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THE ROYAL ENGINEERS JOURNAL

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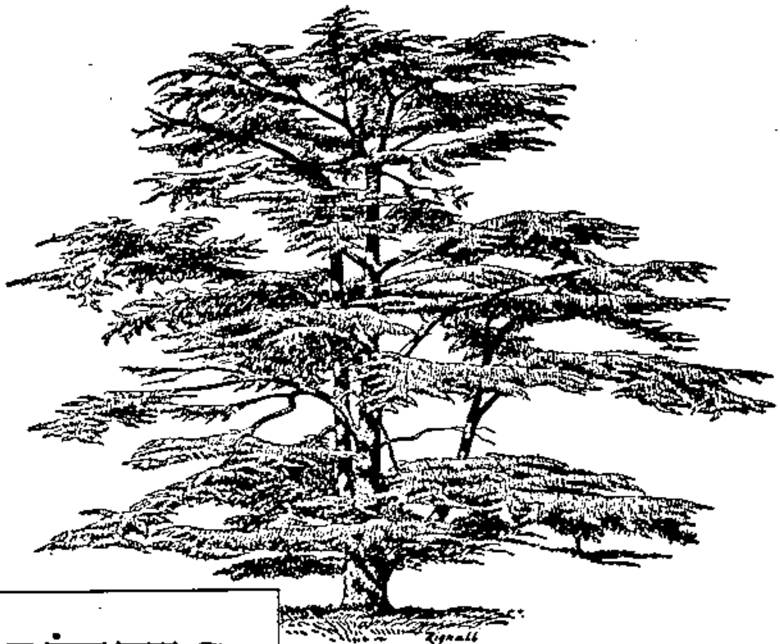

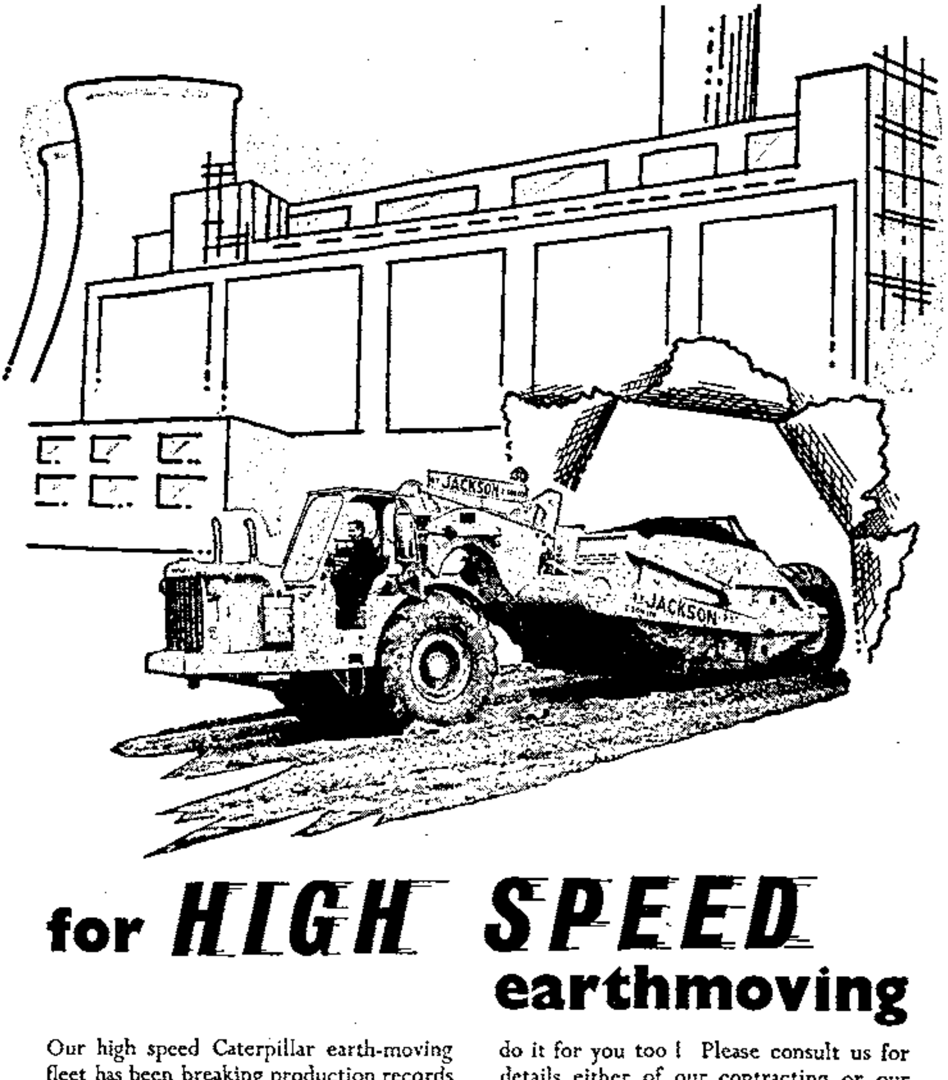
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THE ROYAL ENGINEERS JOURNAL

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PRESENTATION TO H.M. THE QUEEN

Gold and enamel brooch set with diamonds and rubies

PRESENTATION TO ROYAL AUSTRALIAN ENGINEERS

Major-General Shortt handing over the candelabra to Lieut.-Colonel Flint, R.A.E.

Presentation to HM the Queen, Royal Australian Engineers

PRESENTATION OF R.E. BROOCH TO H.M. THE QUEEN

The Corps Committee consisting of The Chief Royal Engineer, General Sir Edwin L. Morris, K.C.B., O.B.E., M.C.; The Representative Colonel Commandant, General Sir Kenneth N. Crawford, K.C.B., M.C.; The Engineer-in-Chief, Major-General J. C. Walkey, C.B., C.B.E.; The Commandant, S.M.E., Brigadier H. C. W. Eking, C.B.E., D.S.O.; and The Assistant Adjutant-General, Colonel G. C. Clark, O.B.E., visited Buckingham Palace on the morning of 4th May to present a regimental brooch to her Majesty the Queen.

The Queen received the Committee alone in a small drawing-room and the Chief Royal Engineer then made the presentation with the following words:—

"Your Majesty we have long wished to present you, as our Colonel-in-Chief, with a regimental brooch.

"We have chosen the occasion of your birthday in order to convey to you with our humble duty the affection as well as the loyalty of all ranks of the Corps of Royal Engineers."

The Queen expressed herself as being delighted with the brooch and then talked for half an hour to all members of the Committee in turn about various aspects of the organization, duties, and welfare of the Corps, in all of which Her Majesty showed great interest.

The following letter was subsequently received from Buckingham Palace:—

Buckingham Palace,
5th May, 1955.

Dear General,

The Queen desires me to write to you and to convey to you and to all ranks of the Corps of Royal Engineers her very warm thanks for the beautiful brooch, which you brought to her yesterday.

It will cause Her Majesty great pleasure, as well as pride, to be able to wear the badge of the Corps, of which she is Colonel-in-Chief, in such an attractive form, and she particularly wishes you to know how grateful she is to you personally for the trouble which you have taken in having it made.

The Queen was very glad to have the opportunity of having a few words with the members of the Committee of the Corps of Royal Engineers, and she sends her best wishes for the success and future prosperity of all who serve in the Royal Engineers.

Yours sincerely,

(Sgd.) M. E. Adeane.

General Sir Edwin L. Morris, K.C.B., O.B.E., M.C.

The official description of the brooch is as follows:—

A Royal Engineers Badge Brooch, with diamond set crown, laurels and centre. Cabochon rubies set as the laurel berries. The Garter, Royal Engineers Ribbon and the Crown cushion are made of gold and are enamelled. The diamonds are all set in platinum, and the whole piece is mounted in gold.

An illustration, showing the brooch to approximately its original size, is reproduced on the frontispiece facing page 206.

PRESENTATION OF A PAIR OF CANDELABRA TO THE OFFICERS OF THE ROYAL AUSTRALIAN ENGINEERS BY THE OFFICERS OF THE ROYAL ENGINEERS

A PAIR of silver candelabra was recently presented by the officers of the Corps to their brother officers of the Corps of Royal Australian Engineers.

The formal presentation was made at a special guest night at the Royal Australian Engineers Officers' Mess, Casula, New South Wales on 10th March, 1955, by Major-General A. C. Shortt, C.B., O.B.E. (late R.E.), who is the Chief Liaison Officer of the United Kingdom Service Liaison Staff in Australia.

The candelabra are suitably inscribed "as a token of friendship and esteem" and carry the two mottoes, "Ubique" and "Facimus et Frangimus", of the respective Corps.

In making the presentation, General Shortt said how proud and pleased he was, as a Sapper, to make this presentation on behalf of his brother officers. He spoke of *ésprit de corps*, and likened regimental tradition to a baton handed on by one runner to another in a relay race—each runner strove to maintain, and if possible improve, his team's position in the race; so each succeeding generation strove to add lustre to the tradition of their Regiment or Corps. Regimental tradition, in the British Army, was generally enshrined in the Headquarters Officers' Mess, where were displayed its regimental colours; medals and portraits of its more distinguished sons; and the regimental plate.

General Shortt went on to describe the appearance of the dining-room in the Corps Headquarters Mess at Brompton Barracks, Chatham, on the occasion of a formal guest night in the days when scarlet mess kit was still worn and when such occasions were a weekly occurrence. He recalled the portraits which lined the walls; the string orchestra in their scarlet tunics; the drill for removing the long damask cloths; and the superb collection of plate to be seen on each of the tables—each piece, he said, commemorated some campaign in which the Corps had played an active part, or some outstanding personality such as Kitchener or Burgoyne. Our plate was in effect a history of the Corps portrayed in silver.

General Shortt concluded by saying that in presenting this piece of plate to the officers of the Royal Australian Engineers, he was, so to speak, passing on the baton, linking our traditions with theirs, as from an old experienced hand, to a young and vigorous runner with the fullness of his achievements still to come.

Lieut.-Colonel C. F. Flint, R.A.E., Chief Instructor of the Australian School of Military Engineering, who presided at the dinner, accepted the candelabra on behalf of the officers of the Royal Australian Engineers. In expressing their appreciation he said that the presentation would serve to strengthen the close affiliation already existing between the Royal Engineers and the Royal Australian Engineers. The two Corps had served and fought side by side in two world wars and together formed a part of an integrated force in the British Commonwealth Forces, Korea. He himself had had the honour of commanding an engineer regiment there comprising Royal Engineers, Royal Australian Engineers and Royal Canadian Engineers, who had all worked together in a very happy team.

Major-General Sir Clive Steele, K.B.E., D.S.O., M.C., V.D., Colonel Commandant of the Royal Australian Engineers, was unfortunately unable to be present, but sent the following letter which was read out by Lieutenant-Colonel Flint:—

"Will you please convey to General Shortt and the other Royal Engineers present, my regret at being unable to be at the S.M.E. on the occasion of the presentation of plate from their Corps to ours.

"Will you also please tell them that in the few generations our Corps has been in being, it has always tried to live up to the traditions, first expressed by Kipling—

> "They send us ahead with a fuse and a mine
> To blow up the gates that are rushed by the line
> But bent by Her Majesty's Engineers,
> Her Majesty's Royal Engineers . . .

"With every good wish to those present and my personal appreciation of the thought behind this gift.

Yours sincerely,

CLIVE STEELE."

Some eighty officers who were present at the occasion included Lieut.-General E. W. Woodward, C.B.E., D.S.O., G.O.C., Eastern Command, Brigadier R. R. McNicoll, the Engineer-in-Chief, and Brigadier B. F. Hussey, Chief Engineer, Eastern Command.

THE YEARS BETWEEN

By Lieut.-Colonel W. G. A. Lawrie, R.E.

Introduction

TROTSKY once said that if any man was looking for a quiet life he ought not to have got himself born into the twentieth century. This is the twentieth century whether we like it or not and we have got to face the facts of the time in which we live.

The March issue of the *R.E. Journal* contained two attempts to face the facts which must have given everyone a lot to think about. Lieut.-Colonel Bennett's article suggested that our immediate policy should be to reduce our overseas garrisons and create a lightly equipped air transportable strategic reserve in the United Kingdom. In the next article, "Benbow" described a land of Green Bull's-eyes which although not everybody's Utopia had several features well worth striving for—economic self-sufficiency, military security and freedom from domestic chores.

Lieut.-Colonel Bennett's England is almost upon us. Is there any hope of escaping from our condition of a nervous hedgehog to the green and pleasant land we would all like to see? This article is an attempt to point out the fallacies of the present short-term policy and to show how we might plan ahead in the years between, first of all to create adequate and well balanced forces and then to establish conditions favourable to a lasting peace.

The Time Factor

Our strategic policy can only be discussed in relation to two sombre facts which overshadow current affairs—Russia's inflexible determination to rule the world, and her possession of the thermonuclear bomb, which gives her the power to destroy our most vital asset—the great body of skilled artisans whose forebears established our industrial supremacy in the nineteenth century, and who alone can produce the machinery and weapons we require for prosperity in peace or success in war.

A dozen well-aimed five-megaton bombs on our industrial regions could wipe out this labour force in one night, and deal us a blow from which it would take us a hundred years to recover. It would give us little satisfaction to know that American bombers would annihilate Russia's factories the next night.

Marshal of the Air Force, Sir John Slessor has said that our strategic policy must be designed "to drive militant Communism back behind it's frontiers and keep it there". This is not enough. The first essential of our strategy is to enable us to survive; then we must plan to drive militant Communism behind its frontiers, and having got it there, we must overthrow its leaders so that the world can breathe again.

In this new Elizabethan age, the deeds and words of Sir Francis Drake are much in men's minds. The prayer which he wrote for his sailors and soldiers on the eve of one of the earliest and most successful of combined operations is most appropriate to our cause today:—

"O Lord God, when Thou givest to Thy servants to endeavour any great matter, grant to us also to know that it is not the beginning but the continuing of the same until it be finished, which yieldeth the true glory."

If we continue united in that spirit and resolution, we may in the end achieve the true glory of peace. Our aim must be peace not only in our time, but in the time of our children's children.

Russia's foreign policy is the result of 2,000 years of isolation, ignorance, oppression and defeat. "The History of Russia", declared Stalin in 1931 "is the history of defeats due to backwardness—military, cultural and agricultural backwardness. She was beaten because to beat her was profitable and could be done with impunity."

At that time, Russia's annual production of coal and steel was only 40 million and 5 million tons respectively. Her industrial backwardness was forcibly brought home during the war with Germany, when she had to be supplied among many other items with 500,000 lorries.

Today she can manufacture that number herself in a single year, and her production of coal and steel has increased by 700 per cent.

The failure of the first Five Year Plan was due to the human element. The workers had not been educated and trained to run a mechanized state. Russia's terrific increase in productive capacity, especially since the war, has been achieved at the expense of the standard of living of her people. The possibility of human failing is still her Achilles' heel and her government know it. The rigid ban on personal contacts with the Western world was imposed in order to conceal from the Russians how far they lagged behind other nations in the everyday standards of food, clothing and the supply of consumer goods.

The rapid progress in Russia's industrial capacity recently enabled her rulers to release more essential materials to meet the needs of her people and so they have relaxed the ban on foreign travel. This is reflected in the recent participation of Russian teams in all sorts of sporting activities on this side of the Iron Curtain; though we have still to see Cossacks riding in the Grand National.

Russia's immediate concern is to raise the standard of living of the man in the street, and so prove that Communism has as much or more to offer than Democracy. Until her attempt to win over world opinion by force of example fails, we may expect the present Cold

War to continue. It may well be ten or twenty years hence before she is ready to embark on a major offensive.

Fortunately the greater skill of our designers and technicians has given us a lead in the field of nuclear warfare. Our first priority task is to retain this technical superiority and to use it as an umbrella behind which we can reorganize our resources.

Our Present Weaknesses

Every strategist tries to read the mind of the enemy. In the case of Russia it is made easier if we remember that chess is her national game and that Russian children are brought up on it. Russian statesmen cannot help visualizing the world as a chessboard, and her armed forces and fellow travellers as the pieces they can move. The early events of the Cold War represent the opening gambits of her pawns and our replies; so far the Red officers are poised in reserve while their future moves are being planned.

The hand-to-mouth character of our strategy since the war has been forced upon us by the skill with which Russia has made her moves, in order to cause us the greatest inconvenience and waste of effort, and to exploit our strategic weaknesses.

Let us examine these weaknesses and see what steps can be taken to remove them. The first difficulty that confronts us is the high concentration of vital targets in the United Kingdom. It is true that this also makes them easier to defend, but it is unsound that our first thoughts should be of defence, when it is unlikely that any concentration of fighter squadrons, guided missiles or anti-aircraft artillery could guarantee anything approaching 100 per cent protection, which is required against atom bombs.

The second basic weakness in our position is our dependence on the North Atlantic sea route, which employs a large proportion of our naval and air strength in a purely defensive rôle. During the last war, the lowest annual rate of imports into the United Kingdom was about 39 million tons. Bearing in mind the reliance of the Western Powers on American aid, there is no reason to suppose that the rate of imports via the North Atlantic pipe-line in the next war would be lower, unless far-reaching reorganization of our needs took place with a view to reducing the scale of naval protection required.

Our other great problem is shortage of manpower. The same type of reliable man is required in essential industries and also in the services. Ways must be explored of obtaining a higher contribution from the other Commonwealth countries, and at the same time all our service establishments must be pruned and pruned again till they are really streamlined.

Thus whatever strategic policy we adopt, it must provide for a reduction in our purely defensive commitments in the United Kingdom and North Atlantic, and for an over-all improvement in our manpower position.

Global Strategy

Our greatest strategic asset, of which we have never taken full advantage, is the fact that we own bases or potential bases which almost encircle Russia, and can force her, if not to fight, then at least to look in several directions at once. These bases should be developed in order to counter her apparent advantage of interior lines. Provided we walk arm in arm with the other members of the Commonwealth we have an advantage in the matter of strategic dispersal possessed by no other nation. Our over-all position could be transformed inside the next twenty years if we embarked with the United States on a policy of developing a ring of independent and interdependent support areas round the ice-free shores of the Soviet bloc.

These support areas would consist of the following geographical zones—Europe, Mediterranean, South-East Asia and Far East (an American responsibility) in the front line, with Africa and North America in reserve. It is fortunate that the necessary associations are now being formed. N.A.T.O., reinforced as it may soon be, by the Western European Union, holds the vital European front from Norway round to Turkey. On the Eastern European flank is the new Balkan pact linking Turkey, Greece and Yugo-Slavia. East of that again a new link is being formed which will join Turkey with Iraq and Pakistan. The latest evidence of the desire to unite for mutual protection against Communist aggression is provided by the conclusion of the South-East Asia Collective Defence Treaty. The only gap in the front line is the Indian sub-continent. Every effort should be made to encourage India and Pakistan to compose their differences and to present a united front against the Communist threat which is now so near them. Once this political problem is solved there is little doubt that these two countries, with their great military traditions and tremendous resources of potential soldiers would join the circle and form an additional support area.

Each support area would require to be as far as possible self-contained, with its own factories, airfields, dockyards and other base installations, its own training organization and training areas, and a high proportion of the service personnel locally recruited. This system would at one blow remove many of the strategic weaknesses from which we are now suffering. Many vital targets could be located away from the United Kingdom, the strain on the North Atlantic route would be relaxed, and our manpower difficulties would be greatly relieved, both by an increased measure of local recruitment and by the release of personnel employed on static defence tasks in the United Kingdom.

Under the circumstances outlined above, it is reasonable to assume that the Cold War will continue for a number of years, and we may therefore expect a series of Moscow-sponsored anti-imperialist uprisings and carefully controlled agitation among the working populations in order to hinder economic development on our side of the Iron Curtain and to force us to disperse our strength and squander our resources. It follows that we must maintain garrisons in all our overseas territories in order to uphold law and order, and guard vital installations. From time to time we may expect to have to reinforce those garrisons whenever the Kremlin moves another pawn.

The Disposition of Mobile Reserves

In order to give effective support to the overseas garrisons, the mobile reserves must be held in a secure base where they can maintain a high state of efficiency and from where they can reach the danger spots in time. Only if the U.K. fulfils these essential operational requirements should it be considered as the location of our strategic reserve. In fact the U.K. is not a secure base. It must essentially contain the organizations required to support our continental armies. The hydrogen bomb has made far more vulnerable and doubtful the proposition of locating additional troops, airfields and base depots superimposed on existing installations in this country. A great part of our mobile reserve might well be destroyed before they ever left England. Neither is the U.K. a place in which troops can reach a high standard of efficiency. In the first place, nowhere in the British Isles can training areas be found where the climate and terrain correspond in any way to those countries where we might fight the Russians, such as the jungles of the Far East, the rocky hills, rolling plains or deserts of the Middle East or the ice and snow of the Far North. Training for European warfare can be carried out without difficulty and far more effectively in Germany over the actual ground where the battles might be fought.

In the second place, the only training area in the U.K. where formation training with armour can be carried out at all is Salisbury Plain. This is extremely restricted and heavily booked. The Schools of Artillery and Infantry, located on the edge of the plain, and the R.A.F. experimental bombing establishment at Boscombe Down could easily make use of the entire training area throughout the year on their own. But the whole conception of British strategy is based on keeping the Territorial Army efficient and able to take its place in the front line in the shortest possible time after mobilization. Even if each Territorial Army division carries out formation training only once in four years, this still entails handing over Salisbury Plain to the Territorial Army for six weeks in the summer and autumn every year.

The greater use in the future of heavy tanks, atomic warheads and guided missiles, will increase the already highly organized opposition to the use of Salisbury Plain as a training area by vested interests such as the County Agricultural Committee, the local highway authority, the Society for the Preservation of Historical Monuments, and owners of gallops for training racehorses, all of which must be handled with respect by an army controlled by elected politicians. In short, if additional divisions stationed in England had to carry out their training on Salisbury Plain, it could only result in dangerous congestion and loss of efficiency by all concerned. Furthermore it is doubtful if any formation can really get down to serious training when the week's work is only regarded by the troops as something to fill in the time between week-ends.

Overseas Garrisons and Support Areas

Our mobile strategic reserve can only fulfil its rôle by being stationed in the support areas. Each support area would have the responsibility of reinforcing a number of garrisons and would be given the necessary resources to do this. The troops in each support area would be specially trained and equipped for this rôle. This policy would impose additional tasks on the garrisons themselves, namely,

(*a*) Holding, maintaining and turning over mobilization equipment including tentage and accommodation stores, rations, petrol, clothing, ammunition, weapons, vehicles and armour. Reinforcements could then be flown in on a light scale and would come into action with the minimum of delay.

(*b*) Holding exercises and cadres at regular intervals for Officers and N.C.Os. of the mobile reserve in the nearest support area.

(*c*) Maintenance of up-to-date operational plans and intelligence records.

In order to carry out its rôle of providing immediate trained reinforcements to any of its garrisons it is clear that a support area must hold at least a division in reserve, with all its ancillary depots and training establishments. It must also contain sufficient airfields and the requisite maintenance organization to enable large-scale troop movements to be carried out by air, and to be provided with air support. Finally in order to protect shipping engaged in carrying essential military supplies, naval forces must be based on the support area, which should therefore contain adequate dockyard facilities. These service installations would be of little value unless they were backed up by the necessary industrial potential and skilled technicians required to maintain them.

The main difficulty in implementing this policy would be to find the necessary manpower, but this can be done by streamlining service establishments, and by enlisting the co-operation of the other Commonwealth countries.

The Need for Balanced Forces

In discussing the reorganization of the three services to fit the circumstances of thermo-nuclear warfare it must be remembered that they may have to operate under widely different conditions. There may be many years of Cold War, but we must also be prepared to deal with a blitz at a moment's notice followed by a long period of broken-backed warfare before we can resume the offensive. However, when the requirements of Malaya are compared with the latest plans for nuclear warfare it is evident that they are to a large extent complementary. The air-transportable, lightly equipped units employed in the Cold War are very much the same as what is required for "nuclear" formations. This gives reason to hope that the versatility expected of the Army can be maintained.

In every case the three services have each a vital part to play. Although air power has become the predominant factor in our strategic calculations both as a deterrent and a striking force, it must not be forgotten that aircraft gain no ground. A powerful army will always be required to seize or retain bases. It is obvious that the transport of troops or freight by air is still in its infancy, and shipping will for many years be the means of carrying the bulk of our requirements. Without control of the sea the Commonwealth becomes a number of weak disconnected units. With a powerful Navy to escort our convoys we can draw our essential supplies from every corner of the globe.

We are living in an age of rapid development in the design of aircraft and weapons. In the last war our timing was perfect. We went into production with Hurricanes and Spitfires just in time to win the Battle of Britain against Germany's less efficient aircraft. The danger of embarking now on large-scale rearmament with the latest types of guns, ships, and aircraft is that they may be outmoded before they come into service. In the succeeding paragraphs certain recommendations are made which can be carried out immediately, and others which can be little more at this stage, than targets for the designers to aim at.

Air Defence

We defeated German bomber attacks in the last war by means of the superior speed and manœuvrability of our fighters, and the skilful use of radar for early warning and target finding. But our defences at no time approached the effectiveness required against jet bombers flying at over 600 m.p.h. Even with our outer radar screen in Germany, Fighter Command would receive warning of attack little earlier than during the Battle of Britain, when we depended on the coastal radar stations, and German aircraft travelled at less than half the speed of modern bombers. Yet there is even greater need for early warning, since it is essential for the R.A.F. fighters to make their interceptions of atomic bombers well out to sea. In theory the problem could be solved by producing large numbers of radar-controlled ground-to-air missiles. This would involve devoting the greater part of our aircraft and electronics industries to a purely defensive measure which would be out of date as soon as the enemy developed supersonic aircraft or guided missiles. The following steps would contribute to a practical solution:—

(*a*) Disperse vital targets outside the United Kingdom.

(*b*) Improve our radar warning technique.

(*c*) Produce an all-weather fighter with radar equipment such as the Javelin and arm it with air-to-air guided rockets.

(*d*) Improve ground-to-air homing missiles with proximity fuses.

Attack, however, is still the best means of defence, and the maintenance by us and America of a sufficient number of high-speed bombers not only provides the main deterrent against Russian aggression but also forces her to dissipate her strength in constructing large numbers of fighters to protect her widespread industrial centres. The invention of thermo-nuclear weapons enables us to maintain this threat of retaliation with the least expenditure of effort and manpower. The following figures are quoted from the American press:—

Table of Comparative Costs for the Same Destructive Effort

Atom Bombs	Conventional Bombs	Conventional Artillery
4 aircraft 4 atom bombs	4,000 aircraft 80,000 tons of high explosive	600 medium guns firing 200 rounds per gun for 2 hours. 120,000–5.5 in shells.
£1.2 million	£16 million	£2.5 million

America's Strategic Air Command is being re-equipped with 1,000 B.47 and 150 B.52 bombers, but this does not mean that we should not maintain our own Strategic Air Force. Indeed it is essential for our national prestige that the R.A.F. should be able to attack in its own right as well as defend. There is no need for us to vie with the United States in numbers. Fifty of our V-class aircraft carrying atom bombs would pack a greater punch than the whole of our war-time Bomber Command, and would strengthen our political influence and military security to a far greater extent than the same expenditure in any other sphere.

Air Transport

The picture of long overseas lines of communication dotted with slow moving cargo vessels is completely out of date. Such a supply route is too slow and too vulnerable from the air, from surface raiders and from submarines. It also depends on the availability of ports at either end of the voyage, which would be a priority target for atom bombs. Everything must be done to reduce the necessity for large-scale movement of supplies by making support areas as far as possible self-sufficient in raw materials, and by relying on synthetic fuels and dehydrated foodstuffs. For the rest, air transport has many advantages. It is both faster and safer than sea transport, and by supplying direct from factory to overseas base, it cuts down handling and storage problems. Since the end of the war, Transport Command has been allowed to run down, and air trooping has been carried out by charter companies using obsolescent aircraft. A new two and a half year contract was awarded last year for the transport of 7,000 troops annually in each direction between Britain and Singapore in Hermes piston-engined aircraft. But larger and faster planes are on the way.

The Beverley Blackburn is probably the best large freighter aircraft in the world today. It will take ninety-four men with their equipment. Twenty-four have been ordered and eight will be in service this year. The 101-seater Britannia and the 120-seater Vickers 1,000 with a range of 2,500 miles are also in production. America is developing the C.123 as an assault aircraft with a payload of 20 tons. This type of aircraft could fly in supplies to the United Kingdom at the rate of 10 million tons a year, only three times the rate of supply with an *ad hoc* organization during the Berlin air lift, thus freeing us from the threat of starvation by heavy attacks on Atlantic convoys. The greatest difficulty in building up a strategic reserve in Transport Command is the cost, but the development of military aircraft must go hand in hand with commercial practice. The proposed development of support areas in South-East Asia, Africa and Canada calls for the establishment of commercial air routes, rather than opening up land communications. A nucleus of large transport aircraft in Transport Command operated in peacetime for the benefit of all three Services could be expanded in time of emergency by calling on civil aircraft. Civil aircraft companies should be encouraged to operate types of planes which could be used by the Services, by providing them with a subsidy in return for a guarantee of serviceability and availability at forty-eight hours notice.

The other contributory factor to the high cost of maintaining a fleet of large transport aircraft is the necessity for long and heavily reinforced runways. However, as the Minister of Supply stated on the eve of the Farnborough Air Show last year, research in Britain is concentrated on techniques designed to enable aircraft to take off vertically or nearly vertically from a horizontal position, thereby doing away with the need for expensive runways.

Tactical Air Forces

Any military action against Russia or her satellites that is not provided with effective local air support is doomed to failure. This can only be achieved by the closest possible liaison between the military and air force commanders and their staffs. It follows therefore that each support area must contain the nucleus of a tactical air force capable of being expanded rapidly when required. This is only possible if the airfields and base installations are functioning in peacetime.

The task of a tactical air force is first to achieve local air superiority and then to turn to the enemy ground forces. The backbone of the force is the fighter/bomber which operates efficiently in either rôle, but it must also contain components which can carry out reconnaissance and air defence tasks by day or night. Modern light and medium bombers may no longer be suitable for close support of ground forces in view of their high speed and ceiling, but the American F.86 which they call the "Megaton Fighter" may well prove to be the answer. Equipped with six air-to-ground rockets with atomic war heads, it could deliver in one sortie a punch equivalent to 250,000 conventional bombers each carrying 4 tons of TNT. It must be accepted that such aircraft would not be able to provide immediate or very close tactical support for our ground forces. Suitable targets would be hostile gun concentrations, assembly areas, bridge-heads, or key defended localities. If the normal method of employing ground troops in the attack will be to exploit the destructive effect of an atomic bombardment, the lack of cab-rank air support will not be serious. The requirement then, in each support area, is for offensive air support to be provided by robust fighter/bombers capable of operating by day or night and in all weathers. They must be able in their fighter rôle to achieve local air superiority over the battle area, and when employed as bombers to deliver an annihilating attack on enemy troop concentrations.

Summary of Air Force Requirements

The truth of Mr. Baldwin's claim of nearly twenty years ago that the bomber will always get through, is becoming more and more firmly established. The increasing efficiency of pilotless aircraft developed from the American Matador squadrons, and super-rockets flying at 5,000 m.p.h. said to be under construction in Russia will make the task of the defenders even more difficult. If our vital targets are dispersed, we can devote all our efforts to producing the type of Air Force we require to defeat the Russians. This requires five main components, in all of which economy can be achieved by insisting on quality rather than quantity:—

(*a*) Bomber Command—our main striking force, for which we require a comparatively small number of aircraft or guided rockets capable of penetrating Russia's widely stretched defensive screen and dropping the most powerful atomic bombs where they will do the worst damage. The importance of accurate and up-to-date intelligence and the latest target-finding technique can hardly be overstressed.

(*b*) Fighter Command—all-weather aircraft flying at supersonic speeds equipped with radar target-finding systems and armed with air-to-air homing rockets.

(*c*) Tactical Air Forces—closely linked with military headquarters in each support area and consisting mainly of all-weather fighter/bombers armed with air-to-ground atomic missiles.

(*d*) Transport Command—to be widely expanded in close co-operation with a large merchant air service all over the world till it is capable of carrying out the demands of strategic airlifts for all three Services as well as taking the place of shipping convoys for essential supplies.

(*e*) Coastal Command—to provide maximum protection for sea routes in close co-operation with the Royal Navy.

This scheme naturally entails a heavy programme of airfield and base construction in each support area and on the main trans-continental routes linking them, but the introduction of vertical-lift aircraft will in time obviate the necessity for long runways.

THE NEW MODEL ARMY

There has been a great deal of loose talk about the type of army we require in this atomic age. The first thing to realize is that however large the stockpile of atomic bombs either side accumulates, there will always be a limit to the number available for any particular front. This will ensure that they are used where they can do the most damage. The priority of targets will be firstly concentrations of population round industrial areas, secondly lines of communication, especially ports, and thirdly base installations. Destroying any of these would pay better dividends than attacking an army in the field.

Another popular misconception is that an atom bomb can wipe out an army. The latest view is that one atom bomb dropped on troops reasonably dispersed and dug in may not cause more than 1,000 casualties. Compare this with World War I when it was not unknown for a single division to lose 5,000 men in a morning.

The realistic view to take is that the advent of atomic warfare places an additional and immensely powerful weapon in the hands of a military commander which is bound to alter the tactical conception of a land battle, but may not necessarily prove decisive. Changes in the organization and equipment of the Army will be required, more particularly behind divisional rear boundaries, where the most vulnerable targets are likely to be found.

THE MANPOWER PROBLEM

It is fruitless to discuss the ideal form of the New Army unless we have the right type of officers and men to take their places in it. The ideal soldier is what Julius Caesar looked for, and Marlborough and Napoleon and Montgomery. The specification is unaltered by the atom bomb. We want a man who is tough, alert, aggressive, inquisitive and self-reliant. The National Service conscript is the raw material but not the final product. The two missing ingredients are selection and training.

The Army of today is handicapped by the shortage of regular N.C.Os. and the rapid turnover of National Servicemen. A unit reaches a certain standard of training at the end of the collective training season, but next year so many of its key personnel have left that it has to start again at the beginning. It is not denied that National Servicemen have done magnificently under operational conditions in Korea, Malaya and East Africa, but just when they are trained and efficient the time comes for them to be released.

The other great drawback to the National Service scheme is the number of regular soldiers tied up in the training organization. It is not unusual to find that a training unit in the United Kingdom has one man on the permanent staff for every two recruits. Even that is not the full story, because with the universal call-up, many men fall by the wayside for one reason or another before they pass out, which represents a dead loss of the regular soldiers who have been engaged in training them.

The Army in its present form is not the type we require to implement our strategic policy. The first step to take is to change the ratio of Regular to National Service soldiers from the present figure of 43 : 57 to an over-all ratio of about 70 : 30. This would mean that no National Serviceman need serve further afield than B.A.O.R., giving a considerable economy in trooping and allowing all units overseas to be 100 per cent regular. The reduction in the training organization and the trooping machine would enable the over-all strength of the Army to be reduced from 420,000 to 320,000 while still carrying out all its present commitments, and 100,000 men could be released for other tasks. At the same time the Army could raise the initial standard and insist on a better type of recruit. The composition of the Army would have been changed from 240,000 National Servicemen and 180,000 Regulars, to 100,000 National Servicemen and 220,000 Regulars. With the present numbers of Volunteers joining the Territorial Army and the reduction of AA Command, 100,000 National Servicemen should produce the numbers required each year to keep its units up to strength, resolving the problem into that of obtaining 40,000 more regular soldiers in the Army. The nation still produces the right material. There are plenty of young men keen on travel and adventure. In any unit posted overseas the National Servicemen rush to sign on for regular engagements. The only thing holding men back from flocking to the Regular Army is what they feel to be a lack of stability.

It is not that the British soldier today feels that he is underpaid. What he cares for far more is that his life shall be reasonably secure. The prospects of useful long service in the Army with the friends he has made in his own unit and a comfortable home for his family in a pleasant cantonment are what really matter to him. Give him reasonable social amenities, educational facilities for his children and a guarantee that he will not be away from home in normal times for more than one year in three and he will be happy. This could well be arranged if a soldier was posted to a support area such as Canada, East Africa or Australia for an initial tour of five years, with the option of extending it to ten years, and was promised assistance to find a job and settle down overseas at the end of his service. This would serve the dual purpose of getting more Regulars to join the Army, and also providing a steady flow of the right type of immigrant to the Commonwealth countries.

Commonwealth Divisions

The policy of dispersing our bases and armed strength strategically over several support areas requires not only the goodwill but also the active support of the other Commonwealth countries. They are fully aware that expansion of their populations by immigration is vital not only to each country but also to the strength of the British Commonwealth as a whole. The plan to redistribute the British working population throughout the Commonwealth would lead to increased economic prosperity and would be welcomed by all sections of the community. The theme running through the C.I.G.S. conference with senior military officers in August last year was Commonwealth co-operation. The Commonwealth representatives made it clear that their countries were ready to play their part in the defence of the British way of life and would accept commitments placed upon them to the maximum of their ability. This readiness to co-operate was confirmed later at the meeting of Commonwealth Prime Ministers in London. There is no doubt that in return for the industrial expansion proposed, they would be willing to provide an increasing share of the manpower required for the armed forces in their own support area. The ideal situation as far as the Army is concerned would be to have one Commonwealth Division in each support area, on the pattern of the 1st Commonwealth Division, which was such an outstanding success in Korea. The maximum use would be made of native troops in overseas garrisons such as Singapore, Hong Kong, and East and West Africa, and British units and staff officers would be posted for tours of duty to these formations. Each division would be equipped and trained for the type of warfare most suited to the local terrain, and would maintain the closest liaison with the R.A.F.

The picture that is being built up begins to emerge more clearly. In Europe we would have an Army fulfilling our N.A.T.O. commitments and containing a proportion of National Servicemen. Elsewhere in the world there would be six Regular Commonwealth Divisions supported by a number of Territorial formations, composed to a greater or lesser degree of local troops, but leavened with British units whose personnel would be long service regular soldiers. They would be largely dependent on local resources and base installations, but controlled by a Commonwealth Chiefs of Staff Committee, which would be located in Canada so as to keep in close touch with the United States. British Army units would be seconded to Commonwealth Divisions for five years to enable them to reach a high standard of training. The men would be picked from volunteers keen to start a new life, and would be given a high standard of accommodation and other amenities for their families. Having got fit, keen, well-trained troops with good administrative backing in the correct strategic locations, the next step is to consider how to organize and equip them for the tasks they may have to perform.

New Administrative Conceptions

The tasks of the New Army will vary from normal garrison duties to cold war campaigns, and it must be ready to bear the brunt of full-scale atomic warfare. The ultimate purpose of all other branches of the Army is to get the infantryman on to a piece of ground and help him to stay there. Give the modern infantry battalion trained regular soldiers armed with the new F.N. rifle and there is not much wrong with it. It is the best fighting machine we can devise for normal warfare, and with certain minor improvements which apply to all teeth arms, there is no reason why it should not function as efficiently in atomic wars. The infantry and armoured division are compact entities which are understood at all levels. Their organization has been severely criticized as being top-heavy. Proposals have been put forward for introducing divisions with two larger brigades or four smaller ones, and even for abolishing divisions altogether and allowing the Corps Commander to fight his battles with eleven brigade groups.

The experiments carried out in "Battle Royal" last year did not produce any conclusive arguments for changing the organization of a division. All the commanders of history built up their armies round the number of subordinates that one man could control efficiently. Modern armies must be organized on the basis of the number of stations that can join one wireless net, and here again the ordinary divisions that have grown out of experience are basically as good as we can get.

An organization is required that can be adapted both to conventional warfare of the Korea pattern and to atomic warfare in Europe, where we could not hope to check the Russian hordes without relying on atom bombs. This requires a study of the type of army needed to carry out the tactical evolutions necessitated by the use of atom bombs in the field. In order to get full advantage from our technical superiority, our defences must be sufficiently dispersed to avoid annihilation by the enemy's atom bombs and yet strong enough to prevent enemy penetration without a full-scale attack, which would provide a target for our own tactical atomic weapons. With reliable helicopters that can fly by night and in all weathers, large dumps would be completely unnecessary. Handling would be reduced to the minimum by the use of integral freight containers each weighing two to three tons. Standard packs would be designed for rations, P.O.L., ammunition, clothing, medical supplies and engineer and ordnance stores. Eight or ten of these packs would go in a cargo plane or two to a helicopter. They would be designed so that they could be lowered direct on to the standard 3-ton truck if the bulk-breaking point was not at helicopter head. Two essentials would be excellent communications for the demanding and organization of daily deliveries, and a very high degree of navigational skill on the part of the pilots.

Air supply on this scale may not be so fantastic as it first appears. The United States, who are ahead of us in this field, carried out a valuable experiment in Korea when they supplied one infantry brigade by helicopter for a period of three days. They used the S-55, which has a range of 150 miles with a load of 1,600 lb. The 6th Transport Company equipped with fourteen S-55s was able to maintain the brigade with clockwork efficiency and a serviceability of 90 per cent. We are planning to use three types of helicopter—the ultra-light for reconnaissance and casualty evacuation, the medium and heavy for cargo and troop-carrying. Experimental organizations are now being tried out at the School of Land/Air Warfare. It is true that one heavy helicopter at present costs about forty times as much as one transport vehicle, but it will do the work of twenty lorries and provide a far more reliable means of support in the conditions of nuclear warfare. The modern range of combat vehicles will cost £250 million if it is introduced as planned, with an annual cost of £50 million for repairs and replacements. Mass-produced helicopters might well be cheaper to build and maintain. A further economy would be achieved by reducing the number of roads and railways required, and the sappers to build and maintain them. Apart from the cost, other objections to the use of helicopters have been raised on the grounds of the difficulties of defending them against air attack and navigating them to the right spot. The helicopter is a clumsy machine and may well be superseded by a new type of aircraft which can land or take off without a runway, but if supply helicopters kept low and made good use of ground they would not be easy targets for supersonic fighters. They would certainly be harder to destroy than the large maintenance areas and long convoys of lorries necessitated by our present supply system. A short-range direction finding apparatus would be required to guide them to where they are to land. This might allow them to travel by night in greater safety than by day. It is up to our scientists to overcome these difficulties as they have overcome so many in the past, because the mobility and tactical freedom bestowed on formations by helicopter supply are inestimable advantages which might well mean the difference between winning or losing a campaign.

Summary of Military Requirements

The type of military forces needed to back up the R.A.F. in either cold or hot war have the following general characteristics:—

(a) More and better regular soldiers, who must be attracted to the Army by offering a more stable career.

(*b*) A more even spread of manpower demands among all Commonwealth countries.

(*c*) A high degree of skill and self-reliance, achieved by progressive training and simpler weapons.

(*d*) Far greater tactical mobility, achieved by better communications, reconnaissance aircraft and cross-country vehicles.

(*e*) A faster and simpler supply system, when transport aircraft and helicopters have replaced slow and vulnerable convoys of ships and lorries.

(*f*) Saving of manpower by cutting the administrative tail in the field, by obviating the need for handling stores in docks and depots, by reducing the numbers tied up in the training organizations, by cutting down A.A. Command and by the introduction of more mechanical devices for carrying out standard engineer tasks such as minelaying and bridge building.

(*g*) Close co-operation with the R.A.F. as regards the indication of targets for atomic missiles and the rapid follow-up of attacks.

This is the Army which should be deployed in peace-time in strategic locations and which would be dependent on bases dispersed throughout the Commonwealth.

War at Sea

The vulnerability of the North Atlantic sea route has been cited as one of our main strategic weaknesses. In course of time this weakness can be eradicated by dispersing our industries and by substituting a merchant air force for sea convoys. But this is looking very far ahead, and for many years to come we will be completely dependent on sea communications. In 1917 and in 1943 we were nearly brought to our knees by German submarine attacks on our shipping. The fact that Russia is concentrating on the construction of ocean-going cruisers and submarines shows that she fully appreciates that severance of sea communications between America and Europe is one of the quickest ways to victory over the N.A.T.O. Powers. It was found that the place to kill German submarines was near the convoys. When packs of U-boats collected outside the range of shore-based aircraft, the solution lay in the development of highly trained support groups working with long-range aircraft. The technique for protecting convoys against swarms of Russia's fast ocean-going submarines would involve the latest radar spotting devices mounted in aircraft flying over the convoy, and fast escort vessels and carrier-based aircraft to hunt them down. The Russians have no aircraft carriers, but high-flying bombers and surface raiders constitute serious threats to our convoys. Nowadays carriers give the Navy not only its eyes, but also its main striking force, and it will be seen that no convoy will be able to put to sea without a composite task force. One or more carriers will be the kernel of the force, but such valuable craft costing £15 to £20 million each, will themselves have to be protected, especially in bad weather, when their aircraft are unable to take off or land.

Cruisers will therefore be required for the protective value of their powerful armaments against surface raiders or enemy air attack, and destroyers and frigates in an anti-submarine rôle. The pattern of naval warfare against Russia would be very different in two essential respects from the last two wars. Unlike Germany Russia is impervious to blockade and we would not require a maritime police force to maintain it. Secondly Russia's naval strength is split up among four main fronts—the Baltic, the Black Sea, the Arctic and the Pacific. The Baltic and the Black Sea are cut off from the others and have narrow outlets controlled by Denmark and Turkey, both of which are N.A.T.O. powers. The Arctic and Pacific are open to the high seas, but are cut off from each other except for a few weeks each year, and in all four seas ice and fog handicap navigation for many months. A great proportion of the numerous ships we have been told Russia is building have a limited range and can only be of value in the local defence of her coasts. The same applies to her 4,000 aircraft. But there will remain sufficient of her ocean-going naval forces and long-range aircraft to force us to maintain a powerful task force containing carriers, cruisers, destroyers and frigates based on each of our support areas. As in the Army and Air Force, Commonwealth personnel would play their full part in manning naval units and shore establishments. There is a further essential requirement for a global air-warning system and a chain of shore bases from which aircraft can cover the maximum length of our arterial convoy routes. Since the Russians have aircraft, destroyers and submarines all capable of laying mines, the Navy must have efficient minelayers equipped with the latest technical devices.

Naval Developments

A broad picture has been given of the organization of the Royal Navy to enable it to carry out its rôle both in the cold war and in a hot war if it should come before our plans for redevelopment and dispersion have been carried out. The Senior Service has been discussed after the other two, because it appears that its rôle in the future may decrease in importance. As Field-Marshal Montgomery said in a speech in London on 21st October, 1954, "The West cannot win if it loses control of the Atlantic, but the time will come when control of the seas eventually passes to the air forces." Until then there is much to be done and many decisions to make, but we should not undertake the construction of expensive capital ships that may never be required. As with the Air Force, technical superiority is what we should aim for. We want faster and handier ships; hull designs need modification to cater for underwater shock waves produced by atomic explosions, crews must be protected from gamma rays—H.M.S. *Rocket* is a frigate with the new enclosed type of structure; H.M.S. *Cumberland* is a cruiser fitted with a device for sluicing radio-active particles from all exposed surfaces. The new rapid-firing 6-in. gun is being installed in the three 30-knot cruisers of the Tiger class. Guided-missile ships are required for firing homing rockets against high-level bombers. Carriers must be able to cater for the latest types of aircraft. We already have the steam catapult and angled deck. Faster aircraft will need to use the vertical-lift principle to take off and slow landing devices to land. There are new fields to explore in the realms of reaction propulsion weapons and submarines driven by hydrogen peroxide and nuclear energy. Naval designers are clearly fully aware of the necessity for quality rather than quantity. As long as naval forces can control sea routes we must have nothing less than the best. For the sake of British prestige we cannot rely on the United States Navy. At the same time we can never escape from the inherent danger of depending on the precarious Atlantic route, which is so costly to defend in men and materials, and no time should be lost in planning the alternatives which have been proposed above.

Conclusion

The issues raised by the subject of this article are vital not only for the future prosperity of the British people but for our very existence. There is a growing tendency for our young men to close their eyes to the realities of life, to waste their time in tawdry amusements, and to listen to Communist agitators demanding more and more pay for less and less work. There has never been a greater need for a cause to win and a leader to follow. It is a terrible reflection on the spirit of the times to admit that our economic position dominates our strategic policy. Our enemies have formulated their policy long ago and for years have been forcing their national economy to produce the means to carry it out. At the moment they are trying to defeat us without risk to themselves by stirring up racial and industrial conflict in order to weaken our economic position, and by pursuing a policy of psychological disarmament calculated to undermine our will to resist. Now is our chance to embark on a policy which would fire the nation with enthusiasm and place us in a dominating position. As one of the speakers on United Nations Day said "The price of peace is strength. The price of safety is unity." The strength of a United Commonwealth could ensure peace for all time.

Over more than two-thirds of the earth's surface human and material resources are only partially utilized. Two-thirds of the world's population live in poverty and near starvation. Some words of Lord Salisbury, then Prime Minister, spoken more than eighty years ago are relevant to the issues which face us today. "Peace and goodwill will not be the result of some clever contrivance which men, by much debating and many experiments, may hope to hit upon. If they obtain it at all it will be by routing out the selfishness which good fortune nurtures and the recklessness which springs from misery." The first step in disarming our enemies is to remove this fertile ground for seeds of discontent by the mass re-deployment of the British race. Africa, Canada and Australia must be developed both agriculturally and industrially. The N.A.T.O. Commanders are basing their plans on the use of tactical atomic weapons to defeat massed Russian attacks on the mainland of Europe. As long as we retain our vital industries in the British Isles the hands of the military commanders are tied, for our use of atom bombs on the battlefield would be the signal for Russia to unleash her strategic bomber force on our country. We are faced with the choice between dispersion and defeat. The transporting of our factory areas and base installations from England to the Commonwealth support areas is the only way of removing the ever-present threat to the safety of our working population and our preoccupation with measures to defend it.

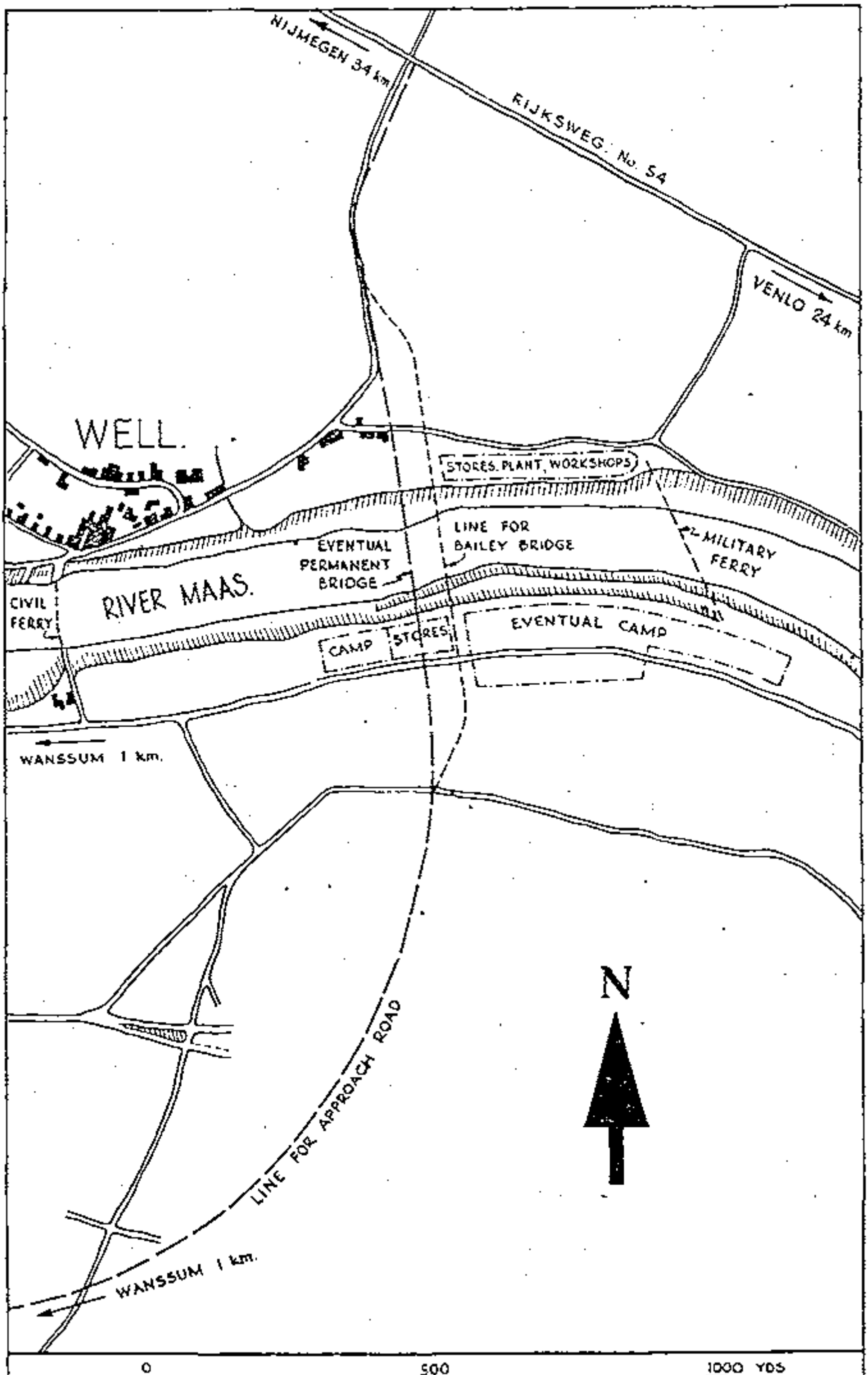
The common need of all our forces is for alert, aggressive men as battle leaders. The spirit is there but it can only be developed with training and experience. This means introducing conditions of Service which will attract the right type of man to a career in the services—especially in the Army. The only way to avoid national bankruptcy is to utilize our technical skill. At present it provides a shield to cover our re-deployment. We must see to it that we keep ahead of the times, so that we can continue to match quantity with quality. So far we have just touched the fringe of nuclear power. There is no limit to its possibilities in the design of aircraft, ships and vehicles, whether for peace or war. The type of forces we require to carry out this policy must be able to function during the interim period without losing sight of the eventual aim. The Air Force will be the dominant arm. The ability of strategic bombers to operate from bases in any of the support areas will enable us to make the best possible use of its flexibility. Development of Transport Command will free us in time from dependence on vulnerable sea communications and endow our land forces with the same strategic flexibility. We need a continental army designed to co-operate with the other N.A.T.O. countries, and Commonwealth divisions specially trained and equipped for local conditions overseas. All units must be streamlined, with simple but technically advanced weapons. All formations must be given freedom to manœuvre by providing them with airborne supplies. The Territorial Army should not be retained in its present form. A number of units and formations would be required in the United Kingdom as a backing for our Continental Army, and also in a civil defence rôle, but the migration of population to the Commonwealth countries will remove a considerable part of the manpower available. At the same time reserve units and formations will be required in the support areas, which will each have their own Territorial Army. The Navy will require fast and powerful task forces to protect convoys, but as air transport is developed and bases are dispersed, balance will be maintained by reducing our capital ships. We should aim at developing fast, small craft which provide no target for the enemy cruisers and submarines, yet are able to destroy them by torpedoes and depth charges.

When our re-deployment is completed and our forces trained and ready we shall be in an immensely stronger position than we are now. Even if saturation point should be reached—that is a situation in which though one side is still superior in its supply of weapons, the other has enough to cause irretrievable devastation—there can still be no hope of victory. The best Russia could hope for would be co-destruction in place of co-existence. So it may come to pass in Sir Winston Churchill's prophetic words, that safety will be the sturdy child of terror and survival the twin brother of annihilation.

It may be twenty or fifty years before we find ourselves in such a position, but we will still be a long way from the Green Bull's-eyes. In this time the communist societies may destroy themselves by virtue of their own internal contradictions or they may so modify their outlook on life that they may be able to live with us in friendship. We must not sit passively and wait for either to happen. If a major war should start, as Lord Hailsham said in the House of Lords, neither America nor Russia would be destroyed. Vast areas of the world would be unaffected, but if anything was left of this country it would be so mutilated and scarred that it would hardly be recognized by the few that remained. We must therefore be dedicated to the cause of peace as no other country, knowing that a false move means annihilation. This will require for many years to come a degree of patriotism and vision which probably no other people has ever in the history of the world been called upon to show. We must, like Cromwell's Ironsides, know what we are fighting for and love what we know. There must among the British Commonwealth of Nations be a burning faith in freedom. Strong in unity, safe in dispersion and inspired by belief in our cause, we must then strive to enlighten the communist masses by every means in our power and to kindle and fan the flame of faith in them till they rise and overthrow their evil masters. Gradual disarmament will naturally follow, and preoccupation with warlike production will give place to improving our way of living. "Benbow's" Utopia need no longer be a dream-pattern.

There at any rate is a suggested blueprint for the years that lie ahead. In the meantime we cannot choose a better motto than Field-Marshal Montgomery's at the unveiling of the Alamein Memorial last year—"Forward, Together, Victory". Forward with a positive inspiring policy. Together with the united strength of the Commonwealth. Victory over the enemies of our way of life as the goal.

QUEENS' BRIDGE.



SITE SKETCH

DRAWING NO. 1.

QUEENS' BRIDGE

By Major K. M. Robertson, R.E.

Introduction

QUEENS' BRIDGE is a Bailey bridge across the Dutch River Maas at Well. It was opened on 3rd September, 1954, by General Sir Richard Gale, Commander-in-Chief, Northern Army Group and British Army of the Rhine. The name he gave was a tribute to Their Majesties, Queen Elizabeth II of Great Britain and Queen Juliana of the Netherlands, to commemorate the endeavours their two countries had made towards the bridge's completion.

In its magnitude the bridge may be considered a worthy tribute to Their Majesties. A semi-permanent structure, built to last for possibly twenty-five years, it ranks among the largest and strongest Bailey bridges ever built. The salient features of its design are as follows:—

(*a*) Standard widened Bailey bridge, single line traffic, quadruple truss construction throughout.

(*b*) Military load class—Class 80 (Centurion).

(*c*) Length—1,385 ft., with a subsidiary span of 140 ft. across a flood channel through the embanked approaches.

(*d*) Weight—1,200 tons, approximately.

Credit for the enterprise may be evenly divided between British and Dutch. The Bailey equipment was a British contribution. The building of the bridge was entrusted to British Royal Engineers and Pontoneers of the Royal Netherlands Army. The concrete foundations on which it rested were constructed by the Rijkswaterstaat, the State Public Works Department of the Netherlands.

In peace-time the bridge will be of inestimable value to civil and commercial traffic in the Province of Limburg. In time of war, should it unfortunately come, the bridge will provide a possible link in the communications of Northern Army Group.

This is how it began.

Planning

During the winter 1951–2 thoughts first turned to the improvement of communications across the River Maas. Between Grave in the north and Roermond in the south, a distance of some sixty miles, there was no bridge suitable for heavy traffic, since the one at Venlo was restricted both in clearance and load class. It was most desirable that a bridge should be built about half-way, and Well offered the most suitable place. The staff in Rhine Army therefore approached the Netherlands authorities to find out what new construction if any, they intended. The latter replied that they were preparing plans for a bridge at Well, but did not contemplate being able to build it for possibly twenty-five years, on account of the cost in relation to more important works.

Since neither the British nor the Dutch could find sufficient funds to finance a civil project, a proposal was made by Rhine-Army that a semi-permanent military bridge should be built by troop labour and ways of sharing the costs, considerably reduced thereby, were suggested. With this proposal as a basis, the Chief Engineer B.A.O.R. met Dutch engineer officers at Well on 2nd May, 1952. It is interesting to note that they stood on the exact site of a Bailey pontoon bridge built in 1945 and dismantled after the war.

As a result of their discussion and reconnaissance, it was agreed to make a plan for a Bailey bridge at a point where the river was some 400 feet wide. This point was a short distance upstream of the site proposed for the eventual permanent bridge and was chosen so that both bridges might use the same approach roads. (See sketch map on page 229.)

Whether the bridge should be built in extra widened or standard widened Bailey was carefully considered. In the end, standard widened was selected because it permitted longer spans to be built over the navigation channels. In the opinion of the waterway authorities, the longest spans of extra widened, capable of carrying Class 80 (Centurion) loads, did not allow sufficient room for barge traffic. Undoubtedly heavy girder bridge would have been preferable to both types of Bailey, but it was realized that quantities would be insufficient for some years to come. The need for the bridge lay in the immediate future and the staff were not prepared to wait.

Planning of the Bailey part of the bridge was undertaken by Rhine-Army on data concerning the gap supplied by the Rijkswaterstaat. It was completed by 22nd May and sent to the Hague for the Rijkswaterstaat to add their part covering the concrete piles, grillages and approaches. During the summer 1952, they surveyed the site and its approaches and made a series of trial borings for the piles. In October a series of meetings were held between the Rijkswaterstaat and officers from Rhine-Army to make the final plan, details of which were as follows:—

(*a*) *Navigation Spans*

There were to be two spans, each 160 ft. quadruple triple construction with bottom storey underslung.

The need to undersling the bottom storey, thereby avoiding the use of overhead bracing, was due to the fact (not mentioned in the handbook) that a centurion on transporter will not clear the overhead bracing of a normal triple storey bridge if a wearing surface is laid on the deck. These spans were to be given a positive gradient of 1:96 towards the point where they met in the centre of the river.

(*b*) *Approach spans*

There were to be six spans, each 80 ft. quadruple single construction, on the east side (Well) and seven similar spans on the west side (Wanssum).

They were to be continuous construction over the supports except for a break midway to allow for expansion. They were to be given a positive gradient of 1 : 30.

(c) Supports

On the west side and in the river, pile foundations for the piers were to be driven. On the east side the soil permitted concrete grillages to be laid. All foundations were designed to support Bailey cribs, each quadruple truss construction, vertical panel type, double panel width. For the piers in the river the concrete caps were designed to be above high water. For piers on the banks, the condition of the soil and the design of the concrete foundations made it necessary for the Bailey cribs to start below ground level. Depths varied from two to eight feet. The height of the piers was determined by the clearance which had to be allowed for river traffic (twenty-five to thirty feet above high water).

(d) Approaches

A new road, a mile long, from Wanssum to the river was planned on the west side, while on the east, a 500-yd. connexion was to be included from the river to the Nijmegen–Venlo road. Embankments for these roads were to be approximately ten feet high at the abutments. The latter were to be built in concrete.

(e) Subsidiary Bridge

A flood channel which ran across the line of the west approach road made it necessary to incorporate a subsidiary bridge of two 70-ft. quadruple single spans in the design. This bridge was to be located 500 yds. from the main one.

(f) Protection of piers

Steel and concrete fenders were planned for the protection of the piers in the river against ice and against collision by barge traffic.

(g) Decking

A 2-in. wearing surface of timber was to be laid over the whole length of the bridge. At the same time a device was to be included which would steady the decking and eliminate the familiar rattle of chesses on stringers when traffic passed over. This envisaged the laying of two rows of 4 × 4 in. timbers ("spiking rails") between stringers and running the length of the bridge. Timbers would be secured to transoms below and decking above, thereby making the whole deck a more rigid structure.

On paper, the bridge looked well. It was aesthetically satisfying that each approach span should be exactly half the length of a navigation span. Likewise the slender aspect of the single storey approach spans somewhat offset the cumbersome appearance of the quadruple truss construction. As it proved, calculation supported the theory that a bridge which looks well is usually technically sound. (See folding plate at end of article.)

Little consideration was given to launching and jacking at this stage. The Rijkswaterstaat offered the loan of large floating cranes to lift the navigation spans into place, but the offer was declined on the account of cost. It was bravely assumed that with ingenuity there was no assembly of multiple Bailey spans which somehow or other could not be got into place and it was reckoned that sappers on their own could show a thing or two.

Between completion of the design in 1952 and the building of the bridge in 1954, only two modifications were introduced. The first was to make the cribs which supported the navigation spans triple panel width as opposed to double. This was to increase the stability of the bridge. The second was to stagger the stringers in a similar fashion to that done with extra widened Bailey bridging, thus assuring the safe load class as Class 80 (Centurion).

When the design was complete, attention was turned to planning the launching and jacking. The methods envisaged and eventually put into practice are described later on. A detailed stores list was also made out and the stocks in 303 E.S.D., who were to supply the material, were adjusted accordingly.

However, it was not all this that took the time. It was because lengthy negotiations were required between British and Dutch on how costs were to be met.

Negotiations

It would be improper to disclose the detail of the financial negotiations which took place in 1952 and 1953. It is sufficient to say that, while both British and Dutch wanted the bridge, neither was able to contribute sufficient towards its costs. H.Q. Allied Forces Central Europe also supported the project but were not empowered to call on N.A.T.O. funds to pay for work such as this. Every effort was made to cut the costs, but at one time it looked very much as if the project would have to be shelved.

In other directions, however, a considerable measure of agreement was reached. If the bridge was ever to be built, it was decided that:—

(*a*) The approach roads and the embankments should be constructed by the Public Works Department of the Province of Limburg.

(*b*) The concrete piles, grillages and abutments should be built by a contractor employed directly by the Rijkswaterstaat.

(*c*) The task of erecting the Bailey should fall jointly on 37th Army Engineer Regiment, R.E. (later reorganized as a Corps Regiment) and on "A" Company 112 Pontoneer Battalion of the Dutch Army.

(*d*) The transportation of the Bailey equipment from 303 E.S.D. at Willich to the site should be undertaken by R.A.S.C. transport.

(*e*) Maintenance of the bridge should devolve on the Rijkswaterstaat when it was built.

(*f*) Methods of accommodating British and Dutch troops at site were considered and approved.

Towards the end of 1953, when hope had almost been given up, the money was found and the signal was given for the work to go ahead.

Preparation

The plans and arrangements already made were set in motion at a conference in the Hague attended by the Chief Engineer, Rhine-Army. The Rijkswaterstaat placed contracts for their part of the work which was scheduled to begin in February, 1954. The British and Dutch units were warned so that they might start training. It was anticipated that they should be ready to start work on the site by the middle of May, 1954.

Meanwhile a complication arose. In view of the increasing weight and size of vehicles, it was decided to examine yet again the possibilities of using extra widened Bailey or even heavy girder bridge. This was extremely difficult since planning was already so far advanced. Nevertheless, a determined effort was made and the advice of M.E.X.E. was sought. In the end, however, the same conclusions as previously were reached and the project went ahead on the original plan entailing the use of Standard Widened Bailey.

37th Regiment started training at Osnabrück in bitterly cold weather in January, 1954. The weather, which almost reached arctic conditions, held up training to a disconcerting extent. Nevertheless some useful lessons were learned which events subsequently proved could not have been missed.

These lessons were:—

(*a*) Without the intelligent employment of cranes, the project was doomed.

(*b*) Jacks far more powerful than the normal Bailey jacks were required. The need was clearly apparent for traversing jacks to correct the alignment of the long approach spans if necessary.

(*c*) For jacking, the unreliability of all but the best timber was noted. This subsequently led to the use of steel packing to assist in the jacking of the navigation spans, as will be described later on.

(*d*) The rapid assembly of an array of panels and transoms, "Olympia" fashion, although impressive to watch, in fact counted for very little. Far more depended on the siting, design and handling of tackles, on packing, and on roller and jacking arrangements. In these aspects of bridging, junior leaders and troops were least competent and it was apparent that the fault lay in their earlier training.

While training was in progress, reconnaissances were made into Holland to find a camp site and to locate the stores, workshops and plant areas adjacent to the bridge. Good areas for stores, workshops, and plant were found right alongside the bridge and the ground was requisitioned. The areas were not large since it was only intended to move small stores and construction gear in bulk to the site. The main items of heavy equipment were to be brought forward from 303 E.S.D. on a phased programme which enabled them to be incorporated straight into bridge.

The selection of a camp site presented a problem owing to the value of the land bordering the bridge. In the end a heath was selected three miles from the site. Communications were poor and water was scarce. Even in January it was realized that the heath would present a considerable fire risk in the summer. However, at the time there was no case for occupying land more suitably placed.

While these things were going on outside, the organization for building the bridge was being worked out. A work table was planned and was drawn up in such a way that it could subsequently be used as a progress chart.

Considerable thought was also put into the preparation of the transport programme. The distance from 303 E.S.D., Willich, to site was some forty miles and a platoon of R.A.S.C. transport was allotted to the task. Just over 1,200 tons of bridging stores had to be brought forward in the right order. Not only had they to be brought forward in the right order, but they had also to be correctly apportioned to each bank of the Maas. This entailed using separate routes from Venlo, one either side of the river. Flexibility in the plan was essential to allow for contingencies in the work at the sites. As it proved, the navigation spans were built from the west side, whereas originally it was intended that they should have been built from the east. The transport programme consisted of a number of serials and twenty-eight appendices, each complete in itself for a particular part of the bridge. Equipment could be called forward, piecemeal and in its right order, merely by the quotation of a serial number and the numbers of lorry loads required. The effort which went into this programme was never regretted. Throughout the work, hold ups and transfers of stores from bank to bank were negligible.

Customs clearance for stores and personnel had to be arranged for the German–Dutch frontier. The quantity of bridging was a finite amount and there was no great difficulty in arranging for the clearance of bridging vehicles through the border posts. It was over the movement of personnel, rations and particularly N.A.A.F.I. stores that care had to be taken. Unless the integrity of military traffic to and fro across the frontier could be guaranteed, great inconvenience would be caused and a number of privileges the unit hoped to enjoy would be stopped. For convenience of both parties, two definite frontier crossing points were fixed and it was not long before good relations with the officials at these places were firmly established.

On 12th April, "A" Company, 112 Pontoneer Battalion of the Dutch Army arrived in Osnabrück to train with Standard Widened Bailey. They also came to shake down with 37th Corps Engineer Regiment, under whose command they were placed, before work started on the bridge. For peace-time it was a unique attachment. The ease with which it was carried through is a good indication of the degree of integration which has taken place between the Forces of the Western Powers today. It is interesting to record too that the Dutch company was not allotted barrack accommodation to itself. Instead, each of its platoons lived with one of the squadrons of the British Regiment. The same cookhouse and barrack amenities were shared by both British and Dutch.

On 27th April, the 34th Field Squadron moved to Well. They were given three weeks in which to prepare the camp and receive the first stores before the remainder of the regiment, with the Dutch company, arrived from Osnabrück. By mid-May a very well-served camp was ready. Also all the small stores, much of the construction gear, a 50/60 raft and two motor tugs were at site. Planning and preparation were over, the task itself was about to begin.

Building

Organization

On 11th May "H.Q. Bridge Control" was established at Well. This organization consisted of O.C. 40th Field Squadron as O.C. Bridge, another officer, the regimental Q.M.S.I. and two draughtsmen. Later, when construction was under way, it was reduced by one officer and one draughtsman. The function of this relatively small H.Q. was that normally associated with "officer in charge of the work" namely, organization of the work and the supply of equipment, the allocation of tasks and priorities, supervision and the recording of progress. The functions of "officers in charge of working parties" were fulfilled by squadron and troop commanders. Co-ordination was effected at a daily conference. C.O. 37th Corps Engineer Regiment held over-all control of the work and indicated weekly the tasks to be completed and the troops to be allotted to them. He and O.C. Bridge also maintained a liaison with the Rijkswaterstaat who had permanent representatives at the site. The building of the Bailey had to be fitted in with the construction of the concrete foundations and approaches, which were still in process of being built when the regiment arrived.

It was this fitting in which presented the first problem. The Rijkswaterstaat had started work in February, but they had been delayed by frost and the severe winter weather. It also had been expected that their work on the east and west sides would progress evenly. The work on the west side in fact was a good deal ahead of the east. This entailed a redeployment of troops and an alteration in the plan of construction. It had originally been intended that the Dutch company should build the west side approach spans and that 37th Regiment should build those on the east side, with the navigation spans over the top of them. There would thus have been a clear-cut division of responsibility between British and Dutch. This was no longer possible. It was decided to switch construction of the navigation spans from the east to the west side and to divide the work, wherever it was, in proportion between the British and Dutch. It is happy to relate that this incurred no difficulties whatever when the time came. In fact it became a common occurrence for O.C. Bridge to conduct a launch employing British and Dutch troops simultaneously. British plant operators were in charge of the hauling and preventer tackles and often Dutch troops were in charge of the rollers and all the other etceteras which occur during a launch. To complete the Allied picture, just such a launch was once carried out while American and Belgian officers watched!

On 16th May, with the move of 37th Regiment and the Dutch company from Osnabrück to Well, the order of battle of troops at the site became:—

37th Corps Engineer Regiment, comprising, 33rd Field Squadron, 34th Field Squadron, 40th Field Squadron with, under command, Detachment, 41st Army Field Park Squadron (Plant, Workshops, Stores); Detachment, 19th L. of C. Signal Regiment; "D" Platoon, 121 Company R.A.S.C.; "A" Company, 112 Pontoneer Battalion (Netherlands Army) with in support 40 Advanced Engineer Stores Regiment and 303 E.S.D.

The right number of specialists were incorporated in the regiment, but it was freely admitted that there were more working numbers in the Field Squadrons than were required. Nevertheless it is very doubtful whether the regiment could have been successfully split. Instead, it was intended to give other training at Well to those who could not be usefully employed on the bridge. Individual and collective training continued, 33rd and 34th Field Squadrons returning to Germany for a week each to carry out their annual range courses. A number of small exercises were also held in Holland itself. In addition, squadrons were appointed "Duty Squadron" for a week at a time. Guards and fire picquets, camp improvement and maintenance and the provision of unloading parties kept the duty squadron fully employed.

Piers on land

The 17th of May saw the first panel laid. By the end of the week six piers, three on each bank, had sprouted up. Two jetties also were built consisting of folding boat equipment and pontoon piers. From these a foot passenger ferry service was run by Mark V and Mark III tugs. The civil ferry 500 yards downstream was used for casual vehicle traffic. In addition the 50/60 raft was launched. This was intended for the building of piers in the water later on, but in the meantime was to be used for watermanship training.

By the end of May all of the eleven piers on land had been built, and 140 ft. of bridge across the flood channel through the approaches was nearly finished.

The sudden outcrop of piers seemed to make progress more impressive than it actually was. It certainly stirred the local populace, particularly the children. From time to time crowds would gather and gape at the strange things going on. These crowds grew as the bridge itself grew, until in the end, wire had to be erected across the ends of the bridge to keep them out of harm's way. The Dutch Press at this time came out with the first of a series of stories which were to follow the progress of the work.

Technically, the building of the piers on land was simple and there is not much to record. The following points however are worthy of note:—

(*a*) Speed and ease of assembly depended much on the careful positioning of the crane and the dump of material in relation to the pier itself. It was desirable to cut down movement of the crane's jib laterally and vertically as much as possible. This was not easy since most of the piers started below ground level and the sites were obstructed by the spoil which had been excavated.

(*b*) It was essential to brace fully and tighten each lift of a pier before adding much to the lift above. If this was not done, the alignment ran crooked and parts at the top could not be fitted together.

(*c*) On the east side, the pier excavations filled with water. Besides the need to pump them out, it at once became apparent that the steel of all piers below ground level should be treated with special anti-rust paint.

(*d*) As all piers were either double or treble panel width, some parties preferred to chord-bolt their panels together before lifting them into the pier. This certainly speeded the work and enabled a larger party to be usefully employed. On the other hand, if a jam or misfit occurred during assembly, it took longer to clear than if panels were hoisted singly.

(*e*) Very little survey was necessary to position the piers. The Rijkswaterstaat left excellent leading marks on their finished foundations.

Approach spans: tackles and anchorages (See Drawing No. 1.)

While the building of piers was still in progress, the arrangements for launching the west side approach spans were started. Trenches were dug for two buried anchorages on each side of the line of the bridge and approximately 200 feet from the abutment. The anchorages themselves each consisted of two transoms with a 3-in. S.W.R. strop round their centre points. They were dug down 4 ft. and their bearing surfaces rested against a revetment of 9 by 3 in. timbers. To these anchorages were fastened two Size I tractors, whose winches provided the power for the launch. The winches were connected to the bridge through an equalizer tackle designed in such a way that the resultant pull was always along the bridge centre line. The actual point of attachment was through two launching links pinned to two cut chords, which in turn were bolted to the underside of each girder.

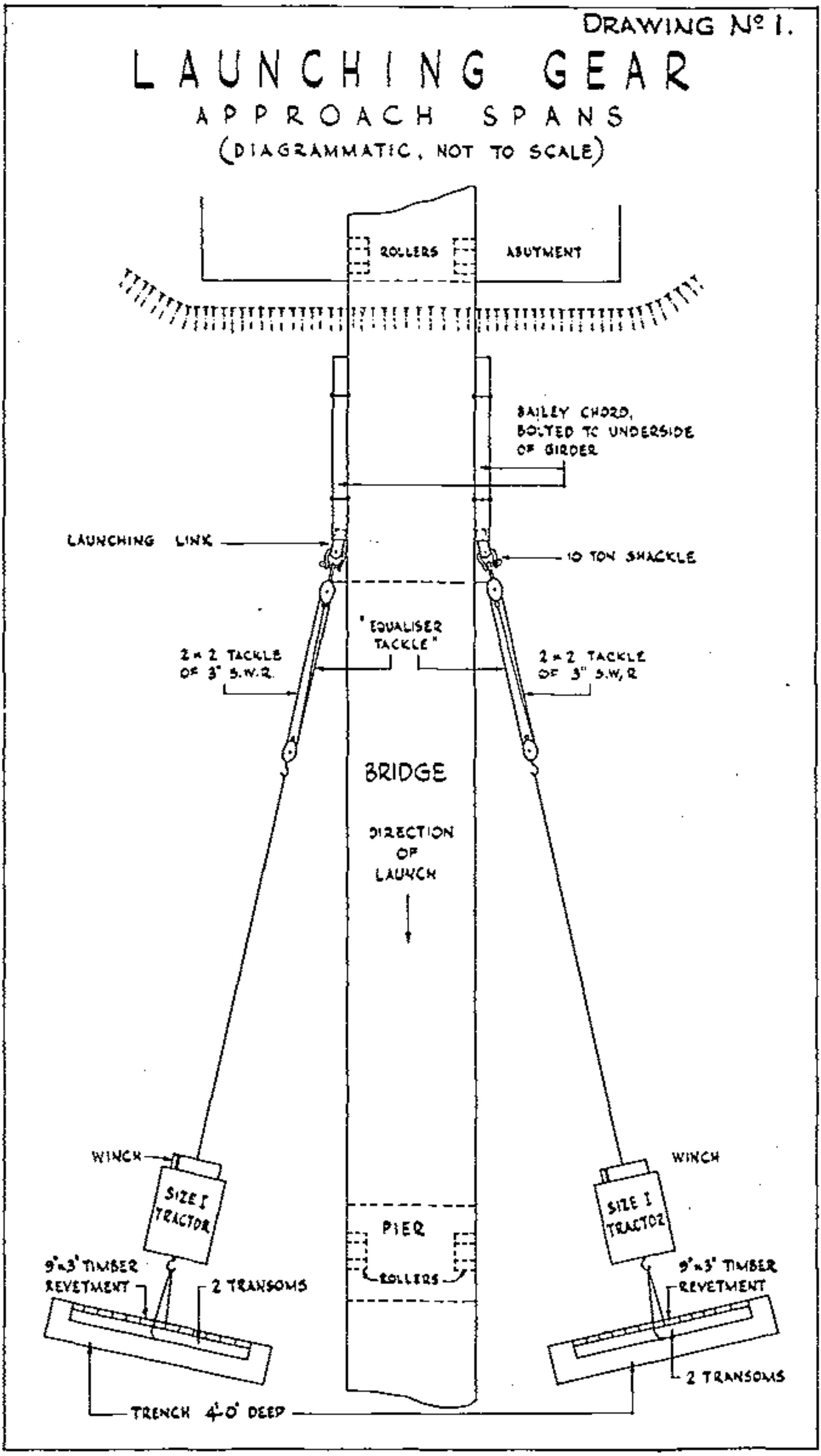
The hauling gear was unduly cumbersome due to the strange fact that in the Service, S.W.R. blocks, shackles and thimbles of uniform strength do not fit each other. There is clearly a need for rationalization in this sphere. 3-in. S.W.R. in good condition may quite safely be loaded up to 10 tons. Yet a single snatch block for the same rope is rated at a safe load of 7 tons only. A 15-ton shackle, besides being unduly cumbersome, is so large that it will not fit the eye of any block rated at 15 tons safe load, nor will it pass through any thimbles. Thus, whereas a single rope passing through two single blocks would have provided a simple equalizing arrangement, two double blocks had to be used because the single ones were not strong enough. This entailed an over-elaborate form of tackle to achieve the same result. Likewise, because the 15-ton shackles could not be connected, the load on each winch had to be reduced to 10 tons. Even so, juggling was necessary as already described to connect tackles to bridge. The reduction in the launching force which could be applied dictated that the approach spans should be launched undecked.

Nevertheless, the hauling gear worked well, in spite of its cumbersome nature. Winches were always used alternately, one stopped, the other hauling. The bridge therefore moved forward in the reduced ratio of 2 : 1 in relation to the speed with which the winch cable was taken in. Adequate control of the launch was thereby achieved. As soon as one side of the equalizer tackle ran chock-a-block, the hauling winch was stopped and the other one took over the pull. In this way the bridge was hauled up the incline until the tackle-attachment almost fouled the rollers on the pier ahead. The whole arrangement was then disconnected, overhauled and reconnected back near the abutment. Preventer gear meanwhile was provided, in the first instance by manually operated cordage tackles, and later by the winch of a Size II tractor, directly connected to the bridge at any convenient point.

The launching arrangement for the east side approach spans was later constructed in exactly the same way. The only refinements were that the anchorages were sited nearer the river and farther apart. The initial launching was done by tractors unanchored. As the head of the bridge approached the river, so the tractors were moved back to where the anchorages were. A point of attachment nearer the head of the bridge was thereby attained and this resulted in an even straighter pull. By placing the anchorages and tractors farther apart, the time when the tackles would foul the rollers and pier ahead was further delayed. Tractors at 60 ft. from the centre line were found to be about right.

Fire

On the 28th May, a disastrous heath-fire swept the officers' lines in camp. A fortnight's dry weather had seen a couple of minor outbreaks already. But these, although disquieting, had soon been brought under control.


DRAWING Nº 1.
LAUNCHING GEAR
APPROACH SPANS
(DIAGRAMMATIC, NOT TO SCALE)
ROLLERS
ABUTMENT
BAILEY CHORD, BOLTED TO UNDERSIDE OF GIRDER
LAUNCHING LINK
10 TON SHACKLE
"EQUALISER TACKLE"
2 × 2 TACKLE OF 3" S.W.R.
2 × 2 TACKLE OF 3" S.W.R.
BRIDGE
DIRECTION OF LAUNCH
WINCH
WINCH
SIZE I TRACTOR
SIZE I TRACTOR
PIER
ROLLERS
9"×3" TIMBER REVETMENT
2 TRANSOMS
9"×3" TIMBER REVETMENT
2 TRANSOMS
TRENCH 4'0" DEEP

On this occasion there was no stopping it and the speed with which the fire spread was almost terrifying. With difficulty it was eventually brought under control but the affair clearly showed that continued camping on the heath involved serious risk to life as well as equipment. Permission was therefore granted to move to another site on the west bank of the river and requisition of the land was authorized together with the additional expenditure necessary.

Camp was moved in the second week of June. Being by the river and right alongside the bridge, the new site was a healthier happier place. The tedious daily journeys to work were eliminated and much time saved. All were able to see and take an interest in the progress of the work. In the end the additional expenditure and time lost in the move were more than repaid.

As the camp was on the west bank, the ferry had to be expanded into a regular service. Another jetty was built and more motor-boats obtained. The running of this service was entrusted to 40th Field Squadron.

Approach spans: construction

Work on the west approach spans had started a few days before the camp was moved. Little happened during that period. A spurt was made afterwards, however, and the spans were ready for jacking down by 17th June. In recording the main features of this part of the work, the remarks which are made apply to the east side spans as well. Work on each side of the river was basically the same, that on the east side lagging a fortnight behind the west.

On the regiment's arrival in May, neither the embanked approaches nor the concrete abutments looked like being ready by the time construction of the approach spans was due to begin. A plan had therefore been made for building up false-work between the abutments and first piers from which they could be constructed. Delay to the regiment's work and the efforts of the contractor in the end made this unnecessary. But although the embankments were made ready for building the bridge, the surface was not in a condition to take the bridging lorries on the west side. Here, Sommerfeld tracking had to be laid along the foot of the embankment and additional cranes used for hoisting the equipment to the construction site on top.

On each side, there was sufficient space to enable 100 ft. of bridge to be built in rear of the abutment. There was therefore no difficulty in launching, since spans were only 80 ft. long. Since they were of continuous construction, a long launching nose was unnecessary. Two bays only with a launching link behind them, were used to offset the sag.

Double sets of rocking rollers were used on all piers. The launching nose, being single truss construction, engaged the inner pair only. The outer pair were free until the outer trusses of the bridge itself

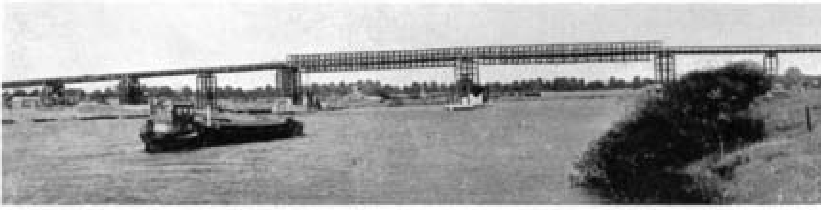


Photo 1.—Queens' Bridge completed.

Photo 2.—Progress on 27th July, 1954. View looking west.

Queens Bridge 1 , 2

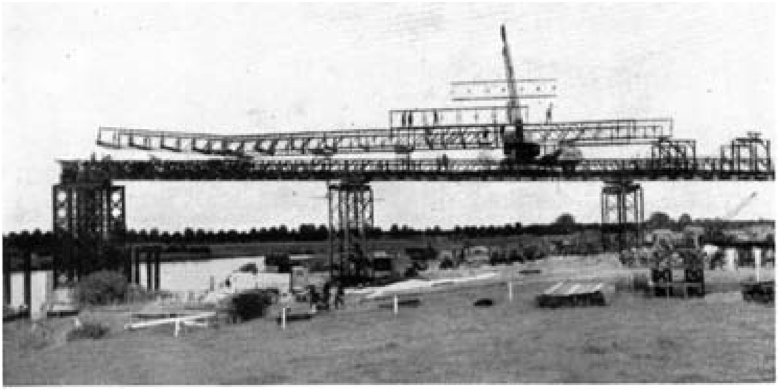


Photo 3.—The nose.

Photo 4.—Construction of centre pier.

Queens Bridge 3 , 4

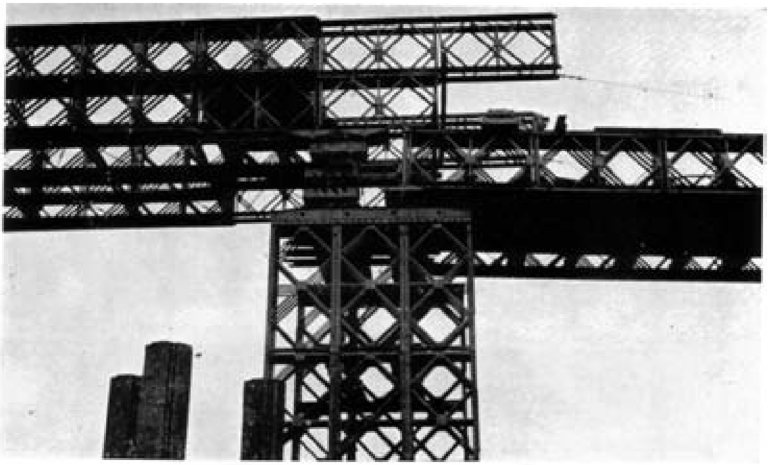


Photo 5.—Balance beam assembly, launching rollers, west side.

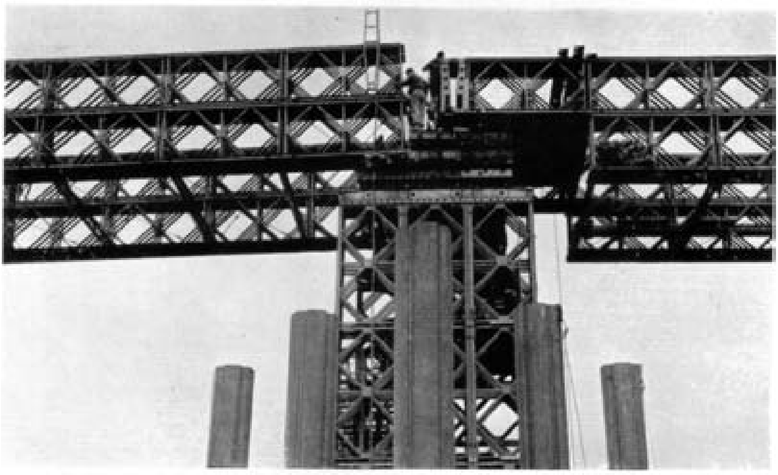


Photo 6.—Jacking at the centre pier.

Queens Bridge 5 , 6

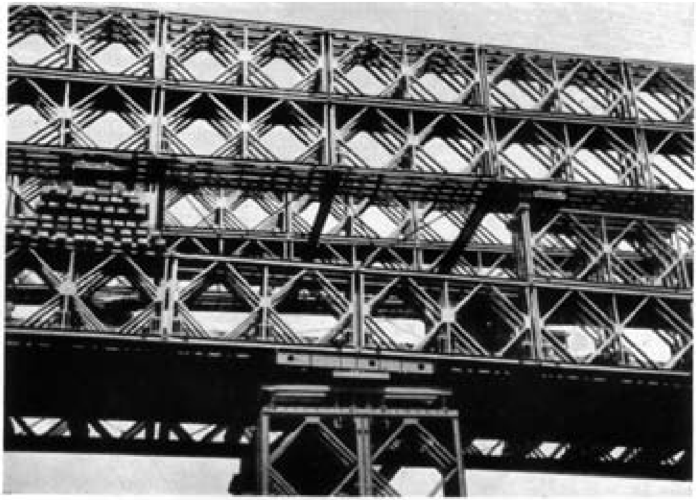


Photo 7.—A study in height. Navigation span on top of approach span.

Photo 8.—The tail of the navigation span being constructed.

Queens Bridge 7 , 8

reached them. The two then engaged with a sharp jerk. On the first occasion that this happened, a roller was knocked off the first pier. This trouble in future was obviated by converting the nose into double truss construction at the bay immediately ahead of the launching link. The outer pair of rollers were thus gradually engaged and the jerk eliminated.

It was extremely difficult to prevent the first span running an inch or so out of line during launching to the first pier. The smallest error had to be corrected or else it would have been magnified along the length of the bridge as it grew. For this task, the traversing jacks which had been demanded proved invaluable.

The break midway along the whole approach was filled with span junction posts; double truss only and launched with no pins and no links in the top chords. These posts accounted for 2 ft. of the 5-ft. gap required. Spans fore and aft of this break therefore had to be pulled 3 ft. apart on completion of launch. Forward spans were halted in their correct position and the ones aft were run back after separation of the two. A "tail" of one bay in double truss construction was therefore attached to the end of the bridge, in order to prevent an overshoot of the rollers at the abutment.

The bridge was used to carry forward the distributing beams which would be required in jacking-down later on. They were placed on top of the girders in the places where they would eventually be required. Hoisting these awkward loads up piers was thus saved. Two transoms below top chords were also positioned at each future jacking point.

Fork lift trucks were given a trial but did not prove of any great value, largely because the building sites were very restricted. A wheeled truck found difficulty with the rough ground and a tracked one was too slow. A proper combination of cranes and lorries gave a better result.

The method of launching and the tackles employed have already been mentioned. It was found that the bridge could be launched fifty or sixty feet at a time before it became necessary to overhaul the tackles and move the points of attachment.

Protruding high over the water, the launching nose required a crane for removal. A crane could not reach it, however, until the bridge had been decked. The head of the bridge was therefore left on temporary packing while jacking down and decking took place.

Approach spans: jacking

Jacking down took place on piers in succession, starting at the head of the bridge. The final gradient of the approach spans was 1 : 30. They were launched at a slope of 1 : 34. Thus only a few inches of jacking was necessary at the head, while 3 ft. was needed at the tail, where the deck had to be lowered to roadway level.

Two 50-ton jacks, with the necessary packing, were inserted between the transoms on each pier-top and those which had been carried forward under the top chords of the bridge. It was found that timber wedges had to be very accurately cut for packing, to compensate for the slope of the bridge. Without these, the transoms were unevenly loaded and the jacks showed a tendency to twist and work out. Once, the loading of transoms was so uneven that one failed under load. Luckily the bridge was only a few inches clear of its rollers at the time. From then on, four transoms, not two, were used under the top chords of the bridge and safety packing was even more carefully placed.

In jacking continuous spans, the loads on the jacks are to a certain extent indeterminate and it is not easy to gauge when one set of jacks is unduly loaded. It is therefore, wise to keep the ends of the bridge high and to prevent much hog developing at the centre.

The 50-ton (railway) jacks proved admirable for the work. Although very heavy and awkward to handle, they held an ample reserve of power and were easy to work once in position. The danger lay in the fact that these jacks were much stronger than the bridge parts with which they were in contact. Therefore there was a risk that the bridge itself would fail before the jacks stopped, unless care was taken. In particular, it was essential to ensure that the parts of the pier on which the bases of the jacks rested were sufficiently strong.

The space for jacking was very restricted. The jacks, the packing and the safety packing took up much of the room, yet clearance had to be left on each pier for the withdrawal of the rollers and the insertion of eight distributing beams. Most of the time taken in jacking was due to working in a confined space. It would have been preferable to have incorporated distributing beams, suitably supported, in a pier while building and to have placed the rollers on top of them. A higher launching plane would have been necessary and there would have been a greater vertical distance to jack, but the whole operation would have been very much simplified. This idea was put into practice on the east side. On certain piers it was possible to insert distributing beams instead of roller-packing without altering the launching plane.

Piers in the river

While the approach spans were building, piling for the river piers had been in progress. The simplicity and smoothness with which this was carried out by the Rijkswaterstaat was a joy to behold. At the same time, the two inshore piers in the river were also constructed. Being treble-panel width, they were more massive than the others and a crane could not be used without employing the 50/60 raft. It was desired to avoid the use of this if possible, since it entailed the withdrawal of motor-boats from the ferry service and the provision of a crew. Also the water-way was already congested with contractors' barges and piling rigs working on the centre pier, and half of it always had to be left open for river traffic. It was therefore decided to transport equipment out to the pier foundations by aerial cableways and to build the piers by davit and by hand. In each case, two cableways were run out from the bank; one for each side of the pier. For each cableway, a pylon of Christchurch cribs was erected at the edge of the pier foundations. The offshore end of the cable was attached to the top of this pylon. The inshore end was attached to a crane, which could then be used to operate the whole apparatus. Equipment was attached to a traveller while the cable was slack. Hoisting by the crane tensioned the cable and the height to which it was raised caused the traveller to run out to the pier. Lowering by the crane then brought the equipment to rest on the foundation, just where it was needed. Control of guide ropes to the traveller was the only manual operation involved.

The pier in the middle of the river could not be built by this means since it was too far from the bank. For it, the 50/60 raft had to be employed. Panels for half the pier were bolted three together on the bank and loaded on to the raft vertically, like a pack of cards. Transoms and other stores for half the pier were loaded on also. A crane was then run on and the ramps removed from one end of the raft. This end was then moored up against the foundations of the pier and the crane used for lifting up the panels, one truss at a time. This method proved extremely effective and the first two lifts of the pier were very soon built. Height precluded the top lift of the pier being assembled in complete trusses, but the crane could still be used for hoisting equipment to a platform at the top of the second lift. It had been feared that rough weather, the current and wind would make precision work by the crane difficult. But this was not the case. With the heavy crane, the raft was sufficiently laden to be stable. (See Photo 4.)

Navigation spans: construction

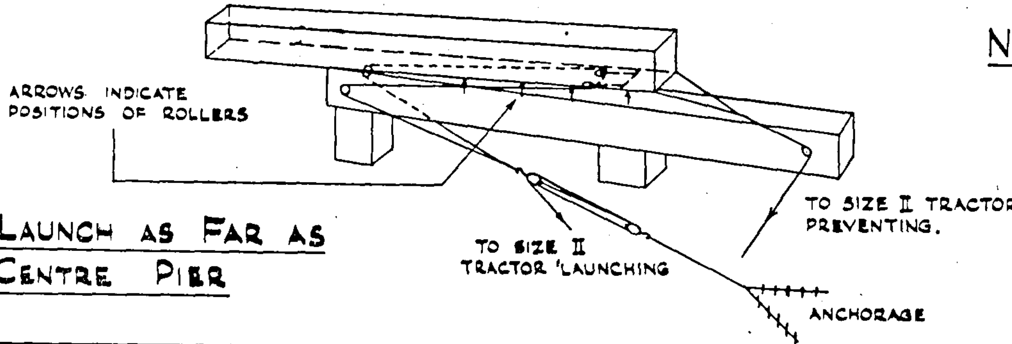
Construction of the navigation spans was in all respects the climax of the work. Their planning was the most complex and their construction the most difficult.

The main problem arose from the fact that, with quadruple truss construction there is no satisfactory way of attaching the underslung storey once the bridge is in position. There is insufficient room between the trusses for the tackles required.

A number of ways of launching the navigation spans suggested themselves, but all held at least one great disadvantage. In the end it was decided to launch them, one behind the other, over the top of the west side approach spans. (See Photos 3 and 7.) To keep the weight down, the top storey and the entire roadway were omitted from the launch. The spans were built in quadruple double

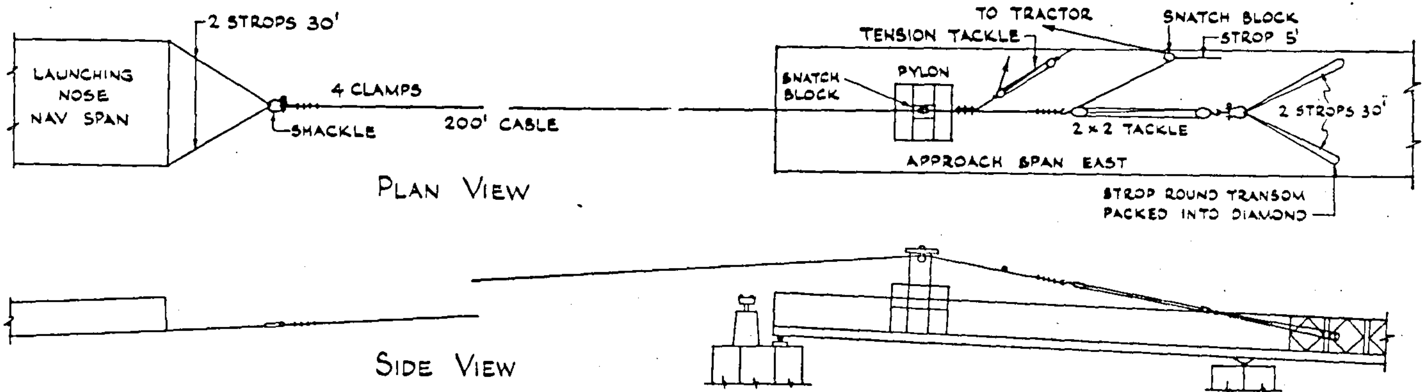
DRAWING No 2.

NAVIGATION SPANS



LAUNCH AS FAR AS CENTRE PIER

DIAGRAMMATIC NOT TO SCALE



NAVIGATION SPANS : FINAL LAUNCH

DIAGRAMMATIC, NOT TO SCALE

construction with one transom per bay in the bottom storey. These transoms eventually became the bracing and were in no way related to the roadway added afterwards. The big disadvantage of this plan was that the bridge had to be jacked down 10 ft. after launching and the end panels of the bottom storeys of each span had to be removed on the way down. It was a formidable undertaking but was in no way considered impossible.

Ten bays of launching nose were employed and two in a tail to guard against an overshoot and to provide a "jacking end". In the nose, launching links were positioned to compensate for a 5-ft. sag. The length of the nose was designed to permit the two spans to be launched "unlocked", that is pinned together in one plane only, with the two spans free to articulate. Unconventionally, these pins were not inserted in the bottom chord but at the neutral axis. This pinning arrangement was to ease separation of the spans after launching and to simplify jacking down.

Also to simplify jacking down, the majority of the panels due to be removed from the bottom storey were not pinned to their adjacent panels and were held in position by their chord bolts only. These panels contributed in no way to the strength of the spans and were only inserted to allow the bridge to pass over the rollers.

Every precaution had to be taken against rollers being knocked off or becoming jammed. Even with the powerful jacks available, it would have been an immense undertaking to lift the bridge clear once the full launching weight came into play. Therefore a considerable amount of welding was done on each balance beam assembly as soon as it became loaded. The rear pair of rollers on each balance beam were welded to their seatings. A metal strap connecting them rigidly together was also welded across their backs.

Originally it had only been intended to build 160 ft. of bridge at a time. Owing to delay with the centre pier, rollers for a further 80 ft. were added so that work might proceed meanwhile. The extra length also gave ample insurance against the point of balance ever passing the wrong side of the launching rollers. There was another advantage as well. The rear span could be completely built without the launching nose needing to protrude unduly beyond the centre pier.

Work on the tail went on 20 ft. above the deck of the bridge below. For this, the best men came forward and they were to be seen clinging like spiders, away up in the air, while the loose panels swayed in the wind. (See Photo 8.)

Launching was carried out in two distinct phases. The first was launching up to the centre pier when hauling tackles were designed to work from the home side. The second was launching beyond the pier when the pull came from the far side. (See Drawing No. 2.) The maximum force required for launching was estimated to be 13 tons.

Launching, to begin with, did not go well. The bridge edged over to the right, an inch for every 10 ft. it moved forward. At first it was thought that this was due to varying frictional forces in the blocks. They were therefore moved so as to give an eccentric pull to offset the drift. The remedy, however, did not succeed. Next, a slight error was detected in the alignment of the launching rollers. The weight of the bridge was taken on traversing jacks, the error corrected and the bridge reset on its line. Nevertheless, in further launching, the drift persisted. Anxiety grew, since the bridge was beginning to get too heavy to jack. Two 10-ton chain blocks were then brought into play. One was connected to pull along the line of the bridge, the other diagonally across it. By hauling on these, the bridge could be moved forward an inch at a time and the drift slowly corrected. This provided a partial solution but did not eradicate the cause. Launching continued with the drift being corrected and even over-corrected from time to time. Strangely enough, when the nose reached the centre pier, it was almost exactly on line. But by this time the drift at the launching rollers had reached a constant amount of 3 in. to the right. It did not alter from this for the rest of the launch and was finally put right in the jacking down. The rollers successfully resisted any further drift and the wisdom of welding them to each other was proved. The real cause of the trouble was never discovered for certain. In the many measurements made to find it, a strange comparison came to light. For some inexplicable reason the navigation spans appeared to be an inch narrower than the bridge below.

The nose having reached the centre pier, the pull was due to be taken from the east side. A first attempt to get a cable across the river without interrupting traffic was made by running if out slack on the river bed. It became fouled, however, and had to be withdrawn. For the next attempt, the cable was hung down from the top of the east side approach spans, with its end just above water level. The other end was made fast to a truck on the deck of the same spans. Then on top of the centre pier, a light line over a pulley was attached at one end to a tackle for hauling it in, while the free end was taken quickly across the river by boat and attached to the cable on the other side. The tackle was then worked fast to pull the cable across, the truck on the other side meanwhile running forward to ensure that the cable stayed slack. The cable was thus "fed" across the river with its end just above water and exerting no great strain because an appreciable dip was maintained. As soon as the cable was over and made fast to the nose, the truck went into reverse and the cable came up tight. The whole operation took ten minutes and only one barge was held up.

With the tractor taking the pull on the east bank, the people supervising the launch were spread over 400 yards, at varying heights and with the river between. Wireless stations were therefore set up at each vital point. Wireless, however, was not a sufficiently reliable or precise means of transmitting orders for launching. It was used only for the dissemination of information about the launch as it proceeded. For the transmission of orders, a simple system of flag signals was devised. At each vital point the party there was equipped with a yellow flag. This they kept hoisted and only when they were ready did they lower it. When all flags were down, O.C. Bridge lowered one himself and waved it low down as a signal for hauling and preventing winches to start work. The moment a flag appeared, O.C. Bridge at once raised his own and the launch stopped. Thus nothing could happen until everyone was ready and even then nothing moved until O.C. Bridge himself gave the signal.

On 17th July, with 170 ft. to go, the final and most critical stage of the launch took place. The task was made doubly difficult by a gale blowing at the time. Nevertheless, in spite of the added difficulty and discomfort, the working parties did their jobs well. By one o'clock the launching nose was across and the River Maas was spanned.

Navigation spans: jacking down

The problem of jacking down the navigation spans was like a Chinese puzzle. The way it was eventually solved is best shown in Drawing No. 3. In practice the solution worked out very well and the task was completed in a week.

To begin with, spans had to be separated 5 ft. apart. Then they had to be lowered 9 ft. over the centre pier and 10 ft. 8 in. at each end. On the way down, end panels of the bottom storeys of each span had to be removed. Finally end posts, bridge bearings and baseplates had to be positioned and the spans brought to rest on them.

In separation, delay occurred in removing the pins which had joined the two spans. With rough treatment their edges had become burred and a great deal of manipulation was necessary to drive them out from the pin-holes. Chain blocks were used for pulling the spans apart, S.W.R. strops being inserted in the gap between spans to prevent an overshoot.

For jacking down, no timber was used for packing. Instead, two types of steel piece were employed. The first was a 4 ft. length cut from an old pattern transom which provided a lift of 10 in. One hundred and twenty of these pieces were supplied. The second was a 3 ft. 6 in. length of Bailey panel chord. This gave a smaller lift of 4 in. and fifty of them were made. Both these types of packing were invaluable. They were light enough to be handled by one man yet were far stronger and more rigid than timber. No allowance had to be made for compressive effect and this made jacking far more precise. With them cribs could safely be built up, four or five feet high, to carry either the bridge or the jacks. (See Photos 5 and 6.)

For distributing loads from spans' ends to jacks, a piece of 50/60 raft equipment was used. The piece is officially known as "links adjustable" and is a bar, some three feet long, with holes along its length. Its shape very conveniently enabled it to fit under a girder and also to sit on the toe of a jack. Being a special steel, it was strong enough to carry safely all loads encountered.

For conveying jacking stores and posts and baseplates out to the centre pier, two bays of decking were built into the spans before launch. These bays were located either side of the joint between spans and were loaded while the spans were being built.

Similarly two davits and tackles were attached to the bridge before launch for lowering rollers, balance beams and panels when disengaged from the work. To receive these pieces, two platforms were built into the centre pier. On these the pieces were kept until there was an opportunity to move them to the shore.

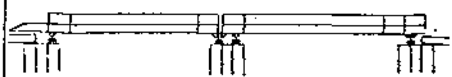
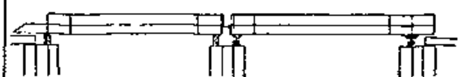
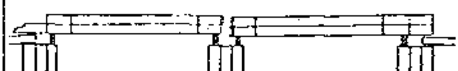
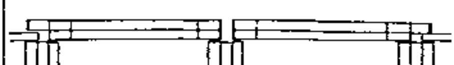
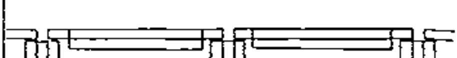
For ease of access to the top of the centre pier, a gangway was laid along one side of the west navigation span and a staircase of Christchurch cribs built up inside the pier itself. There were some who did not mind walking out along the chords of the bridge, but the majority preferred one of the less spectacular ways. Finally, field telephone linked all jacking points with Bridge Control.

Jacking-down went according to plan and it was an impressive sight to watch the great spans dip first this way and then that. The end panels came out easier than expected. For safety, the three inner ones of each girder were removed first and packing substituted before the fourth was taken away. Towards the end, the span junction posts which had been used for jacking were removed and the end posts fitted ready for the last few lifts. With only three inches to go, trouble started. An end post fractured across its back while on the jack. The welding on a second started giving way by the transom gate. On a third, small cracks were discernible, also across its back. On removal, the three posts were closely examined and it was noted with concern that the welding where they had broken was corroded for most of its cross-section. Other end posts, not yet put into bridge, were then examined and the welds on a number were found to contain flaws. Out of one post a bagful of rust was taken.

The Officers Commanding 303 E.S.D. and the Bridging Inspection Team visited the bridge next day in response to an urgent request. With them it was decided that twelve fresh posts, with welding reconditioned, would be supplied. They would be used for those trusses against which the jacking was to be done. It was also thought that the trouble might partly have been due to the jacks not being designed for fitting the posts. Consequently it was decided also to give standard Bailey hydraulic jacks a trial. When the fresh posts came these jacks were employed. They failed, however, to achieve their rated lifting capacity and were unable to raise the bridge from its packing. A return was made to the old 50-ton jacks

DRAWING No. 3

JACKING PLAN

	STAGE	EAST DIAGRAM WEST
1	Stop launching with East span over correct position. Jack. Remove balance beam and substitute packing	
2.	Separate spans slightly in lower storey fasten all span-junction posts to West side span with launching links in top chords. Fasten 3" straps on each side of bridge in gap between spans Separate spans completely Meanwhile East end has been jacked under launching nose, rollers removed and packing substituted.	
3.	Jack under West end, remove balance beam and substitute packing. Then jack under front of West end, remove rollers and lower 10". End now at + 5'- 5" .	
4.	Remove launching nose and replace panels in top storey to provide "jacking end" for East end. At same time remove lower panels of tail at West end to provide "jacking end" for West end. Fasten span-junction posts to both ends. (Ends to be double construction) Meanwhile readjust span-junction posts at centre as shown.	
5.	Jack at both ends and at centre alternately until spans are lowered as far as jacking ends and bottom chords of spans allow.	
6.	Pack under "jacking ends" to take weight of ends of spans. Remove end panels of lower storey. Base plates and packing plates to be positioned, then pack up under upper storey. (Jack to relieve loads from jacking ends)	
7.	Remove "jacking ends" and attach span junction posts to ends of spans. Position jacks under these posts.	
8.	At centre, remove span junction posts from lower storeys of both spans. Attach them with launching links in top chords to posts in upper storeys. Pack up under these posts. With jacks take weight off lower panels. Remove panels and then lower away. Pack up under upper storeys (not forgetting placing of baseplates) (remove panels of 3 inner trusses first and add packing, then take away panel of 4th truss)	
9.	Jack at ends and centre alternately until spans are almost in final position. Remove span junction posts. Fit end posts and bridge bearings and lower to rest.	
10.	Remove surplus transoms from packing. Clean up.	

and with them the bridge was successfully lowered to rest. It would be unfair therefore to attribute any of the trouble to the 50-ton jacks.

With the jacking down completed, the whole operation was as good as over.

Navigation spans: Roadway and third storey

There is little to record about the roadway and third storey. The roadway was laid from each end simultaneously. First, transoms were slung out by crane and clamped into position. Next, stringers were slid out and laid staggered, as in the rest of the bridge. The decking, with the special spiking rails below, was added. With the completion of each bay, the crane moved forward and the process was repeated. The gaps between spans were filled with specially cut stringers. At these points and also at the abutments, steel packing was welded beneath the centres of end transoms. A 2-in. wearing surface of timber was laid, planks being angled at 30 deg. across the deck. Their ends were secured under the ribands, the longer riband bolts necessary being supplied by the Rijkswaterstaat.

The third storey was erected with the help of chord jacks. Erection started at the centre of each span and proceeded outwards towards the ends. This enabled the sag in the spans to be progressively reduced. Consequently, pins in the third storey were driven more easily than if work had started at one end.

It only took four days to add the roadway and erect the third storey and the 31st July saw the bridge finished.

The final touches

Although the building of the bridge was completed on 31st July, it could not be opened to traffic for some weeks. The Rijkswaterstaat had yet to trim up the abutments, finish the approach roads and install the traffic lights. The latter were designed to be manually operated by day and automatically controlled by night.

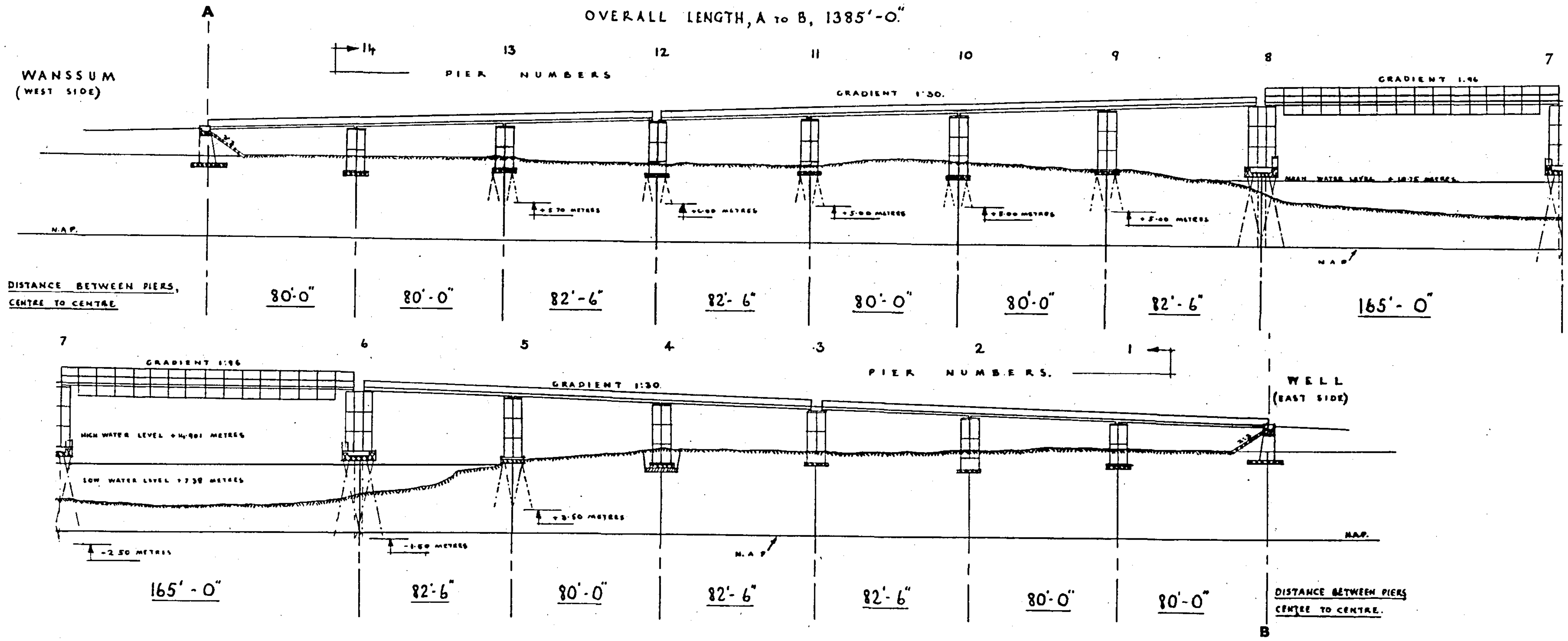
The final touches were made on 2nd September, ready for the ceremonial opening the next day.

This account has laid stress on the parts played by the British and Dutch units concerned and by the Rijkswaterstaat. True they actually built the bridge, but there were many others who had a prominent share in the work in planning, supply of equipment, or in some other way. To them also the bridge owes the honour of being called **Queens' Bridge**.

May it prove worthy of the name.

QUEENS' BRIDGE: GENERAL ARRANGEMENT.

OVERALL LENGTH, A to B, 1385'-0."



THE LEAP OF WATER

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

Even as he spoke his busy pencil moved,
Drawing the leap of water off the side
Where the great clipper trampled iron-hooved,
Making the blue hills of the sea divide

"Dauber" by John Masefield

THE wave made by a swift ship at sea is a joy to the eye, as poor Dauber, of Masefield's poem, knew well, but there are some facts about wave making which should be of use to Royal Engineer officers whose duty or pleasure takes them afloat.

When I was first commissioned I bought a 12-ft. I.Y.R.U. dinghy which I used to sail and race in the Medway. Very soon after I bought her, I got an impressive speed out of her on a reach, which I estimated, in my foolishness, as nine knots! A few days later, reading Claud Worth's *Yacht Cruising*, I found a statement that a yacht's speed could not exceed $1.4 \sqrt{L}$ knots, where L was the waterline length in feet. This put my poor little dinghy's maximum speed as under five knots, a sad disillusionment.

Nowadays dinghies, when driven beyond their theoretical maximum speed, will get out and plane; in those days they used to adopt the rather unpleasant alternative of diving into their bow wave when running too hard: they were quite unable to lift, partly because their shape was wrong for lifting, and partly because the mast was in the eyes of the boat, so that with the boom well but inadequately squared away there was a considerable downward reaction transmitted by the sail to the mast and thus to the bow of the boat.

At this stage we may turn to the principles underlying this peculiar behaviour.

Speed of Waves

It is a generally accepted scientific fact that, except in very shallow water, the speed of a wave, over the range of speeds which need concern us, is simply related to the wave length or distance from crest to crest. Calling the wave length L feet and S the speed in knots:—

$$S = 1.34\sqrt{L}$$

From this, the following table can be produced:—

TABLE I.—WAVE LENGTHS AND SPEEDS

Speed of wave disturbance in knots	Wave length in feet	Speed of wave disturbance in knots	Wave length in feet
5	13·9	17	161
6	20.0	18	180
7	27·3	19	201
8	35·8	20	223
9	45·1	21	246
10	55·7	22	270
11	67.4	23	294
12	80.2	24	321
13	94·1	25	348
14	109	30	501
15	125	35	682
16	143	40	891

A vessel moving through the water must set up a wave disturbance which travels at the speed at which she is moving through the water: therefore the wave length of the disturbance she is creating follows the formula $S = 1.34\sqrt{L}$ and Table I above, and in this case S is also equal to the speed of the ship relative to the water.

SHIPS OF MODERATE OR HEAVY DISPLACEMENT

If we first consider a ship of unremarkable power for her weight, when her speed rises so that the wave length is slightly less than her own length, she has reached her "natural maximum" speed (see Plate II, Fig. 3). If she exceeds this speed she will have to climb on to the reverse slope of her own bow wave and, in other words, travel uphill. For her to be able to do this she will require a great increase in power (see Plate II, Fig. 4).

The steepness of the wave disturbance created by the passage of a ship varies according to the hull form: the light displacement craft, or the craft with fine lines, will produce a more gentle wave form than the heavy displacement craft or the craft with blunt ends. The craft with a bluff bow will pile her bow wave in front of herself (see Plate I, Fig. 1). The craft with a fine entrance will have very little effect on the water ahead of herself, so the crest of the bow wave will be considerably abaft the bow: the effect of this latter circumstance is to bring the crest of the second wave further aft and, therefore, to cause the finer lined craft to "run uphill" at a rather lower speed than a bluff one of the same length. In point of fact, this rarely affects adversely the speed of the finer lined craft since up to the stage she is "running uphill" she requires far less power for a given speed than

than the bluff ship; secondly the wave disturbance she creates is shallower so that even when she is just "running uphill" she is only running up a very gentle slope (see Plate II, Figs. 5 and 6). This tendency can be further reduced by a full after overhang to prevent squatting aft.

Most merchant vessels and warships have very small overhangs compared with their waterline length, but in sailing yachts the overhangs can be relatively great. Thus with sailing yachts the maximum wave length can be considerably greater than the waterline length though less than the over-all length, before the yacht has to run uphill. That is why yachtsmen have adopted the rough and ready formula $S = 1.4\sqrt{L}$ when using the waterline length of the yacht for L in the formula.

A seagoing sailing yacht will usually develop her highest speed when sailing with a following or quartering sea. In such cases she may exceed her theoretical maximum speed, for the reason that when she is on the forward slope of a roller she can climb up on her own bow wave and still be travelling downhill; she, therefore, goes faster. On the reverse slope she has to climb the roller and so decelerates. As the rollers are also travelling roughly in the same direction as the yacht—and travelling faster than her, as they must—it stands to reason that the yacht will spend a longer time on the forward slope of the roller than on the reverse slope, since the roller is overtaking her slower on the forward slope. Her average speed will thus be increased.

In a rising wind, with the seas travelling only a little faster than the yacht's theoretical maximum speed, a yacht may be driven even faster still, through lingering on the crest of the roller. In a wave the actual movement of the water is roughly circular or elliptical in a vertical plane: thus on the crest the water is moving in the direction of the wave motion, and a fairly light displacement yacht can utilize this motion to keep her on the wave crest for several seconds. Having experienced this "surf-riding" when at the helm of *Right Royal*, I can recommend it as an exhilarating experience.

Turning back to Table I, it should be pointed out that practically all sea-going sailing yachts come under the category of ships which can be driven up to a speed which allows them to sit in the trough of their own wave and no more. To give two examples of this from R.E.Y.C. logs, *Ilex*'s best hour in the Transatlantic Race of 1931 gave 9.35 knots, corresponding to a wavelength of 48.7 ft.: *Ilex*'s waterline length was 41.5 ft. and her over-all length 51 ft. The second example is *Right Royal*, whose best logged speed so far has been 8.25 knots for two hours on end, corresponding to a wave length of 37.3 ft. *Right Royal* has a waterline length of 28.6 ft. and an over-all length of 39.2 ft.

PLATE II

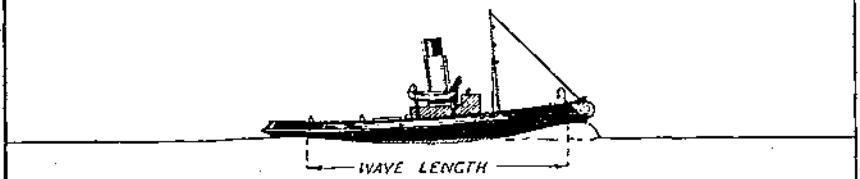


FIG. 3. STEAM TUG AT FULL SPEED RIDING IN TROUGH OF OWN WAVE

FIG. 4. SMALL, POWERFUL CRAFT RIDING REVERSE SLOPE OF OWN WAVE - "STEAMING UPHILL".

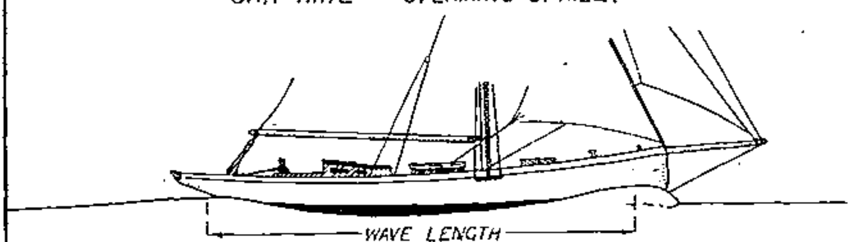


FIG. 5. TYPICAL WAVE DISTURBANCE OF HEAVY DISPLACEMENT YACHT AT FULL SPEED - NOTE STEEP FORM AND CRESTS WELL FORWARD.

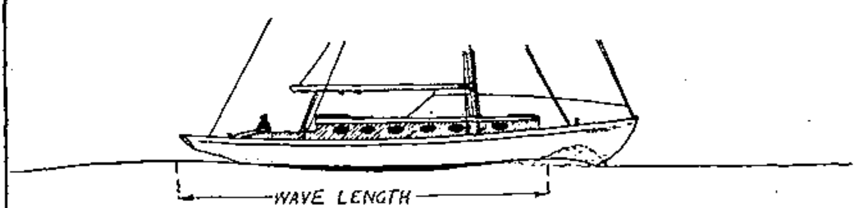


FIG. 6. TYPICAL WAVE DISTURBANCE OF LIGHT DISPLACEMENT YACHT AT FULL SPEED - NOTE EASIER FORM AND CRESTS FURTHER AFT.

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Merchant vessels rarely attain speeds which allow them to do as much as to sit in the trough of a single wave of their own making. The *Queen Mary* at 32 knots (her best day's run ever) was making a wave 570 ft. long from crest to crest, while her over-all length is 1,018 ft. The *United States* gets a little nearer at 36 knots, with a wave length of 722 ft. on an over-all length of about 980 ft. The new P. & O. *Himalaya*, just over 700 ft. long, at her designed speed of 23 knots sets up a wave under 300 ft. long.

In the Merchant Navy, indeed, it is the cross-Channel packets which most nearly run in the trough of a single wave. These ships nowadays have lengths of 300 to just under 400 ft. and their speeds of 20 to 25 knots mean wave lengths of roughly 220 to 350 ft. The crests of the bow waves of these fine-lined vessels lie some way abaft the bow and in consequence many of them are, so to speak, on the verge of, if not actually, "steaming uphill".

An interesting example may here be given. In 1920 to 1922 four very fine-geared turbine steamers, *Anglia*, *Cambria*, *Hibernia* and *Scotia*, were built for the Holyhead to Kingstown mail service. These were 25-knot ships displacing some 3,400 tons: their length was about 390 ft. and thus they were able to take their own 384-foot wave in their stride. The engines gave 15,000 s.h.p. These four beautiful ships have now all gone—three to the scrappers and one bombed and sunk in the Dunkirk operation—and the modern namesakes of two of them are slower motorships.

As against the *Anglia* and her sisters, the modern Newhaven to Dieppe packets have a speed of 24 knots: they are smaller, displacing only a little over 2,000 tons, and their over-all length is only about 310 ft. Thus they cannot take their own 321-foot wave in their stride and at full speed they must be "travelling uphill", a tendency which is reduced by a buoyant stern which fills out rapidly above the normal waterline. In consequence, 18,000 s.h.p.—20 per cent more than the *Anglia*—is required to give these ships of two-thirds the weight a speed 1 knot less than the older vessels. This gives an idea of the extra power needed once the "natural maximum" speed of a ship is exceeded, for at 20 knots it is probable that the Newhaven boats require less power than would have been necessary for the old *Anglia* at the same speed (see Plate III, Figs. 7 and 8).

Warships, as a whole, are faster in relation to their length than merchantmen. Many modern cruisers and all destroyers exceed their "natural maximum" speed. Most modern destroyers are between 350 and 420 ft. long and many have speeds of the order of 36 knots, giving a wave length of over 700 ft. (see Plate III, Fig. 9). Thus these all ride on the reverse slope of their own bow waves and consequently need a lot of power to do it. They are helped by their fine lines and light displacement which keep the wave form shallow and give them less weight to drag uphill, a full buoyant stern helping to reduce the angle of slope.

PLATE III

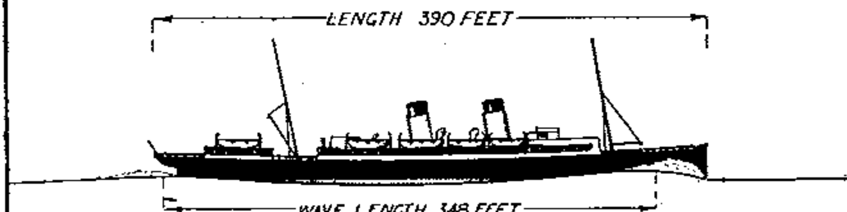

FIG. 7 OLD HOLYHEAD - KINGSTOWN PACKET "ANGLIA" AT 25 KNOTS, TAKING OWN WAVE IN HER STRIDE.

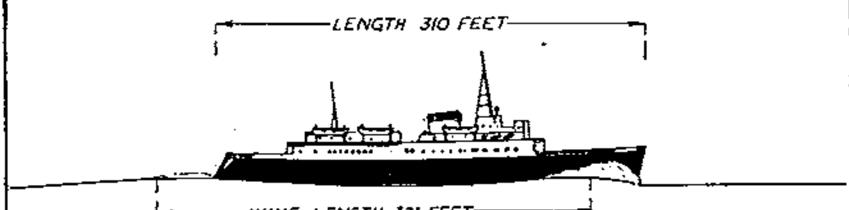

FIG. 8. MODERN NEWHAVEN - DIEPPE PACKET AT 24 KNOTS, MAKING WAVE LONGER THAN HERSELF.

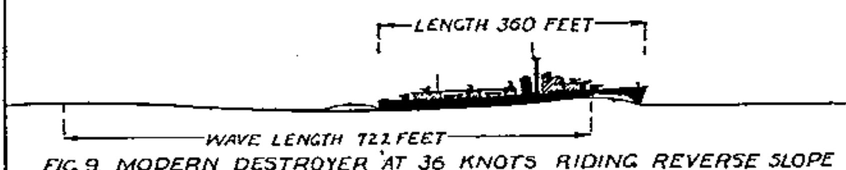

FIG. 9. MODERN DESTROYER AT 36 KNOTS RIDING REVERSE SLOPE OF OWN WAVE - BUOYANT STERN PREVENTS SQUATTING AND REDUCES UPHILL SLOPE OF SHIP.

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Planing

Passing again to smaller vessels, very light hulls can be caused to plane. A ship at rest displaces exactly its own weight of water: so, more or less, does a normal ship in motion. But a hull which planes displaces a weight of water less than its weight (when planing), additional upward thrust to balance the weight being provided by the reaction between the moving bottom of the hull and the surface of the water. For a vessel to plane, the power/weight ratio must be good, and the shape of the lines such as to give the necessary lift to the hull.

The wave disturbance caused by a planing hull at a given speed is far less than that caused by a normal hull travelling at the same speed. Thus the wave produced is not at all steep and the ship rides on the crest of it. As an example, the old storm boat of the last war, which had a length of 20 ft., would plane at 19 knots with a crew of two on board, when powered with a 50-h.p. Evinrude, producing a wave length of 200 ft.

Modern sailing dinghies and other light sailing craft can plane given the right conditions. It is to be noted that craft, whether powered or sailing, are particularly light on the helm when this condition is achieved, and all who have tried it will agree that it is an exhilarating experience.

"Uphill" Steaming

I have already mentioned what I have called uphill steaming or sailing, for want of a better name, and this must not be confused with planing, since a craft steaming uphill, not being a planing type, still displaces approximately her own weight of water. Such craft need wide buoyant sterns (a characteristic usually shared by planing craft) to prevent themselves squatting excessively and their high speed is only obtained by a great increase in power. For speeds well inside the "natural maximum" of a ship, the power required varies roughly with the cube of the speed, but as soon as uphill work starts the power required is increased sharply above this relation.

Two examples with a Corps flavour may here be cited. Firstly, the war-time storm boat, when laden with twelve men, ceased to be a planing craft, but the power of the engine was such that the boat could just start to "steam uphill". At 6.8 knots, which was about its maximum with the 50 h.p. Evinrude, a wave 25.7 ft. long was formed and the boat, 20 ft. long, steamed uphill with the stern wave, steep and menacing, following closely behind the low transom. If the engine was suddenly stopped this steep stern wave overtook the boat and, on occasions, flooded her in the process. It is notable that with an engine of one-third the rated power of the Evinrude, the craft, similarly loaded, could make 6 knots: this indeed shows how sharply the power curve must rise once the natural maximum speed is exceeded; this is not perhaps an absolutely fair example as under these conditions the Evinrude engine did not develop its maximum power and the propellor was inefficient for this kind of work: nevertheless, the tendency is clear.

A second example is the Mark 5 Tug, a craft 23 ft. long, having a weight of 2¾ tons. Its maximum speed is 12.5 knots and its wave length is, therefore, about 87 feet. It must steam uphill hard, but it is helped by its shape and it probably planes half-heartedly. A newer and heavier type of tug is a little longer and slower and provides a beautiful example of steaming uphill, for it is not a planing craft.

Pontoons

Here we come to another peculiar case which also fits into the pattern. The tripartite pontoon pier of the Bailey Pontoon Bridge, 60 ft. long, would, on the basis of the foregoing, have been safe in a current of over 10 knots, but in fact it was not. The tripartite pier was under three feet deep and had a bluff scow bow. This would build up a steep wave disturbance, which long before 10 knots—or even before 5 knots in a laden pier—was reached, would break over the bow and destroy the pier's stability. Some improvement, as everyone knows, was obtained by fitting a raised false bow: the limit was now reached when the crest of the second wave started to break over the pontoon sides.

Owing to lack of freeboard, therefore, one cannot expect the pontoon piers of an equipment bridge to stand in currents where the piers would produce waves of length comparable with the pier lengths. Post-war design, however, has improved the bow form so that the new piers can stand worse currents than the old B.P.B.

High Speed Bow Wave

With fine-lined ships travelling fast, apart from the main wave disturbance (which, being shallow for a well designed vessel, is not very noticeable), a feather of foam or spray is thrown by the leading edge of the bow high above the main wave disturbance. The position of its crest bears no relation to the position of the crest of the main wave and in fact it is generally well forward of it. (See Plate I, Fig. 2.)

Final Example

An example which serves to summarize the effect of most of the foregoing may be taken from a certain type of boat powered by an outboard motor. This particular boat has a square transom which allows two boats to be buttoned together, transom to transom, to form a double length craft. When light, both single and double length boats plane, and fairly naturally the short single craft is the faster.

PLATE IV

FIG 10. SINGLE BOAT, LIGHT LOAD – CRAFT PLANING.

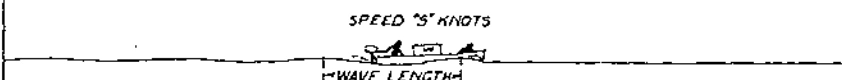


FIG 11 SINGLE BOAT, PAY LOAD 'W' – CRAFT "STEAMING UPHILL.

FIG 12 DOUBLE BOAT, LIGHT LOAD – CRAFT PLANING

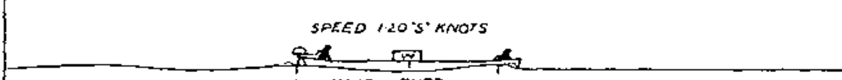


FIG 13 DOUBLE BOAT, PAY LOAD 'W' – CRAFT AT 'NATURAL MAXIMUM' SPEED.

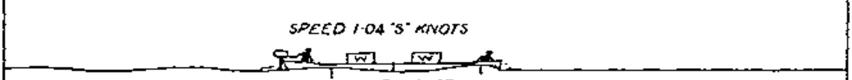


FIG 14. DOUBLE BOAT, PAY LOAD 2 'W' – CRAFT AT WELL BELOW 'NATURAL MAXIMUM' SPEED.

But when each carry the same pay load the long boat is considerably faster and even with a double pay load in the longer boat she is faster than the single boat with a single pay load. The fact is that under laden conditions, the long boat is not exceeding her natural maximum speed, while the single boat is "steaming uphill". Comparative figures are given below, taking L feet as the length of the single boat and S knots the speed of the single boat with the pay load, viz.:—

	Length	Load	Speed (kts.)	Condition
Single boat	L'	Light, 2 crew	$2.44S$	Planing
Single boat	L'	Laden, 2 crew plus 1 ton pay load	$1.00S$	Steaming uphill
Double boat	$2L'$	Light, 2 crew	$1.80S$	Planing
Double boat	$2L'$	Laden, 2 crew plus 1 ton pay load	$2.20S$	Normal
Double boat	$2L'$	Heavily laden, 2 crew plus 2 tons pay load	$1.04S$	Normal

The natural maximum speed of the single boat is about $0.8S$ and that of the double boat about $1.2S$. The five situations above are illustrated at Plate IV, Figs. 10 to 14, to clarify the matter further.

Conclusion

A certain well-known ocean racing skipper refuses to tow a log, which, he says, takes a fraction of a knot off his ship's speed: he has, therefore, made a series of marks along the rail of the yacht corresponding to different speeds and by noting the position of the crest of his quarter wave (or second wave) he can take reading of the speed of his yacht, off the rail, and thus calculate the distance sailed without the use of a log. This may be carrying the matter to extremes, but perhaps these notes, which only express the problem in its simplest form, may assist officers to judge speeds of craft and currents more reasonably than before, or perhaps suggest some forms of amusement to those with inquiring minds and nautical leanings.

Acknowledgement

My acknowledgement is due to the Society of Authors for permission to quote the four lines from Dauber, by John Masefield, at the beginning of the article.

CORPS OTHER RANK MANPOWER—ITS PROVISION AND ALLOCATION IN QUANTITY AND QUALITY

By MAJOR A. F. L. COLSON, M.B.E., R.E.

IT is thought that it may be of interest to set out briefly certain points connected with the planning and distribution of the Corps Other Rank manpower, and with the allocation of recruits to trades and employments during their passage through the training machine. It is intended to discuss the subject under the following headings:—

(*a*) The principles on which the manpower of the Corps is controlled and distributed to fulfil commitments throughout the world.

(*b*) Some of the factors involved in planning the content of intakes to meet the various qualitative needs of the Corps.

(*c*) The allocation of the individuals in the intakes to trades and employments to meet the requirements of the Corps, in its different branches, for skilled men and N.C.Os.

CONTROL AND DISTRIBUTION OF MANPOWER

The size of the Army in any particular financial year is decided by the Cabinet. There are three main factors which govern their decision. Firstly, the nation's world-wide commitment, which is assessed by the Defence Policy Committee and agreed by the Cabinet. Secondly, there is the amount of money available for defence as a whole and for the Army in particular, and the proportion of this share to be spent on manning. Both these items are subject to Parliamentary control. Lastly, there is the available manpower in the country which is only partially subject to the control of Parliament.

At any one time one or more of these factors may outweigh the remainder in importance. For example, at the beginning of the Korean War, manpower set an absolute limit to the build-up of the Army: at the present time, by contrast, the limit is financial. So the eventual size of the Army is at best the result of a compromise solution.

From the total figure authorized by the Cabinet decision, the War Office sub-allots manpower to overseas Commands, and to certain home Commands and War Office Directors, in accordance with their operational commitments or functions. The officer who is responsible for the manpower in each case is known as the manpower holder.

When each manpower holder knows the figure which has been sub-allotted to him by the War Office he is in a position to prepare his Field Force Conspectus (F.F.C.) target document and to do this he bases his calculations on his outline order of battle and various operational and administrative assumptions. At the same time another document is produced which is entitled the Split to Parent Arms: this shows, so far as the Corps is concerned, the numbers of men wearing the Sapper cap badge who are to be included in the particular manpower holder's sub-allotment. These documents are then submitted to the War Office, and the actual manpower commitment throughout the world, for the year in question, of each arm or service is calculated from them.

To arrive at the total manpower requirement for an arm or service due allowance must be made for the numbers of men who will not be available, at any particular moment, to meet the manpower commitment which has been assessed in the manner described in the previous paragraph. Such men are termed non-effectives and they include all those who are not filling vacancies in authorized establishments. Students attending courses in static training units, men in holding units awaiting drafting, posting and discharge and whilst attending vocational training courses and taking disembarkation leave, and those men in transit throughout the world, all come under this heading.

Naturally the quantity of manpower which can be classed as non-effective is constantly fluctuating throughout the year and the numbers of men in some of the caetgories within the total are impossible to forecast exactly. Therefore in computing the allowance to cover non-effectives it is necessary to make assumptions of various kinds.

On the basis of these figures and the size of the Army's share for the year of the National Service Pool, it is then possible to divide the fortnightly Army intakes amongst the various arms and services, so that their strengths are maintained at the correct level to allow them to meet their commitments throughout the world. The fortnightly intake is composed mainly of men in the National Service Pool: that is to say those men who are called up for National Service or would have been had they not undertaken Regular engagements. It will be seen therefore that the intake comprises a known number of National Servicemen, called forward by the Ministry of Labour from War Office demands, and an estimated number of men who it is expected will enlist on regular engagements and be available for call-up with a particular intake. In addition, there are other categories of recruits to swell the Corps intakes, such as apprentice and regimental boys entering upon man's service, re-enlistments from civilian life, transfers from other arms, and so forth. Consequently the size of the intake is to a large extent dependent on fluctuations in the numbers of Regulars recruited and thus, forecasting these numbers requires study.

A rise or fall in Regular recruiting can be brought about by many different causes whose effects are, to varying degrees, difficult to predict. Pay increases, small wars, conditions for family life, new terms of service, amongst many other factors, all affect recruiting, rather unpredictably, to a greater or lesser extent. Seasonal trends are, however, apparent year by year and, in general, recruiting in the winter months is better than it is in the summer. To maintain the intake at a figure close to the one which was planned it is necessary to decrease or increase the National Service portion to offset any rise or fall, which has amounted to a definite trend, in Regular recruiting. Such adjustments can only be made after six weeks warning to the Ministry of Labour and they are quite unsuited as a means of compensating for slight variations in the number of Regulars recruited in successive intakes.

Although the intakes to the Corps are planned to enable the Corps to meet its commitments throughout the world the effective manpower available at any given moment is almost always insufficient to fill all the vacancies authorized in the F.F.C. documents. The more important causes of this continual shortage are the outside influences bearing on the recruiting rate, which are beyond the control of the recruiting organization, unforeseen operational demands and excessive manpower loss in non-effectives. Operational requirements may involve the strengthening of existing units, the formation of new ones, or the retention of units in the Order of Battle after the date planned for their disbandment: all unforeseen changes of this nature mean that the available trained manpower must be stretched still more thinly to cover all the Corps commitments.

The struggle to reduce the numbers of non-effectives goes on continuously. The official estimate on which all manpower calculations are based, is derived from the figures given in the statistical returns from the previous year. Allowances based on estimates of this kind are bound to prove inadequate from time to time. For instance, in 1953 it was decided that troops should serve one winter only in Korea. This resulted in a reinforcement demand quite outside the scope of statistical anticipation. Similarly, when sea transport was requisitioned for the Indian Custodian Force and the return of ex-prisoners of war, there was an unforseeable delay in the drafting programme. Each of these examples shows how the number of non-effectives may rise substantially above the calculated allowance. In general, the total allowance for non-effectives is never as large as it might be according to the, perhaps, more biased calculations produced by A.G.7. Consequently whenever there is a difference between the two figures it is felt in the Corps as a shortage of effective manpower, and never as a surplus. Another small source of manpower loss is Unspecified Extra Regimental Employments (E.R.E. II). Though strictly speaking this cannot be classed as non-effective manpower, personnel serving in E.R.E. II over and above the F.F.C. allowance are, from the point of view of filling vacancies in Corps establishments, just as much a loss as if they were permanently sick. The allowance is very small and is at present 124. There are many demands for men to fill this type of vacancy and despite the grim determination with which every possible application is refused, the Corps strength in E.R.E. II has usually been between 180 and 200 over the past eighteen months.

In addition to these causes of shortage in Corps manpower many units are actually allotted a manpower cover which is less than their establishment shows. This might mean for example that the lower establishment of a unit was 200, the manpower cover in the F.F.C. document 189, while the forecast of available manpower to fill the vacancies in the unit at a given date allowed a posted strength of only 175. To ensure that any shortage which exists is borne throughout the world in the way least injurious to operational requirements the available manpower is allocated by the E.-in-C.

Every three months a forecast is made of the Corps strength at a date eight months ahead. This forecast is as accurate as it is possible to make it but as the rates of run-out and recruitment of Regulars, amongst other imponderables, have to be estimated the final answer can never be exact. At the same time the commitments of the Corps at the particular date are listed and changes which are expected to occur in the eight-month period are taken into account. The difference between the forecast commitments and the available manpower to meet them inevitably takes the form of a shortage of effective manpower. In his quarterly manpower allocation the E.-in-C. indicates which commands overseas and which units at home are to bear specified portions of the shortage.

The O.I.C. R.E. Records can then plan his reinforcement and posting programme for a three-month period on the figures contained in the E.-in-C's. manpower allocation. In due course, a month or so before the beginning of the particular three-month period, overseas commands are informed of the manpower figure which has been allotted to them, and which it is hoped to provide.

Planning the Content of the Corps Intake

The actual size of the Corps intake is decided in the manner already described; the content of the intake now remains to be planned. The Corps has a requirement for many different types of men who are needed to produce its Officers, N.C.Os., skilled tradesmen and general dutymen. It has been found that only about 35 per cent of the men, who offer themselves as candidates for commissions, actually become officers. By using this success rate it is possible to deduce the number of men, of officer standard, required to ensure that the officer strength of the Corps is maintained.

In order to build an adequate trade structure, men of various aptitudes, levels of education and intelligence are required to undergo training in some of the 130 trades for which the Corps has a commitment. However, as the training capacity of the Corps is insufficient to supply all its needs, it is essential to include in the intakes sufficient skilled men whose previous experience enables them to pass or claim exemption from particular trade tests. Lastly there is a requirement for men of suitably low standard to fill all the vacancies for general dutymen: it is obviously uneconomical to use higher quality men for employment of this kind.

The numbers in each of these categories which are required quarterly, half-yearly or annually are notified to or known by the Manpower Planning Directorate which is responsible for the control and allocation of manpower to the whole Army. The technical corps naturally have a need for more men of the higher intelligence and educational levels than say, Infantry or R.A.S.C. Due allowance is made for this and the following average figures reflect the larger percentages of the better quality men in the Corps intake as compared to that of the Army as a whole:—

	Percentage of this category* in the Corps intake	Percentage of this category* in the Army intake
S.G.1 (highest intelligence group)	15.6	8.5
Above median (i.e., above average intelligence)	66.7	47.1
Educational Level 3 or better	15.4	8.1
O.R.1 (potential officers)	12.1	6.2
O.R.4 (potential N.C.Os.)	24.3	19.3

*Each of these categories should be considered separately and only in relation to the intake as a whole. For instance, all S.G.1s. are above the median, and the majority of them will be Educational Level 3 or above and also graded O.R.1.

The incoming manpower which must be distributed throughout the Army to meet its qualitative requirements is composed of the Regulars, whose numbers fluctuate from intake to intake, and the National Servicemen who join in definite numbers. It is necessary to consider these two groups separately in order to understand how each contributes in supplying the qualitative demands of the Corps. It will be as well for this purpose to understand in outline the process of enlistment for both Regulars and National Servicemen..

A man wishing to join the Corps as a Regular can apply to do so at any recruiting office. To assess his suitability for service on a regular engagement he is medically examined, subjected to a simple intelligence test (R. Test 57) and interviewed by the recruiting officer who is in possession of the test results.

The standards for acceptance of men on regular engagements are set out in recruiting instructions. Medical standards, which vary for different trades, are contained in the Pulheems Administrative Pamphlet (1953). The minimum test scores, which also vary for different trades, are shown in an appendix to the recruiting instructions. Provided that a man is up to these standards for the trade he wishes to serve in, and fulfils all the other conditions, he may be enlisted into the Corps and his trade preference is recorded: no guarantee can be given that he will eventually be allocated to that trade, but he is so allocated whenever possible. To control the numbers of regulars enlisted as potential tradesmen in the different trades it is necessary from time to time, to close certain trades to recruiting and to place restrictions on others. Trades are closed if they are grossly over-subscribed or there is no demand from units for tradesmen of that type. There is no training available in some Corps trades and it is therefore necessary to restrict recruitment for these to men who have qualifications or experience which will allow them to claim exemption from or to pass a trade test without further training. Finally there are those trades which are popular but for which the training capacity is limited: for these trades, recruiting officers are required to contact R.E. Records before carrying out an enlistment in order that the number of aspirants for training can be related to the course vacancies, and the number of disappointed Regular recruits be kept to a minimum.

It will be seen that beyond exercising these controls there is little that can be done to obtain a suitable trade structure amongst Regular recruits. The structure is simply a result of the personal preferences of the men enlisting.

The National Serviceman, on the other hand, provides a source of manpower which is much more easily moulded to the Army's requirements. His attributes are assessed, in the first instance, in much the same way as are the potential Regular's. Before call-up each man is medically examined, tested for intelligence and interviewed by a Military Interviewing Officer. His qualification form, the A.F.B214, is partially filled in with the information obtained from the medical examinations, tests and interviews and is then passed to the War Office (M.P.3).

Before deciding which National Servicemen are to be allocated to the Corps to fill its quota in any intake, M.P.3 take a large number of factors into consideration: many of them are conflicting, but the final decision is intended to make the best use of a man's whole-time and part-time service. It may be of interest to discuss some of these factors in view of the surprise which is sometimes expressed at the allocation to arm of particular individuals.

A man's intelligence and educational standards influence the decision a great deal. The intelligence is assessed from the R Test 57 and the educational standards are considered in three divisions: below General Certificate of Education (Ordinary Level), up to that level, and degree or diploma. The latter class are given special consideration as Joint Recruiting Board candidates and every effort is made to fit them into the part of the Army where their knowledge can be put to best use either as officers or other ranks.

Naturally, trade skill or potential counts a great deal in the present-day technical Army. The intake of skilled tradesmen is essential for the efficiency of the Army and therefore their allocation to arms and services must allow scope for the employment of their skill. The call-up of men serving apprenticeships is normally postponed to enable them to complete their training and they are known when they eventually join as deferred apprentices. Their trades, of course, largely govern their allocation within the Army. Apart from these, other classes of tradesmen or potential tradesmen are available in the manpower pool. A Corps demand for tradesmen for each quarter is submitted to M.P.3 who use it as a guide when allocating tradesmen. It may be that in some cases, when the demand in a certain trade has been met, men who seem especially suitable for service in the Corps may be allocated, for a variety of reasons, to another arm or service.

The Ministry of Labour recommends in many cases, in which the individual possesses some special qualification, the trades and arm or service in which they consider the best employment is available. These recommendations are another factor for M.P.3 to take into account.

There are special arrangements for the allocation to the Corps of certain types of skilled men. Examples are men previously employed by the Ordnance Survey, the General Post Office, the Railway Executive and the Docks and Harbour Board. Such men come to the Corps irrespective of the demand or of the vacancies in the specialist branches of the Corps for which they are suited. It is not always possible as a result to employ them all in their specialized trades. Other special allocations result from demands made through A.G.7 for individuals by name because of family connexions with the Corps, or because of recommendations from past or present members of the Corps.

The needs of the Reserve Army must also receive attention. The area in which a man expects to reside after his whole-time service has a strong bearing on his allocation within the Active Army. It is the aim that a man should be able to join, for his part-time service, a Territorial Army unit which is close to his home. Another point in this connexion is pre-call-up military experience. The fact that a man has served in a cadet force unit or in an A.E.R. or T.A. unit during a period of deferment of call-up weighs heavily, particularly in conjunction with a strongly expressed personal preference for a particular Corps, when his allocation within the active army is being considered.

The last two points, which may be of overriding importance, are restrictions imposed by medical categories and a man's attitude to employment as a cook or on medical work. Every individual is asked by the Military Interviewing Officer what his attitude is to these types of work. His answers, which are usually written down as "averse", "not averse" or "keen", are recorded in Section I of the Qualification Form A.F.B214. The demand for suitable men for the R.A.M.C. and A.C.C. is such that a man who does not express himself as being "averse" to such employment is likely to find himself allocated to one of these Corps. Even though he might seem qualified for a Sapper trade he might well be allocated, providing there was not a shortage in the trade for which he appears suited, for employment as a nursing orderly or cook.

With so many conflicting factors to take into consideration, it would be humanly impossible to satisfy all sections of the Army and the public in every case. All these factors are however, taken into account by M.P.3, and the Ministry of Labour is informed which men of a particular fortnightly intake to the Army are to join the Corps. The Ministry is then able to send out enlistment notices to the men concerned and in due course several hundred men report on a predetermined Thursday to 1 Training Regiment R.E. at Malvern. It is inevitable that the qualitative content of this intake will not exactly match the fortnightly requirements in all branches of the Corps. The discrepancy between the requirement and the availability of suitably qualified men in the intake varies at different times of the year. For instance, it is well known that after the end of the school year there is an influx of men of a higher educational standard: on the other hand, the output from universities, technical colleges and the majority of apprentices occurs in the middle of the year and the graduates join the Army in October and November. No matter what the content of the intakes, the Personnel Selection Team, operating at 1 and 6 Training Regiments, R.E., has the task, fortnight by fortnight, of fitting the Regular and National Service recruits into the trades and employments in which the Corps needs them and for which they are considered to be the best suited from amongst those available.

Allocation within the Corps of Men to Trades and Employments

Before embarking on the difficulties facing the Personnal Selection Team and attempting to describe the procedure they employ, it will be necessary to sketch briefly the methods used to control the outputs of the different parts of the training machine, and the various sequences of preliminary training applicable to particular trades.

Once a year the trades training requirements for the following financial year are worked out in detail. The forecast commitment in each trade is obtained from information supplied by R.E. Records for the United Kingdom, and from overseas commands for the rest of the world. The strengths in each trade at the end of the following year are then estimated: allowance is made for the run-out of Regular and National Service tradesmen, for the intakes of skilled men, deferred apprentices (National Servicemen), ex-apprentices from army schools and so forth. The number of course vacancies, allowing for a standard failure rate, required to meet the commitment in each trade is then calculated.

The resulting figures are sometimes greatly below the capacity, in certain trades, of the training machine. It is essential, however, to provide sufficient vacancies in these trades for the training of the inexperienced Regulars who are likely to elect to serve in them. In other trades the training capacity may be insufficient to meet the requirement. In those cases, if the provision of more tradesmen is considered essential, steps are taken to increase the training capacity by providing additional staff, accommodation or equipment or even by obtaining training facilities outside the Army.

When the trades training requirements have been agreed within the War Office the details are passed to the appropriate Corps training establishments such as the S.M.E. and Transportation Centre. Course programmes for the year in question are then prepared: in the planning of the course dates consideration is given to the influxes of the higher grade men which will occur after the end of the school and university years. However, the strength of the instructional staffs usually necessitates the even spreading of courses throughout the year.

The strength in each trade is reviewed every three months on the basis of a return supplied by R.E. Records. If the position in a particular trade is shown to be unsatisfactory, adjustments to the training programmes can sometimes be made to remedy the trouble.

All men entering the Corps spend a fortnight at 1 or 6 Training Regiment, R.E., undergoing selection procedure. After that period their routes through the training machine diverge and, depending upon the trades to which they have been allocated, they may be placed in:—

Category "C" in which they will do general military training in 1 or 6 Training Regiment, R.E., before going on to clerical training in the former regiment.

Category "M" in which they will do only general military training in 1 or 6 Training Regiment, R.E., before going on to trades training or being posted to a unit.

Category "D" in which they will do their general military training (six weeks) and their driver training (six weeks) in 4 Training Regiment, R.E., before either going on to trades training or being posted to a unit.

Category "F" in which they will do their general military training (six weeks) and Field Engineer training (eight weeks) in 3 or 9 Training Regiment, R.E., before either going on to trades training or being posted to a unit.

The detail of the more important trades contained within each category is shown at Appendix "A".

Before each fortnightly intake, immediately the size of the complete intake is known, A.G.7. issues to 1 and 6 Training Regiments, R.E., a form indicating how the total number is to be split, showing Regulars and National Servicemen separately, amongst the categories and branches of the Corps listed in Appendix "A". In the main this "split" results from calculations designed to provide each branch of the Corps with a supply of suitable manpower, sufficient to meet all its commitments. If the annual forecast were proved in the event to be entirely accurate it would be possible to maintain a fixed fortnightly allotment to each branch. But as variations inevitably occur, and to ensure that the strength of one branch does not grow disproportionately to the others, it is necessary at intervals to alter the size of the fortnightly allotment. Then again, the allotment must be in keeping with the capacities of the different parts of the training machine. For instance, the training of drivers is at present being run at full capacity and, despite the need for more, the allotment must remain in step with the limited training capacity in 4 Training Regiment R.E.

When considering the division of each allotment between Regulars and National Servicemen, due allowance must be made for the fact that Regulars are given the trade of their choice whenever possible. The numbers who will choose or can be persuaded to choose particular trades, is a limiting factor in making the division. Further, the present policy is that priority for trades training will be given to Regulars, and National Servicemen will only be allotted vacancies in trades courses if such training is in the interests of the Corps. It is therefore difficult to maintain the proper balance between Regulars and National Servicemen in the various trades and to control the flow of tradesmen into the Reserve Army. Nevertheless, it is essential to do everything possible to achieve a balanced trade structure in order to prevent the National Servicemen from forming an undue proportion of the strength in a trade and especially in the higher grade trades which require lengthy periods of training. If too much reliance is placed on National Servicemen, the Corps might find itself in an awkward position if the period of whole-time service were reduced: on the other hand, if the proportion of Regulars in a trade is too high the Reserve Army will be starved of that type of tradesman.

The passage of men through the training machine is shown diagrammatically in Appendix "B". The fortnightly arrival of the heterogeneous collection of manpower is shown at the left; it passes through the selection fortnight and is ejected, through the regulating sieve of the A.G.7. split, into the appropriate parts of the training machine to undergo preliminary training.

With this background it is possible to gauge the task of the Personnel Selection Team. On the one hand they have several hundred men, comprising an intake—the Regulars have virtually selected themselves, but the National Serviceman have been selected by the War Office (M.P.3) from the total Army intake to meet, as far as it is possible to do so, the requirements of the Corps: on the other, they are confined within the rough limits of the A.G.7 split and the vacancies on future trade courses in the many different training establishments. This task is largely completed within the first fortnight of the men's service.

It is not intended to deal with the selection procedure in any detail, but it is essential to cover the rudiments of its working. Selection is undoubtedly a subject in which a little knowledge is a dangerous thing, but if its methods are unknown the results it achieves cannot be appreciated. For this reason, the risk of presenting it in over-simplified form is worth taking. Its success can no longer be in doubt: the pass rate of 92 per cent on all basic courses in the Corps (less drivers who do not in the main reach trade test standard) provides impressive proof.

Soon after arrival at 1 or 6 Training Regiment, R.E., every man is medically examined and given a Pulheems assessment: in most cases the findings of the Ministry of Labour medical boards are confirmed, but in some, which are mainly psychiatric in character, differences arise. Every recruit is then given the five basic selection tests. The titles of the tests and the qualities that can be assessed from the results are as follows:—

(*a*)	Dominoes (DOM)	General intelligence irrespective of education or experience.
(*b*)	Problems (PRO)	Mechanical aptitude and knowledge of simple mechanics.
(*c*)	Arithmetic (ARI)	Knowledge of arithmetic and simple mathematics.
(*d*)	Verbal (VER)	Spelling and vocabulary.
(*e*)	Instructions (INS)	Ability to read and carry out written instructions.

These tests give much more detailed and reliable results than the single Recruiting Office Test (R. Test 57). Occasionally this additional data reveals the fact that a man, who was signed on as a Regular in a recruiting office as a potential tradesman of a particular type, is not in fact suited for employment or training of that kind: these men are then allocated to another trade for which they are shown to be suitable.

In addition to the basic tests many recruits are given Tests of Trade Knowledge (T.T.K.). There are a number of these, each of which is designed to test knowledge in a certain trade. For instance, T.T.K. No. 2 is given to potential Electricians, R.E. The scores which recruits achieve in these tests provide the Personnel Selection Officer (P.S.O.) with further data on which to base his recommendations.

The results of these tests are shown in table form in the A.F.B214 as selection gradings thus:—

M TEST
RESULTS

	S.G.	DOM	PRO	ARI	VER	INS	ASS	OR. IN	TTK	TTK	TTK	DATE OF R.O. TESTING TEST
Score	13	29	28	51	41	83	Not at present in use		40			
Group	2	3P	2	2	3M	2			A			

The figures under "S.G." derive from the results of all five tests: the lower figure can be taken as an indication on the scale—1, 2, 3 plus, 3 minus, 4, 5—of a man's general intelligence.

Each man is then interviewed individually by a P.S.O. During the interview his educational standard is assessed on an eight-point scale, the limits of which are a university degree and complete illiteracy. Each point on the scale is given a secondary figure, 1, 2, or 3, which indicates the type of education as arts, science, or commerce/legal/administrative. The P.S.O. also obtains, by question and answer, some details of the man's past experience, interests and, in the case of National Servicemen and Regulars on short engagements, the employment he intends to take up on leaving the Army. All this information is entered on the A.F.B214, together with the P.S.O's. assessment of the man's officer or N.C.O. potential which is shown as follows:—

OR 1 (Officer Rating 1)—Potential Officer
OR 4 (Officer Rating 4)—Potential N.C.O.
OR 0 (Officer Rating 0)—No officer or N.C.O. potential.

The P.S.O. is then in possession of sufficient data to make trade recommendations. Before he can do this he must consult the standards set out in the selection handbook for the trades for which he is considering a man. Against each trade in the selection handbook is shown a minimum medical standard (including a Pulheems profile), a minimum selection grading profile (that is to say minimum scores in each of the five selection tests), and an educational standard, thus:—

Trade or Employment	TEST MINIMA					EDUCATIONAL STANDARD		MIN. HT.	MIN. WT.		PULHEEMS PROFILE							
	DOM	PROB	ARITH	VER	INST	LEVEL	QUALITY	(IN.)	(LB.)	CP	P	U	L	H	E	E	M	S
Electrician R.E.	28	26	48	40	40	5	—	62	110	3	3	3	3	2	8/5	8/5	2	2
											3	3	7	7	8/5	8/5	2	3

It will be noted that there are two standards on the Pulheems profile: the higher one is for Regulars.

It is therefore possible to see whether a man is up to the required standard for a trade by comparing his results with the minimum standards laid down. The disposal of cases on the borderline of selection gradings is decided after considering the man's background and from the subsequent interview. As a matter of interest it will be noted that the example test results shown above are high enough in each case to satisfy the minimum test standards for electrician which was the example taken from the Selection Handbook. This means that, providing the man's educational standard was equally suitable, he would be capable of assimilating the instruction given on an Electrician R.E. Course at the S.M.E. and he could therefore be allocated to that trade.

The process sounds quite simple and straightforward, but every decision is by no means easy to make. The main difficulties, some of which have been previously mentioned, with which the selection team has to contend when allocating men to trades and employments are:—

(*a*) *Regulars can choose their trades.*—Providing the medical and selection tests confirm a man's suitability for the trade in which he was enlisted, he is allocated to that trade whenever possible. A glance at the figures given in (*b*) below will show that there are many groups of trades which are very unpopular with Regular recruits. In some cases the P.S.O. is able to persuade a man to enter one of these less popular trades instead of the one he originally chose. In general, however, the free choice of trade which has been granted to Regular recruits means that National Servicemen must be used to meet the requirements in the unpopular but essential trades.

(*b*) *Filling the unpopular trades.*—There are a number of very necessary Corps trades in which very few men in each intake actually want to serve. Nevertheless the Corps requires skilled men in these trades and the vacancies on the courses must be filled. The trades in question, with the numbers of men which have to be found from each intake and the likely number of Regular volunteers, are shown below:—

	Number required to be found from each intake	Likely number of Regular volunteers
Clerk G.D.	30	2
Checker Clerk (traffic)	25	1
Postal worker	13	2
Storeman (technical) Clerk (technical) }	17	1
Tn. trades	20	7
Driver trades (including all driver operators)	112	40
Engineer clerk and storekeeper	6	1
	223	54

It will be noticed that four of these trades are clerical in character. Of course, the majority of men with civilian experience as clerks go to the R.A.S.C. and R.A.P.C. The Corps therefore has to train a large number of men to meet its own commitments, and suitable men must possess a fair standard of intelligence and education.

From the figures given above it is plain that a considerable number of better quality National Servicemen must be allocated to these clerical and other trades no matter what their experience or employment was before call-up. The P.S.O. can be tolerably certain that the men they allocate to these trades are capable, so far as intelligence and aptitude are concerned, of assimilating the instruction and eventually carrying out the necessary work. It may well be, therefore, that a National Serviceman, who is well qualified in one of the comparatively plentiful trades such as carpenter and joiner, plumber and pipefitter or bricklayer, may be allocated as a Clerk G.D. Later in his Army career his qualifications as, say a carpenter and joiner, may be noticed and great surprise expressed that he should have been allocated as a Clerk G.D. The reasons for such apparent mis-allocations are, as just explained, necessity and expedience. The Personnel Selection Team must meet the requirements of the training machine intake by intake. The whole Corps is not the pool from which selections are made. For economy in manpower, men with two and three years to serve must be trained early in their service and employed for as long as possible in the trade they have been taught.

(*c*) *Available course vacancies.*—Unless a man, who requires trades training, is a Regular on a 22-year engagement it is uneconomical to allocate him to a trade for which there is no course vacancy within about two months of the completion date of his general military, driver or field engineer training. It is not possible to avoid such allocations in all cases but the numbers are kept to the minimum.

(*d*) *Influx of higher grade men.*—This point has already been mentioned. When the higher quality men report in considerable numbers, it is extremely difficult to place them all satisfactorily and still meet the steady requirements in the unpopular trades.

(*e*) *Pulheems standards.*—If a man is not up to the Pulheems standard required for a trade, he cannot be allocated to it. In consequence, it is sometimes not possible to allocate a man to the Army trade for which he is well qualified by his civilian training and experience.

(*f*) *Standards for field engineer training.*—As field engineer training is a pre-requisite for all field trades it is necessary that men should be up to the medical and selection standards for field engineer if they are to be allocated to a field trade. Occasionally some highly skilled men are debarred from employment in their trade because they cannot satisfy the minimum standards, this particularly applies to the Pulheems assessment, for field engineer.

(*g*) *Specially qualified men.*—These men, examples of whom are deferred apprentices and those earmarked as a result of previous employment in the Ordnance Survey, General Post Office, or under the Railway Executive or Docks and Harbour Board, should if possible be allocated to trades in the appropriate branches of the Corps. However, the vacancies available and the demands in other trades do not always make this possible.

When all the allocations are made the task has by no means been completed. During the following weeks the work done will be upset by all sorts of changes. Six to ten weeks later, some O.R.1 will pass their W.O.S.Bs. and be removed from the sphere of selection procedure: others, who fail, will require to have their trade allocations reviewed. Some Regulars after visiting the S.M.E. or Transportation Centre on a probationary tour, which is designed to enable men who are uncertain of the line they wish to follow to make a final choice of trade, may decide to ask for allocation to a trade different from their original tentative choice. Some men will be selected for N.C.O. training and future employment as instructors in the Training

Brigade: the trade courses, for which they have been earmarked, will have to be filled by, perhaps, reallocating other men. Finally, sickness always comes into the picture requiring another batch of alterations to be made.

It will be realized from all that has been said that the process of allocating men to trades is not one that can be operated neatly, exactly and tidily, leaving behind no loose ends. If the Corps is not to contain four times as many building tradesmen as it requires and no clerks at all, it is inevitable that some men with civilian experience of engineering will find themselves being trained as clerks of one kind or another. Whilst the present terms of service for Regulars exist it is also inevitable that, at the same moment, a qualified bricklayer, called-up for National Service, will be under training as say a checker whilst an inexperienced Regular is attending a bricklayer's trade course. However, it may be that enough has been said to indicate what the problems are and what methods are used to solve them.

Conclusion

It will be apparent that there are many obstacles in the way of achieving the ideal employment of manpower, in which exactly the right number of the right sort of men are always in just those places where they are wanted. There are the inevitable misfits, apparent misemployments and actual shortages which attract the military and sometimes the public attention. Despite these obstacles, a surprisingly large number of customers, both in and out of the Army, seem to have been satisfied at least some of the time.

Appendix "A"

List of the Trades in the Training Categories C, M, D and F

Category "C"

Clerks G.D.

Category "M"

Survey trades (11) including draughtsman G.D.

Transportation trades (28).

Movement control trades (2).

Postal trade (postal worker).

Works services trades for training or trade test at the S.M.E. (Quantity surveying assistant, engineer clerks and storekeepers and the deputy clerks of works (constructional, electrical, mechanical).)

G.D. men (National Servicemen only).

Drivers for training in field units in U.K. (drivers FU).

Category "D"

Drivers.

Vehicle mechanics.

Crane operators (field).

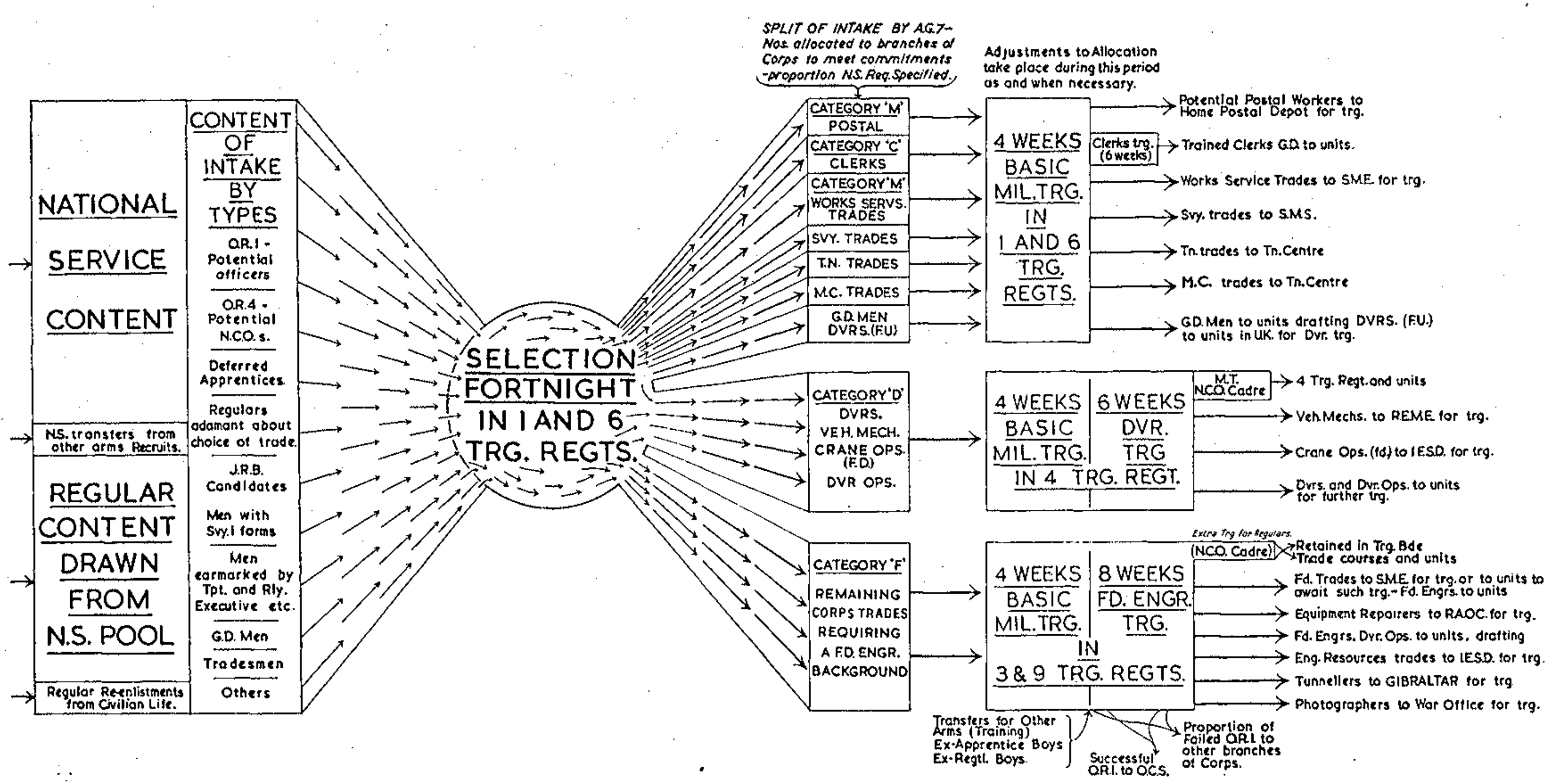
Driver operators.

Category "F"

All remaining Corps trades and including some men for training as driver operators.

APPENDIX B

THE PASSAGE OF MEN THROUGH THE TRAINING MACHINE



FREE-PISTON GAS GENERATORS

By LIEUT.-COLONEL R. A. LINDSELL, M.C., A.M.I.MECH.E., A.M.I.E.E., R.E.

INTRODUCTION

IN the March, 1955, volume of *The R.E. Journal*, Major Hiscock published an article on gas turbines, in which he devoted a paragraph to free-piston gas generators and suggested that the subject was worthy of a separate article. This short article is intended to meet such a need. In it, I have attempted to explain the principles and practice of the gas generator or "gasifier" in non-technical language. In view of the comparatively small amount of development which has taken place in this country, the information in this article has inevitably been culled mainly from the technical press and has been suitably acknowledged in the concluding paragraph.

DEFINITION

A gas generator or "gasifier" may be defined as any unit in which the power is first generated in the form of hot gas and is then converted into mechanical work in the blading of a turbine or the cylinder of a reciprocating engine. Obviously, therefore, a gasifier is not in itself a complete power unit but must be matched with a suitable mechanical device in order to produce useful work. The free-piston gas generator is a particular type of gas generator, which utilizes the free-piston principle, the practical applications of which were first demonstrated by the Marquis de Pescara in his classic researches during the years 1922–8.

EARLY HISTORY

The credit for originating the first practical gas generator belongs to Sulzer Bros. of Winterthur, Switzerland. They first developed an opposed piston two-stroke engine, having two crankshafts geared together, supercharged by an exhaust turbo blower, mechanically connected to one of the crankshafts. This engine was, however, only designed for pressure charging up to 2½ atmospheres and was built solely for experimental purposes. Subsequent experimental work showed that by raising the supercharging pressure to about six atmospheres, the entire power output of the engine was absorbed by the blower and the use of the exhaust gases as a source of power became apparent.

Simultaneously a 400 h.p. free-piston unit was developed by the same firm and later a three-unit generator with a total gas horsepower of 7,000 was constructed.

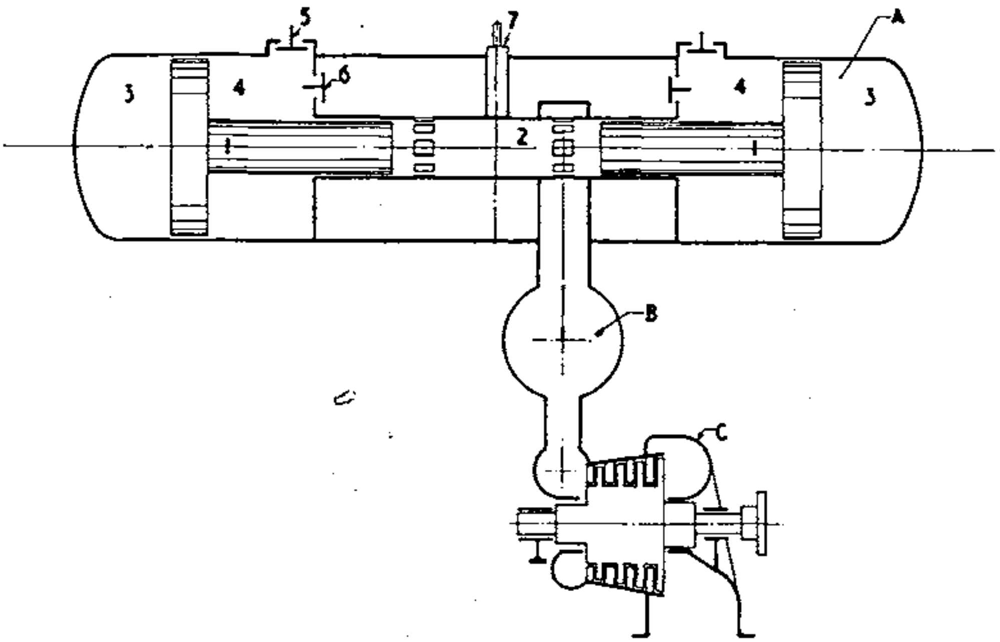


Fig. 1.—Diagrammatic sketch of a free-piston gas generator and gas turbine.

(A) Gas generator; (B) Gas collector; (C) Gas turbine

(1) Piston
(2) Engine cylinder
(3) Cushion cylinder
(4) Compressor cylinder
(5) Suction valves
(6) Delivery valves
(7) Fuel injector

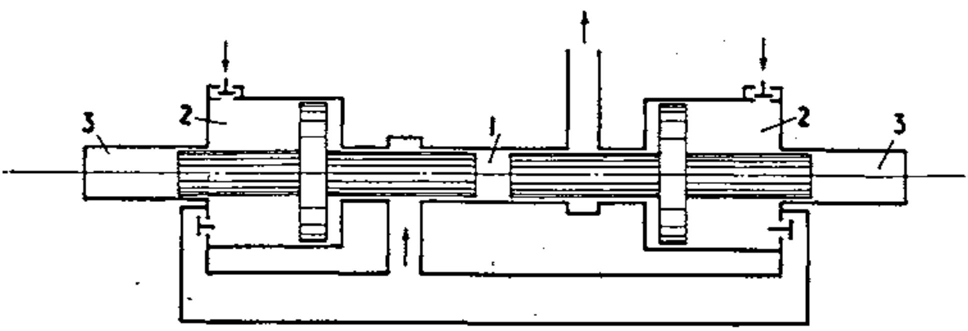


Fig. 2.—Diagram of outward-compressing type of free-piston gas generator.

(1) Engine cylinder
(2) Compressor cylinder
(3) Cushion cylinder

Description

The free-piston engine consists essentially of a single cylinder two-stroke diesel engine operating a piston type air compressor. The arrangement is shown diagrammatically in Fig. 1 and shows two identical reciprocating assemblies, each consisting of a "combustion" piston and a "compressor" piston rigidly interconnected. The expansion of the gas in the engine cylinder moves the piston, which compresses the air in the compressor cylinder. The piston is therefore absolutely free to move in either direction according to the difference between pressures acting on opposite sides. A form of linkage is provided to synchronize the movement of the piston assemblies and to limit their travel in the event of abnormal combustion conditions (e.g., excessive fuel injection when starting).

The whole of the air from the compressor is delivered to the engine cylinder, which is therefore highly supercharged, the large excess of air passing out to the exhaust.

The hot exhaust products together with the heated scavange air constitute the "power gas" delivered to the turbine. This consists of at least 75 per cent unburnt air, the remainder being the normal products of combustion. The over-all compression and expansion ratio of the cycle is very high, since it is virtually two stage. The first "stage" of the compression takes place in the compressor cylinder and the second "stage" in the combusion space. Similarly the high pressure portion of the expansion takes place subsequently in the combustion space and the second "stage" in the turbine. The effect of this is to make possible a high over-all thermal efficiency. It will be seen from the diagram that the end spaces (3) store the energy for the return stroke and hence form what may be described as a "pneumatic flywheel". Fresh air is drawn through the suction valves (5) and is delivered through the delivery valves (6) into the "engine case", which surrounds the cylinder. The fuel is injected by several injectors (7) mounted in the central plane of the combusion chamber.

Different Types of Free-Piston Gas Generator

There are two main types of single acting free-piston design, namely the "inward" and "outward" compressing. The former, which appears to be most favoured and which has been extensively developed in France, is illustrated in Fig. 1. The latter (Fig. 2), which is being developed in the U.S.A. and Switzerland, is inherently a heavier and more complex design, involving increased difficulty in piston cooling. It seems probable therefore that future development in this country will favour the inward compressing type.

Development and Production

In France, considerable development has taken place since the war. The most successful unit has been the 1,250 h.p. GS-34, of which some sixty have been manufactured and at least forty are in use for electrical generation, rail traction and ship propulsion.

In this country, Messrs. Alan Munz & Co. have been developing an inward compressing design—the CS-75. The following table gives comparative data of these two types:—

	(French) GS-34	(British) CS-75
*Gas h.p.	1,250	420
Weight (tons)	8.5	2
Engine cylinder bore (inches)	13.4	7.5
Compressor cylinder bore (inches)	35.4	20.75
*Oscillations per minute	570	1,000
*Piston speed (ft./min.)	1,650	1,580
*Gas temperature (°F.)	819	869
Specific fuel consumption (lb. per gas h.p.-hr.)	0.320	0.325
Thermal efficiency (per cent)	43	42

(*These figures refer to conditions at continuous maximum rating.)

The term "gas horse power" in the above table indicates the power available from an adiabatic expansion of the "power gas" to atmospheric pressure. Pictures of both types are shown in Figs. 3 and 5, the former being taken from a full-scale model. In addition the piston assemblies of the CS-75 are shown in Fig. 4. The toothed rods above the combustion pistons form "the rack" of the rack and pinion synchronizing device. The GS-34 on the other hand is fitted with a kinematic linkage for this purpose.

Utilization

The high thermal efficiency given in the preceding table refers, of course, to the efficiency of generation of "power gas". Account must also be taken of the efficiency of the turbine and the losses in the gas ducting. Recent figures quoted for the (GS-34) gas generator-turbine installation at Rheims were as follows:—

	per cent
Turbine efficiency	86
Losses in gas ducting	1.3
Alternator efficiency	96
Auxiliaries	1.2
Over-all efficiency of generation	33.5

It is interesting to compare this figure with that for a diesel-engined generator of comparable size—about 35.5 per cent. It is, of course, possible for a number of gas generators to be coupled to a single turbine (Fig. 6) and in such cases it is usual to resort to "de-phasing" (running out of phase) to avoid cyclic irregularities.

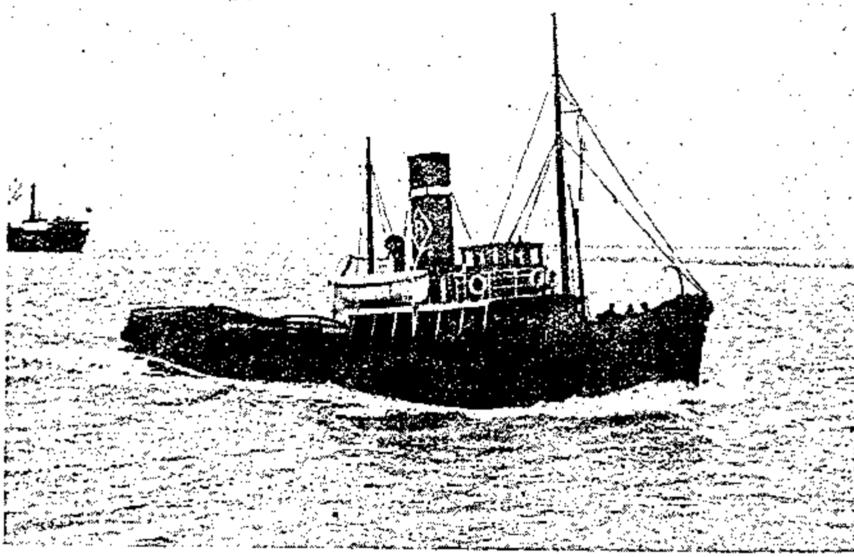


Fig. 1.—Steam Tug *Plumgarth* showing the steep form of the wave produced by a heavy displacement vessel with crest of bow wave well forward. This tug is 95 ft. long and wave length appears to be thirty-five to forty feet, so she is making about eight knots.

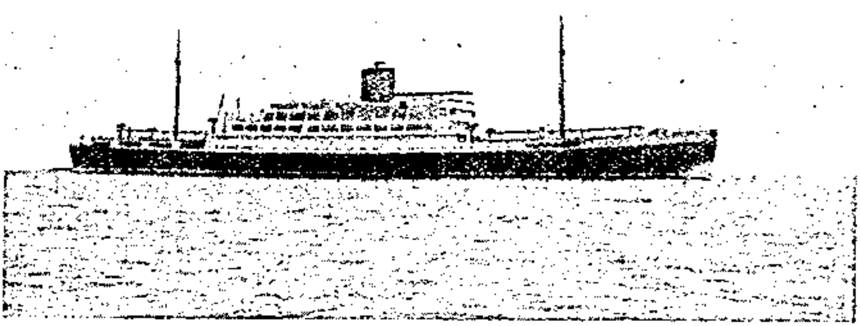


Fig. 2.—Norddeutscher Lloyd liner *Potsdam* (now *Empire Fowey*) in Heligoland Bight. Apart from the feather of foam at the bow typical of a fine lined, high speed ship, the wave form is so slight that it is difficult to distinguish. The ship is over 600 feet long and was probably making about nineteen knots, taking three waves to her length.

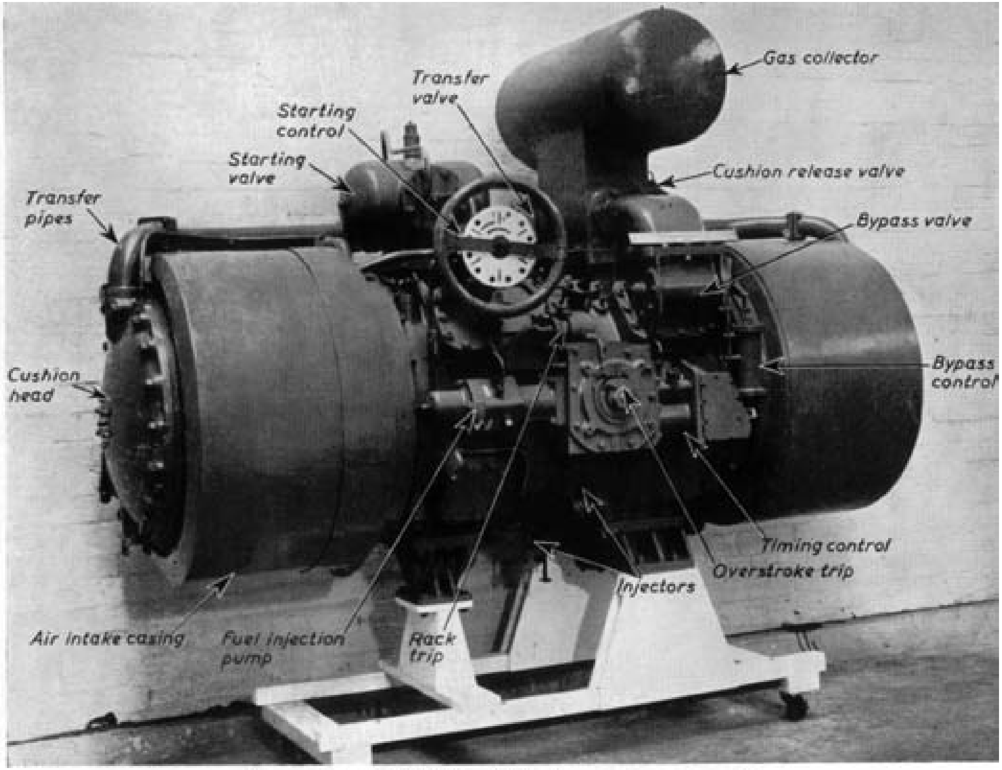


Fig. 3.—Full Scale Model of CS.75 free-piston gas generator.

Free Pistion Gas Generatiors 3

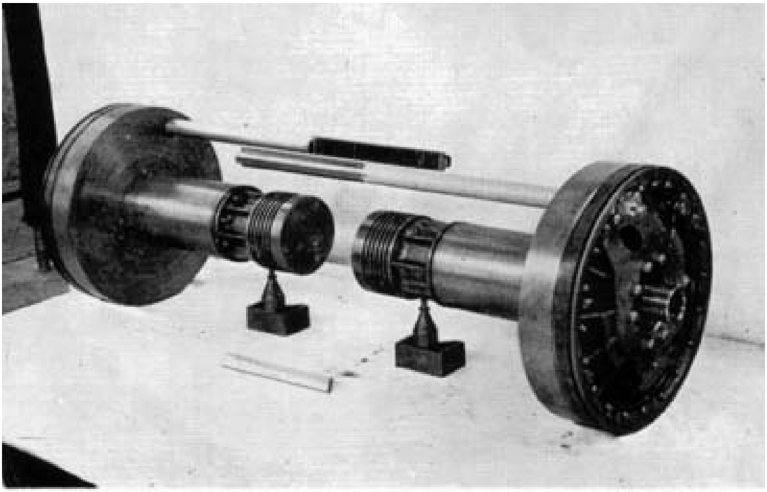


Fig. 4.—CS.75 prototype—moving parts.

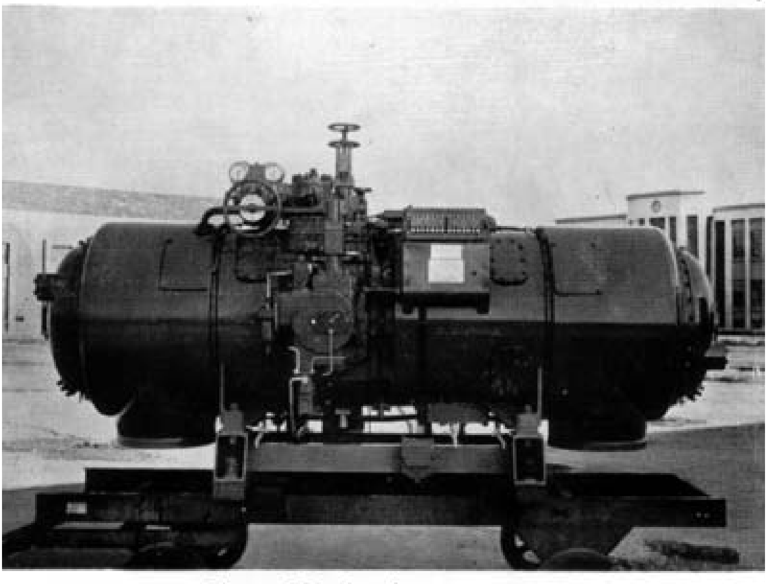


Fig. 5.—GS.34 free-piston gas generator.

Free Pistion Gas Generatiors 4 , 5

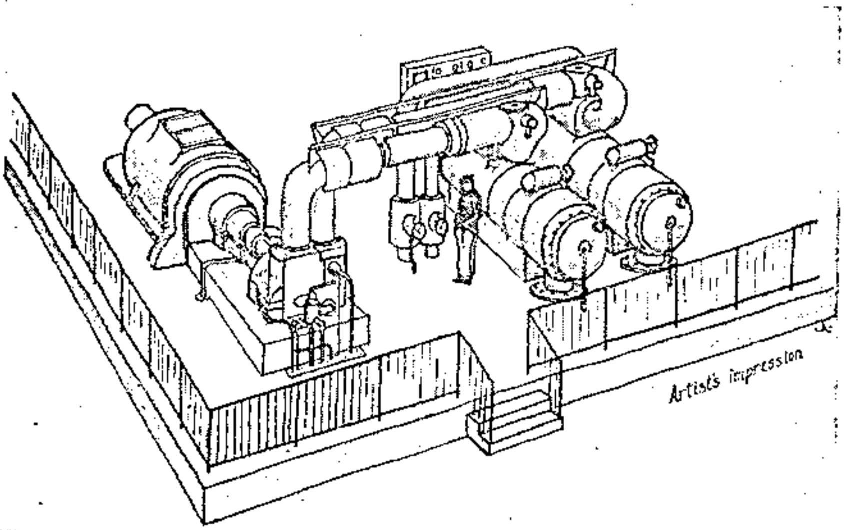


Fig. 6.—1,250 kW. free-piston gas generator/turbine set installed at the Electricité de France, Rheims.

ADVANTAGES

The following advantages are claimed for the gas generator:—

1. Elimination of crankshafts and camshafts, and hence lower initial cost and less frequent and cheaper maintenance.

2. No special materials required for manufacture of the power turbine, since the maximum operating temperature will not exceed 500° C.

3. Low first cost and east of installation. The generator is compact and of reasonable weight with comparatively little vibration, hence great savings can be effected in the size of foundations.

4. *Reasonable power-weight ratio.*
Including turbine and gearing, the power weight ratios of the GS-34 and CS-75 are 38 lb./s.h.p. and 22 lb./s.h.p. respectively. (These figures approximate to those of a modern high speed diesel engine.)

5. *Ease of maintenance.*
The gas generator is inherently less complex than the diesel and can be rapidly stripped and handled. It is claimed that the main reciprocating units of the GS-34 can be removed for inspection by a skilled team within fifteen minutes.

6. *Low fuel consumption.*
Specific fuel consumption compares favourably with the modern diesel, both on full and part load. Only below half load does the diesel show any appreciable advantage.

7. *Ability to burn low-grade fuel.*

Due to the high scavange, the gas generator is much less susceptible to low quality fuel than the diesel. Thus not only can low-grade fuel be used, but filtration and injection problems are markedly simplified. The Renault locomotive (with GS-34 gas generator) has completed nearly 100,000 miles running on a light-grade boiler fuel oil.

8. *Flexibility.*

A number of gas generators may be connected in parallel to supply one turbine. This gives great flexibility in layout and may also be used to obviate the difficulties of part load operation, since individual generators can be cut out as the load falls.

Fig. 6 shows a typical power station arrangement comprising two "gasifiers" in parallel with one turbo-generator.

For marine and automotive applications the ability to dispense with a mechanical connexion between gas generator and power turbine may prove of great significance.

Comparison with the Open Cycle Gas Turbine

The gas generator may be regarded as a compromise between the diesel engine and the gas turbine, since, in effect, we are replacing the combustion chamber of the gas turbine by a diesel engine cylinder. In the gas turbine, it is necessary to cool the hot gases from their initial temperature of 1,500–2,000° C. to about 600–800° C., which is the maximum temperature, which the turbine blading will tolerate. This is done by mixing the gases with excess air, involving considerable loss of energy.

In the gas generator—turbine system, the cooling takes place by near-adiabatic expansion of the gases and thus contributes energy to the system. The latter cycle is therefore inherently much the more efficient and will give approximately twice the thermal efficiency of the simple gas turbine without heat exchanger.

Admittedly a great deal more development has been done on the gas turbine than on the gas generator but it must be remembered that basically the latter comprises conventional components (diesel engine—compressor—turbine), of known performance and proven reliability. The main design problems appear to be centred around the lubrication of the heavy reciprocating parts involved and the valves, which must handle comparatively large volumes of gas and air. Potentially the gas generator is much cheaper than the open cycle gas turbine with heat exchanger of equivalent power, since the costly special alloys for turbine blading can be dispensed with. Figures of £700 per ton compared with £1,500 per ton for the gas turbine have been unofficially quoted. Control at low speeds may prove a difficult problem as is the case with the single shaft gas turbine, but this has been partially overcome by incorporating "blow-off" devices to operate at low speeds. None the less it would appear that the future of the gas generator lies mainly in the field of comparatively constant load, such as electrical-power generation or ship propulsion.

Ease of maintenance is probably the most important single factor from the military point of view and here the gas generator lies midway between the conventional diesel and the simple gas turbine. Whilst dispensing with the heavily loaded crankshaft bearings, which are the source of so large a proportion of maintenance operations, the gas generator yet retains valves, subject to carbon deposits and heavy reciprocating masses requiring lubrication and cooling. This compares unfavourably with the inherent simplicity of the gas turbine.

Possible Military Applications of the Gas Generator

The major possible military applications may be summarized as follows:—

(*a*) Prime movers for A, B, or C class vehicles.

(*b*) Electrical Power Generation.

(*c*) Prime movers for water and petroleum pumps, and miscellaneous engineer plant.

In each case the requirement is for compact lightweight units with the minimum possible maintenance commitment. In addition units must be capable of being rapidly produced in war with due regard to scarcity of special materials, skilled labour and machine tools. Initial cost and fuel consumption must also be of a reasonable order. As already pointed out, it is the constant load applications, which are likely to prove most suitable for the gas generator—turbine combination and at first sight it would appear an attractive system for military equipments of this type, e.g., generators and pumps. On the other hand, the simple open-cycle gas turbine with heat exchanger is likely to prove overwhelmingly superior on three counts:—

1. Ease of maintenance.
2. Ability to operate without cooling water.
3. Simplicity of lubrication.

The development of improved high temperature alloys for turbine blading is likely to continue, giving the probability of higher turbine inlet temperatures and therefore improved efficiencies. Simultaneously much research is proceeding on the production of a compact and efficient heat exchanger. It seems possible, therefore, that the gas turbine will eventually reach such a degree of efficiency as to place it in an impregnable position *vis-à-vis* the gas generator for military applications.

Conclusions

1. Although little has yet been heard of the gas generator in this country, it has been the subject of considerable development both on the Continent and in the U.S.A. In France, it has progressed far beyond the prototype stage and may be regarded as a machine of proven reliability.

2. Inherently it offers the possibility of high thermal efficiencies over a wide range of loads.

3. It should prove comparatively cheap to mass produce, since it dispenses with the crankshaft of the conventional diesel engine and the special alloys of the gas turbine.

4. On the other hand, apart from efficiency and low initial cost, it can be outbid by the simple open-cycle gas turbine on many counts for military applications. Whilst therefore a strong case can undoubtedly be made out for the adoption of the gas generator-turbine for certain military purposes today, future developments on the gas turbine may well render a re-appraisal necessary within the next five to ten years.

Finally, it must be remembered, that the encouragement given to the free-piston design of air compressor by both the Admiralty and the Ministry of Supply is largely responsible for the great advance made in connexion with this application. Thus, should the free-piston gas generator fail to establish itself in this country as a power unit, the free-piston air compressor will yet undoubtedly extend its reputation as a light and robust machine of proven performance and thus justify the many years of research and development, which the engineering industry have so patiently expended on this ingenious principle.

Acknowledgements

In writing this article, I have made use of the paper by Messrs. Muntz and Huber published in the transactions of the Institute of Marine Engineers (Vol. LXVI, Sept., 1954). I am particularly indebted to Mr. F. A. I. Muntz (Managing Director of Alan Muntz & Co.) for permission to reproduce the photographs of the GS-34 and CS-75.

My thanks are also due to Mr. R. W. Stuart Mitchell of the English Electric Company for his permission to make use of certain material from his lecture on "Current trends in diesel engine development", and to Mr. J. Calderwood of The Brush Group Ltd. for his helpful suggestions in connexion with the preparation of this article.

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ROAD DENIAL IN WELL-ROADED COUNTRY

By LIEUT.-COLONEL R. L. CLUTTERBUCK, R.E.

INTRODUCTION

Past Experience and the Future

ROAD denial is nothing new, but only in recent years have we begun to think it worthy of a name of its own. The Germans practised it extensively from 1942 to 1945. By enabling them to keep the Allies' pursuit under control between successive defensive positions, it helped to prevent them from reaching the heart of Germany, via Italy and Russia, for 2½ years. Without it, the war might have been over a year earlier. Moreover, those 2½ years of delay brought the Germans very close to winning the race for rocket and atomic weapons, before their laboratories and factories were overrun.

The German technique was admirably described in this Journal by Major M. L. Crosthwait in June, 1952. This technique worked well, *provided* that one of two conditions applied:—

either (*a*) There were very few roads (as in Italy or Russia);

or (*b*) The withdrawals were in short bites, between two strongly held defensive positions, allowing ample time for preparation and organization.

(*a*) In rugged, sparsely roaded country, road denial tactics are straightforward. The nature of such country usually prevents demolitions being by-passed or firing parties being outflanked. The basic essential is a controlled start to the withdrawal on every route. Thereafter, the pace of the advance will be the pace of the sappers opening the road, which will be far slower than the rate at which their retreating sappers can prepare fresh demolitions and mines. That is a "sappers' war" in which the techniques on both sides are well known.

(*b*) Even in well-roaded country there is no great engineer problem in road denial in a short withdrawal between two strongly defended positions. The Germans repeatedly fought such withdrawals in Italy, and Russia using "false front" tactics. By such means they prevented the Allies from breaking into the Po Valley before the rains came in September, 1944, and had similar successes throughout Italy and Russia. It is perfectly possible to put several demolitions and many mines in every mile of road in conditions such as these. There is plenty of time, and each bite of the withdrawal is short and controlled. The technique was well covered in Major Crosthwait's article, and will not be dealt with in this one.

In future, however, evenly contested withdrawals are less likely to occur, as the balance and structure of the opposing naval, army and air force is so totally different. None have occurred in either of the "limited" wars (Indochina and Korea). They are even less likely in nuclear warfare, in which both sides will almost certainly keep their main forces well apart and dispersed, with only covering troops in contact, until one or other makes a rapid thrust, possibly following up a nuclear attack.

In either "limited" or nuclear wars of the near future, therefore, the rapid movement of armies, and its prevention, will be of greater importance than ever. We have seen how easily road denial can prevent it in *sparsely roaded* country (other than desert). Can road denial help to prevent it in *well-roaded* country such as western Europe? That is the theme of this article.

Definitions

Types of Delay

There are four ways in which road denial may delay an advancing enemy:—

Tactical delay of his leading troops.

Delay of support and replenishment by delaying the opening of wheeled routes, so that his tanks and infantry are held up by lack of fire support, petrol or ammunition.

Delay of build-up so that, after reaching our next main position, he is unable to build-up the troops and supplies to overcome it for some days, owing to the low traffic capacity of the roads behind him.

Harassing his assembly and deployment for attack. Road denial within 10,000 yards of our own main position will congest and delay the deployment of the enemy's artillery, the distribution of ammunition, and the regrouping, forming up and launching of his attacking formations and reserves.

Types of Operation

Having excluded the "false front" withdrawal, we must consider the suitability of road denial for two different types of withdrawal.

The fighting withdrawal in which the commander aims to delay the enemy's leading troops by a series of local delaying actions. In such a case, road denial must be fitted in with the operation without unduly hampering it. Tactical delay and the security of the fighting troops are the paramount requirements.

The uncontested withdrawal in which the commander aims to carry out an extensive demolition programme, with only a screen of light covering troops to observe and harass the enemy, but not to engage him closely except in emergency. In this case there will be fewer troops deployed and less difficulty in extricating them, so that the engineers will have far greater freedom in their road denial task.

Road Denial Terminology

There is as yet no standard terminology for road denial, so the following terms will be used hereafter in this article.

Damage refers to blocking a road in such a way that there will be a *permanent* reduction of its traffic capacity. Any normal demolition falls into this category, since temporary bridges or culverts, with roughly graded and surfaced approaches are sure to reduce traffic capacity. Rooting, cratering or "shallow cratering" of stretches of road surface also constitute *damage*.

Obstructions are any form of blockage, *whether or not the damage is permanent*. Some obstructions do no "damage"—e.g., road blocks, felled trees, and the mining of stretches of roads without disrupting the surface.

Widespread road denial refers to damage or obstruction of every road and track, at the most technically suitable sites, *scattered all over the map*.

Bands of road denial refer to bands, one to five miles deep, across the front, in which every road and track is extensively damaged.

Belts, as always, comprise the demolition of every crossing over a natural obstacle such as a river, railway embankment or range of hills. Where there are gaps in the natural obstacle, the belt may be completed by road denial and minefields. A belt differs from a band in that it presents a continuous obstacle to cross-country movement.

Opportunity mines, demolitions and road blocks are those which help the fighting troops in fighting a delaying battle between belts or bands. "Opportunity" does not mean that they have not been planned in advance, but it does imply that the local commander has full liberty to use them, or not, as he sees fit. Generally, owing to the existence of undamaged diversions, opportunity obstructions have little value once they cease to be covered by fire.

Types of Delay

Tactical Delay

An abundance of roads is a sign of a highly developed country, with intensive agriculture, which means plenty of streams, ditches, banks, walls and minor obstacles. Wheeled vehicles cannot move far across such country without funnelling on to the roads or tracks in order to cross these obstacles. If every one of such crossings, including those on the smallest cart track, is destroyed, even tanks will find difficulty in moving deployed, and their movement will in any case be slow. Only infantry can move unimpeded, with such weapons and ammunition as they can carry.

In certain conditions therefore, it might be possible to impose as much tactical delay by *widespread road denial in an uncontested withdrawal*, as it would by fighting, and without any risk of casualties. It is important, however, not to be over optimistic about this. Minor

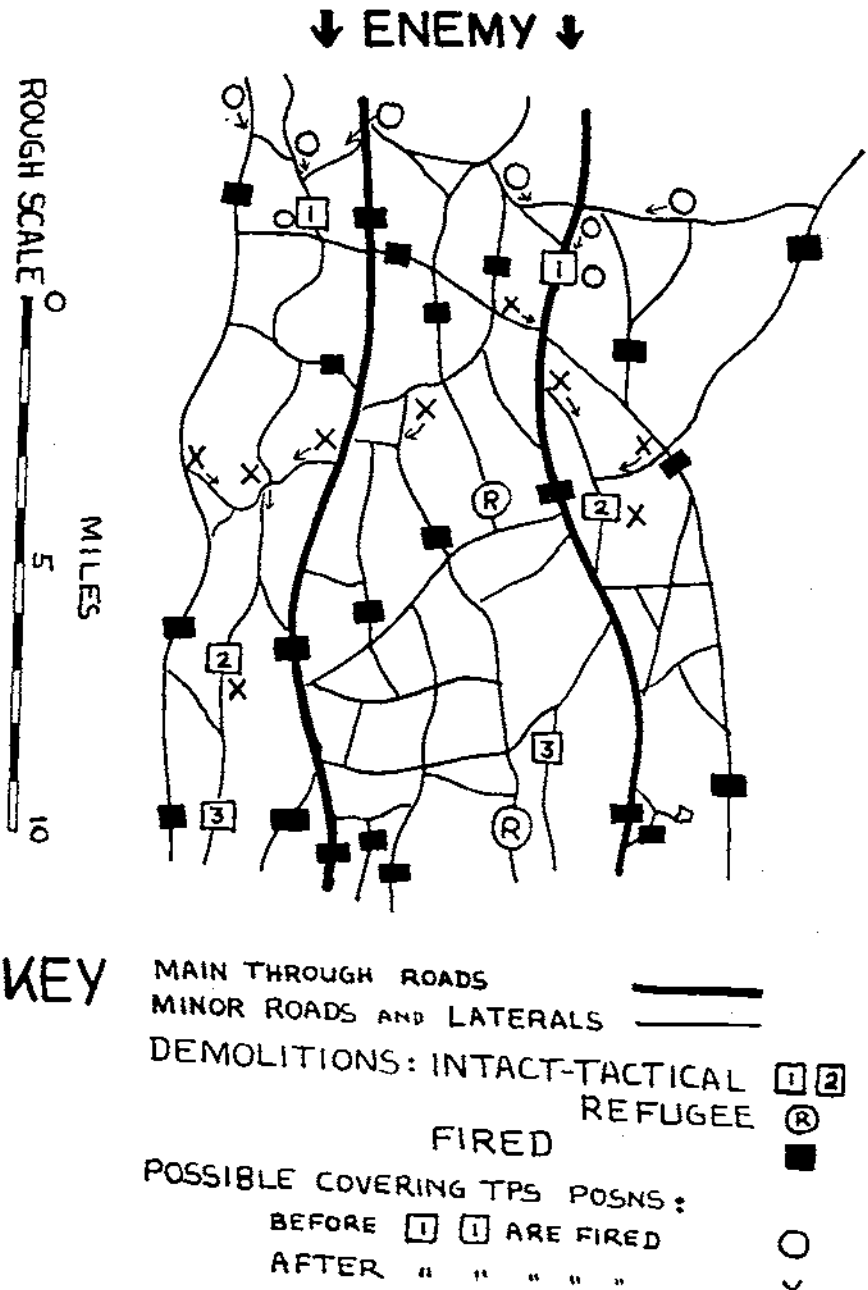


FIG. 1 TACTICAL LIMITATIONS OF WIDESPREAD ROAD DENIAL

obstacles which are not covered by fire will only impose a brief delay on determined troops. A commander who is charged with delaying the enemy for a specified time will seldom be able to rely on road denial alone without fighting, unless the country is exceptionally close or hilly—or unless there is a *certainty of seasonal rain* which will make the countryside impassable.

Refugees, moreover, will alone often rule out such an operation in well-roaded (i.e., populous) country, even if the withdrawal is uncontested. Widespread road denial inevitably requires the bulk of damage to be by preliminary demolitions, mining or rooting, leaving only one or two tactical routes through the maze for withdrawal of covering troops. The refugees will congest and block these routes, and will also try to delay the firing of demolitions on any other routes they are trying to use; they will not be deterred by threats of fire, as they will quickly learn that British troops will not shoot down women and children.

Fig. 1 shows a sketch of the road network some miles east of Bristol, on which are marked the best sites for obstructing the roads. To achieve any worth-while effect from widespread road denial, all these sites must be dealt with. Let us visualize a density of refugees (including those from Bristol) comparable to that in Belgium in 1940, and assume that only light covering troops are operating. The maximum number of routes they could afford to leave open on a 5-mile front would be three—two tactical routes for their own withdrawal and one (to be closed only slightly earlier) for refugees, as shown on the sketch. It would prove extremely difficult to force the refugees to keep to their own route, and the problem of extricating the firing parties and covering troops might well prove insurmountable, even if the commander were allowed to withdraw as fast as he could fire the demolitions.

Normally, however, the commander is charged with imposing delay for a specified time, and he will have to carry out a *fighting withdrawal*. A glance at Fig. 1 leaves no doubt that widespread road denial would be unacceptable to him. Of all battles, a fighting withdrawal can never be expected to follow a rigid plan made by the defender. The enemy has the initiative, and commanders at every level must have freedom to move their mobile reserves quickly. Moreover, the existence of *minor* obstacles with only a few crossings puts our own troops at a serious tactical disadvantage. The enemy tanks can afford risking a crossing anywhere, whereas if one of our own gets bogged it may well be lost and so may all those behind it. A stream or bank which is only a mild "deterrent" to enemy tanks must therefore be respected as an "obstacle" by our own.

It follows that if we are to assist, rather than hinder, the commander in imposing tactical delay, we must normally restrict our road denial to:—

(*a*) *Belts* between which free manœuvre is possible. The commander can negotiate these by placing part of his force in position behind them while the remainder break contact and withdraw through them. Such belts are particularly valuable in enabling the withdrawing force to collect itself, rest and replenish at night. Even a minor obstacle is adequate to prevent major penetration for one night, provided the enemy is denied daylight reconnaissance, and all crossings are watched by patrols who can bring down small arms or registered mortar or artillery fire.

(*b*) *Bands of road denial.* Tactically, these can be treated in the same way as belts, and should impose some tactical delay at night provided that the enemy is denied reconnaissance in daylight. Where no suitable obstacle is available for a belt, a band of road denial is the next best thing.

(*c*) *Opportunity obstructions.* Only if covered by fire can these impose any real delay.

DELAY OF SUPPORT AND REPLENISHMENT

In a long advance, enemy tanks and infantry are unlikely to press forward much more than fifteen miles ahead of their wheels. For many reasons, no army is yet in sight of a 100 per cent tracked basis for its heavy weapons, artillery and maintenance. Close air support and air supply can as yet only partly replace artillery support and land-borne supplies. Strip any unit of all its wheeled vehicles, and it will be at a serious disadvantage against an enemy who has his vehicles and an intact road network on which to manœuvre them.

There is still, therefore, a tactical dividend to be gained from delaying the opening of the enemy's wheeled axis. This presupposes that *every passable wheeled track*, however bad, is destroyed, and the delay is largely determined by the *rate of repair* by enemy sappers of the route he chooses to trace amongst these tracks.

If the aim is to restrict, by these means, his average rate of advance to, say, eight miles per day, we must site our obstructions so that within eight miles of *any* route he can trace, he will meet enough to keep him working for twenty-four hours before he can get his wheeled vehicles over, or round them.

As discussed earlier under tactical delay, this can be achieved by *widespread* road denial *only* if the withdrawal is to be uncontested and if there is no serious refugee problem.

Normally, however, the need to fight and to allow for refugees will restrict road denial to *belts* across substantial obstacles, on which the approaches to every possible crossing are so heavily damaged or mined that each will take twenty-four hours to repair. We cannot expect such an obstacle every 8 miles—so we will more often have to rely on *bands of road denial*, narrow enough to be treated tactically as belts. Within the band, every route is either rooted, cratered or mined enough to need twenty-four hours to reopen, or contains, say, three to four demolitions each demanding an eight-hour task. This presupposes that not even a cross-country track for wheels can be opened through the band any quicker, and that these times are the least that he will take for the very roughest of repairs, which is all he will need to get the few wheeled vehicles of his leading units across. This is the only delay we can be absolutely certain of getting.

There should, however, be a "bonus" from these rough crossings. Their low traffic capacity should soon cause a queue to form behind them, consisting of H.Qs., reserve units, guns and bridging equipment. These cannot all cross together, and for some time the leading troops are likely to be hampered by lack of one or other of them. This kind of delay cannot be taken for granted, but it has certainly caused serious trouble in our own highly mechanized army in the past. Even our likely enemies will need quite a few vehicles to keep up an advance of eight miles a day.

As an example of the task of creating such a band of road denial, a study has been made of a typical stretch of agricultural country astride the Bristol–Oxford road (of which a small portion is sketched in Fig. 1). Taking any cross section on a 20-mile front astride this axis, there are on an average:—

Four main roads Four secondary roads	which generally keep separate from each other, making eight through routes in all
Six minor roads Six unmetalled tracks railways, etc.	passable to wheels, but *not* through routes. They are, however, available for diversions round any obstructions on the through routes

In other words, there is some kind of passable route for wheels every mile.

To ensure that the enemy cannot open any route through this 20-mile front, without meeting at least *one* obstruction, twenty obstructions would be needed. If the average delay on each is assessed at eight hours, three will be needed on each route, or about sixty in all, spread over a band from one to five miles deep, to give twenty-four hours delay. To open a single route through this band, the enemy will need to commit about one engineer company. Assuming that he has deployed two divisions on this frontage, his divisional engineers will be able to open all the routes needed for immediate support and replenishment to continue the advance in twenty-four hours.

Each obstruction will consist either of a demolished bridge or culvert with mines in the debris, or a short stretch of tarmac road rooted or shallow-cratered and mined, or mines concealed in a stretch of earth track. On an average, a troop could prepare, fire and mine five such obstructions in a day. Sixty would therefore require two field squadrons for two days.

Alternatively, if the withdrawal were foreseen well in advance, the two field squadrons could *prepare* the sixty sites in two days (by digging demolition chambers, laying and marking most of the mines, etc.) and could then charge and fire the demolitions, unmark the mines, etc. in one day when the withdrawal began.

This is a tremendous engineer effort to achieve only twenty-four hours certain delay (plus a "bonus" dependent on the enemy getting his guns tangled up with his bridging lorries etc.). Unless ample engineer effort is available, it may not seem worth attempting this type of delay at all. As discussed under "Tactical Delay", however, a band of road denial suitably sited may have the added value of giving the fighting troops some security at night, and the importance of this may make the engineer effort worth while.

DELAY OF BUILD-UP

The arguments so far, can be applied equally to nuclear and conventional warfare, except that the need for speed of movement in nuclear warfare will tend to make any road denial more effective.

From now on, however, we must be prepared to consider them separately, for the way in which the enemy builds up his force to attack our main defensive position at the end of his advance may differ greatly.

At the end of every long withdrawal, our aim will be to halt the enemy at a defensive position which is too strong for his leading troops to overcome. Before he can hope to launch a successful assault he will need to assemble several thousand vehicle loads, consisting of fresh troops, artillery, ammunition, petrol, bridging equipment, etc.

Under nuclear threat, these assembly areas will be dispersed, and he will need to prepare fast converging routes from them to the points where he intends to make an atomic breach. He may need fewer troops, as our own defences will also be more dispersed. At all events, he will have plenty of time to bring these troops forward to their assembly areas before the converging routes are ready, so road denial is unlikely to impose much delay on his "build-up" in nuclear warfare. The more road denial we can do on what are likely to be his converging routes, however, the better, and these are considered under 'Harrassing of Assembly and Deployment".

It now remains to be seen how much we can delay the assembly of these several thousand vehicles in conventional warfare. This is no place to argue whether conventional warfare is likely to occur again, but it is at least worth our while to be prepared for another Indochina or Korea, where mass attacks by several divisions were common, under the heaviest conventional artillery concentrations of all time.

How can we delay the mounting of such an attack at the end of our 50-mile withdrawal through the well-roaded corridor East from Bristol? What is the *traffic capacity* of the road network, and what traffic capacity does the enemy need? Can we damage all these roads so extensively that the enemy engineers will be hard put to open more than three or four through routes, and that the *traffic capacity* of these is permanently reduced? If so, how many days can we force him to take to assemble his troops and dump his ammunition? Will that delay be long enough to prove decisive in enabling us to regroup, collect our own reserves and improve our defences?

It is first necessary to touch on the theory of road capacity. The maximum capacity for military traffic on main and secondary roads is in practice about 800 v.p.h. (vehicles per hour) assuming air superiority. Day or night makes little difference, since by night vehicles travel slowly and densely, while by day they travel faster with wider gaps.

The capacity of any road, however, is the capacity of its worst bottleneck. If *one* stretch of a main road has been rooted, its capacity after temporary resurfacing is unlikely to exceed 400 v.p.h. (i.e., roughly the same as a minor road).

If, moreover, the rooted stretch is up a long steep hill, or alternatively the obstruction is a demolition involving a diversion with a steep uphill exit, the capacity of the road may be reduced to 200 v.p.h. (i.e., roughly the same as a cart-track).

Finally, if there is a light floating bridge, or a really tortuous exit, the capacity may be reduced to 100 v.p.h. This is less than two vehicles per minute; we can scarcely hope to prevent the enemy bringing the capacity of his main axes at least to this level within a day or two.

Not all of this 800, 400, 200 or 100 v.p.h. will be available for build-up. Some allowance must be made for daily maintenance, casual traffic and for hold-ups. But daily maintenance is a surprisingly small commitment, and even including casual traffic—commanders, liaison officers, movement of semi-static installations, etc.—it may not amount to more than 480 vehicles per day, or 20 v.p.h., for a corps of three divisions.

Finally there are hold-ups. These are hard to forecast. Assuming ruthless traffic control at the bottlenecks, with well trained drivers, not more than 15 per cent capacity should be lost.

What capacity, then, will remain for "build-up traffic" at the bottlenecks we have described?

	v.p.h.			
Maximum capacity	800	400	200	100
Less: daily maintenance and casual traffic	20	20	20	20
Hold-up (15 per cent)	120	60	30	15
Available for build-up	660	310	150	65

In our 20-mile corridor, let us assume that we have damaged all the roads so badly that the enemy is only able to open and keep open four one-way routes—two up and two down.

The minimum force that the enemy is likely to concentrate for a conventional break-through on the 20-mile front is one army of two corps, one corps using each up route. Follow up formations might amount to approximately 70 per cent of the leading corps. We can assume that in a 50-mile advance the enemy will be using his full scale of vehicles (which is, say, about half our own last-war scale).

The following table shows the delay that would be imposed on *each route* allowing a build-up capacity of 300, 150 or 75 v.p.h.:—

	Number of vehicle loads, including dumping	Route capacity		
		v.p.h.		
		300	150	75
Leading corps	10,800	1½ days	3 days	6 days
Follow-up	7,200	1 day	2 days	4 days
Total	18,000	2½ days	5 days	10 days

In our example, we must so damage the eight through routes (and their twelve possible diversions) that enemy engineer resources are fully occupied in keeping open two up and two down routes, and cannot supplement even the worst bottlenecks with relief tracks. Moreover, the damage must constitute such a running sore that the capacity of the worst bottleneck on each remains at the most 200 v.p.h., leaving 150 v.p.h. available for build-up. Even this will only add three days to the build-up of the leading corps, or five days including the follow-up force. This is hardly more delay than they would need in any case for artillery survey and registration, reconnaissance and deployment, and turn-round of their vehicles for dumping the logistic loads.

The conclusion is that, where there are plenty of roads to choose from, *no practicable degree of road denial is likely to impose much more delay on the enemy build-up than he will need in any case for his normal preparations for attack.*

The best way to regard any such delay is as a bonus or by-product from road denial primarily aimed at one of the other forms of delay.

HARASSING OF ASSEMBLY AND DEPLOYMENT

If we cannot greatly delay the arrival of the attacking force in the forward area, we can certainly harass and delay its assembly and deployment after arrival, the distribution of ammunition to gun positions, and the launching of the various waves into the attack. If the assembly area is intersected by banks and streams (as in western Europe), comprehensive road denial and mining should yield good dividends—perhaps considerably greater than would be gained by attempting to lower the traffic capacity of the maintenance routes behind.

These dividends will be even greater in nuclear warfare, as he is unlikely to launch his attack until he has opened a large number of converging routes from his dispersed assembly areas to his intended points of atomic breach. The longer we can make him take to open these routes, the better. Moreover, their pattern will give us an indication of his plan, and we may have time to prepare a decisive blow against it.

A further advantage is that the damaged points will mainly be in range of our own artillery, and their positions accurately known to us, so that we should often be able to block the diversions round them by knocking out vehicles with harassing fire. The cumulative effect of such blockages can well be imagined by anyone who took part in any of our own major attacks in the last war.

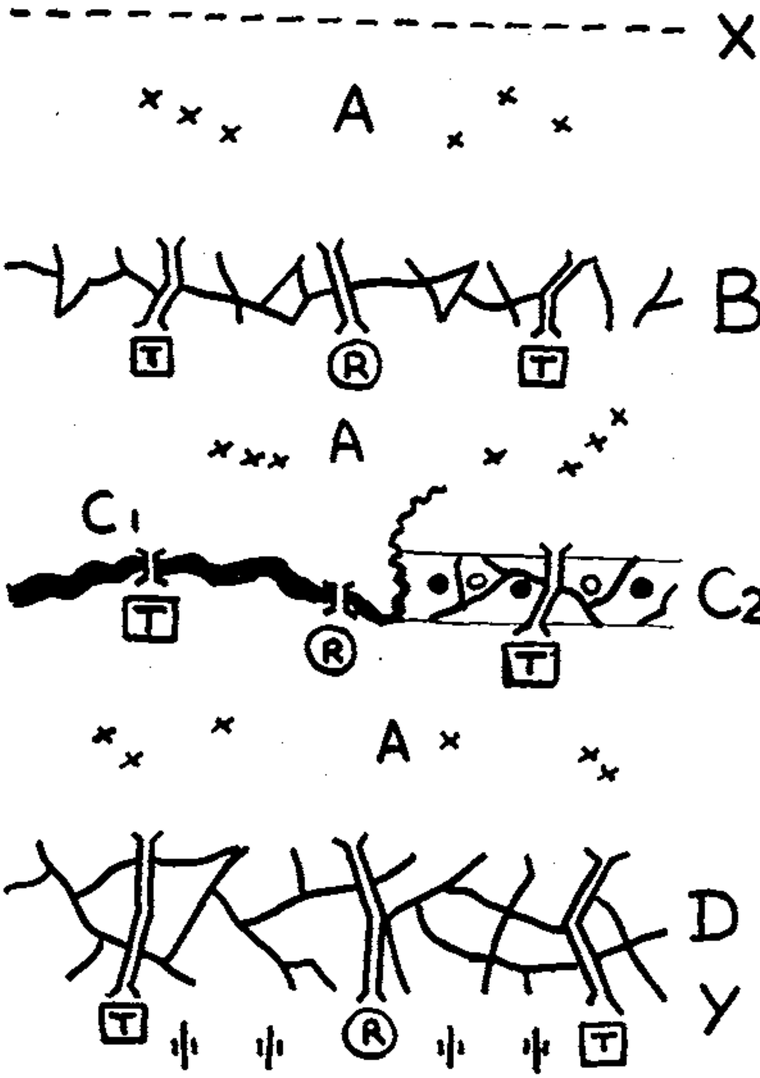
Such a band of road denial may, however, show its greatest value when the enemy has succeeded in making a breach in our main position, whether nuclear or conventional. His aim will then be to pour in mechanized reserves to exploit this breach before we can block it. That is the moment at which a large number of routes of high traffic capacity will be most important for him, and their denial most vital to our own survival. For this reason, the maximum damage should be done to the *main roads* through such a band, which means that these should be taken out as preliminaries, leaving minor routes as tactical axes for the withdrawal of our own troops.

Design of a Road Denial Plan

We can now draw some conclusions for the design of a road denial plan in well-roaded country.

Delay of repair versus permanent damage. Giving the enemy a long repair task seems generally more profitable than aiming primarily to reduce road capacity. The *cunning use of mines and booby-traps* on every demolition and damaged stretch will add greatly to the time of repair, and will have a cumulative effect in making the enemy cautious. "Running sore" demolitions, designed to ensure low capacity and frequent blockage after repair will, however, give considerable value at the end of our withdrawal, sited within range of our own artillery. This will apply even more in nuclear warfare.

Every road and track must be blocked, otherwise the road denial plan will have very little military value once the obstructions cease to be covered by fire. The tempting theory of destroying the main roads, or even destroying all the metalled roads, while clearly applicable in undeveloped terrain, has no application in well-developed country, unless we can be fairly certain that *rain* will make movement across country or on unmetalled tracks impossible. Apart from the logistic calculations in this article, this was abundantly proved in Europe in 1945, where a whole British corps advanced 200 miles using an axis which was unmarked on the *Michelin Guide.*



X START of Withdrawal

A OPPORTUNITY Tasks under Control of Fighting Troops

B BAND of Road Denial. Also night posn. for Fighting Troops

C1 BELT on Natural Obstacle } Also def. posn. for Fighting

C2 MINEFIELD and Road Denial } Troops—one or more nights

D BAND of Road Denial close to our main def. posn.

Y MAIN DEF. POSN. at end of Withdrawal

[T] TACTICAL Crossing or Route for Fighting Troops

(R) REFUGEE Crossing or Route—left as late as possible

FIG. 2. TYPICAL ROAD DENIAL PLAN

FOR RAPID WITHDRAWAL IN WELL-ROADED COUNTRY

Widespread road denial, scattered all over the map, would clearly give the best technical results, as all the most effective sites could be used, and their very dispersal would help to saturate the enemy sappers in their task of keeping their axes open. This is only possible, however, in slow controlled withdrawals, and in the more rapid types of withdrawal we are considering it will seldom be practicable owing to tactical and refugee problems.

A band of road denial across the front will provide fewer effective demolition sites than widespread road denial, but is more likely to prove tactically acceptable. It may impose direct tactical delay on the enemy's leading troops, and further indirect tactical delay by holding up their support and replenishment by wheeled vehicles. If sited close to our own main defensive position, such bands will have added value in delaying the enemy's assembly and deployment for attack, and his exploitation of any breach he may make in our main position.

A belt based on a natural obstacle is likely to remain, as it has been for centuries, the best means of imposing delay, both tactical and logistical. Tactically, it helps the fighting troops to keep the withdrawal under control (particularly at night), while leaving them freedom of manœuvre between bounds. As regards delaying the enemy's support and replenishment, it is true that he need only overcome one demolition to open a route, but it should be possible to damage the approaches so badly that this will take him as long as opening a route through a band of road denial. It will therefore pay to concentrate road denial around even a minor lateral obstacle wherever one exists, and if necessary to fill up gaps in it with minefields.

Opportunity demolition and mining, covered by fire, remain a useful aid to mobile troops in imposing delay. It is not worth aiming at a road denial dividend from these obstructions, as the local commander must retain the right to leave them intact if he is in difficulty over extricating his own troops. As we have seen, even one minor track left open will nullify the effect of a road denial plan.

A typical road denial plan, based on these conclusions, is suggested in Fig. 2.

Finally, as was said at the beginning, engineer effort put into road denial can inflict vastly greater effort (and casualties) on the engineers who have to clear it up. At the higher levels of command, where a long view is taken, this may result in formations being ordered to carry out road denial, irrespective of its immediate tactical value. Taking all in all it seems that the Corps will do best to assume that road denial will be their normal basic task in withdrawal, whatever the terrain, and whatever weapons are used to fight the war.

THE USE OF PLASTICS FOR THE PROTECTION OF OLD STONE AND BRICK IN BUILDINGS

By BRIGADIER I. SIMSON

FOR several years plastics have been used and have proved successful for the preservation and polish of wooden surfaces—e.g., on furniture, floors, sink boards, etc. Their use is steadily increasing for such purposes on ships (naval and mercantile marine), in barracks and in private houses. These plastics are remarkably inert and resistant to hot water, steam and the vegetable acids and cooking fumes present generally in kitchens. Their upper temperature limit varies, but is usually in the range 180° to 230° F. Plastics also have quite a good resistance to abrasion—on floors for example.

After satisfactory use of plastics *inside* the house, the writer first tried them in 1952 *outside* an old house in the Witney area. The inertness and general resistance of plastics to most things—except possibly strong detergents—indicated that they should be able "to stop the rot" in decomposing and badly weathered stone and brickwork. Such "weathering" is proving an exceedingly serious problem with many old buildings all over the world. In Britain alone many buildings are becoming unsightly and even dangerous owing to "weathering" or decomposition of their stone and brickwork. In Oxford for example medium-sized buildings in stone have recently been, or are to be refaced at costs in the neighbourhood of £100,000 per building—with no guarantee, of course, that the "new face" itself will not require replacement in about a couple of centuries. More durable (Clipsham) stone is, however, now being used for modern refacing, instead of other "stones" which deteriorated far more quickly. The Government Building Research Station at Watford is helping to find a general solution for this problem, but so far there is no decision. In Oxford, trials of many stone preservatives were started in 1949, but these excluded plastics. In June, 1954, trials of plastics on a small scale were carried out at Christ Church (Oxford) for the Treasurer by the writer as a sequel to the Witney trials.

Deterioration of stone and brick is usually due to two main reasons. Firstly, a porous surface may absorb rainwater. In winter, freezing may occur before this surface can dry out sufficiently. Action then occurs similar to that which bursts a water pipe; and the surface is "burst off" in large or small flakes—a process which can sometimes be watched with the naked eye, in brickwork, by those hardy enough to try this out in frosty weather! This is the main cause of flaking trouble in porous brickwork and soft porous building stones. Secondly, chemical action of one sort or another occurs in many building stones—particularly limestone (calcium carbonate). If sited downwind from gasworks or in towns with many open coal fires the surface is exposed to sulphur dioxide fumes. Moisture may hold this "poison" in contact with the stone. This gradually forms black blisters—which on analysis prove to be calcium sulphate. This sulphate "skin" expands and contracts with temperature changes, differently from the main body of carbonate underneath, until finally they part company. Decay is often cavernous and usually worse on walls facing south because of their greater temperature changes. Sometimes limestone is in contact with sandstone. If the former decays to calcium sulphate, this in solution is drawn by capillarity into the sandstone and the line of contact shows rapid decay.

The procedure for protection was the same for all types of decaying surfaces of limestone, sandstone and brickwork; whatever the cause of deterioration and whatever the chemical composition of the stone.

All loose materials, encrustations, black blisters, dirt etc., were first cleaned off by hand, using a stiff dry wire brush. The liquid plastic was then applied with a brush, or dabbed on with a clean rag. Stone and brick form an excellent key for the plastic. It adheres well, probably because it penetrates the pores by capillarity and then sets. In about three hours the plastic has set hard enough for a second coat if necessary. The surface looks slightly glazed for a few hours or days; but this effect usually disappears quickly owing to dust, traffic film etc., adhering to the surface. The plastic itself is practically colourless and transparent. The basic colour of the material covered shows through just as it does in a stalactite or stalagmite—which, in fact, the plastic sheath much resembles. But the basic colour of dry stone or brick is permanently and slightly darkened to about the same extent as occurs when such surfaces are wetted with water. In some situations this darkening of the natural "dry" colour may prove an objection, but in the writer's opinion it has never yet been sufficient to prove inappropriate or offensive on a building. No complete building, but only small areas have, however, been treated so far. The over-all effect is thus unknown.

The external or weather side of the decomposing stone or brick is thus completely sealed and protected from damage by wet, frost or the chemical actions mentioned earlier. The joint between individual stones or bricks is also sealed. "Breathing" or gradual adjustments of internal pressures due to dampness, temperature changes or absorbed gases, can and will continue to take place through the internal or non-sealed surfaces. These, in fact, act as a safety valve and should never be sealed. In any event, there is no need to seal them and moreover they are seldom accessible being usually covered by plaster, boarding, wallpaper . . . all of which still permit sufficient "breathing" between summer and winter conditions.

The plastic is best applied when the external surface is really dry, if only to a shallow depth. If moisture exists deeper it then proves innocuous, causes no further flaking under frost and will gradually dry out via the internal non-sealed surfaces, since no further moisture, deleterious liquids or gases can now enter from the exposed side. To assist thorough internal drying during say July to September, the plastic is thus best applied in May or June, on a dry day after a short dry spell. Of some twenty trials in the Witney area on these lines, not a single failure has so far occurred in over three years (i.e., since May/June, 1952). Frost, however, did cause failure where plastic was (for experimental purposes) deliberately applied to wet porous brickwork. Over these three years the plastic protection applied to dry stone and brick has, in fact, so far proved complete in every aspect. Admittedly this is much too short a period to reach a definite conclusion. But the results are uniformly promising so far, in that there is no vestige of further deterioration, no hair cracks in the plastic are visible under magnifying glass, no further change of colour; whereas serious deterioration and flaking has continued visibly in neighbouring stones and bricks—and even the untreated half of the same stone or same brick—where climatic and chemical conditions were identical for treated and untreated surfaces throughout the period of the three years.

These facts seem sufficiently encouraging to justify full-scale trial of plastics for preserving old stone and brick in their worn shapes and forms of today.

To the small owner, with a few perished bricks or porous bricks or stone which cause damp patches on the inside surface of the wall, it is probably much the easiest, quickest and cheapest solution. But full-scale trials are also indicated. The more trials are carried out the quicker we shall reach a decision on over-all suitability and the best technique for application on a commercial scale. With regard to pre-cleaning of the stone or brick, in some cases water or steam may be necessary; but chemicals, and detergents in particular, *should not* be used for fear of delayed action on the stone and because of the known deleterious effect on the plastic. The writer favours dry wire brushing; and for large surfaces, electrically driven brushes or dry scrubbers are likely to prove essential, since hand brushing is heavy work, slow and costly. Brushing should never be deeper than just sufficient to remove loose material and dirt. The carving and mouldings on stonework may even require several types and sizes of wire brush. Deep pitting of very soft sandstone is found to be protected just as efficiently as the hardest limestone. If the plastic is applied by brush the latter wears out very rapidly. Brushes are expensive and difficult to clean of plastic after the day's work. For large areas the most economical method is likely to be dabbing or "swabbing" it on with a cloth or mop which can be thrown away daily; or the plastic may be sprayed on. Brush or cloth is, however, likely to give a much more thorough and longer lasting job for the all-important first coat, since spraying may not work the material into the pores. Spray will probably prove best and cheapest for the second and all subsequent coats, even after many years. Consumption of plastic varies appreciably depending on the porosity of the material covered. For two coats, a gallon of plastic on the average covers about seven or eight square yards. Of this consumption, the first coat accounts for about two-thirds. This is due to absorption; it forms the real seal and so should not be stinted. In fact, it is doubtful whether a second coat will really be necessary except after several years (if not generations!) and only perhaps when the stone or brick first begins to show flaking or discoloration again. Discoloration will be a very sure sign of breakdown of the protecting plastic seal. This discoloration is in fact akin to the warning rust stain on reinforced concrete whenever moisture reaches the steel rod inside owing to a crack or other failure of the protecting concrete. The plastic/stone (or plastic/brick) relationship is, in fact, somewhat similar to the concrete/steel relationship in reinforced concrete. The inert outer "sheath" protects the inner material from moisture, frost, acid fumes and all those things that cause decomposition of the inner material. In each, the coefficient of expansion of the inner and outer material is the same, or so nearly the same, that the two materials do not part company at any rate over the climatic variations of temperatures. For plastic this may, however, be due to the sheath remaining sufficiently plastic after setting, so that it can still adjust itself to expansion and contraction of the inner substance. It remains to be seen whether plasticity is retained over long periods of exposure, e.g., ten to fifty years. If not, even then it may still be a good and economical proposition to spray a second or subsequent coat to seal any hair cracks which may develop; but the old and failing surface of plastic could then probably be best pre-cleaned by water jet (fire hose) and not by dry wire brushing.

In conclusion, most countries possess many structures as a national heritage which they may wish to protect and to retain for posterity. Whether these take the form of the Sphinx, Greek and Roman temples and aqueducts, or the younger magnificent cathedrals, castles, palaces, university colleges, manor houses, etc., of Western Europe, they, one and all, are slowly succumbing to the ravages of time, due to desert-sand blast, sea air, sun, rain, wind, frost and the fumes which pollute the air from certain factories and in large towns. The writer's small scale trials certainly point to a promising, and above all an affordable, solution to the problem. The last adjective will perhaps prove to be the key point, since few governments or people anywhere nowadays can afford to spend large sums on preservation of items which give no financial return or safety to the nation. Where deterioration of the structure has already reached the point of unsightliness and/or danger, plastic of course cannot help; but where this point has not yet been reached, the use of plastics seems to promise such a cheap and "easy" solution that it merits attention and full-scale trial. And here arises an aesthetic point worthy of consideration now, if the only objections raised so far are indicative of a widely held opinion. The argument runs thus. It is all very well to wrap up a battleship, a destroyer, a tank, etc., in "a plastic cocoon" to preserve it for the day when it may be required some few years hence. But my dear chap . . . to put the Sphinx, that temple, cathedral or other old building . . . into a plastic jacket is just sheer sacrilege. And the critic goes on to say that he would rather spend a large sum on refacing the item, with little or no guarantee on the refaced life, than one-tenth (or less) of that sum on preventing further damage. Quite apart from the question of finance and the basic difficulty of finding the very large sums for completely refacing buildings, the writer personally comes down solidly on the side of the "plastician" rather than the "face-lifter". An old building which has been refaced always jars for many, many years. Throughout one's liftime it certainly looks too new. It is now too bright, the "wrong" colour, has smooth surfaces with sharp new angles and new mouldings everywhere. To reface it, may certainly make it look exactly like it was many, many centuries ago, when it was new. But I certainly never saw it thus; nor did all the generations who are alive today each side of my own generation. I still like to see and think of that building in the form I have always known it—mellow with age and experience, no bright colours, no dead smooth surfaces, no sharp corners . . . in fact its worn and pitted condition shows that it has seen and weathered the many storms of life. I believe that the majority of people would also prefer to see old buildings left as nearly as possible in the condition that they have always seen and known them. Their beauty and personality is not only in simple design and correct proportion, but it is also very largely conveyed by their old, experienced, mellow look and not redressed in the new clothes of several centuries ago.

To put it another way, satisfying beauty and the *lasting* impression of a person or of a building requires a good blend of expression, colouring and complexion; not merely fine clear-cut features and balanced proportions. The innate wisdom, serenity, character, personality (call it what you will) of even a perfectly proportioned building is rarely conveyed by "brand newness". It is certainly increased by that air of experienced mellowed age, including all those surface knocks which the centuries have produced. Only time can achieve this complete blend of all the desiderata. The plastic solution covering all those worn edges and scars, captures and holds that mellow expression and character for the living and future generations of mankind. At reasonable cost, and by occasionally renewed application as may prove necessary, the use of plastic should permanently halt the structure's march towards unsightliness, senility, danger, complete decay and death, when such is due to external causes other than earthquake, fire, flood and tempest and, of course, the lunatic with a knife and his world-famous initial. Plastics unfortunately will not protect against such individuals.

Plastics suitable for this type of work, are manufactured ready-mixed for immediate use, or they require an "accelerator" to be mixed with them just prior to use so as to reduce the setting time. Being intended primarily for wood protection and polish indoors, the ready-mixed plastics often contain ingredients such as tung oil. It seems advisable to exclude all such ingredients for external stone and brickwork fully exposed to weather. With tung oil and other additions, the light brown colour is scarcely sufficient to deepen the colour of the finished stone surface; but the seal against weather, gases and liquids is unlikely to be so permanent and there may be more risk of chemical action in the stone or of damage from frost. The writer thus prefers the perfectly colourless, perfectly transparent plastic, despite the extra trouble of mixing the accelerator at site and also of cleaning hands, brushes, and clothes, since its protective life is likely to prove appreciably greater under exposure to weather.

If anyone wishes to experiment further the writer will gladly put them in touch with the manufacturers of various plastics used so far. Inquiries should be addressed through the Secretary, The Institution of Royal Engineers, Chatham, Kent.

CORRESPONDENCE

FIGHTING ABILITY AND CONSTRUCTION POWER

Lieut.-Colonel G. W. Kirkland, M.B.E., M.I. STRUCT.E.
60/63 Aldermanbury, London, E.C.2.

The Editor,
R.E. Journal.

Dear Sir,

Colonel Crosthwaite's episodes from U.S. sources quoted in his article "Fighting Ability and Construction Power", published in *The R.E. Journal* for June, 1955, are of considerable interest, but while not flattering to us, are biased and give scant credit to the Corps.

The chapter "U.S. Army Engineers" provides ammunition for another view.

I was one of two R.E. Majors sent into Persia on the heels of the invasion force with instructions to build roads, airfields, etc., etc., in August 1941.

Within six months, seven R.E. Officers and nine B.O.R's. most of them living in E.P.I.P. tents on the roadside, responsible for their own security in a bandit infested country, and to a large extent, "living on the land", had organized and superintended construction work on some 3,000 miles of road, co-ordinating non-British resident skill and utilizing local labour and materials. They accomplished sufficient construction and established adequate maintenance to permit two-way Aid to Russia convoys to proceed in all weathers. Our lines of communication were via Basra, Bombay, the Cape, Freetown and mid Atlantic somewhere near the Azores!

Months later the task had increased to over 5,000 miles of road, twenty-one airfields, hospitals, camps, etc., etc., and was to be shared by our American Ally.

The United States Persian Gulf Command allocated for this purpose five engineer battalions, three white and two black, who proceeded over the first three months to build magnificent camps with water-borne sewage, permanent masonry mess halls, comfortable barrack huts and every convenience including P.X. stores, ice cream and "coke" parlours, while awaiting the arrival of liberty ships carrying more mechanical equipment than their R.E. counterpart believed to exist.

Admitted, when the U.S.P.G.C. did start work, they literally moved mountains. For example, having completed the essentials in one area they razed 1,000 feet from the top of the 13,000 feet Assadabad Pass, and carried a new road formation over a man-made plateau the size of a polo field. Unfortunately, snow had been discounted and the new work induced drifting so that road formation and snow clearing equipment were lost for days, and on these occasions while blizzards raged the despised R.E. road carried the convoys.

Similarly, in the desert section leading to Khorramshahr, the need to find work for hungry equipment led to making improvements to a road we had carefully planned following the course of the River Khaki, which is notorious for its unpredictable twists. A straight alignment taken from the crest of two bends on our road gave a formation which came within fifty yards of the river bank. A definite improvement for the few days preceding a storm in the hills, which overnight washed out river bank and road, and we finished the war on the old R.E. alignment.

I cannot deny gratitude for the modicum of plant which reached us later under "Reciprocal Aid", but contend its use was infinitely more effective and efficient by virtue of its scarcity.

As a consulting engineer, one of my problems is, how to deal with the "plant mad" contractor who is ever anxious to put in heavy and expensive plant for some "2 × 4" job of work which can often be tackled more cheaply and efficiently by some compromise method of man and smaller machine, frequently by so doing avoiding the jeopardy in which the new construction is sometimes placed.

The sort of thing I deplore is the excavation of foundation trenches in clay by mechanical equipment, left untimbered and open for long periods because of the time differential between excavation and following operations.

By all means, let us have plant in plenty but leave it in the hands of specialists and ensure that Command knows how and when to use his specialist.

Yours faithfully,

G. W. Kirkland,

(Late) Lieut.-Colonel, R.E.

MEMOIRS

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

MAJOR-GENERAL SIR JOHN EDWARD CAPPER, one of the four R.E. officers who commanded divisions on the Western Front in World War I, died on 24th May at Eastbourne, at the age of 93 years 5 months, the oldest officer of the Corps. He was best known for his pioneer work in the early days of military ballooning, and for his administrative work in the organization of the Tank Corps, of which he was the first Colonel Commandant, but he had a great variety of employment, scientific, military and administrative, and served in three campaigns. His slight, light-weight, but tough and active figure, never seemed to change.

The son of Mr. W. C. Capper of the Bengal Civil Service, his elder brother, William, was Commandant of Sandhurst, and a younger brother, Thompson, was killed in command of the 7th Division at the Battle of Loos, 1915. Educated at Temple Grove and Wellington College (1875–8), he was in the Classical Upper VI and a school prefect when he left, on passing into the R.M. Academy.

At Woolwich he was an under-officer—Fenton Aylmer (later V.C. and baronet) being the S.U.O.—and joined at Chatham, third of his batch, in September, 1880. There, not being very skilful at games, he spent much time sailing and was in request as a coxswain.

On the conclusion of the S.M.E. Course he elected for service in India, and in Burma, where he spent sixteen years (1883–99), with one three-month leave home. In 1895 he married Edith Mary, eldest daughter of Mr. Joseph Beausire, who died in 1942.

After joining the Bengal Sappers and Miners and being employed on the construction of the Hurnai road, he was engaged, mainly in the Military Works Department, on road and railway survey and construction, building a suspension bridge on the Gilgit road, and a pack road over two passes 12,000 to 13,000 ft. high in Kashmir. In 1898 he was on active service in the Tirah Campaign and made the first road for wheeled transport up the Khyber Pass.

At the outbreak of the South African War in 1899 he was sent to the Cape as Assistant Director of Railway Transport, and raised the 1st Battalion Railway Pioneer Regiment for the reconstruction of bridges destroyed by the enemy. He later raised three other battalions to guard the railways, and was in command at Virginia Siding, Orange Free State, which guarded the bridge over the Zand river, when Commandant Roux made his unsuccessful attack on it. Later he was Chief Staff Officer to the Rand Rifles, a somewhat unruly force of some 14,000 men collected for the defence of Johannesburg and the Rand mines. For his services he was in 1900 given a brevet Lieut.-Colonelcy (substantive in 1905) and in 1902 made C.B.

In 1882 on completion of his S.M.E. course he had been attached for a few months to the small balloon factory under Major Templer, a militia man and balloonist, who wanted a mathematician to help him on the construction of the first military balloon, *The Sapper*; this must have been remembered by the War Office, for on his return to England in 1903, although officers with experience of military balloons in the South African War were available, he was given command of the Balloon Sections (later companies) at Aldershot, and in 1905 appointed Commandant and Superintendant of the Balloon School and Factory at South Farnborough. In that year he flew in a man-lifting kite at the Army manœuvres in Oxfordshire.

In 1904 he had attended the St. Louis exhibition on behalf of the War Office to report on anything of military interest and had taken the opportunity to visit the Wright Brothers at Dayton; but he was unable to induce the War Office to employ them, or take any interest in aeroplanes, and expenditure on experiments with the Cody and Dunne machines was prohibited—not until 1910 was money provided to purchase a Farman aeroplane. He did, however, obtain sanction for the construction of a non-rigid airship, and in 1907 was pilot of the first military airship, which he had designed and built, the *Nulli Secundus*, with Mr. F. S. Cody (an American, killed flying in 1913) in charge of the engines, on a flight from Farnborough, lasting three hours and a half, over London, round St. Paul's; head winds embarrassed her return to base but she made a safe landing at the Crystal Palace. He was engaged on the design and construction of later airships, which were of the pattern used successfully as "Blimps" in World War I.*

During Capper's time at Farnborough, the Cody man-lifting kites were adopted and perfected. He also built the first glider; in 1907 succeeded in making a soaring flight; and initiated wireless communication between air and land. It was said of him by a subordinate that he never asked anyone to do anything that he would not do himself, and though very strict on duty, was very kindly and hospitable at other times.

On Capper's completion of five years' service as a Regimental Lieut.-Colonel (with brevet-Colonelcy in 1906), he was placed on half pay, the War Office considering that the position of head of the Air Service was not important enough for an officer of his rank; but he was informed that if he liked, he might stay on, but if he did so must not expect further promtion—an offer he did not accept. In April, 1911, however, he was appointed Commandant S.M.E. Except the celebration of the School's centenary in July, 1912, no special event marked his tour of office until mobilization in August, 1914, when the small staff successfully dealt with the large number

*In this period the Germans were constructing and evolving the Dragon balloons (with pouch) for artillery observers, and the Zeppelin rigid air-ship for long flights.

of reservists and recruits, who joined at once instead of in driblets as expected in the mobilization instructions.

In September, with the rank of Brigadier-General, Capper was sent to France to be Deputy Inspector of L. of C.; but four months later with the rank of Major-General was appointed Chief Engineer of the III Corps, on the Armentières front, which was not engaged in active operations in 1915. When his brother, Thompson, one of the best divisional commanders, and a most inspiring leader, was killed in September, 1915, the Commander-in-Chief, Sir John French, seems to have thought that there was something in blood; for he selected John Capper, who was not *p.s.c.* and had never commanded or trained a brigade, to be G.O.C. of the 24th Division, one of the two New Army divisions which had failed so lamentably in the Battle of Loos owing to indifferent training and bad leadership. He had hit on the right man; for Capper was able to change a broken and disheartened division into, as a former member of it, writing to *The Times*, said, "A fine fighting formation in high morale", adding that Capper's "unfailing consideration for his troops, and charm of manner made it a privilege to serve in his command." It is a matter of history that Capper led the 24th Division with success on 18th August, 1916, in the attack on Guillemont, and on 25th August in repelling the German counter-attack with flame-throwers, on Delville Wood in the Somme offensive, and in April, 1917, on the left of the Canadian Corps, at Vimy Ridge, capturing Angres, in the Arras offensive. He was awarded the K.C.B., but his only son, John Copeland Capper, M.C., a subaltern in the Royal Horse Artillery, had been killed on the Somme in 1916.

As there was little likelihood of a Corps command becoming available, in May, 1917, he was selected to be Commandant of the Machine Gun Corps Training Centre, as the training depot of the Tank Corps was first called, and on the completion of the organization of the Corps was called to be Chairman of the Tanks Committee and Director-General of the Tank Corps at the War Office. On the abolition of this post in 1918, he was given command at Norwich of the 64th Division, consisting of Second Line Highland Territorial units, until demobilization.

In July, 1920, he was appointed Lieut.-Governor and G.O.C. of Guernsey and Alderney, and remained in this pleasant office for the customary five years, when he went to the retired list. He was created a K.C.V.O. in 1921, and in 1923 became Colonel Commandent of the Royal Tank Corps.

His retirement from the Active List by no means brought an end to his activities: he kept up his connexion with the 24th Division, never missing the annual dinner, nor the Ceremony of Remembrance at the Divisional War Memorial in Battersea Park; he remained Colonel-Commandant of the Royal Tank Corps until

1934 having been given a three-year extension, and on several occasions a battalion camped in his fields at Bramdean House, Hampshire. He was from 1928 to1934 a Governor of his old school, where his son and grandson followed him, the latter, the child of his only daughter, to his great satisfaction becoming head of the school; and he was a generous benefactor of it. He took an active part in the work of the British Legion and was Chairman of the Hampshire branch for some years. In the second World War he was a company commander of the Home Guard. On the occasion of his ninetieth birthday the Corps of Royal Engineers entertained him at luncheon, when he appeared as alert and well-preserved as ever. Shortly after, in 1952, he was asked to be President of the Airship Club and pilot the *Bournemouth* on her maiden trip. He felt, though he held the first (British) Airship Pilot's Licence, that he must refuse, but offered himself as a passenger. As the ship could not obtain a certificate of air-worthiness, the trip did not take place. In his last days, his sight became indifferent and his hearing began to fail; but his mind remained active and he made a point of solving *The Times* crossword puzzle every day. The only assistance he required was someone to read to him. J.E.E.

COLONEL G. D. DE'ATH, O.B.E., M.C.

DUDLEY DE'ATH, son of the late George Hanby De'Ath, Surgeon, was born in 1893. From Cheltenham College he gained a prize cadetship at the "Shop", where he became an under officer. He obtained his commission in the Corps in August, 1913, and before he had finished the normal Y.O. Course at the S.M.E. Chatham, war was declared on Germany in August, 1914.

He was soon sent to France where he served first with the 11th Field Company, then with the 154th Field Company (37 Division) until May, 1916, and then as Adjutant 55th Divisional Engineers until he was sent home suffering from shell-shock in mid-1917—he had previously sustained a head wound in the earlier stages of the war. It was in 1917 that he was awarded the Military Cross and promoted Captain.

After a brief period at the R.E. Depot, Chatham, he was appointed Adjutant Reserve Mounted Depot, Aldershot, but returned to Chatham after the war to attend No. 1 Supplementary Course at the S.M.E., after which he spent the next four years as Assistant Instructor in Electricity there. A "Long" E. and M. Course followed, after which he went to the War Office as Staff Captain in F.W.9, and retired after two years in that post as a Captain in 1927, largely owing to ill health directly attributable to his old head wound.

Major-General Sir John E Capper KCB KCVO

Colonel G De'Ath OBE MC

By this time, however, De'Ath's ability as an electrical engineer was generally recognized, and this combined with his knowledge of both civil and mechanical engineering made him eminently suitable for the important post of Resident Engineer at Fort William during the construction of the North British Aluminium Company's new works there. Besides the construction of extensive buildings to house the large amount of machinery there was a considerable quantity of heavy civil engineering works. It says a great deal for De'Ath's qualifications that as a Sapper Captain he should have been selected for this very important post, and as a proof of his capabilities, on completion of the constructional work he was appointed to be Chief Engineer there. Later he was transferred to Swansea to the company's shadow factory, but ill health led to his resignation in 1941.

After a short rest he rejoined the Army as a 2nd Lieutenant, R.E., in the Bomb Disposal Directorate, Home Forces, quickly rising to Lieut.-Colonel and becoming Director (Colonel) in 1945. Between then and 1947, when he left the Army again, he was mostly engaged in the clearance of beach minefields. He was awarded the O.B.E. in 1946.

In 1947 De'Ath joined the United Africa (Managing Agency) Ltd. and later the Overseas Food Corporation, and became head of the Engineering Advisors' Branch working on the ill-starred "Groundnuts" scheme. Fate, however, ruled the abandonment of that scheme, and so in 1951 De'Ath went to Mauritius to advise the Colonial Government regarding the provision of electric power there. After a few months he had the misfortune to contract a little-known tropical disease, from which he died on the 24th December, 1954, after two years of suffering most bravely borne.

In 1917 he married Miss Eileen Morris (daughter of Doctor Clarke Morris and sister of General Sir Edwin Morris, K.C.B., O.B.E., M.C., Chief Royal Engineer), who survives him together with one son, Major Ian De'Ath, D.S.O., M.B.E., Royal Marines, and three daughters.

Dudley De'Ath was a most likeable man with a cheerful outlook on life, wide interests, and a marked capacity for making friends. For years he was handicapped with bad health due to his head wound but few would have guessed it. He was an enthusiast at everything he undertook and could turn his hand to most things. Many letters received from those who knew and worked with him testify to the esteem and affection in which he was held. H.H.B.

BOOK REVIEWS

ATOMIC WEAPONS AND ARMS

By F. O. Miksche

(Published by Faber & Faber. Price 25s.)

Many books and articles have been published in recent years on the effects of nuclear weapons on the organization and tactics of armies in the field. Few of the authors can claim to have a completely objective background; whereas Miksche—having served with several European armies—can claim, at least, a wider horizon.

The first section of the book reviews the strategy and tactics employed in the wars of the past 200 years, with emphasis on the two Great Wars. The author's main thesis is the interdependence of fire and movement; suggesting that when these are balanced an army is as efficient a fighting machine as it is possible to make it. At present the available fire-power of an army has so greatly outstripped its power of movement that, without overwhelming air support, it is unable to move with any safety.

In attempting to draw conclusions on the use of particular tactics or strategies in the last war, he concludes that no campaign in the last war can be taken as a model, for major battles were always won when the victor had great superiority in fire, air support and usually numbers. But in this respect it may be asked whether this is not usually the case?

Having established a basis for the discussion in Part II of the book, the author analyses the campaign in Belgium in 1940 presuming that both sides possessed a considerable stock of nuclear weapons. He concludes that, with the then existing Divisional and Corps organization (which is little different from that at present), a position of stalemate would have been accepted after three or four weeks. Air power would have played a decisive part, and neither the tactics nor the organizations of the armies were suited to a nuclear war.

It has frequently been said that to concentrate in a nuclear war is to take one step nearer the grave. Miksche suggests solutions both in attack and defence which provide a basis for further thought. He is of the opinion that even with a superiority of atomic weapons an attacker needs to have a 3 : 1 ratio of troops on the ground.

He suggests radical changes in organizations and equipment. Divisions, for instance, should have about 8,500 men; from which can be produced, for short periods, as many men in the front line as does the present organization. This will mean a drastic cut in staff. But this new "division" will have to be ready to fight both a normal and a nuclear war. Armour will become of increased importance, and tanks should be light and manœuverable. And since one atomic cannon can deliver the equivalent fire-power of at least one hundred conventional guns, the logistic effort required at present to supply the guns will be enormously reduced.

In conclusion he considers the type of warfare which might be waged in the future, and remarks that "for a Power weak in standing armies, it might be of advantage in the early stages to avoid mobile warfare altogether, and to adopt a purely defensive attitude, warding off a hostile invasion from a kind of A-maginot line".

This book is recommended not because the solutions that the author proposes are necessarily the correct ones, but because it will stimulate thought and new ideas on the subjects of tactics and organizations required for a nuclear war.

H.S.

U.S. MARINE OPERATIONS IN KOREA, 1950–3
Vol. I—THE PUSAN PERIMETER

(Published by the Historical Branch, U.S. Marine Corps, 1954. Price $2.00)

A well-known German writer has recently suggested that the quality and quantity of a nation's professional literature about war are a sure measure of the skill and form of its fighting services. Judged by this criterion, Great Britain does not excel. Except perhaps in the realm of regimental histories, our contemporary literature of all kinds is not extensive, nor does it seem to appeal much to the reading public. This is a pity. The welfare state, with its marked tendency always to talk down war, badly requires a proportion of people, who are interested in military affairs. Our military historians could help in this matter by giving a more democratic flavour to their writings. After all, Lord Montgomery owed not a little of his success as a military leader to the democratic slant, which he gave to the business of commanding troops in the field.

The U.S. Marine Corps shows in this book that it well understands how to add the democratic touch to military history. The two authors are at pains to describe the more notable exploits of the lieutenants, the N.C.Os. and "the men" of the Marines. Thirty-two pages of magnificent photographs illustrate the activities of the rank and file, as well as those of the senior officers and the commanding generals. Ordinary readers thus gain an over-all picture of the fighting and get to realize the tremendous importance of the enlisted men, their discipline and their training. No doubt some of these readers will become permanently interested in the problems of war. Yet the expert will not find that this democratic flavour spoils the book. There is still plenty for him to think about.

General MacArthur demanded a Marine Brigade for Korea by telegram to the U.S.A. on 2nd July, 1950. The brigade, formed round the 5th Regiment of Marines sailed for Korea on 12th–14th July. It included supporting arms of artillery, tanks and particularly various kinds of aircraft. The First Provisional Marine Brigade was, in fact, an air-ground team of all arms, which its commander could and often did control from the air in a machine from his helicopter unit.

Having embarked the many and various components of their air-ground combat team for Korea with astounding speed, the commander and his staff sped on by air to Japan to ensure that the team was profitably employed on its arrival. It certainly was, since it landed at Pusan one afternoon and marched into battle the next day. During the critical month of the defence of the Pusan perimeter, the Marine Brigade restored a desperate situation on three separate occasions and was then pulled out of the line to take its place in the First Marine Division for the landing at Inchon and the capture of Seoul. The story of this dramatic strategic counterstroke will be told in Volume II.

The authors have divided their book into twelve chapters, of which the titled paragraphs help much to keep the reader on the rails. The sketches are excellent, although it would be useful in the letterpress to give the number of the sketch which happens to be in action. Some of the abbreviations, e.g. PFC, are missing from the glossary. The order of battle is most useful and so is the index.

U.S. Marine Operations in Korea, Volume I, is an eye-opener to the possibilities of the air-ground combat team as the formation of the future. It would be encouraging to hear of experiments with such a team in the British Army. By now the various kinds of aircraft, tanks, guns, mortars, mines, etc. must surely be available? In the meantime any airman, marine or soldier who wishes for ideas on the subject will find an ample store of them in this volume. B.T.W.

HISTORICAL RECORDS OF THE SURVEY OF INDIA, Vol. III 1815 to 1830

Collected and compiled by COLONEL R. H. PHILLIMORE, C.I.E., D.S.O.
Surveyor General of India, Dehra Dun, U.P., India, 1954

(pp. xxii and 534 and 24 plates. Price £1. 11s. or Rs. 20.)

The publication of Volume III of this monumental compilation of the early history of the Survey of India marks the completion of half of the whole project of recording in the minutest detail the full story of the birth, growth and achievements of this department of the Government of India in which Sapper officers have played so large a part.

The story in outline is well recorded in E. W. C. Sandes' *The Military Engineer in India* (Chatham, 1933–5) and, in rather more detail in Clements Markham's *A Memoir on the Indian Surveys*, 1878, but nowhere has there been any readily accessible information on the technical, organizational and administrative problems and their solutions, nor on what is perhaps the most fascinating facet of all, the clash of personalities and the reactions of the style of European life in India on the execution of the survey and the presentation of the results.

Such information was particularly desirable in published form in relation to the early years covering the slow growth of the Presidency surveys and their fusion into the single organization of the Survey of India. This, the formative period is now covered by the three volumes so far published, Volume I *The 18th Century*, Volume II *1800–15* and the volume under review, and leaves the years of achievement to be dealt with in the remaining volumes, the next two of which are planned, appropriately enough, to cover the periods of office of the two great Surveyors General, George Everest, 1830–43 and Andrew Waugh, 1844–61.

The period covered by Volume III is from the establishment of the post of Surveyor General of India in 1815 to the appointment of George Everest as Surveyor General in 1830 and covers the final step in the unification of the department, when in 1823, on the death of Lambton, Everest was appointed Superintendent of the Great Trigonometrical Survey, which was at the same time placed under the orders of the Surveyor General.

The method of presentation follows that of the earlier volumes with a general narrative in Chapter I followed by details of work by localities in eleven chapters, eight chapters on professional and technical details and eight chapters on organization, administration and personnel. Ninety-five pages of very full and fascinating biographical notes and a comprehensive index complete the volume.

By its nature it is not a volume which can be easily or enjoyably read as a continuous narrative; the interpolation of quotations and extracts from letters in the text and the numerous footnotes interrupt the sequence and reference back to determine the subject is often necessary when the narrative is resumed, but this form is necessitated by the object of the work and the indexing is so complete that any separate subject can be examined with the greatest facility and with the assurance that practically all the information now extant has been reviewed, which, after all, is the prime purpose of historical records. On a lighter plane, it is the most delightful browsing ground which the reviewer has yet come across, with the possible exception of a few select Government files.

The period dealt with is extremely interesting and has many lessons for the present day, for the mistakes of side-tracking long term efforts to meet short term demands of other departments; of dissipating the efforts of highly skilled professional men by refusing to provide suitably trained subordinates or the most up-to-date instruments; and of frustrating efficient field work by attempting control from a distance are ones which are frequently being made throughout the Empire today.

The present story tells of the inception of the quarter inch to one mile engraved Atlas of India which in later years was to produce some of the most beautiful maps that have ever been engraved; of Valentine Blacker's devoted maintenance of the objective in relation to the Great Trigonometrical Survey, which has paid such a rich dividend since; of the detection of the great change in the plumb line deflection in the foothills of the Himalaya; of the first systematic measurements of the heights of the 25,000-ft. peaks of the Garhwal and Kumaon Himalaya; of Russia's keen interest in Webb's exploration northwards in 1817; of the incalculable value of the liaison with European scientists afforded by Everest's four years' sick leave from 1826 to 1830 and of much else on every aspect of survey life.

The pre-1947 Survey of India is to be congratulated on having found such an able historian and the successor department of the Union of India, the present Survey of India, on the excellence of the production of the volume which has been printed at its letterpress printing establishment in Dehra Dun. D.R.C.

DIESEL MAINTENANCE

By T. H. Parkinson, M.I.Mech.E.

(Published for *Motor Transport* by Iliffe & Sons, Ltd. Price 12s. 6d.).

The author of this book has for many years been intimately connected with motor transport either as works manager or as municipal transport superintendent.

It is not surprising, therefore, that the book, which represents the fruits of considerable experience, deals with automotive diesel engines to the exclusion of industrial engines, except in so far as the same type of engine is used for both purposes.

The subject matter is well arranged, and written primarily for fleet or plant engineers; it is therefore eminently suited for service officers in charge of heavy transport or plant units. The book will also be of great value to the experienced engine fitter or vehicle mechanic.

The book commences with a chapter on the history of the automotive diesel engine, which serves to introduce the reader to the many types of engines now in use.

In the following chapter, valuable information is given on the keeping of engine records, inspections, testing, the planning of servicing schedules, training of staffs, and garage and workshop layouts.

The third chapter, under the title "Engine Maintenance", gives much useful advice concerning preventive and corrective maintenance, rates of wear and normal and maximum clearances, etc.

It is with the fuel injection equipment, however, that the author extends himself. Half the book is devoted to this most important subject, and although much of the testing equipment mentioned will not be encountered except in the larger specialists' workshops, information is given which should prove of value to the operator and maintenance engineer of the small fleet.

In writing this book the author set out to give guidance in the maintenance of automotive engines. In this he has been very successful, and the fourth edition of *Diesel Maintenance* has provided a very useful reference book. L.H.P.

MIX DESIGN AND QUALITY CONTROL OF CONCRETE

(Published by the Cement & Concrete Association. Price 45s.)

In May, 1954, the Cement & Concrete Association arranged a symposium to provide an opportunity for research workers and practising engineers to discuss present-day British practice in designing mixes and controlling concrete quality and to focus attention on outstanding problems. This book now published is a report of the proceedings at that symposium. It has certain advantages over the normal text book in that the comments of numerous experts on the various papers presented are given in addition to the views of the authors. Above all it gives the current thoughts on the subject, particularly the problems associated with the production of good concrete. While, therefore, in no way a text book, it should be of great value to anyone who desires to go farther than M.E. Vol. XIV, Part I, into the subject.

Altogether twenty-two papers presented are reported on. Mix design is covered in ten papers, the majority dealing with the special aspects ranging from the special effects of sands through frost and abrasion resistance, steam curing, vacuum process, surface vibration of flexural strength design, high strength concrete and special building concretes, including that required for radiation shielding.

Quality control is covered in another ten papers, the authors being mainly associated with the practical side of concrete production. Their experiences and views on the control of concrete quality on large and small sites, for hydraulic structures, pavements, normal structures and precast work, are clearly given together with those of their critics and supporters. This half of the book should be of great value to anyone faced with the problem of maintaining uniform quality.

Many of the views expressed are necessarily those of research workers, but these are well leavened with those of the men who have to make the theories work. The whole aim of mix design and quality control is to save money. This is done by designing the mix to suit the materials and compaction equipment economically available, and the degree of quality control which can be achieved. A very good example of this was given in the article "Concreting in the Monte Bello Islands" published in the June number of the *Journal*. G.V.J.M.S.

THE PROCEEDINGS OF A SYMPOSIUM ON CONCRETE SHELL ROOF CONSTRUCTION

(Published by the Cement & Concrete Association. Price 30s.)

The proceedings record both the set papers and discussions of the three-day symposium, which brought together the architect, designer and contractor. The proceedings dealing with the architectural use of shells, from the Cathedral of Santa Sophia at Istanbul to the new drill shed at the Royal Marine Barracks at Deal, and those dealing with the contractor's concern of formwork and erection costs, are both interesting and provide comparatively light reading.

The section on design is naturally complex, and requires some previous working knowledge of the existing methods of analysis and their limitations.

Research has recently been carried out on scale models of concrete roof shells, of normal and prestressed construction, but difficulty arises when making scale models where the shell thickness of the full size is only 3 in.

Specialist designers in shell design have, however, already developed semi-empirical methods of analysis and details of these methods are slowly being made available. A.J.L.

TECHNICAL NOTES

THE MILITARY ENGINEER

(Journal of the Society of American Military Engineers)

MARCH–APRIL, 1955

"Military Nuclear Power" by Major W. B. Taylor, Corps of Engineers (retd.)

The author is employed in the Army Reactors Branch of the Atomic Energy Commission after previous service in the Nuclear Power Division of the Office, Chief of Engineers and on the Manhattan Project. In an interesting article he describes what is being done to utilize the tremendous power density of nuclear fuels, which is the basis of the major military advantages of nuclear power. The reader is reminded that the complete fission of one gram of uranium releases heat energy of about 24,000 kWh. or one megawatt day. The use of such a fuel in, for example, remote Arctic bases simplifies the supply problem by replacing hundreds of tons of conventional fuel by one cargo helicopter load of nuclear fuel for three year's supply.

The author explains, perhaps over simply, the principles of reactor design, the advantages of enriched uranium and illustrates his article with an operating sketch and photograph of the scale model APPR (Army Package Power Reactor) to be built as a prototype plant at Fort Belvoir for completion in 1957. A third of the output will produce space heating and the remaining output will drive a 1,300 kW. generator. A single fuel loading will last for approximately three years' operation. The lump sum contract price is reported to be $2,096,753, shared by the A.E.C. and the Army. The future of military nuclear power appears promising and developments on the lines of barge- or ship-mounted plants for support of military operations appear likely, and as reactor technology advances, railway mounted plants may emerge.

MAY–JUNE, 1955

"Educating America for the Atomic Age", by Lieut.-General Leslie R. Groves (retd.).

The author, head of the war-time atom bomb project and later Chief of the Armed Forces Special Weapons Project, was an officer of the Corps of Engineers and is now Vice-President of Remington Rand. In a challenging article General Groves finds that the Atomic Age has brought with it responsibilities for which mankind is not mentally ready. The American educational system is failing to produce young scientists, engineers, technicians and leaders in the numbers required. Existing educational facilities are being wasted on a large number who attend college, primarily for the sake of becoming college graduates, and who have not either the intellectual capacity or the desire for real college work. This expansion of quantity at the expense of quality has resulted in a reduction of the number of graduates who are capable of doing advanced study in the scientific and technical fields where they are needed, and the principle source of teachers who are capable of going beyond the level of average mediocrity is being destroyed. Poor students beget poor teachers who produce poorer pupils. How long can America expect to survive if the present annual production of engineers is only 20,000 and not increasing, while Russia's is 54,000 and constantly increasing?

Improvements are required also in the schools of the Armed Services. Military Commanders must be qualified to consider intelligently, and not blindly, the highly technical problems and recommendations of their technical advisers. Unfortunately, in the selection of the Army's General officers for command and higher staff duties, the most desirable attribute seems to be that the selectee has had experience as a battalion commander of infantry. The ability to understand the technical advances of yesterday, today, and tomorrow is not a requisite for selection, and appears in some cases to be almost a bar to consideration for higher promotion.

In educating America for the atomic age the basic problem is how to break away from the mean; how to find, develop, and reward those talents we most need; and how, at the same time, to maintain and improve those qualities of the people to fit America for her place in world leadership.

"Looking Forward with Engineer Research", by Colonel A. F. Sykes, jun.

The author, the Commander of the Engineer Research and Development Laboratories at Fort Belvoir, gives a very interesting and fairly complete account of the many research and development problems now in hand and the lines on which effort is now being directed. The accepted background for future wars is an open battlefield with highly mobile forces. Speed, mobility and dispersion are emphasized and the article includes a general appeal to all engineer officers who read it to forward to the writer any constructive contributions they have to make on the problems under consideration. Such contributions are welcomed on the grounds that: research and development are not the exclusive prerogative of anyone or any group; they are problems to which all engineers, through their ingenuity, experience, and imagination may make contributions in terms of ideas and suggestions.

ENGINEERING JOURNAL OF CANADA

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

Shoran Controlled Photography

The military importance of air survey, especially in undeveloped country where ground movement is restricted to particular seasons, is apparent. Adequate geodetic control is, however, essential if reasonable accuracy is to be achieved: two examples of failure in this respect have recently been noted in *The R.E. Journal* (Technical Notes, December, 1954 and March, 1955). The development of electronic measurement of distance is obviously bound to find an application in survey methods, and this paper gives a comprehensive but concise account of its use for mapping a large area in North Western Canada.

"Shoran" is a contraction of the term "short range navigation", and denotes a system of indicating the distance of an aircraft from each of two ground stations by measuring the time between transmission and receipt of a "reflected" radio signal. The absolute position of the aircraft at the given moment can then be computed, giving the precise location of the plumb points of photographs.

By this means horizontal control was established over inaccessible territory and large areas were mapped quickly and efficiently by aerial survey. The existing geodetic network was quite inadequate for control purposes, but additional ground stations were fixed by "Shoran" to provide the necessary framework. Calibration and corrections are discussed, and organization and operating methods described.

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

Niagara Remedial Works

The general story of hydro-electric development at Niagara was concisely told in *The Engineering Journal of Canada*, August, 1954 (see *R.E. Journal*, December, 1954) and, in accordance with the terms of the Niagara Treaty of 1950, the U.S.A and Canada are now co-operating in work to preserve and enhance the beauty of the Falls and to exploit still further the available power resources.

The study of the problem and the design of remedial works were based upon large-scale models, by means of which hydraulic conditions were reproduced and observed. For the accurate construction of these models detailed and exact survey was necessary over the whole river area from Lake Erie to the Falls. Much of this work was done by conventional methods, but to obtain soundings and to plot the water surface in the rapids, where boat work was impracticable, unusual measures were adopted. These included sounding by specially designed weights lowered from a helicopter, the position of which was fixed, horizontally and vertically, by theodolite from the shore; a somewhat similar method employing helium-inflated balloons ; and surface readings by theodolite on the reflection of searchlight beams. All readings were synchronized by radio.

After careful testing and some adjustment based on additional survey data, the models were found to reproduce actual hydraulic conditions with remarkable accuracy. Proposed remedial works were then incorporated in the models and the results checked. This method made it possible to examine the effect upon the American Falls when control structures in the Canadian area were in position, to determine the number and sizes of gates necessary to maintain the desired pool levels, and to assess the flow per foot to be maintained in order to preserve the scenic beauty.

On the basis of an extensive series of tests the final plan was approved. The actual work is now in progress, and the paper concludes with some interesting details of the constructional methods being used.

The Impact of the New Plastics on Engineering

Plastics, though man-made substances, are already regarded as engineering materials and have in fact made possible many things otherwise impracticable or uneconomical. This paper outlines the history of their evolution, summarizes their classification and properties, and indicates some of the future developments to be expected. This is a subject which must be of interest to every modern engineer, and the basic facts are here set out briefly and simply. The characteristics and appropriate uses of the main types are stated and methods of conversion into finished products are summarized.

It is stated that the output of the plastics industry in Canada and the U.S.A. rose from £6 million in 1922 to £2,800 million in 1954, and that production has already overtaken that of aluminium.

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

Inclined Hangers as Bridge Stiffeners

The January, 1954, issue of *The Engineering Journal* contained a paper entitled "The stabilization of suspension bridges", in which it was suggested that the use of diagonal instead of vertical hangers, on the lines of the Warren girder, would overcome dangerous distortion due to wind pressure. The present paper is, in the main, a mathematical analysis of the design of arches with inclined hangers, but the writer considers briefly the analogous case of truss-form suspension. He concludes that it would be wise to "hasten slowly" in adopting this method of design for suspension bridges chiefly because, in a truss, one of a pair of web members meeting at a chord point is usually in compression. With non-rigid hangers, such a member would be temporarily out of action altogether, and the structure would then tend to deform considerably unless one of the cords were made suitably rigid. The sudden return of a diagonal into action might lead to failure through shock. The Tacoma disaster is cited as a warning.

Accidental Air in Concrete

Air entrainment is now a recognized process in concrete mixing. During the last ten years, however, cases have occurred in Northern Canada where the local aggregate had the property of entrapping air accidentally, with unforeseen effect on the density of the concrete produced and a consequent reduction in compressive strength by as much as 50 per cent.

Although known instances are limited to a particular geographical area, military engineers might encounter this problem and, as they must normally use what is available locally, should understand how such difficulties can be overcome.

This paper gives interesting data about tests and field control. Briefly, adequate control of air content and consistency can be achieved by adding an air-entraining agent to the mix and then eliminating the unstable air by means of a foam control agent. Mixing time should also be controlled between both minimum and maximum limits, as unduly long mixing, whether in a batching plant or in transit mixers, increases the accidental air content. The suggested maximum is fifteen to twenty minutes.

CIVIL ENGINEERING

Extracts from *Civil Engineering*, March, 1955.

The Design of Concrete Dams

There is a most interesting article on the Design of Concrete Dams. The significance of the influence of canyon shape on the selection of type of dam and its structural behaviour are discussed in this paper. Both arch type dams and straight gravity dams are considered.

Load Distribution in a Model Prestressed Concrete Bridge

It is common for short-span prestressed concrete bridges to be formed by placing a number of precast beams side by side and prestressing them together transversely. The surfacing is not usually sufficiently substantial to be effective in aiding the distribution of load over a transverse section of the bridge. Therefore the transverse prestressing force represents the sole interconnexion between the members acting, as it were, as a continuous diaphragm. The efficiency of the distribution of load and the range of loading over which this efficiency is maintained is clearly dependent upon the amount of transverse prestress, since when the transverse bending moments are sufficient to overcome the transverse moment of resistance the effective interconnexion deteriorates and the initial efficiency of distribution is destroyed. The conditions are analogous to those for a prestressed beam in which cracks have developed. Some extremely interesting tests have been carried out with the aid of the Ministry of Transport's abnormal load trailer and the results are fully detailed in this article.

Stud Welding a Viaduct

The construction of the large viaduct as part of the Ministry of Transport's Neath By-pass project in Glamorganshire has been of great interest. The two plate girder and reinforced concrete viaducts which form an important part of this project are the first bridges in Britain where extensive use has been made of stud welding equipment in the construction. The article gives a description of this technique and mentions the economy achieved.

The Damodar Valley Project

Out of the £1,500 million of India's first Five Year Plan, more than £400 million has been allocated for reclamation, irrigation and other river valley projects. The Damodar Valley Project, costing about £70 million in the first stage, is one of these large-scale projects. The article gives an interesting description of the work in hand and some of the difficulties which have to be overcome.

Civil Engineering and Geophysical Prospecting

For those who are interested in geophysics there is a description of some survey work which has been done in Wales and Scotland by this method. The article is well illustrated with diagrams and photographs.

Review of Contractors Plant and Equipment

Portable Mixer and Dryer

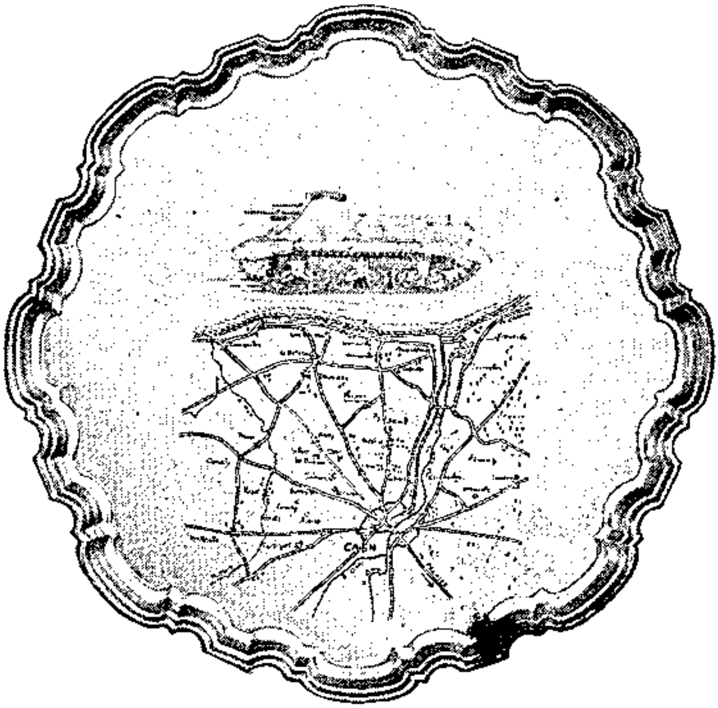
A portable mixer and dryer, the model 804 "Mixall", suitable for various types of bituminous materials is a recent addition to the range of equipment manufactured in this country by Barber-Greene Olding & Co. Ltd. The machine's capacity is up to five tons per hour for hot mix and ten tons per hour for cold mixes and it is suitable for a wide range of maintenance and repair jobs. Pneumatic tyred road wheels are fitted and the machine can be towed to the site where it will be ready to operate immediately on arrival. It is particularly useful in cold weather when the aggregate may be frozen.

34-ton Rear Dump Trucks

Emphasis these days is on heavy plant of all types and we now have the large rear dump truck built by the Euclid Division of General Motors Corporation, operating in this country. These are enormous vehicles. Their all-up weight with pay load is 136,000 lb. and their heaped capacity is 23.3 cu. yds. With full pay load they have a top speed of 28.8 m.p.h., and they're powered by two 200 h.p. Cummins diesel engines mounted side by side.

New Danarm Chain Saw

The new chain saw which supersedes the Danarm "Tornado", petrol-driven one-man chain saw, is known as the "Whipper" and weighs only 27 lb. It has a 14-in. guide blade and is well balanced in both the felling and cross cutting position. A feature of the machine is the centrifugal clutch which enables the operator to change hands, or work with one hand, and permits the gear box and blade assembly to be rotated to any angle independently of the engine.



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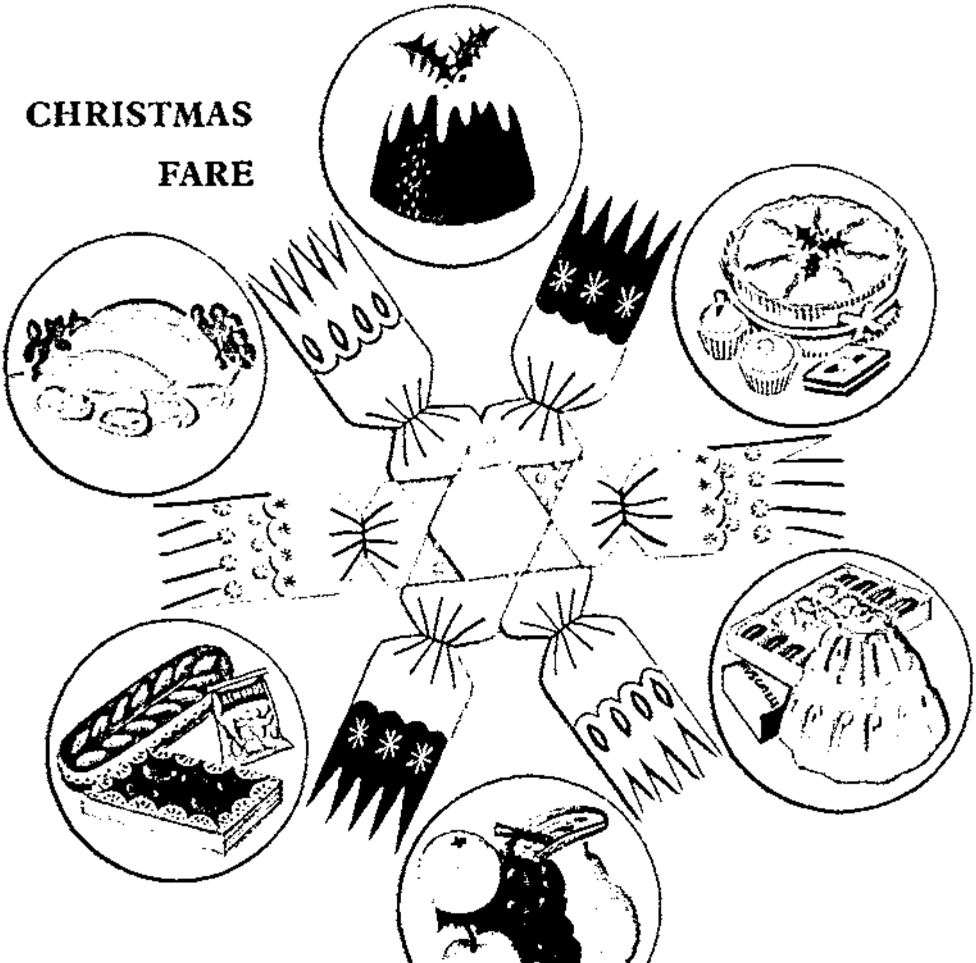

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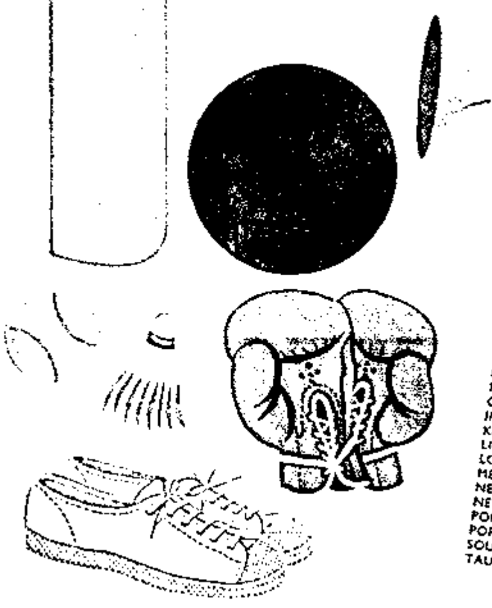

Toy Fairs

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BELFAST, Victoria Barracks.
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BOVINGTON CAMP, Dorset.
BULFORD CAMP, Ward Barracks.
CATTERICK CAMP, Mons Lines.
CHATHAM, Naafi, Prince Arthur Rd.
CHESTER, Saighton Camp.
COSFORD, Naafi, R.A.F. Station.
CRANWELL, R.A.F. Station.
DERBY, Normanton Barracks.
DEVONPORT, Naafi, Prospect Row.
EDINBURGH, Redford Cavalry Bks.
FULFORD, Imphal Barracks.
GLASGOW, Maryhill Barracks.
INVERNESS, Fort George.
KINLOSS, R.A.F. Station.
LICHFIELD, Whittington Barracks.
LONDON, Naafi, Kennings Way S.E.11.
MELKSHAM, R.A.F. Station.
NEWCASTLE-on-TYNE, Fenham Bks.
NEWPORT, MON., Artillery Barracks.
PORTLAND, Naafi, Castletown.
PORTSMOUTH, Naafi, Anson Rd., Milton.
SOUTHAMPTON, Winchester Rd., Bassett.
TAUNTON, Sherford Camp.