The Royal Engineers Journal

VOL. LIX DECEMBER, 1945

CONTENTS

Published Quarterly by

THE INSTITUTION OF ROYAL ENGINEERS

CHATHAM, KENT

Telephone: Chatham 2669

AGENTS and PRINTERS: W. & J. MACKAY & CO., LTD., CHATHAM.

LONDON AGENTS: HUGH REES, LTD., 47, PALL MALL, S.W.1.

THE ROYAL ENGINEERS JOURNAL—DECEMBER. Pages 223—328.

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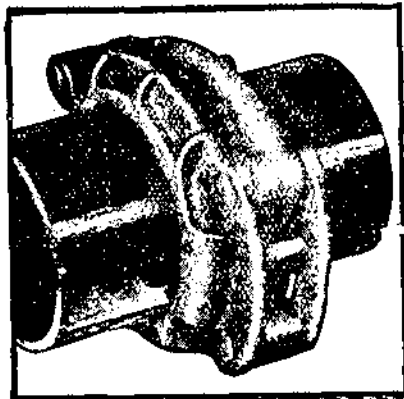

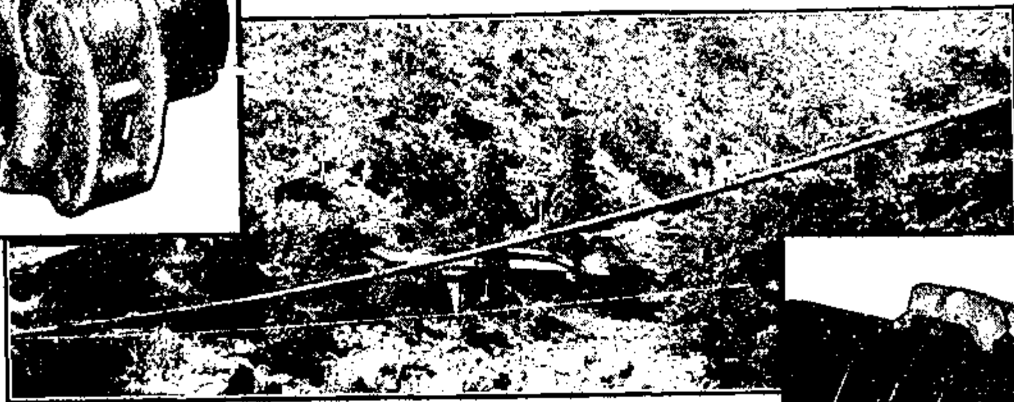

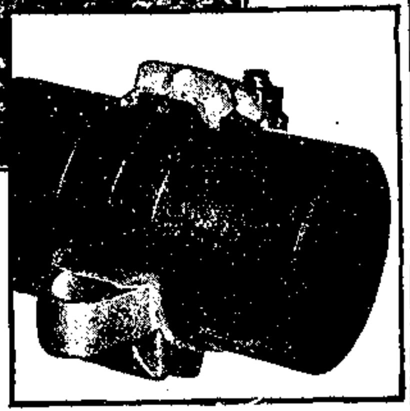

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THE ROYAL ENGINEERS JOURNAL

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VOL. LIX CONTENTS DECEMBER, 1945

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Lt.-Gen. Sir RONALD CHARLES, Chief Royal Engineer, depositing the Roll in St. Paul's Cathedral.

Canadian Engineers Roll of Honour 1914-1918

EDITORIAL NOTES

1. End of War

THE surrender of Japan and the end of World War II has occurred since our previous *Journal* went to Press.

His Majesty the King has sent the following message to all his troops :—

MESSAGE FROM HIS MAJESTY THE KING TO THE NAVIES, ARMIES AND AIR FORCES OF THE BRITISH COMMONWEALTH AND EMPIRE

The surrender of Japan has brought to a victorious end the war which has engaged our full fighting strength all over the world. I send my heartfelt congratulations to the men and women of my Navies, Armies and Air Forces throughout the British Commonwealth and Empire.

Through the long years of the grim struggle with our enemies in the West and in the East, your unflinching resolution and indomitable courage in the face of manifold adversity have earned you the eternal gratitude of your countrymen.

Many of your comrades have fallen in the fight. With you, I grieve for their loss, for the sufferings of the wounded and for the sorrows of the bereaved. With you, I look forward to the safe homecoming of those who have had to endure captivity.

By God's mercy, the forces of evil have been overthrown. But many tasks remain to be accomplished if the full blessings of peace are to be restored to a suffering world.

It is the duty of each one of us to ensure that your comrades have not died in vain, and that your own hard-won achievements are not lost to the cause of Freedom, in which you undertook them.

On behalf of all my peoples, I thank you. God bless you all.

GEORGE R.I.

2. Canadian Engineers' Roll of Honour 1914–18

In the August *Supplement* a brief description was published of the ceremony of installing the Canadian Engineers' Roll of Honour, for the War of 1914–18, in All Souls' Chapel, St. Paul's Cathedral, on 6th July, 1945. We are now able to publish a photograph showing Lt.-Gen. Sir Ronald Charles, Chief Royal Engineer, about to place the Roll in the Recess. Opposite to him is Mr. Vincent Massey, the High Commissioner for Canada.

All Souls' Chapel is in the North-west corner of St. Paul's Cathedral. It contains the effigy, in white marble, of Lord Kitchener. Against the west wall and flanking a high window are statues of St. Michael and St. George. In the north wall is a recess approximately 2 ft. wide and 3 ft. high with a double, heavily grilled, brass door bearing, on each section of the door, the crest of the Royal Engineers. In the upper part of the recess the R.E. Book is mounted, almost upright. It is on a sliding frame permitting it to be pulled forward clear of the recess, where it can be opened without removing it from the frame. In the bottom compartment are the following books :—

Royal Engineers (supplement).
Australian Imperial Force Engineers.
New Zealand Engineers.
Canadian Engineers.
Three Regular Corps of Indian Sappers and Miners.
The Sirmur Sappers and Miners.

It will be noted that the memorial of the South African Engineers has not yet been received.

The Canadian Book of Remembrance is bound in red English Morocco lined with blue Morocco. A large cross in the centre and the border are modelled in relief. It is made up of 36 pages of heavy calf-skin vellum, size 19 in. by 14½ in. It contains the names of 2,004 fallen officers and men of the Canadian Engineers, Signals and Pioneers. These pages have illuminated borders showing shoulder badges of Canadian Engineer Units and various Engineer motifs. Other pages are beautifully illuminated and contain the poem *We Mourn the Dead* by the Canadian Poet, Duncan Campbell Scott, a quotation from Lawrence Binyon's poem *For the Fallen* and a *Prayer for Canada* also by Duncan Campbell Scott.

All the illuminated work has been done by the Canadian Artist, Miss Grace Melvin of Vancouver, B.C.

3. R.E. Officers' Special Appointments

Just recently the following Royal Engineer Officers have taken over appointments as follows:—

Lt.-Gen. Sir Edward Grassett, K.B.E., C.B., D.S.O., M.C., as Lieut.-Governor of Jersey.

Lt.-Gen. Philip Neame, V.C., C.B., D.S.O., as Lieut.-Governor of Guernsey.

Maj.-Gen. F. V. B. Witts, C.B., C.B.E., D.S.O., M.C., as Lieut.-Governor and Secretary of The Royal Hospital, Chelsea.

4. Articles in this Issue of the *Journal*

An interesting article on "Post-War R.E. Problems" will give officers an opportunity of discussing and thinking about some of the many problems which are now coming to the fore. The article gives certain points of view in connection with each subject as seen by the author, but he wisely makes no attempt to give any answers to these problems, which can only be settled as a result of discussion and after taking into consideration many questions of policy in connection with the post-war army, of which details have not yet been published.

An article on "The Education of the R.E. Officer" taken from the unpublished Corps History, gives details of the problems which arose after the last war and shows how they were solved. Many of the problems are the same today and the decisions previously made, and the reasons for them, should prove of value to all officers who have now to plan for the present and future requirements of the Corps.

On page 265 is an article on "Road Surfacings for Tank Traffic," which gives the results of extensive tests carried out by the Dept. of Scientific and Industrial Research and should be of general interest to R.E. Officers, who will be responsible for the maintenance of roads in barracks and elsewhere wherever tanks or other track vehicles are stationed.

An article on "R.E. Work in Thrace" on page 294 gives a picture of unusual conditions of work where Sappers had to be diplomatists as well as engineers.

An article on "Concussion Charges" is an abbreviated description of extensive experiments carried out to ascertain the best methods of demolishing heavily reinforced concrete structures.

Interesting accounts of war work are given in the articles on "Engineer Work with the Fourteenth Army," "San Andrea Bridge," "The First British Bridge over the Rhine," and "Attack on Walcheren."

5. Membership of the Institution of Royal Engineers

Since the particulars of the Membership of the Institution were published in the September *Journal*, the Council has drawn up rather fuller and clearer definitions of the rules on the subject as follows :—

1. The following officers are entitled to Full Membership of the Institution :—
   (*a*) All serving or retired regular Commissioned Officers of the Corps of Royal Engineers.
   (*b*) All officers serving, or who have served, in the Royal Engineer branch of any of the auxiliary forces in the U.K., such as Territorial Army, Supplementary Reserve, Special Reserve or Militia, etc., or who hold, or have held, temporary or emergency commissions in the Corps of Royal Engineers.
   (*c*) All officers serving, or who have served, in the engineer arm of the land forces, whether permanent or otherwise, of :—
      (i) The Dominions.
      (ii) India.
      (iii) The Colonies or Dependencies.

   Recommendations for Membership of such overseas officers to be submitted through the senior engineer officer of their country.
2. All officers referred to in sub-paras (*b*) and (*c*) above, shall be eligible for Associate Membership instead of Full Membership, if they so desire. Civilian officers of the Works Services Staff are also eligible for Associate Membership, if recommended by the senior engineer officer of the Command in which they are serving.
3. Associate Members joining after 24th October, 1945, will receive free copies of the *R.E. Quarterly Journal*, but not the *Supplement* or the *R.E. List*. The two latter publications can, of course, be obtained on payment.
4. The rates of subscription remain as shown on page 222 of the September *Journal*, and are repeated on page 328 of this issue.

6. Annual Subscriptions to the Institution.

Members are reminded that all annual subscriptions are due on the 1st January, 1946.

7. Use of the Suffix "M.Inst.R.E."

The question of using the suffix "M.Inst.R.E." having been raised, i has been decided by the Council of the Institution of Royal Engineers that this is to be deprecated. In view of the fact that the only qualification for Membership of the Institution is that of being, or having been, an Engineer Officer, the use of this suffix might tend to convey a false impression and is, therefore, in the opinion of the Council, undesirable.

R.E. POST-WAR PLANNING

Anonymous

Introduction

THE object of this article is to draw attention to R.E. post-war problems in order to promote thought and discussion of them amongst R.E. officers generally. It is felt that the more widely the many post-war planning problems are realized and considered the better is the chance of sound conclusions being reached which will meet with the approval of the majority of officers of the Corps.

Since much of what follows will have been drafted more than four months before publication, it is possible that policy will have already been decided in respect of many of the problems referred to herein.

This article does not refer to the many immediate demobilization and kindred problems, but rather to ultimate post-war planning for the period beginning about 7 years after the end of the present world war. This long term planning is important in order to provide a target at which plans to deal with immediate problems may be aimed.

Some of the problems in connection with ultimate R.E. post-war planning, and some of the factors affecting them, are briefly noted in what follows. An endeavour is made to state these fairly, but where a tendency towards particular views is detected it must be realized that these views are those of the writer and are not to be regarded as having any official backing.

Composition and Organization of R.E.

Branches of R.E.

If in a Reinforcement Camp, or on leave, you meet an officer or other rank wearing an R.E. badge, you have no clue whether he has been in a field unit, a more specialized L. of C. unit, a railway construction unit, or whether he specializes in stevedoring, surveying, or postal sorting. While the majority of R.E. officers have had an engineering training, there are many who have not. R.E. other ranks include both tradesmen and non-tradesmen, some of whom have had training and experience in many sorts of field engineering and many who have not been concerned with it at all.

The total strength of R.E. in Army Groups in Europe early in 1945 was divided between branches roughly as follows :—

R.E. Fd. and L. of C. ..	61%	R.E. Mov. Control ..	2½%
*R.E. Tn.	33%	R.E. Camouflage ..	1%
R.E. Svy.	1½%	R.E. Postal	1%

Problems concerning the future of Tn., Mov., and Svy. are referred to in subsequent paras. As regards Camouflage, since this must be the responsibility of the general staff and all arms, there is little case for the maintenance of specialist camouflage R.E. units, though there needs to be a Camouflage Development and Training Centre which would run courses of instruction for officers and N.C.O.'s of all arms. What should be the future of the Postal Service ? Some people say that, since mails are normally delivered and collected in ration lorries, it would be more reasonable for Postal to be a

* R.E. Tn. manpower is roughly one-third construction and two-thirds operating.

branch of R.A.S.C. rather than of R.E. Other people urge that Postal Service should be run by R. Sigs., since, when it was known that the local intensity of signal traffic would mean considerable delay for low priority communications, messages could easily be sent by post if more likely to arrive quicker by that route. On the other hand, the Army Postal Service continued to be manned by R.E. when the Army Signal Service R.E. became a separate corps in 1922, and many serving members of R.E. (Postal) would be loath to change their "R.E."

Some officers hold the view that the R.E. should continue to shed off those branches in which officers do not need a general engineering training or in which they have to be so specialized that they cease to be suitable for other than their special employment. This follows the tendency in the past in which we have parted with such branches as submarine mining, mechanical transport, ballooning, flying, signals and searchlights. Other officers urge that we should strive to keep the R.E. a big Corps and that, rather than continue to shed off branches, we should foster a spirit of unity and comradeship amongst our Corps as a whole. The bigger the Corps, the greater the importance of the D.R.E./E.-in-C. and the greater the likelihood of adequate attention being given by general staff and other branches of H.Q. to R.E. problems. Also, the bigger and better can be such institutions as the R.E. Old Comrades Association and R.E. Benevolent Fund, and the lower can be the individual rates of subscription to such Corps concerns as the R.E. Band Fund. A big issue for future R.E. planning is therefore to what extent should the Corps be limited to certain types of engineers only or be kept large and include many branches?

(This question was considered by Col. Davidson-Houston in his article "The Future of the Corps of Royal Engineers," published in *The R.E. Journal* for March, 1945.)

R.E. Transportation

During the war R.E. (Tn.) has been responsible for the construction and repair of railways and port facilities as well as for operating them. The railwayman claims that it is essential that his bridges and line should be built by specialists because of the special characteristics required of them, and the fact that the efficiency and economy of effort with which a railway can be worked depends on comparatively small variations in its initial design and construction, which cannot readily be altered once built. It is claimed that loss in manpower and tonnage carried far outweighs the cost of specializing the engineer force, and the railwayman points to the fact that throughout the world civil railways undertake their own constructional engineering, though often employing contractors to swell their engineering labour force. Likewise, some officers stress that Port Construction is similarly a specialist job for which some specialist units are needed. Against this view it is argued that specialization and divided control of constructional engineering troops of largely similar function, equipment, and stores, reduces flexibility, and is not essential in war, whilst the increased loads now being carried on the roads reduce the difference between road and railway bridging. It is recommended that all Tn. construction, as well as road and other engineering constructional work, should be the responsibility of E.-in-C.'s and C.E.'s.

Which is right?—The Tn. specialist who claims he more than saves in operating manpower anything that may be lost in maintaining specialist Tn. construction troops, or the other R.E. officer who claims that all engineer constructional resources should be controlled by one authority, as is done in the U.S. army organization?

At present there is an uneasy and artificial division of responsibility for waterborne transport between R.E.(Tn.) and R.A.S.C., and, except as a tribute to tradition, any such division is almost indefensible. Who should take the whole responsibility in future ?

Then why should the railwayman claim the right to carry out his own third and fourth line repairs in Rly. Wksp. units, and why should both R.E.(Tn.) and R.A.S.C. make the same claim afloat ? Why should they not bow to R.E.M.E. like the rest of the Army ?

R.E. Movement Control

All movement must be centrally controlled, but must the particular staff branch concerned claim the unique distinction of being its own Service, by having its own units on the ground directly responsible to it ? Is Movement a staff function or a technical one ? If it is the former should it remain R.E., and if the latter should it be a Service ?

Would it be possible to restrict the functions of Q.(Mov.) to the purely staff aspect of their work, leaving the existing services concerned to implement their instructions as does any other staff branch ? Should the work of Mov. Control Gps. pass to R.E.(Tn.), and that of Traffic Control Gps. to the R.A.S.C., together possibly with Air Despatch Secs. ? Some officers will argue that the present system has worked, that Q.(Mov.) has a staff function needing technical qualifications, and that it can only successfully fulfil its function by means of an integrated organization, which can suit itself simultaneously to the distribution of H.Q.'s and the geographical layout of the transportation facilities, two requirements often conflicting which could not be reconciled by any organization based on a strict staff and service basis. Other officers will assert that adequate Movements staff training should be provided, and that the executive control of movements could be dealt with by R.E.(Tn.) and R.A.S.C. without having a separate Movement Control Service.

R.E. Survey

Some say that, since officers for Survey need such a very specialized training, they should be trained only for Survey and remain in it for the whole of their service. Others point out that, since it is not possible to say before an officer goes to survey whether he is going to like it and make a good surveyor or not, the existing system must continue whereby officers are not bound to stay in Survey but may transfer to another branch of the Corps. It is also stated that a regular military survey service cannot be large enough to attract suitable recruits and exist as a separate Corps.

Before the war, R.E. officers who went to Survey were left largely to acquire their technical knowledge by experience at their work. Moreover, civilian surveyors who went to Colonial Surveys or other branches of the civil profession were not given any complete specialized basic technical training, or any insight into the problem of adapting peace-time technical methods to the more rapid, and therefore more exacting, requirements of war surveys. Would it not be desirable for the technical training for all such surveyors to be centralized, so that the R.E. officers get an adequate technical training, and those civilian officers, in the sources which must form the reserve for R.E. expansion in war, get an understanding of military requirements ? A single large school should result in overall efficiency as well as economy.

In order that military survey may receive its due attention and be suitably organized for any future expansion, is it not essential to retain a Survey Directorate at the War Office, a Survey Training Centre for both officers, other ranks, and boys, and some regular survey field units ? Is it not also desirable to organize reserve units on a militia basis from officers and men with Ordnance and Colonial Surveys ?

Works

Since the requirements both in U.K. and at overseas stations are mainly static, and continue in war on an increased scale compared with peace, it would seem that combatant R.E. officers are not required for this role which might be mainly filled by retired R.E. officers or civilians. On the other hand, since engineer works have to be carried out in operational theatres in war, it is highly desirable that at least a proportion of R.E. officers should get experience of the control of works in peace. This means that works services must be staffed, at least partly, by regular officers in peace in order to give them some experience to fit them for controlling works in active areas in war. Moreover, since works in war areas are largely carried out by R.E. units with attached labour, it is desirable that works projects in peace should be executed in this way, as much as practicable.

The 1937 *Engineer Training*, and *Regs. for Engineer Services—Peace, 1940*, Part I, para. 222 (iv.), advocated the employment of complete R.E. units on specific services, but both only visualized the employment on works of single Coys. rather than the employment of a group of works units under the control of a C.R.E. Works H.Q. as in war. A question which arises for post-war planning is the amount of worth-while works there are likely to be, both in U.K. and overseas, for execution in peace by R.E., and the extent to which R.E. units will be allowed to undertake civilian projects. Hence on what scale should regular C.R.E. Works, Works Secs., Army Tps. Coys., Art. Works Coys., Pioneer units, etc. be included in the post-war active army? Also can the C.R.E. Works command units as well as controlling works? If a second C.R.E. is required to command units employed on works, how should the two be co-ordinated?

The future responsibilities for airfield construction, repair, and maintenance, are of very important concern to R.E. Is all construction in operational areas to be an R.E. responsibility, and if so, should not R.E. be responsible also for airfield construction in rearward and non-operational areas? It is easy to understand the desires of R.A.F. officers to have entire control of the whole of this work, but rather than R.A.F. maintaining its own constructional plant, supervisory staffs, construction units, and stores organization, is it not better that all such engineer resources should be controlled by R.E.? There are also the questions of priority for the use of available transport by railway, road, etc. and the priority for allotment of labour in the theatre—these need to be controlled by army Q., particularly in such cases as the reconquest of Burma where the long communications had a very limited carrying capacity.

(The question of whether Works Services for the Army should be staffed by R.E. or civilians was discussed by Maj.-Gen. A. G. B. Buchanan in *The R.E. Journal* for March, 1945.)

Engineer Stores

There are some R.E., as well as many officers of other arms, who advocate that engineer stores should be added to the responsibilities of R.A.O.C. They urge that this would avoid gaps and overlaps in provisioning, and that increased overall economy in stores handling would result. On the other hand, R.E. officers who have had experience of the work connected with engineer stores supply, distribution, and issue, generally point out that co-ordination over provision between ordnance stores and engineer stores staffs is no more difficult than the co-ordination between the various provision branches of ordnance staffs; and that, since in practice, compared with the R.E. stores organization R.A.O.C. usually has over treble the manpower per ton of stores handled, no overall economy is likely to result.

R.E. officers also point out that, generally speaking, the procedure of indenting and issuing is quite different in the cases of ordnance and most engineer stores. In the case of ordnance stores, it is usually possible to quote a Vocab. No., name the item, and demand the number required—a comparatively simple procedure largely impossible in the case of engineer stores. Many engineer stores demands are in the form of stores for hutted accommodation of so many men, or for delivery of so many gallons of water per day over a certain distance against a certain static head, or for so much h.p. for driving machinery. In such cases, the R.E. Stores officer has to consider stores availabilities and give the works officer, or unit commander concerned, a practical solution to his stores problem, suggesting the roofing to be used, the combination of pumps, piping and tankage, and whether the power supply and distribution should be oil engine and/or A.C., D.C., etc. It is not simply a case of making designs and then indenting for flat 8-ft. c.g.i. sheets, centrifugal pumps of particular ratings with characteristics suitable for operation in parallel, or D.C. generators and motors, since none of these particular items may be obtainable although other alternatives can be had.

Before the present world war, the magnitude of the engineer stores problem had scarcely begun to be appreciated, and the organization for dealing with it is still largely in a state of development. The following are a few of the organization questions :—Is the more flexible Mideast and Alfsea W.E. for a H.Q. Engr. Stores Coy. and Stores Pls. better than the British E.S.B.D. estabt. ? If Stores Pls. of the Engr. Stores Coy. are distributed on the L. of C. forward to Corps areas inclusive, should the Wksp. and Pk. Coy. become merely a Wksp. Coy. ?

If we are to have an efficient engineer stores organization at the start of any future wars, will it not be essential to keep engineer stores staffs and engineer stores units in existence and functioning in peace ? If so, there must be an adequate turn-over of engineer stores to provide experience for these staffs and units, and the problem then becomes one of the extent to which works services both overseas and in U.K. can be made dependent for stores on R.E. stores organization rather than on contractors ?

Mechanical Equipment

From the service point of view, it is necessary to standardize on a very limited number of basic types of machines, and a limited range of sizes, to simplify the training and supply of reinforcement operators and the supply of plant, spares, etc. What types and sizes of machines and attachments should be standardized ? To consider one type, for example ; is the basic requirement for a crawler tractor one designed primarily for use as an angle-dozer and to be fitted with a winch or P.C.U. ? Is it practical for chassis to be designed so that a proportion may be armoured without overloading them ? To what extent can the need for transporters be obviated by increasing the mobility of plant on its own tracks ? Can production of the service types of mechanical equipment be arranged commercially within the British Commonwealth ?

How many types of Mech. Eqpt. Pl. are necessary, how should they be organized, what should be their basic scales of plant, and how many operators per prime-mover should establishments be based on ? Should not these be made one-class units and the separate class of non-tradesmen Driver be excluded ? Should H.Q. Mech. Eqpt. Coys. be made to parent the Mech. Eqpt. sub-units with Fd. Pk. Sqns./Coys., Rd. Constr. Coys., etc., be regarded as the normal channel of supply of specially-trained Mech. Eqpt. officer and other rank reinforcements, hold a small scale of reserve plant, be the normal channel of replacement plant supply, and have R.E.M.E. 2nd echelon maintenance sub-unit attached? Should H.Q. Mech. Eqpt. Coys. be provided on a scale of one H.Q. Coy. per four Mech. Eqpt. Pls. or equivalent, and Mech. Eqpt. Pk. Coys. on a scale of one per four H.Q. Coys., or is a different organization advocated which can be more closely integrated with the supply and maintenance of other stores and plant?

How is the problem of maintaining an adequate scale of plant and operators in peace to be solved, since the latter should have opportunities for gaining experience and improving their skill? Can R.E. Mech. Eqpt. units be allowed to take on sub-contracts from big civilian contractors, R.E. works services, and colonial P.W.D.'s?

Armoured Engineers

There are many problems concerning the equipment and organization of armoured engineers in future and their training in peace, and opinions on these problems differ since experiences of officers in different theatres have not been entirely similar.

Should the A.V.R.E. be armed with a "petard" or other means of projecting an explosive charge, or should the turret be dispensed with? Some officers say that at least a proportion of A.V.R.E.'s should be so armed, even if R.A.C. tanks are capable of firing a projectile comparable with the "dustbin" for destruction of defended buildings, or road blocks, or for clearing gaps through mine belts when under enemy fire. Other officers, who have had different operational experience, consider the "petard" unnecessary.

Is a special armoured dozer required, or is it practical for a proportion of A.V.R.E.'s to be fitted with dozers? Is there a separate requirement for an armoured vehicle primarily as a tracked carrier of sappers and their equipment? Should there be two or more types of A.V.R.E. on the same tracked chassis, some having projectors, some having dozers, some being equipped as command vehicles? There is also the problem of assault bridging under fire. Are Arks necessary, should a proportion of A.V.R.E.'s be capable of use as Arks, or will the eventual solution be variable lengths of heavy assault bridge which can be launched by A.V.R.E.'s?

What should be the normal planning scale of armoured engineers for inclusion in forces in future? Is it agreed that one armoured squadron is required per Div., and should the scale of provision be an Armd. Engr. Regt. per Corps? Some officers say that a lower scale is inadequate in ops. because the crews do not get enough rest and there is insufficient time for tank maintenance. Some officers point out that, since Great Britain always enters a major war on the defensive, a lower scale of Armd. Engrs. would suffice for the post-war army. Should we have a high proportion of Armd. Engrs. ready for minor operations?

Case for and against Engineer Field Regiments

It has been strongly advocated from some theatres that we should follow the U.S. Army pattern in that our existing groupings known as Div. Engrs., Corps tps., Army tps., G.H.Q. tps. engrs., should be slightly modified and re-designated as Engr. Fd. regts. (or Div. Engr. bns.). The modifications advocated have included increases in mech. eqpt. and total working strength, these increases to be partly counter-balanced by some reduction in total adm. staffs due to centralization. These recommendations assume Div. Engrs. remain basically as at present as regards total manpower. An attempt is made briefly to summarize the factors for and against these suggestions in the following paras.

FOR grouping into Engr. Fd. regts. :—

Follows the pattern of R.A.C., R.A., Inf., and U.S. Engrs., and easier for our staffs and those of our Allies to understand that C.R.E.'s commands should be treated as single, normally indivisible entities.

Simplifies planning and Orders of Battle, in that there will be few types of regiments instead of the many squadrons, companies, etc.

Simplifies reinforcement procedure, and A. and Q. work generally, due to large degree of centralization of adm. Moreover better arrangements for welfare and amenities would be possible.

Slight overall economy due to increased centralization of tps. and equipment reserves.

Fosters a "regimental spirit," and, due to this, companies in such regiments would tend to know and understand each other better than if regarded as a collection of independent units.

AGAINST grouping into Engr. Fd. regts. :—

To combine the duties of engr. adviser to the Div. comd. with that of Engr. Fd. regt. comd., which really means living in two places at the same time, is unsatisfactory, as many U.S. engr. officers admit.

Engr. Fd. regts. with airborne and armd. divs. must be slightly different from those with inf. divs., and regts. with corps and army tps. will also differ slightly, such as by having E. and M. pls. instead of bridging pls. Hence there would need to be at least three types of standard Engr. Fd. regts.—Equivalent simplification could be got by thinking of a new name for Corps tps., Army tps., G.H.Q. tps. engrs., such as by calling them "Support Engrs."

While Div., etc., Engrs. generally operate as an entity under C.R.E.'s comd. in major ops., much of Great Britain's warfare is on a smaller scale and in such cases the bulk of ops. may be by bde. gps. with only a very loose div. control for long periods. For such cases, Fd. Coys. need to be organized much as at present. The U.S. Army organization is not similarly influenced by this consideration, nor by our lack of manpower.

Since coys. would become part of a regt., the coy. comds. would find it harder to maintain a "company spirit."

C.R.E., who has hitherto been primarily concerned with G. matters, would become fully responsible for A. and Q. of whole Div. Engrs. also. He would become "C.O." of whole regt., and it would be harder to delegate legal powers as "C.O.'s" over their own units to Coy. Comds.

What changes, if any, from existing organizations, are recommended for the future?

Divisional Engineers

Is a strengthening of Div. Engrs. advisable? It has previously been suggested that existing Div. Engrs. shold be permanently augmented by an Engr. bn. (referred to in next para), since the work on road communications in div. area is normally more than div. engrs. can cope with. Against this, it has been argued that div. engrs. are primarily mobile fighting tps. and that any work in div. areas beyond their capacity should be undertaken by corps taking over such work forward into div. areas.

The addition of a fourth Fd. Coy. to Div. Engrs. has been advocated, and some R.E. officers have also advocated a fourth pl. being added to each Fd. Coy., together with the distribution of subalterns on the basis of two per pl. If such manpower strengthening of Div. Engrs. were agreed on, then would not Div. Engrs. become too large a comd. for one lt.-col., especially since he often has other units under comd., and since the C.R.E. has the dual role of adviser as well as comd.?

Existing Div. Engrs. is a larger comd. than the Inf. bn. and nearly 50% larger than the R.A. Fd. Regt., neither of whose comds. are also advisers in the same way that the C.R.E. is expected to be. It is noteworthy that H.Q. Div. R.A. is the same as an A.G.R.A. and commanded by a brigadier. On the R.A. pattern, there would seem to be a case of the Div. Engrs. to be divided into two regts., and for a C.A.G.R.E. to comd. both, and advise Div. comd. Is such an organization possible, while still having Fd. Coys. capable of being detached to support independent bdes., or bdes. moving on different axes in div. ops., in small wars ?

A few officers have suggested that an alternative would be to leave the Div. Engr. Regt. a lt.-col's. comd. and have a S.O.R.E.II added to Div. staff ? It is said that the S.O.R.E.II could interpret the C.E.'s instructions to the div. comd. and ensure that the div. staff did not give unreasonable tasks to the div. engrs. How many, if any, C.R.E.'s are likely to agree with this suggestion ?

If the Div. Engrs. are to be reorganized, the proportion of officers by ranks also needs to be remembered. On the basis of the numbers of officers of each rank in existing W.E.'s, the R.E. subaltern at present has a worse chance of promotion to captain than the R.A.C. officer, gunner, or infantry officer, although his ultimate chance of reaching lt.-col. is slightly better. Should the number of Captain's appointments in Div. Engrs., etc. be doubled ?

Some officers say that we do not need such a high proportion of tradesmen in Div. Engrs., and should have a larger proportion of pioneers instead. Some officers say that there will often be work for tradesmen in Div. Engrs. and that, only by having a high proportion of them, will it be possible to produce adequate numbers of the particular type of tradesmen in demand at any one time. Besides, units in Div. Engrs. should be interchangeable with units in Army or G.H.Q. Tps. Engrs., in which the need for tradesmen may sometimes be greater. Some officers admit that there is very little need for tradesmen as such in most R.E. field units, but stress that it is only by having a high proportion of tradesmen, who are more highly paid and more intelligent than pioneers, that Div. Engrs. can be trained to carry out efficiently the large variety of tasks which they have to undertake in war. Should the tendency be to increase rather than to diminish the proportion of the more highly paid men in R.E. field units ?

Engineer Battalions R.E.?

If it is agreed that Div. Engrs. should continue to be composed basically of self administering Fd. Coys., capable of operating efficiently for long periods away from other R.E. units and largely independent of C.R.E.'s control; then it must be admitted that there is much field engineer work on the construction and repair of roads, airfields and ports, and much field engineer work in support of Div. Engrs. in large scale bridging operations, for which a larger basic engineer unit, able to deploy a larger proportion of its total strength on the work, is desirable.

The Indian Army has Indian Engineer Bns. including only about 20% tradesmen and these are allotted to corps on the basis of one Ind. Engr. Bn. per div. plus one for the Corps ; also to Ind. Forward Airfield Engrs., and to Army tps. Many R.E. officers who have operated in Mediterranean and N.W. European theatres have advocated the requirement for engineer bns. primarily for road repairs and replacing bridges.

Should Engr. Bns. R.E. be formed ? If so; what should be their normal basis of allotment to formations for planning purposes ? What proportion of tradesmen should the bn. include, and should these be concentrated in a

Trade Coy. or Trade Pls. ? Should they include their own element of mech. equipment, or would not greater efficiency in the employment of mechanical equipment result from concentrating mechanical equipment resources in separate mechanical equipment units ? Should bn. transport consist mainly of tippers, and what about mechanical plant for loading ?

R.E. Officers and Their Training

Officer Strengths

The proportion of R.E. officers to R.E. other ranks has generally been higher in peace-time than in the case of most other arms, due to the longer time R.E. officers have to spend under training, and the high proportion of R.E. officers to R.E. other ranks in India, in Colonial stations, and in Works Services. In the years 1932–33 the total officer : other rank proportion in R.E. was 1 : 6, whereas now it is more in the order of 1 : 12. In active armies, the officer : other rank proportion in R.E. is about 1 : 25. If conscription is continued in peace, and men who have left the active army on completion of their compulsory service are held on the strength of a large auxiliary army, then a regular cadre will be wanted for administration and training analogous to what the pre-war Territorial Army needed. Since the officers are unlikely to form less than about 1 in 4 of the total regular cadre, it follows that conscription will not only increase the total requirements of regular R.E. officers in military employment, but also increase the proportion of R.E. officers required compared with the requirements of R.E. other ranks.

For the past few years, the Indian Engineers have exceeded the strength of the Royal Engineers, and the requirements of engineer officers in India after this war are likely to be considerably greater than before it. Although Indians commissioned into I.E. will gradually replace R.E. officers, the requirements of the latter in India are likely to be considerable for a good many years. The strategical importance of the British Commonwealth communications through Mideast remain undiminished. The world importance of the oil reserves in Iraq-Iran is increasing. Hence the maintenance of adequate active imperial forces in Mideast is indicated. The total requirements of R.E. officers overseas seem likely to be at least 50% of the whole, and the proportion overseas would be greater if there should be no compulsory service and no large auxiliary army in U.K.

Many people are anxious to know how many R.E. officers are going to be wanted in the post-war army, in what types of employment, and in what ranks ? The first question can only be answered after many assumptions and guesses. If one assumes that the British Government introduces compulsory service in peace-time, that the Corps of R.E. receives its due share of the total army manpower, that replacement of R.E. officers in India by Indians does not take place more rapidly than hitherto, and that Works Services continue largely to be run by combatant R.E. officers, then the ultimate total post-war requirements of R.E. officers might be as much as four times pre-war. But, to what extent are the foregoing assumptions reasonable ? If they are agreed to be so, then, as a guide, one might further deduce that R.E. officers would be distributed amongst types of employment, extremely roughly, in the following percentages :—Under instruction 15%, with active units 20%, in training organizations (including auxiliary army cadres) 25%, works and engineer stores 25%, other staff employ 15%.

As regards ranks, there will be no demand for junior subalterns in auxiliary army cadres or staff employ, and possibly little or none in Works Services. With increasing Indianization, the demand for subalterns in India will disappear. Hence an increased proportion of Captains and Majors compared with pre-war, and more rapid promotion for junior R.E. officers would be indicated, but will R.E. be allowed quicker promotion than say R.A.? The proportion of lt.-cols. compared with total officer appointments is higher in staff employ, in Works Services, and in the training organizations, than in active army formations. On the basis of the above assumptions, it is likely that R.E. will need at least twice the number of lt.-cols. that there were before the war.

Officer Training

Subjects of initial training for the R.E. Y.O. were given in *Engineer Training*, 1937, sec. 5 as:—

(i) "To fit him for the normal responsibilities of a junior subaltern."

(ii) "To provide him with a broad military and engineering education on which to build, throughout his service, by study and experience."

Criticisms of (i) above were, owing to the various types of employment to which junior officers were liable to be posted, that this was not really practicable, and the effort to fit a Y.O. for such different roles as Div. Engrs., A.A. Searchlights, Works Services, meant the period a Y.O. had to be under continuous instruction was too long before he got executive employment.

Criticisms of (ii) above, as regards the broad military education, were that in fact this amounted to recruit training done with the training battalion and instruction on administration from which it was difficult to get full value since officers were likely to have over 2 years more under instruction before being posted to a unit. The "tactics" instruction included much repetition for most Y.O.'s of teaching on such subjects as messages, orders, appreciations, organization, previously given in O.T.C. and at the "Shop." Moreover, the Tewt's run by a P.S.C. major usually began with the forces of "eastland" and "westland" and seldom dealt with tactics from the point of view of any officer junior to that of bn. comd. Hence Y.O.'s, when eventually posted to Fd. Coys., usually felt the lack of instruction in the tactical handling of pl., and felt ill-equipped to teach the handling of secs. in the field.

The *Engineer Training* section quoted considered regular officer training as consisting of "initial training," experience with troops, and advanced "post graduate" instruction for a limited number of officers to specialize in certain subjects. A factor which will affect post-war Y.O. training is compulsory service. It is hoped that this will be enforced generally, and will cover recruit training before future officers go to the Army College. Hence it is to be hoped that the Y.O. will have already been given a broad military background before being commissioned, and this should enable the length of the basic Y.O. course to be reduced.

Another factor to be considered is the benefit derived from short courses introduced during the war. S.M.E. has been running 2 i/c.'s, coy. comds., and C.R.E.'s courses. Should we not consider post-war R.E. officer training as consisting of "basic" Y.O. training, and "post-basic" training for all regular officers, as well as "specialized" training for particular officers? Should not the basic Y.O. training be limited almost to a broad engineering education, and should not the principle of post-basic training at S.M.E.'s, in U.K. and abroad, be extended to include short courses for subalterns to fit them for their duties in the type of employment to which posted?

It was considered before the war that officers "should gain experience of the command of men before being allowed to take up employment away from troops," while the types of employment with troops open to Y.O.'s were limited almost to divisional engineer units and searchlight battalions, at about only 50% W.E. strength in U.K.; or training units. Some officers went to units and spent most of their service with troops, while others spent most of their service with Works Services. During the war, large numbers of other types of units have been raised dealing with engineer works and stores, and many R.E. officers have been employed in this way, compared with those employed in field units. Opinion now seems generally to be that we should plan the service of R.E. officers post-war so that all officers will have had experience both with troops and in charge of works before coming up for promotion to lt.-col.

If this opinion is accepted, then should not post-basic courses be normal before, or shortly after, going to field unit employ or to works services? In other words, should not the subaltern who is to get experience both with troops and with works, undergo a "pl. comd.'s" course and a "works" course respectively when going to each particular type of employment?

The amount and nature of engineering training to be given to R.E. officers raises many questions. The object of technical training is indicated in the following extracts from *Engineer Training*, 1940, Pt. I:—

> "In the field, the engineer officer assists the commander in two ways; firstly, with advice on the bearing of technical factors on plans contemplated; and secondly, by the execution of work required in furtherance of plans."
>
> "In a small war the engineer . . . officers must be able to deal with a wide variety of engineering problems."

In a great war "the permanent cadre is reinforced by an influx from all branches of the engineering profession in civil life . . . to direct the activities of this reinforcement, the officers of the permanent cadre must be not only trained soldiers, but also engineers of wide experience; and the filling of the key positions will demand officers whose technical qualifications are such as to command the confidence of their subordinates drawn from civil life."

Before the war, Y.O.'s spent two college years at Cambridge and had to obtain an honours degree in Mechanical Sciences Tripos. This provided an opportunity of getting their basic engineer training along with their civilian contemporaries, and of obtaining a definite qualifying standard which the latter could appreciate. On the other hand, attendance at the University had the disadvantage of starting only once a year, whereas officers were commissioned at half-yearly intervals, thus making the time from commissioning to posting to a unit a minimum of about 2½ years in the case of batches commissioned in January, and, moreover, the University gave a rather too theoretical training for the needs of R.E. officers.

Technical qualifications for R.E. officers there must be, but an alternative to University training is a course at S.M.E. and/or Military College of Science, during which officers would be required to pass certain civilian examinations such as those for A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E.

Should University training for R.E. officers be insisted on post-war, or, if not, what standards should be set instead?

In addition to their basic technical training, the subsequent training and employment of R.E. officers should be designed to ensure that they become "engineers of wide experience." It is generally agreed that the attachment of a few officers keen to specialize, to civilian firms, and the employment of a large proportion on supervising Part III Works Services, did not suffice before the war. A question is how best, within Army budget limitations, can R.E. officers be given the necessary wide experience in control of real engineer work in future?

Location of the S.M.E.

Since the S.M.E. in the U.K. is the base of R.E. officer training, and there has been much discussion regarding its post-war location, it is relevant to note here what is desirable before considering what locations are practical.

The S.M.E. in U.K. should be the S.M.E., which all members of the British Commonwealth will acknowledge as such, to which colleges and schools of all arms of the British army, and other S.M.E.'s, will send officers to learn the latest doctrine and latest methods of instruction in military engineering. This suggests :—

> That the S.M.E. should be located within easy access by road of the principal colleges and schools concerned, including School of Infantry, A.F.V. School, and Army Staff Colleges, so that their instructors and those of the S.M.E. can easily maintain touch with each other ; and to encourage parties of officer students to visit the S.M.E. from other schools and colleges and know about R.E. The locations of these are expected to be at Warminster, Bovington, Camberley and Minley respectively.
>
> It should be possible for visitors to see all types of S.M.E. training in a short time. This implies that the activities of the various E. and M., Construction, Field Engineering and other schools, including both dry and wet gap bridging should be representatively displayed close together. Since, owing to English geography, all their main training sites cannot be located at one place, and a detached camp for wet gap training may be necessary, a requirement at the S.M.E. itself is some river or lake on which rafting and bridging equipments can be shown.

Obviously the training grounds at or close to the S.M.E. should be extensive, and it is desirable that different types of country should be within easy reach. Suitable dry gaps for bridging can be prepared anywhere with mechanical equipment, provided drainage from such gaps is possible. A moderate current is essential for training in watermanship and river crossing, and tidal conditions with a moderate rise and fall are desirable ; but should the gaps for normal training in use of floating bridge equipments preferably not exceed about 200 feet, and would not wider gaps be preferable for training in rafting ?

For proper training of Y.O.'s and others attending courses at the S.M.E., the E. and M. School should have workshops equipped with the main common types of modern plant and machine tools, a foundry, and a power station ; though these need not be large. In view of the nature of modern war, should not these be largely constructed inside a hill or deep underground and out of reach of bombs ? There would be advantages in having a working example of such construction, with the various strutting, lighting, ventilating, heating and other problems satisfactorily dealt with. Besides the electrical and mechanical trades, classes at the S.M.E. have to learn about the construction trades ; hence is not the logical deduction that all the trade training for other ranks of R.E. (Fd. and L. of C.) should be done at the S.M.E. ?

Though not yet regarded as a trade in the army, M.T. driver's duties have also to be taught to classes at the S.M.E. and, so long as M.T. driver training continues to be given only to less than 20% of R.E. other ranks, would there not be advantages to those on S.M.E. courses if driver training were done there ? Would possible disadvantages to driver training be greater ?

It is obviously undesirable that the S.M.E. should be located in a part of the country liable to long periods of cold or much wet weather, but this factor applies also to other army schools, from which the S.M.E. should not be remote. A location near R.N. and R.A.F. stations would help us and them to know each other and our jobs, and contacts with these services are particularly important for R.E.

The S.M.E. should be in a place which most of the Corps would be glad to revisit during their army life; and after retirement. In this respect friendly messes are the main requirement, but the location should be one where amenities are available. But what do you understand by the term "amenities"? Many regard amenities mainly as opportunities for such activities as hunting, shooting, fishing, yachting, rowing, swimming and games, but the tendency nowadays is rather to regard "amenities" as amusements in the evenings and after dark.

If the former view is taken, then a location in pleasant and suitable country close to the sea is indicated. To suit the latter view, a location in or very close to a large centre of population is wanted by many; though if the S.M.E. is large enough, then the provision of such amenities on a reasonably adequate scale would be justified within the barracks or camp.

Good rail access from London is desirable since travel via London is usually convenient between any location in the South of England and other parts of Great Britain, and it is also desirable to facilitate contact with the War Office, and enable officers from there easily to visit S.M.E. On this account, a quick rail journey from London and a location near an important main line station would be advantageous. The fact that the climate of Great Britain is such that one cannot depend on being able to travel by air on a particular date is a point to be remembered.

Research and development must be provided for, and an important factor is that S.M.E. instructors hear from students, from all parts of the world, their problems and difficulties met in practice. These views are particularly valuable to those responsible for research and development. It is also important that S.M.E. instructors should know what experimental work is going on, and the latest trend in developments. The ability to take a lively interest in this helps to keep the instructors fresh in their ideas and their instruction. Is it not therefore very desirable that those responsible for experimental work should either belong to the S.M.E. Mess or be located near enough to be able to maintain easily a very close liaison?

Owing to the many factors, and the varying degrees of importance attached to each by different officers, opinions vary regarding alternative locations for the S.M.E. The choice has to be limited to sites where much W.D. land and accommodation already exists, since the possibility of acquiring new land and getting new barracks built in near future is very remote.

R.E. Other Ranks and Their Training

Boys

Before 1939, the majority of the W.O.'s and senior N.C.O.'s of the R.E. were "ex-boys." The proportion of the Sapper intake which came from boy training was in the order of about 10%. What proportion of the post-war R.E. other rank intake should come from boy training establishments?

Hitherto ex-boys have been better educated than the majority of direct-entry recruits whose compulsory education ceased at 14. The school leaving age is being raised and it may eventually reach 18, as in U.S.A., but is it not probable that for many years the army will be able to provide better teachers than the average in civilian schools? Besides the advantages of a boarding school education with full physical and recreational training compared with attendance at day schools, giving the army boy a basically military education, and bringing him up accustomed to smartness and military discipline, should make him a potential N.C.O. earlier than the civilian.

Since the demand in modern armies is for N.C.O.'s who are alert and active and good leaders, is this not an added reason for an increased proportion of "ex-boys" in future?

There is also the question of provision of the many types of army tradesmen of those trades which are either not analagous to, or are a combination of two or more, civil trades. Should such peculiarly army trades be those mainly taught to army boys? Will the majority of ex-boys rapidly become N.C.O.'s and hence be lost to the service as tradesmen?

Should we not press for the training of an increased proportion of *R.E.* boys rather than *Army* boys? This would enable them to be brought up with our *esprit de corps*, enable specialization in R.E. trade requirements, and avoid the suspicions of chicanery in the postings from Army Technical Schools to various corps.

Sappers and Drivers

Must we continue to have non-tradesmen M.T. drivers in R.E.? What proportion of our other ranks should be trained in M.T. driving? Should all other ranks for *all* branches of R.E. be enlisted as sappers, instead of only in R.E. (Postal)? Should all who are to become drivers be trained as Pioneers R.E. before being trained in M.T. duties? Should they also be basically trained in a corps trade before their M.T. training, as is done in I.E.?

How many R.E. training battalions will be required? As regards regulars, the numbers to be under training are dependent mainly on the annual output required to maintain the R.E. strength of the post-war army, and the length of training recruits are to be given. But it is hoped there will be compulsory service in U.K. for all males from age 18 to 19, so it would be reasonable to expect that, of the army share of conscripts, R.E. (Fd. and L. of C.) should get not less than 9%, and R.E.(Tn.) and R.E.(Svy.) a total of perhaps about 4½%. Hence the total R.E. conscript intake might exceed 20,000 per annum.

Assuming that all army recruits go first to Primary Training Wings for 2 months before selection for particular arms, and that the majority should spend 6 months of their year's compulsory service in an active unit, then only 4 months is left for corps training. Is it reasonable to assume that both sapper and driver recruits for all branches of R.E., other than Postal, should undergo the same basic corps training? If this is accepted, and it is assumed that training battalions each consist of three training companies each of four recruit pls., then a total of about *ten* R.E. training battalions would be required for basic conscript training alone. There will also need to be further training for those who enlist on regular engagements; though different for each branch of R.E.

Where should R.E. training battalions be located? Should there be individual training battalions dispersed throughout Great Britain, or should battalions be grouped together in R.E. training centres?

The former would be more popular with most Battalion Commanders, and would enable the R.E. flag to be shown widely. Training Centres, including three or four battalions, commanded by Colonels or Brigadiers would enable certain officer and N.C.O. training, L/Cpls. cadre classes, higher educational training, good model rooms, and a large scale of training equipment, to be centralized, besides a good share of the admin., thus allowing C.O.'s of battalions more time to attend to recruit training. Moreover, it would enable amenities such as N.A.A.F.I. and cinema to be on a bigger and better scale than is possible with single battalions. If the grouping of training battalions in R.E. training centres is agreed to, should not such training centres be located in both the North and South of England?

Would it be desirable for training centres to include provision for M.T. training of drivers ? Should they cater for any trade training, or should all this be centralized at S.M.E., for those trades common to all branches of R.E. ?

N.C.O.'s and W.O.'s

There is much truth in the statement that the heart of a unit is the Sjts.' Mess. To make a good unit there must be good Officers and good W.O.'s and N.C.O.'s, and the latter are the more numerous. Yet how comparatively little attention is paid in most of the R.E. to their selection and training ?

Is it right in peace time that suitability for promotion should be decided solely by unit commanders throughout the world who judge men on different standards ? Would it not be better if the unit commander's recommendation, that he would be willing to have the N.C.O. back in his own unit after promotion, merely qualified the N.C.O. to be allotted a vacancy on a promotion course run centrally ? On such courses, all N.C.O.'s of the same rank who are " R." or " S.R." could be given N.C.O. training for about 2–3 months and their relative abilities, powers of command, and general suitability for promotion, could be judged on a common standard.

If this principle is agreed, then would it not be desirable to have separate promotion courses held centrally, each quarter, for those L/Cpls. " R " for Cpl., for Cpls. " R " for Sjt., and for Sjts. " R " for W.O. ? Special provision would be needed for technical N.C.O.'s such as clerks, Tpt. N.C.O.'s, and those in E. for E.S. A big advantage of such promotion courses is that N.C.O.'s can be given training for the next higher rank ; and a foundation of knowledge, on which they can build up their experience, should produce good N.C.O.'s quicker than if they are simply left to " pick up " their new duties.

It would be desirable that all promotion courses for the important step to Serjeant, and the subsequent step to W.O., should be run at the S.M.E. in U.K. Will air travel be allowed from distant overseas stations to attend such courses in U.K. ? Will adequate establishments be sanctioned for instructional staffs, and also for depot holding of " N.C.O.'s under training and in transit " so that units can get prompt replacements for N.C.O.'s who go on these courses ?

Concluding Note

This article has briefly touched on a few of the R.E. planning problems ; but there are many others. Amongst these are the questions of whether much of our training could not be better carried out in Canada or East Africa instead of in Great Britain, and whether there should not be representatives from R.E., and Engrs of each Dominion, on the staff of every S.M.E.

After the more finite problems, one wonders how soon aircraft will cease to need long runways ; while younger officers may wonder whether they may have to supervise the trade testing of Operators, Subterrine, or decide whether the atomic fission stores for use by Demolition Pls., R.E., should be items of ordnance or engineer supply !

ENGINEER OPERATIONS WITH THE FOURTEENTH ARMY IN 1943-44

By Brig. H. F. Horsfield, C.B.E., M.C.

1. THE Fourteenth Army area of operations can be divided into three parts. In the South, the East Bengal Plain and Arakan Coastal Strip of paddy-fields and mud flats leading to the Lushai and Mayu Hills; in the middle, the Khasi, Naga and Chin Hills leading to the Kavaw Valley and the Chindwin River, and in the North, the Brahmaputra Valley. The chief military engineer trouble is that there is no stone in the South, and little in the North. It will, therefore, be realized that to undertake any permanent airfield, road, or similar construction, large masses of stone must be moved over long distances, or alternatively, hard material must be made locally, for example by the burning of bricks from local clay, which requires the movement into the area of vast quantities of coal or wood. In order to cope with this a special organization was set up, and a fleet of engineer boats collected, or made, for the movement of stone by tortuous waterways from the Khasi Hills right down to the Arakan Coast: a million tons was the task.

2. As the most important part of the offensive was to be by the air the Engineer operations in support of this will be dealt with first.

For the operations in Arakan, early in the year, 15 Corps Forward Airfield Engineers carved out many "Fair Weather" airfields from paddy and jungle, including long approach roads, and accommodation for the personnel of the R.A.F. Squadrons. Similarly, for the Chin Hills and Kabaw Valley operations, 4 Corps Forward Airfield Engineers constructed many such airfields in the Imphal Plain and Kabaw Valley. They all had to be completed in an incredibly short time as soon as the ground was dry, as they were vital for the support of the land operations.

Behind these forward airfields, which were mostly for the use of Fighters, a very big programme of "All Weather" airfields for bomber and transport planes had been in progress throughout the Army area. In N.E. Assam especially, very large works on airfields were undertaken also for the American Air Force. It is perhaps not generally known that all the work on this vast programme of airfield construction in N.E. Assam for the American Air Force, for the support of their operations in the Hukawing Valley, and for the transport service to China, had been carried out entirely by the British. It is not always realized that, apart from buildings, an airfield is equivalent to 60 miles of concrete road, involving a tremendous amount of Sapper work.

3. Referring to land operations, I will deal first with those on the 15 Corps front in the Arakan. In 1943, the initial object of the operations on this front was the re-capture of Maungdaw and Buthidaung. In this trackless country of paddy fields, mud hills, and numerous creeks, rivers, and streams, the greatest task of the Engineers, apart from the airfields, was the maintenance of communications up to the forward troops. One of the most spectacular works was the cutting of a jeep track, later improved to take tanks, over the Ngakyedauk Pass by the 7th Divisional Engineers under Lt.-Col. Cator, the C.R.E., who, later, was killed during a forward reconnaissance for the continuation of his road. The road over this Pass is, however, a fitting memorial to him.

Another notable engineering feat was the construction of the road and ropeway over the Goppe Pass. This moving ropeway is $2\frac{1}{2}$ miles long, is strung between high peaks over deep ravines, and is driven by an engine installed at the top of the pass. It was constructed by a military unit, and is the first of its kind to be made entirely by Indian Engineers.

4. Behind the operational area a great engineer effort was necessary for the maintenance of the Corps in its fighting role. These works were the responsibility of Col. Tucker, whom I regret to say, subsequently met with a fatal accident while flying. Apart from the "All Weather" Airfields in the area already mentioned, his most vital, difficult, and biggest task was the construction of the Arakan Road from Chittagong to Bawli Bazaar, with branches to Cox's Bazaar and Ultakhali, where there was no road before. It is almost 200 miles long with 5 miles of bridging. With a rainfall of 160 ins., the country is under water from June to December, and consequently the road had to be on an earth bund averaging 6 ft. high and 30 ft. wide. It was completed in six months by hand labour only. In these parts bricks had to be burned for the road surface, and some 8 crores of bricks were burnt and laid in the same time, but we were beaten by the monsoon of 1943. In 1944, 180 million bricks were burnt and laid, but again not enough before the monsoon broke.

Another great work was the enlargement of Chittagong Port. Coupled with this, and to supplement the road, the waterways in this part of the world were developed to the maximum, with new quays, approach roads, and other facilities in many subsidiary ports.

In addition there was a colossal programme of buildings for hospitals, accommodation for personnel during the monsoon, and storage for all the commodities which an army requires.

5. I will now describe the 4 Corps front in the Chin Hills. Unlike the Arakan, the country here is hilly, with no waterways, etc., to supplement the roads, but with many defiles through which all the supplies must pass. It was quite impossible to undertake any operations on a large scale until proper Lines of Communication had been constructed behind the Forward Troops. At the beginning of the campaigning season the Engineers were, therefore, faced with a very large road programme. A good two way road had been completed in 1942-43 for 175 miles from Dimapur to Palel. Beyond this there was a "Fair Weather" track through the hills, pushed through in great haste at the time of the evacuation from Burma. Through the Chin Hills a rough road to Tiddim, 165 miles from Imphal, had also been cut.

The cutting and making of a 100 miles, two way, "All Weather" road for 30 ton loads, through the hills from Palel to the Chindwin, to replace the existing track, was an engineer task of the first magnitude. It was given to an engineer force known as *GREF.* With plenty of machinery, organized to the highest efficiency, the road very quickly took shape. The great pity was that it was interrupted, just before its completion, by the Jap invasion in 1944, and the fine Hamilton and Bailey bridges over the Lokchao and other rivers on this road had to be demolished.

At the beginning of the year the Tiddim Road was a rough track, completed by hand labour during the previous year, with no surface. Here again, machinery made it possible to make it into a good road, on which were constructed some very fine bridges in wonderful settings of mountain scenery. The Bailey bridge over the Manipur River was one of the best looking bridges I have ever seen. It was built by the Tehri Garwhal Field Coy., and was opened by the Maharajah of that State himself. Unfortunately all these bridges had to be destroyed to prevent their use by the Japs; it fell to the lot of the same unit to demolish the Manipur River bridge. Another spectacular Section on this road is that known as the "Chocolate Staircase," which, in purple shale, winds itself up in 50 hairpin bends from the Baltang Lui to the Tiddim heights.

One of the many very fine engineering feats in the Tiddim area was the water-supply system constructed by the 17th Divisional Engineers.* Water in Tiddim itself was scarce, and had to be augmented from the valley 3,000 ft. below. For this they constructed a nine stage pumping system with Diesel engine pumps at each stage. All this had to be destroyed before the evacuation. There are some very sad moments in a Military Engineer's experience.

6. In the counter-offensive by 33 Corps, from Dimapur up the Imphal Road, the Engineers were set the very difficult problem of maintaining communications with the troops along the narrow paths in the wild Naga Hills in very wet weather. By the manufacture and use of miles and miles of bamboo mats, corduroy, and other devices, these communications were always kept open, and were just sufficient to maintain the forces. There were many other new tasks for the Engineers. The hills were so steep that tanks could not get up them to deal with the Jap resistance points, normally at the top. The Engineers were, therefore, repeatedly called upon to make tracks and haul tanks up the steep slopes with bulldozers and tackles. Perhaps the most famous of these tasks was getting the tank up Summerhouse Hill in Kohima, as this was the deciding point in the battle for the Deputy Commissioner's bungalow and Kohima. Many heroic deeds were performed in the blowing-in of Jap bunkers and the clearing of road blocks during the advance.

7. Behind the 4 Corps area and the American Air Force in N.E. Assam there were a great many large works in addition to the Airfield construction. The chief of these were :—

(*a*) The improvement and maintenance of Imphal Road. This was the main artery for the forward troops, and had always been as incomprehensible and fickle as any member of the fair sex. At one time mud slid over the road at mile 42. At another time, a driver left his car on the road overnight, and in the morning found that that bit of the road had just slipped down, and there was his car, still on the road, but 30 ft. below the road level. Life was never dull on this 135 mile Hill road, especially when it was pouring with rain and the ditches were overflowing.

(*b*) The reconstruction of the Assam Trunk Road to take intensive road traffic in case the railway should break again, as it did the previous year. With this was coupled the improvement of many of the railway lines.

(*c*) The development of big bases at Pandu, Manipur Road, Palel and other places.

(*d*) The bridging of the Barak River at Silchar with a bridge of Eastern Army boats, a feat which was said to be quite impossible, but which, except for three breaks, due to rapid rises in the river and the piling up of debris against the bridge, was maintained throughout the monsoon.

(*e*) The construction of hundreds of miles of petrol pipelines.

I cannot leave this part of the Front without paying tribute to one unit, whose activities have extended not only over the whole of Assam but over the whole of the 4 Corps front, continuously for 2 years; that unit is a Mechanical Excavating Coy. of the Royal Engineers. The men of this unit and their bulldozers never stopped working throughout the period of their stay on American airfields in N.E. Assam, the railways in Assam, and forward roads right up the enemy positions in 4 Corps area. A body of men with a greater devotion to duty, under the most impossible conditions, would be difficult to find. They are closely challenged by their fellow Mechanical Excavating Coys. of the Indian Engineers.

* Described in detail in *The R.E. Journal* for June, 1945.

SAN ANDREA BRIDGE, SANTERNO RIVER, ITALY

By Major G. A. Culham, M.B.E., R.E.

FROM the 23rd Sept., 1944, to the 4th Oct., 1944, 56 Fd. Coy., R.E., had been working day and night to open up the main mountain road running north-east from Dicomano to Faenza. This road had been considered as the possible route of the main thrust and the link up with the 8th Army, but more up-to-date information gave us an idea that weight was being switched over to the central sector, on to the provincial road to Imola, running from San Piero, through Scaperia and Castel Del Rio. In view of this possible move round, the Coy. was earmarked for employment on this road, and my C.R.E. and myself made a recce. of possible tasks on the 4th Oct., on this "maybe" new commitment.

Apart from the appalling state of the road, San Andrea bridge was the only large bridging task, the site being in the heart of the Apennines. The Santerno river wound its way northwards through a deep valley and originally a bridge had spanned the river on a large "S" bend. There was a diversion running at the foot of the mountains, some four hundred yards in length, descending from the north and south approaches of the bridge, crossing the river at the bottom by a low level Bailey bridge, two hundred feet in length. (See Plate 1.) Gradients on this diversion were very steep; further, it was only one way traffic and the low level bridge was in constant danger of being washed away by any sudden floods. There were two courses open to us. One was to construct an additional road on a higher level than the existing diversion, the other was to try to bridge the gap. The latter course was considered to be the better solution, working on a long term policy, and taking into account that this road was to be the main axis.

That night I received a warning order that I was to move to the area San Andrea with my Coy. and attached labour, some eight hundred men in all, and commence building the following day, the 5th Oct. The C.R.E. came over to see me later that night, accompanied by O.C. Fd. Pk. Coy. A list of stores and immediate requirements were made there and then and arrangements made for delivery.

At first light advance parties left from Coy. H.Q. and from subordinate H.Q., their tasks being to find accommodation for their own units. My Recce. Officer proceeded to the site where, in foul weather, he endeavoured to make a detailed survey of the task. The remainder of the Coy. left at 07.30 hrs. with the attached labour, rear H.Q., consisting of M.T., and stores not required, finding accommodation in Scaperia. The move entailed covering a distance of 56 miles, but with a great amount of luck we had everybody settled in by 17.00 hrs. True, the greater part were under canvas, but it was a miracle that we found anywhere at all, considering that three Divs. were using the road and the Americans were just pulling out!

Our first loads of stores arrived at 17.30 hrs.

It was now that we realized what we were up against. Apart from the bridge, itself a problem of no mean proportion, our working parties were, on an average, seven miles from the site, camp areas in the vicinity being non-existent. The weather, mud, and traffic delays due to the diversion hindered us considerably, and, finally, we had to work to a limit of seven days to open the bridge to traffic.

SAN ANDREA BRIDGE

Plate 1.—Low level diversion bridge in foreground. High level completed Bailey in background

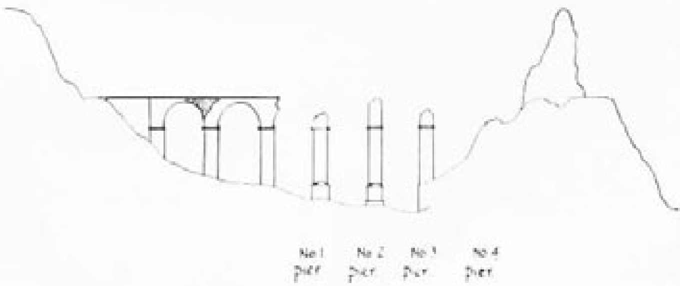


Plate 2

Section of gap as found on 5 Oct '44

San Andrea bridge 1 & 2

Plate 3.—Bridge Cantilevered out over piers Nos. 1-3

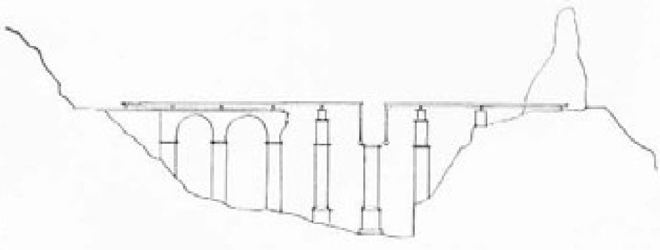


Plate 4
Showing Nos 1, 3 and 4 piers complete, work commencing on No 2 pier.

San Andrea bridge 2

Plate 5.—The completed bridge

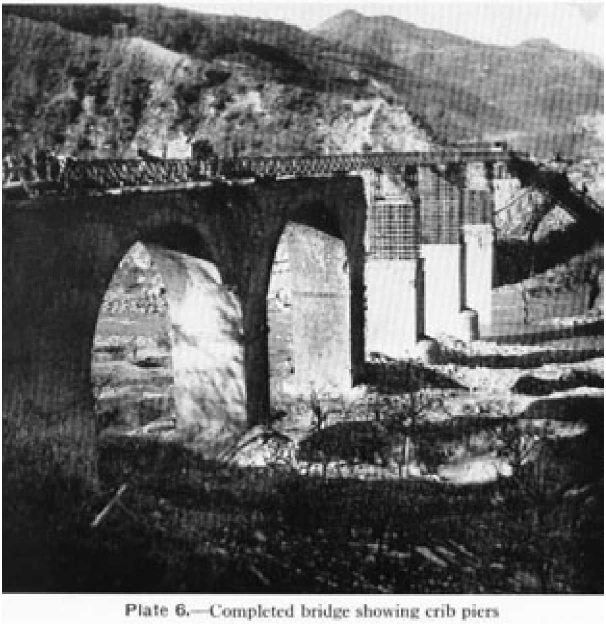


Plate 6.—Completed bridge showing crib piers

San Andrea bridge 3

The actual gap was approximately 350 ft., the original bridge being a six-span brick arch bridge some 100 ft. high. Two of the arches were still standing, but as they had been badly damaged on each side of the arch crowns, this portion was rendered useless. However, it did provide building space, which even then was meagre. Of the remaining four piers three were partially, and one completely demolished. No. 1 and No. 3 piers having 10 ft. of brick and masonry core above the springer to be removed, No. 2 pier having 30 ft. and No. 4 pier, which was in fact the original north abutment, being totally destroyed. (See Plate 2.) Our task therefore was to build four piers, three being each about 36 ft. high and one being about 14 ft. high. A 500-ft. Bailey bridge was required to span the complete gap.

At 18.00 hrs. on the 5th Oct. we held a conference at which all platoon commanders and commanders of auxiliary units were present. The following points were decided :—

Firstly, it was obvious that owing to the restricted site on the south bank, 3,000 sq. ft. only, we could not find sufficient space for stores to build a continuous bridge to span the entire gap.

Secondly, No. 1 and No. 3 piers could be scaled by ladders, but No. 2 pier, being 80 ft. high, presented a difficulty. Therefore, it would be easier to build from both sides, cantilevering the bridges over No. 1 and No. 3 piers, and joining the completed bridges in the centre on No. 2 pier. The bridges over No. 1 and No. 3 piers to be used as building platforms until the piers were built.

Thirdly, it was decided not to join the bridges in the centre to make one continuous span as, bearing in mind the time limit, we foresaw difficulty in engaging the lugs, remembering that each separate span would have to be launched by mechanical power owing to its length and weight. Also, it was realized that as No. 2 pier would be taking the maximum movement of the entire bridge, it would be better to terminate both spans on base plates, connecting the gap by cut and welded stringers. This we thought would anchor the pier more satisfactorily, the ends of the bridge being on bearings and baseplates, rather than on distributing beams.

It was decided, therefore, that we should build from each side, work to commence on No. 1 and No. 3 piers with ladders, whilst the bridge from the south side was built and boomed out as a cantilevered building platform over No. 1 pier. Similarly, No. 4 pier was to be built as soon as possible, the bridge from the north bank being boomed out as a cantilevered building platform over No. 3 pier. On completion of these piers, each bridge to be boomed across to over No. 2 pier, where work would be carried out from each side. Owing to 40 ft. of building space only being available on the north bank, a counterweight, in the form of a bulldozer, would have to be used until the bridge could be supported on No. 3 pier.

At dawn on the 6th Oct. we started to prepare a site for building, stacking and unloading stores. Two feet of mud had to be cleared from the south approach road before any work could be started, and in addition a parapet wall, running each side of the road, 150 ft. in length, had to be demolished, as the width of the road was only 17 ft. 6 in., giving us insufficient space to construct the bridge. A platoon was given as its task, the piers. A second platoon was made responsible for clearing the approach road, setting out, erection of launching and building rollers, and construction of bridge. Part of the third platoon to unload and organize stores with Italian pioneer labour. The remaining sections of this platoon were held in reserve for work that night.

By 18.00 hrs. the preliminary tasks were completed, and building bridge was ready to commence. Work had been going on during the day on No. 1 and

No. 3 piers, and a site for No. 4 pier on the north bank was being prepared. 80 ft. of bridge was built that night, and thirty loads of stores unloaded.

By the 8th Oct., No. 1 and No. 3 piers were cut down to the springers, and 250 ft. of bridge had been built on the south side. Unfortunately a snag arose concerning the piers, for during the demolition by the enemy, part of the masonry on the north sides had been cracked and weakened, resulting in these portions having to be cut away. This was done, the voids being filled with Christchurch cribs built up level with the remaining pier head. That evening the south bridge was boomed out over to No. 1 pier, and tackles were reeved at the end of the cantilevered bridge for raising and lowering stores to the working parties. No. 2 pier gave us some worry, as it looked as though it would delay us considerably, so, as an experiment, we asked for an anti-tank gun to pound it down. The combined efforts of a 6-pdr. and a 17-pdr. reduced it from thirty to ten feet, which helped considerably. However, even then it could not be scaled without elaborate scaffolding, but it did mean less work for us later, when men could be lowered from the bridges.

By 18.00 hrs. on the 9th Oct., 90 ft. of bridge had been built on the north bank and No. 1 and No. 3 piers were half complete. (See Plate 3.) No. 4 pier was complete by the 12th Oct., together with No. 1 pier and the south bridge was boomed out to over No. 2 pier. Later that evening No. 3 pier was completed and the north bridge boomed out to over No. 2 pier. (See Plate 4.) Work now started on this pier from both sides, and the removal of the ten feet of masonry and brickwork was completed early on the morning of the 13th, and the erection of steel cribs began. No. 2 pier was completed on the 14th, and during the night the bridge was jacked up and distributing beams inserted, the entire bridge being completed by 09.30 hrs., 15th Oct. The 190-ft. span from the north side was broken, and 40 ft. ramped down to road level, both portions resting on No. 4 pier. A 30-ft. ramp was built on the south side and a 10-ft. rubble ramp on the south approach to ease the corner.

The bridge, false-decked complete, was opened to traffic at 12.45 hrs. on the 15th Oct. (See Plates 5 and 6.)

Notes on Construction

Owing to the fact that it was impossible to get transport down to the base of the piers, the greater part of the work on them had to be done from the top. In view of this difficulty, the only way we could build the piers was to use the bridge as a building platform, the bridge to be cantilevered over the piers to be constructed. (Plates 3 and 4.) As it was the first time this method had been adopted we paid careful attention to our counterweights, for we found that with excess weights the bridge tended to hog over the rocking rollers and wander from its centre line. Further, a strict check had to be kept on the number of men working on the nose and the weight of stores taken forward of the rocking rollers. The scheme worked very well indeed and no major snags arose, apart from a slight wandering, which was easily remedied by using jacks horizontally, easing the bridge back into position. The unsupported lengths of bridge used as building platforms were eighty feet. These lengths were only lightly decked, and covered with cat-walks of chesses laid longitudinally.

The original piers were built of masonry blocks up to the springer, heights being approximately 50 ft. From the springer to actual road level was 34 ft. 6 ins. This portion consisted of a hard masonry core in cement, surrounded by a soft brick skin. The springing of the arches came up about 5 ft., the ring being 3 ft. thick. Pier sizes were all the same, 20 ft. wide by 13 ft. deep. On No. 1 and No. 3 piers ten feet only of cap remained, which entailed a removal of 96 cubic yards of masonry and brick skin from each pier. No. 2 pier was 30 ft. high above the springer, but, as already stated, the efforts of an anti-tank gun reduced it to the same height as the other two. On each of No. 1 and No. 3 piers a further 20 cubic yards of masonry had to be removed for patching with steel cribs. These cribs were lowered on to the piers and some pulled up by hand from the base of the piers. Transomes, with the lugs removed, and baulk timbers for distributing the load over the vertical angles of the crib piers, were lowered from the top. When 22 ft. of crib pier was built, including distributing load platforms, transomes were lowered down from the bridge, resting on the pier and the first transome of the launching nose, and down these runners were slid the panels for our vertical Bailey piers which we were building on top of the crib piers. We built these crib piers because we found it easier and quicker handling cribs at night than Bailey panels, especially as working space on top of the piers was very restricted.

Men had to be lowered on to No. 2 pier and a lift was made by using a steel crib suspended at each end by 3-in. cordage lines, a safety line running down the centre. These 3-in. cordage lines ran through to single snatch blocks lashed to the trusses at each side of the bridge, joining in the centre and connected to a 3-in. line from a 15-cwt. compressor truck. The lift was raised and lowered by this truck running backwards and forwards on the bridge on the building side of the rocking rollers. We used the compressor truck, as it was already on the bridge for working pneumatic hammers when cutting down the piers. This lift worked extremely well, as men could sit inside it when being raised and lowered.

For overcoming the thrust on the piers, as the bridge was boomed out and over them, special reins of S.W.R. and sway brace were made by Fd. Pk. Coy. One end of the sway brace was inserted in the diagonal bracing of the Bailey panel, where the two members join at the chord, the other end attached to the S.W.R. by special thimbles, the end of this S.W.R. being attached to a block anchored by two O.P. holdfasts picketed into the road under the bridge. These reins, of course, were continuous so that an equal strain was put on each side of the pier. It was found that launching with a launching link was not advisable when launching on to or over a pier was concerned. Initial thrust due to the launching link was distinctly marked by the tightening of the reins as the bridge mounted the rocking rollers on No. 1 pier. The bridge from the north side was launched without a link and initial thrust was considerably reduced. To get the bridge on to its rocking rollers the launching nose was jacked up on to a pair of plain rollers, the bridge then being boomed over. Thrust due to sag on the spans was negligible. Both bridges were launched by bulldozers, preventer tackles in each case being manned by the building parties. The launching link in the launching nose of the south span was removed when the bridge proper was on the rocking rollers on No. 1 pier. Later this launching nose was double-trussed and used as part of the bridge. The finished position of both spans was over the centre of No. 2 pier, with only a gap of one foot between them.

The main problem in jacking up to fit distributing beams was the fact that the ends of the bridges rested on a pier. Because of this, care had to be taken when jacking up the ends as high as possible. Packing, to cover the maximum area, was inserted beneath the lower chord to ensure that the spans had a reasonable and suitable bearing surface. Although jacking up and packing up ends took a considerable time, mainly because it was being performed at night, three sets of beams and two ends of bridge were jacked down in two and a half hours, including positioning of distributing beams.

We proved that by jacking up the ends of the spans as high as possible, the remainder of our jacking problems were comparatively easy.

The overall length of the bridge constructed, including the 30-ft. ramp on the south abutment, was 510 ft., the bridge being made up of three spans, one of 280 ft., and a 30-ft. ramp, one of 160 ft., and one of 40 ft., ramped down on to the north abutment. We had hoped to use span junction posts for this 40-ft. ramped span, as it would have given us more room for the approach, which was on a sharp bend. However, span junction posts being unavailable, we had to break the bridge over No. 4 pier again, joining the gap caused there with cut and welded stringers. The whole construction was double single, each separate span being on an average of 75 ft., giving a load classification of Class 40. Five sets of distributing beams were put in, each set being locked with angle iron, welded in situ on completion of construction. Base plates and bearings were greased to allow for expansion on all bearing points with exception of those on No. 2 pier, which were anchored.

In all, four piers were built. Two consisting of 22-ft. steel crib towers, with 10-ft. double vertical Bailey panel piers, one 36-ft. steel crib pier, and one 14-ft. steel crib pier on the north abutment. Each steel crib pier was 18 ft. by 12 ft. The height of deck level from the river bed was 100 ft.

The bridge was constructed by one field company, 56 Field Company, Royal Engineers, plus 60 British pioneers and 50 Italian pioneers. The remainder of the attached labour was employed on road maintenance and other tasks not connected with the bridge.

The total time taken to complete the task including all unloading, was 9½ days. It had been estimated that the time required to build the bridge complete was seven days, and this could have been done if facilities and conditions had been better. Heavy rain was experienced on the first, second and third days, and owing to the very heavy traffic, the diversion and odd shelling, it took at least eight hours to get vehicles on to the site during the day; even then they could only be unloaded two at a time. Actually, two and a half days were lost in unloading stores, but even then we considered we did well, in that, during that time one hundred and twenty lorryloads of bridging equipment were unloaded and stacked.

Wireless communication proved invaluable and supply was excellent, considering that many controlled items had to be transported nearly two hundred miles to the bridge site.

CALCULATION AND PLACING OF CONCUSSION CHARGES IN REINFORCED CONCRETE STRUCTURES

By

Lt.-Col. A. Borlase, A.M.Inst.C.E., R.E.

In November, 1944, it was decided that an investigation should be made concerning, *inter alia*, the accuracy of existing concussion formulæ and the technique of placing charges. A special team of officers and N.C.O's. was formed to carry out experimental demolitions on German structures in Belgium and the Siegfried Line.

From the beginning, it was essential to have standardized assessment of results and, to assist in the determination of any formula, the following definitions were applied :—

(*a*) A successful demolition—the complete breaking up of the roof and its removal from the walls, the breaking of all the main corners with a minimum wall/floor displacement of 18 in. and the fracture or disintegration of the floor.

(*b*) A reasonably successful demolition—a charge which is sufficient to cause extensive damage but because of variable strengths in similar structures there would be a probability of failure.

The types of structures were personnel shelters, pillboxes, command posts, etc., of 1, 2 and 3·5 metres thick walls and roof. With one or two exceptions all floors were 80 cm. thick. The reinforcement consisted of a cubic mesh of ½-in. diameter bars at 10-in. centres through the total thickness of any section. Bars were hooked and tied with binding wire at intersections.

Light section steel R.S.Js. formed the underside of ceilings, with thin sheet steel plates resting on the bottom flanges. These R.S.Js. had approximately 12 in. of bearing on the walls and had no resistance to the lifting of the roof.

Initially, concussion charges for 2-metre structures were calculated from the following formulæ :—

(*a*) $C = \frac{KAT^2}{10}$ (*M.E.* Vol. IV, Part I).

(*b*) $C = \frac{2\,VT}{100}$ (*R.E. Recce Pocket Book*).

(*c*) $C = \frac{3\,VT^2}{2}$ kilos (Belgian), where

V = air volume in cu. metres.
T = thickness of wall in metres.

In the first trial, a value of $K = 2{\cdot}9$ was taken and it was found that the charge calculated from $\frac{KAT^2}{10}$ was excessive. Charges calculated from $\frac{2\,VT}{100}$ were, on the other hand, too small to carry out a successful demolition. The formula $\frac{3\,VT^2}{2}$ (kilos) produced a good demolition on a shelter of 2,400 cu. ft. internal air volume, but gave over-charges for larger structures.

By plotting values of "C" (charge in lb.) with respect to "A" (floor area in sq. ft.) it was clear that the floor area was not directly proportional to the charge required ; the inclination of the curve being too great.

A graph was plotted showing "C" with respect to "V" (net internal air volume in cu. ft.) of all the demolished 2-metre structures and a curve slope of $V^{0.5}$ was provisionally accepted. From this, the required charge $C = 18{\cdot}3\sqrt{V}$.

The pillboxes and shelters in the Siegfried Line were generally 1·5 metre thick. This provided the opportunity to find out the value of "T" (thickness of wall in ft.) which should be inserted in a formula. A series of charges was fired in structures of the same type until the correct weight and position was found. The slope of curve $\sqrt{V}$ was justified and $T^{1.5}$ was selected from inspection of the plots on the graph.

By conversion of $18{\cdot}3\sqrt{V}$ for $T = 6{\cdot}5$ ft. the formula becomes $1{\cdot}1\sqrt{V}\ T^{1.5}$, or, more simply expressed, $C = 1{\cdot}1\sqrt{VT^3}$, where V = net internal air volume in cu. ft., T = thickness of wall in ft. and C = weight of explosive in lbs. in German bombs. The accompanying graph shows the plots of the various charges and the curves selected for three thicknesses of wall.

Only one 1-metre shelter and one 3·5-metre command post were available for trials on the new formula. Demolition results were successful in each case and showed no evidence of over-charge.

On the Belgian coast the Germans had constructed a number of small two-storey OPs, with 80 cm. walls above ground. One of these was used for a trial with 3 SC 50 bombs (150-lb. explosive) in the ground floor section. Subsequent investigation showed that the charge used was approximately that which would have been obtained from the new formula.

Further investigation on structures of large internal volume (exceeding 7,000 cu. ft.) and those exceeding 2 metres thick had to be cancelled for operational reasons. The experience gained, however, is sufficient to say that concussion charges calculated from this formula should deal adequately with all reinforced concrete structures, reinforced with ½-in. bars at 10-in. centres, when backed up with earth or semi-buried with not more than 3 ft. of soil on the roof.

The charges calculated from $C = 1{\cdot}1\sqrt{VT^3}$ may be reduced as follows when using TNT bulk explosive :—

(*a*) Structures with 1·5 m. walls :—

(i) Net internal air volume less than 2,500 cu. ft.	No reduction.
(ii) Net internal air volume exceeding 2,500 cu. ft.	10% reduction.

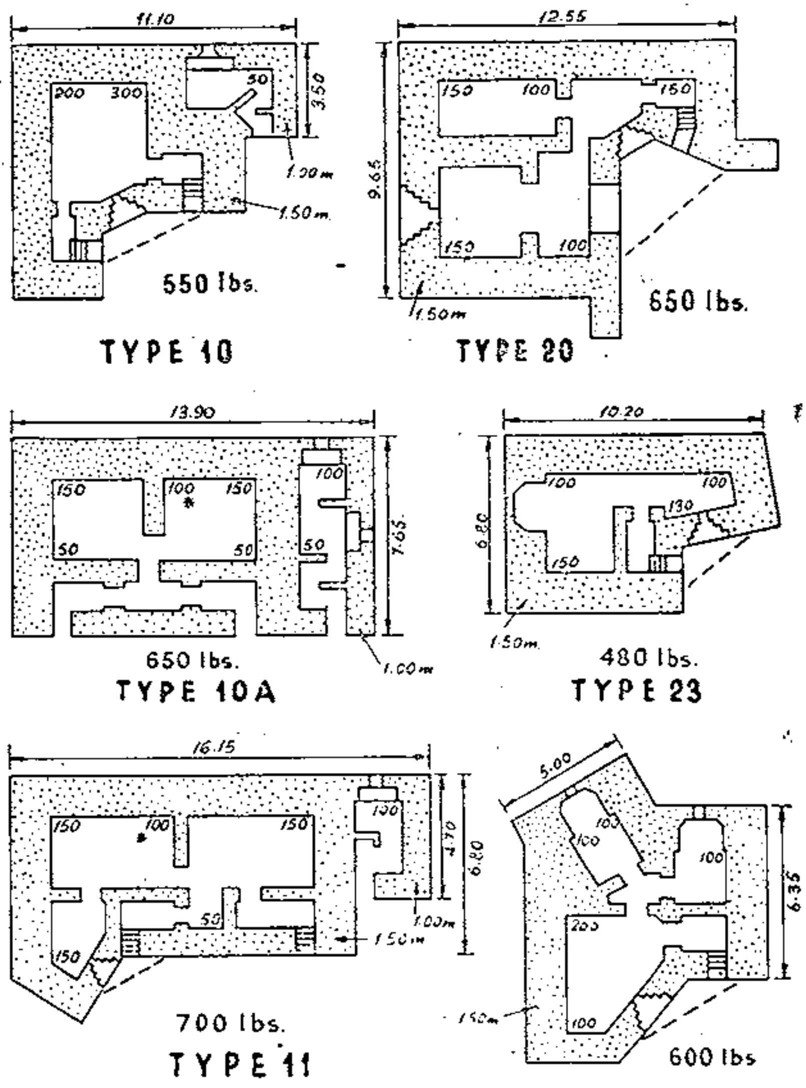
(*b*) Structures with 2 m. walls :—

Net internal air volume less than 5,000 cu. ft.	10% reduction.

When the walls of 1·5 and 2-metre structures are not protected by soil, the quantity of explosive required can be reduced by 10% (or $\sqrt{VT^3}$ by calculation). A greater reduction of charge is not advisable.

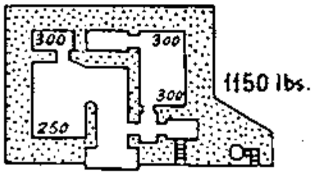
It was found in the few trials available on 2-metre mass concrete magazines, which were buried in sand dunes, that a concussion charge calculated from $C = \frac{VT}{50}$ would give adequate results. The formula quoted in the *R.E. Recce Pocket Book* for mass concrete, i.e., $C = \frac{VT}{100}$, proved to be inadequate.

The explosive used consisted of SC 50, SC 250 and SC 500 (50, 300 and 485 lb. approx. explosive respectively) German bombs (of the latter, only a few were used because of their weight), German 3 kg. and 1 kg. TNT charges, British CE/TNT and American TNT.

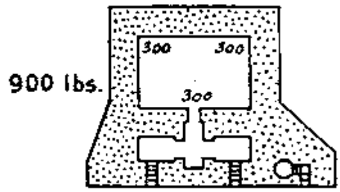


NOTE: CHARGE MARKED * - THESE SHOULD BE PLACED IN CONTACT WITH THE PARTY WALL AND NOT IN CONTACT WITH THE MAIN WALL

SOME TYPES OF PILLBOX/SHELTER IN SIEGFRIED LINE

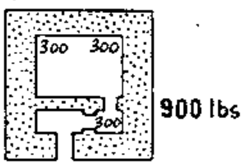


TYPE 411A

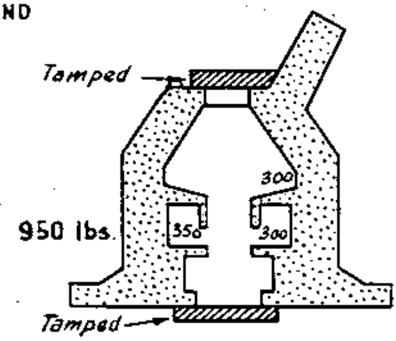


TYPE 621

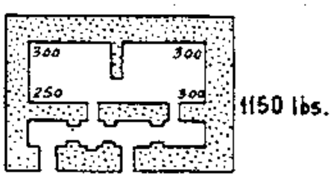
NOTE. ALL EXTERNAL WALLS AND ROOFS 2 m. THICK.



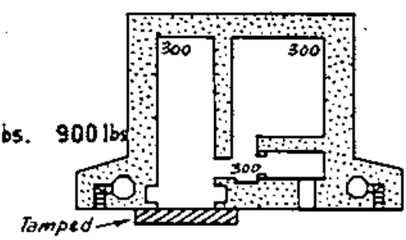
TYPE 501



TYPE 612



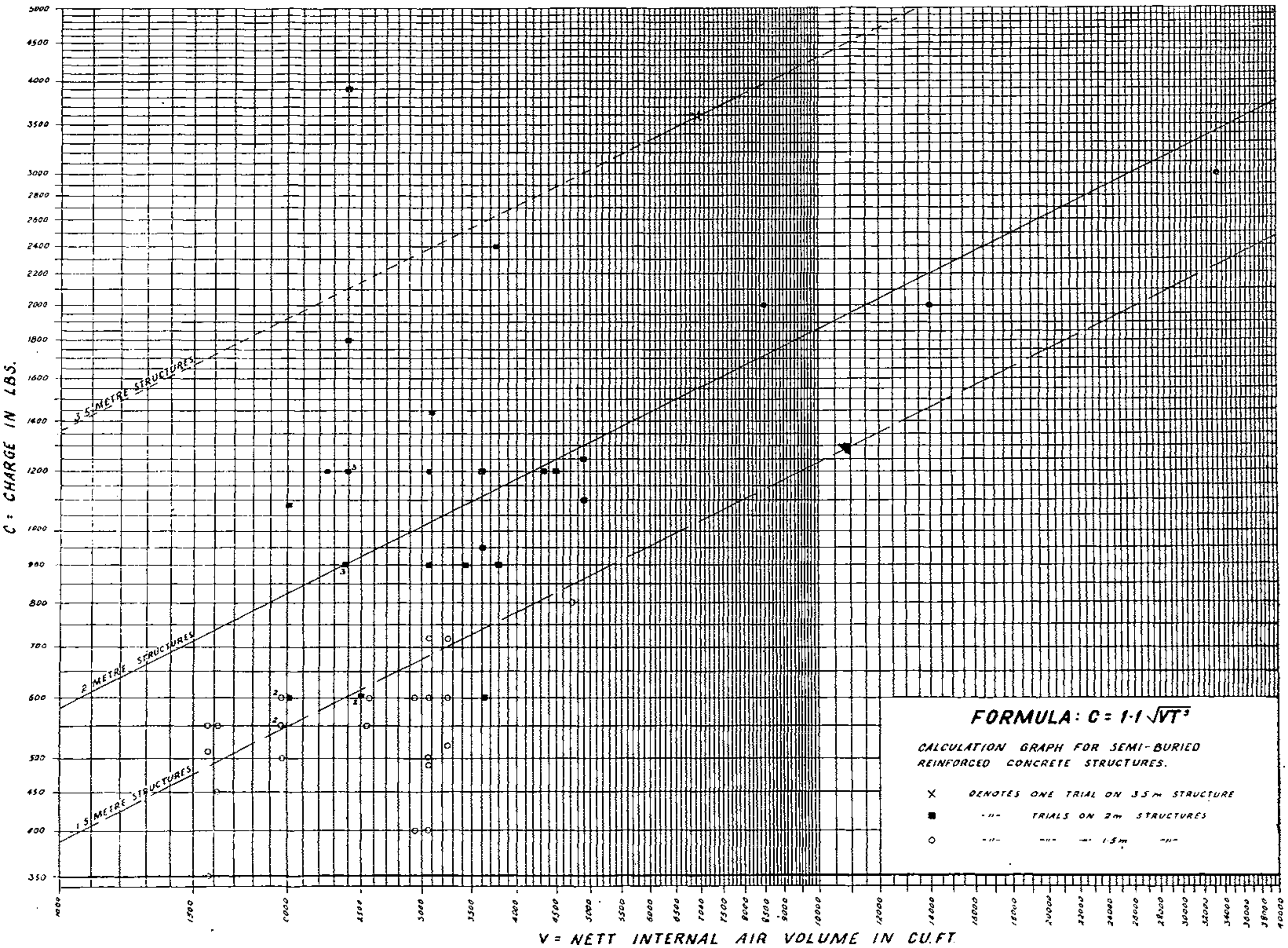
TYPE 502



TYPE 629*

*NOTE: IN THIS TYPE CHARGE REQUIRED IS REDUCED BELOW THAT GIVEN BY THE FORMULA OWING TO LARGE EXPOSED GUN ENTRANCE

SOME TYPES OF STRUCTURE IN BELGIUM



FORMULA: C = 1·1 √VT³
CALCULATION GRAPH FOR SEMI-BURIED REINFORCED CONCRETE STRUCTURES.
× DENOTES ONE TRIAL ON 3.5m STRUCTURE
■ -"- TRIALS ON 2m STRUCTURES
○ -"- -"- -"- 1.5m -"-
3.5 METRE STRUCTURES
2 METRE STRUCTURES
1.5 METRE STRUCTURES
C = CHARGE IN LBS.
V = NETT INTERNAL AIR VOLUME IN CU.FT.

An interesting feature was the failure of bar reinforcement in tension and lapped bars without hooks, the numerous instances of hooks being pulled straight and the breaking of bond between steel and concrete. One demolition revealed the existence of $\frac{5}{8}$ *in. bar* reinforcement which had a noticeable reduction in demolition effect. If a 2-metre structure is reinforced with $\frac{3}{4}$-in. bars at 10-in. centres, the formula would require modification and might be of the order $C = 2{\cdot}8\sqrt{V}.T.$ This latter equation is, at best, conjecture from limited experience.

In some cases roofs had been poured after the concrete in the walls had taken a permanent set; this revealed a plane of weakness. In other structures more care had been taken to bond the wall and roof concrete; this showed itself as a ragged 45° plane of sheer extending upwards and outwards from the ends of the roof R.S.Js.

The weakest wall of all rectangular shelters is the entrance wall and, in every instance, debris will be thrown out normal to the face of this wall. Little debris is thrown out from walls which are completely backed with sand or soil.

Where structures have one or two re-entrant angles in the entrance walls, this wall is much stronger because of the "arching" action against expansion of gas.

The shape of a structure, therefore, has an important influence on the positioning of charges. Charges should be placed where the structural strength is greatest, e.g., in the main corners and against strong party walls, which tend to brace the roof and walls together.

Tamping is not necessary to small embrasure openings and where entrances are "dog-legged"; if doors or shutters are provided these may be shut. Where structures have large entrances for equipment and embrasures, it is essential that these be tamped with about 10 ft. of soil. The accompanying illustrations show some of the types dealt with and the positions of the charges.

THE FIRST BRITISH BRIDGE ACROSS THE RHINE

By

C.R.E. 8 Corps Troops

PRELIMINARY STAGES

THE planning stages for the Rhine crossing really started at the crossing of the Meuse. For the whole winter we had been facing the Germans on opposite banks of this river, and plans for the frontal assault across it had been worked out in the greatest detail for a number of alternative sites. All recces were carried out on the ground, Sapper officers becoming quite expert in moving about on night recces, camouflaged in snow suits. Eventually, however, a frontal assault across the Meuse was not carried out on our front owing to the rapid advance of an American Armoured Combat Group coming up from the south, on the opposite bank, and capturing Venlo.

At a few hours' notice the 100 (R. Mon.) Fd. Coy. built an F.B.E. across the Meuse at Venlo on March 1st, 1945. (See Plate 1.) This bridge went well.

Before leaving the Meuse I must record how impressed I was with the efficiency and drive of the American Armoured Combat Group that captured Venlo. The Armoured element of this particular Combat Group consisted of a coloured tank battalion. Their motto appeared to be "drive and shoot," and they certainly put the fear of God into the Boche that night in

Venlo, driving and shooting tracer all over the town. I crossed the Meuse in the early hours of March 1st, with the bridge recce party, and made my way on foot (luckily we landed to one side of an enemy minefield) to contact the Commander of this U.S. Combat Group, where I had an excellent breakfast preceded by a cognac ! and was present at his "O" Group immediately afterwards.

They had advanced 30 km. up the east bank of the Meuse the day before, stopping at nothing, including anti-tank ditches, and captured Venlo during the night. The Commander had received no information of the progress of our drive from the north, and I gave him the latest information as I knew it; he then gave orders accordingly, with regard to axis of advance, order of march and objectives to be reached up to 15 miles beyond Venlo, all of which were in fact captured by his Combat Group that day.

Having successfully crossed the Meuse and started tackling route clearances in Venlo, we took up positions in Germany and learnt that our next big task was to be the building of an F.B.E. bridge across the Rhine. It would be, apart from the Remagen bridgehead, the first bridge across and speed was essential.

No dates, of course, could be forecast at that time, but it was obvious that there would be two to three weeks to prepare, as the enemy were fighting bitterly all the way back to the river.

Soon detailed plans of the crossing were out and the bridge site fixed. Air photos, all available data and history of the river's behaviour were collected and carefully studied, and a tentative plan drawn up.

Recces

Our infantry reached the river and took up positions some way back, patrolling the bank at night.

Recces were only allowed by night and nothing was to be done that might attract the enemy's attention to that particular site. We had several good daytime "looks" at the river from Artillery O.Ps., and an officer was attached to the infantry coy. holding the village at Wardt, some two miles from the river. He went out on two night patrols with the infantry, having a general look at the site and checking on a number of points.

An enormous stroke of luck came when fog one morning entirely hid the near bank from enemy observation. The recce officer was able to walk almost unhindered, covering the entire site and approaches.

No recces of the far bank were done, but from air photos and daytime observation a reasonable picture was built up.

Planning

The information gathered was very complete and enabled me to make a detailed plan of the whole operation.

A scale model of the entire site and marshalling areas was constructed. I briefed Coy. Commanders, giving them their tasks in detail, and held several conferences to thrash out any points about which they had doubts. Later the scale model was loaned to Coy. Commanders, who briefed their officers and N.C.O.s with its help. All agreed that the model was good value.

Training

The whole formation built two training bridges over the Meuse, duplicating as far as possible the conditions expected for the Rhine.

Early on it was evident that the bottleneck would be anchor casting in the fast Rhine current.

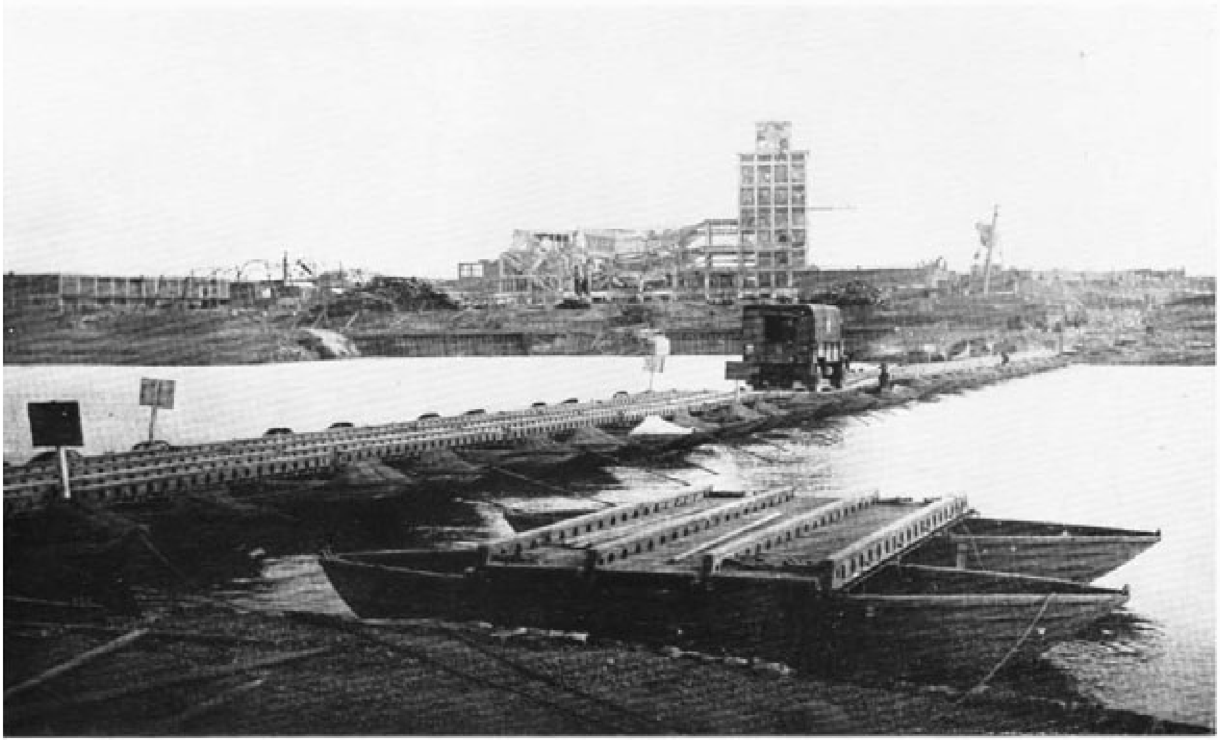


PLATE 1.—F.B.E. bridge across the Meuse at Venlo built by 100 (R. Mon.) Fd. Coy., R.E.

First bridge across the Rhine opp p 254

THE FIRST BRITISH BRIDGE ACROSS THE RHINE

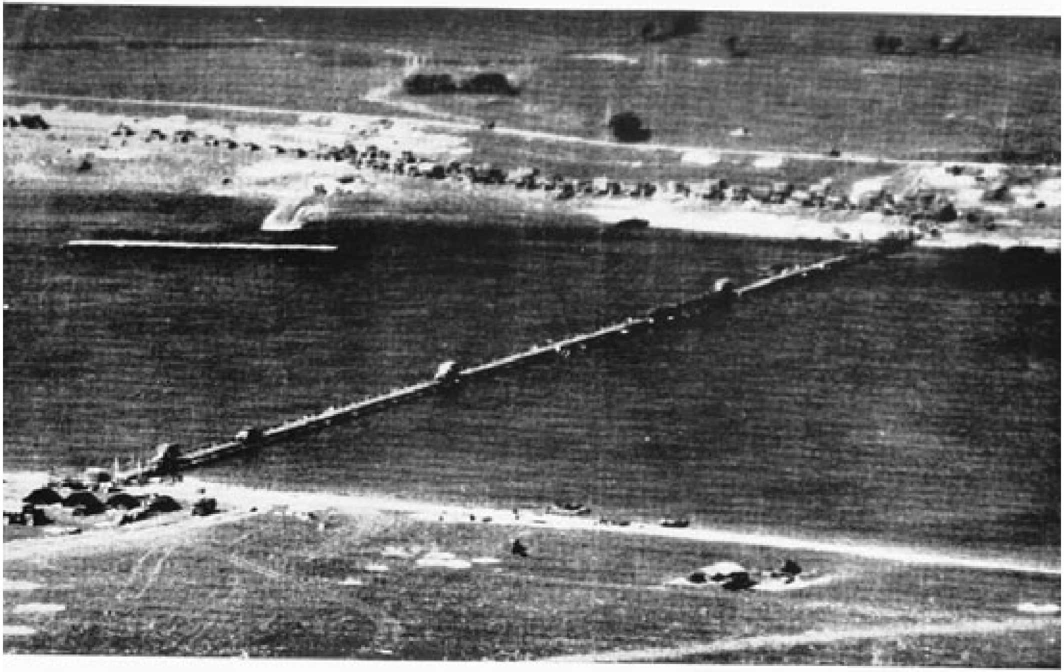


PLATE 2.—F.B.E. bridge across river Rhine at Xanten, 8 Corps. Tps. Engrs.

First bridge across the Rhine opp p 255

As a result of this training period, we evolved a good method for casting anchors, which consisted of establishing a captive ferry on balloon cable just upstream of the line on which the anchors would be cast. The ferry, one floating bay F.B.E., powered with two propulsion units, carried anchors to the correct positions, where they were cast. Cables, fixed beforehand to the anchors, were walked along the bridge while the ferry went out, and attached to the rafts as they came in to bridge. On account of the swift current Bailey Pontoon anchors had to be used instead of F.B.E. anchors, which we found had dragged on the Meuse.

Organization

For the operation the formation was put under command 11 A.G.R.E., who gave approval for all moves forward, and orders for the commencement of work.

Within the formation the organization was as given in Appendix 1, and this worked most successfully on the operation.

All bridge equipment, track stores, and other materials required for the construction of the bridge were held in a R.E. concentration area some miles back. Three days before the operation everything was on wheels in this area, where it was sorted into pre-arranged vehicle columns, each column being approximately 60 vehicles, numbered serially in the order in which they would be off-loaded at the bridge site. This marshalling was carried out under the supervision of an officer from the formation, who remained until all columns had left for the forward marshalling area. The call forward to the marshalling area was controlled by the A.G.R.E. on demand from the C.R.E. at the bridge control point.

Personnel vehicle serials were handled, as for stores and equipment, from an area within the main R.E. concentration area.

The careful pre-loading and assembly of the 167 bridging vehicles and specially loaded three tonners required for the operation, paid a very good dividend.

The bridge equipment was demanded several days in advance. It was allotted and brought into my Corps Fd. Pk. Coy. bridging dump. There a Fd. Coy. was given the task of unloading, checking, repairing, cleaning up and reloading all the equipment. This proved of great value as much equipment was damaged and needed repair. The pre-arranged loading of vehicles carrying stores other than standard bridge equipment involved much careful work.

Anchor cables were well soaked and tensioned between lorries, carefully measured and marked according to the order they would be required in bridge, and put on the same lorry as the Bailey anchors with which they would be used.

All this is rather contrary to the normal doctrine of supply and moving forward of bridge equipment, but in the writer's opinion it is the only possible way of dealing with a large bridging operation, where nothing in the matter of the state of the equipment can be left to chance, and almost a "private army" of bridge equipment and specially loaded vehicles has to be assembled for the operation.

The Operation

At zero hour (02.00 hours in our sector), with a small party from H.Q., R.E., I went forward to the site and established contact with "crossing control" to follow events and report back to 11 A.G.R.E. until they should give the order to start.

The drive up through Xanten was most interesting. The intense din from our barrage, accompanied by illuminated tracer and houses on both sides of the main route through Xanten well and truly ablaze from enemy fire, made an impression I shall never forget.

The marshalling area was signed and laid out, and phones connected up as the assault was going in.

On our site the assaulting infantry were held up by strong machine gun positions dug into the flood bank, and for a long time could make no progress inland. During the hours of darkness we walked the foreshore and building sites, and I fixed the exact position for the start of the bridge.

An hour before first light advance parties arrived and started work. There was mortaring, 20 mm. fire and unaimed small arms fire from the enemy. With the coming of light, machine guns and 20 mm. cannon fire made work difficult. Our neighbours on the left, building close support rafts, had to pull out after suffering casualties, and we were ordered to cease work for the time being.

In the meantime the main body was arriving and the equipment and stores were coming into our bridging marshalling area, where they were parked on a pre-arranged plan in fields behind the floodbank. Enemy guns began to shell the marshalling area fairly consistently, and we had to have a wider dispersal of vehicles than had been allowed for in the original plan.

Forward of the flood bank the site was unhealthy, being completely overlooked by the far bank, where our infantry had not been able to get on. After a discussion with C.E., 12Corps, I sent a recce party to report on the possibility of bridging some miles upstream, where the far bank had been cleared of the enemy. Bad approaches on both banks ruled out this new site.

By 10.30 hours our infantry coming up on the far bank had pinched out the machine gun positions, and work started once more. With the cessation of aimed M.G. and small arms fire, work went forward rapidly, though a trifle slowed by mortaring and shelling which continued until the afternoon. The first bridging vehicles arrived on site at 11.00 hours, at which time I crossed the river in a Buffalo with a recce party, and fixed the position of the end of bridge and exits up to the floodbank on the far side.

The anchor party got their cable across by Storm boat, quite a feat, and established the anchor casting ferry. Soon the bridge was going steadily forward, raft building just keeping pace nicely with forming of bridge and anchor casting.

In the meantime the approach on the near bank and the exit on the far bank, totalling nearly a mile of Somerfeld Track on Chespale over grass fields, was going smoothly. All traffic during building was run over the fields clear of the final alignment of the approach. Track stores for the far bank were ferried over in D.U.K.W.s and Buffaloes, which were placed under our command for that purpose.

A Buffalo ferry service for the infantry was being operated upstream of our bridging site and twice Buffaloes, out of control, broke the anchor cable, which had to be promptly renewed. Later I managed to get this ferry service moved downstream of the bridging site.

Hundreds of gliders and Dakotas, flying-in low for the Airborne drop, made a most heartening sight during the morning.

Work went on according to plan, and the bridge was open to traffic at 23.30 hours, twelve and a half hours after the first bridging vehicles had arrived on site. The completed bridge was 1,500 feet long (see Plate 2).

Once we had really got started the enemy opposition was negligible, there being no enemy air attack at all. This gave us a sense of false security, which cost us dearly in subsequent bridging operations in the campaign, particularly on the Weser and the Elbe, where we acquired a very high respect for the enemy's low-level air bombing attacks.

Appendix 1

H.Q., R.E.—All recces and planning. Staffing and running marshalling area and bridge control. Controlling movement of bridging vehicles to the off-loading points.

100 (R.Mon.) Fd. Coy.—Building trestle bays on both banks.
Building floating bays and warping them to the head of the bridge, where they were handed over to 224 Fd. Coy.
Temporary approaches to raft building sites.

224 Fd. Coy.—Casting anchors.
Taking over rafts at head of bridge.
Connecting up the formed bridge and fixing anchor cables.
Fixing land line anchorages.
Operating personnel ferry to far bank.

101 (R.Mon.) Fd. Coy.—All approaches and exits on both banks.
Ferrying across track stores to far bank (using D.U.K.W.s).
Providing an "Anti-Floater" patrol to secure any out-of-control Buffalo or other heavy floating objects from damaging the bridge.

508 Corps. Fd. Pk. Coy.—Signing the routes Up and Down for personnel and bridging equipment.
Providing personnel rescue service on the water.
Maintaining "Evinrudes" and propulsion units.
Fixing all signs on the bridge itself, including vehicle spacing signs.
Lighting the bridge at night if necessary.

Postscript

Appreciation by other Arms of Engineer work.—The following letter addressed to me was received from Lt.-Gen. Sir Miles Dempsey, Commanding Second Army, and was greatly appreciated by all ranks of 8 Corps Tps., R.E.

To—8 Corps Tps., Engineers. H.Q. Second Army.
29th March, 1945.

Dear

The Battle of the Rhine has been won and our leading troops are now, five days after the crossing, breaking out from the bridgehead.

I want you to realize how much of this success is due to the work which you and those under your command have carried out.

The crossing and bridging of the Rhine could not be described as an easy operation. It was, however, essential to success that the build-up on the other side of armour, artillery, vehicles and stores should proceed quickly.

Thanks to the skill and energy with which you carried out the tasks allotted to you this was achieved, and I would be glad if you would tell all ranks how much I appreciate and admire their splendid work.

Yours sincerely,
M. C. DEMPSEY.

THE EDUCATION OF R.E. OFFICERS AFTER THE 1914–18 WAR

Extract From Unpublished Corps History

Supplementary Courses at Chatham to complete Education of R.E. Officers commissioned during the War of 1914–18

At the beginning of 1919 there were in the Corps over four hundred junior officers who, during the course of the war, had received permanent commissions as Second-Lieutenants in the R.E., after a training of six months only at the R.M.A., Woolwich. Owing to the urgent need for subalterns for the field units engaged in the war these officers had been given only a short course of instruction in field engineering and military subjects at the S.M.E. before being posted to units at the theatre of war. It was, therefore, necessary to complete the training of all these officers in the technical subjects of the profession of the Royal Engineer, viz., constructional engineering, survey, electricity, workshop machinery, etc. Arrangements were at once made to form classes of these officers for the purpose of putting them through these courses at the S.M.E. For this purpose they had to be collected from wherever they were serving and brought to Chatham. They were chosen as far as possible by seniority, beginning with those who had received their commissions in July, 1913, but exigencies of the service and difficulties of replacement in many cases prevented the return in their proper order of some of those at foreign stations. The first class, of 25 officers, was formed at the S.M.E. on 31st January, 1919 and was known as No. 1 Supplementary Class: No. 2 assembled in May, 1919, and No. 3 in August of the same year.

It was obvious that many years would be required to pass all the 400 or more officers through these courses. The capacity of the S.M.E. in instructional facilities, quarters, etc., was limited, and it had, in addition to the Supplementary Classes, to provide training for the large batches of young officers who were then being commissioned from Woolwich at half-yearly intervals. The S.M.E. Courses for Junior Officers lasted two years and those for the Supplementary Classes only a little less. There would thus always be four batches of Junior Officers present and undergoing training simultaneously. The instructional staff, accommodation, etc., at the S.M.E. were such as to make it impossible to take, in addition to the four Junior Officers' Classes, more than two Supplementary Classes at a time. At this rate it would necessarily take over ten years to work off all the 400 or more officers who were in need of these Supplementary Courses. Such a situation could not be accepted. During the period before they underwent the courses, the officers would be unfit to carry out the technical duties of many of the services to which they were liable to be posted in peace time, and this would not only lead to inefficiency in the public service but also possibly to financial losses to the State. It was, therefore, imperative to find some method of quickening up the process of giving this supplementary training.

During the summer of 1919 a War Office Committee, of which Lord Rawlinson was the President, was held for the purpose of making recommendations on Engineer Organization. The terms of reference of this Committee included the question of the training and entry of young officers into the Corps of R.E. and the length and scope of their training courses. The recommendation of the Committee in regard to the training in engineering subjects was that in future all R.E. officers should receive their training in constructional, electrical, and mechanical engineering at Cambridge University, and that they should undergo at Chatham the necessary courses in fortification and survey, and a practical workshops course in electrical and mechanical engineering, as well as their military training. The reasons given by the Committee for this recommendation were that engineering science and practice were advancing by leaps and bounds, and that their influence on future military operations would be most intimate and intense. They considered that the time given to engineering subjects should be increased. To provide at Chatham for the increased importance of these subjects it would be necessary to expand the S.M.E., to amplify and extend the courses in constructional, electrical, and mechanical engineering, and to provide an equipment and teaching staff of the first order, equal to those found in the best civil engineering institutions. The difficulties and expense of such a scheme would be considerably greater than those of sending the officers to Cambridge. The latter course also would, the Committee pointed out, have the advantage of obtaining the best and most highly trained teachers and that of broadening the outlook of the officers and giving them opportunities of mixing with their civil comrades.

When the difficulty in providing at Chatham supplementary courses for the officers commissioned during the War became pressing, the attention of the War Office authorities naturally turned to the above recommendation of the Rawlinson Committee. Although the recommendation referred to officers newly commissioned from Woolwich, it was decided to ask the University authorities whether they could help to meet the temporary and urgent need of the Corps by providing similar training for the Supplementary Classes.

Soon after Major-General H. F. Thuillier took up the appointment of Commandant, S.M.E., in November, 1919, he was directed to get into touch with the Cambridge University authorities and see if they would be good enough to allow fifty R.E. officers at a time to undergo an engineering course lasting one year. This necessitated rather lengthy and delicate negotiations. The ordinary university course for the engineering tripos (known as the mechanical science tripos) lasts three years, and to cover the subject in a one-year course necessitated a great deal of condensation of the teaching and some additional staff to conduct the course. It was very fortunate for the Corps that the professor in charge of the University Engineering School was Professor C. E. Inglis, O.B.E., F.R.S., who had served in the Corps during the War and was the designer of the well known and much used Inglis Bridge. Professor Inglis was a strong supporter of the idea of giving young R.E. officers their training at Cambridge, and he was most helpful in arranging for a course to suit the special requirements of the Supplementary Class officers. There remained the question of getting the various colleges to agree to accept the officers as resident undergraduates. It was specially desired that the officers should not be segregated in any way from the general body of undergraduates and this required that they should be distributed among all the colleges. Since the right of acceptance of applicants for admission rests with the colleges themselves and not with the University governing body, it was necessary to make application to each of the eighteen colleges with a view to inducing them each to accept a certain number of R.E. officers, ranging from two in the case of the smaller colleges to six in that of the largest. This entailed interviews with the Heads of all the colleges, some of whom were at first rather difficult to interest in the proposal. The negotiations were carried out with much tact and diplomacy by Major J. A. McQueen, D.S.O., M.C., R.E. (now Lieutenant-Colonel, retired list), the

Brigade Major at the S.M.E., with the valuable support of Professor Inglis, and eventually the consent of all of them was secured.

The War Office agreed to pay all the University and college tuition and other obligatory fees and expenses, the officers themselves, who continued to receive regimental and engineer pay, being required to pay for their commons in Hall. The officers were to be in all respects subject to University and college rules of discipline. The University appointed two tutors for the purpose of assisting in the tuition and generally supervising the work of the R.E. officers, while the War Office agreed to appoint a senior R.E. officer to reside at Cambridge for the purpose of liaison with the University authorities in all matters concerning the R.E. students and for their general military supervision. The first officer to be appointed by the War Office for this purpose was Major and Brevet Lt.-Col. G. H. Addison, C.M.G., D.S.O., R.E. (now Major-General, C.B., C.M.G., D.S.O., M.A., M.I.Mech.E.). The tact and efficiency with which he performed these duties and the good impression he made on the college authorities, combined with the backing he got from Professor Inglis, had the effect of overcoming any lingering objections to the intrusion of the military element into the University, and was a principal factor in the success of the experiment.

The first batch of fifty officers (Nos. 5 and 6 Supplementary Classes) went up to Cambridge in October, 1920, and others followed, two classes at a time, at yearly intervals, till all those who had been commissioned between July, 1913, and September, 1918, inclusive, had been through courses either at the S.M.E. or at Cambridge, the last two classes finishing the University course in June, 1925.

The one-year course for Supplementary Class officers was necessarily insufficient to permit of their taking the University tripos examination at the end of it, but the authorities arranged for an examination at the end of the course, on the results of which the officers were graded in three classes, which might be regarded as indicating the classes they would have taken in the tripos had they undergone the complete tripos course. They also gave facilities for any officer who wished to take the tripos, and to receive the B.A. degree on passing, to do so by remaining up at the University for an additional year with the leave of the War Office. This was part of a general concession granted after the War to all undergraduates who had served in the War, permitting them to graduate and take a degree after two years' residence instead of the normal term of three years. The War Office fell in with this concession by allowing R.E. officers, who wished to take advantage of it a year's leave without pay, the officer paying his own expenses at the University. A few officers did so, and passed the tripos with Honours, and took the B.A. degree.

In addition to these courses at Cambridge, the Supplementary Classes had to undergo at Chatham short courses in field works and bridging, survey, and practical workshop courses in steam, internal combustion and electrical machinery. Advantage was taken of the long vacation in summer to do the outdoor courses, and the others were done at the end of the Cambridge course.

There can be no doubt that these Cambridge courses for the Supplementary Classes filled an urgent need, since they quickened up the training of the whole number by three to four years. They also provided an excellent training, which, however, would have been better if it had not been necessary to crowd so much into so short a time. The course was undeniably a difficult one, involving a great deal of mathematics of a high standard. It must have presented great difficulties to officers, none of whom had had any opportunities to keep up their mathematical knowledge during the five years which had passed since they had left school. They must also have found certain difficulties in fitting themselves into the University life and discipline after having spent five years as officers in the Army. Nevertheless, they all tackled the difficulties with courage and perseverance, and succeeded so well in overcoming them that the University authorities expressed themselves as very well satisfied with their work. They also entered fully into the social and athletic life of the other undergraduates and very favourably impressed the authorities in regard to their conduct and tone also. Great credit is due to them for this, especially to those of the first few classes to undergo the course, who by their conduct and success set the high standard which others kept up. The C.I.G.S.—Lord Cavan—wrote his congratulations to Lt.-Col. Addison, R.E., and to the officers of the Supplementary Cambridge Course under his supervision. Had they not achieved this success it is probable that the subsequent extension to the young officer classes of the privilege of receiving their engineering education at the University could not have been brought about, since, apart from the possibility of opposition from the University authorities themselves, who were not all in favour of the scheme at first, opposition to it in army circles would almost certainly have been too strong. A considerable number of senior officers of the Corps felt apprehension lest the influence of residence at the University might cause those who underwent it to imbibe subversive habits of thought and conduct which would lower the standard of discipline and military spirit in the Corps. No such results were, however, observed in the members of the Supplementary Classes after they had been there. A noticeable difference was observable between the classes who had been to Cambridge and those who had not had that opportunity, by the instructors who had to deal with them at Chatham. The former had a distinctly wider outlook, a more mature judgment and were more receptive of teaching.

Lt.-Col. G. H. Addison, the first supervising officer, was asked to give an opinion whether the tripos course was a suitable course for young R.E. officers, or whether it would be beyond their capacity. He considered that the only certain way of testing this was to make a personal trial of it himself, so he went through the whole of the Tripos course, and at the end of two years succeeded in passing the examination with Honours in the Second Class—a very notable achievement for a man of 46, who had no special mathematical ability and whose life since leaving school had been spent in the normal employment of the engineer officer. His successor, Major and Brevet Lt.-Col. B. L. Eddis, D.S.O., R.E. (now Brigadier) followed suit later and performed the same feat at a slightly younger age. After that it was intimated to later successors that they need be under no obligation to reach this standard.

When Lt.-Col. Addison completed his tenure of the appointment of supervising officer at Cambridge, Professor Inglis was good enough to express his great regret at his departure, and his very warm appreciation of his tact and talents in establishing such excellent relations between the Royal Engineers and the University, an appreciation which the Corps has every reason to reciprocate to Professor Inglis.

R.E. Officers' Education at Chatham and Cambridge

The preceding paragraphs have shown that the idea of giving young R.E. officers their education in engineering subjects at Cambridge University was first propounded by the Rawlinson Committee on Engineer Organization in 1919, and that it was first tried out in connection with the training of the Supplementary Classes, i.e., those officers who had been commissioned during the War. While the Supplementary Classes were going on the question of what permanent arrangements should be made for providing training in engineering subjects to the young officers on first appointment from Woolwich was fully investigated and discussed. The grounds given by the Rawlinson Committee for their recommendation that they should receive it at Cambridge were that the rapid progress of all kinds of engineering and the ever increasing dependence of military organization and practice on mechanization and engineering made it necessary to give a greatly advanced and more modern training in this subject to the engineers of the post-war period than that which sufficed before the War. This would be much more easily and more effectively given at Cambridge than at Chatham. Even if the initial great expense of the necessary expansion and re-equipment with the latest machinery and appliances of the S.M.E. were faced, it could not be expected that the teaching at Chatham would be able to keep pace with the year by year advance of engineering science in the same way that a great and well organized university would. Financial considerations naturally had to receive the most careful consideration.

When the satisfactory effects of the training of the Supplementary Classes at Cambridge became apparent, General Thuillier began consultations with the University authorities to ascertain whether they would, when the Supplementary Classes came to an end, take two classes a year of Junior Officers as a permanent arrangement. No difficulties were raised from the University side, the excellent impression made on the authorities by the Supplementary Classes making them very willing to continue the association of the Royal Engineers with the University. For the juniors it was proposed that they should do the full tripos course and take the examination at the end. To allow of this the University agreed that the period of the cadets' course at Woolwich should count as equivalent to the first year at the University, so that by doing two academic years (six terms) of residence the R.E. officers would be eligible to take the tripos examination and qualify for the B.A. degree. Considerable difficulty, however, arose in fitting the University terms with the training required at Chatham in subjects not covered by the University course, without greatly extending the length of the time the officers were to be under instruction. It will be realized that the longer the officers' training period lasts, and the longer they are thereby kept from undertaking their Corps duties, the greater is the expense to the State.

The subjects in which it was necessary for them to undergo courses at Chatham, and the length of time required for each, were as follows :—

Military duties, on first joining ..	10 weeks
Field works and bridging	15 weeks
Survey	12 weeks

All the above courses are subjects not covered at all by the University course. Further courses necessary were :—

Construction .. .. 8 weeks

This is to cover the special applications of constructional engineering to military purposes, e.g., War Department design and practice in regard to barracks, hospitals, hutted camps, water supplies, roads, drainage and sanitation, etc., also the practice of the various building trades.

Workshops .. .. 8 weeks

This consists of practical demonstrations of the various wood-working, metal and machinery trades employed in the Royal Engineers ; in the layout and organization of workshops, and the types of machinery, engines and pumps ordinarily used for army purposes.

Electricity .. .. 3 weeks

This similarly deals with the usual practice in wiring and lighting military buildings, hutments, etc., firing charges electrically, and with the types of electrical plant, searchlights, etc., normally used in the Army.

Military duties (refresher course before finally leaving) .. .. .. 3 weeks

Desirable in view of the period spent at the University away from military practice and influences.

To get all these courses in without unduly extending the total period of instruction it was proposed to utilize the greater part of the University long vacation in the summer for part of the Chatham courses. This was bound to have the effect of greatly increasing the difficulty of getting First Class Honours, since practically all civil aspirants for the First Class do special voluntary courses during the long vacations. This, however, is a less important objection to that of prolonging the total period of courses. By this means it was possible, though with difficulty, to get the six University terms and all the additional Chatham courses mentioned above into a total period of two years and nine months, or nine months longer than the usual course for officers who were given all their training at the S.M.E. When it is considered that as long ago as 1865 the duration of the S.M.E. courses was two years, and that in the interval the whole range of engineering science had been enormously extended, and its application to military operations had vastly increased in importance, an extension of nine months can hardly be considered excessive.

This scheme became the subject of considerable and prolonged discussion before it was accepted. The misgivings expressed when the Supplementary Classes were first sent to Cambridge, that residence at the University would lead to undesirable habits of thought and conduct subversive of discipline and military spirit were considerably increased when the proposal was made to subject to this form of life, for the greater part of their first two or three years of service, young officers who had only just left Woolwich. In addition to this the successive Commandants at the R.M.A., Woolwich, and their mathematical instructors expressed their conviction that the full tripos course would be beyond the capacity of all but the top few of each batch. The last objection was overcome by the practical example afforded by the passing of the full course with Honours by Lt.-Col. Addison and by those officers who stayed up for a second year at their own expense and had also all passed with Honours. If Lt.-Col. Addison could do it at the age of 46 it was fairly obvious that any officer fit to remain in the Corps should be able to do it at the age of 22 or 23.

Early in 1923 a War Office Committe was appointed, under the chairmanship of Viscount Haldane, to enquire into the system of entering officers for the combatant branches of the Army, the length of time spent at the cadet colleges, and the character and scope of the general and professional education given there and immediately after commissioning. General Thuillier was invited to put before this committee his scheme for the training of R.E. officers partly at Chatham and partly at Cambridge which has been described above. The committee examined the proposals with care, spending two days at Cambridge for the purpose. In their report they recommended that in future the training of R.E. officers after leaving Woolwich should be partly at Chatham and partly at Cambridge and they embodied General Thuillier's proposals in their report. The committee, which made a large number of recommendations regarding the entrance into, and education at, Woolwich and Sandhurst, also recommended the reduction of the Woolwich and Sandhurst courses from two years (four terms) to one and a half year (three terms), and that the Royal Artillery cadets should complete their technical training by a course of instruction at Larkhill.

The recommendation of the Cambridge scheme by so strong a body as the Haldane Committee was no doubt the main factor in inducing the War Office to accept it, though discussions on the financial aspect of the scheme caused long delays and it was not till 1925 that it was finally approved. The decision, however, had not been arrived at by the time the last of the Supplementary Classes completed their Cambridge terms in 1925, and, in order that there should be no break in the continuity of the connection of the R.E. with the University, the War Office arranged to send a certain number of selected officers of Nos. 12 and 13 J.O. batches (FitzGerald-Lombard's, commissioned in January, 1925, and Anderson's commissioned in September, 1925) to Cambridge for a one-year course only, namely, the second year of the ordinary tripos course, up to and including the "Mays" examination. Certain of these officers were allowed to stay a further year at Cambridge, if they desired to do so, in order to complete the course, take the tripos examination, and get their degree. These officers received their regimental pay, but had to pay all University fees themselves. A few took advantage of this permission. In October, 1926, selected members of No. 14 J.O. batch (Jones's, comissioned February, 1926, but antedated to September, 1925) and the whole of No. 15 (Chapman's, commissioned February, 1926) went up to Cambridge. The members of No. 14 batch only did one year, like Nos. 12 and 13 before them, but No. 15 remained for the full course of two years. They were followed in October, 1927, by the next two batches, and thenceforward the two-year course became the regular practice. The conditions approved as regards payments for the J.O. Classes were similar to those for the Supplementary Classes, namely, that the War Office pay all instructional fees and obligatory charges, while the officers, who receive full regimental and Corps pay of their rank, pay for their commons.

The War Office made certain conditions in regard to the granting of commissions in the R.E. to cadets from Woolwich who receive the Cambridge training. One was that it was to be obligatory in every case for the officer to pass the tripos with at least Third Class Honours. The other was that after completion of the course, which, it will be seen was entirely at Government expense, voluntary resignation of his commission by an officer would not be permitted till a certain period of years had passed. The former condition brought up the problem of what should be done in the case of any officer who failed to get Third Class Honours in the tripos. It was decided that such officers should be liable to be called on to resign their commissions, but that the Army Council should decide in each case whether they would enforce resignation or not; after receiving reports from the Professor in charge of the University Engineering School and the Commandant, S.M.E., on the officer's conduct and capacity. Very few such cases have in practice arisen.

THE RESISTANCE OF ROAD SURFACINGS TO TANK TRAFFIC*

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SUMMARY

THIS note describes investigations into the resistance of road surfaces to wear by intense tank traffic. Both concrete and bituminous surfacings have been investigated using special testing methods including a tank wear testing machine and an indentation test.

With concrete surfacings the results show that :—

(1) The rate of wear increases rapidly with increase of intensity of pressure between the tank track and the road.

(2) The rate of wear in the initial stages is governed mainly by the crushing strength of the concrete, irrespective of the age and water-cement ratio. The mix proportions appear to have a minor effect.

(3) The initial rate of wear of concrete with a crushing strength of 2,000 lb./sq. in. is about five times that of concrete having a strength of 4,000 lb./sq. in., but above 4,000 lb./sq. in. the increase in wear resistance is not very great.

(4) The type of aggregate used has an important effect on the later stages of wear of medium and low strength concrete, best results being given by crushed igneous rocks and worst results by flint gravels. The type of aggregate has, however, little effect on the wear resistance of concrete having a strength of more than 6,000 lb./sq. in.

Some results of a full-scale road test are included. These corroborate the main conclusions and show that concrete having a crushing strength of more than 4,000 lb./sq. in. gives satisfactory service. They also emphasize the importance of joint design and construction in concrete roads.

With bituminous surfacings the results show that :—

(5) The best resistance to wear is given by mastic asphalt. Recently developed dense tar surfacing and rolled asphalt also give good results. The binder content has a marked influence on the resistance to wear; there is an optimum value above and below which wear increases.

(6) In the case of the dense tar surfacing, the resistance to wear increases with increase in viscosity of the tar binder.

(7) Resistance to wear of rolled asphalt is increased with increase in filler content.

(8) To avoid undue indentation of mastic asphalt by standing tanks the grit content of the mastic should lie between 45% and 50%, using

an ungritted mastic containing 13%–15% of 30–40 penetration bitumen and a limestone powder having 45% to 60% passing 200 mesh.

(9) Within the limits $\frac{3}{4}$ in. to $\frac{1}{8}$ in., the size of the grit added to the mastic makes no significant difference in the resistance to indentation.

Recommendations for the construction of tank roads in concrete and bituminous materials are given in the text.

Introduction

The increased use of metal-tracked vehicles as a result of the war has introduced new problems for the road engineer. These problems are met in their most acute form in tank depots and factories, but in certain districts they are also serious on public highways where surfaces, which in peacetime, would have been considered quite satisfactory, have been severely damaged by tank traffic.

This paper describes experiments that have been made by the Road Research Laboratory to investigate the factors that affect the wearing of roads by tank traffic and the ways in which good wearing resistance can be obtained.

Although the tracks of a tank are designed so that the pressure on soft ground is low enough to prevent sinkage, the pressures exerted on a hard road are very much higher. Thus the average pressure over the nominal area of contact between the track shoe and the road is of the order of 200 lb./sq. in., and this pressure may be increased many times by projections on the track and the road or by tipping of the track during turning. These high pressures, combined with the turning motion of the tracks, cause many road surfaces to wear rapidly.

Of the types of surface in general use those that have shown best resistance to wear have been mastic asphalt and certain types of concrete roads that have been laid under carefully controlled conditions. For this reason most of the experiments described here have been with these materials, but attention has also been given to rolled asphalt and rolled tar surfacings.

Examination of the movement of tanks over road surfaces shows that the mechanism of wearing may vary with the type of surfacing. In the case of concrete, where the surface is hard and not absolutely flat, high pressures are developed over small areas and the concrete fails by localized crushing. In the case of mastic asphalt, however, the surface is comparatively smooth and the tank shoe usually polishes it. If the mastic is too soft, the shoe may indent the surface and a layer may be shaved off when the tank turns. When rolled asphalt fails it is through particles of stone being torn from the surface by the shoes of slewing tanks.

Whilst the worst damage occurs at corners, due to the slewing of the tanks, wear may also occur on the straight, particularly on brittle types of surfacing, as a result of the impact of the tracks of fast-moving tanks. In general, however, this type of wear is less serious than that at corners. Experimental work has therefore been directed mainly to the measurement of the resistance to wear by concentrated sliding loads and a machine designed to produce accelerated wear by this means has been used. For the work with bituminous materials a special indentation testing machine has also been developed to measure the resistance of the materials to static loads at a summer road temperature assumed to be 45°C. (113°F.)

THE RESISTANCES OF ROAD SURFACES

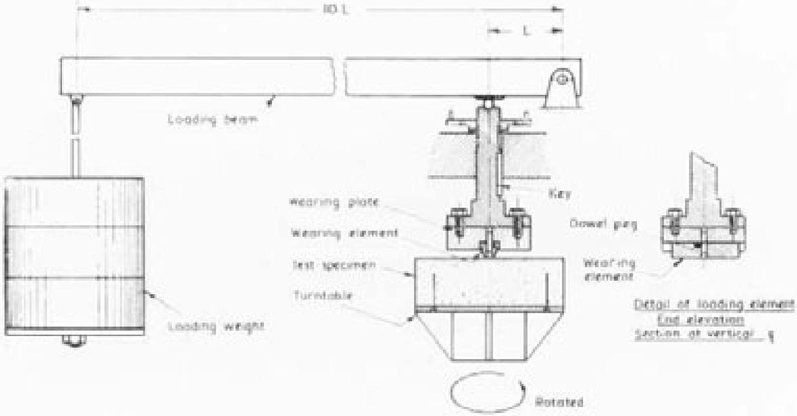


FIG. 1.—Arrangement of tank wear machine

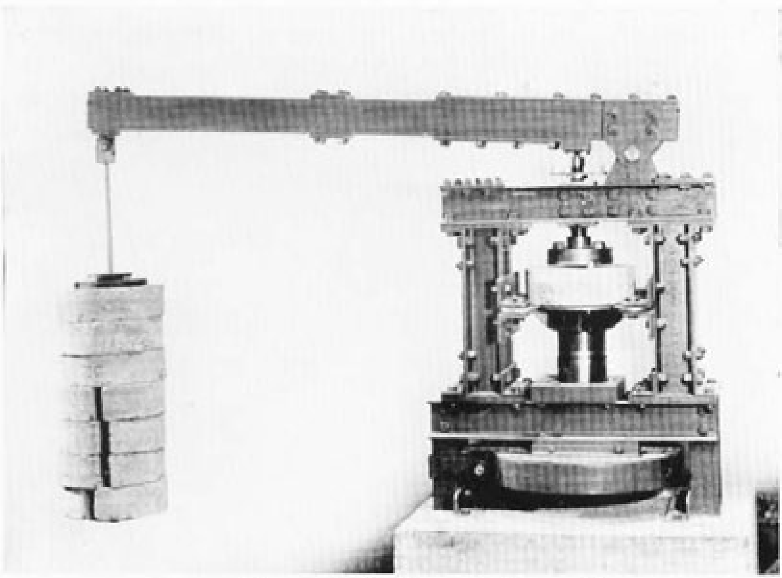
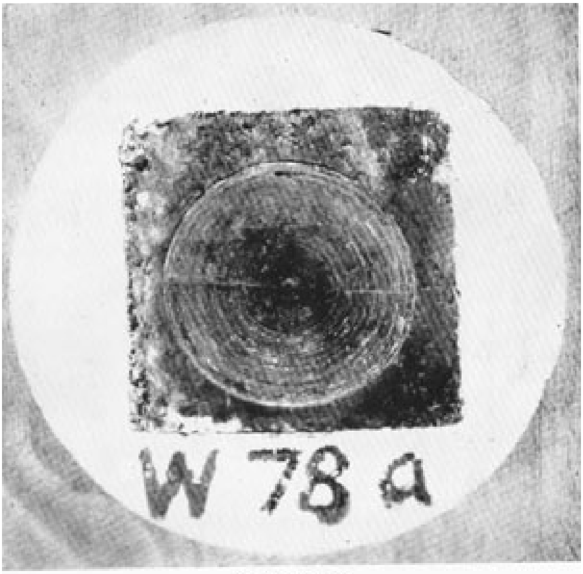
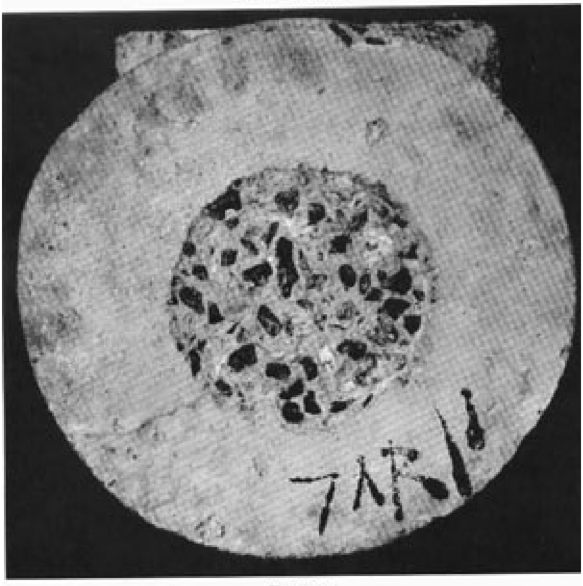


FIG. 2.—Photograph of tank-wear testing machine

The resistance of road surfaces 1 & 2



Mastic asphalt



Concrete

Fig. 3.—Typical specimens after test

The resistance of road surfaces 3

I. Apparatus

(a) *The Tank Wear Testing Machine*

For the sake of simplicity, the testing machine was made to apply rotation only. It consists essentially of a fixed wearing element pressing against a revolving test specimen. The wearing element is mounted on a plate supported on a sliding vertical column, through which loads varying from about 600 lb. to 4,000 lb. can be applied by means of a weighted lever arm. A sketch and photograph of the machine are shown in Figs. 1 and 2.

Preliminary tests were made with a wearing element consisting of a piece of tank track used with its normal wearing surface flat on the test specimen. This, however, failed to produce very much wear, even under an intensity of loading several times greater than the average pressure produced by a tank, but when the track element was tilted slightly, so as to present one edge to the concrete, very much greater wear occurred. As already mentioned, such tilting of the track has been observed to occur during turning. However, it was not found convenient to employ pieces of tank track as wearing elements because of their variability and of changes in their shape during the process of wearing. The element finally used consisted of an easily replaceable steel cylinder representing the edge of a tilted track. The cylinder was of mild steel one inch diameter and 5 in. long placed with the axis parallel to the surface of the specimen. Rotation of the cylinder about its own axis was prevented by means of a dowel peg. A new cylinder was used for each test specimen or after six revolutions of the same specimen.

The test specimens consisted of concrete cylinders 12 in. diameter and 4 in. high, containing four steel pegs in the base that engaged with holes in the turntable of the testing machine. For tests on bituminous materials a 7 in. square insert of the material to be tested was placed in a recess in the surface of the concrete cylinder. Speed of rotation which was originally about 1/6 r.p.m. was later changed to 2/3 r.p.m. All bituminous materials were tested at a temperature of 15°C.

The amount of wear is expressed as the mean depth of material worn away. It is measured by weighing the loose material brushed away from the surface after each complete revolution of the machine. Typical specimens of concrete and bituminous materials after test are shown in Fig. 3.

(b) *The Tank Indentation Test*

This test is intended to reproduce in the laboratory the conditions under the steel track of a tank standing on a bituminous surfacing in the hottest time of a summer day. The testing machine consists essentially of a flat ended cylindrical plunger 2 in. diameter, which can be brought into contact with a piece of the surfacing and loaded to give a standard pressure of 175 lb./sq. in. by means of a lever device. The indentation of the plunger into the surfacing material is measured by means of a dial gauge graduated in 1/1,000ths of an inch. The test results are expressed as the depth of penetration of the loaded plunger into the surface in 30 minutes. The test is always made at a temperature of 45°C. (113°F.)

Typical curves showing the depth of penetration plotted on a time base are shown in Fig. 15.

II. Concrete Surfaces

The performance of concrete tank roads in practice has been found to be very variable. Some have given very good results while others have rapidly failed. The causes of success or failure have been attributed to various factors, but examination of the evidence, afforded by practice, showed that the most important of these were likely to be the general quality of the concrete and the aggregate used.

(a) Laboratory Tests

Laboratory tests on concrete have included an examination of the following factors :—

(1) Relation between wear and load applied to the wearing element.

(2) Factors affecting the early stages of wear near the original surface of the concrete as produced by one revolution of the testing machine under constant load.

(3) Factors affecting the later stages of wear below the original surface as produced by five revolutions of the testing machine under constant load.

All the test specimens were made with one batch of cement and were stored in air at a relative humidity of about 90–95 per cent and a temperature of 65°F. until tested. Three wear-test specimens and six 4 in. cubes were made from each mix. The wearing surfaces of all specimens were given a reasonably smooth finish, but were not heavily trowelled. All mix proportions are by weight.

(i) Effect of Load

The relation between the wear after various numbers of revolutions of the testing machine and the load applied to the wearing element is given in Fig. 4. The curves show a rapid increase in wear with load and a steady increase with the number of revolutions. As a result of these tests, a load of 3,000 lb. was chosen for the remainder of the experiments on concrete as giving sufficiently accelerated wear.

(ii) Early Stages of Wear (One Revolution of Machine)

The amount of wear after one revolution of the machine is shown plotted against the compressive strength of the concrete in Figs. 5 and 6. Fig. 5 shows the relationship for concrete of 1 : 2 : 4 and 1 : 1½ : 3 proportions by weight made with flint gravel and river sand aggregates. Variation in strength was produced by changes in water-cement ratio and age at test. The figure shows a general relation between wear and crushing strength which, within the limits of the variability of the results, appears to be independent of the age and water-cement ratio. The mixes of 1 : 1½ : 3 proportions with strengths below 4,000 lb./sq. in. have slightly greater resistance to wear than the leaner mixes of the same strength. At present, however, it cannot be stated that this difference is really significant.

The results shown in Fig. 6 are for concrete of 1 : 1½ : 3 proportions made with river sand and various coarse aggregates and also for mortars of 1 : 3 and 1 : 1½ proportions. Variations in strength were again produced by changes in water-cement ratio and age at test. The curves shown are those for the 1 : 2 : 4 and 1 : 1½ : 3 mixes given in Fig. 5. The relation between initial wear and crushing strength for the various aggregates is very similar to that for the 1 : 1½ : 3 mixes with flint gravel and it therefore appears that the aggregate has little significant effect during this stage of the wearing process.

The wear obtained with the mortar specimens is rather more variable, but appears to be rather greater than that for concrete of the same crushing strength.

(iii) Wear in Later Stages (After Five Revolutions of Machine)

The wear in the later stages for 1 : 1½ : 3 concrete made with various aggregates and a 1 : 1½ mortar is shown in Fig. 7. For concrete with a strength of more than 6,000 lb./sq. in. the effect of the aggregate is small, but as the strength is reduced the aggregate becomes increasingly important. Best results have so far been obtained with hard igneous and metamorphic rock aggregates (granite and hornfels).

The wear resistance of the mortar appears to be almost independent of its strength over the range tested. At strengths above 5,000 lb./sq. in. the wear is greater than that for all types of concrete of the same strength and below this figure wear is still greater than that of concrete made with the better aggregates.

(b) Full-Scale Experiments

In order to correlate the results obtained in the laboratory with those obtained under ordinary conditions of use, an experimental test road has been built at a military tank depot.

This road is composed of eight different sections of concrete surface and one of mastic asphalt, set round a curve of constant radius as shown in Fig. 8. Various types of joint were also laid in a straight section leading to the curve. All the concrete sections, except that containing the joints, were of very good quality and had crushing strengths varying from 4,000–5,000 lb./sq. in. at 28 days.

The road has now been in use for nearly two years and little or no wear has occurred except at some of the joints between the sections and at one point where the road has cracked. Direct comparison with the laboratory tests cannot yet be made, but the experiment has confirmed the laboratory tests to the extent of showing that high strength concrete of various compositions will provide satisfactory wear resistance. Further use of the road, however, may show the increased effect of the aggregate indicated by the results of the laboratory tests.

(c) Joints

In the above full-scale experiment most of the wear in the main experimental sections occurred at the joints. The wearing of the straight section of lower quality concrete containing the various types of joint was somewhat greater than that of the main sections and indicated quite clearly the order of merit of the designs tried out. Photographs of typical sections of each type of joint after use are shown in Figs. 9, 10, 11 and 12. The joints of normal construction, both with and without the load-transfer dowel (types A and D), have suffered considerable spalling. The joint edged with granite setts (type C) has suffered less spalling, but the setts became loose. Best results, with almost no spalling, were obtained with the deep V-groove joint (type B).

(d) Conclusions

The results of the tests on concrete allow the following conclusions to be made :—

(1) The rate of wear of concrete surfaces increases rapidly with increase of intensity of pressure between the tank track and the road.

(2) The rate of wear in the initial stages is governed mainly by the crushing strength of the concrete, irrespective of the age and water-cement ratio.

(3) The type of aggregate used has an important effect on the later stages of wear of medium and low strength concrete, best results

being given by crushed igneous rocks and worst results by flint gravels. The type of aggregate has, however, little effect on the wear resistance of concrete having a crushing strength of more than 6,000 lb./sq. in.

(4) The wear resistance of mixes of 1 : 1½ : 3 proportions by weight appears to be rather better than that of leaner mixes.

(e) *Recommendations for the Construction of Concrete Roads to carry Tank Traffic*

The following recommendations can be made as a result of the experimental work that has been described above and as a result of experience in examining road failures due to tank traffic:—

(1) Concrete tank roads must be made of high quality concrete and their construction carefully controlled.

(2) The slab thickness must be adequate to prevent cracks. Reinforcement should be used to prevent the opening of any cracks that do occur.

(3) Mix proportions for the wearing surface should be 1 : 1½ : 3.

(4) The crushing strength of the surface concrete should exceed 5,000 lb./sq. in. at 28 days.

(5) A tough igneous or metamorphic rock should be used as a coarse aggregate. A nominal maximum size of ¾ in. to 1½ in. would be suitable.

(6) Vibration should be used for compaction when possible. If hand compaction is used the slump should not exceed 2 in.

(7) The surface should be finished smooth, but not floated excessively.

(8) Curing is very important. Damp or waterproof covers should be applied as soon as the surface is finished and maintained for at least 14 days for ordinary and rapid-hardening Portland cements, or from 3 to 7 days with high alumina or ultra rapid-hardening Portland cements. These periods should be extended in cold weather by not counting days on which the temperature does not rise above 40°F.

(9) Careful attention should be paid to all expansion, contraction, dummy and construction joints. Details of the V-joint which proved to be satisfactory in the experimental road are shown in Fig. 13.

III. Bituminous Surfacings

Experience has shown that certain forms of bituminous surfacings provide a very good wearing surface for carrying intense tank traffic. In tank depots mastic asphalt has proved especially useful, and on public roads carrying heavy tank traffic certain rolled asphalts and rolled tar surfacings are giving satisfactory service. The rolled type of surfacing provides the cheapest means of repairing a road which has suffered serious wear under tank traffic.

In the present work the resistance to wear has been measured by means of the tank wear testing machine and the resistance to marking and pushing by means of the indentation test described above. Samples of surfacings from a number of actual roads have been tested to obtain correlation between test results and road behaviour under tank traffic. Tests have also been made on some laboratory-prepared specimens to find if material mixed and consolidated on a small scale will give indentation and wear test results similar to those obtained with the corresponding full-scale road carpets.

(a) *Tests on Bituminous Surfacing with the Tank Wear Testing Machine*

The results of wear tests on some actual samples of bituminous road surfacings together with a description of their composition and behaviour under heavy tank traffic are given in Table 1. (See folding plate at end.) Some results of wear tests on laboratory prepared specimens of the same composition as the road surfacings are also included in this table.

It will be seen from the wear results that the order of merit of the surfacings when tested on the machine with 1,000 lb. load is substantially the same as that indicated by reference to the column describing the road behaviour of the respective materials, namely :—

(1) Mastic asphalt.
(2) Dense tar surfacing.*
(3) Rolled asphalt.
(4) The remaining tar surfacings.

When a load of 2,000 lb. is used on the machine the order of merit tends to change; the softer of the two mastic asphalt specimens gives a much higher loss than either the harder mastic asphalt or the dense tar surfacing. When 3,000 lb. load is used, the very high loss shown by mastic asphalt does not correspond at all to observed behaviour under practical conditions.

Bearing these points in mind it would seem that, to simulate road conditions on bituminous surfacings, the load of the tank wear testing machine should be 1,000 lb.

It will be seen that with 1,000 lb. load the results from laboratory-prepared specimens are in fairly good agreement with the corresponding specimen taken from road surfaces.

The results obtained in the present work suggest that the depth of wear recorded by the tank wear test on bituminous surfacing correspond to behaviour on the road as follows :—

LOAD 1,000 LB.

Road behaviour	*Mean depth of wear in inches for 6 revolutions at 15°C.*
Satisfactory for use on corners or turning circles taking heaviest tank traffic.	0–0·015
Satisfactory for corners of public roads or in positions carrying a fair proportion of slewing tanks.	0·015–0·030
Satisfactory for carrying heavy tank traffic with little slewing and turning.	0·030–0·150
Unsatisfactory for carrying heavy tank traffic.	over 0·150

It must be stressed that these figures are only tentative and will probably have to be modified as more experimental data are collected.

(b) *Application of the Tank Wear Testing Machine to the Design of Bituminous Surfacings.*

The tank wear testing machine has not yet been used to any considerable extent in the design of bituminous surfacings, but an illustration can be given of the way in which it is intended to make use of it.

*A. R. Lee and P. J. Rigden. The use of Mechanical Tests in the Design of Bituminous surfacing mixtures. Part I. *Dense Tar Surfacing.* J.Soc.Chem.Ind., *Lond.*, 1945, 64(6) 153–61.
H. G. Barnes and G. H. Fuidge. Experiences in the Manufacture and Laying of Dense Tar Surfacing. *Surveyor, Lond.*, 1945, **104** (2769), 91 : (2770), 109.

When the poor resistance to tank traffic of certain rolled asphalt surfacings was first considered, it was thought that, in view of the good behaviour of mastic asphalt with its high proportion of fine aggregate, an increase in the filler content of the rolled material would be beneficial. Tests were made, therefore, to find if this supposition was correct.

The composition of the specimens was as follows :—

	Specimen A	Specimen B
Stone (¾-in. granite)	32%	32%
Sand	50·7–56·7%	45–51%
Filler (limestone-200 mesh)	6·3%	12%
Soluble bitumen (40 pen.) ..	5–11%	5–11%

The results of the tests made on the machine loaded with 1,000 lb. are shown plotted in Fig. 14.

It will be seen that the resistance to wear depends primarily on the binder content but that an increase in filler content from 6½% to 12% almost halves the wear of the optimum composition.

Arrangements have been made for a trial section of rolled asphalt having a high filler content to be laid on a road in a tank depot.

(*c*) *Tests on Bituminous Surfacings with the Tank Indentation Testing Machine*

To calibrate this machine against road behaviour an initial series of tests was made on samples taken from existing road carpets which had shown various degrees of resistance to indentation by tank tracks in hot weather. The results of these tests are shown in Table 1. (See folding plate at end).

It will be seen from Table 1 that the mastic asphalt surfacings show the deepest indentation and that some of the rolled type of surfacings give very small indentations. A comparison of these results with notes made during inspections of the corresponding road surfaces suggests that surfacings giving indentation figures of 0·1 in. and under will show only superficial marking under the heaviest tank traffic; surfacings having an indentation of less than 0·3 in. would show indentation under tank traffic, but the surface would not be seriously affected and would largely be smoothed by subsequent traffic. A test result of 0·3 in. may be considered the upper limit for satisfactory material.

Some indentation tests have been made on laboratory prepared specimens of mastic asphalt to find out how the rather variable resistance to indentation can be improved.

(*d*) *Effect of Size and Quantity of Stone and Bitumen Content on Indentation of Mastic Asphalt*

In view of the variations likely to occur when stone is added to the ungritted mastic on the site, the effect of size and quantity of stone on resistance to indentation has been investigated. The effect of variations in bitumen content of the ungritted mastic has also been studied.

(*i*) *The Effect of Stone Size*

Tests have been made on a series of small hand-mixed specimens of mastic surfacing containing various sizes of single-sized stone ranging from ⅛ in. to ¾ in. All the specimens had the same composition which was as follows :—

Granite	50·0%
Limestone powder (45% passing 200 mesh) (See Table 3)	42·5%
Trinidad A.C. (40 pen.) (Soluble)	7·5%

The results of the indentation test are given in Table 2.

TABLE 2

Effect of size of added stone on resistance of mastic asphalt to indentation

Temperature 45°C. Load 175 lb./sq. in.

Size of added stone	Indention (of 2-in. diameter plunger in 30 min.)
Passing $\frac{1}{4}$ in. ret. $\frac{1}{8}$ in.	0·195 in.
,, $\frac{3}{8}$ in. ,, $\frac{1}{4}$ in.	0·177 in.
,, $\frac{1}{2}$ in. ,, $\frac{3}{8}$ in.	0·187 in.
,, $\frac{3}{4}$ in. ,, $\frac{1}{2}$ in.	0·207 in.

There appears to be no significant change in indentation with change in stone size within the limits $\frac{1}{8}$ in. to $\frac{3}{4}$ in. The use of stone smaller than the specified size, which has been found in surfacings recently examined, is not therefore the cause of their low resistance to indentation. The tolerance allowed on stone size by most mastic asphalt specifications appears to be unduly restrictive.

(ii) The Effect of Stone and Bitumen Contents

A series of laboratory prepared specimens has been made up with stone contents ranging from 40% to 55%, using ungritted mastic having soluble bitumen contents between 13% and 18%. The bitumen used in these 6 specimens was the softest allowed by the existing War Office specification for tank road surfacings (40 pen. at 25°C.) and the limestone dust had a grading as shown in Table 3.

TABLE 3

Grading of Limestone Powder

Sieve Sizes	Percentage by weight
Passing 8 B.S. mesh. ret. 36 B.S. mesh ..	13·8
,, 36 ,, ,, ,, 85 ,, ,, ..	24·0
,, 85 ,, ,, ,, 200 ,, ,, ..	16·4
,, 200 ,, ,,	45·8

Curves showing the relation between the bitumen content of the ungritted mastic and indentation for stone contents of 40, 45, 50 and 55 per cent of stone are given in Fig. 16. The curves illustrate the serious effect which the addition of too little stone has on the resistance to indentation of the surfacing.

It will be seen that for any particular stone content there is a maximum bitumen content above which the mastic surfacing rapidly becomes soft with further increase in bitumen. Furthermore it appears that a bitumen content which is satisfactory for a stone content of 40 to 50 per cent would generally be unsatisfactory for a stone content of 30 to 40 per cent. A wide tolerance on stone content necessitates a narrow tolerance on the bitumen content (see note to Fig. 16). For example, considering the material mixed in the laboratory, although for a 40 per cent stone content the bitumen content may vary between 12·0 and 14·0 per cent on the ungritted mastic, and for a

50 per cent stone content it may vary between 13·0 and 16·5 per cent, the satisfactory bitumen content which is common to both 40 and 50 per cent stone ranges from only 13·0 to 14·0 per cent. Similarly, if the stone tolerance is reduced to 5 per cent (45–50 per cent) the bitumen tolerance may be increased to 2 per cent (13–15 per cent).

The results of penetration tests on the twelve samples of mastic asphalt (containing 42–45 per cent stone), taken from a road, given in Table 1, are shown plotted against their respective bitumen contents in Fig. 16. It will be seen that they fall close to the corresponding curve for the laboratory prepared specimens. This lends weight to the laboratory results which indicate that the limits of mastic asphalt to give adequate resistance to indentation are as follows :—

	Percentage by weight *Minimum*	*Maximum*
Stone ($\frac{3}{8}$ in.–$\frac{1}{8}$ in.)	45%	50%
Limestone dust (45%–60% of 200) 87%–85% } Soluble bitumen (30 pen.–40 pen.) 13%–15% }	50%	55%

The results show that the use of 55 per cent of stone makes a further very large improvement in resistance to indentation. While the use of such a high stone content may produce difficulties in laying, it is possible that the use of stone contents greater than those used in current practice may have some advantages.

(e) *Conclusions*

The results of the test on bituminous materials indicate the following conclusions :—

(i) The tank wear and indentation testing machines give a useful indication of the behaviour of the surfacing material under tank traffic providing the conditions of test are kept within certain limits.

(ii) Results of tests on laboratory prepared specimens are substantially the same as those from corresponding material taken from the road.

(iii) *Mastic asphalt surfacing.*—While mastic asphalt gives good resistance to wear even under the heaviest tank traffic it is liable to suffer considerable indentation in hot weather if not correctly designed. The resistance to indentation depends on the bitumen content and on the amount of grit added to the mastic and not to any appreciable extent on the grading or size of the grit.

(iv) *Rolled asphalt.*—The resistance of rolled asphalt to indentation is usually adequate but its resistance to wear by slewing tanks is sometimes poor. The resistance to wear of dense surfacings, containing 30%–40% stone, is affected by the bitumen content and the filler content. An increase in the filler content above the proportion normally used makes a substantial improvement in resistance to wear.

(v) *Dense tar surfacing.*—Tar surfacing materials can be designed to give satisfactory resistance to tank traffic. These materials have high filler contents and are made with high viscosity tar.

(f) *Recommendations*

The following compositions, which are based on the experimental results given in the report and on practical experience, are recommended for use on roads carrying tanks :—

(*i*) *Mastic Asphalt*

(For use on roads in tank factories and depots.) The surfacing should have a final composition within the following limits :—

	Percentage by weight Minimum	Maximum
Granite chippings passing ½ in. mesh and retained ⅛ in. mesh	45·0	50·0
Limestone dust passing ⅛ in. mesh retained on 200 mesh	16·8	26·6
Limestone dust passing 200 mesh	18·9	29·0
Soluble bitumen (Penetration 30–40 at 25°C.) ..	6·5	8·2

Particular care should be taken to ensure that the correct amount of chippings is added to the mastic on the site.

This composition is obtained by adding 45 to 50 per cent of the chippings to ungritted mastic having the following composition :—

	Percentage by weight Minimum	Maximum
Limestone dust (containing 45 to 60 per cent passing 200 mesh)	85	87
Soluble bitumen (penetration 30–40 at 25°C.)	13	15

(*ii*) *Rolled Asphalt.*—Two specifications are suggested :—

(*a*) Where a very smooth surface is permissible

	Percentage by weight
Granite (¾ in. to ⅛ in.)	35·0
Sand (⅛ in. to 200 mesh)	44·5
Filler (material passing 200 mesh)	13·5
Soluble bitumen (35–45 pen. at 25°C.) ..	7·0

(*b*) Where a texture suitable for normal traffic is required :—

	Percentage by weight
Granite (¾ in. to ⅛ in.)	50·0
Sand (⅛ in. to 200 mesh)	33·5
Filler (material passing 200 mesh)	10·0
Soluble bitumen (35–45 pen. at 25°C.) ..	6·5

(*iii*) *Dense tar surfacing.* (For use on public roads)

	Percentage by weight
Slag or granite (¾ in.–⅛ in.)	32·0
Sand (⅛ in. to 200 mesh)	46·5
Filler (Material passing 200 mesh)	14·0
Coal tar (60° E.V.T.)	7·5

(*iv*) Roads which are required to carry heavy tank traffic must have good foundations.

When rolled stone-filled asphalt or dense tar surfacing is used to resurface a worn concrete road which has not failed structurally, it is usually sufficient to level off the surface by rolling a suitable bituminous base material into the depressions and then lay the wearing surface on top. Particular care should be taken to obtain good consolidation of both the base and surfacing material.

Acknowledgment.—The work described in this paper was carried out as part of the programme of the Road Research Board of the Department of Scientific and Industrial Research. The paper is published by permission of the Director of Road Research.

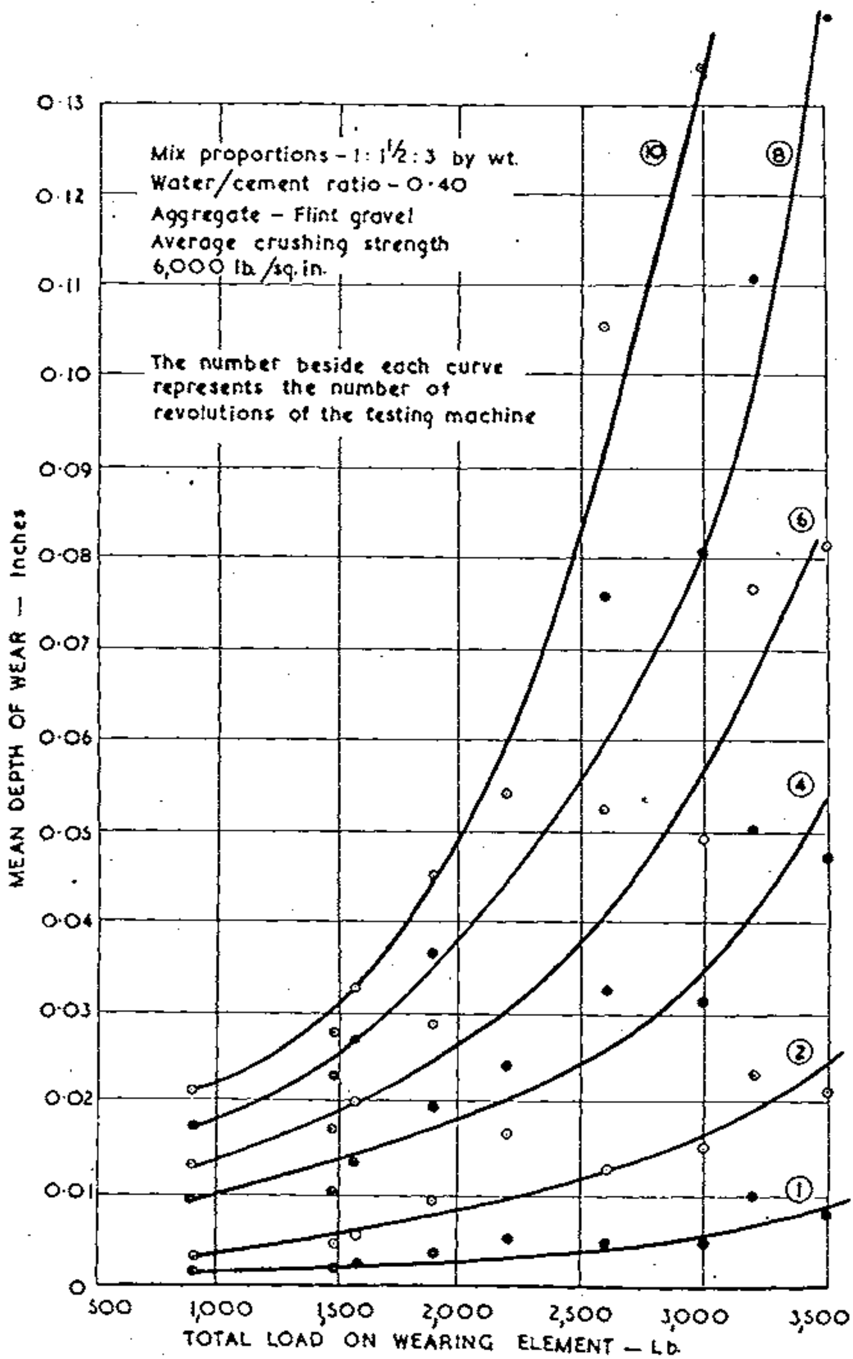


Fig. 4. EFFECT OF LOAD ON WEAR OF CONCRETE

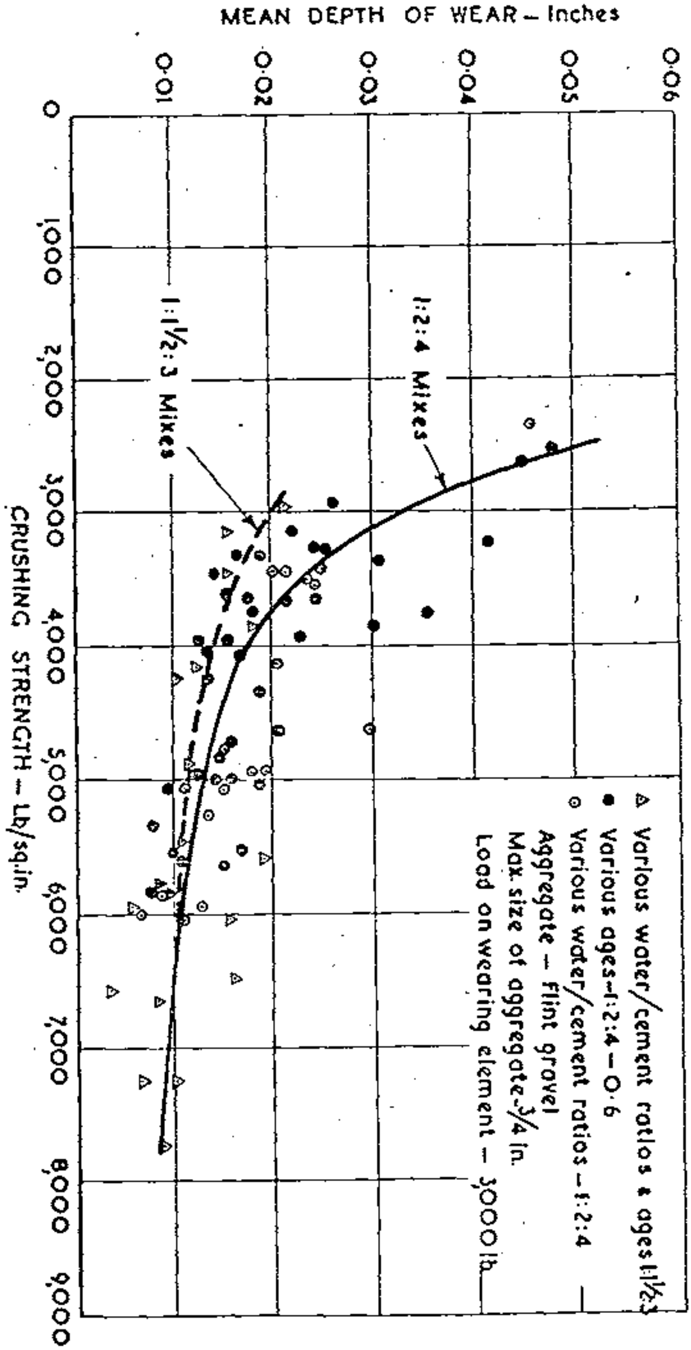


Fig. 5. RELATIONSHIP BETWEEN WEAR AFTER ONE REVOLUTION OF TESTING MACHINE AND CRUSHING STRENGTH OF CONCRETE

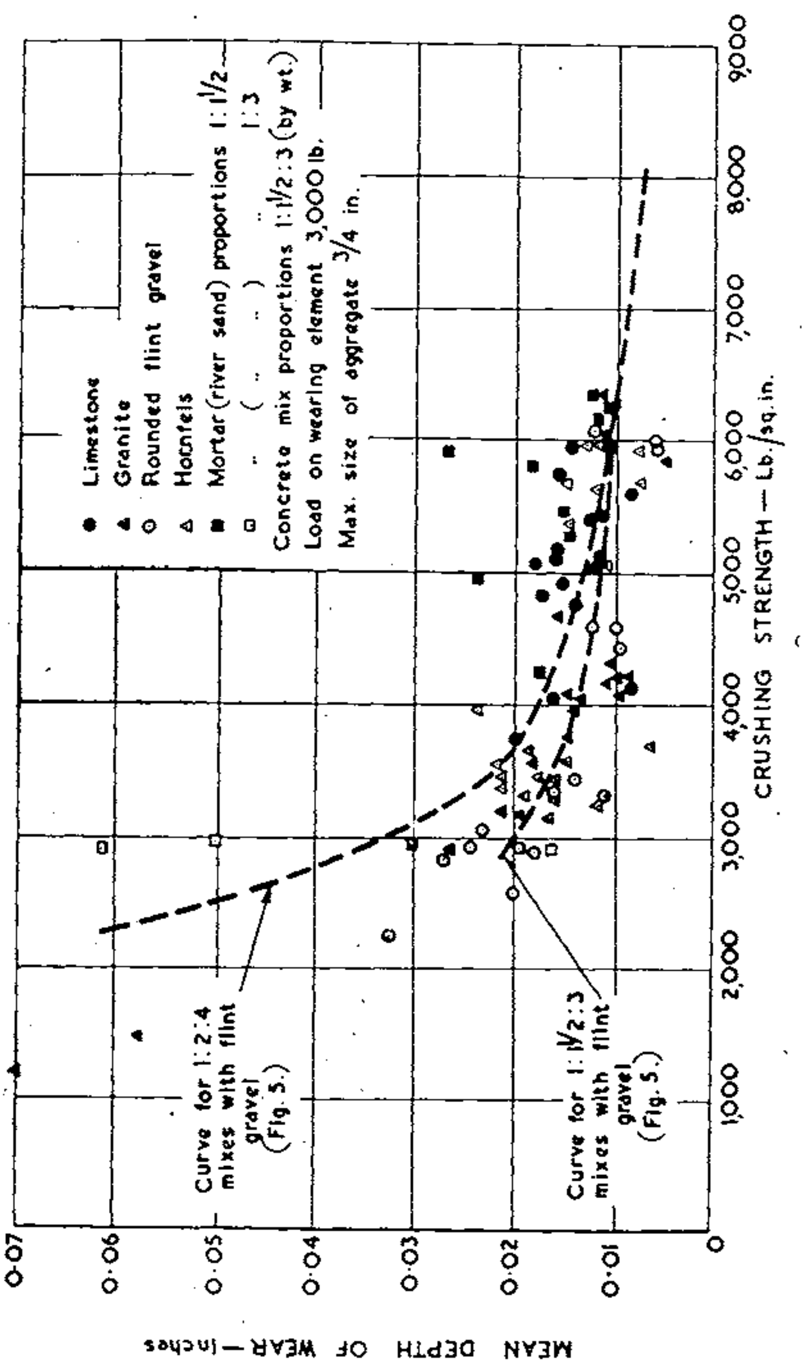


Fig. 6. RELATIONSHIP BETWEEN WEAR AFTER ONE REVOLUTION OF TESTING MACHINE AND CRUSHING STRENGTH OF CONCRETE MADE WITH VARIOUS AGGREGATES

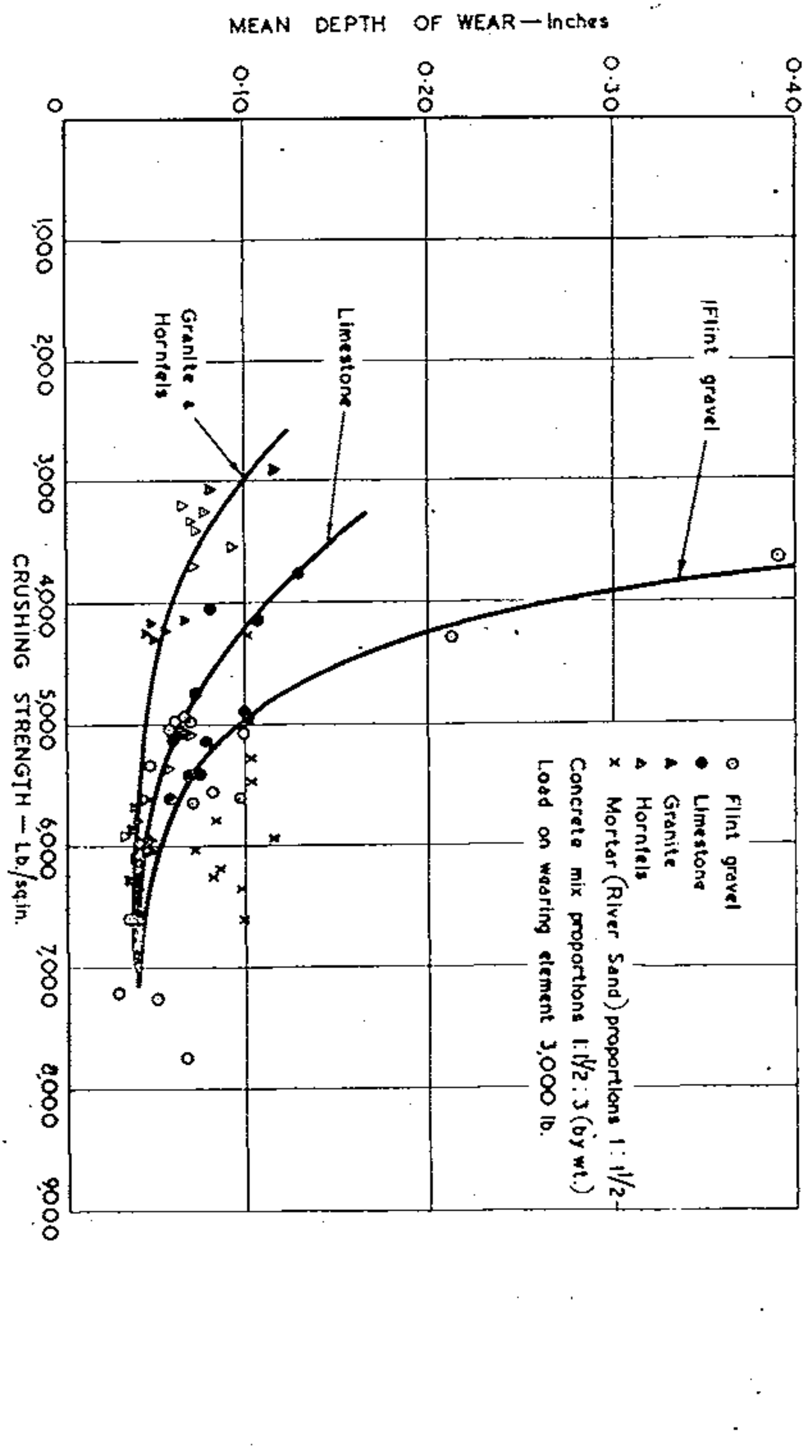
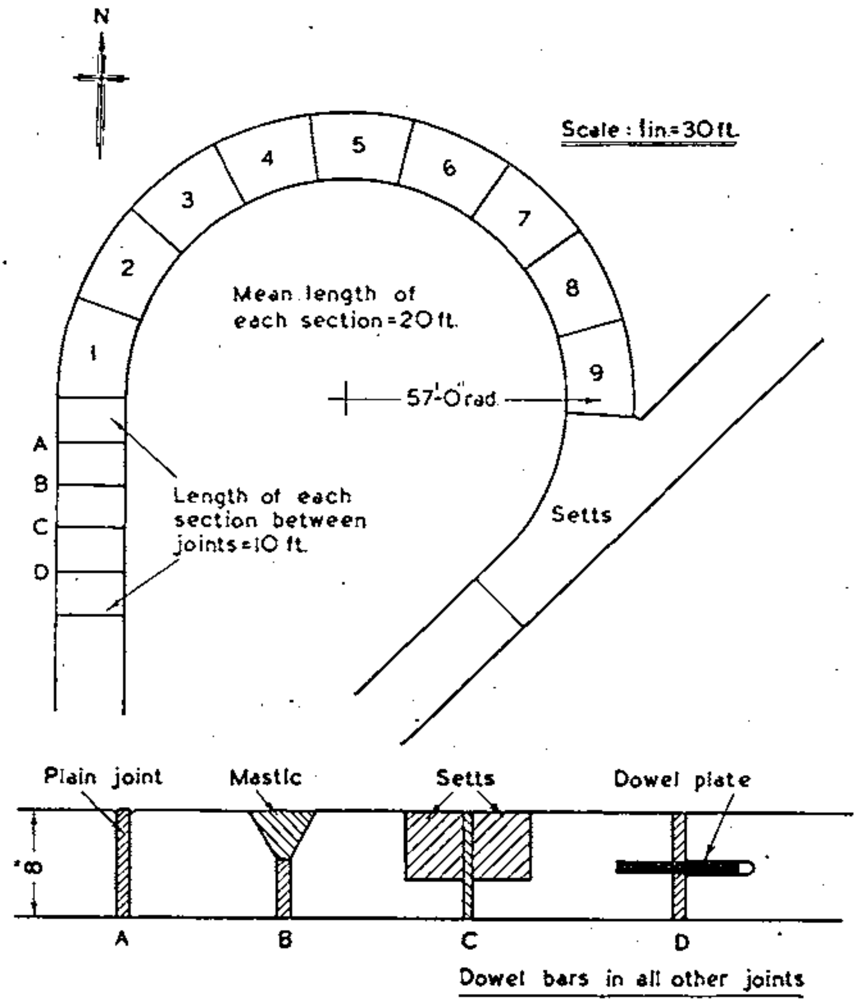


Fig. 7 RELATIONSHIP BETWEEN WEAR AFTER 5 REVOLUTIONS OF TESTING MACHINE AND CRUSHING STRENGTH OF CONCRETE MADE WITH VARIOUS AGGREGATES



Section	Mix proportions by Wt. †	W/C by Wt.	Aggregate	Placing and finishing
Joints	1:2:4	0·60	1½" Gravel	Hand placed and floated
1 *	1:2:4	0·60	1½" Gravel	
2	1:1½:3	0·42	2" Dolerite	
3	1:1½:3	0·44	¾" ..	
4	1:1½:3	0·47	¼" ..	
5	1:1½:3	0·48	2" ..	Hand placed, screed finish
6	1:1½:3	0·32	2" ..	Hand placed and floated
7	1:2:4	0·47	2" ..	Vibrated, hand floated
8	1:1½:3	0·28	2" ..	
9	1:1½:3	0·36	1½" ROUNDED FLINT GRAVEL	Hand placed and floated

* Section (1) Surfaced with 1½" Mastic Asphalt
† Normal Portland Cement used throughout

Fig. 8. GENERAL ARRANGEMENT OF EXPERIMENTAL TANK ROAD

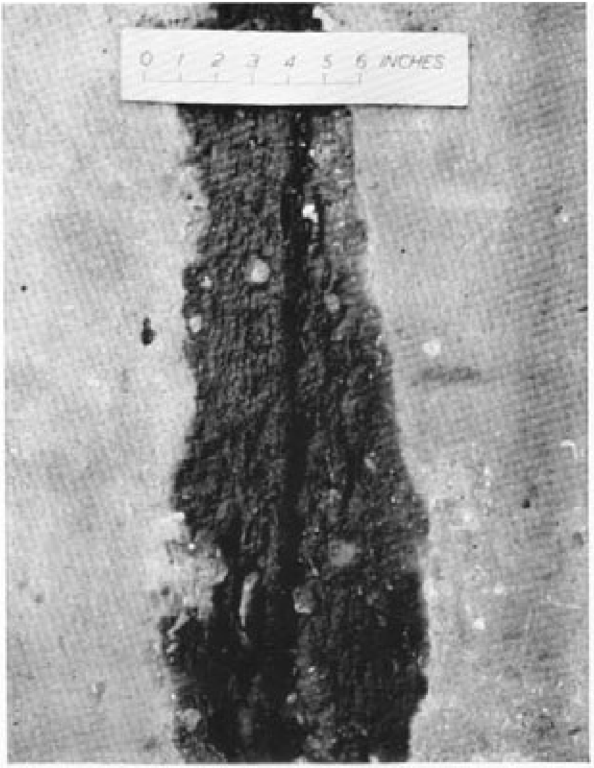


FIG. 9.—Dowel Plate Joint
Type D.

FIG. 10.— Plain Butt Joint
Type A.

The resistance of road surfaces Fig 9 & 10

Fig 11.—V-groove Joint
Type B.

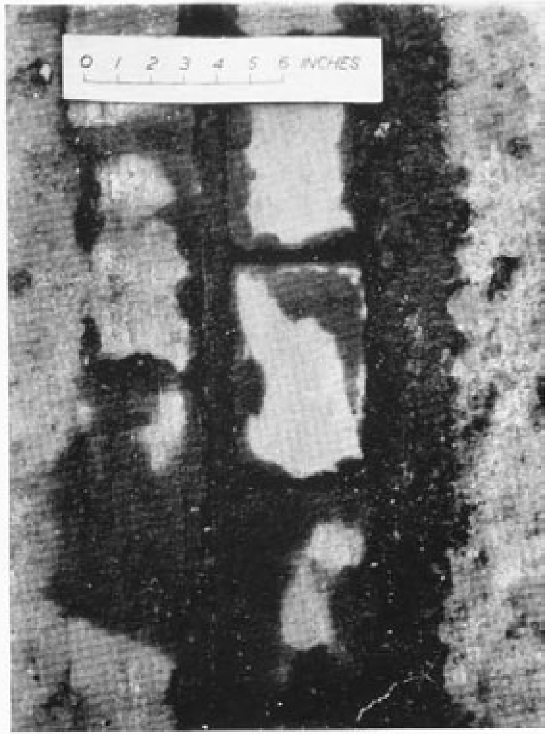


Fig. 12.—Granite—Set Joint
Type C.

The resistance of road surfaces Fig 11 & 12

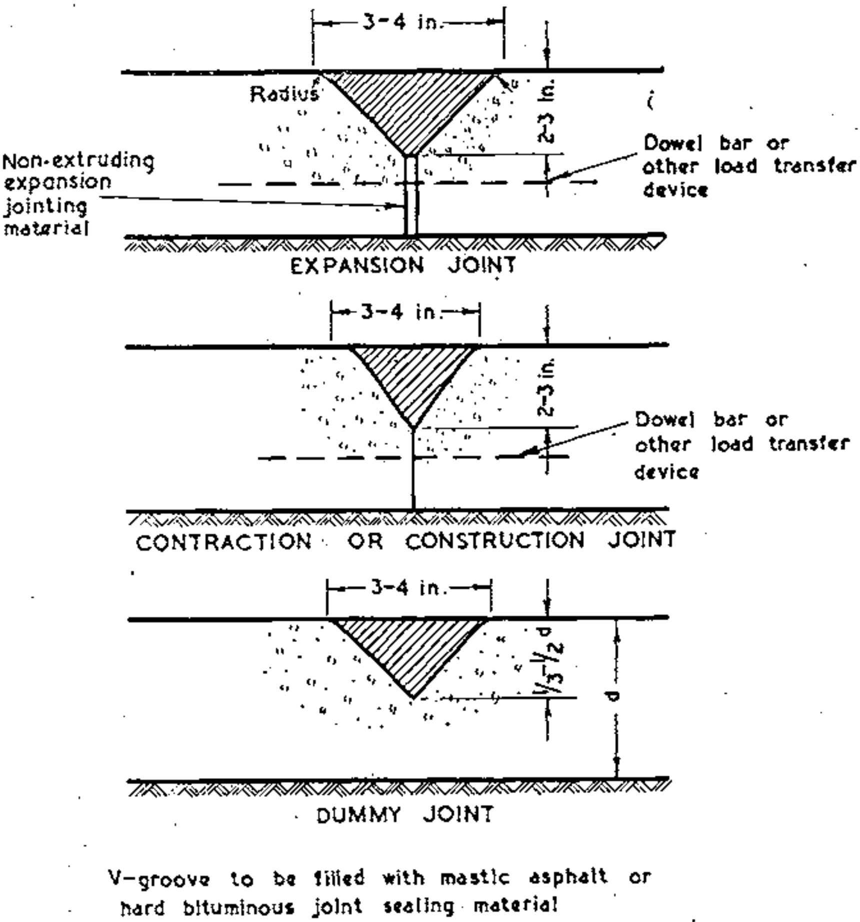


Fig. 13 JOINTS RECOMMENDED FOR CONCRETE TANK ROADS

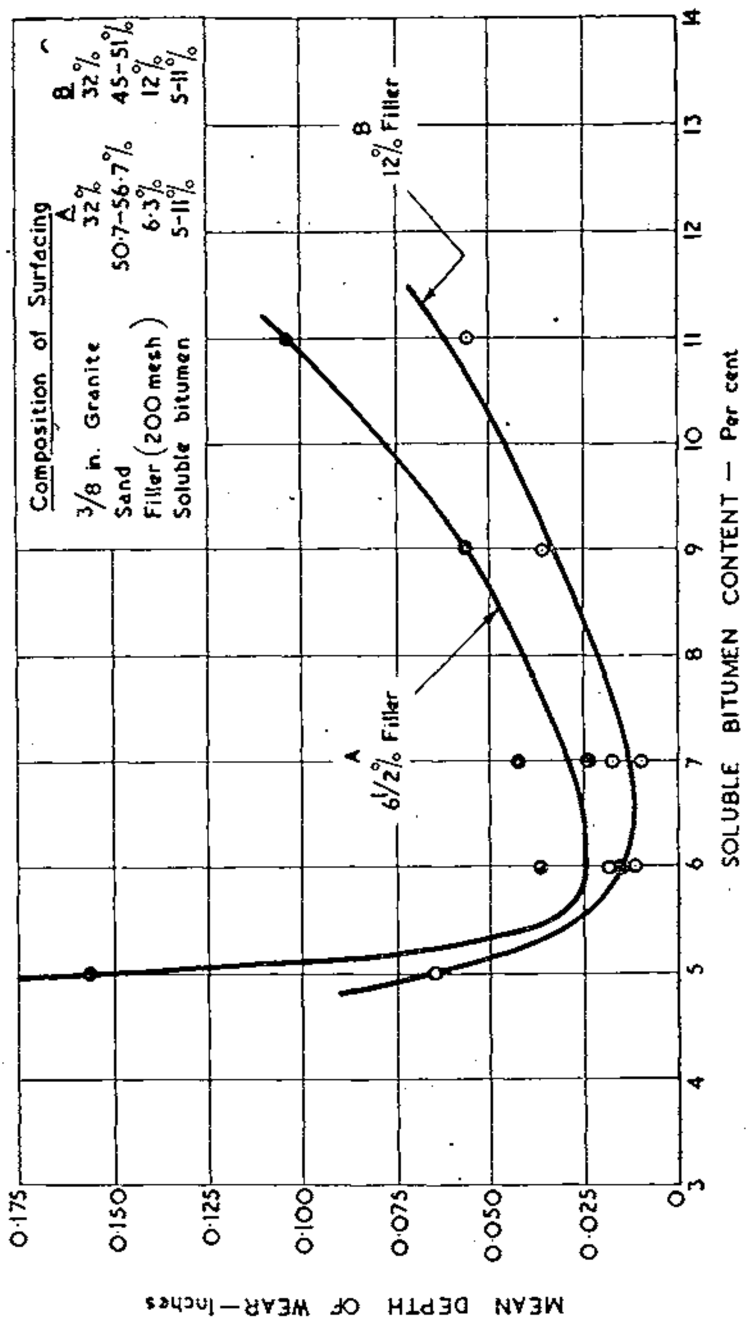


Fig. 14. RELATIONSHIP BETWEEN TOTAL WEAR AND BITUMEN CONTENT FOR ROLLED ASPHALTS HAVING DIFFERENT FILLER CONTENTS

Load 1,000 lb. Temperature of test 15° C.

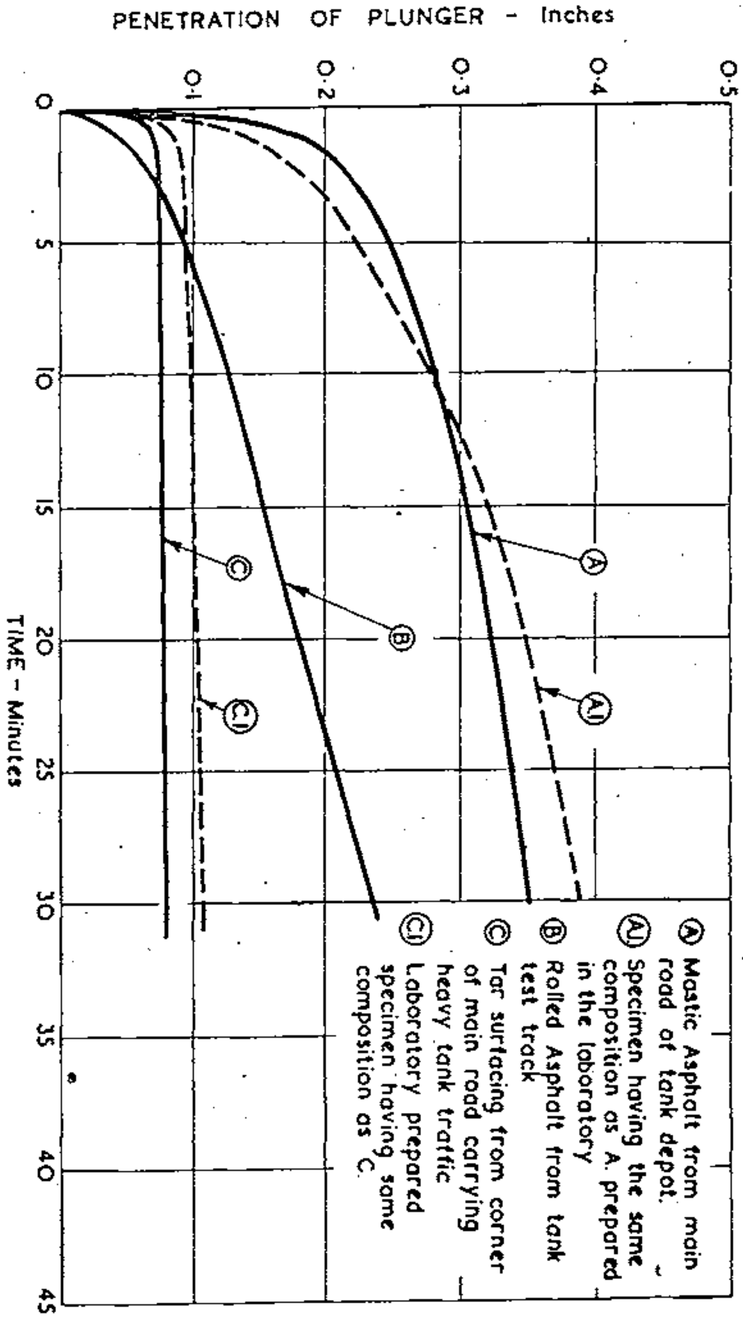


Fig. 15. TYPICAL INDENTATION CURVES OBTAINED WITH THE TANK INDENTATION TEST ON VARIOUS TYPES OF ROAD SURFACING.

Dia. of plunger 2·0 in. Pressure 175 lb./sq.in. Temperature of test 45°C. (113°F.)

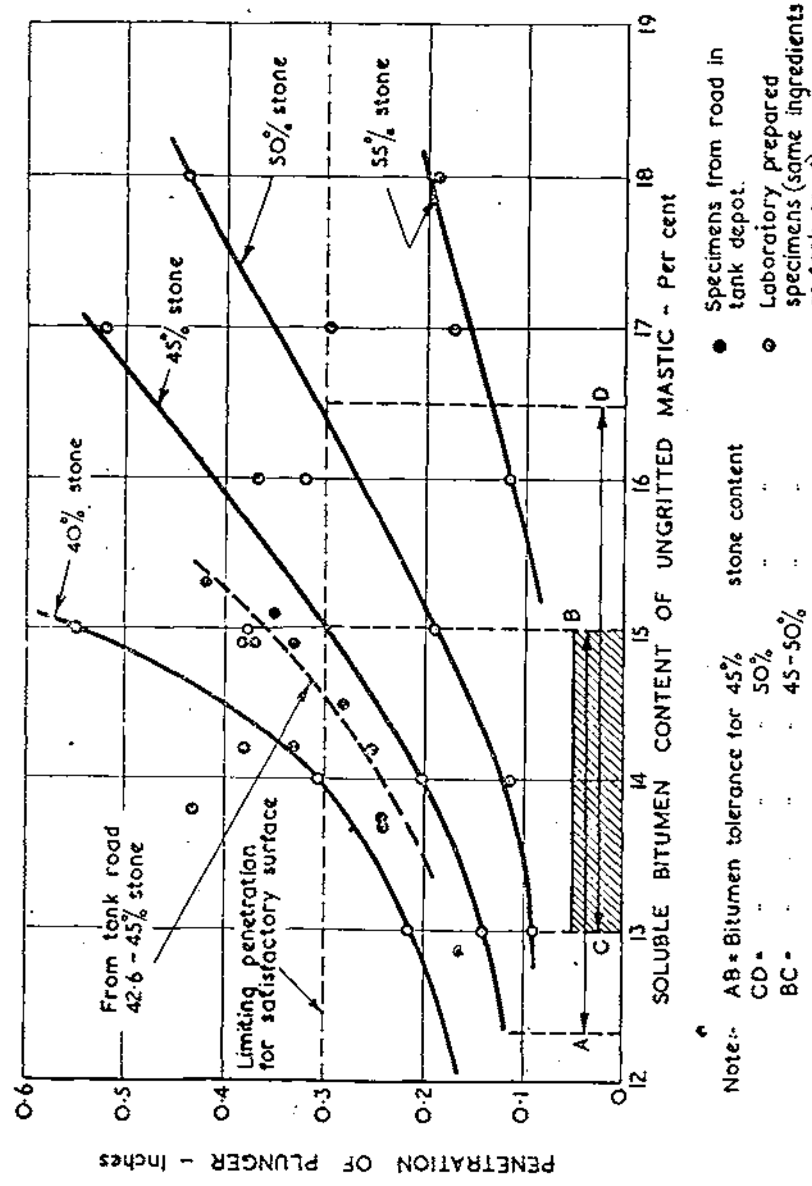


Fig.16. THE EFFECT OF BINDER CONTENT AND ADDED STONE CONTENT ON RESISTANCE TO INDENTATION OF MASTIC ASPHALT AT 45°C.
(2in. dia. Flat ended plunger loaded to 175 lb./sq.in. for 30 minutes)

TABLE 1

Comparison of the Road Behaviour of Various Surfacing Materials with Results of the Tank Wear and Penetration Tests made on Samples from the Road and on Laboratory Prepared Specimens.

<table>
<tr><th rowspan="3">Type of surfacing</th><th colspan="5">Specimens cut from road surface</th><th colspan="3">Specimens of the same composition made in the laboratory</th></tr>
<tr><th rowspan="2">Composition and date laid</th><th rowspan="2">Behaviour of surfacing on road</th><th colspan="2">Tank wear test</th><th rowspan="2">Penetration at 45°C. 175 lb./sq. in. for 30 mins. (in.)*</th><th colspan="2">Tank wear test</th><th rowspan="2">Penetration at 45°C. 175 lb. sq. in. for 30 mins. (in.)</th></tr>
<tr><th>Load (lb.)</th><th>Mean depth of wear (6 revs.) (in.)</th><th>Load</th><th>Mean dep. of wear (6 revs.) (in.)</th></tr>
<tr><td rowspan="3">Mastic asphalt</td><td rowspan="3">(By analysis)
Stone 42·6–45·0%
Limestone dust (47%–200) 46·8–49·9%
Soluble bitumen 7·5–8·4%
Laid Jan.–Feb., 1944 (Samples taken Sept., 1944).</td><td rowspan="3">Very good resistance to wear on main road of large tank depot carrying exceptionally heavy traffic but tended to mark in hot weather under slow-moving or stationary tanks. Very little cracking even at joints in concrete base. (Inspection Sept., 1944.)
Little sign of wear.
(Inspection Oct., 1945.)</td><td>1000</td><td>0·006   0·004</td><td rowspan="3">0·24 (7·5%)
0·24 (7·5%)
0·25 (7·8%)
0·28 (8·0%)
0·33 (8·2%)
0·33 (7·8%)
0·35 (8·3%)
0·37 (7·8%)
0·38 (8·2%)
0·38 (8·4%)
0·42 (8·4%)
0·43 (7·6%)</td><td>1000</td><td>0·0062</td><td rowspan="3">0·38
(8·25% bitumen)</td></tr>
<tr><td>2000</td><td>0·034   0·119</td><td>2000</td><td>0·064</td></tr>
<tr><td>3000</td><td>0·227 from normal area   0·370 from soft area</td><td>3000</td><td>0·352</td></tr>
<tr><td>Rolled stone-filled asphalt (Bitumen binder)</td><td>(By analysis)
Stone (granite) 38–50%
Sand 42–49%
Filler 4·2–7·2%
Soluble bitumen 7·4–7·8%
Surfacing laid Nov. 1943.
(Samples taken Feb. 1944.)</td><td>Good resistance to wear by tanks on straight portions and slight bends, but tended to be torn up by slewing tanks. Negligible cracking and only very shallow marking. Laid on tank test track. (Inspection Sept. 1944.)</td><td>1000
,,
,,
,,</td><td>0·148
0·073
0·045
0·114</td><td>0·29

0·24</td><td>1000</td><td>0·042</td><td>0·20</td></tr>
<tr><td>Dense Tar Surfacing (coal tar binder)</td><td>Stone (slag) 35%
Sand 50%
Filler 15%
Coal tar (60°E.V.T.) 7·5%
(Laid May, 1944).</td><td>Good resistance to wear on corner of public road carrying heavy tank traffic. No sign of cracking and negligible marks.
(Inspection Aug., 1944).
Good condition. Slight wear on corner. (Inspection Oct., 1945.)</td><td>1000
2000
3000</td><td>0·009
0·031
0·087</td><td>0·08</td><td>2000
3000</td><td>0·017
0·110</td><td>0·11</td></tr>
<tr><td></td><td>Stone (slag) 35%
Sand 50%
Filler 15%
Coal tar (50°E.V.T.) 7·5%
(Laid Feb., 1944)</td><td>Good resistance to wear on straight sections of road but said to be unreliable on corners.
(Inspection Aug., 1944).</td><td>1000</td><td>0·310</td><td>0·10</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td></td><td>Stone (slag) 35%
Sand 50%
Filler 15%
Coal tar (34°E.V.T.) 6·8%
(Laid Feb., 1944).</td><td>Pushed severely by tank and heavy lorry traffic. Unsatisfactory.
(Inspection Aug., 1944)</td><td>1000</td><td>0·368
for 1½ revs.</td><td>0·19</td><td>—</td><td>—</td><td>—</td></tr>
</table>

*Soluble bitumen content of each sample is shown in brackets.

THE ATTACK ON WALCHEREN ISLAND

By Lieut.-Col. E. W. L. Whitehorn, R.E.

Explanation of Abbreviations Used

L.V.T.	Landing Vehicle Tracked.
L.C.T.	Landing Craft Tank.
B.M.A.	Beach Maintenance Area.
P.B.M.	Principal Beach Master.
L.C.O.C.U.	Naval personnel who clear under water obstacles.
A.V.R.E.	Assault Vehicle, R.E.
P.M.D.	Polish Mine Detector.
F.D.S.	Field Dressing Station.

1. Preliminary

THE attack on Walcheren known as Operation "Infatuate" was designed to open the port of Antwerp by silencing the guns on Walcheren Island which were preventing shipping from using the Scheldt Estuary. It involved a combined operations landing on the island after preliminary land, sea and air bombardment and the flooding of the centre portion as a result of the breaching of the dykes.

2. Preliminary Planning

The task of landing on Walcheren Island and silencing the guns was originally given to 4 S.S. Bde. and the Commander, in addition to other supporting arms, asked for, and was allotted two Fd. Coys., R.E., to carry out R.E. work and also a C.R.E. to act as adviser on engineer problems. The C.R.E. was not allowed to use his third Fd. Coy. and his Fd. Pk. Coy. was not under his command but, in fact, it worked for him and without it the collection of all the R.E. Stores needed would have been impossible. Further a Fd. Pk. Coy. detachment went on the expedition and proved invaluable in organizing, collecting and issuing engineer stores.

3. Geographical Considerations and Defences

Walcheren Island resembles a square saucer. The centre portion is below sea level and the high steep sand dunes and massive artificial dykes which keep out the sea represent the rim of the saucer. Middelburg, near the centre, and the port of Flushing, at one corner, are the only large centres of population.

The interior of the island is flat and much intersected by small ditches and dykes, while the Germans had erected large numbers of anti-landing poles and wire to add to the difficulty of movement.

Minefields abounded, and were chiefly sited in the sand dunes between the coastal batteries, but some fields were known to be inland.

Conflicting reports had been received about the presence of flame-throwers, but these were found in the sandhills wherever there was a defile up which troops or tanks might possibly have climbed. They were sited in groups of up to eight and were wired for electric firing from remote control points.

However, even in the area of the Westkapelle landing, none were operated as far as is known.

4. Flooding

It was decided, reluctantly, that in order to save casualties it would be necessary to breach the sea walls and so flood the centre of the island. This would have the effect of isolating, and perhaps drowning, batteries in the centre of the island, preventing counter-attacks and the movement of reinforcements and of lowering the morale of the defenders, who already referred to the place as a " penal settlement."

The first attacks were made by the R.A.F. against the dykes near Westkapelle, and a breach was made some three weeks before the operation was due to start. Subsequently three more breaches were made in different parts of the island and the original one was widened to about 300 yards. As a result practically the whole of the centre of the island was flooded by the end of October, and at high tide water poured in through the gaps and at low tide there was a very strong flow seawards through well defined channels about 5 feet deep.

5. Transport

Even before the flooding, movement off the roads was practically impossible in wheeled vehicles, so it was decided to use nothing but amphibious craft, which had a good performance on mud or sand and which could swim in the sea, if necessary, and be landed from L.C.T.'s. The only other vehicles to be landed were flails, A.V.R.E.'s and bulldozers—all tracked machines.

The two types of amphibians chosen were L.V.T.'s, which could take a load of 4–5 tons or 25 armed men, and Weasels, which could carry three passengers in addition to the driver or a load of about 10 cwt. Both were tracked vehicles, the L.C.T. having rather a narrow track with large grousers, which were very destructive to brick or pave roads, and the Weasel a wide track of 22 inches with a resulting very low bearing pressure. The performance of these craft was astonishingly good, the L.V.T. being much more suited to the water, in which it could negotiate cross currents of 6 knots or more, sometimes fully floating, sometimes partly waterborne and partly crawling on sand or mud banks. On land the Weasel resembled the Jeep in its ability to climb anything and manœuvre through the smallest opening. It swam well in calm water, but was not safe in strong currents or rough water.

In fact these two amphibians corresponded to the three-ton lorry and the jeep and were used as such. The chief drawbacks were, in both types, the inability to climb out of water, in which they were floating, on to a bank unless it was ramped down so that the tracks could get a good grip on the ground under the water as they approached the bank, and in the case of the L.V.T. the damage which was done to the track grousers if any distance was covered on hard roads. The grousers became broken or crushed and, although the cross country performance was not greatly affected, swimming performance was much reduced.

6. Plan

The plan was frequently varied in detail during the planning stage, but the main outline was the same. This involved a landing of three or four Commandos of 4 S.S. Bde. in or near the Westkapelle gap, a movement along the dyke and sand dunes, north towards the Domburg batteries and south through Zoutelande towards Flushing, and the destruction of the batteries *en route*.

At a later date, when identifications of prisoners in other places indicated that some of the island defenders had been used elsewhere, it was decided to make, in addition, a preliminary attack on Flushing and to work towards Westkapelle after the capture of the port.

7. R.E. Tasks

The R.E. tasks divided themselves into four main parts :—

- (i) To assist the Commandos to get through beach obstacles and other obstacles and minefields inland, and to assist in the destruction of pillboxes, casemates and strongpoints.
- (ii) To carry out all engineer work in connection with the landing of stores, the operation of the B.M.A. and the opening and maintenance of supply routes and the provision of water.
- (iii) To operate the L.V.T.'s.
- (iv) To land A.V.R.E.'s so as to assist in the capture of Westkapelle.

These last two were done by Assault R.E. It is not proposed to deal with their work in these notes.

As the Sappers available for the operation had come from a " follow-up " Division in the Normandy landing the work was unfamiliar. An allotment was made of one platoon to each of four Commandos and one section to a fifth, to give assistance during landing and subsequent operations, thus leaving only one Fd. Coy., less 2 pls., and one Fd. Coy., less 2 pls. and one Sec., for work in the B.M.A. in the early stages of the attack. The bulk of the R.E. force was to report to the command of the C.R.E. after the initial landing.

The work envisaged there was the clearance of one maintenance beach of obstacles, the levelling off of an area of sand dunes for the stores layout, the setting up of a water storage point (see para. 10) and miscellaneous jobs such as the construction of P.O.W. cages, signing and marking of routes and dumps. A generous allotment of six bulldozers was made, and it was considered that if four of these were landed safely the work could be done easily.

In point of fact, the Sappers who went in support of the Commandos did not have much engineer work to do and were frequently used as infantry—one L/Cpl. single-handed captured a pillbox with seven occupants, to his great delight—and as load carriers, while the Sappers in the B.M.A. whose bulldozers failed to materialize were unable to keep pace with the work, which was considerably increased by the loss of stores and equipment and by bad weather.

If another similar operation were to be undertaken an allotment of two sections per Commando would be considered ample, except where a special task is proposed.

It was decided that the Sappers supporting the Commandos should carry heavy explosive charges, such as Gen. Wades and 30 lb. beehives, to be used against enemy emplacements, but actually none were needed for this purpose as all concrete defences were captured with grenade and bayonet.

8. Training

Although no landing rehearsals were possible, Sappers and Commandos were able to train together for two or three weeks on sand dunes, very similar to those on the island, including minefields and concrete defences. This training period was invaluable as the various teams got to know each other thoroughly and a good state of physical fitness was reached, which was very necessary because of the great strain of continual movement up and down sandhills of loose sand.

9. Stores

R.E. Stores estimates were prepared as follows :—

(*a*) To be carried on the man in the actual landing.
(*b*) To be landed on D day to last until D + 6.
(*c*) Stores for D + 7 to D + 13 } held at Ostend for delivery
(*d*) Stores for D + 14 to D + 21 } to Walcheren after D + 2.
(*e*) Stores for one R.E. Pl. for 21 days to be held at Breskens for use by the Commando and attached R.E., which landed at Flushing.

In view of the fact that there were to be no wheeled vehicles and that the amphibians were equally at home on sand, mud, or water, it was not considered necessary to take Sommerfeld track, chespale or other track materials in any quantity. Although small supplies were landed on D day, they were taken in case of emergency, and actually those which survived the landing were never required.

Explosives formed the bulk of the engineer stores and were essential for clearing beaches, gapping anti-tank obstacles, breaching wire, etc. Use was also made of captured German explosives, shells and hand grenades from pillboxes. Small waterproof made-up charges, connected together by cordtex strands, were invaluable for the rapid destruction of beach obstacles, particularly those under water.

It is hardly necessary to stress the need on any operation for enormous quantities of tracing tape, notice boards, paint and brushes. This one was no exception.

No. 4 Polish mine detectors were asked for for two reasons, firstly, because they would not be affected by water in the event of a difficult landing and, secondly because reports of the minefields suggested that schu-mines were common and their greater sensitivity would be of special use.

One way in which the C.R.E. erred may be of interest and of value to others. Indents were made out for P.M.D. No. 4 and not, as should have been done, for P.M.D. No. 4, complete with batteries, plus 100% spare batteries. As a result, a few days before sailing the detectors arrived without any batteries at all and it was only with the greatest difficulty that an inadequate supply was collected.

As the result of much experience of clearing mine-fields in the Ostend area, where every known type of mine was encountered, an ideal type of mine prodder was evolved for use in sand.

The standard type is too heavy and clumsy for use with schu-mines and an 18 inch length of steel wire, about 10 or 11 gauge, with a suitable handle of wood, or bound on to tracing tape, proved light and portable, very delicate in use, and penetrated the sand easily.

The planning instructions laid down that stores loads were to be kept down to two man loads, but as this was impossible in the case of such items as Sommerfeld track, water storage tanks, etc., it was arranged that the heavier items should be carried on sledges to be towed by the bulldozers.

10. Water

On the island it was likely to be a case of " Water, water everywhere nor any drop to drink " owing to the flooding of the land with sea water and the smashing of water mains by bombing. It was arranged therefore that water in jerricans should be included in the supplies, sufficient to give a ration of half a gallon per man per day for all purposes for the first three days, and that a total of about 9,000 gallons should be carried in the tanks of the three L.C.T.'s carrying stores. R.E. Stores were to include four sets of standard nesting tanks (total capacity 12,000 gallons) and two Mk. IV pumping sets. These tanks were to be fitted with bibcocks and erected on shore close to the L.C.T.'s, when they beached, and the water was to be pumped into them so as to give about 6 days supply at the same ration rate.

There was a water pumping station in the sand dunes between Zoutelande and Flushing and it was hoped that it would be sufficiently undamaged, when eventually reached, to give an ample supply. The Germans were known to store water in their strongpoints, but, as this was a totally unknown quantity, it was regarded as a bonus only to offset the needs of prisoners, civilians, etc.

11. Landing Beaches

It had been arranged that four teams, each consisting of flails, A.V.R.E.'s and a bulldozer, should land on the Westkapelle dyke assisted by Naval L.C.O.C.U.'s, that one of the C.R.E.'s six bulldozers should land on the left hand side of the gap as seen from the sea, and that the remaining five bulldozers should be landed on the right-hand side of the gap, where they would be needed for the development of the B.M.A., the clearance of maintenance beaches and the opening up of routes.

It was considered from a study of air photos that, apart from the dyke which was known to be faced with stone, the gap would probably have a fairly level sandy surface which should present no difficulties to tracked vehicles.

All information received suggested that there were no minefields in the immediate vicinity of the gap.

THE OPERATION

12. The Landing

The landing at Flushing was successful, though underwater obstacles holed some of the L.C.T.'s and the Sappers, at any rate, had to wade ashore in deep water. However, they were able to get their stores ashore and carried out their task of clearing the beach of obstacles, ready for the follow-up brigade, most successfully and luckily without casualties, though they were under machine gun and mortar fire. No bulldozers could be got ashore at this stage and all clearance work was done with explosive charges, mostly made up before landing.

At Westkapelle the landing was scheduled for 0945 hrs. on 1st November, 1944, but, owing to a delay in the arrival of the supporting aircraft, took place about half an hour late. There was a good deal of enemy shelling and many of the Naval support craft, which did a magnificent job, were damaged or sunk. However, the first two Commandos with their supporting Sappers got ashore and quickly secured the two flanks of the gap.

It was then that a great Sapper tragedy occurred. The L.C.T.'s were nearly all beached at the left hand edge of the gap and four of the C.R.E.'s six bulldozers landed here straight into a patch of mud below high water. The teams of flails, A.V.R.E.'s with their four bulldozers also landed here. Of the total of eight bulldozers only two managed to scramble through the mud and on to the dyke and though an attempt was made to tow out some of those which were bogged it was unavailing and the rising tide drowned them all together with several flails and A.V.R.E.'s. One survivor belonged to the C.R.E. and one to the Assault R.E.

Only one bulldozer was landed on the right-hand side of the gap and in wading through shallow water on a firm sandy beach it unfortunately fell into a submerged crater and was drowned.

One bulldozer was never landed because the craft carrying it was hit and returned to Ostend, where it remained throughout the operation.

Thus the C.R.E. within a few minutes of landing was left with one bulldozer out of six, and that one was on the wrong side of a channel which varied from a 100 ft. wide, 5 ft deep stream of 6 knots at low tide, to a gap of 300 yards wide, with sea rollers, at high tide.

To make matters worse the Assault R.E. bulldozer was shortly afterwards blown up on a mine and was *hors de combat*.

These were not the only misfortunes for all the four sledges were lost and their contents were not recovered until the next low tide. Most of the nesting tanks were saved, but the two pumping sets were ruined by submersion in the salt water, and, as if this was not enough, they were burnt out next day when shell-fire set an L.V.T., carrying ammunition, on fire.

Three L.C.T.'s each carrying R.E. Stores, ammunition, supplies, petrol and water were scheduled to arrive on the afternoon of D day but, in fact, one was sunk by a mine, and the other two did not arrive until 0300 hrs. on D + 2, after an unsuccessful attempt to land in daylight on D + 1, when heavy shell fire forced them to withdraw.

Added to this, of the 5 L.V.T.'s allotted to R.E. for the transportation of stores, only one got ashore safely, and that one belonged to H.Q.R.E. and the Fd. Pk. Stores detachment. The remaining four were accounted for as follows : One was on an L.C.T. which was hit by shell fire and had to return to Ostend with all its L.V.T.'s still on board. One was drowned while crossing the gap. One was blown up on a mine and immediately brewed up and one had its track blown off on a mine. Thus practically all R.E. officers and men landed safely, but with very little plant and equipment with which to work.

13. Mines

The first task at Westkapelle was to clear an area for the B.M.A. and F.D.S. and unfortunately the only possible site was pitted with very deep craters and covered with mines which took toll of the first L.V.T.'s to arrive and of several personnel including the A.D.M.S.

A lane for vehicles was soon cleared by Sappers using No. 4 mine detectors and prodders, and work was started to level off by hand an area for the R.A.M.C. and the stores.

Unfortunately another L.V.T. was mined, this time in the cleared lane and a further sweeping produced one or two mines which had not been found on the first search.

These mines were Holz mines mixed with a few schu-mines and it soon became evident that they were buried up to four feet deep, or rather in the course of months sand had silted over them to that depth in some places and less in others. This made clearance very difficult as the sand kept rutting and sinking under the weight of the L.V.T.'s and periodically a mine which had been beyond the reach of detectors and prodders would come into the danger zone and another vehicle would be destroyed. As no other path was possible at this time it was necessary to sweep and prod the vehicle lane at two-hour intervals and each time one or two mines were discovered.

A neighbouring field had French A/Tk mines laid in pairs, and again these were deeply buried, and some at least were outside the minefield marking fence and later caused the loss of a bulldozer.

On the sand dunes buried shells were found under the double apron fence which marked one minefield. Some of the pickets supporting the wire were screwed into the fuze caps of the shells and arranged so that movement out of the vertical, such as would be produced by a man pulling them, would detonate the shells.

14. Beach Clearance

On D + 1 the P.B.M. asked for a new beach to be cleared and, as it was covered with Element " C," and had a double row of wooden poles set in the stone face of the dyke at the back of the beach, it was considered essential to get a bulldozer to work. The L.C.O.C.U. parties started to blow up the element " C," but it was a slow process and very dangerous to the rest of the men in the area, and projecting pieces of steel were left firmly embedded in the sand.

A successful attempt was therefore made to transfer the sole remaining bulldozer from across the channel at low tide and it arrived amidst loud cheers, but not before the water had risen to the windows in the operator's compartment.

Once there it did noble work on the beach removing the element " C " and cutting off the wooden posts in about half an hour, working on a slippery basalt faced side slope of one in ten. Next day a similar operation on an adjacent beach took one platoon, armed with explosives and Danarm and hand saws, a whole morning.

15. B.M.A.

The invaluable bulldozer then started work on the B.M.A., first cutting a road from the top of the sand hills to the sea level on the landward side of the dunes, so as to provide a mine free route for L.V.T.'s to reach the stores area, and later filled up some of the worst of the craters. This was not easy, as the sand was very loose and the craters closely spaced, so that room for manœuvre was much restricted, and twice the machine fell into a crater and was only recovered after much digging by German prisoners.

Bad luck still dogged the bulldozers for the sole survivor was then mined and the track was damaged beyond repair.

16. Routes

The battle moved away from the B.M.A. southwards to Zoutelande and Flushing, and northwards across the gap towards Domburg. All stores had to be taken to the forward units in L.V.T.'s and in the southern direction there was no road except the last quarter of a mile into Zoutelande, all the rest being under water. The L.V.T.'s soon beat down a rough track along the foot of the sand hills on the land side, and this was a switchback affair which wound between craters, minefields and flooded areas in a crazy manner. Later it continued beyond Zoutelande across the breach in the dyke near Flushing into the town.

The going was so bad that a journey of 4 kilometres took well over half an hour in a weasel at first, and was practically impossible at night except on foot.

Sappers were soon sent to improve the route, but it was very hard and slow work without any mechanical equipment, and after two days the combined efforts of two platoons was very unimpressive. Nevertheless the going was improved, though the L.V.T.'s were most destructive at corners and on the brick on edge roads through and beyond Zoutelande.

On the evening of D + 5 three more bulldozers were landed on an extremely awkward beach, south of Westkapelle gap, and it took twelve hours to get them to the route for work and even then one was very temperamental and needed a good deal of attention, and a second was blown up on a mine next morning.

The bulldozer in soft sand can do more harm than good, unless the operator is very experienced, and sometimes the result of an hour's work was worse than the original state. An auto-patrol would have been invaluable and should certainly be demanded on any future expedition of the same kind.

The northern route to Domburg, once the gap was crossed, had been badly damaged in places by bombs and shells. However, there were not enough Sappers to put to work on this stretch.

17. Water

The original plan of pumping water from the stores L.C.T.'s into storage tanks was carried out, but as most of the nesting tanks had been damaged during the landing or subsequently by shell fire, only 3,000 gallons of water was pumped ashore.

On about D + 4 a gale produced such a high tide and strong waves that part of the B.M.A. was flooded and all the fresh water not in jerricans was lost, but luckily by this time an ample supply had been found on land. A recce. of the pumping station south of Zoutelande showed that, though the pumps were out of action owing to failure of electricity supply, the wells were intact and there was an underground reservoir containing a very large quantity of pure drinking water.

A water point was set up here consisting of six of the standard German water tanks, which were collected from various living bunkers in the neighbourhood, and fitted with the three nozzle can-filling fittings. This gave a capacity of about 1,500 gallons of water.

An old I.C. engined pumping set was found and used to pump water from the reservoir into the storage tanks and a No. 4 Pumping Set was brought over from Flushing to act as a standby.

Empty jerricans were collected and sent by L.V.T. to the Water Point for filling and were then delivered to units.

In the Domburg area, which was a long way away, there were a number of small wells in the German defence areas, some of which were fitted with hand pumps. These wells supplied the needs of the troops fighting in the vicinity.

18. Equipment

Various types of equipment for the man were used.

(i) *Dennison Smock.*—This was excellent in every way. It kept out the wind, was showerproof, was comfortable and had large pockets. The coat, reversible, is even better.

(ii) *Assault Jerkin.*—This is very good for the assault troops as it gives ample accommodation for personal equipment and for special loads such as made up charges, detonator tins, small tools, etc., is comfortable to wear and can be taken off quickly without fear of losing the component parts.

(iii) *Everest Packs.*—These were used for carrying heavier loads and made a comfortable means of carrying an awkward package, such as a compo pack or a 30 lb. beehive.

(iv) *The Yukon Pack* was used in training but was discarded as uncomfortable and inferior to items (ii) and (iii).

19. Conclusions

(i) In an operation of this kind extreme flexibility of plan is essential. In spite of a month of preparation, few things went as arranged from an R.E. point of view, and numerous unforeseen contingencies had to be faced. This had been realized beforehand and was impressed on all officers.

(ii) It is also essential to plan the carriage of stores so that the utmost dispersion among all the available craft is obtained. This may mean asking for more stores than are actually necessary, in order to be sure that enough are eventually available. Although this point had been considered it was not adhered to sufficiently, as realized later.

(iii) In this operation there was no R.E. unit detailed solely for work in the beach area. So many problems arose in connection with beach clearance, unloading of craft, mine sweeping in the B.M.A., disposal of P.O.W., etc., that the C.R.E.'s slender Sapper resources were severely strained and it was difficult to deal properly with the equally vital tasks of support to the infantry, maintenance of routes and water supply.

(iv) The military training of Sappers must not be neglected. On numerous occasions they had to act as infantry and use all their personal weapons.

(v) Every Sapper should have a working knowledge of all German explosives and accessories. So much was captured in the various defended positions that there was never a shortage of explosives in spite of the great use that was made of them.

(vi) Every man including cooks and clerks should carry ashore waterproofed initiation sets.

(vii) The No. 4 Polish Mine Detector is excellent. One was salvaged after being under the sea for four days and worked perfectly.

R.E. WORK IN THRACE

Between May, 1940, and May, 1941

By Brig. G. B. Gifford Hull, C.B.E.

Preliminary

THE formation of the Construction Parties in Turkey was the outcome of an Agreement made between military representatives of Britain, France and Turkey at a Conference which was held at Aleppo, Syria, from March 15th-20th, 1940, to discuss in detailed terms the provision of Allied Military aid to Turkey, which had been discussed in general terms in Cairo during the previous month.

After the meeting had agreed on the various hypotheses to be discussed, the French and British representatives emphasized that lack of port facilities and of communications, limited the amount of Allied aid to a maximum of 5 Divisions, and that even this would not be possible until adequate port works had been constructed along the north coast of the Dardanelles, between Eceabat and Gelibolu; and a first class asphalt road built from the Port to, at least, as far north as Uzunkopru, in the vicinity of which place it was expected that Allied Troops would occupy positions.

The discussions were continued within the framework of a combined aid of 5 Divisions, one of which would be armoured, the Allied Troops occupying positions west and south of a line Uzunkopru—Sarkoy.

The Conference also considered the question of Air Support, and the construction of both dry-weather and all-weather landing grounds in Thrace and Anatolia.

It was ultimately agreed that the Allies and the Turks should co-operate in the building of the Road, Port works and Airfields, the Allies to supply the necessary plant, stores, etc., together with technical assistance, the Turks supplying skilled and unskilled labour and such raw material, such as stone and sand, as was available in Turkey.

The works allotted to the British consisted of the Road between Eceabat and Havsa, a distance of 207 Km.; Port works at Kilya and Gelibolu, and Airfields in Anatolia; and the British undertook to supply M.T., plant, material and stores to the value of £70,000 for the works in Thrace and to the value of £100,000 for the works in Anatolia.

The British stated that the time required for the completion of the Road and Port works in Thrace was five months, and tabled lists showing the plant and materials which would be provided by the British, and the amount of skilled and unskilled labour expected from the Turks, required for the completion of the Road in this period.

Reconnaissance

There already existed a rough dry-weather track, between Eceabat and Havsa, about 25 Km. of which were lightly metalled to a width of 4 metres to form a second-class macadam road, and at the end of February, 1940, two R.E. officers made a two-day reconnaissance along it. At that time the road was covered with snow, and the conditions for a reconnaissance were as unfavourable as could be, particularly from the point of view of ascertaining, even approximately, the location of suitable stone deposits and obtaining a rough idea of their possible output; and this important information was not obtained. It was assumed, however, that sufficient stone would be found, and in estimating the M.T. required an allowance was made to cover the probable average distance from quarries to Road. This allowance proved to be very wide of the mark, the average distance of stone deposits from the line of the Road being 60% greater than that estimated or guessed, which caused a proportionate reduction in the amount of stone which could be hauled per lorry per day, from the amount estimated.

It appears to have been generally thought that to have any military value the Road had to be finished before September, 1940, and the calculations of plant required were made on this basis. This involved the quarrying, transport and laying of 4,000 cubic metres of stone daily, with a corresponding number of compressors and drills to quarry it, lorries to haul it, rollers, crushers, bitumen, mixers and boilers, etc. It meant, also, that bitumen, and P.O.L. supplies had to be shipped from Egypt at the required rate. The anticipated rate of progress greatly exceeded anything previously accomplished on a Road to the proposed Specification in Europe or even in America, where experienced operatives make rapid road building possible; and in view of the lack of information about stone, uncertainties with regard to weather and labour, particularly the skilled labour for driving and maintaining M.T., the assumption that so high a rate of progress could be maintained was not justified.

Nevertheless, the reconnaissance report stated that given 10,000 men and 800 drivers, and the amount of plant and stores therein listed, a first-class tar-mac road, 6 m. wide and 207 Km. long, together with all bridges and culverts necessary, could be completed by the end of August, 1940, provided work started at the beginning of April.

This period of construction—5 months—was given at the Aleppo Conference and, later, the Turks were given a list of plant and equipment which the British would supply and which was based on the above-mentioned period of construction.

The Reconnaissance party assumed that the Road would closely follow the alignment of the existing Road or track, except in two places where the track followed the coast and the hillside above it is susceptible to slips. They therefore made no provision in their estimated time of completion for other deviations or any major re-grading, rightly considering that as the Road was required primarily for military purposes the present alignment and grading—both of which were good—were adequate. Experience proved that this did not coincide with the views of the Turks.

Construction

The work allocated to No. 1 Construction Party consisted of:—

(*a*) A tar-mac Road from Eceabat (Maidos), a small coastal village on the north side of the Dardanelles opposite Canakkale, to Havsa, a small town 30 Km. from the Greek Frontier on the main road from Edirne (Adrianople) to Istanbul. The length of the road was 207 Km. and its width 6 metres. It was to consist of 0.25 m. of soling, 0.10 m. of crushed stone pre-mixed with bitumen, and surfaced with a wearing coat of 0.02 m. of chippings. Thirteen bridges of various spans and 253 culverts were required.

(*b*) Three jetties with a minimum of 8 ft. of water, for lighters, and one mole, 600 ft. long and 40 ft. wide, and with a length of 400 ft. and 26 ft. of water, for ocean-going ships. These were to be constructed in Kilya Bay, 3 Km. north of Maidos.

The condition of its completion by the end of August was that work should start in April. A Construction Party consisting of 7 Officers and 60 O.R. arrived in Istanbul at the end of April and the first consignment of M.T., plant and stores and tentage at the beginning of May. Part of the plant, and stores, were sent to Kilya by water and part to Uzunkopru by rail, while the M.T. and caterpillar tractors were driven by members of the Party via Tekirdag and Malkara to Kesan, part being taken south to Kilya, the rest north to Uzunkopru. The journey of about 350 Km. took 5 days, due to the very bad state of the roads beyond Tekirdag after heavy rain, many vehicles being bogged.

By the middle of May, the Party was established in tented camps at Kilya and Uzunkopru respectively.

It was initially intended that the British should organize and supervise the work on the Road, operating and maintaining the plant and equipment and that the Turks would supply labour and raw material; but before the Party arrived in Turkey, the Turkish Government had decided to let the whole of the work out to contract and to use the Staff of the Public Works Department (known as the Nafia) to supervise it; and at the time of arrival of the Party the relative contract documents were on the point of completion.

The Director of the Nafia explained that the "direct labour" method of carrying out work had been tried on a previous occasion and that it had proved to be unsatisfactory. The Minister had therefore decided to adopt the contract method and had selected the biggest Contractor in Turkey, one who had satisfactorily carried out a large Government Railway Contract, to do the Roadwork. He was confident that this method would be entirely successful and that no other method would. This radically altered the conditions under which the British had expected to work and virtually limited their interposition to the supply of materials and stores.

The Contractor's representative first came to the site of the work at the end of May and at an interview with him early in June he stated that 5,000 men would be working by mid-June and 10,000 men by the end of June; and that he proposed, altogether, to employ 12,000 men. He undertook to produce a programme of work on June 15th.

Meanwhile the British and Turkish engineers occupied their time in searching for stone deposits. Five were found between Havsa and Kavak, a distance of 135 Km., these varying between 3 and 30 Km. from the line of the Road with no access tracks to them. Except for a deposit of soft stone under 20 ft. of overburden near Gelibolu and a soft stone cliff at Akbasi no stone was found south of Kavak, and it began to appear that for the bulk of this length of 75 Km. stone would have to be brought from Anatolia and that jetties for unloading it would have to be built at various places along the coast.

On June 15th, British officers proceeded to Gelibolu for the purpose of discussing the Contractor's programme of work promised for that day and had meanwhile prepared a programme themselves covering the use of plant and M.T., with special reference to its maintenance, with the idea of assisting the Turks as much as possible. The Contractor, however, had not prepared a programme and had no plan or proposed method of construction to discuss. He excused himself by saying that the Nafia had not yet fulfilled their obligation under the contract of stating where the stone was to be obtained, and until he knew this a quarrying and haulage programme could not be prepared. This was unanswerable. The Chief Engineer of the Nafia then announced that the Nafia had decided that the stone for the southern section should come from the Island of Marmara and that a programme could be completed when agreement between the Nafia and the Contractor had been reached on the question of cost of water transport.

Instead of the promised 5,000, the Contractor now had about 1,000 men at work, chiefly engaged on preparing "service roads," that is, dirt tracks across fields and roughly parallel to the line of the Road, which were to be used for the haulage of stone, with similar tracks leading to the stone deposits.

Although at the Aleppo conference the road was regarded as a necessary military work, in deciding that the responsibility for its construction should be given to the Nafia, the Turkish General Staff did not, apparently, emphasize the military aspect, and it was not until late in the season when Marshal Chakmak visited the Road and made some very pungent comments about progress, that the Nafia ceased to regard it purely from their own point of view.

Starting from Gelibolu on June 17th, the Director of the Department made a 4-day tour of the work. A meeting previously took place at Gelibolu at which the Director showed the C.R.E. a programme of work which had been hurriedly and jointly prepared for his visit by the C.E. of the Nafia and the Contractor. As the programme showed no provision for the maintenance of vehicles, it was pointed out to him that without regular attention and maintenance lorries could not withstand the severe conditions of service, having in mind the very rough tracks over which they would have to travel, and that it was essential that the proposal for the establishment and operation of maintenance depots, which had been prepared by the British, should be adopted. The Director said that the importance of maintenance had been fully recognized when preparing the contract and a clause covering it had been included. He stated that he did not wish the British to interfere in any way in this matter as he was afraid that the Contractor would use that intervention as an excuse for evading his own responsibilities and serious trouble would result, as he himself would lose his control of the work which the contract gave him.

It was clear that the Director had complete confidence in the ability of the Contractor to fulfil his contract. All he wanted from the British was the amount of plant, etc., which they had undertaken to supply. The Turks could do the rest.

The Nafia Contractor programme showed that all the stone required for the Road would be quarried and delivered by August and the soling laid. The top metal would be broken and distributed, but its mixing with bitumen and laying as tar-mac, depended upon the bitumen, boilers, mixers, and rollers which were to be supplied by the British and of which only a small proportion had so far been sent. The programme was based on estimated figures of daily output from quarries, furnished by the Contractor and agreed to by the Nafia. During the tour, the five stone deposits, which were then being worked, were visited, and it was apparent from the quarrying methods adopted that the daily outputs given to them under the programme could not be reached if those methods continued. At none of the quarries had the Contractor made any provision whatever for the sharpening of steel, a most essential feature of quarrying. It was abundantly clear that the Contractor did not understand quarrying and that the high outputs expected from the quarries could not possibly be reached; and both during the tour with practical demonstration and on paper at its conclusion, the C.R.E. showed the Director that his programme was certain to break down and urged him to instruct the Contractor to adopt conventional methods. He replied that he could not do so. The methods were those best suited to Turkey and to Turkish labour. Though they might appear crude, their crudity could be overcome by employing sufficient labour and he was satisfied that this could be done, that the outputs would be reached and the programme completed. He in turn urged the C.R.E. not to intervene and to give the Nafia and Contractor an opportunity of showing what they could do; and to do all possible himself to expedite the delivery of that part of the promised plant and equipment which had not yet been delivered. It was clear from this attitude that only the acid test of experience would convince him that the Nafia programme could not be met; clear also that until that test had shown who was right and who was wrong, there was little use in requesting the Military Attaché to take action through the T.G.S. The time was not ripe.

Having regard to the reduction in stone output which must follow the lack of sharp drill steel, and the Contractor's ignorance of its importance, the British decided to offer a free drill-sharpening service to sub-contractors, and to set up a sharpening centre for this purpose; and at the same time to give a course of instruction to selected Turkish blacksmiths in the operation and maintenance of mechanical sharpeners. The plant was set up at Kurudag, a district 17 km. south of Kesan, handy to three of the quarry access roads. Blunt steels were collected from the various sub-contractors, sharpened and delivered to their camps alongside the main road. It proved to be a very successful service. A repair shop for M.T. operated by R.A.O.C. personnel was also established at Kurudag and although it was against the wishes of the Nafia as it infringed the terms of the contract, repairs to M.T. were effected when authorized by the C.E. of the Nafia.

The Contractor divided the work into 13 sub-contracts starting from the northern end where stone was first found. In conjunction with the Nafia he allotted to each sub-contractor vehicles and plant proportionate to the amount of stone which each had to quarry and transport and made them responsible for engaging, accommodating, feeding and paying labour; and with regard to his responsibility for the maintenance of M.T. it was arranged with the Nafia that he would supply skilled drivers, each of whom would be capable of maintaining his own vehicle. But as great demands were made by the Turkish Army on this comparatively rare class of man, he could not find enough of them.

His value to the work appeared to be negligible. He received free plant, equipment, tools, lorries, spare parts, petrol and lubricating oils. He was not called upon to exercise more than a very modest proportion of his reputed financial strength in spending money on preliminaries. He had no experienced staff, no one who knew how to operate the special plant supplied by the British or how stone deposits should be developed; and never visited the work himself.

All he seemed to have was political influence, which is a useless qualification for meeting engineering difficulties.

Events proved that the confidence the Nafia officials had in him was entirely misplaced. It is difficult to see how this could have been anticipated by the British, or, if it had been, how the signing of the contract could have been prevented. The acid test referred to above had not, at the time of signing the contract, been made.

Before the end of July, however, it had. By then it was abundantly clear from the records of quarry outputs available that the daily amount of stone obtainable would not reach one half of the programme amount. Many lorries were off the road from bad driving, overloading, and lack of maintenance. The number of men employed had not reached half of the 10,000 promised for the end of June. Work on the southern side of the road had not been started, or even been set out, and only two months remained in which to finish the work in the time given at Aleppo.

Handicapped by the scarcity of stone and the shortage of both skilled and unskilled labour, and by various other lacunae such as tyres, explosives, spare parts, bitumen plant and rollers, the job had proved to be too big for completion by the date given at Aleppo. The time thus seemed propitious for a review of all phases of the work. It was proposed that a meeting should be held in Ankara between the British and the Turks at which the situation could be discussed and a combined effort made to effect improvement, particularly in the treatment of vehicles, and above all, to acknowledge that it was impossible to complete the road before the winter set in and to advise the respective Military Staffs accordingly.

But the recent entry of Italy into the war and the defection of France had introduced new problems. The British had not yet implemented their undertaking with regard to the provision of plant given at Aleppo, and with newly created and urgent commitments elsewhere, combined with the Italian menace from the Dodeconese, it seemed unlikely that this could be done in time. In answer to criticisms of Turkish working methods, non-supply of the promised labour, etc., the Turks could so easily refer to the British shortcomings, which also contributed to lack of progress. With these facts in mind and having regard also to the paramount consideration underlying the British effort in Turkey, which was the cultivation of political friendship, it seemed expedient not to enter into any controversy at this juncture; and the meeting did not take place.

Work therefore continued with no change in method, and the Contractor was left to pursue his own course unmolested. The Nafia engineers pegged out deviations involving high embankments and new bridges and the fleet of vehicles was gradually put out of action from lack of maintenance, overloading and overdriving on the rough service roads. The British did all possible with the few men available to repair vehicles by sending small parties of R.A.O.C. personnel to those stranded along the road, but could tackle only a small proportion of the whole fleet. The Nafia took no steps to force the Contractor to fulfil his contract with regard to maintenance, relying on their paper power to deduct the cost of repairs (when they were made) from money due to him.

At no time did the labour employed on the Road exceed 4,000. Due to the calling up of additional classes by the Army, coupled with the Cabinet's order to increase agricultural production, labour became very scarce. Further, some of the sub-contractors paid their workmen irregularly, and made unduly heavy deductions from wages for food, and men left the work on this account. As the southern part of the Road, that is, the length between the Port of Kilya then in process of construction, and the defence line just south of Kavak, was considered by the British to be more urgent than the northern part, the British urged that the available labour and M.T. should be concentrated in the south. The T.G.S. thought differently and instructed the Nafia to concentrate in the north, in order, apparently, to facilitate the withdrawal of Turkish troops from that area. In late Autumn the T.G.S. instructed the Nafia to concentrate on the southern end, but by then over 50 per cent of the vehicles which had been employed on the north end were out of action and could not be brought south.

Except for a small scattered deposit at Ata Tepe, a hill 15 km. inland from Akbasi, no hard stone was found between Kavak and Eceabat, a distance of about 75 kms.; and most of the stone for the road from Gelibolu had to be brought in lighters from the Island of Marmara, an average sail of 60 kms., which can only be made in fair weather. A number of small jetties were built between Akbasi and Gelibolu for unloading, and considering the many difficulties in bringing it, shortage of lighters, damage to jetties by storms, etc., the effort made by the Turks in this respect was most commendable. In an attempt to increase the sub-contractor's output of stone from Ata

Tepe, the British undertook the drilling at this quarry, using a compressor truck for the purpose. This almost doubled the output, and, incidentally, confirmed the value of this highly mobile unit. A considerable proportion of the stone supplied to the Road was got out by hand-drilling shallow holes. This naturally proved expensive in explosive, and to avoid this cost some of the quarry contractors resorted to winning the stone by bar, sledge and wedge. It says much for the physical endurance of the Turkish peasant when he will perform this arduous labour for 12 or more hours a day on a diet of bread and onions.

By various means and with considerable difficulty the quarry sub-contractors continued to worry out stone until the weather forced them to cease work. At the approach of the harvest season the peasant labour from the farms left the quarries and the road and returned to gather the harvest, returning again to the Road when it was done. In the autumn, after Marshal Chakmak's visit, orders were issued to the Nafia to prepare a "winter passage" between Havsa and Kilya, and with the help of the local sub-governors, some 600 ox and pony-drawn carts were put to work on hauling stone from quarries which were inaccessible to M.T. The sub-governors personally visited the villages and decided which of the men should remain on agricultural work, and sent the rest, and some of the women, to work on the Road. A great effort was made by the Nafia, in the too-short working period then available before winter came, to provide the "winter passage" demanded. Although much was accomplished, complete success eluded them; and interspersed between sections of laid soling, in some cases reduced to 3 metres in width in an attempt to get the passage through, were short lengths of mud which M.T. could not cross. Some of the high embankments spewed under the action of rains and soling settled into them.

Work ceased altogether by about the end of November, the weather conditions being too severe for men to live in bivouacs on the roadside, although some of the villagers worked on occasional fine days on quarrying stone for haulage next season.

The main problem at the end of the working season was the repair, during the winter, of at least enough vehicles to complete the Road in the next season. In October the British had asked the Nafia to acquire two buildings, one at Uzumbupru and one at Gelibolu which could be converted into workshops for this purpose and the Nafia had undertaken to have these ready by the end of November, but they had no funds available for it, and the British had to help by supplying such construction material as they had spare. At length the Cabinet voted money to the Nafia and after many irritating delays rough workshop buildings were available at the end of January—two months late. They were at once equipped by the British with workshop machinery and tools. The Nafia had undertaken to provide 62 mechanics, and with the first few, work began early in February. The strength of Turkish mechanics was finally brought up to 40, less than half of them being experienced. These were divided between Uzunkopru and Gelibolu, taught and supervised at each place by 3 R.A.O.C. personnel. Certain of the Infantry drivers who had shown aptitude as fitters were also put to work on repairs. Only a small quantity of spare parts had been originally sent with the vehicles from Egypt and it had not been possible to obtain more, but by cannibalism and local manufacutre, sufficient were found to repair lorries at the rate of 6–8 per week.

At the same time R.E. machinery, such as compressors, rollers, etc., was overhauled and reconditioned, 2 R.E. fitters, 2 Infantry drivers and 8 Turks being the total force available for this work. The work done in the trying winter conditions by the repair parties was excellent and when winter ended in March, and it was possible to recommence work on the Road, 82 vehicles, 8 rollers and 4 compressors had been reconditioned, as well as drills and other small plant.

Because of the neglect and the treatment of M.T. and plant, by the Contractor, and his general incompetence, the British decided to ask for his removal from the remainder of the work, and on January 22nd, 1941, a meeting between the C.R.E. and the Director of the Department took place in Ankara to discuss this. It emerged at the meeting that the Contractor had countered criticism for not fulfilling his contract by showing that he had actually exceeded the contract quantities and against the contract figure of 700,000 cub. metres of earthworks had done 800,000; had built 400 bridges and culverts against 266 and had done 30% more haulage, and he had blamed British deficiencies in the supply of rollers, tyres, etc., for the general delay. The Director said that if the contract were terminated, lengthy litigation would result and the Minister did not feel in a strong enough position to resist it successfully. The Minister had not, apparently, attached much significance to the fact that only half of the contract amount of stone had been produced, or to have enquired in what way shortage of rollers and tyres affected quarrying, nor did he appear to be unduly disturbed by the knowledge that most of the vehicles were out of action. At any rate, such obvious offsets to the Contractor's claim were not mentioned. Incidentally, it is to be noted that the extra earthworks and bridges were consequent upon the deviations which the British had sought to avoid, and the extra haulage followed the fact that the contract figure was a guess, forced by the lack of knowledge of where stone was to be found.

In spite of the Minister's dilemma, which the British recognized, the idea of handing over again to the same Contractor for the same mauling, the vehicles which the R.A.O.C. were then, under many handicaps, struggling to repair, was too repugnant to contemplate, and with the firm backing of the M.A., the British declined to do it. It became necessary, therefore, to consider an alternative method of carrying out the work, one under which the Contractor could be allowed to save his face before his political friends and prevent the litigation feared by the Minister; and one which would make reasonable progress possible. It was ultimately decided that the Director would recommend the Minister to limit the Contractor's future work to the finishing of the Road north of Kavak, he to supply his own M.T., and that the Nafia should control, through four selected contractors (those who had done best as sub-contractors during the past season), the work from Kavak south and that M.T. and plant should be concentrated on this section.

In order that the Nafia should fully appreciate the facts confronting them in their new task and to avoid ambiguities or misunderstanding, all phases of the work, from the obtaining of stone to its final rolling, were closely analysed in terms of the plant and material available and with the knowledge that it was unlikely that more would be sent. Because of deficiencies in bitumen mixing plant, the specification for part of the Road was changed to water-bound macadam with a bitumen-sprayed surface, which could be re-surfaced when conditions permitted. As crushers were not available, it was decided to break stone for the cushion by hand and as 43,000 cubic metres had to be broken in this manner, to start as soon as possible with 400 men. As storms had wrecked the jetties built to deal with stone from Marmara, and as it was thought that weather conditions would prevent water transport until April, it was decided to fill the gaps in the soling south of Galata with 14,000 cubic metres of the soft stone from the Akbasi cliffs. As the Kilya-Akbasi diversion (11 km.) which was not started till late in the past season and on which little progress had been made, could not be finished till towards the end of the coming season, it was decided to provide a usable alternative route quickly by widening the narrow coast track between these two places and soling it with the Akbasi stone. Priorities of work were established, equal priority being given to the Kilya-Akbasi section and the by-pass round Gelibolu, as that town was so congested with Turkish troops and supplies that a passage through its main street was impossible without lengthy stoppages.

It was decided also that the Nafia would adopt the proposal for the maintenance of M.T. advocated by the British in the preceding June, and that when winter ended, the Uzumburpru workshop, machinery, tools and men should be brought to Gelibolu and amalgamated with the shop there, repair work being carried out by mechanics engaged and paid by the Nafia under British guidance and control; and agreement was reached as to the number of mechanics, etc., the Nafia would provide for this work.

The Minister in due course approved the new proposals, and the Nafia lost no time in putting their part in them into effect. Freed from the incubus of a malignant contract, and with the confidence of the Military, who had adjudged the Contractor to be the chief delinquent; and supported by the Cabinet by the provision of adequate finance, the Nafia was put on its mettle and its officials and engineers admirably rose to their opportunity. They were helped by two propitious circumstances—good weather and a good supply of labour. The winter proved to be shorter than usual and was not immediately followed by the usual spring rains. Anticipating repercussions in Turkey from the battle then being fought in Greece, the T.G.S. withdrew its forces to the Bulair and Chatalja lines and evacuated the peasants from Northern Thrace, who were glad to find work in the south. Favoured thus by good luck in weather and labour, the Nafia had 1,500 men at work by the end of March. Quarrying was in progress and stone was being brought over by water to the jetties at Kilya, Galata and Gelibolu which had been built by the British. Widening and soling of the coast road between Akbasi and Kilya were in hand, and work on the main diversion had been recommenced.

The Uzunkopru workshop and its personnel had been brought to Gelibolu and three Field Maintenance Depots set up between there and Kilya. The Nafia made every effort to find the promised number of fitters and mechanics, but only partially succeeded. Nevertheless, under the instruction of the R.A.O.C. personnel the Turkish fitters soon grew more efficient and repair and maintenance work kept abreast of the work in the field.

By May, the labour force had been increased to 4,000, all employed on the southern end of the Road. Stone from Marmara Island was being brought over in steadily increasing quantities, and a newly found deposit at Fendicle, about 12 km. from the Road was being developed. The Nafia had collected 17 rollers from various parts of evacuated Thrace, which brought the number available to 30; and the general progress was excellent.

The Contractor made a lethargic start on his work, north of Kavak, in late April, using hired civilian M.T. and such military M.T. as he could recondition from those he had wrecked during the previous season. As the northern part of the Road had ceased to have immediate military significance, he was not pressed by the Nafia for rapid progress.

Except for the supervision of M.T. repairs in the Gelibolu workshops, No. 1 Party was now in a position of having no work to do, as all the jetties, 7 in number, had been built, and were in use by the Turks. On the Road most of the soling was complete, except for widening over a length of about 15 km., but there still remained to be done about half of the broken stone cushion and the surfacing, all of which was being done by the Nafia.

It was thought that M.T. repairs alone did not warrant the retention in

Thrace of officers and men who could more usefully be employed elsewhere. Besides, the occupation by the Germans of the Islands of Mitylene and Khios, the revolt in Iraq and the attack on Crete indicated the probability that they were more likely to try to reach Syria from bases in Greece and Crete, than to attempt an immediate drive through Turkey; and that in consequence, British aid would preferably take the shape of air support in Anatolia rather than the Infantry help in Thrace proposed a year ago; and therefore the construction of additional landing grounds in Anatolia was of more immediate import than additional work in Thrace.

With this regard, orders were received from Ankara to move No. 1 Party and its equipment into Anatolia, with its Headquarters at Canakkale, and to take over from No. 2 Party the construction of landing grounds north and west of Balekesir. This was accordingly done, and the work of No. 1 Party in Thrace brought to an end.

General

Setting aside its present and future military value, and its future value in the agricultural and mercantile development of N.W. Thrace, the R.E. work in Thrace can more properly be regarded as one of the means employed to establish and maintain, during a critical period of the war's development, and against severe German competition, a political friendship with the Turks, than as an engineering work carried out under normal conditions. It was one of the tools used to build a political structure, and to appraise its worth it is necessary to measure its cost, which was approximately £300,000, and the temporary loss of 7 officers and 60 other ranks to the Middle East theatre of war, against the diplomatic achievement it helped to produce.

It would be out of place, in an account of R.E. work, to comment on political struggles; but a review of the quick and momentous political and military changes which took place in the near East during 1940 and 1941, will show how gravely Turkey was menaced by them. In spite of that, Turkey stood fast, and remained completely loyal to her Agreement with Britain. It is only necessary to consider the effect on the War in the Middle East of a hostile Turkey, to appreciate the high value of the diplomacy which kept her friendly; and if the R.E. work in Turkey helped in the achievement of that position, as it was intended to do, its modest cost was justified.

THE EVOLUTION OF THE MOTORCYCLE

(Part II)

By Lieut.-Col. E. W. C. Sandes, D.S.O., M.C., R.E. (retd.)

THE first motor bicycle I ever saw was a most original machine. This was the 1¾ h.p. Singer of 1901. (See Plate 4). A model was stocked by a firm in New Brompton, who were prepared to hire it out to any young R.E. officer at 10/- an hour. The Singer was really a pedal cycle with a motor back wheel and was probably the first bicycle of British manufacture to be fitted with the low-tension magneto system developed in 1899 by Mr. F. R. Simms, who held the Bosch rights. The air-cooled engine was mounted inside a heavily dished steel or aluminium back wheel, and was supported on trunnions projecting from the crank case and attached to the ends of the frame. The wheel ran on ball bearings on one of the trunnions and had a spring chain-sprocket to lessen harshness of drive. The inlet valve was automatic, and the exhaust valve was operated mechanically by a cam on a half-speed shaft. Another cam operated a make-and-break inside the cylinder head for current supplied by a magneto on a platform behind the engine. In front of the engine was a surface carburettor with air and throttle valves. Easy starting was secured by an exhaust valve lifter operated by twisting the left hand-grip, and the same hand-grip controlled the throttle. The air valve was adjusted by a lever on the top tube. Transmission was by a forward chain drive from the engine to a hollow countershaft in the pedal crank-bracket, and thence by another chain to the back wheel sprocket. A spindle, with pedalling cranks, ran through the countershaft to which it was connected by epicyclic gearing. Lubrication was effected by a hand-pump from an oil compartment in the tank. The Singer had a low centre of gravity, but as the wheel base was only 48" and the load concentrated on the back wheel, it was liable to bounce and skid. In the original design, the engine was most inaccessible as it was enclosed almost completely in a hollow back wheel. The dished wheel, open at one side, removed this defect, though it added weight. It is believed that the Singer Company designed this machine to popularize the motor-wheel, which they hoped to apply to a number of other vehicles. It was certainly much in advance of its time, notably in its magneto ignition, handlebar control, exhaust valve lifter and oil pump, and it was a fairly reliable, if unconventional, mount.

In 1902, the 2 h.p. Werner set the fashion to the motorcycle trade. (See Plate 5). Its vertical engine was incorporated in the frame in front of the crank-bracket, an arrangement which was soon copied by most makers. The cylinder head, cast separately, contained an automatic inlet valve and a mechanical exhaust valve, in addition to a compression tap for easy starting. A pair of fly-wheels occupied the crank case, and lubrication was by hand-pump. The Werner was chiefly remarkable in having a float-feed spray carburettor, V-belt drive to the back wheel, an efficient foot-brake acting on the belt rim, and adequate mudguarding. Ignition, however, was secured by the standard accumulator and non-trembler coil. The engine could run up to 1,500 r.p.m.—a high speed for automatic-valve intake—and the whole machine weighed only 89 lbs. It was, in fact, a well designed motor bicycle and not merely a pedal cycle with a conversion set added. Of course, it had its defects, such as lack of front springing, poor silencing, a single brake and no stand. The absence of a stand was felt severely when a back-tyre puncture occurred. In such

PLATE 4.

1¾ H.P. SINGER, 1901

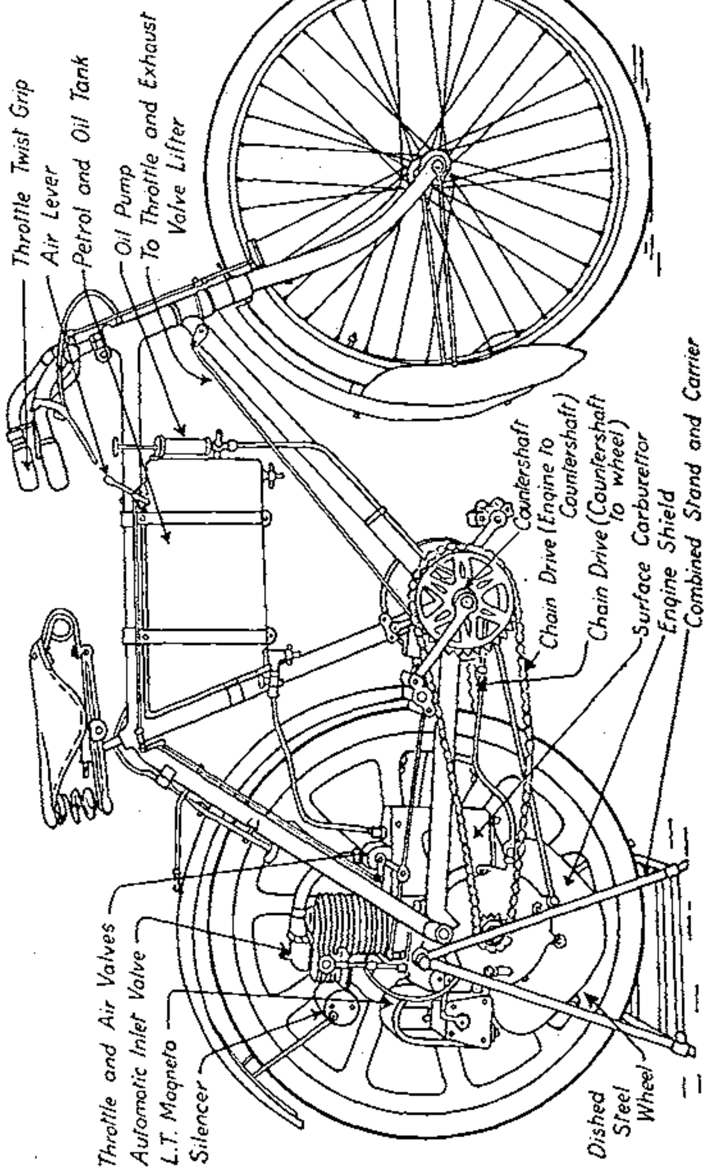
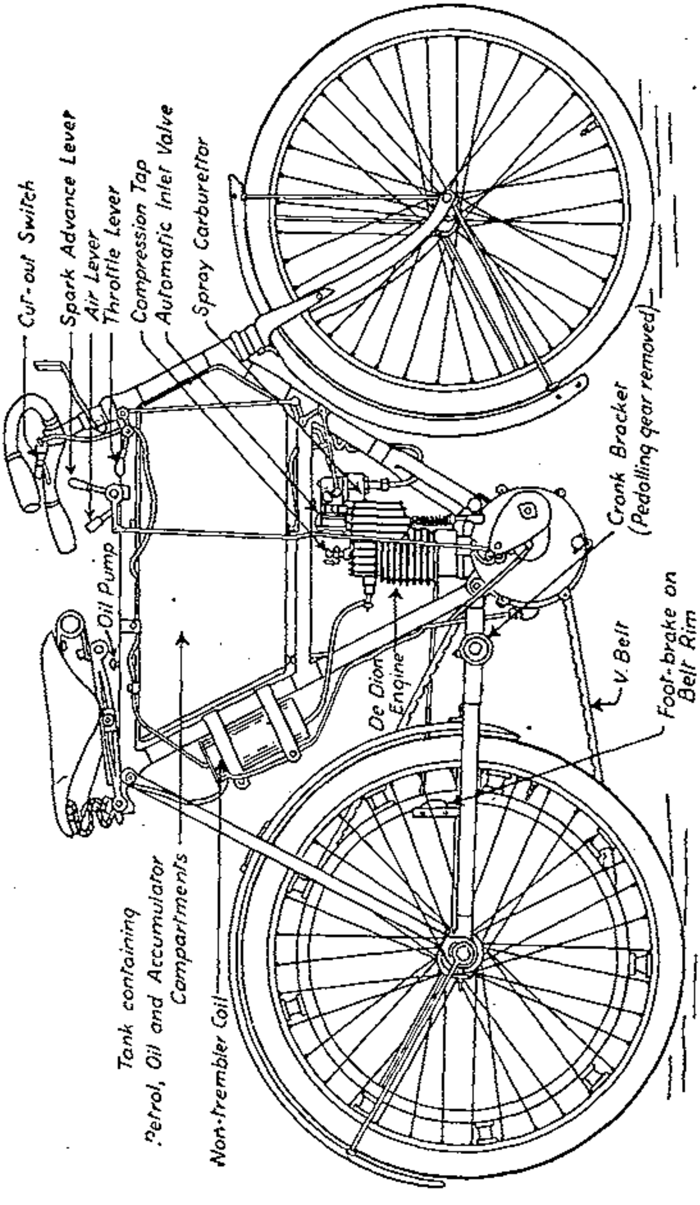


PLATE 5.

2 H.P. WERNER, 1902



a predicament it was usual to push the machine to the nearest gate, remove the leather belt, lift the back wheel, and lash the frame to the gate with the belt. The owner of the gate was not always too pleased.

Although most of the leading pedal cycle firms, such as the Triumph, Enfield and Raleigh companies, were building component motor bicycles in 1902, some did not follow immediately the Werner layout. For example, the Matchless, produced by Collier & Sons, Plumstead, had an inclined 2¾ h.p. De Dion engine attached to the front down-tube, and the Phelon and Moore carried an inclined 1½ h.p. built-in engine, replacing the front down-tube, and had an all-chain drive to the back wheel through a reduction at the pedal crank-bracket. The Matchless was an unusually high-powered and fast machine. Few makers in 1902 dared to instal an engine of more than 2 h.p.

The 2 h.p. Rex, as designed and built in Coventry in 1902, was a serious financial challenge to the entire motorcycle trade. The Rex Company embarked on mass production of a cheap and simple machine of modified Werner pattern. They catered for the man who could not afford the usual £45 or £50 and soon commanded large sales. They adhered rigidly to a policy of one model per season, and at 25 guineas the Rex was marvellous value. It was a smart, if somewhat roughly finished, little machine with surface carburettor, battery ignition, tank controls and belt drive to the back wheel. Later having captured a fine market, the Rex Company added some refinements and doubled the price; but they succeeded in retaining their market by allowing £25 for an old machine of any make given in part payment for the improved model. According to Major-General A. E. Davidson, the 3 h.p. Rex of 1903 pattern was known as the "Bee-hive silencer" type because the silencer was formed by an extension of the cylinder head in the shape of a square box covered by a perforated lid. The surface carburettor occupied a separate compartment in the tank, and General Davidson explains one advantage of this arrangement. "When travelling by rail," he writes, "all petrol had, of course, to be drained from the machine; but it was sufficient, as a rule, to open the tap of *either* the main tank or the carburetting compartment, whichever contained the less petrol, and to drain that part dry for official satisfaction. Then there was ample spirit left to continue the journey later by road."

The Army was slow to recognize the possibilities of the motorcycle. It is true that in 1900 the War Office bought some motor tricycles for despatch-riding work in the South African War, and that in 1903 it purchased a few R.O.C. motor bicycles for issue to the R.A.S.C., but General Davidson's "Bee-hive" Rex was the first motorcycle to be employed on military convoy duties. It accompanied a convoy of traction engines and trailers sent from Leeds to Westbury during the Army Manœuvres of 1903 and proved invaluable in making arrangements for the daily march. Yet the War Office remained wary and non-committal and showed no interest until the publication of the Mechanical Transport Committee's report in 1908. A 3½ h.p. Triumph was purchased in 1909, and a 2¾ h.p. Douglas in 1910, when Capt. E. G. Wace, R.E., organized a special reserve of civilian motorcycle despatch riders for the Signals. After the manœuvres in 1910, the Committee recommended that motorcycles should be allotted to all M.T. Companies of the R.A.S.C.; but the only result was the purchase of ten machines in 1911, and not until the war of 1914-18 did motor bicycles come into general military use.

Reverting now to 1903, we find that in that year many reliable motor bicycles, such as the Minerva, F.N., Kerry, Vindec and Sarolea, were being imported from Belgium, and that the United States were sending over the Mitchell, There were a number of good British makes on the market, for instance the Humber, Excelsior, Triumph, Bradbury, James, Enfield Rex, and Quadrant. British firms such as the B.S.A. Company, Brown Bros., Chater-Lea, Ltd., Riley Bros., and Alldays & Onions, Ltd., specialized in component parts. Spray carburettors gained favour, and Messrs. Brown & Barlow and Amac, Ltd., entered into competition with the producers of the famous Longuemare. A few machines were fitted with Simms-Bosch magneto ignition as standard. Bowden wire simplified handlebar control. Mechanical inlet valves began to displace the automatic variety whose operation was prone to be either too slow for high speeds or too fast for low speeds. Brooke's saddles earned a high reputation. Messrs. Mills & Fulford produced the sidecar and forecar to compete with the primitive trailer. Towards the end of the year it became clear that motor bicycles were in the process of standardization, for the Werner layout was seen on every side; but they still suffered from vibration, unreliable ignition, high centre of gravity, belt trouble, poor flexibility, lack of change-speed gear, weak brakes, and unsuitable fittings such as heavy acetylene lamps. The motorcyclist, however, was not troubled by legal restrictions. There were no driving licences, insurance certificates, nor even number plates. The 12 m.p.h. speed limit was never enforced, and the rider paid a tax of 15/- a year to the Inland Revenue because his machine was classed as a "dog-cart." By 1903, the motor bicycle was fairly established in the public regard as affording the cheapest and quickest means of light road transport. The general principles of correct design were understood, and it remained only to apply and elaborate them and to secure steady improvement in component parts and fittings.

A few personal experiences and general remarks will suffice to indicate the trend of design from 1903 onwards, and thus to complete the story of the evolution of the motorcycle.

In January, 1903, I paid £80 to a Bombay firm for a surface-carburettor, belt-driven, Quadrant and chose a 3 h.p. model in preference to a 2 h.p. although it was said to be too powerful for safe riding. The machine was one of the first in Southern India, and I ran it in the Nilgiris at heights exceeding 6,000 feet. At Secunderabad, in 1904, there was no electric installation, so I had to send my accumulators 400 miles to Bombay for charging, and as they always returned with the acid spilled and plates damaged, I replaced them with dry batteries. Petrol from Bombay cost 6/8d. a gallon delivered at Secunderabad. The V-section leather belt was a nightmare. From accumulation of oil and dust it developed a glazed surface which soon refused to grip the driving pulley, when the only remedy was to cut an inch off it and bore a new hole for the hook-fastener. The tension was then often too great for the fastener, which tore through and allowed the belt to drop on the road while the engine raced and roared. There followed the incredibly filthy job of cutting another inch off the belt and inserting a short length with two fasteners, and the belt became in time a conglomeration of short lengths and fasteners. Every dog, and almost every cow, enraged by the novel sound of the exhaust, charged on sight, so I carried a bag-full of stones as ammunition and a cutting whip for work at close quarters. Yet in spite of its drawbacks, the old Quadrant was a delightful mount when in good fettle, and I had many short runs on it in company with a friend who rode an F.N. with flat belt drive. It taught me more than could be learned from any textbook.

Lieut.-Colonel R. E. Stace owned a Royal Sovereign motor bicycle in 1903 and took it later to India, Burma and Aden. "To get it going," he writes, "one pushed it along the road and let down the exhaust valve lifter, when the engine might, or might not, start. If it did, one had to mount somehow, which was not easy with the pedals flying round. When I arrived with it in Aden in

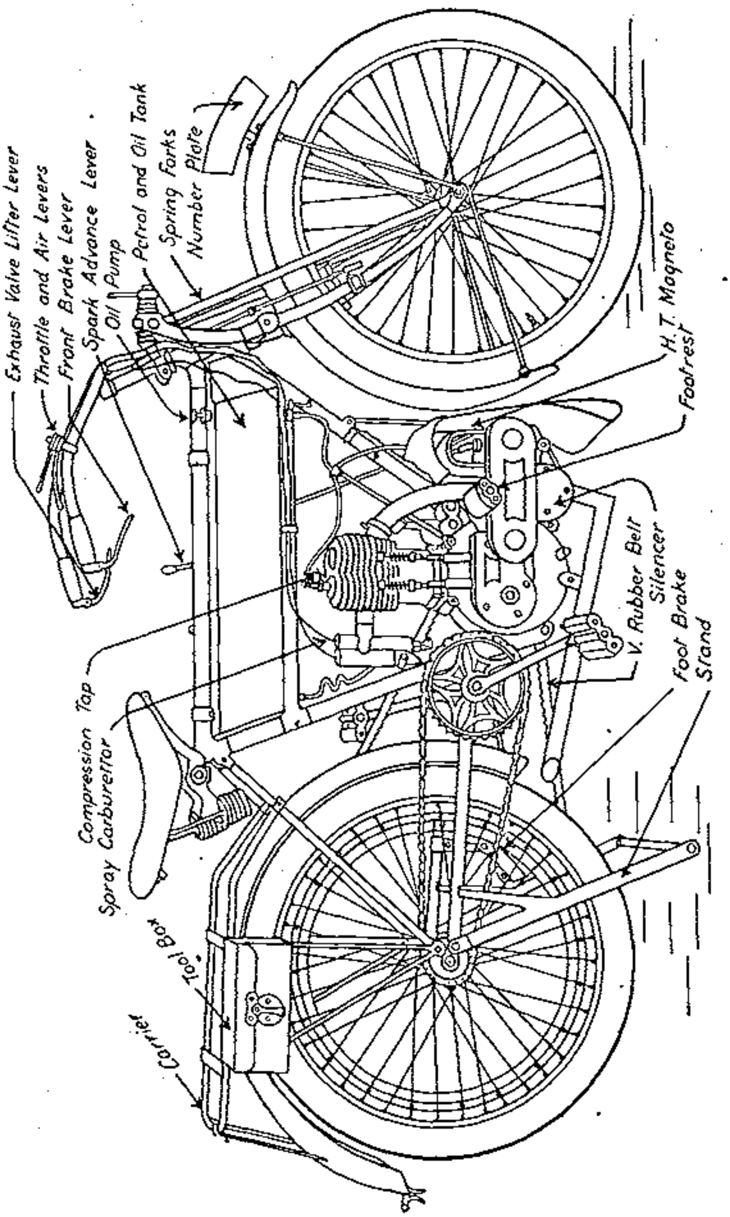
1906, I found no other motor vehicles there and no petrol. However, being determined to run the machine once more, I bought a bottle of benzine from a chemist and motored a mile or so. Afterwards, when in Quetta, I had an old belt-driven Humber. When out one morning on a deserted road I wanted to stop and accordingly pulled back the control lever on the tank to break the ignition circuit. Immediately, the machine burst into flames. Petrol had oozed through a small crack in the top of the tank and had been fired by a spark at the switch. Jumping off quickly, I took off my coat and wrapped it round the tank. Then followed my waistcoat, and finally, in desperation, my trousers. These extinguished the flames but at that moment the entire Quetta Hunt emerged from a side road, walking their horses, and what the men and girls thought of the spectacle of a half-naked man with his clothes draped artistically around a stationary motorcycle I cannot imagine."

My second machine, a 3 h.p. Triumph bought in 1905, was a great advance on the Quadrant. It had a ball-bearing engine, H.T. magneto ignition, spray carburettor, mechanically operated side-by-side valves, exhaust valve lifter operated by Bowden wire from the handlebar (though the other controls were on the tank), a compression tap, V-section "Gloria" rubber belt, footbrake on the belt rim, large saddle, footrests and combined carrier and stand. The front forks were of girder pattern without springing. The machine was priced at £48, but a battery-and-coil model cost only £43. The Triumph was a prizewinner in competitions, beautifully finished, and a pleasure to ride in good weather on decent roads. But the English roads in winter were usually bad, and the weather often vile. Here is the log of a trip from Weymouth to London in December. "Monday, 10 a.m. Left Weymouth. 10.30 a.m. Mended puncture. 11 a.m.—noon. Negotiated patches of unrolled road-metal at 200 yds. intervals for 13 miles. Choice of charging or pushing. After one spill, pushed. 1 p.m. Rain. 2 p.m. Deluge. Engine started misfiring. Removed coating of mud from magneto and proceeded. 2.45 p.m. Belt slipping. Pedal assistance needed on hills. Tightened belt. 4 p.m. Dusk. Arrived Winchester, distance 65 miles. Mud dripping from handlebars. Put up for night and had machine cleaned. Tuesday, 10 a.m. Left Winchester after clearing carburettor of water. 11 a.m. Mended puncture. Ran into fog. 11.30 a.m. Fog thicker. Unable to drive in goggles. Removed them. 12.15 p.m. Lost. Freezing hard. Walked machine ¼ mile to main road. 1.30 p.m. Arrived destination. Distance 60 miles. Eyes aching. Machine again in filthy mess. Left it at garage to be cleaned." Occasionally I towed a passenger in a basket trailer—a dangerous contraption on corners—and once tried fitting a smaller belt-pulley to get more power. The power was increased, but I soon discarded the new pulley because the engine overheated. The machine was unlicensed and had no registration number. Late in 1905 I took it to India and used it at Meerut until the spring of 1909. Strings of bullock carts, meandering in the hot weather along the country roads, were most difficult to pass. On one occasion, when a lone cart would not budge in spite of prolonged hooting, I jacked up the Triumph, ran to the bullocks, turned them round, and sent the cart back by the way it had come, and all without waking the driver. I should have liked to see his astonishment when he opened his eyes.

Every year brought improvement in design and elaboration of detail. The 3½ h.p. Triumph of 1907, (see Plate 6), which unfortunately I did not own, was a notable advance on the 3 h.p. of 1905 and represented an important stage in motorcycle development, for it had spring forks (introduced in 1906), handlebar throttle and air controls, better braking, mudguarding and silencing, a comfortable saddle and a large toolcase. The unsatisfactory features were a right-angle bend in the exhaust pipe and the exposed position of the magneto.

PLATE 6.

3½ H.P. TRIUMPH, 1907



It was a machine of very high performance and did splendidly in competition. Of course, it lacked the refinements of a clutch, change-speed gear, kick starter and electric lighting system; but it was pleasing to the eye and resembled in many ways the wonderful machines of the present day, and the provision of ball bearings throughout the engine gave very smooth running.

While on leave in England in 1909 I bought my third machine, a 5 h.p. Rex twin-cylinder, and ran it occasionally with a Mills & Fulford basket sidecar fitted with a trailing wheel which eased the strain on corners. The heavy Rex V-twin was a powerful mount, but its finish was somewhat rough and the belt drive could not stand up properly to sidecar work though an R.O.C. 2-speed gear and clutch were incorporated in the rear hub. H.T. magneto ignition and spray carburettor were fitted as standard, and a detachable starting handle was provided. The machine had footrests but no pedalling gear. As the tyres were inadequate, punctures were frequent, so I fitted patent inner tubes with spigot and socket ends, covered by a rubber sleeve, and carried a piece of soap to make the joints secure. Leakage ceased after a few strokes of the pump. To be able to change a tube without removing the back wheel was a great boon. In the summer I toured—solo, I may say—from Weymouth to Gretna Green and back with sufficient kit in a carrier valise to be able to stop the night anywhere. Often, I put up at a commercial hotel and joined the travellers at the "general table." The etiquette in those days was rigid and needed some learning, but I assume that I was accepted as a supposed traveller in "motorbikes." In the Yorkshire wilds I ran out of petrol and reached the nearest supply only by emptying the contents of a petrol squirt, and then a paraffin squirt, into the carburettor. The test hill at Sutton Bank was encountered unawares, and the Rex failed on a short stretch of 1 in 3·9 and dragged me into the ditch, but a flying start from a neighbouring field enabled me to reach the top. Touring in 1909 was great fun if one was prepared to take the rough with the smooth. There was hardly any motor traffic on the roads and every motorist was a comrade in adventure.

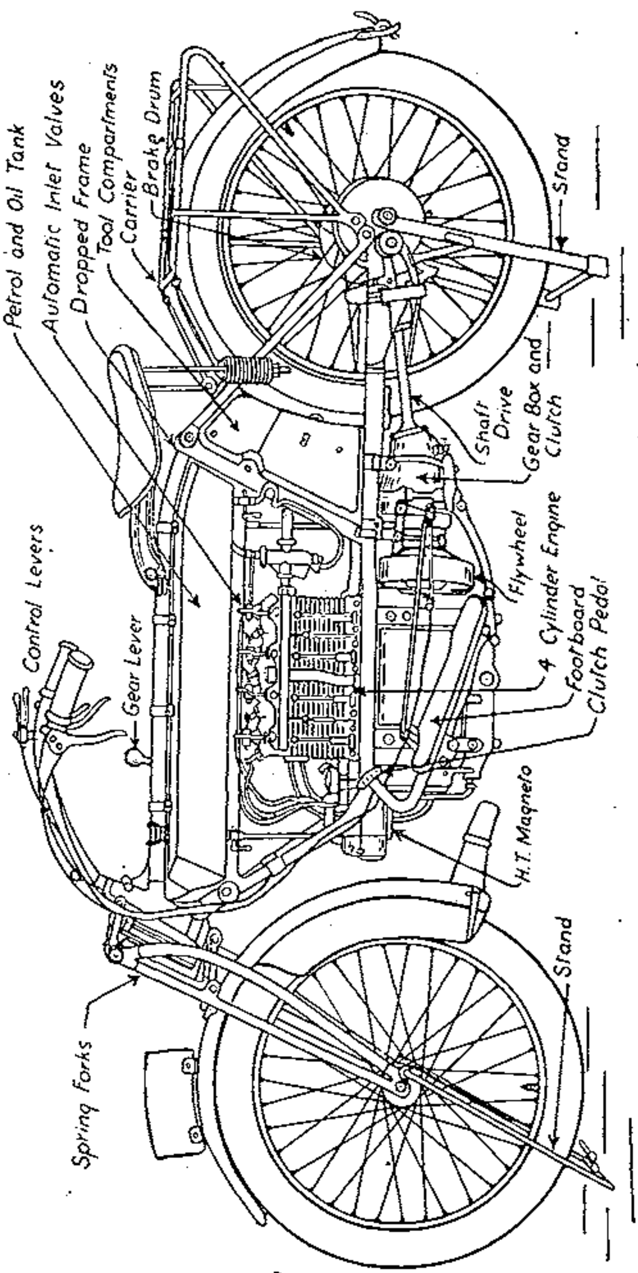
Before sailing for India in September, 1909, I sold the Rex heavyweight and invested in a V-twin lightweight. The new mount was a 2½ h.p. Moto-Reve, of so-called 1910 pattern, weighing only 90 lbs. yet guaranteed to climb a gradient of 1 in 7. This machine, and the Motasacoche, hailed from Switzerland where there was a lightweight boom. The little Moto-Reve was a well designed, belt-driven twin with H.T. magneto and spring forks, but its tiny automatic inlet valves caused much trouble and the machine was too light for the roads around Calcutta, where I ran it in 1910. In Calcutta I was required, for the first time, to pass a driving test, so I rode from the Fort down Strand Road, negotiating successfully heavy traffic composed of trams, bullock carts, gharries, coolies, wandering dogs and donkeys and occasional cars. On arrival at the examiner's office, I was asked by that official where I had come from and how. I told him I had ridden from Fort William along Strand Road. "Good enough" said he, and handed over the driving licence without another word.

My fifth and last motor bicycle was a 5-6 h.p. Clyno V-twin of 1913 model, which I ran with a coachbuilt sidecar. This heavyweight had many refinements, including automatic sight-feed lubrication, 3-speed gearbox on car lines, all-chain drive, kick starter and detachable wheels, and it cost £75. The Clyno combination was ideal for use on up-country roads in India for it was very strong and reliable and the engine had ample power. The sidecar was sufficiently large to accommodate a small tent and other camp equipment and often did so. I sold the outfit in 1915, and when I returned to Roorkee in 1920 it was still running.

Many interesting machines came on the market shortly before the Great

PLATE 7.

5 H.P. F.N., 1913



War of 1914-18. Among these was the Pearson & Cox Steam Motor Bicycle, built on Serpollet steam car lines but omitting a condenser and much of the usual automatic mechanism. Another was the 5 h.p. 4-cylinder F.N. of 1913 pattern (see Plate 7), a development of the design produced in 1905 by the Fabrique Nationale Company of Liege. The F.N. followed car lines in that it had a clutch, shaft drive and bevel tear transmission. The engine was extremely flexible and the drive very smooth, but as the machine weighed 200 lbs. it was not a mount for the weak or timorous, and the adjustment of its four automatic inlet valves was an expert job. These two machines are mentioned as radical departures from standard design. By 1914, most British manufacturers followed standard practice with distinctive modifications in detail.

Although the side-valve V-twin had gained much popularity before the Great War, it had to yield first place to the single cylinder for war purposes. The Triumph and Phelon & Moore singles were outstanding on the western front, with the Douglas flat-twin a good third. War experience brought little new in design but considerable modification in detail. It almost killed belt transmission and eliminated the hub gear in favour of the countershaft type. Only a few makes, such as the Rudge, Wooler and Zenith, clung for a time to belt drive. Mechanically-operated inlet valves of overhead type began to appear. Flat-twins were shown by many firms in addition to the Douglas Company, among them being the Humber, Raleigh, Zenith and Harley Davidson concerns. Two-stroke engines retained much of their popularity though more delicate than the four-stroke variety. The Matchless, Douglas, Raleigh, Indian and Clyno machines had spring frames, and the Sunbeam a laminated-spring front fork. Electric lighting equipment appeared. Prices soared during, and after, the war. For instance, whereas in 1913 the Triumph cost £57 10s. 0d., it was listed in 1921 at £140. Within the next few years, however, prices gradually regained their normal level.

It is impossible to trace further the evolution of the motorcycle. That modern machines such as the Matchless, Norton, A.J.S., Triumph, Ariel, Rudge, B.S.A., Excelsior, Sunbeam and Royal Enfield should be the lineal descendants of Butler's tricycle and Daimler's bone-shaker is one of the marvels of the age. The British motorcyclist owes much to Butler, Holden and other pioneers who, in the face of public apathy, introduced and developed in this country the most economical form of mechanized road transport the world has ever seen.

SEQUEL TO "PLUTO"

Submitted by I.C.I Ltd.

NOW that the story of "Operation Pluto" has been released it is also possible to make known an interesting sequel.

Whilst the pipelines carrying fuel to our armies on the Continent along the bed of the Channel were naturally of very sturdy construction, they were none the less susceptible to damage from such objects as ships' anchors, and towards the end of 1944 a number of lines had begun to leak or had suffered actual fractures. The precise location of the damage was not known and no method was available for accurate detection, such as would enable divers to be sent down to effect repairs.

The Petroleum Warfare Department bethought them of the dyestuff Fluorescein L.T., which is used to assist in rescuing airmen forced down on the sea. It produces large coloured patches on the sea's surface visible at a great distance to patrolling ships or aircraft. Why should not Fluorescein solution be pumped through the damaged pipe until it emerged on the sea's surface and so reveal the presence of the fracture? Imperial Chemical Industries were approached. Enormous quantities of the solution would however be required to colour a sufficient volume of sea water, which would necessarily be from the bottom of the sea up to the surface, in order to be observed at any distance. The thing appeared impracticable. Experiments were at once carried out, however, in the Dyehouse and later at a South Coast Harbour to see whether a solution of Fluorescein L.T. could not be produced which would rise to the surface of the sea without mixing with it and then spread out over a large area.

Such a solution was evolved and arrangements were made forthwith to try it out in the damaged pipelines. Preparation of the large quantity of the solution involved was undertaken on the site of the pumping station by an R.A.S.C. unit under supervision. In spite of desperately cold weather, which froze the ingredients in their containers and choked the pumps with ice, the experiment was entirely successful. The solution was introduced into one of the damaged lines and at the same time ships of the Royal Navy, assisted by a "Walrus" spotting plane, began to move out along the course of the submarine pipes. In due course, the fluorescent patch appeared on the surface. One end of the fracture had been found. As the ends had become separated by an appreciable distance, perhaps due to dragging by ships' anchors, it was found necessary to ship quantities of the liquid to France and repeat the operation from the opposite shore. Once again the exact location of the fractured end was revealed. Without the assistance of this device, employed on more than one occasion, there is no doubt that "Pluto's" efficiency must have been seriously curtailed.

Special Notice

The fact that goods, made of raw materials in short supply owing to war conditions, are advertised in this magazine should not be taken as an indication that they are necessarily available for export.

General Sir Hugh J Elles LCB KCMG KCVO

MEMOIR

GENERAL SIR HUGH JAMESON ELLES, K.C.B., K.C.M.G., K.C.V.O., D.S.O.

Colonel Commandant Royal Engineers and Colonel Commandant Royal Tank Regiment

HIS chief characteristic was, I think, his forthrightness, a forthrightness that led him often into difficulties, but gained staunch friendships and made him a leader of men. He reached high rank, he left his mark on every office he held both in his military service and in those few brief years of civil duty towards the end of his long life of endeavour. Honours and advancement came freely to him, his own satisfaction came, not from these, but from the sense of accomplishment. His chief ambition in life was to do his job as thoroughly as he could, and he would not rest until he had convinced himself that he had actually achieved what he had set out to do. He was not pliant either in his private or his public life. A strong vein of stubbornness threatened in his early service to check his progress. He sought the very roots of every subject he studied and was impatient of accepting the fruits of others' labours and experience. He was staunch in his friendships and outspoken in his criticism. There was no hero-worship in his composition, except, I think of his father, whom he admired beyond all other men and whom he closely resembled in outlook and who, like Hugh himself, after a singularly successful military career, suffered his first rebuff at the end of his military service.

His character was, as perhaps all men's characters are, largely the outcome of his early experiences and he ripened early. There were very few changes in the personality, temperament and methods of the Hugh Elles whom I first met in his early twenties—when he was known as the Babe—and the full General with all those letters after his name, still vigorous, still keenly interested in all that was transpiring, still imbued with a strong sense of duty, whom I last saw only a few brief weeks before his death.

He was born in 1880, educated at Clifton College, and passed high into the Shop where, in due course, he became an under-officer. During most of his boyhood his father was serving in India, his mother, a singularly gracious and high-idealed lady, had much to do with the moulding of his mind. I have forgotten how often she voyaged between India and home, spending her time and sacrificing her health to satisfy the rival claims that her duties as wife and mother made on her. She had her reward in the unstinted devotion of her family. There were three sons and one daughter in the family. Both his brothers died in early manhood, the elder, also an R.E., in a gallant attempt to save the life of an Indian Sapper who had fallen into the Ganges canal, the younger of enteric shortly afterwards. His sister achieved literary fame as Patricia Wentworth. Hugh himself, once wrote a work of fiction, but he was not proud of it and I do not know if it ever saw the light of print.

His early military career was not remarkable. He saw the tail-end of the South African war, serving in the 7th Field Company, then did a tour of five years with the Sappers and Miners at Roorkee. It was during this tour that he first really got to know his father, then serving as Military Member of Council in India, and between the two there sprang up unusually close ties of mutual respect and real affection, drawn still closer by the grim series of calamities that befell the family circle, for the loss of his two brothers did not long precede the death of his mother. A little later his father, caught in the vortex of the Kitchener-Curzon controversy in India, abruptly terminated his military service and returned to England to carve out a long and distinguished career in important civil duties.

Hugh Elles himself, after a year as Asst. Adjt. at Chatham and four years as Adjt. R.E. Troops at Aldershot, entered the Staff College at the beginning of 1913 to find his first real opportunity on the outbreak of war in 1914. He left the Staff College to join the Staff of the 4th Div. as D.A.Q.M.G. and with the Division served through Le Cateau, the retreat to the Seine and the advance to the Aisne and at the battle of Armentières. His first honour—the D.S.O.—was conferred in February, 1915, and he joined, almost at the same time, the 10th Bde. as Bde.-Major. He was already a man marked for advancement and a few months later was appointed to the Operations Section of the G.S. at G.H.Q. We have heard much during these last few months of the remarkable band of young officers whom Field Marshal Sir B. Montgomery used as his "eyes and ears" to get first-hand news of the operations he controlled. It was no new practice. In 1915, Sir William Robertson, then C.G.S., adopted the same system, and Hugh Elles joined the "crêche" as they were nicknamed. Still further opportunity beckoned to him when Sir Douglas Haig, then C.-in-C., selected him to go home and report on the progress of the manufacture of the tanks which he so anxiously awaited, and on their capabilities for battle. Until then he had had little direct contact with Sir Douglas Haig. The acumen of his report and his personality at the subsequent interviews so impressed the C.-in-C. that when later on, Sir Douglas, not fully satisfied with the results achieved by the early efforts of the tanks in battle in France, decided to appoint an officer with intimate knowledge of the conditions and of warfare to take over control of the Tank Corps, he selected Hugh Elles for the task. It was his first great opportunity and he seized it with both hands. He devised the tactical training required and pressed it forward with all his energy; his personality inspired all ranks; he gave them confidence in themselves and in him, and when at Cambrai, for the first time, the new weapon was used in mass, he led the 350 tanks in person in the leading tank of the central division. That day was probably the greatest day of Elles's life. It marked a revolution in land warfare. Mobile armour became the most formidable item in the war potential of a national army. To some extent the tactics of the employment of armour in mass was later forgotten and had to be learnt again in after years, but students of war can see the close similarity of the underlying features of the tactics of the tanks at Cambrai and their use in the campaigns in France in the present war. Tanks, still under Elles, played a strenuous, but never so prominent, part in the later stages of the 1914-18 war. At its end, Elles now a K.C.M.G. and temporary Maj.-Gen. reverted to the rank of Col. on the Staff, in command of the tank Training Centre at Wool. A variety of appointments in their ordinary succession, as a Brigade Commander, Col. on the Staff of a Command, a Directorship at the W.O., and a brief spell of unemployment on the Half-Pay List, filled the next few years without any important official incident, but there were vicissitudes that reveal some aspects of his character. The W.O., in the years immediately after the end of the first world war, appeared to be little impressed with the lessons of armoured warfare in France and paid small attention to Elles's recommendations as to their training and use. So little indeed, that Elles felt impelled to approach the Chief of the Air Staff to see whether that ambitious and energetic service would not take over the mechanical land forces from the imperfect care of the W.O. I do not know how far the negotiations went, or indeed, whether they were ever initiated; anyhow nothing came of the idea and by 1926 a better appreciation of the situation had arisen at the

W.O., and it was with the direct purpose of re-invigorating belief in mechanical warfare that Elles was appointed Director of Military Training. Sir Ronald Charles was, at the time, Master-General of the Ordnance, and as his term of office drew to its close, he was impressed with the conviction that Tank policy was still undefined and the right type of armoured fighting vehicle still not settled. Conscious of the grave danger of this defect in our war organization, Charles recommended that Elles should succeed him as M.G.O., and carry on from where Charles had perforce to leave off. In May, 1934, Elles took up the appointment. Almost simultaneously the Cabinet of the day awoke to the fact that something more than mere paper plans was required if British industry were to be able to meet satisfactorily the immediate requirements of the armed forces on the outbreak of war. Some, perhaps, of the more prescient of the members of the Cabinet realized that war was no longer a distant danger. The co-ordinating machinery of the various ministries at that time consisted of a " Principal Supply Officers " sub-committee of the Committee of Imperial Defence, of which the M.G.O. was a member, and under them a " Supply Board." It was not until the following year that a Cabinet Minister was especially charged with the task of co-ordinating all defence problems. As the production difficulties, which were in the end so to hamper our national expansion in 1939 and 1940, became more and more apparent it was resolved to make a new appointment at the W.O., that of Director-General of Production, and for some reason—not then nor now apparent—the new official, Vice-Admiral Sir Harold Brown, was made co-equal with the M.G.O. Divided responsibility had reached its zenith. But worse was to come. A change of War Ministers brought the remarkable decision to take away all responsibility whatsoever from the Army Council and transfer it a newly created Ministry of Supply. The office of M.G.O. was to be abolished and in its place a Director-General of Munitions Production, in the person of the Admiral, was to remain. Elles's reaction was immediate. As soon as he heard of the proposed alteration, he immediately tendered his resignation so as to allow the reorganization to take place with the least possible delay. No notice was taken of his letter. It was not even acknowledged. Other changes in high office were afoot. Several weeks later Elles together with two other members of the Army Council received curt intimations that their resignations would appear in the forthcoming *Gazette*.

Resignation under such circumstances, of three Military Members of the Army Council at a time when the international atmosphere was already tense with forebodings of war, implied, in the mind of all who had no knowledge of all that had preceded it, much more than the mere lack of confidence of their civilian superiors. It was the stigma of failure. Serving soldiers have no public redress. The fact that Elles had already tendered his resignation to facilitate the change over to a new organization in the inception of which he had himself participated, was not made public. It was a cruel blow, accentuated by the loss of his wife who died suddenly, her death hastened by the shock of the knowledge of the termination of her husband's military career. A lesser man would have succumbed. Elles was fortified by the trust and confidence of all who knew his work and perhaps by the recollection that his father, at the end of an almost equally distinguished military career had suffered a similar experience as the result of a clash between civil and military considerations, and had not given way. He retired at once, and the sympathy and confidence of the industrialists and others with whom he had had much to do as M.G.O., found practical expression in the immediate offer of two important directorships.

When war broke out, realizing that his age, then approaching sixty, would militate against suitable military employment, he applied to be released from the Reserve of Officers and offered his services to the Civil Defence Organization. For a short time he, outwardly with complete contentment, fitted gas-masks on the features of the anxious public. A.R.P. in those early days of the war, was not a model of good organization. Early in 1940, he was appointed chief of the operational staff of the Civil Defence Services and in September of the same year, he became Regional Commissioner of the South Western Region and threw himself into the task with renewed energy and efficiency. Others must tell of his work there. I know nothing of it, save that in the course of many journeys during war-time to his area, I heard nothing but praise of his work and respect for his personality. That respect is best shown by the following extract from a letter written to his widow by one who was his Principal Assistant from 1941-1944. He wrote :—

> " My mind goes back to the many hundreds of days when I have seen that commanding figure, reticule under arm and chin well out, beat up the silly little drive of that preposterous villa at Regional Headquarters. Of the subsequent hours of work in which I learnt so much about the handling of men and things—I don't know which he excelled in most—and, for that matter, women and ideas. The glee with which he would produce a perfectly phrased letter, the zeal with which he would conduct a conflict (never with malice, and only with malevolence on the very rare occasions when his sense of justice and fairness was violently outraged). The gentleness with which he would accept advice, even when proffered by someone with a judgment generally much less well-balanced than his own. His almost universal acceptance of the good in human beings, while ignoring as far as possible their deficiencies. All these things and many others make me feel, in their recollection, almost broken-hearted today."

Like most men of strong character and strong virility, he set great store on the companionship of his home life. He was married three times. His first wife—Geraldine, the daughter of Gen. Sir Gerald Morton, whom he married in 1912, died in 1922. The following year he married the widow of Lt.-Col. George Franks, C.M.G., D.S.O. She died in 1937, and in 1939 he married the widow of Col. A. H. Du Boulay who, with two daughters of his first wife, survives him.

Almost the last time I saw him, he asked me whether it was not time for me " to give up work, sit back and look on." " Did your father," I asked, " and will you ? " " Oh me," he said, " I shall go on until the end."

That end was not long delayed. His last illness was brief and its termination merciful. If it is indeed true that the Master of all good workmen, sets us to work anew, we may be confident Hugh Jameson Elles will be given a great task and that it will be well done.

J.C.

BOOK REVIEWS

PSYCHOLOGY FOR THE ARMED SERVICES

Editor, EDWIN G. BORING, Professor of Psychology, Harvard University. (Published by *The Infantry Journal*, Washington, pp. 533. $3.00.)

To the practical mind of the British officer, Psychology has still an academic sound and the activities of the psychiatrists have not, one gathers, won universal confidence. But we must agree that "man management" is a subject of primary importance to all leaders, and it is with "man management" in a wide sense that the volume under review sets out to deal. Prepared under the direction of the National Research Council of the U.S.A., and based on the labours of a wealth of academic talent, it is intended to provide a text book "on the college level" for the instruction of members of the armed forces and also for their individual reading and reference. Whether it is perfectly suited to its purpose may be doubted. It bears the mark of its academic origin and is at once diffuse and yet, in some directions, superficial. But, for the reader interested in the subject, it will well repay the labour of perusal and there are many chapters of great interest and value.

Its contents cover a wide field. Beginning with the psycho-physiology of sight, hearing and smell, under such aspects as observation, night vision, camouflage, deafness and hearing under battle conditions, the recognition of military and racial smells (an amusing chapter, this last), we pass from topographical orientation and mental map-making to efficiency and fatigue, the effects of boredom and lack of sleep, of temperature and climate—Canada and Siberia, it appears, can never hope to have a high culture, but Great Britain is saved to civilization by the Gulf Stream—of altitude, anoxia and alcohol. This last is condemned from every aspect. Tobacco as a cause of unfitness is found "not guilty." Both tea and coffee are valuable physical and mental stimulants, but strangely enough the military value of gum-chewing is not examined.

We come next to the selection of individuals and their allocation to "jobs" based on "job analysis." The subject has been only generally treated, and no detailed account of the tests applied to the American armed forces is given. But it is interesting that the Army's General Classification Test has proved a better guide than scholastic records to probable military efficiency. On the other hand it seems to be doubted whether the official tests for the selection of potential leaders have been proved as valuable as had been hoped. It will be interesting to know what is our own experience in this respect.

We next pass through chapters on methods of learning and of military instruction to the more truly psychological subjects of human behaviour under military and battle conditions and the chapters which follow on motivation psychological mechanisms and determiners of morale are of great interest. Considered among the last are food and drink, cleanliness, warmth, fatigue, realistic news, recreation and leave, self importance (including recognition by the leader of personal identity and of work done and the reason—why of unpleasant duties), leadership, ideology and religion. *Esprit de corps* is not given the importance which we attach to it: morale indeed is treated rather as a personal rather than a group characteristic.

Under Personal Adjustment there is a valuable analysis of the conscript's psychological reaction to military conditions. The young soldier can, as we know, be made or marred by sympathetic understanding, or the lack of it, in his party officer or N.C.O. Repression as an escape mechanism, fear and its control, and sex problems are next considered followed by leadership, rumours and their prevention, panic and mob psychology. A chapter on "Group Polls" and their result deals with a subject new to the British Army and rather foreign to our ideas of discipline. It is satisfactory to know that such polls show that American soldiers tend to like the British and to like them more the longer they stay in Great Britain. Chapters on propaganda and racial differences end a long, perhaps too long, and comprehensive manual.

L.V.B.

BRITISH WORK ON PERSIAN RAILWAYS

(Reprinted from *The Railway Gazette*. Publishers: The Railway Gazette, 33, Tothill Street, London. S.W.1. Price 1s. od.)

In December, 1941, a British Transportation Directorate under Brig. Sir Godfrey Rhodes was sent to Persia to assist the Persian Administration to deal with the heavy traffic of supplies for Russia. To achieve this object a force of three Railway Operating Coys., one Railway Construction Coy., one Railway Transportation Coy., one Railway Workshop Coy., and one Mobile Railway Workshop Coy., with a total strength of about 2,500 men was sent to Persia.

When this force arrived the Persian Railways had 86 main line locos, of which 16 were out of commission and all the others required major overhauls. During the 15 months of R.E. work most of these locos were repaired and an additional 270 locos were imported and erected in the Railway Workshops.

Besides building some 100 miles of new line and many miles of sidings, the R.E. force increased the northward bound traffic from about 18,000 tons to 143,000 tons a quarter.

Considering the difficulties of language, partly overcome by using different coloured cards in some cases, the fact that the R.E. personnel were mostly young and untrained, the lack of stores and spare parts, intense heat and lack of water, the results achieved can be counted as a splendid performance.

In 1943, the Americans took over this railway work and were able to provide much larger numbers of personnel as well as many more locos, including 56 high-powered diesel electric locos. In consequence they stepped up the traffic considerably more, but it must be remembered that the British force had laid the foundations well and truly and dealt with the many teething troubles in the early stages.

The small pamphlet gives a very concise picture of the many difficulties which arose and had to be overcome and speaks very highly of the skill of the Sappers at organizing, improvising and producing order out of chaos. It is recommended to be read by all R.E. Officers, who will, however, be irritated by the constant use of that horrible, incorrect abbreviation "the R.E's."

C.C.P.

MAGAZINE REVIEWS

EMPIRE SURVEY REVIEW, July, 1945

(Published by The Crown Agents for the Colonies)

Sir E. Dowson and V. L. O. Sheppard give the first part of an interesting account of *The Cadastral Survey of Egypt*, initiated in 1879 as a consequence of the need for a complete reform of the land taxation system. Owing to almost complete disregard of sound principles and reliable methods, the account of which makes amazing reading, the early stages of the survey were a failure, and it was not until some 18 years later that, under Lyons, it was put on a proper footing.

Major-General Cheetham contributes an account of *The Post-War Programme of the Ordnance Survey*. Certain maps on new scales are mentioned the most important of which is the 1/25,000. Among the more interesting features are the survey of urban areas on the 1/1,250 scale ; the use of metal plates instead of paper for drawing plans ; the introduction of a National Grid on the metric scale ; and the adoption of square instead of rectangular sheets for the large scales.

H. F. Rainsford completes his discussion of the Clarke formulæ for Latitude, etc.

E.M.J.

GEOGRAPHICAL JOURNAL

(Published by The Royal Geographical Society, London)

Nov.-Dec., 1944.

J. Hanbury-Tracy gives a lively account of *Journeys in the Northern Andes*, undertaken chiefly for botanical purposes. Interesting descriptions are given of the native tribes encountered, and the illustrations are excellent.

S. H. Beaver gives a most interesting résumé, in *Minerals and Planning*, of the extraction of minerals of all kinds from the ground, and the effect on agricultural land, landscape, and the amenities of life, and hence on the problems of planning. The photographs are most illuminating.

Dr. J. Schacht gives an account of the Arabic Edition of the *British Council Map of Europe and the Middle East.*

There is an interesting series of fine air photographs taken in the neighbourhood of Nanda Devi, with notes by Squadron Leaders Waymouth and Young, who took the photos, and by Mr. Eric Shipton and Dr. Odell.

Jan.-Feb., 1945.

Mr. and Mrs. Ingrams give an account of journeys in the Hadhramaut, and a description of the effect of the war on this region ; being a continuation of previous pre-war contributions. The paper includes some account of famine relief and of welfare work among the natives.

Brigadier Bagnold gives a fascinating account of *Early Days of the Long Range Desert Group*, in which he and a few other leaders were able to utilize the knowledge they had gained in desert expeditions undertaken years before, with the greatest benefit to our operations.

J. K. St. Joseph describes the value of air photography to archæological research. This subject has been dealt with in many previous papers and publications, but the photographs which illustrate his article show in the most vivid and startling manner the power of air photography to reveal details which are otherwise quite invisible.

E.M.J.

THE ENGINEERING JOURNAL

(Published monthly by the *Engineering Institute of Canada*)

May, 1945.—The first two articles deal with much the same subject, viz.:—*Soil Mechanics as applied to Prairie Farm Rehabilitation Problems with Special Reference to the Proposed St. Mary Dam* and the *Application of Soil Mechanics to the Design and Maintenance of Prairie Highways.*

These two articles explain the application of Soil Mechanics to dam and road construction respectively. The methods used and the equipment employed both in the laboratory and the field are described.

An article on *Metallurgy and Machine Design* next appears. Modern metallurgy offers many methods of overcoming objectionable stresses in structures and machines without having to resort to large factors of safety. Some of these methods are reviewed and the experimental equipment described.

The last article deals with *Radio on Overland Long Distance Telephone Service.* The inhabited part of Canada consists roughly of an area 4,000 miles long and of average width 250 miles. The importance of low cost communication, not unduly affected by weather conditions, will be readily appreciated. The author discusses the use of ultra high frequency (50 to 100 megacycles and above) radio telephony.

The *June*, 1945, number begins with a review of *The Principles involved in a Modern Concept of Airline Operation.* Speed of flight, safety, regularity, comfort, convenience and cost of operation are all dealt with. The importance of developing automatic flight control towards eliminating the human element is emphasized.

The Engineering Selection of an Airline Aeroplane is then discussed. As its title implies this article deals with the technical aspects, viz.: specifications, stressed skin structure versus internal structural skeleton, nose and tail wheels, low wing versus high wing, safety, speed, size, high altitude performance, fuel capacity, etc.

The Future Aspects of Radio and Communication in Air Transportation. In this article the many uses of radio in aircraft for communication, direction finding, landing and approach systems, etc. are described and the use of Radar to prevent collisions is referred to.

This number concludes with a paper on *Recent Developments in the Field of Materials and Processes*, dealing with the remarkable developments during the war in aluminium alloys, special steels, specially treated woods, plastics, adhesives, fuels, etc., with particular reference to their use in aircraft.

The *July*, 1945, issue contains first an informative article on *The Evaluation of Aeroplane Metals.* The test results given apply mainly to the new aluminium alloys, but for comparative purposes a few tests on magnesium alloys and stainless steel are included.

Canada's New Voice. Engineering Features of C.B.C.'s International Short Wave Station. This is a technical description of the high power short wave directional transmitting system at Sackville, Canada, which covers practically the whole world.

Canada's Pulp and Paper Industry. This industry is a major contributor to Canada's export trade. The writer explains the factors involved in forest conservation.

Post-War Engineering Opportunities in Alaska and the Canadian Sub-Arctic. These areas offer immense opportunities for development and with the Alaska Highway and air transport they are no longer isolated.

W.M.

JOURNAL OF THE UNITED SERVICE INSTITUTION OF INDIA.

(Published by The Civil and Military Gazette, Ltd., The Mall, Lahore)

April, 1945.—In *India's Strategical Future* Auspex plans for the next war in twenty years—he is optimistic enough to say that it is not inevitable. India should be responsible for the defence of a large part of the globe, from Cyprus and Egypt to the Philippines. The war will be fought mainly by troops landed by air well inside enemy territory, but this will not be possible on a large scale until air superiority has been obtained. The Navy is given a comparatively small role, as sea-borne traffic will be covered by land-based aircraft. War factories should be underground, and it will be of no use trying to defend a naval base unless there is plenty of room in the hinterland for aerodromes. The author asks whether atomic bombs will have been invented by then, and what effect they will have on warfare.

Post-war planning of Defence Services by Brij Narayan is a valuable contribution on the same subject. His prolegomena include a self-governing India as a part of the British Commonwealth, and he assumes that we remain on the same good terms as at present with the U.S.A., U.S.S.R., and China, and that inter-communal clashes are a thing of the past. There is no mention of the Indian princes, and of the part they are expected to play. The article is a useful one and deserves study.

With the Indian Soldier Today, is an enthusiastic tribute to the sepoy, by "Bengal Lancer" whose death in December, 1944, we all deplore. The Indian yeoman is rapidly becoming a mechanist. Tribute is paid to the new regiments being formed of Madrasis, who are taking their place worthily in the fighting line as they did of yore. The author was much impressed by a Bengali wing commander of the R.A.F. at Kohat.

The narrative of the *First Burma Campaign* is concluded; a series of heroic rearguard actions against an enemy superior in numbers, better equipped, and holding the mastery of the air. The British India force had to retreat 1,000 miles, but "that retreat was a turning point in the war with Japan."

Officers, past, present and future, has valuable ideas on the subject. British Infantry is the main theme. In the past, the chief fault lay in the very long time spent as a subaltern, generally with insufficient responsibility. The proposed method of entry into the officer cadre is as follows—matriculation, service in the O.T.C., service in the ranks of the conscript army, selection board, two years at a varsity as an ordinary undergrad, and a degree in military science. Commissions are to be antedated in accordance with the results of the final exam. The infantry will be one cadre (the Corps of R.E. is quoted as an example of the benefits of such an arrangement). A syllabus of the career proposed for an officer is given. Altogether, a stimulating article which deserves study.

The Burmese Navy, which was still in process of formation when the Japanese War broke out consisted then of only five motor launches fitted with 3-pounder guns. It worked wonders. The personnel is British, Anglo-Burmese, and Burmese, and all must be able to speak English.

An *I.A.C. Recce Regiment in Italy* pays a great tribute to the sepoy who fought well, undeterred by the bitter weather experienced by the Eighth Army. The only exception that can be taken to an otherwise excellent article is the sketch map. There is no scale and the map seems to be distorted. Of the sixteen places shown on the map, ten only are mentioned in the text, one of which is spelt differently in the two. Four places mentioned in the text are not shown on the map. Finally, there is no explanation of a dotted line shown on the map, presumably the British front during the winter of 1943–44.

Man versus Weather deals with acclimatization, which is defined, admittedly imperfectly, as the ability to perspire efficiently. There is much useful information, combined with intimations that much remains to be learned. Housing is touched on. In India, the tendency is to scatter bungalows; in Iraq, where the climate is just as trying, to jam them together, so that one building helps to cool its neighbour. There is much to be said for the latter method.

An Officer of the Red Army is instructive. The etiquette in a Soviet Officers' Club is on a par with the best traditions of messes in the British Army.

F.C.M.

THE INDIAN FORESTER

(Published by The Civil and Military Gazette, Ltd., The Mall, Lahore)

April, 1945.—The number includes photos of Dehra Dun under snow, which fell to a depth of three inches on the night of January, 10th–11th of this year. Snowfall is a very rare occurrence there, the last occasion being a light fall about 1905. Many exotic trees suffered badly from the weight of snow and its subsequent thaw. Dehra Dun lies at 2,300 feet above sea-level, and its latitude is 30° North.

May, 1945.—Many who have enjoyed the shelter of Forest resthouses know how well found they are. There is in this number a sketch of one, the whole material of which, above plinth level, except for chimneys and corrugated iron roof, is wood, locally procured. The sketch is not to scale and no dimensions are given, but it would appear to be about 44 ft. by 20 ft, exclusive of porch. It consists of dining room, pantry, two bedrooms, two bathrooms with flush closets, and two stores. Timber was obtained free, except for a royalty of As. 7 per c. ft. Including levelling site, water-supply, garage and outhouses, the cost of the building was Rs. 8,000 (1943–44). The site is in the Bengal hills, 6,500 ft. above sea level, where there is a very heavy rainfall. The timber used in the main structure is *Catanopsis hystrix*, believed to be a kind of chestnut.

Another resthouse in the plains is also described where the timber used was mainly *sal*. The cost was Rs. 4,000 only, for apparently the same accommodation, less fireplaces. The building was erected on piles, as a protection against damp and termites.

June, 1945. The sixth silvicultural conference has met and discussed post-war problems in Indian Forestry. The past five years have inevitably brought dislocation of working plans—advance fellings have been made, and particular ranges of sizes have been cut to meet war demands—and there are many other postponed problems. The next conference will be held in October–November of next year.

The number contains two extracts on the subject of pruning, which may interest us both as tree-growers and as amateur gardeners, so here is a tip. When a tree is pruned, the cut should be made as near as possible to cambium, that is to say the layer immediately under the bark which serves to increase the girth of the tree, and to heal the bark when damaged. Otherwise, a jagged stump remains, which forms a bad knot, takes longer to heal, and may rot and so serve as an adit for fungi.

F.C.M.

INFANTRY JOURNAL

(Published by the U.S. Infantry Association)

May, 1945.—*Battle of the Bulge* by Sjt. Theodore Draper gives a good account of the fighting during the German counter-attack in the Ardennes in January, 1945. The snow and ice made the movement of guns, transport and supplies almost impossible, but somehow the impossible was overcome and the Germans were destroyed or thrown out of the whole area they had overrun.

Battalion Surgeon Infantry by Capt. Amos Cahan shows how necessary it is for the medical officer with a battalion to keep in the picture and forestall probable moves without getting in the way of the fighting troops.

Battle Facts, include a number of interesting items including *Action was Light* giving a description of a number of patrol actions, which are always taking place when there is no big action on hand. *Jap Ambushes* and *Raid on Schierwaldenrath* give details of small actions in the Pacific and in Germany. *Red Army's Small Arms* by Lieut. G. Underhill gives details, with photographs, of the various small arms weapons used by the Russian Army.

June, 1945.—*D. Day on Omaha Beach* by Col. Paul W. Thompson gives a very clear picture of the initial stages of the American landings on the Normandy beaches on the west of the Cherbourg Peninsula. The landings commenced at low tide and an essential part of the scheme was the clearing of lanes through the numerous obstacles on the beaches before the tide rose, when the obstacles would become more and more effective and prevent landing craft coming in. The assault engineers had the task of cutting these obstacles with hand-placed explosives under extremely heavy enemy fire, with the tide rising up the beach at the rate of about 2 yards a minute and with about 600 yards depth of beach to clear in the six hours before high tide. In spite of heroic efforts and perpetual work this task proved too much for them.

The second string for clearing these lanes relied on Sherman Tanks fitted with bull-dozers. Most of these were knocked out by enemy fire either while still in the landing craft or after they had got ashore. Fortunately, in spite of these setbacks the obstacles proved to be less effective than had been expected and a considerable proportion of landing craft managed to beach satisfactorily without cleared lanes.

Battle Facts include *Jap Mines* a description of some of the types of mines which were expected to be found in increasing numbers with the Japs on the defensive and as we got nearer to their homeland. *Successful Patrolling* gives a good account of the points to be looked to in selecting the men, equipment and arms most suitable for any particular patrol. Noise must be eliminated at all costs and this means not only rattling equipment, but that men with colds must not be taken.

July, 1945.—This issue contains two interesting articles on what might be termed "local actions." One, *Hill 40* by Lt.-Col. Frank Sackton describes very heavy fighting by an American Infantry Regiment in dense jungle country, with extremely difficult communications, both for supplies and messages. The other, *Assault along the Ridge* by Lt. Komer describes hill fighting in Italy, also with difficulties over supply and communications. Both stories show the heavy fighting which may be necessary as a preliminary to other more important operations and of which little is usually heard in the daily papers. There are also the usual series of articles under the heading *Battle Facts*.

C.C.P.

THE MILITARY ENGINEER

(Published by the Society of American Engineers)

April, 1945.—*New Equipment for Army Engineers* by Brig.-Gen. J. W. N. Schulz, President The Engineer Board.

The article describes the plan for assuring that Engineer troops, and troops of other arms using Engineer equipment, are provided with the most effective and up to date means of carrying out their war tasks.

The main agency is The Engineer Board, working directly under the Chief of Engineers.

The Engineer Board consists of the Board proper, with a membership of six officers, and a Technical Staff divided into Divisions, each of which is itself divided into a number of branches; each branch is responsible for a definite field of engineering development. The personnel of the Board in December, 1944, numbered 148 Officers, 251 enlisted men and 783 civilians; for testing equipment outside help is brought into the scheme.

The article describes in some detail a number of items of equipment which have been dealt with.

New Method of Moving Buildings by Lt.-Col. W. S. Corkran. The movement of large buildings is seldom practised in England, though in the U.S.A. it is a common occurrence.

This article describes how Bailey bridge trusses were employed in moving several buildings, including a two-story one which looks in the photographs, with which the article is well furnished, like a block of four Married Soldiers' Quarters.

Other articles include *Fighting "Flash" Floods on the Arno river* by Lt. M. Cornin; *The clean up of Valognes* in which 1st Lt. C. Helmetag describes the work done in that town in clearing the roads of debris, left after heavy bombardment, so as to facilitate traffic. *Reconstruction of Japanese Air Base on Peleliu Island* by Lt.-Cmdr. P. Corrad describes how this necessary work was carried out at this Pacific base.

May, 1945.—*Military Needs of Inter-American Transportation* by Major-Gen. J. L. Schley (retd.) Assistant Co-ordinator, Office of inter-American affairs.

This article deals with the planning that has been done and that which still needs to be done to improve the transportation in and between all countries in the Western Hemisphere. (Canada, by the way, appears to be out of the scheme.)

In view of the avowed intention of the present Government of Great Britain to nationalize transport in this country for peace-time purposes it is interesting to read that the U.S. Board recommends "solely from the military point of view" that though Railways are now either owned or controlled by Government regulation, shipping and air-lines are not so controlled, but that some at any rate should be.

Coral, our Pacific Life Saver by Commodore J. R. Perry, U.S. Navy. The uses to which coral has been put for making roads and landing grounds is fully described, it being claimed that without the coral, the work could not have been done.

One very interesting characteristic of coral is noted. In Florida, in the 15th century, the Spaniards built a sea-wall of blocks cut from a rock of a composition very similar to coral, they used no mortar, yet, after 400 years, the wall is not only standing but the sea water has caused the seams to cement, and today the wall is as much of one piece as if it had been carved from a cliff of solid rock.

Coral is therefore, not only an expedient but, on occasions, the best possible material.

Breaching the Siegfried Line by Major A. M. Sterba, describes in considerable detail the work done by the Engineers during the attack on this famous " line " near Holland.

The success of the operation was in no small measure due to thorough Engineer reconnaissance, carried out under great difficulties and with great determination.

In connection with the above, special interest attaches to the article *Assault Demolition Equipment* by Ernest Mayer and B. L. Krause, of the Engineer Office, which describes in detail the special equipment provided for breaching enemy obstacles and attacking pill boxes.

June, 1945.—*Our Business is Beachheads* by Brig.-Gen. D. A. D. Ogden, tells of the activities of the 3rd Engineer Special Brigade in the South-West Pacific.

It is an interesting tale of varied and strenuous work, a further article giving more technical details would be of great value.

Airfield Construction in France by Col. R. E. Smyser, junr., gives an instructive résumé of the problems met and solved during the first six months of the operations in France. The work is described in considerable detail and well illustrated. The experience gained should be of value in similar circumstances in the future.

Engineer-Pioneer Training at West Point by Lt.-Col. W. J. Wells, is of particular interest as showing (presumably) the trend of American opinion on the question of the provision of Officers for the Army.

It also shows clearly the importance attached by the U.S.A. authorities to the need for all arms to have a thorough practical knowledge of the work of every branch.

The article fully describes how this is carried out as far as Engineering training is concerned.

In the section of this issue devoted to *Engineer News* a claim is made that the " treadway pontoon bridge " built by the U.S. Engineers across the Rhine, 1,146 feet in 9 hours while under fire, " is the fastest, record breaking, bridge building feat in history."

July, 1945.—*Amphibian Engineers in Action* by Brig.-Gen. W. F. Heavey, tells the story of the work done by the Engineer Special Brigades on the way to Corregidor.

It is a stirring tale of hard work, good organization and tough fighting, during a period of over a year.

Cribbing in Military Bridges by Col. F. X. Purcell, junr. This article describes the repair of two demolished bridges, one over the Moselle, the other over the Nied river. The original bridge was a steel latticed truss of three 80-ft. spans in the first case, the other a stone arched bridge.

In both cases, as must occur with most demolished bridges, the debris made trestles or piling almost impossible, cribbing was therefore adopted to provide the necessary intermediate supports.

The work on the Moselle bridge was subjected to serious floods which " took out " at least a dozen pile and trestle structures up and down stream of the one described, but the cribbed one stood the strain ; so that cribbing, though it has many obvious disadvantages, may be the correct answer to many similar problems.

A.R.A.I.

INSTITUTION OF ROYAL ENGINEERS

1. The following officers are entitled to Full Membership of the Institution :—
   (*a*) All serving or retired regular Commissioned Officers of the Corps of Royal Engineers.
   (*b*) All officers serving, or who have served, in the Royal Engineer branch of any of the auxiliary forces in the U.K., such as Territorial Army, Supplementary Reserve, Special Reserve or Militia, etc., or who hold, or have held, temporary or emergency commissions in the Corps of Royal Engineers.
   (*c*) All officers serving, or who have served, in the engineer arm of the land forces, whether permanent or otherwise, of :—
      (i) The Dominions.
      (ii) India.
      (iii) The Colonies or Dependencies.

   Recommendations for Membership of such overseas officers to be submitted through the senior engineer officer of their country.

2. All officers referred to in sub-paras (*b*) and (*c*) above, shall be eligible for Associate Membership instead of Full Membership, if they so desire. Civilian officers of the Works Services Staff are also eligible for Associate Membership, if recommended by the senior engineer officer of the Command in which they are serving.

3. The entrance fee and annual subscriptions are as follows :—

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6. All Institution publications may be purchased at reduced rates.

7. Associates have no voice in the management of the Institution.

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