducts etc. The traditional approach is to construct a flow net giving two sets of orthogonal curves; equipotential lines (or lines of constant total head) and flow lines. This method is often tedious, and is at best an approximation. A purely analytical technique has been used successfully in simple cases, but this again is difficult. The difficulties in these methods can be avoided by making use of an electrical analogue; either an electolytic tank or conducting paper. These analogues are based on the fact that the steady-state flow of current in a conducting medium obeys the same laws as seepage water in a permeable soil. Electric potential corresponds to total head, current to rate of seepage flow, and conductance to permeability. This article developes the theme a stage further, and describes a technique whereby values of seepage can be obtained rapidly and simply from direct electrical measurements without having to construct a flow net. The accuracy of the method is shown to be within 2 per cent of the values given by analytical solutions where these are available.

SHEAR EFFECTS IN BEAMS REINFORCED WITH SPECIAL STEEL BARS. In recent years the use of deformed bars as reinforcement has increased considerably. Many types are available and are claimed to be superior to plain mild steel bars. The Code of Practice for Reinforced Concrete (C.P. 114) allow a 25 per cent increase in bond stresses for such bars. This article describes the results of tests to determine the performance of square twisted bars used as shear reinforcement. On the whole deformed bars are shown to be advantageous when used as stirrups, and the authors recommend an increase in permissible stress in square twisted stirrups to 24,000 lb/sq in.

C.F.R.

Notes from *Civil Engineering and Public Works Review*, December 1964

EFFECTS OF ADVERSE WEATHER ON BUILDING AND CIVIL ENGINEERING OPERATIONS. The problems of rain, low temperature, high winds and poor visibility are considered, mainly in respect of working hours lost. The information on rain and low temperature is supplemented with tables showing, for each month of the year, the average percentage duration of heavy rainfall, and the average percentage of working hours with temperatures below 34°F; separate values in the tables are based on records from London, Manchester and Glasgow. Precipitation of over 0.5 mm/hr is considered sufficient for work to be "rained-off", although a lesser figure may make conditions unbearable if the temperature is low. As well as causing interruptions in almost all concreting work, extreme low temperatures increase the risk of accidents and may well hinder excavation work; sometimes however frost may be an advantage. The information given should be most useful in estimating the probable duration of any large project in the UK.

CONSTRUCTION OF THE FOUNDATIONS OF A STEAM GENERATING HEAVY WATER REACTOR. This refers to a new experimental reactor being built at Winfrith Heath in Dorset. The subsoil is of gravel and sand with pockets of silt; well-point dewatering was necessary, and led to considerable washing out of the silt pockets; the steps taken to alleviate this condition are given. The concrete enclosure for the reactor had to be airtight and extremely rigid; special attention was paid to compaction and to the construction joints; the concrete work is described in some detail.

OBLIQUE MOMENTS APPLIED TO COLUMN FOOTINGS, RC COLUMNS, AND RC BEAMS. For a plain rectangular concrete member, there are six typical shapes for the compressive stress diagram, depending on the proportions of the base and applied moments. Tables and formulae are given to enable suitable sections to be designed for any loading; the method, which can be extended to more complicated shapes, entails trial and error, so that some experience is necessary in choosing suitable dimensions. The apparently complex design system is fortunately illustrated with several worked examples.

CONSTRUCTING THE NEW GLADESVILLE BRIDGE. This bridge has recently been built a few miles upstream of the famous Sydney Harbour Bridge. The main span of 1,000 ft consists of four concrete arches side-by-side and made up from precast hollow box units. The roadway is carried over the approaches and arch on a system of precast columns and beams. Erection work entailed falsework resting on piled supports across almost all the water gap, with only a 220 ft span left for navigation. This is an interesting general article on the whole project.

CAR PARK FEATURE. A special feature this month reviews current practice in the provision of off-street car parks, and examines various systems. Particular attention is paid to economics, and to the policy for provision of car parking facilities; some interesting illustrations and descriptions of recently built car parks are included.

J.C.P.

Notes from *Civil Engineering and Public Works Review*: January 1965

CANADIAN RESEARCH ON MECHANICAL FASTENERS IN TIMBER CONSTRUCTION. This article describes experiments carried out at the Forest Products Research Branch of the Department of Forestry of Canada. It mainly covers the withdrawal resistance of nails and considers how the withdrawal resistance varies with surface finish of the nail, moisture content of the timber, method of driving, mode of failure and other factors. It also contains an interesting report of how modern architecture and living conditions have altered the snow loading on roofs, so that what was accepted good practice in the construction of roof joints is now unsafe.

THE USE IN PRE-STRESSED CONCRETE STRUCTURES OF LIGHTWEIGHT-AGGREGATE (LYTAG) CONCRETE. The May and June 1964 issues of *Civil Engineering and Public Works Review* contained an article on the use of Lytag concrete in reinforced concrete beams. CP 116 (Draft) permits the use of lightweight aggregate concrete in pre-stressed precast concrete members. This article gives the results of tests to determine the properties of Lytag concrete, modulus of elasticity, shrinkage and creep etc., and concludes that, although, due to creep, loss in pre-stress is high, there is still a worth-while saving in dead weight over members made from gravel concrete.

THE 4,2000 FT LONG MANCUNIAN WAY. Describes the construction of pre-stressed concrete elevated roadway as part of a comprehensive scheme for improving traffic flow in the Manchester area. The roadway is supported on *in-situ* reinforced concrete columns on piled foundations (bored piles and cylinders), the roadway itself being constructed of pre-stressed concrete units stressed together.

A 300 TON RAIL BRIDGE PLACED AT MILL HILL. A short report on the rolling in of a 75 ft long 300 ton railway bridge at Mill Hill. The bridge was constructed on military trestling and rolled sideways 40 ft on large ball bearings to its final alignment.

D.F.M.

THE MILITARY ENGINEER

SEPTEMBER–OCTOBER 1964

ENGINEERING PROPERTIES OF NUCLEAR EXCAVATIONS, by Captain Louis J. Cicero, Corps of Engineers US Army. The Atomic Energy Commission and the Army Corps of Engineers are engaged on a joint programme to develop nuclear excavation technology. This article describes some of the tests carried and the conclusions drawn from them. There is no account of how the nuclear explosions are produced nor is there any reference to radio-active hazards.

TEST FACILITIES FOR NUCLEAR ROCKETS, by Colonel B. F. Rose Jr and US Army Reserve (retd.) The Russians are said to be active in this field but from this article the Americans must be well up with them if not ahead. The article is a description of the nuclear rocket engine test installation which is being constructed at the Nevada Test Site at Jackass Flats not far from Las Vegas. The installation will be used for ground testing hydrogen fueled Nerva, the first American full-scale nuclear rocket engine which is now in development. In Nerva the addition of heat to a lightweight propellant (hydrogen) by means of a nuclear reactor will nearly double the specific impulse of present chemical systems. Severe requirements imposed by the nuclear radiation field and large flow rates of high-temperature hydrogen in the exhaust presented unprecedented technical difficulties and design problems. The problems and their solutions are discussed in this interesting and well illustrated article.

REMOVAL OF NUCLEAR REACTOR CORE—CAMP CENTURY, By Captain Joseph P. Franklin and Captain William T. Stockhausen, Corps of Engineers US Army. Camp Century is the "City under the Ice" 138 miles out on the permanent Greenland ice cap built

by the Army Polar Research and Development Centre in 1960. The decision to close the camp for the winter 1963–4 involved the removal of the nuclear reactor core of PM-2A, the 10-mw (T) portable nuclear power plant which had provided electrical power to the Camp since March 1961. The plant was described in an article in *ME* Sept–Oct 1961. Interesting details of the design of the power plant are given and a very complete account of how the dismantling was carried out. There are good illustrations.

Company A Engineers in Mexico, 1846–7, by Gustavus W. Smith, formerly Lieut and Brevet Captain, United States Army. Until the war with Mexico there were no enlisted engineer soldiers in the United States Army. The Corps of Engineers consisted of officers only, in spite of strong recommendations from the Chief of Engineers. Soon after hostilities with Mexico broke out, however, authority to raise a company of engineer soldiers was given and this article describes the formation of the unit and its experiences in the early stages of the war.

Multi-use Defence Centre, by Charles D. Morrisey. This is a description in considerable detail of a centre for emergency operation of the State government which has been provided by New York State near the State capital at Albany. The centre is a blast-resistant two-story concrete structure buried below ground and designed to resist the effects of 50 psi overpressure. The above-ground building houses military and civil defence branches of the State government.

Earth Sciences in Tomorrow's Engineering, by Christopher E. Barthel Jr. The Coast and Geodetic Survey conducts activities in certain areas of the earth sciences. This article summarises many of these activities and describes fields in which further progress may be expected. The subjects covered are, oceanography, photogrammety and geodesy-seismological research and the development of new navigational systems and aids. The future is discussed in relation to new engineering requirements, for instance ocean floor mining engineering, cartographic engineering, the provision of charts and maps to meet the needs of high speed movement among other things, and earthquake engineering with a view to improving the position regarding forecasting earthquakes.

The article describes how the above studies are related to the rapid progress in science and technology which is taking place and many of the methods being used.

Engineering For Inner Space, by Captain W. J. Christensen, Civil Engineer Corps, US Navy. "Inner Space" is an expression used to describe the oceans of the world which are as little explored as outer space and are, from an economic and defence point of view, as important. This article describes the exploratory work in progress under the direction of the Naval Civil Engineering Laboratory into the problems of construction work on the sea bed of the continental shelf and in deeper waters. The structures envisaged may include antisubmarine warfare gear; navigational beacons; research towers and structures; underwater communication facilities; repair facilities and anchorages; power stations; supply and storage systems and, in the words of the article, things yet to be conceived. The problems are similar to but widely different from those of construction on land. The nature of the foundation soils is being studied by the extraction of cores. The magnitude of the forces which can be expected against ocean structures can be compared with the forces of the wind but a 3 mph ocean current exerts forces approximating to those produced by a 90 mph wind. These and many other factors are referred to in this interesting and well illustrated article.

Military Engineer Field Notes

Deep Sea Diving Engineers, by Captain Lawrence E. Crawford, Corps of Engineers US Army. This is a description of the training course for army divers which qualifies them as salvage divers. The course lasts sixteen weeks.

TACTICAL AIR AND SURFACE MINING, by Harry C. Smith. The Army Engineer Research and Development Laboratories have a research programme "Multiple Mining Methods" of which the object is to devise methods of producing rapidly, artificial barriers to enemy movement. Minefields are an obvious part solution and this short article describes a plastic mine under consideration which could be laid from army aircraft from heights up to 3,000 ft. No design details are given and it is probable that the problem has not yet been completely solved.

UNUSUAL BRIDGE CONSTRUCTION AT "30 BELOW", by Captain Charles F. Neale Jr, Corps of Engineers. This describes the method adopted by an Engineer Battalion in constructing a Bailey bridge across a frozen river in Alaska when they found that the rollers were frozen solid and defied all efforts to thaw them. The essence of the method was the construction of two timber crib piers on the ice and launching the bridge across them, keeping the level right by using supporting jacks on sleds. J.S.W.S.

THE MILITARY ENGINEER

NOVEMBER–DECEMBER 1964

HYDRAULIC ASSIST FOR SUPER SHIPS, by John F. Paterson. The builders of the Panama Canal did not foresee the "super" ships of the present day which in some cases have a beam only 5 ft less than the width of the locks, and power is needed literally to ram them through the locks. In this well illustrated and interesting article the working of the locks and the method by which the difficulty has been overcome is described. This is called the "Hydraulic Assist" and briefly consists in admitting water from the upper level into the lock behind the ship, which has the effect of driving it forward.

MINUTEMAN AUGERED IN, by Captain Leroy D. Hammond, Corps of Engineers. Specifications required that a shaft 15 ft in diameter should be sunk 95 ft in the ground at each end of the two hundred launcher sites required by Wing V of Minuteman ICBM system. The article is an account of the way in which this was carried out by using specially designed earth augers. When using the 15 ft auger the rig is the largest post-hole digger in the world. There are clear photographs in illustration.

NUCLEAR EXCAVATION APPLICATIONS, Captain Louis J. Cicero, Jr. This is a continuation of an article "Engineering Properties of Nuclear Excavations" published in the Sept.–Oct. number of the Journal. Applications concerned with roadway excavation, drainage, aggregate production and landslide control are described in some detail with illustrations. There is no information on how the radio-active dangers are avoided.

VERTICAL ASSEMBLY BUILDING, by Max O. Urbahn. The Vertical Assembly Building at Merritt Island Florida ia s completely enclosed structure for the vertical assembly and check-out of space vehicles and their components. Specifically, it is designed for the Saturn V on which the Apollo spacecraft will be mounted. In order to enclose a completely assembled Saturn V which stands 362 ft high the building itself rises above the ground to a height of 524 ft. At its base it measures 513 ft by 692 ft and covers about 8 acres. It will be the largest building in the world. The article gives some details of the accommodation being provided and touches on some of the major technical problems which had to be solved, for instance the design of the doors through which the vertical space vehicle, 425 ft high, has to be passed. As the author says "The highlights of the design features and problems faced in this enormous project have only been touched upon. The scope, size, and complexity of the Vertical Assembly Building are almost beyond the comprehension of anyone on this project. Nevertheless the building has been designed and it is being constructed for the moon exploration project Apollo."

DIGITAL COMPUTERS IN ENGINEERING, by Watts S. Humphrey, Jr. A description with diagrams of the various uses to which computers can be put with particular reference to their value in helping the engineer to solve problems of design.

THE MOBILE FLOATING ASSAULT BRIDGE FERRY. This equipment was fully described in the December 1964 issue of the RE *Journal*.

US NAVY SNOW-COMPACTION EQUIPMENT, by Robert Easton. The US Navy first investigated the feasibility of producing static and dynamic load-bearing snow in the Antarctic in 1947. Since then cold-processing snow-compaction techniques have been developed that will produce high-strength snow which will support vehicles and aircraft on snow fields. The equipment includes a snow mixer, to pulverise and intermix (depth process) the natural snow, and a large roller to compact the pulverised mass, as well as drags, planers, finishers and sprayers. This article describes these machines and explains their use. There are numerous illustrations.

USING SPACE FOR GEODESY, by Lt Col Edward G. Anderson, Corps of Engineers. This is a description of the SECOR system which is essentially an electronic distance measuring device making use of the intermediary space positions of artificial satelites in determining geodetic positions on earth. The theory of the system is discussed and then, in considerable detail, the design and employment of the various pieces of equipment are described and illustrated.

ENGINEERING MATERIALS FOR TOMORROW'S CONSTRUCTION, by Col Alex G. Sutton, Jr. and Frederick R. Brown. After describing in general terms the need for continued research into the provision of new materials for all kinds of engineering techniques the article discusses at some length the advances being made in the field of concrete with particular reference to the use of nonmetallic reinforcement, ultra-strength concrete as high as 15,000 psi, expanding concrete to combat shrinking, and ultra-light concrete. The latter is useful for thermal insulation. It has a military application as a surround for underground structures isolating them from earth motion caused by nuclear detonations. Other subjects covered are soil stablization and materials for protective construction. For this research a blast load generator has been devised of which a description is given.

ERDL NOTES. These contain a photograph of the Combat Engineer Vehicle (CEV) which will soon undergo field tests. It is an advanced type of AVRE with an A frame boom capable of lifting 30,000 lbs and a bull-dozer blade. It is armed with a 165mm assault gun. There is also a note on an explosive device for the rapid excavation of foxholes in hard earth.

MILITARY ENGINEER FIELD NOTES

TESTING THE TANK DOZER, by Major Richard E. Leonard, Corps of Engineers. An account of tests being carried out, with photographs of the CEV referred to above.

BLAST IT WITH FERTILIZER, by Capt. John R. Hill, Corps of Engineers. A blasting agent is a chemical or chemical compound that will detonate only with a powerful booster charge. The most widely used one is a combination of ammonium nitrate and fuel oil known for short as ANFO. The note describes the method of use and the advantages of ANFO.

STUDIES OF SEA ICE, by N. S. Stehle and Robert Easton. In addition to the studies in snow compaction referred to in the article "Navy Snow Compaction Equipment", reviewed above, the Naval Civil Engineering Laboratory has developed a technique for thickening sea ice at a faster rate than occurs naturally, mainly to provide aircraft runways.

J.S.W.S.