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CONTENTS

Presentation to the Corps by Greek Engineers 1
Atomic Energy in Outline . . . . . . Colonel F. A. Iles 2
What the Russians think of our Representative Colonel Commandant . 14
Making Gaps in a German Minefield . Lieut.-Col. M. C. A. Henniker 16
The Church of St. Thomas à Becket, Hamburg Lieut.-Col. C. G. Phipps 19
Eastern Army Boat Factory, Kalewa . . Major G. G Layton 25
Winter Service on the Austrian Roads . . Lieut.-Col. A. Bennetts 29
Adaptation of Materials in the Sudan . . Captain T. G. Layton 33
Types of Road Surfacing 35
Mountbatten Bridge, Shwell River . . . Lieut.-Col. P. A. Easton 36
Dr. Jekyll and Mr. Hyde 38
The New Scottish H.E. Plant at Lochalsh. . . Richard Costain, Ltd. 39
" Q " (Quartering) Problems in Malaya During 1947 Major D. J. Willison 41
The Move of the S.M.E. (India) from Roorkee and its Re-establishment at Kirkee . Lieut.-Col. Sir John S. Forbes 52
Advertising the Corps . . . . Maj.-Gen. H. L. Pritchard 59
The Right Type of R.E. Officer and How to Get Him . " Centurion " 61
The Ordnance Survey in the Near East . Lieut.-Col. H. E. M. Newman 64
The Cariboo Trail . . . . . . Brigadier G. MacLeod Ross 78
A Garrison Engineer in Southern Ireland . . Major D. G. B. Boyd 83
Sapper Officers in the Peninsular War 85
Memoirs, Book Reviews, Technical Notes 87

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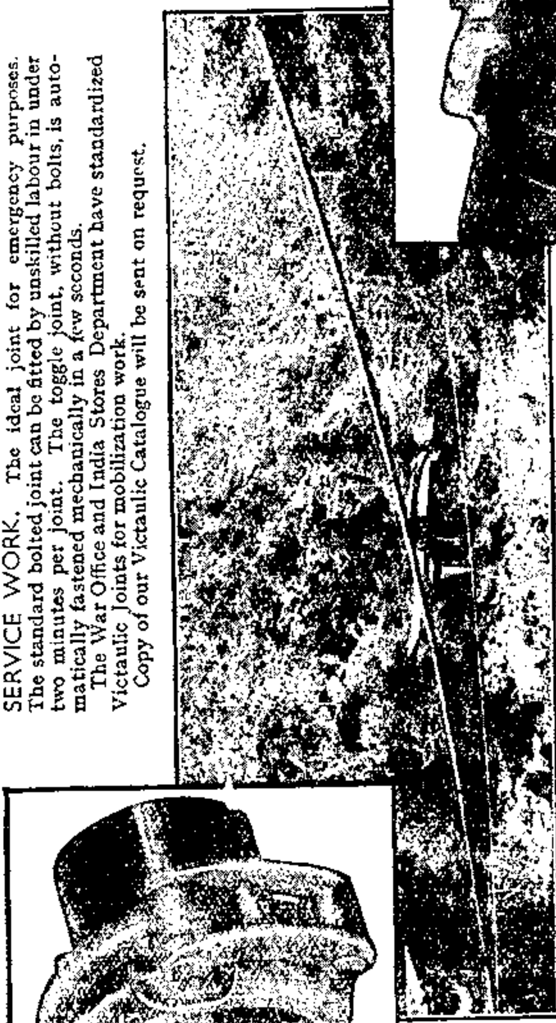

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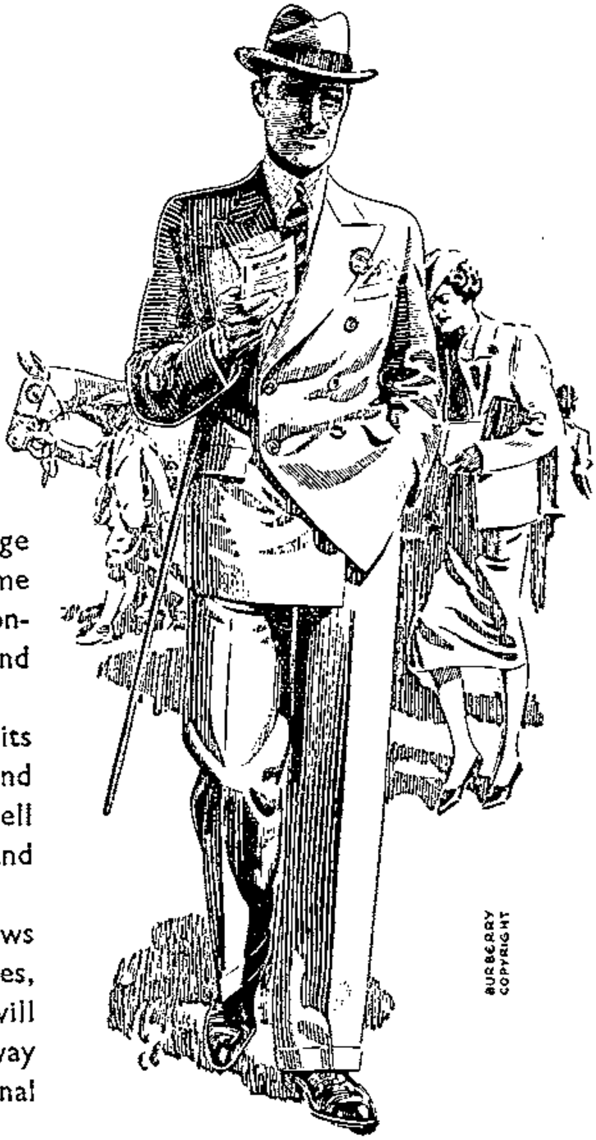
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VOL. LXIII CONTENTS MARCH, 1949

PAGE

1. Presentation to the Corps by Greek Engineers. (*With Photograph*) . 1
2. Atomic Energy in Outline. By Col. F. A. Iles, C.B.E., D.S.O. (Retd.) . 2
3. What the Russians Think of our Representative Colonel Commandant 14
4. Making Gaps in a German Minefield. By Lieut.-Col. M. C. A. Henniker, D.S.O., O.B.E., M.C., R.E. 16
5. The Church of St. Thomas à Becket, Hamburg. By Lieut.-Col. C. G. Phipps, O.B.E., R.E. (*With Photographs*) 19
6. Eastern Army Boat Factory, Kalewa. By Major G. G. Layton, M.B.E., R.E. (*With Photographs and Diagrams*) 25
7. Winter Service on the Austrian Roads. By Lieut.-Col. A. Bennetts, R.E. (*With Photographs and Map*) 29
8. Adaptation of Materials in the Sudan, 1941-2. By Captain T. G. Layton, R.E. (Retd.) 33
9. Types of Road Surfacing 35
10. Mountbatten Bridge, Shweli River. By Lieut.-Col. P. A. Easton, O.B.E., R.E. (*With Photographs and Diagrams*) 36
11. Dr. Jekyll and Mr. Hyde 38
12. The New Scottish H.E. Plant at Lochalsh. Submitted by Richard Costain, Ltd. (*With Photographs*) 39
13. "Q" (Quartering) Problems in Malaya During 1947. By Major D. J. Willison, M.C., R.E. 41
14. The Move of the S.M.E. (India) from Roorkee and its Re-establishment at Kirkee. By Lieut.-Col. Sir John S. Forbes, Bt., D.S.O., R.E. (*With Sketch*) 52
15. Advertising the Corps. By Maj.-Gen. H. L. Pritchard, C.B., C.M.G., D.S.O. 59
16. The Right Type of R.E. Officer and How to Get Him. By "Centurion" 61
17. The Ordnance Survey in the Near East. By Lieut.-Col. H. E. M. Newman, R.E. (*With Sketches*) 64
18. The Cariboo Trail. By Brigadier G. MacLeod Ross, M.C., M.Eng., M.Inst.C.E. (*With Map*) 78
19. A Garrison Engineer in Southern Ireland. By Major D. G. B. Boyd, R.E. 83
20. Sapper Officers in the Peninsular War 85
21. Memoirs 87
    - Lieut.-Col. W. A. Harrison, R.E. (*With Photograph*) . C.C.P.
    - Maj.-Gen. H. B. H. Wright, C.B., C.M.G. (*With Photograph*) R.E.M.R.
    - Lieut.-Col. J. R. Garwood, D.S.O., R.E. . . . . A.G.B.B.
22. Book Reviews 93
    - The Indian Sappers and Miners . . . . M.C.A.H.
    - Design for Welding . . . . C.S.B.
    - Production Engineering . . . . C.D.A.F.
    - Straight on for Tokyo . . . . M.C.A.H.
    - Troopship . . . . C.C.P.
    - Dowsing . . . . C.C.P.
    - The Elements of Dowsing . . . . C.C.P.
    - Practical Five-figure Mathematical Tables . . . E.M.E.C.
    - Prejudice and Judgement . . . . M.C.A.H.
    - Cementone No. 2 Waterproofing Powder . . . . C.C.P.
23. Technical Notes 101
    - Flame Cleaning Steelwork before Painting
    - Wind Tunnel for Suspension Bridge Models
    - Mechanized Cargo Handling
    - Swing Bridge Renewal on the Chicago and North Western Railway
    - Aluminium Bridge at Sunderland Docks
    - Deterioration of Structures of Timber, Metal, and Concrete Exposed to the Action of Sea-water
    - Air Power as Affected by Airdrome Construction

PRESENTATION TO THE CORPS BY GREEK ENGINEERS

Marble plaque.

PRESENTATION TO THE CORPS BY GREEK ENGINEERS

PRESENTATION OF A MARBLE PLAQUE
BY THE OFFICERS OF THE ENGINEERS CORPS OF THE GREEK NATIONAL ARMY
TO THE OFFICERS OF THE CORPS OF ROYAL ENGINEERS
AT THE GREEK S.M.E. AT LOUTRAKI

ON 6th October, 1948, Maj.-Gen. D. Carachristos, the Engineer-in-Chief of the Greek National Army, on behalf of the Officers of the Greek Engineer Corps, presented to Maj.-Gen. W. M. Broomhall, D.S.O., O.B.E., Chief Engineer, M.E.L.F., the Marble Plaque, a photograph of which is shown opposite, as a gift to the Officers of the Corps of Royal Engineers.

The presentation was made at a Guest Night in the Officers' Mess at the Greek School of Military Engineering, which is situated at Loutraki, on the north bank of the west end of the Corinth Canal.

In the morning Maj.-Gen. Broomhall inspected the S.M.E. and then gave lunch to the Greek E.-in-C. and to the Commandant and some officers of the School in a restaurant in the town, and in the evening he attended the Guest Night in company with Brigadier C. D. Steel, O.B.E., Colonel A. C. Shortt, O.B.E., Lieut.-Cols. T. E. Robinson, F. M. Hill and C. E. H. Sparrow, M.C., Majors J. G. O'Ferrall, A. F. Bell, M.B.E., and W. E. Skinner.

The plaque measures about 1 ft. 9 in. by 1 ft. 6 in. and is beautifully carved in relief from Pendelic marble, the same marble which was used by the Greeks in ancient times for the building of the Parthenon and for Praxitile's statue of Hermes at Olympia.

It shows a Greek Sapper with upraised pick silhouetted against the map of Greece and the inscription at the foot states that it is given :—" To the Officers of the British Engineers from the Officers of the Greek Engineers as a sign of the unbreakable bonds of friendship forged in their common cause."

The plaque is accompanied by an album of photographs showing some of the beauty of Greece and illustrating the work of the Greek Engineer Corps from the liberation up to the present time.

A dedicating speech was made by Maj.-Gen. Carachristos, to which Maj.-Gen. Broomhall replied offering thanks on behalf of the Officers of the Corps.

The Guest Night was rounded off by the singing of the " C.R.E.", in which the procession was led by the Greek E.-in-C., followed by Greek dancing and the playing of the National Anthems of the two countries.

The plaque can be seen at the S.M.E., Chatham, and the photograph album is at present located at the R.E. Officers' Mess at Ripon.

ATOMIC ENERGY IN OUTLINE

By Colonel F. A. Iles, C.B.E., D.S.O. (Retd.)

As an introduction to the subject of Atomic Energy it is helpful to trace the development of the idea of the atom in men's minds.

The idea of all solid matter as being capable of being divided and sub-divided down to an ultimate particle too small to admit of further sub-division was developed in the fourth century B.C. by Democritus, and held generally by the Greek philosophers, who called that particle the "uncuttable." This idea was further popularized, three centuries later, by Lucretius, and held the field for over 2,000 years, though not without set-backs in popularity, for under the domination of human thought by Plato and Aristotle it was for many centuries less regarded.

From the Dark Ages little interest could be expected, and no progress, but with the revival of learning which followed the invention of printing, and the release of literary treasures by the fall of Constantinople, there followed a general revival of the idea that all matter consisted of minute, discrete atoms. This belief was largely due to Francis Bacon, whose writings influenced Boyle and Newton, and through the latter Dalton, and so helped to establish this conception of the atom in chemistry and in physics. Alongside it there grew up its corollary, that in nature there existed a certain number of elements (the number of which, known to man, was being added to from time to time), each element differing from each, so that there existed as many kinds of atoms as of elements, no more and no less. Whether atoms were composed of smaller particles or not seems to have affected the chemists very little, if at all, since chemistry in the nineteenth century made huge advances, working on the simple homogeneous atom. Chemistry's concern was with measurable quantities. It was dealing with larger amounts, with a multitude of atoms or of molecules, but not with units. To this there was only one exception, but that a very important one; viz., that one of the ways of reading the chemical symbols and formulae, showing by equations the products of chemical change, claimed validity also for the single atom. For the chemists the Daltonian atom was a bed-rock standing on which they appeared once and for all to relegate to limbo the dream of the alchemists, i.e., that of the intercovertibility of the elements. This latter idea, was, however, to return as a certainty, within limitations, once the atom had been proved not to be the ultimate particle. The open-sesame of this lock was, of course, radiation, the discovery of which had to engage man's notice in spite of its being invisible. Although the chemists of the time were satisfied with the Daltonian atom on which they were able to build the vast edifice of organic, as well as of inorganic chemistry of the nineteenth century, the physicists were far from satisfied. In the latter half of that century Crookes, William Thompson and J. J. Thomson all suggested that the atom instead of being indivisible was composed of still smaller particles or corpuscles. The theory of the electric atom may, however, be traced back to 1850, when Geissler sealed platinum electrodes into the ends of a glass tube, pumped out the air, and applied an induction-coil to the electrodes. The inside of the tube then glowed with a cold, softly radiant light. In 1875 Sir William Crookes much increased the degree of exhaustion of the air in a Geissler tube and then found that when the H.T. was applied to the terminals there was an actual stream of negatively-charged particles travelling from cathode to anode. He called the stream "cathode-rays," and found the velocity of the particles composing it to be one-tenth of the velocity of light. The next great discovery was more important and more startling. In 1895 Röntgen, experimenting with a Crookes tube, found new rays being emitted from the inner surface of the tube where the cathode-rays impinged upon it. W. H. and W. M. Bragg showed that these new rays, called by Röntgen X-rays, are electro-magnetic waves like those of light, only one-thousandth shorter, i.e., about half the wave-length of the shortest ultra-violet ray. As they act on a photographic plate like light-rays, but pass through certain substances opaque to light, X-rays make possible the photography of objects invisible to the eye. As they further cause certain salts, e.g., calcium tungstate, to fluoresce, the same result can be obtained without photography, using a fluorescent screen, as in Edison's fluoroscope. These X- or Röntgen-rays found an immediate application in surgical and medical practice, and became world-famous not only for the aid given to diagnosis, but also for their direct effect upon organs and tissues.

Surprised as not only the public, but also the scientific world had been by the discovery of X-rays in 1895, in less than a year men of science were shaken more severely still by the discovery of Radio-Activity.

Radio-Activity

This phenomenon discovered in 1896 by Becquerel upset all ideas both of the indivisibility of the atom and of the immutability of the elements. In fact, it resuscitated the brilliant idea of the English chemist, Prout, who in 1815 from a study of the periodicities, properties, resemblances, groupings and atomic weights of the then known elements, had suggested that all elements were in some way or other composed of hydrogen. In this bold deduction of his, Prout did not only nearly get a bull's-eye, he got nearly the centre of the bull. He got right within one part, in 1840, the proportion of the mass of the electron, which is missing from the hydrogen atom, to that of the proton, which forms the remainder. Small wonder that a proposal (serious) has been made to re-name the proton after him, the prouton!

As we date from Becquerel's discovery of radio-activity all subsequent progress in the understanding of the atom, and of its application, control and use for human purposes, we may dwell for a few moments on its origin. It originated in a discussion between Poincaré and Becquerel, which followed a sitting of the French Academy early in 1896, at which Poincaré had reported to the members on the experiments recently carried out by Röntgen, which have been referred to above, in which energy of motion had been converted into energy of radiation. Poincaré and Becquerel agreed that a systematic research must be made of fluorescence to determine when and how such conversions occur. Becquerel in his modest laboratory in Paris started at once, choosing for his purpose uranium salts. He exposed these to the sun's rays and actually blackened with them photographic plates, which had been protected against ordinary light. Thus it seemed as if the uranium salts by fluorescence were producing short-wave rays. It soon proved, however, that the blackening had quite another cause. There were two good reasons against his first supposition (1) the air is impervious to very short-wave rays, and (2) in fluorescence, waves of shorter wave-length than that of the light that excites them, never arise. It is therefore impossible for sunlight to be converted into Röntgen-rays. The progress of Becquerel's investigations was now interrupted by a spell of bad weather, but on 1st March, he developed a plate which had been lying in a cupboard for some days next to uranium salts. On the plate were two black spots. This historical plate is preserved to this day as a museum piece. Becquerel deduced that the blackening rays emanated from the uranium salts. He called them the Becquerel rays and qualified the salts as radio-active. He was soon able to confirm that the origin of the rays was the element uranium itself. Nowadays we should suggest that the source of radiation should be sought in the atoms of the element, but at that time one was groping completely in the dark. We needed an entirely new conception of the structure of the atom.

Rutherford was the first to answer the question "How is radio-activity explained ?" by his conception of a new model of the atom. According to this idea each atom consists of a miniature planetary system in which electrons revolve like planets round a central nucleus as their sun. Nowadays we look upon this model as over-simplified. As a picture, however, it still does good service, and the foundation pictures of a small, but heavy, nucleus and a light envelope of electrons may be considered as settled. The nucleus is the seat of the atom's chemical properties. The nucleus itself is composed of elementary particles, which are held together by powerful forces. At the end of the Periodic system of elements, where the radio-active elements like uranium and radium occur, the nucleus is specially heavy, consisting in the case of uranium of at least 236 elementary particles. Apparently these complicated structures are not in the long run completely stable. Sooner or later the nucleus "disintegrates," that is to say, it loses an elementary particle. Thus of course the atom's chemical properties change. In fact, by disintegration one element changes into another. The enormous energy which is thus freed, is expressed in the incredible violence, with which a particle is hurled forth, measuring millions of electron-volts.

(NOTE.—The Mev or million-electron-volt is a convenient unit for measuring energy in nuclear physics. It is the kinetic energy of one electron propelled by a difference of potential of 1 million volts. It has as a unit of energy an equivalent measured either in ergs or in kilowatt-hours.)

After Becquerel's discoveries, Madame Curie found in 1898, and reported to the French Academy, that the salts of thorium gave off rays like those of uranium, and later this scientist separated out from pitchblende, the first radio-active substance, which, as she was Polish by birth, was named in her honour polonium. Finding that the rays given off by uranium were weaker than those from the pitchblende originally containing it, the Curies then sought for and found the most radio-active element of all, which they called radium.

All these substances, uranium, thorium and radium give off complex rays, which were analysed in 1902 by Rutherford, who found their differing powers of penetration as well as different behaviour in a magnetic field. He separately identified the components and named them alpha, beta and gamma radiation. The first two kinds turned out to be corpuscular, the last non-corpuscular. In fact, α-rays consist of α-particles which are the nuclei of helium atoms, or protons, hence carrying a positive charge and deflected in a magnetic field ; while β-rays consist of β-particles, which turned out to be electrons, hence carrying a negative charge and deflected in a magnetic field in the opposite direction to the α-rays. γ-rays are very short and penetrating electro-magnetic waves.

The rate of disintegration of radio-active elements can be measured, and varies between the widest limits, from 10^{-4} second (radium C) to 5 billion years (uranium). These are the times of what is called the half-life, i.e., the time of half disintegration. Nothing that we can do can hasten or change the rate of decomposition. After the half-life the law of diminishing returns applies, to infinity.

The first observed phenomenon of radio-activity, viz., the blackening of photographic plates has, in regard to scientific value, been largely superseded by the ability of radio-active substances to ionize gases, i.e., to make air and other gases better conductors. This property was discovered by Becquerel very early: since when the rate of discharge of an electroscope has served as a measure of radio-activity, and most instruments for studying radio-active phenomena embody ionization.

Means of Bombardment, or Atom-Smashers

These are machines to produce charged particles with energies great enough to penetrate the nucleus. In 1932 experiments were under way both in England and the U.S.A. to invent such machines. Although million-volt X-rays had been produced, neither the production of X-rays for therapeutic use, nor for testing insulators, required the voltage to be applied steadily. Such machines were therefore unsuitable for nuclear research. For this purpose have been produced :—

1. *The Voltage-Doubler*, by Cockcroft and Walton, which was built up of a set of linked transformers, has attained 1 million volts.

2. *The Impulse-generator*, which depends only on condensers, and reaches its high peak voltage, which happens only about one-thousandth of the time the generator runs, when the whole process has to start over again. This is a grave disadvantage when compared with Cockcroft and Walton's voltage-doubler, which produces a large continuous current at a constant voltage.

3. *Van de Graaff Generator.*—This is an electrostatic generator depending on the fact that it is possible to carry an electric charge on a moving belt by insulated metallic points (gramophone needles) and, at some further point in its travel to remove the charge again. A further essential principle is that although a closed conducting sphere is charged to a high voltage, there are no electrical forces inside it, any such penetrating the sphere and distributing themselves evenly on the outside. These generators were very cheap to make and the results with the first small generator and with one of $1\frac{1}{2}$ million volts were so encouraging that Van de Graaff decided to go in for something much larger. He doubled the voltage by having two similar terminals, one charged positively and the other negatively. Accelerating tubes for these high voltages gave great trouble, but can be made to function at lower voltages, i.e., with smaller generators. With many developments, sometimes used together, and sometimes in part, the Van de Graaff generator has become a reliable source of high voltage particles. Like the voltage-doubler it produces a continuous stream of particles all accelerated to a stable and known voltage. So it is extensively used for nuclear research. At Harvard one of these generators only $8\frac{1}{2}$ ft. high is in operation producing 600,000 volt deuterons.

For hospital use Van de Graaff generators have accelerated electrons to over 1 million electron-volts. Such electrons can be used as projectiles in X-ray tubes, producing 1 million-volt X-rays.

4. *The Cyclotron.*—The cyclotron imparts to moving particles by successive stages the necessary fillip which causes them to increase their speed, as the timed impulses on a swing give the swing greater momentum. The particles in a uniform magnetic field travel at ever increasing speed in ever increasing circles, in fact in a spiral. The utilization of this simple fact allowed acceleration to be applied to the particles each time they left one electrode, to enter the other, thus eliminating all necessity for greater lengths of accelerating tube, the feature that had caused so much trouble with other high-voltage machines. As the circles constantly increase in diameter the speed

of the particles increases, for they have a greater distance to travel and yet do it in the same time. The first cyclotron was quite small, only 4 in. across, but the results were so encouraging that Lawrence built a 12-in. cyclotron. There is now at the Cavendish Laboratory a 36-in. cyclotron which produces 9 million volt deuterons. Inside the two hollow semi-cylindrical electrodes (half pill-boxes) the particles travel in field-free spaces, like the inside of the Van de Graaff spheres. They are accelerated only when they leave the D's for the space between the electrodes, where the field is concentrated. The cyclotron does not produce a steady current at a known and constant voltage, like the voltage-doubler and the Van de Graaff generator, but the voltage available from the cyclotron is far higher than that from any other source in nuclear research. The cyclotron is the most powerful weapon available today for nuclear disintegration.

Instruments.—Without Geiger's Counter, by means of which the particles can be heard passing, and T. R. Wilson's Cloud-Chamber by which they can be seen passing, the utility and value of the foregoing atom-smashers would have been immeasurably less.

The Problem of Atomic Energy

Believed to be the first suggestion that the atom was not solid, impenetrable and indivisible was the Kelvin Vortex Atom. Sir William Thompson in 1850 conceived the atom as a vortex in the ether, which, like a smoke-ring in the air, receives from its motion the physical properties of rigidity, stability and weight. The idea of the atom as an energy-centre was born, and later, popular handbooks appeared on the dynamics of rotation, spinning-tops, smoke-rings, etc.

In 1896 came the earliest scheme for a purely electrical atom, formulated by J. J. Thomson. It consisted of a minute sphere of positive electricity in which one or more corpuscles (negative charges) circulated. In 1910 Sir Ernest Rutherford was able to improve greatly on J. J. Thomson's electric atom. Finding that α-particles of radio-active substances passed through the atoms of metal foils and not through the spaces between them, he deduced that atoms, though crowded together, were themselves largely emptiness, and conceived the atom, referred to above and known as the Rutherford atom, having a minute very compact nucleus round which negatively charged particles revolve. Since Rutherford, in 1911, gave to the world his nuclear theory of the atom, the idea has steadily grown and spread that there are in all matter, even the tiniest portion, vast stores of energy ; that this energy differs from the energy released in chemical reactions, like the combustion of coal or oil, or the detonation of explosives, and is probably more of the nature of what occurs on earth in naturally radio-active elements, and what is taking place inside the " fixed " stars, like our sun. Some idea of the energy involved was indeed conveyed to his audience at London University in 1920 when that G.O.M. of Science, Sir Oliver Lodge, after showing on the blackboard what even a minute mass could achieve in the way of energy by travelling fast enough, announced that there was enough (atomic) energy in the piece of chalk between his fingers to drive a liner across the Atlantic.

Although since Becquerel's discovery of 1896 men have become increasingly familiar with the idea of vast stores of atomic energy, the way in which this energy might be made available was foreseen either dimly, or not at all. Fermi indeed suggested to Bohr that if an atom could be truly split, i.e., not only have particles knocked off, or even, out of it, the result would be the release of vast quantities of energy in the form of neutrons.

This proved correct, and now that it has happened the next requirements for atomic energy to be available for human purposes are the self-sustaining chain-reaction, and the control at present provided by the pile.

The first practical indication of how atomic energy might be made available to man was when Hàhn and Strassmann in Berlin in November, 1938, found that a result of the bombardment of uranium by neutrons was to produce not only isotopes of uranium, which they expected, but also an isotope of barium, which they did not expect.

This story is told later under the heading of " Nuclear Fission."

Matter and Energy

Two principles have been the foundation of the structures of modern science. They are :—

(1) The Law of the *Conservation of Matter* : viz., that all matter is indestructible. It can only be changed in form—solid, liquid or gaseous. This was enunciated in the eighteenth century, has been, and is still the basis of all chemistry-teaching.

(2) The Law of the *Conservation of Energy* : viz., that energy including all losses by friction, dissipation, degradation, etc., cannot be destroyed, neither can it be created, but only converted from one form to another. This law was formulated in the next century after the Law of the Conservation of Matter. It followed the discovery that heat is only a mode of motion (Tyndall) and that all energy on earth derives from the sun, being stored by the chlorophyll in the vegetation and so, if not already eaten, later in coal-measures, so that solar energy reappears as heat, motion, potential or kinetic energy in steam, electricity and through food in all animal activity.

Since 1940 these two laws have changed fundamentally. They will continue for all practical purposes to govern scientific understanding and practice, with the modification that matter and energy are now known to be, in certain very limited conditions, interconvertible. This knowledge may be regarded as having its starting-point when in 1896 Becquerel discovered radio-activity or spontaneous atomic disintegration. The scientific world was thus startled and shocked by the loss of two great pillars upon which it had built, the indivisibility of the atom, and the immutability of the elements.

The origin of this fundamental change was when in 1904 Einstein produced his Special Theory of Relativity. He laid down that it is entirely impossible to observe any difference in the speed of light. This principle of the Constancy of the Speed of light holds good for all natural phenomena, viz., that it is not by any means possible to determine an absolute motion, not even against an ether absolutely at rest. Upon this foundation is built the enormous structure of the Theory of Relativity. Not only light, but all electro-magnetic phenomena appear exactly in the same way to every observer, whether he is in motion or at rest. Against this absolute constancy of the speed of light, the measurements of space and time are variable, depending on the relative motion of the observer. But not only space and time are relative, also the mass of a body depends upon its speed. When the speed of a body is the same as the velocity of light, i.e., the maximum speed possible, its mass becomes infinite. Thus energy becomes mass, and mass energy—a phenomenon now observable in the dissolution of atoms. The two Laws are still true within limits, i.e., matter is conserved when it changes its form, and energy is consumed when it changes its form : without those limits matter is converted to energy whenever atomic fission takes place, by radio-activity spontaneous or artificially produced. In the case of systems moving in a straight line with uniform velocity the two Laws of Conservation are now replaced by a single axiom " The sum of Energy and Matter is constant."

In 1917 Einstein produced his General Theory of Relativity, an attempt to embrace also accelerated systems, electro-magnetic phenomena and also gravity. In this he equated the inertia of accelerated systems and the pull exerted in mass attraction.

Since 1905, when Einstein laid it down as part of his Theory of Relativity, there were indeed indirect, but conclusive proofs that energy and matter were interconvertible. The chief obstacle in the way of direct evidence on the subject was the vast disproportion of the ratio between the two, seeing that the most minute mass contains incredible amounts of energy. Chemistry could never have discovered this fantastic difference.

Bombardment

By bombardment is meant the application of particles moving with the utmost speed to a target, such as a nucleus or a screen. Bombardments have been carried out using the following as projectiles :—

(1) *α-particles.*—The α-particle, i.e., the helium nucleus, which consists of two protons and two neutrons (or the helium atom short of two electrons), was first used for bombardment purposes by Rutherford in 1919, and with it he showed for the first time that the nature of the atom can be changed. A radio-active source of α-particles sending its rays through dry nitrogen, showed by means of scintillations on a zinc sulphide screen, that the nitrogen was being robbed of protons, i.e., of the nuclei of hydrogen atoms, in other words, the nitrogen was turning into oxygen. Regarded physically the α-particle had penetrated the nitrogen nucleus and knocked a proton out of it. With acknowledgements to the chemists for borrowing their notation, we might express what happened by :—

$$N + He = H + O$$

To the old-time chemists, accustomed to regard equations as describing what happens when things are poured into test-tubes, this statement must have appeared to be nonsense, even though it works out by atomic weights, thus :—

$$14 + 4 = 1 + 17 \text{ (heavy isotope)}$$

But the modern chemists took it otherwise, and behaved handsomely as regards this invasion by physics into chemistry's province. Indeed, they recommended Rutherford for the Nobel prize for chemistry, and when in due course he received the award, and a dinner was given in Stockholm in his honour, Rutherford was able to tell the company (and incidentally to " bring down the house " by saying) that, much as he had studied transmutations, none had surprised him more than finding a physicist transformed into a chemist !

Rutherford and Chadwick continued their transmutation experiments and were shortly able to report on five more cases.

β-particles, naturally produced from radio-active elements, are readily available, endowed with sufficient energy to enter the nucleus. Nevertheless, they have various disadvantages compared with other projectiles, such as :—

(2) *The Proton.*—The proton, i.e., the hydrogen atom minus its electron, is as a particle far more feasible for nuclear penetration than the α-particle. Smaller than the α-particle it has unit mass and a single charge. Each of these features facilitates its entry into the nucleus. When protons are produced artificially this charge is useful for getting them going.

(3) *The Neutron.*—The neutron, i.e., the chargeless proton, seems to be an ideal particle for attacks on the nucleus, since it does not interact with the electric field and can easily penetrate the nuclear defences, but it is not easy

to start it off in the right direction. It is the ease with which the nucleus can capture it, that gives the neutron its importance in bombarding nuclei. The neutrons which are used for bombarding are made on the spot by an earlier disintegration. Chadwick in 1932 had found that beryllium, bombarded with α-particles, gave off, not γ-radiation as supposed, but neutrons. These neutrons, used at first in experiments for determining the properties of the neutron, are today used as projectiles.

(4) *The Deuteron.*—The deuteron, i.e, the nucleus of the heavy hydrogen atom, possesses the properties of both proton and neutron. It is bound together far less tightly than the α-particle : it is able to break up into its components under proper provocation. As it has a single charge it can easily be accelerated and sent on its way towards the nucleus. Sometimes the deuteron enters the nucleus complete with its accompanying neutron, but more often it loses its neutron while still outside, and the neutron goes on and enters the nucleus alone. " Radiative capture " is the name given to nuclear bombardment in which the bombarding neutron remains in the nucleus, producing only γ-rays. Most atomic nuclei are penetrable by one or more of the foregoing projectiles, and/or by γ-rays ; resulting in a nuclear rearrangement by which a particle is expelled from the nucleus with great violence, or radiation occurs, or both. The change in the nucleus generally is to another type, which is radio-active and so decays, and thus radio-activity may continue in the next type formed and so on, until eventually a stable type is reached. These cases of artificially radio-active substances differ from natural radio-activity in that change occurs in some cases by the emission of a positron, which is unknown in natural radio-activity. In all cases measurements tend to show that the equivalence of matter and energy holds good, viz.: $m \times e = k$.

Neutrons, Fast and Slow

In 1930 Bothe and Becker in Berlin observed that when α-particles from a natural radio-active source, viz., polonium, were used for bombarding beryllium, a very penetrating radiation was emitted. This emission was investigated by the Curies and others, and eventually Chadwick at Cambridge in 1932 showed that the stream, besides γ-rays, consisted of particles of the mass of protons, but electrically neutral. These particles received the name " neutrons " and, as their existence had been predicted, in fact Rutherford had been searching for them for twelve years, they were at once fitted into the order of things and took their place alongside the proton as constituents of the atomic nucleus.

The neutron's lack of electrical charge made it an ideal projectile for bombardment of nuclei, which strongly repel charged particles, and thus effecting nuclear transformations. This idea first occurred to Fermi in Rome and he followed it up by using neutrons to bombard the nuclei of heavy atoms, e.g., uranium, which are guarded by powerful electric fields of force. He thus produced elements 93 and 94, not yet found in nature ; as well as more uranium isotopes.

The greatest result of the discovery of the neutron was the flood of light it threw upon our understanding of the Periodic Table of the Elements: viz., that :—

(1) Each element in the table differs from the element preceding, i.e., of one lower atomic number, by having one more electron revolving round its nucleus.

(2) That the number of electrons revolving is the same as the number of protons in the nucleus, and that this number is the element's atomic number.

(3) That the number of neutrons in the nucleus of the atom of each element is the difference between the element's atomic weight and its atomic number, or the atomic weight is the sum total of protons and neutrons in the nucleus, referred to hydrogen as unity.

The first distinction between fast and slow neutrons appears to have been made in a forecast by Fermi in March, 1939, when he suggested the possibility of achieving a considerable reaction, i.e., release of energy, by using *fast* neutrons for causing fission, and a controllable reaction by using *slow* neutrons. Fermi's liaison with the United States, where most of the work was being done, was good, and it appears there by June, 1940, to have been generally known, that :—

(1) The fission of thorium and of proto-actinium could be produced only by bombardment of their nuclei by *fast* neutrons (i.e., those with velocities of the order of thousands of miles per second).

(2) The same was true of the uranium isotopes, with one exception, U235.

(3) The probability of causing fission in U235 was greater with *slow* (or thermal velocity) neutrons, than with *fast* ones.

Here the first distinction comes in between atomic energy used for peaceful purposes, and the same used for war. The deduction was that as a source of a controlled chain-reaction U235 would be suitable for atomic power purposes —using " power " as the general public does in horse-power, power-station, etc.—whilst other uranium isotopes would be best for bringing about explosions. There was, however, a snag in this, viz., that U235 occurs in such small quantities in uranium (0·7 per cent) that the supply of ore in sufficient quantities for war purposes would be difficult. Before seeing how this difficulty was brilliantly overcome we should consider Natural Transmutations.

Natural Transmutations

These occur in four series, the first three named after radium, thorium and proto-actinium respectively, while the fourth which starts from an isotope U233, not found in nature, awaits christening. As regards the way radioactivity works in these four natural series, Rutherford and Soddy suggested that in giving off an α-particle or a β-particle the substance changes its chemical nature, becoming an entirely different element ; thus, in the radium series, uranium by giving off five α-particles and three β-particles passes through some fourteen stages, by way of ionium, radium and polonium to become lead. Similar changes are formed by the other three series each also ending in a lead isotope.

Isotopes

Discrepancies found in the atomic weights of samples of one and the same element had troubled chemists, until it was discovered that isotopes existed, i.e., that an element could occur in more forms than one, differing only in atomic weights. Similarly they must have troubled a physicist, like Moseley, who was trying to introduce greater significance and order into Mendelieff's Table of Elements, which had been defined as " more or less successfully arranging in eight columns and eight sub-groups, the elements possessing more or less similar chemical properties." Certainly the new table which might be called Mendelieff-Thomson-Rutherford-Moseley-Bohr shows a vast approach to reality.

In 1910, J. J. Thomson, experimenting with the positive-rays, discovered by Goldstein, invented the apparatus in which positive-radiation produces the positive-ray parabola. He arranged with great skill to produce enough positive particles to register on a fluorescent screen. He then found that all particles having the same ratio of mass to charge fell on the screen in a curve, viz., a parabola, any variation in their speed causing their position on the curve to vary, but not the parabola itself; the position of which on the screen was determined only by the mass to charge relationship. J. J. Thomson thus made the first physical measurements of the masses of heavy particles. He had found a method of determining atomic weights, which was far beyond that of the chemist, with his averages of the masses of comparatively enormous quantities. Moreover, he was able to relate all atomic weights to an unimpeachable and fundamental standard, the hydrogen nucleus, or proton, the hydrogen atom less its electron. With neon, the atomic weight of which was held to be 20·2, Thomson found that, however much he purified the gas, he invariably found two parabolas described by the particles, one fainter than the other. He deduced that the neon used was not one gas, but a mixture of two gases, the atomic weights of which were about twenty and about twenty-two respectively.

The Pile

A pile is an arrangement for (1) making a self-sustaining chain-reaction, and (2) for controlling the same. It provides a target for bombardment by high-speed particles from a cyclotron or other source of high-speed particles. The pile consists of a matrix composed of a moderator, such as graphite in which are embedded in rows at regular intervals and "line ahead" slugs of uranium, which become radio-active when bombarded by, say, neutrons from an external source. High-speed neutrons emitted by the "slugs" owing to the fission of the uranium under bombardment by neutrons from the cyclotron are slowed down by the moderator to slow, or thermal, speed. They are then suitable for producing a self-sustaining slow neutron chain, such as is required for the production of atomic energy. A pile is thus :—

(1) *A target for particles*, e.g., neutrons, received from an outside source, e.g., a cyclotron, or other ejector of high-speed particles, the purpose of bombardment by which is to cause the uranium-slugs, which make up the target, to emit more neutrons than it receives.

(2) An *amplifier*, since it produces more neutrons than it receives.

(3) *A converter*, since matter in it, viz., the uranium of which the slugs are made, is disintegrated by the bombardment of high-speed particles, reappearing as energy of radiation.

(4) *The source of a self-sustaining chain-reaction* in that the fission of the uranium slugs causes an emission of neutrons over and above the number of bombarding neutrons, so that energy is released in increasing amount.

(5) *A choke or damper of energy*, an office which is performed by the matrix of the pile which is composed of some moderator, like graphite, heavy water or beryllium.

Chain-Reaction

A simple form of chain-reaction is the domestic fire. The parallel with the chain-reaction set off by uranium-fission would be closer, given automatic stoking operated by the fire itself. The first condition of the operation of atomic energy is the fission of uranium by bombardment with neutrons, and this applies to all purposes from peace to war, from atomic power-plants to bombs. The second condition is that such bombardment should set up a self-sustaining chain-reaction, i.e., the bombarding neutrons must produce by the uranium-fission enough new neutrons to make good all losses of neutrons due to (1) capture by uranium, not resulting in fission, (2) capture by impurities, and (3) escape. The chain-reaction occurs when there is a surplus of neutrons produced over and above these losses. The seat of this self-sustaining chain-reaction is the pile.

Rutherford having pronounced that the atom's chemical properties were given by the revolving electrons, and its mass by its nucleus, proceeded to Artificial Nuclear Disintegration.

Artificial Nuclear Disintegration

This he carried out by bombarding the nucleus with α-particles with the result pointed out above that he brought about the first transmutation of elements, a few atoms of nitrogen bombarded by helium nuclei actually yielding atoms of two different elements—oxygen and hydrogen.

Instead of α-particles, Cockcroft and Walton used protons, and made two elements, lithium and hydrogen, unite to form a third, helium: —

$$Li + H = 2He$$

The neutron, being chargeless, stood a greater chance of penetrating the nucleus than either of the above-mentioned projectiles. It was successfully used to make boron and helium out of nitrogen.

As regards the behaviour of uranium isotopes, Bohr, in his Theory of Fission, foretold, and subsequently confirmed by experiment, that U235 would undergo fission even with low-velocity bombarding neutrons, while U238 would respond only with high velocity neutrons.

Seeing that out of the uranium ore used only 0.7 per cent were of U235, while 99·3 per cent were of U238, the prospects for nuclear bombardment were not bright. Fortunately a new phenomenon was discovered, which enabled the surmounting of the difficulty in brilliant fashion. By using U238 as the starting-point of a number of transformations it was possible to lead up to Plutonium (Element No. 94), which, as the Bohr-Wheeler Theory predicted, resembles U235 in undergoing fission with great ease when bombarded by low-energy neutrons. In other words, the abundant U238, which is unsuitable for bombardment is now providing an element, plutonium, which is as good for that purpose, as the rare U235.

Nuclear Fission

Twenty years after Rutherford had astonished the world by his success in nuclear disintegration, by bombarding the nucleus with α-particles, and long after the public had become familiar with the idea of the atom as an energy-centre, and "splitting the atom" had become a comic-paper joke, the atom was truly and fairly split, i.e., it was broken into two approximately equal portions. The result was so astounding that it could not at first be appreciated—using that word in its military sense—even by those who had brought it about.

In 1934 Fermi and others in Rome began an extensive study of the effect of bombardment by neutrons on most of the elements. They found, especially among the elements of high atomic weight, many isotopes, which appeared to be always of higher atomic weight than the element bombarded.

In January, 1939, Hahn and Strassman of the K.W. Institute for Chemistry in Berlin reported, however, that among uranium isotopes, resulting from nuclear bombardment they had found an isotope of barium, the atomic weight of which is approximately half that of uranium, and this barium, contrary to expectations, turned out to be highly radio-active. These two scientists with Miss Meitner, their assistant, had split the atom, but they refused to believe it, and wrote to the scientific press to say so. A possible explanation of this disbelief is that the other half into which the uranium split was the inert gas, krypton. Meanwhile things were happening quickly. Miss Meitner went to Copenhagen, having been expelled from Germany, and entered the Institute of Theoretical Physics under Professor Bohr. She could not have taken her knowledge to a better man, considering not only his position in the scientific world, but especially his good relations with scientists in the United States and in England.

In Copenhagen Miss Meitner found a fresh colleague, Dr. Frisch, also a refugee from Germany ; and they wrote jointly to the scientific press pointing out that Hahn's discovery could only mean that a nuclear reaction had taken place of a kind utterly different from any so far studied, in fact that the uranium nucleus had split into two parts of nearly equal mass, behaving like a drop of water, which when it gets too large, breaks up into drops almost equal in size. But this comparison, however, useful as a picture, cannot stand pressing, since in the case of the atoms the offspring resemble neither the parent nor each other. When Frisch and Meitner pointed out the significance of this entirely novel phenomenon, the creation out of one element of two entirely different elements, having combined atomic weights equal to the atomic weight of the parent-element, they proposed for it the name of nuclear fission.

Analysis of Nuclear Fission

As has been already mentioned above, nuclear-fission came into being when an uranium atom being sufficiently shocked produced a barium atom. It turned out that the uranium atom was being truly split into two parts, not equal but approximately equal and further that it had different ways of splitting. In fact an uranium atom could split either into an atom of rubidium and an atom of caesium, or into an atom of barium and an atom of krypton. This was a dramatic proof of the correctness of the atomic theories of Rutherford, Moseley and Bohr. Also it had further implications. Apart from such important questions as, "How does it do it ?" and, "Why does it do it ?" there is the chance here of accounting for the explosion.

From the Periodic Table :—

	Uranium	*Rubidium*	*Caesium*	*Krypton*	*Barium*
Atomic weight ..	238	85	133	84	137
Atomic number	92	37	55	36	56
Hence the compositions of the nuclei :—					
Protons	92	37	55	36	56
Neutrons ..	146	48	78	48	81

Hence when the *U* nucleus splits into *Rb* and *Cs* nuclei the protons balance, for $92 = 37 + 55$, while the neutrons have a surplus of twenty over the requirements of the new components. Similarly for the other pair, only this time the surplus of neutrons comes to seventeen. This is in accordance with what Fermi foretold and affords in a way a measure of the explosion.

And So—What ?

If this question be taken with regard to the future it is perhaps best left alone. If it is in regard to the present then it would be wise to recognize that, for good or evil, the Atomic Age has begun. Over three years ago that fact was made abundantly clear by the bolt from the blue which most suddenly and surprisingly put an end to the war with Japan.

Atomic energy has now given us war's most powerful weapon. Without a suspicion of vying with Pickwick's Fat Boy it is surely permissible to point out that, to the atomic bomb's blasting effect and to the searing effect of blazing gases, there must now be added, on the evidence of the experiments at Bikini atoll, an after-effect of infection, seeing that radio-activity is spread broadcast from the explosion, is imparted to neighbouring bodies and remains effective, i.e., dangerous to life, for long periods.

If we admit that as regards war the Atomic Age is already here, on the other side, the utility of atomic energy to man for civilized purposes has also started. Cyclotrons (still electrically driven) are in use or being built in the U.S.A. and in England. Neutrons are already produced commercially in the United States for sale to those who wish to transmute less useful into more useful elements, e.g., uranium into plutonium. It is true that we have not yet seen atomic energy substituting coal and oil, and that those who look upon the Age of Atomic Energy as one in which a man will carry around in his pocket a plutonium pill to do the work of his household, is still only a (necessary) dream. But even without these things atomic energy has already given us for civil purposes an accession of strength. Statisticians have worked out in a graph the relative wealth-levels of the average citizen in many countries. An identical graph has been produced for the availability of energy in those same countries. The inference is obvious. Man needs all the energy he can get, whatever the source. Atomic energy where it does not supplant, will supplement. On the civil side the greatest trouble is the radio-activity, dangerous not only to health, but to life, radiated so intensely that human beings need protection by a moderator such as tanks full of heavy water. This drawback rules out atomic energy in small units, and in all but stationary units, except those like ocean-liners in which the extra weight carried is immaterial.

Reverting to the military side, the infection by atomic bombs is a matter for A.R.P., and the most hopeful sign is that the Government has been wise enough not only to raise a Civil Defence Force, a body of men and women, who will cover the country, but also to arrange for this force to be trained and ready in peace-time. They will know what to do when the balloon goes up, and their very presence will have a steadying effect upon the general public.

This step was only commonsense, but there is no reason why we should not be grateful for commonsense.

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WHAT THE RUSSIANS THINK OF OUR REPRESENTATIVE COLONAL COMMANDANT

(Translation of article in Russian *New Times*, 24th November, 1948.)
(*The Russian " New Times " corresponds to " The Times " in our country.*)

Warmongers at Work—General Martel's Plan

GENERAL G. Martel of the British army and former head of the British Military Mission in Moscow is in no way remarkable except for the irrepressible hate he harbours for the Soviet people. It is probably for this reason that this superannuated participator in the " campaign of the fourteen states " against the young Soviet Republic is still regarded in British reactionary circles as an " expert on Russian affairs." Not long ago he retailed a few more scraps of his scanty knowledge in this field in the arch-reactionary *Daily Mail.*

A disciple of Churchill, who together with his master tasted defeat in the days of intervention in Soviet Russia, he now limps after him along the slippery path of journalistic warmongering.

In his notorious Llandudno speech, Churchill, in his usual hypocritical style sketched in broad outline the picture of his dreams—the re-imposition of the yoke of imperialism on the " eleven ancient capitals of Eastern Europe " and the opening of the " larger areas " of the Soviet Union to the rule of British and American monopolies. Martel, with the pedantry of an old staff officer, has undertaken to touch in the individual details on Churchill's canvas—the figment of the hallucinations of an incorrigible reactionary.

Justice requires it to be said that Martel has deemed it necessary somewhat to correct his chief. He does not consider that the " atomic bomb should be used against Russia immediately." Certain preparatory measures must first be taken. As Martel sees it, only three such measures are necessary ; first, Czechoslovakia and Austria must be " freed " ; secondly, Germany and Poland must also be " freed " ; thirdly, " Russian merchant shipping must be restricted." All this, Martel calculates, can be done with the help of " twenty full-strength, regular divisions " for use in Germany, plus subversive activity in the people's democracies and the use by the Western Powers of " their complete command of the seas."

Martel reposes particular hope in subversive activity in the East-European states, or " organizing resistance movements," as he prefers to call it. " We had much experience in this work during the last war," he boasts—although he would do better to recall the numerous ignominious failures of the agents of Anglo-American imperialism in the people's democracies.

Only a purblind reactionary can hope to succeed in so insane an enterprise. From whom does this British knight-in-armour intend to " free " Czechoslovakia and Poland ? The people of these countries have only just thrown off the detested rule of the capitalists and landlords, they are advancing confidently along the road to Socialism, and will allow nobody to climb on their backs again.

But it is not given to this retired interventionist to realize how comical is his pose of liberator. " We could march in and free those countries with ease," he declares with an air of conviction and finality. And, when all this has been done, Russia should be approached " in the best Foreign Office style " and requested to substantially demobilize her forces and accept international inspection of these forces.

In fine, Martel already sees himself riding into Moscow on a white horse. But he betrays a last glimmering of a sense of reality ; he admits the possibility that the Soviet Union and the people's democracies might not accept the demands of the imperialists. Well, in that case, he exclaims with raised fists, the American atomic bombs will have to be brought into play.

General Martel is obviously envious of the laurels of Lord Curzon, who was also a worshipper of ultimatums. But even a quarter of a century ago the language of ultimatums proved unsuitable when addressing the Soviet state, even though it was still in its infancy. One must be devoid of all common sense to hope that this language can succeed today, when the forces of democracy and socialism have grown so immeasurably. But Martel's masters, the imperialists who have outlived their day, are losing, it seems, the last grains of common sense. They are riding for an ignominious fall, these inveterate reactionaries—for the peoples are keeping a vigilant eye on their intrigues against the peace of the world.

V. Berezhkov.

MAKING GAPS IN A GERMAN MINEFIELD

By Lieut.-Col. M. C. A. Henniker, D.S.O., O.B.E., M.C., R.E.

THE manner in which a certain field company made a path through a minefield in Holland in January, 1945, may be worth recording while still fresh in the memory.

Some companies knew all about mines. They learnt by bitter experience. The company with which we are here concerned had been lucky. It had hitherto seldom met mines in large numbers.

Experiments had, however, been made with various devices to deal with minefields. Not one of them could be described as wholely successful. " Flail " tanks were good on hard ground ; but off the road, in winter, they got bogged at once. The various machines for throwing an explosive " rope " across a minefield were unsatisfactory.

The theory was that a rocket or mortar should be fired across the minefield. Behind the projectile was a " rope " of some explosive substance. In theory, the " rope " was laid on the ground ; and when exploded, the mines beneath it exploded too ; thus clearing a track.

In practice it did not work like that. The " rope " often broke. A cross-wind laid it in a loop. But the principal cause of failure was the nature of the ground. The " rope " did not lie evenly on the ground as it would on a barrack square. It caught in bushes ; or it passed over a hedge ; or when the minefield was laid in a wood it could not be used at all.

The alternative was to clear mines by hand. A mine detector was useful in some circumstances, but not always. Barbed wire and shell splinters affected it. If the ground was planted with beet-roots or turnips it was difficult to use. Finally, it was not able to detect the most modern types of mine. Prodding for mines with various instruments had been tried with some success. But it was desperately slow and not always reliable.

In fact it was easier to see the difficulties than to overcome them ; and yet they had to be overcome in order to capture a village (whose name I forget) which was the key to the German position.

From a roof-top in our lines the village was clearly visible. It was about 1,000 yds. away : some reddish brown houses, rather battered but still houses, clustered round a church with a tall thin steeple. A narrow road trailed like a yellow tape from us to the village. The road was a defensive fire task for both sides. Whenever there was an alarm it was shelled. There was an anti-tank ditch across the road. On either side of the road was farm land : sugar-beet, cabbages, roots of all kinds, and small plantations of willow for basket making. Here and there were orchards or grass fields, with wire cattle-fences round them. The ground was undulating and might have been taken from a conventional landscape target.

An American division had been in the line before the British took over. They had laid many mines. No adequate plans of these existed. Our own infantry had laid more mines and numerous booby traps ; and, because of the lack of land marks and the difficulty of accurate map reading these too were only vaguely plotted. Finally, the Germans were known to have laid an extensive belt, or belts, of mines in defence of the village. Patrol reports indicated beyond doubt that the German minefield contained both anti-personnel and anti-tank mines mixed. For various reasons no one knew the actual limits of the minefield. But nobody doubted that it was there.

The Germans holding the village came from a second-class division. For two months nothing had happened on the front ; both sides enjoyed a comfortable feeling of security that was not really justified.

The capture of the village was entrusted to one battalion, and the operation was therefore, in a way, only a minor one. But because it was the prelude to a series of operations expected to last a week, it gained an importance out of proportion to its size. Within reasonable limits the battalion could have any support it asked. It was made clear to everyone that failure would not be tolerated in any circumstances whatever ; and, unless something could be done about the minefield, the prospect of assaulting through it was not regarded with equanimity by anyone who knew it would be his duty to do so.

Viewing the scene from the roof-top in our lines certain factors were obvious :—

(*a*) The infantry assault could not go up the road to the village because of the defensive fire. No one would have lived to tell the tale. It must therefore go through the fields and orchards ; and where it crossed the minefield gaps must be made.

(*b*) The ground on either side of the road was so soft that the battalion carriers, anti-tank guns and supporting tanks would have to go up the road.

(*c*) There was a re-entrant away to the right leading up to the village. It looked as though anyone in that re-entrant would be able to approach the village without being seen, except from the village steeple and from two or three places out in the surrounding country-side. Careful study of the map confirmed that this was so. It was the chink in the enemy's armour. If, therefore, the points from which the re-entrant was visible were shelled or smoked, it seemed probable that an assault up the re-entrant would not be costly, provided the mines could be lifted. It was, in fact, as much a technical problem as a tactical one.

A field company, with a platoon from another field company under command, was put in support of the battalion. This re-enforced field company had two tasks :—

1. To clear three gaps in the minefield, somewhere in the re-entrant, for the infantry assault.
2. To open the road for the supporting weapons as soon as the village was captured. (This being a straightforward task, it calls for no further comment. It was done by the attached platoon.)

In order to clear three gaps in the minefield in the re-entrant the plan adopted was as follows :—

(*a*) The brigade arranged a fire-plan designed to prevent the Germans watching what was going on in the re-entrant. As indicated above, this was not difficult. The duration agreed upon was forty-five minutes.

(*b*) A Forward Observation Officer from the gunners with a man-pack wireless set was detailed to go with the R.E. gapping parties. He was a hostage to fortune. It is a psychological point that deserves note. On the one hand, he took good care to verify before the battle that the fire-plan would, in fact, do all that was claimed for it. On the other, he could modify it during the battle if it seemed necessary.

(*c*) A platoon of the field company was made responsible for each gap. Each was to provide its own local protection.

(*d*) A signal net was arranged to keep everyone in touch with what was happening, and to call the infantry through the gaps when made.

After some debate it was decided to do the attack in daylight—at tea-time, as you might say. Everyone had complete faith in the fire-plan. It was considered that the work of dealing with the mines would be quicker in daylight. Also, if anything went wrong another attempt could be made in different circumstances—in the dark.

The night before the attack, each platoon sent out a patrol, covered by infantry, to try and find the near edge of the minefield. Only one succeeded. But the other two came back with useful negative information. They established that up to a certain point on each route there were no mines. Next morning it was estimated that the distances from these points to the village did not exceed 500 yds.

In each platoon there were about forty sappers. Each sapper was equipped with a length of water-pipe 10 ft. long, filled with explosive and with an igniter at one end. There was a reserve of pipes ready for each platoon.

The day of the attack was bright and sunny, with a sharp frost in the morning. In the afternoon the setting sun began to shine into the eyes of the Germans. A gentle breeze blew across the front. At zero hour the fire-plan began.

The sappers set out in three columns, each man carrying a pipe of explosive. They looked like pikemen of a medaeival army. Before them rolled the barrage. To right and left of the re-entrant, and beyond it, spouts of earth rose into the air where shells pitched. The village was wreathed in smoke and not visible. Machine guns, besas and mortars hammered a tattoo like the kettledrums of a band.

The din was terrific. But there was no retaliation. The Germans were taken by surprise.

Led by their officers, each column of sappers went to its appointed place. Some men lay down. The majority began to dig. One by one the sappers went forward, each with his explosive pipe. The first man laid his on the ground from the point at which it had been decided the gapping should begin. He fired the igniter and withdrew. After a few seconds there was an explosion. A blackened trough, 10 ft. long and about 18 in. wide, marked where the pipe had been. There could be no mines there.

The next sapper came, walked up the blasted way made by his predecessor, laid his pipe so as to make contact nicely with the ground and fired it. The proceeding continued. The exploding of a mine, from time to time, was marked by a column of black smoke, rising into the air.

In this way the three platoons each blasted a path. The principal danger was from the flying pieces of pipe. The sapper working in one gap risked death from pieces of pipe from another. To prevent this, the three officers each had a "walkey-talkey" wireless set; and, being within shouting distance of the sapper, at work, the explosions were co-ordinated.

One gap ended in an enemy listening post containing a dead German. A clear lane from there to the village was visible. The next led to a cart track with such recent ruts that it was safe to assume it was clear of mines. The third led to a well-worn footpath. There was no doubt that the minefield was passed, and the infantry assault went through.

What are the conclusions from this primitive battle? It is difficult to suggest a better way of making gaps. Only one man is in the gap at a time, and he does not have to stay there long. The remainder can be dug-in or concealed. Mechanically, there is very little to go wrong. Finally, the fire-plan has but to produce for the sappers conditions that are essential for the assault anyway. If the assault is possible, the minefield clearance is possible too. It is a comfortable feeling that there is some answer to the field of mixed anti-tank and anti-personnel mines. It may not be the best answer, but it is better than nothing.

THE CHURCH OF ST. THOMAS À BECKET, HAMBURG

A WORKS PROJECT

By LIEUT.-COL. C. G. PHIPPS, O.B.E., R.E.

ON the centre of the South wall facing the main entrance of the English Church in Hamburg, the plaque shown in Photo 1 is to be seen. The crest in gold of the Royal Engineers surmounts the gilded lettering carved in unpolished marble. The wording is as follows :—

BY THE GRACE OF GOD
THIS CHURCH WAS SPARED
FROM TOTAL DESTRUCTION
IN THE SECOND WORLD WAR
1939–1945
IT WAS FULLY RESTORED
BY THE DEVOTED LABOURS
OF THE ROYAL ENGINEERS
DURING THE YEARS
1945–1947

To the many Englishmen and Sappers who may visit Hamburg, the story of that plaque and the older history of the church may be of some interest.

The existence of an English Church in the city of Hamburg, though not widely known, has its origin back in the year 1612. At that time the Company of Merchant Adventurers of England first established their chapel in the city. They had come to Hamburg the year before and, in the teeth of Lutheran opposition, had obtained from the State of Hamburg the exclusive right of Anglican Worship. They had also obtained a monopoly in cloth and their size and importance increased steadily over the next twenty-five years until they were deprived of this most valuable concession. From then on they declined until the Company was eventually wound up on the orders of Napoleon, during his occupation of the city in 1806. On the winding up of the Company, their building reverted to the State, who repaid the Merchants 23,500 marks. Nine years passed before serious efforts were made to revive both the guild and divine worship. The British Consul, apparently a hasty and irate gentleman, transmitted a memorial to the Foreign Secretary concerning the guild's revival and the need for a renewal of divine worship " in the interest of British Seamen, since it would evidently conduce to the amelioration of their moral character and consequently of their social habits." This Consul was often at feud with ships' captains. Many and frequent memorials were sent to the Foreign Secretary, but a further nine years passed before agreement in principle was reached and the Senate of Hamburg was induced to give a plot of land at a nominal rent " on which to build a place of worship."

The church could, however, not be built for a nominal sum. The 23,500 marks (£1,324) were given by the treasurer of the late guild, to start a fund, but that was totally inadequate.

The British Government was approached under an Act of Parliament, which allows "a grant from public funds of a sum equal to the amount subscribed voluntarily, for the building of a place of worship, for British communities abroad." The Committee quickly had valued the old books, organ and plate given them by the Merchant Adventurers and so put up the "Voluntary Subscription" by £825. Even these sums, when doubled, would have been insufficient and the Committee decided to open a public subscription. Only about £1,300 were raised in this way. Apparently appeals to some of the more prominent members of the colony fell on thorny ground. It is recorded that Mr. Edye "will never subscribe while Mr. Baker is clergyman" and a Mr. Brumpton "will not give a drilling to save all Bishops, Priests and Deacons from damnation and wishes them all in Hell." Then finally came news that the Government had refused the grant.

However, a total of £2,650 had been raised and an architect was instructed to design a cheaper building for this sum. A builder contracted to build the church for £2,230 and so work began and the foundation stone was laid. It was soon discovered that an error of somewhat over one hundred per cent had been made in the estimate. The work of the sculptors, joiners, painters, glaziers, turners and metalworkers had not been included. It is due to the good fortune of this error that the church was ever built, for had a correct estimate been made it is certain that the church would never have been begun. However, between mortgages, periodic stoppages of work and more subscriptions, the church was finally completed some two and a half years later. The records of this period are very complete and it is interesting to note all the same troubles and disappointments besetting the Committee as are met with today in steering similar work through "Finance" and the various Ministries of Labour, Supply, Town and Country Planning and others.

The accepting of the lowest tender and the insistence on cheapness in design, seem also to have brought the usual troubles in their train. The roof leaked even before the church was opened, the specified iron stoves proved inefficient and had to be replaced, the carpenters, builders, upholsterers, plasterers and stone masons, all overcharged and most noticeable of all is the deep disappointment over the slow progress of the finishing stages. As in most works, progress was very satisfactory up to the time the builder reported completion of all work except the interior. That was one year after the laying of the foundation. It was not for another eighteen months that the building was eventually completed.

The church was consecrated on 11th November, 1838. From that day until the late war the main fabric remained pretty well untouched except for minor alterations and repairs. It survived the 1914-18 war undamaged, but during the second world war, it, like the rest of Hamburg, suffered terrible devastation.

In design it was a simple neo-classical structure. The plan was a rectangle 98 ft. long by 55 ft. wide, with an Ionic portico of four columns projecting from the face. The exterior was solid and featureless, and the interior though in earlier accounts described as "somewhat dingy," possessed in design considerable character. It was divided into seven bays by square piers which supported galleries over the north and south aisles. From gallery level the piers continued upwards to the ceiling in the form of elegant Corinthian columns. At the east end, a recess, eight feet deep, formed a chancel which was ceiled by a coffered barrel vault. The chancel was lit by a large semi-circular window of coloured glass, representing the rising sun. Beneath this the reredos was divided into three sections by pilasters supporting the window. The centre panel contained a copy of Raphael's Sistine Madonna, while the side panels were inscribed with the Lord's Prayer and Creed on the south side and the ten commandments on the north (see Photo 3). This is believed to have been done deliberately to combine the peculiarities of the High and the Puritan Churches. On either side of the chancel were the vestry, the caretaker's quarters and the boiler room.

At the beginning of the late war, the church was cleared and turned into a store. In January and July, 1943, fire bombs penetrated the roof, but fortunately fell on the paving of the aisle and the damage was not serious. In June of the following year an H.E. bomb fell near the west end of the portico. It had passed through the roof, destroying the balcony, several of the Corinthian pillars, making a large hole in the wall and blowing down two of the four portico columns. Most of the roof and the entire ceiling were destroyed. In March, 1945, another bomb fell at the base of the North wall, near the east corner of the building. This destroyed part of the foundations, blew a considerable hole in the wall and seriously strained the north-east corner of the building, while the interior, which had already been exposed to the elements since the previous June, lost the last remnants of its plaster and decoration.

Thus we found it three months later. The organ seemed damaged beyond repair and the floor, now reduced to mother earth, was piled high with the debris of the English Church, which had stood undamaged in a foreign land for over one hundred years.

The Commander of Hamburg* at once gave orders for a survey to be carried out and a report made on the possibility of repairing the building. We were fortunate at the time in having as a D.C.R.E.† a brilliant architect who had specialized in ecclesiastical architecture and he set his mind to the task. No sooner had he started his researches than he was posted away, not too soon, however, to prevent him completing his report in his new station, and submitting it by post. He considered the structure was worth rebuilding and the Commander immediately gave authority for the work to be carried out. He had chosen the psychological moment to give such an order. Twenty years of argument and bitter financial strife had had to pass before the foundations of the original building had been begun and had the Commander's decision been delayed, another twenty years might well have passed before the files were closed on the "work projected on the English Church at Hamburg."

To assess the scale of the project a rough estimate was made of £8,000. At that time no service under £12,500 was even recorded in Progress reports and so amongst the vast number of far greater projects, which we had and continued to have on hand, this work was soon forgotten by all but the Commander and those entrusted with its execution. Very soon we were to lose the Commander, who had taken full responsibility for carrying out the work. His deep interest and intense enthusiasm had always been an inspiration to everyone under his Command and that inspiration remained to the very completion of the project.

The first contract was placed towards the end of June for the clearance of all debris. From then on a steady flow of plans and drawings were prepared, followed by specifications and contracts timed to keep an even progress of work. Although this is the normal sequence of events under wartime conditions, yet, provided the desperate pressure of war is not

* Brigadier H. S. Pinder, C.B.E., M.C.

† Major Lindsay, R.E.

there to worry the designer, it is the ideal way to carry out a work of this sort. Continuous evolution of one's ideas throughout the whole period of building creates a work as nearly perfect as is possible within one's own limitations. Work on the site proceeds smoothly and alterations to drawings and contracts once signed, practically never occur.

Work soon followed on under-pinning the east end of the north wall and repairing the foundations. At the same time the damaged walls were built up once more. We had hoped to restore the roof and complete the clothing of the building before the winter, but this we were unable to do, due to a very severe and early winter and to difficulty in obtaining sufficient large baulks of seasoned timber for the very heavy truss members. Serious progress on the site was thus held up until April. Other work was, however, able to continue. The organ was sent away to be rebuilt. We had completely altered its layout to conform with the new drawings of the interior of the church (see Photo 2).

The pews (see Photos 3 and 4) had been designed, as had also the two staircases (see Photo 5) up to the North and South galleries. All were to be hand carved natural oak and the contracts for these kept quite a number of skilled craftsmen busy throughout the winter and beyond. We had been lucky in obtaining quantities of very fine quality seasoned oak, sufficient for the whole project. It had presumably been imported for the shipbuilding trade of Hamburg, which had not recently been flourishing. Thus, though the shortage of soft timber was chronic, we always had hard-wood in abundance. Considerable quantities of very fine marble were also available and we early collected all we needed for the aisles and altar steps. From the first, we had made an ample collection of all stores and with the early exception of soft timber, we were never seriously handicapped by any shortages. The great chandeliers (see Photo 6) and the wall lights in the body of the church were designed in wrought iron and the magnificent craftsmen, who carried out the work, were fully occupied throughout the winter.

With the coming of the spring, work on the site once more came to life. The roof and the walls were completed and with the finishing of the work on the structure of the portico, the interior of the building was at last sealed. Scaffolding work for the ceiling filled the body of the church and while the plasterers worked slowly and meticulously, carvers were busy fashioning, in timber, the tops of the new Corinthian pillars.

Meanwhile work on the drawing board continued steadily. The original piers supporting the galleries and the columns at the West end had been too heavy and the dimensions of these were reduced to more balanced proportions. The walls and ceilings, below gallery level, had been quite plain. These were panelled in plaster as seen framing the R.E. plaque. We sunk the radiators into the lower panels and faced them with hand wrought iron grilles. Square flush lights were set into each corner of the ceiling panels on the underside of the balcony and were proved later to provide a beautifully diffused and apparently indirect light.

Coloured glass to replace the original feature of the rising sun over the reredos could not be found, nor was it considered that this feature would be in keeping with the interior as now designed. The space was therefore filled in and finished in plain moulding, fitting the general design.

Indirect lighting was installed in its place. Into the cornice below the vault of the chancel, we sunk strip lighting to shed even illumination over the whole of the chancel ceiling, and the lower half we lit by a floodlight concealed in the ceiling next to the first chandelier.

Photo 1.—The marble plaque and inscription.

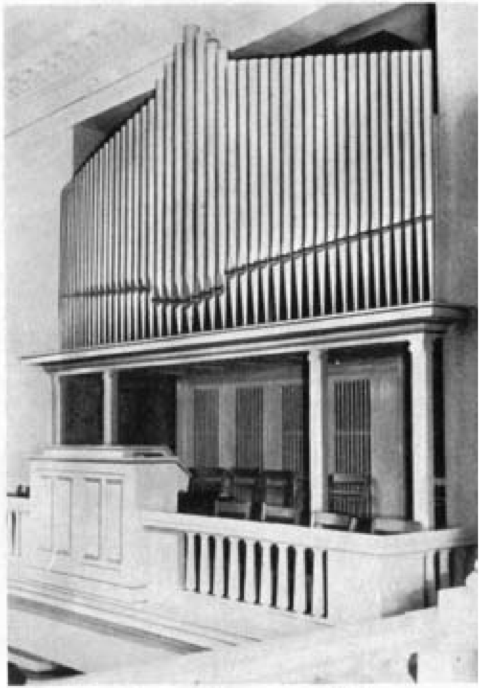


Photo 2.—The organ as rebuilt.

The Church Of St.Thomas A Becket,Hamburg 1,2

Photo 3.—The new oak altar and pews.

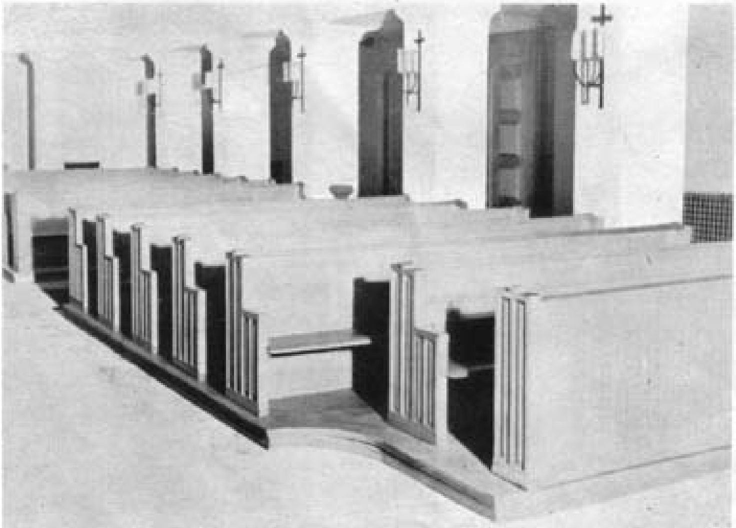


Photo 4.—The new oak pews.

The Church Of St.Thomas A Becket,Hamburg 3,4

On either side at the West end, a small door had given on to the staircase to the galleries. These doors and the wall for the full width of the side aisles we removed, throwing open the two staircases to the full view of the church. The old staircases had been of very poor design and rickety construction and entirely new ones were designed in their place.

Other new features were introduced into the West end. A tiled lavatory and wash basin were built in on one side and a wireless control room on the other.

A special feature has been made of this West entrance. Between the outer door and the entrance into the church is a small, comfortable and brightly lit ante-room. The centre of the ceiling throws down its indirect light from a ring of concealed bulbs, while from two bowls in each wall light is reflected to the walls and ceiling. Two heavily upholstered seats on hewn stone bases are on either side and the deep carved doorways on the other two sides complete a dignified and quiet room, where brides or late arrivals may, at their ease, await the appropriate moment to enter.

Thus while more work was being prepared for the contractors, the ceiling was completed, the wiring and piping were concealed in the walls and the plasterers finished their work down to floor level. From years of exposure to the elements, damp had penetrated deep into the walls and into the earth in the body of the church and soon the new plaster was stained and patches of fluorescence crept over the surface from many places. A year later, as the result of an exceptional summer, most of these marks had dried out and were concealed for ever by the subsequent distemper. Certain patches still continued, however, and time alone can tell when they will be dried out sufficiently to take a final coat of distemper.

The floor of the church which had been left as long as possible to dry out was concreted over and work began on the laying of the oak flooring of the nave. This floor was raised a few inches above the level of the aisle, thus accentuating the line of demarcation between the oak and the stone flooring and producing a more striking effect.

When designing the East end of the church, much information was sought of the old caretaker, as nothing of the old appointments could be found. She had lived over twenty-six years in the church and never left it throughout all its bombings. The original pulpit on the North side had been a very low one and the prayer desk had been in the body of the church on the opposite side. This layout we retained designing them and the altar rail in the narrow panelling used on the side of the pews.

Many drawings were made before finally deciding on the design of the altar table. Having carried out all the woodwork so far in the plain narrow panelling, this naturally was bound considerably to influence the design. Considering the background of the altar, we decided to incorporate the general features of the reredos and to fill the space between the stiles with narrow panelling. It was executed in beautiful grained oak carved with very fine workmanship and the effect can be clearly seen from Photo 3.

Towards the end of the summer of 1946, financial control was beginning to replace the good times of war and this once insignificant service attained at last a place in progress reports. It appeared also on labour returns and although stores were rarely demanded, it occurred to those having other claims to press, that it must be consuming stores. A minor recovery in the city's industry and very large increase in civilian building activity were fast causing both a labour and a building materials shortage. On return from leave in September it was found that a somewhat drastic order had been given to remove all the labour and to use the materials collected on site for other more urgent works. At this stage in the work, very highly skilled craftsmen in small numbers, were almost exclusively used. Further the materials for the remainder of the work were negligible and the work was nearly ninety per cent complete. Neither could in any way affect the many and vast projects we had in hand. But the damage was done, though fortunately all the seasoned oak required was already out with contractors who were able to continue working in their shops, their labour not being included in the official returns.

After a strenuous battle the instruction was rescinded, but not before the hardest winter ever recorded had settled over Hamburg. It was not till April that work was able again to start up. So also was a new form of financial control. Money already allotted for a service was re-allotted by quarters, the expenditure being calculated by the percentage progress of the work. How a building once started could progress at a varying speed quarter by quarter as arbitrarily dictated by the staff is not quite clear, but what was clear was that the financial allocation given this quarter was nil. The situation seemed difficult till a peculiarity in the case became apparent. What the staff were really demanding was a monthly progress of nil and seen from that angle the difficulties vanished as quickly as they had arisen. Work, though very quietly, proceeded very steadily and towards the end of the quarter only a small amount remained to be done. During this period the interest in the church by the Consul General, the Missions to Seamen who had before the war always provided the padre, senior chaplains and visiting bishops became very considerable. The Consul informed the Foreign Office of the progress of events and received permission to re-open the church. He invited the Bishop of Fulham to perform the ceremony of dedication, formed a council to manage the affairs of the church and invited the Services to use it as their Garrison Church. It was, of course, and still is, a civilian church, but consequent upon all this interest, the full sum needed to complete the work was allotted in the ensuing quarter. It was fortunate that we had a bit of progress " in hand " or the task would have been far from simple.

In the early part of April it was discovered that the original font which had been stored and presumed to be undamaged, was in fact beyond repair and so we were faced with designing a new one. It was in some ways fortunate as it enabled us to produce a font in keeping with the whole interior of the church. A very simple design in unpolished stone surmounted by a bronze cross integral with the lid, was placed in the aisle by the West door, and with this last addition the work on the church was complete.

On 12th September, 1947, the Bishop of Fulham, in the presence of the Consul General and high German dignitaries of both Church and State, the heads of all Services and a full congregation both military and civil, rededicated the church, changing the name from the English Church which it had borne for more than a century and re-naming it the Church of St. Thomas à Becket.

Photo 5.—The new oak staircase.

Photo 6.—The wrought iron chandeliers.

The Church Of St.Thomas A Becket,Hamburg 5,6

Photo 1.—Boat-building site—Kalewa.

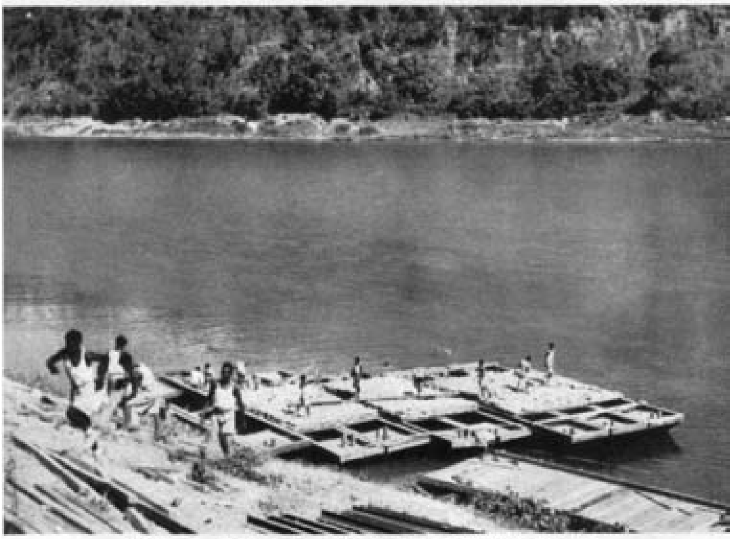


Photo 2.—Eastern Army boats under test load at Kalewa.

Eastern Army Boat Factory, Kalewa

EASTERN ARMY BOAT FACTORY, KALEWA

By Major G. G. Layton, M.B.E., R.E.

FOR the Burma Campaign of 1945, it was planned that Fourteenth Army L. of C. should consist, between Kalewa and Myingyan, of a ferry service down the river Chindwin, a distance of 200 miles. For this purpose a considerable number of craft were required. In order to avoid the difficulty of transporting these forward (either complete or in sections) it was decided to install a boat factory on the river in the Kalewa Area; the type of craft chosen being that known as the "Eastern Army boat." An article on the Eastern Army boat bridge was published in the September, 1945, *R.E. Journal*, and in the September, 1947, *R.E. Journal* an article by Lieut.-Col. D. C. Merry gave a description of the development of the I.W.T. L. of C. on the Chindwin. The present article gives more particulars of the boat-building factory at Kalewa, which was organized to build the boats required for the river L. of C.

The boat which was designed at H.Q. Eastern Army in December, 1942, expressly for ferrying and bridging in this theatre, is a heavily constructed punt-shaped wooden pontoon 40 ft. long by 6 ft. wide by 3 ft. 9 in. high, weighing approximately 3 tons. (See Diagram and Appendix I.) It was constructed in prefabricated sections capable of being carried by jeep over jungle tracks prior to assembly on the launching site. When completed it possessed great strength to withstand the impact of flood-born debris and jetsam under monsoon conditions.

536 Art. Wks. Coy., I.E., having specialized previously in boat construction, were selected for the job. Their establishment was modified to suit the work; nearly all tradesmen were carpenters or boatbuilders, and arrangements were made with a contractor in Calcutta to supply tradesmen (drawn from as far away as Sylhet, Chittagong and Tezpur), who were fitted into the boat building organization. In addition two Forestry companies, a Workshop and Park company, an Indian Pioneer company and one platoon General Transport were available, in support, for this task.

Setting-up shop proved a fairly lengthy business. A site was selected on the river some miles north of Kalewa, comprising a fairly steep beach about 600 yds. long by 120 ft. wide, with deep water close inshore suitable for launching the boats. On 25th December, 1944, 536 Art. Wks. Coy. arrived in Dukws, and were settled in a camp by 1st January, 1945. 1488 Ind. Pioneer Coy. arrived on 5th January, and began to build service roads and cut timber storage bays in the bank; meanwhile approach roads from Kalewa, including eight 70 ft. bridges were under construction. All preliminary work was finished by 18th January.

On 19th January, the small stock of prefabricated parts, previously held in India, arrived on the site and boat building began. Construction from scratch did not start until 336 and 338 Forestry Coys. were able to provide timber. No suitable timber was available locally and these companies had to operate, fifteen and sixty-one miles away respectively, on the Tamu-Kalewa road. They started work on 28th January, haulage to the site being undertaken by the General Transport platoon in support. 343 Wksp. and Pk. Coy. arrived on the 27th January and opened up a sawmill (for conversion of timber sizes), workshops and a forge; turning out bolts, spikes, bilge pumps and handling the metal work side of construction generally.

When in full production the factory was employing over 1,100 men on the site (see Appendix II). Incoming materials (6 in. × 4 in. timber, 6 in. × 1 in. timber, spikes, etc.) were handled by a stores organization comprising a workshop unloading point, timber reception point, and caulking and steelwork stores. Adjacent to the timber reception point were saw benches operating three compressor saws which cut timber for the various members as detailed in Appendix I. When completed these parts were stacked at a sawn timber collection point, from which they passed to the mass production bays. Here all prefabricated parts were made and these were then carried to the beach for erection.

140 boats were frequently on the beach at one time, in various stages of construction (see Photo 1). Parties worked their way through these boats in succession until they were completed and launched. Sequence of parties was as follows :—

1.	Constructors.	Assembly of prefabricated parts. Planking roughly spiked on.
2.	Drilling Party.	Drilling for remaining spikes.
3.	Spiking Party.	Driving all remaining spikes.
4.	Caulking Party.	
5.	Pitching Party.	
6.	Turning and launching party.	

After launching the boats were made into rafts, decked with P.S.P., and loaded with thirty tons of sandbags (see Photo 2). After a twenty-four hour test, if satisfactory, they were handed over to I.W.T.

It had been hoped to achieve an output of ten boats per day, but this was not possible. Construction went well in January while the prefabricated sections were being used; later on the supply of timber limited the output and from time to time shortage of small stores (e.g. spikes and caulking) caused anxiety, which was only allayed by flying in special items. The production figures by months were as follows :—

January	69	March	143	May	10
February	185	April	124		

A few gunboats were also constructed under R.N. supervision. By 2nd May, when the factory closed down, it had produced 541 Eastern Army boats, of which the bulk were employed as three-boat rafts by I.W.T. carrying the essential stores (700 tons per day) forward to Fourteenth Army.

APPENDIX I

Construction Details (See Diagram)

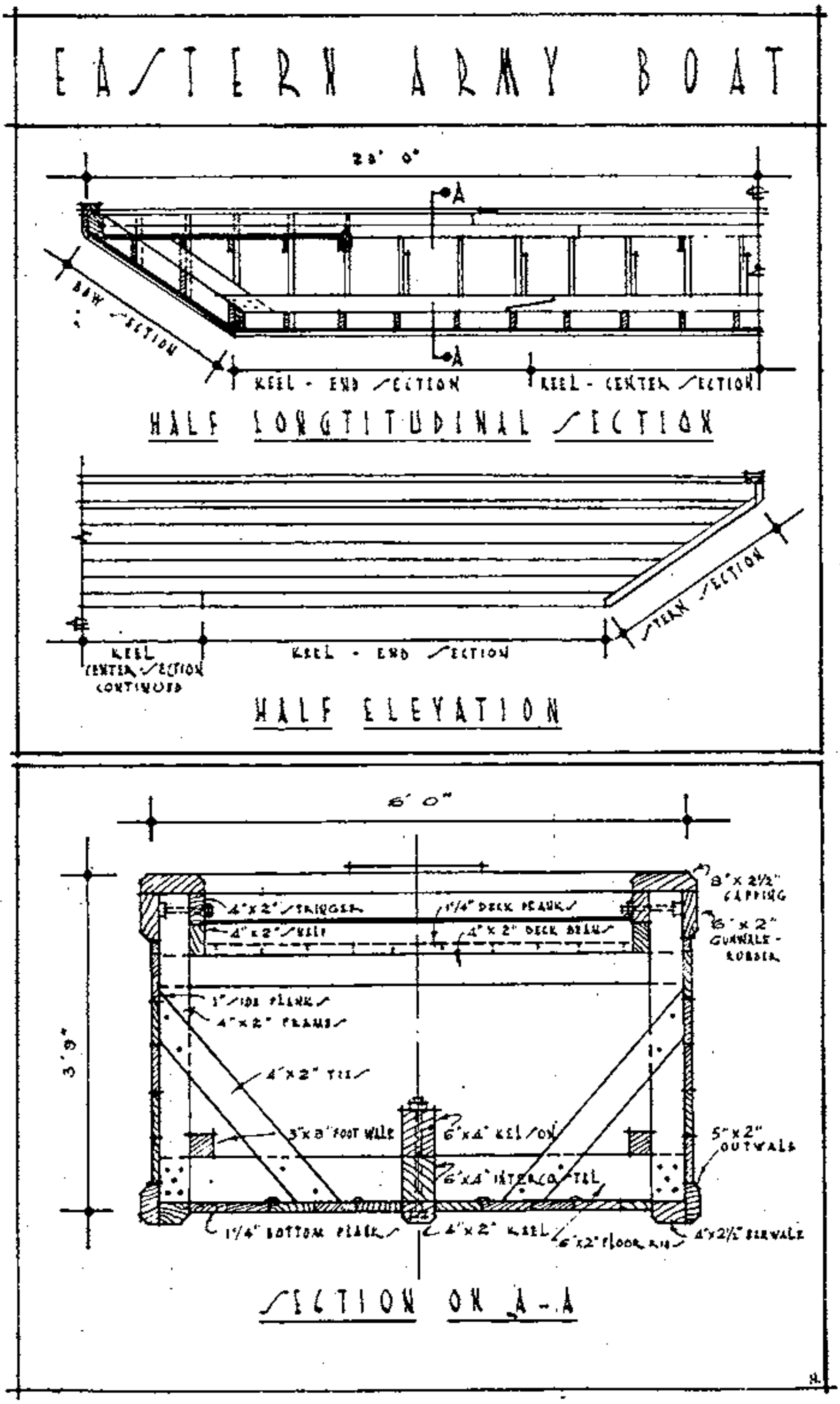
The chief members were sawn to shape at the three saw benches as follows :—

Floor Ribs	Barwales	Gunwales rubbers
Frames	Outwales	Stringers
Ties	Footwales	Capping
Keelsons	Deck beams.	

The floor of the boat (including keel, intercostals and keelson, floor ribs and footwales) was then made up in three types of section :—

Bow (or stern) section
Keel end section
Keel centre section

and these prefabricated parts with remaining members and planking were supplied to the beach for construction, spiking and caulking, etc.


EASTERN ARMY BOAT
23' 0"
BOW SECTION
KEEL - END SECTION
KEEL - CENTER SECTION
HALF LONGTITUDINAL SECTION
STERN SECTION
KEEL CENTER SECTION CONTINUED
KEEL - END SECTION
HALF ELEVATION
6' 0"
3' 9"
3"x 2½" CAPPING
6"x 2" GUNWALE - RUBBER
4"x 2" STRINGER
4"x 2" KEEL
1¼" DECK PLANKS
4"x 2" DECK BEAMS
1" SIDE PLANKS
4"x 2" FRAMES
4"x 2" TIES
3"x 3" FOOT WALE
6"x 4" KELSON
6"x 4" INTERCOSTEL
5"x 2" OUTWALE
1¼" BOTTOM PLANKS
4"x 2" KEEL
6"x 2" FLOOR RIB
4"x 2½" BERWALE
SECTION ON A-A

APPENDIX II

COMPOSITION OF WORKING PARTIES

Party	No. of Parties	Artisan Works Coy.		Pioneers	Civilians				In Charge
		N.C.Os.	Sappers		Carpenters	Machinists and Sawyers	Caulkers	Pitchers	
Stores	1	2		110					
Saw Bench	3			15		10			One Subaltern
Workshop .. .. (Mass Production)	2	1	5	30	60				
Constructors	24	1	5	3	3				
Drilling	1	1	5	3		2			One Subaltern
Spiking	1		1		6				
Caulking	14						10		
Pitching	1							15	One Subaltern
Turning and Launching	1			35					
Raft Construction and Testing ..	1	2	5	30	100				One Subaltern
Naval Construction ..	4	1	8	36	8				One Subaltern

WINTER SERVICE ON THE AUSTRIAN ROADS

By Lieut.-Col. A. Bennetts, R.E.

General

WINTER Service on the Austrian Roads (Strassenwinterdienst) is a task of great magnitude and importance. For the Winter of 1946–47, its cost in the British Zone of Occupation alone amounted to 3,175,000 schillings. This is a large slice out of the portion of the budget available for roads and bridges.

Organization

Before describing of what this winter service consists, an outline of the Austrian organization, which exists to handle this task, is considered desirable.

The Ministry responsible for the construction and upkeep of roads and bridges is that of Commerce and Reconstruction (Bundesministerium für Handel und Wiederaufbau). It consists of six sections, each of which is again sub-divided into departments. Department 4 of section I is the one responsible for roads, and is under a "Ministerialrat." In the Provinces (Länder), the Provincial Government organization (Landesregierung) includes a Building Office (Landesbauamt) which is also divided into departments, each of which deals with its own type of engineering, one of which is that of roads and bridges. This department is responsible for both Federal (Bundesstrassen) and Provincial roads (Landestrassen). The former are the main arterial roads and are maintained with funds voted by the Federal Parliament. The latter, the more important of the rest of the road system, with funds voted by the Provincial Government, although contribution towards their upkeep is also made by the Federal Parliament. In the British Zone, there are 1,300 km. of Federal and 4,665 km. of Provincial roads.

Towns, with a population of over 6,000, are however responsible for the upkeep of both these classes of road within their boundaries. The smaller often have the work carried out under the supervision of the Landesbauamt. The Federal Budget, however, pays the salaries and allowances of engineers, and other civil servants on a monthly salary, employed throughout the Provincial set-up. Plant and machinery are normally also bought out of this budget and used as occasion demands on both classes of road, without any financial adjustment for hire and other charges, except P.O.L. The location of the various offices is shown on the map of our Zone, at the end of this article.

Winter Service

This can be considered as consisting of two phases, preparatory and active.

Preparatory. These are taken in the Autumn and consist of the erection of snow fences and roadside markers and the collection of grit at dangerous corners and on steep gradients. The markers are placed at about fifty metre intervals on both sides of the road and their object is to define the limits to which the snow ploughs can work, without coming into contact with other permanent objects. They are of wood about 1½ in. in diameter and about 6 ft. long and should be painted in alternate bands of black and white.

Losses by theft are considerable. Snow fences in Austria are generally of timber, in sections about 3 metres long and $1\frac{1}{2}$ metres high. Their siting depends upon local conditions, recorded often only in the heads of the road foreman (Strassenmeister) and the ganger (Strassenwärter), of the prevailing wind and of ground formations which tend to form drifts. They should be erected at a distance of eight times their effective height from the area they are protecting.

The erection and maintenance of avalanche shedding is also another preparatory task, but only its maintenance is normally required as, once erected, it remains in place.

Active. These are the clearance of the roads by snow ploughs and manual labour, the spreading of grit and the application of salts to thaw out icy conditions.

Plans for snow clearance. Roads are classified for snow clearance into three classes. Class 1 are roads which must be cleared to full width at all times, Class 2, clearance must be carried out as soon as possible and Class 3, those which are kept clear only for one-way traffic, with passing places. A map and chart are prepared to show the sections of the roads allotted to each snow plough or ploughs. A plough may be required to clear only one class of priority road or all three, depending upon its location. The length allotted to each plough depends upon the width, gradient and altitude of the particular roads. The map shows the roads in our Zone which were kept clear during Winter 1946–47 by mechanized ploughs. The lengths were Class 1, 1,681 km., Class 2, 1,560 km. and Class 3, 819 km. These lengths can be compared with those given earlier on in this article, when it will be seen that clearance covered a large proportion of Federal and Provincial roads, the remainder being cleared by horse-drawn ploughs and manual labour or by vehicles held in reserve for, and not fully employed on, other sections. The distance covered by mechanized ploughs, actually at work clearing snow, during Winter 1946–47, was 191,724 km., of which February claimed 86,902 km.

Clearance does not commence until a snow depth of between ten to fifteen cm. exists, the ploughs being set to leave such a depth upon the road, the snow cover acting as a protection against changes of temperature.

Types of Snow Ploughs

Blade ploughs. The greatest number of ploughs in use are the single-sided blade (Einseitige) and the wedge (V) blade (Keil) ploughs, mounted on the front of a motor truck (Vorbauschneepflug). These ploughs are raised and lowered by one of the crew from inside the driver's cab, usually by means of a wheel connected to the lifting gear by a shaft, but electrical or hydraulic devices are also used. They are attached to the truck by two plates, known in German as the Aufhängeplatte and the Fahrzeugplatte, the latter remaining fixed to the chassis side members to which it is bolted, once it has been attached, the former being removed when the use of the plough is no longer necessary, but it is not part of the plough, from which it is easily removed. A very suitable truck is a four-wheel drive short wheelbase vehicle of adequate horse power, fitted with snow chains on all wheels. A.E.C. Matadors, of which twenty-seven were in use during the winter, have also proved very suitable and are very popular with their crews. (It is noted that they were used in the U.K. for the same purpose.) Each vehicle has a crew of three or four, and the work seems to attract a very good type of man, who take a great pride in their job and vehicle. Blade single-sided ploughs vary in weight from 490 kg. to 980 kg. and in width from

Photo 1.—Grassmuck type of plough—back view.

Photo 2.—Daimler-Benz truck fitted with front and side ploughs.

Photo 3.—A.F.R. half-track vehicle fitted with Grassmuck plough.

Winter Service On The Australian Roads 1,2,3

Photo 4.—" Schleuder " plough with rotors, fitted to Ost.

Photo 5.—Wheeled Schneefräse made by Laffley.

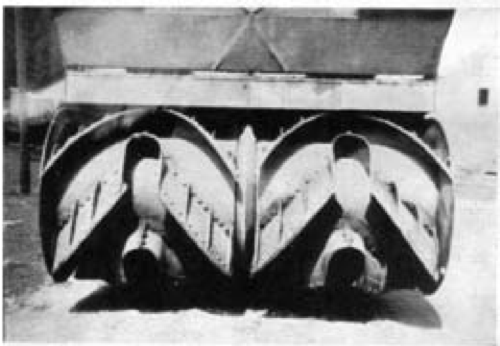


Photo 6.—" Frästrommel " (milling drums).

Winter Service On The Australian Roads 4,5,6

2,400 mm. to 3,500 mm. The unit of measurement used for width is always millimetres. The Schmidt is the type most generally found in Austria, made by the firm of that name of St. Blasien.

Wedge blade ploughs most generally found are the Schmidt and the Grassmuck, made in Vienna. The Grassmuck shown in Photo I is considered the most efficient of the wedge ploughs, due to the design of the blade, which gives the most effective throw to the snow, a very important matter if banks of snow, which make each subsequent clearing more difficult, reduced road width, restricted visibility and conditions favourable for snow drifts are to be avoided. V. blade ploughs vary in weight from 345 kg. to 980 kg. and widths from 2,400 mm. to 3,200 mm.

There is also a convertible plough, made by the firm Miag of Oberramstadt, which can be used single or double sided, but although this appears the ideal, they are not particularly popular.

In addition to a plough attached at the front, a side plough (Seitenpflug) may also be used, positioned to one or both sides of the truck, mounted on a trestle fitted to the body. These are not used much in Austria, as roads do not lend themselves to this width of equipment. Photo No. 2 shows a truck fitted with one of these. The truck is of interest, a 1914 Daimler-Benz fitted with wooden type artillery wheels, twin at rear, and solid rubber tyres. Other blade ploughs which have been evolved are the "clipping" plough (Abräumpflug), somewhat similar to a Seitenpflug, but raised so as to remove snow from the tops of the banks formed by other ploughs. Another is the Schneeheber, designed to remove such banks by cutting into the bank as the plough moves forward and throwing the snow away, over the top, farther to the side.

A purpose-made vehicle for snow clearing with blade ploughs is the A.F.R. (Austro-Fiat Raupe), the word "raupe" being used in its name to indicate that it is a track, actually a half track, vehicle. Photo No. 3 shows one of these fitted with a wedge plough by Grassmuck. Powered by a diesel engine, they are excellent for the job, but cannot usefully be employed on many other jobs and are therefore something of a luxury.

Method of use. The single-sided ploughs can clear up to fifty cms. snow and the wedge up to seventy-five cms. without difficulty. A speed of 25/30 k.p.h. should be obtained if the snow is to be thrown well clear. It is usual to clear to both sides of the road and the first run of the plough is then made down the centre, succeeding runs being made on either side to widen the lane cleared.

Rotary type snow ploughs. Drifts and avalanches often make it impossible for blade ploughs to clear a way through and it then becomes necessary to use other methods. These may be manual clearance or powered rotary ploughs or very often a combination of both.

Rotary snow ploughs are purpose-made machines and can weigh up to sixteen tons. There are two types, the Schneeschleuder and the Schneefräse, both of which may be wheeled or tracked. It is difficult to find an English equivalent for the words "schleuder" and "fräse." The Schneeschleuder depends upon its wedge plough to force the snow onto the blades of the rotors and so are only suitable for snow, which has not become tightly packed. The Schneefräse, on the other hand, actually cuts or mills the snow with its rotors, which also throw the snow clear. They are, therefore, able to clear snow which has become compacted and for this reason will probably replace the "schleuder" type. One such machine is a Cletrac, a tracked "schleuder" made by the Cleveland Tractor Coy. of U.S.A. The rotors in this machine revolve in the same direction as that in which it moves.

They are driven through a gear and shaft connected to the front end of the engine by a dog clutch.

Photo No. 4 illustrates another type of "schleuder," an OST, built by three firms in conjunction, to the order of the former German Inspector of Roads. This is also tracked and is powered by three Ford V8 engines, one of each driving one of the rotors and the third the tracks. The rotors revolve in a direction at right angles to that of machine movement.

Photo No. 5 illustrates a wheeled Schneefräse, made by Laffly, a French firm. It is diesel-electric, but petrol-electric machines similar to it are also made. Whether diesel or petrol-electric, the electric motors drive the wheels or tracks and the I.C. engine(s) the milling drums (Frästrommel) which consist of two symmetrical halves, of a diameter of 1·2 m. and a clearing width of 2·5 m. When driven by petrol engines (Ford V8), governed to 2,500 r.p.m., they are geared to revolve at 260 r.p.m. Both engines drive a common shaft, which transmits their power to the milling drums and to the electric generator. When driven by a diesel engine, the drums are driven at the slightly higher speed of 280 r.p.m. Electric drive has been chosen for the drive to the wheels or tracks as it gives a finer speed regulation for forward movement, which is very essential for adjusting it to the capacity of the drum, which varies with the snow conditions.

Photo No. 6 illustrates the Frästrommel.

Horse drawn snow ploughs. These are still used to a great extent to clear all minor roads, the upkeep of which is the responsibility of the Bürgermeister. These are made of timber and shod with iron. They are usually filled with ballast to increase their weight. Six to eight horses are required, depending upon their draft, which are obtained on requisition, as also is any additional labour required, snow clearance being compulsory by law.

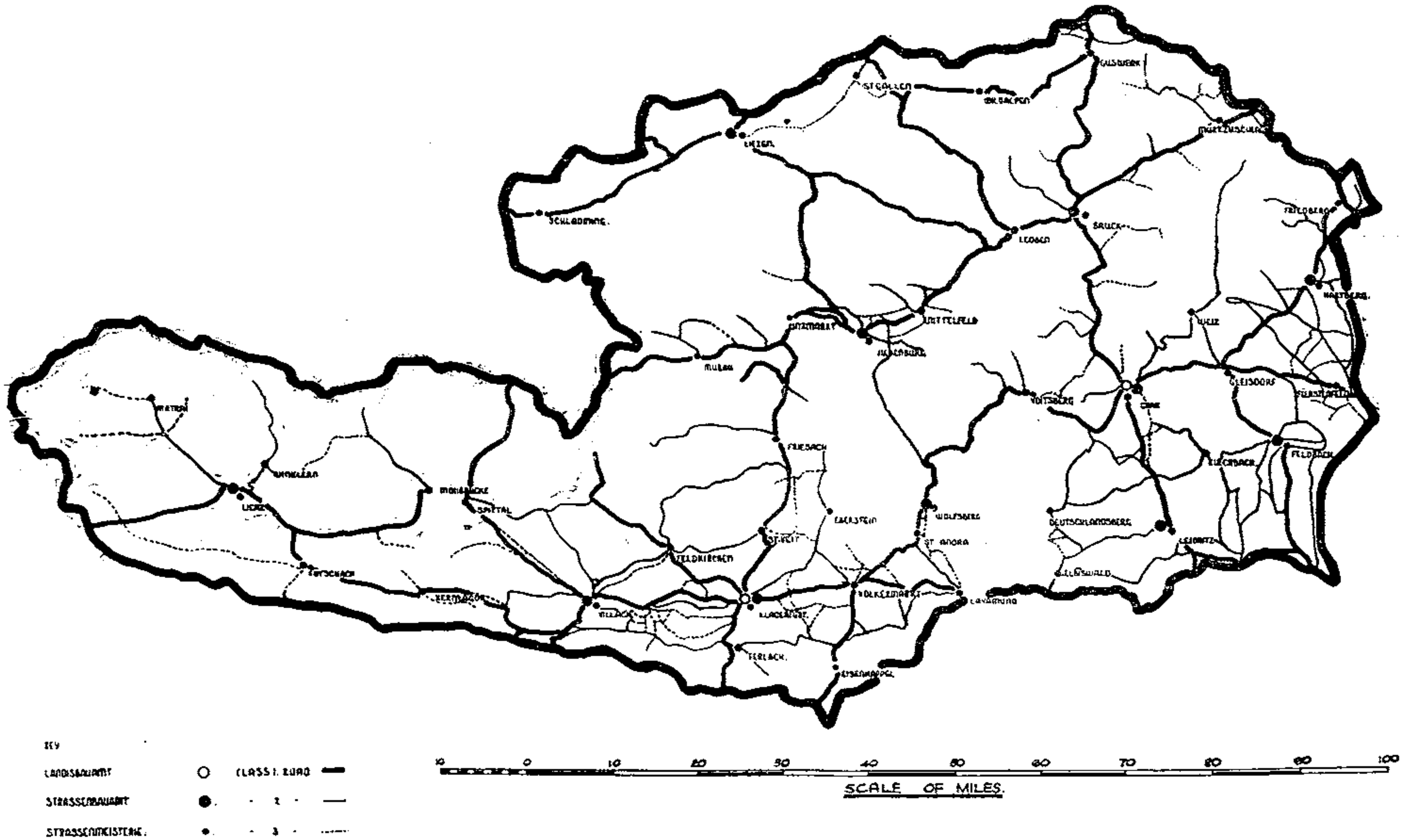
Conclusion

The following snow clearance equipment, excluding reserves and that for the larger towns, was required for the plan for Winter 1946–47 for the British Zone:

84 Vehicles with blade ploughs
2 A.F.R.
5 Schneeschleuder
4 Fräse.

The work was efficiently performed in spite of very heavy snow, and the roads were kept open except for short periods when drifts or avalanches necessitated the use of rotary ploughs or manual labour. Great credit is due to the crews, who carried on for long spells of work under bad conditions, usually inadequately clothed and underfed. Credit is also due to the mechanics for keeping equipment, which was generally old, on the road with an insufficiency of hand tools and an acute shortage of all kinds of spares.

BRITISH ZONE AUSTRIA



ADAPTATION OF MATERIALS IN THE SUDAN, 1941-2

By CAPTAIN T. G. LAYTON, R.E. (Retd.)

MANY accounts could be written on the subject of adaptation of materials for urgent works services in the field, and undoubtedly, many will go unrecorded, but the following brief accounts of "Sapper" ways and means, will I feel, be of interest to readers, and I hope recall happy memories to some.

Let me say at once that the ideas used were collective, and subscribed to by all members of the staff of the C.R.E., Red Sea Area, Lieut.-Col. E. R. Green, R.E., in team work of the highest possible order.

On an exceedingly hot and sticky morning in August, 1941, the C.R.E. was confronted by the Area Commander, with a high priority service, to provide storage accommodation for cased petrol. Area could not help with acquisition of stores or labour, but at the same time required the service to be completed in the absolute minimum of time.

A quick survey of the situation brought the following dismal facts to light:—

Site	About thirty miles south of base (at Port Sudan), many miles of open desert, with a very thin coverage of camel thorn.
Materials	For normal construction—nil.
Labour	In short supply. Contractors capable of handling the work—nil.

With conditions such as the above, every possible avenue had of necessity to be explored, and in view of the extreme urgency of the work, it was decided not to build at all, but to dig and cover the cased fuel.

The totals in bulk, however, precluded the possibility of digging and covering in trenches, since the total storage, under these conditions, would have meant a layout over an enormous acreage.

In early August, the services of two likely contractors were co-opted, and excavations for storage pits began. These pits were some 165 ft. long by 8 ft. deep, with a span over berms of some 48 ft.

Some 160 of these pits were required, and were in fact completed, and up to this point the question of materials did not worry us unduly. The sides and ends of these pits were then revetted with sandbags, and the job so far, was tidy and useful.

Roofing was the difficulty, and it was at this stage, that the C.R.E. had to "cope" with yet another priority item—a vehicle assembly depot—again with no suitable materials. However, the vehicles arrived in crates, and this particular circumstance enabled us to move one step nearer to the solution of our problems.

It was found that the native labour were attacking the crates with picks and hammers, with disastrous results to both the crating and their contents, so a suitable nail extractor was devised, from 2-ft. lengths of water pipe, offset at each end, sharpened, and "V" cut to get under the heads of nails.

Some 200 of these "extractors" were provided and recoveries became a reality. Two contracts were then let, one for the recovery of timber, nails, bolts, straps, metal strips, and clips, and the other for the production of sizeable timber sections from recoveries.

The author, who " laid on " these contracts kept records, and for the outlay of £2,772, by way of contracting, materials valued at £7,500 were recovered.

The production of suitable trussing over a 48-ft. span next presented itself, and the average length of timber available had to be taken into account. This average was not more than 6 ft. 6 in., so a design for trussing on the Belfast pattern was put into production. " Laminate " was the word that went round, and by skilful use of laminated short length timber, thoughtful bolting, and binding with metal strips, the job was completed very successfully.

Next came the awful thought of purlins and coverage material for roof areas. Bamboo poles, secured to truss members with recovered metal strips solved the problem, with palm frond " gareed " gridding* in mats, overlaying the purlins, to form the roof area. This produced a strong resilient coverage, over which was laid two layers of " Bursh," native grass matting, followed by old and unserviceable tentage material wired into position to keep goats from eating the grass matting. The whole roof surface was then treated with bituminous emulsion, and finally covered with sand to a depth of 4 in.

It was found that this roofing medium, provided on trussing at 6 ft. centres, was adequate against the high temperatures experienced and safely carried the dead load of the coverage, with the additional " live " load of stray animals in that area. Ventilation was provided at stepped entrances at either end, and at the centre, along the sides of the pits, and although the storage pits could not of course be fire-proofed, no loss or damage by fire, in fact, ever occurred.

The author learned, whilst in London, in 1945, that when these same storage pits were proclaimed redundent, interested parties in the Sudan, tendered for demolition and recovery of materials on site, with the result that a handsome credit was obtained for the " reappropriations in aid " vote of that year.

Uses to which " crating " may be directed are many, and were widely used during the war years, but I feel that the Port Sudan staff, really put up a good show in this connexion. It was found that aircraft and vehicle crating conformed to generally useable standards, in so far as dimensions and construction were concerned, and complete sets of drawings were made available to G.H.Q. (through the usual channels), embodying the possibilities of such materials.

One such sidelight was the production of specimen hutting in Port Sudan. Since staff quarters to hutted scales were not permissible, experimental hutting was erected from recovered sections of crating, and really valuable data obtained, as to quantities and erection details. Time and material costs were low, compared with those for the normal types of construction.

These experimental types of construction were erected in October, 1941, and the author had an opportunity of inspecting them in May, 1945. They were still doing good service (as a customs post), and were in remarkably good condition, considering the hot, humid climate in that part of Africa.

These particular experimental types also did duty as an excellent W.O's. and Sergt's. mess and quarters, which will be remembered as " comfortable " by the occupants.

* " Gareed " gridding is made from the centre frond of the date palm leaf, and is woven into sheets having a square mesh of approx. 3 in. It is used largely in Egypt as crates for vegetables, etc. It is extremely strong and does not split with age.

Yet another type of "adaptation" was that of a lock-up transit shed for cement, in the C.R.E. store, Port Sudan. In this case absolutely no stores of any kind were available for normal construction. The provision was a necessity, and something *had* to be done about it.

In this case, some old, but serviceable "sunt" poles (mis-shapen tree trunks of an exceedingly hard redwood) were retrieved from fencing, and erected as main supports for the framework of the shelter. To these palm "gareed" gridding was lashed, with native fibre string. Sufficient 4 in. × 1 in. fillets were obtained to make up light roof trussing, over a span of 12 ft., and these were notched into the tops of the sunt poles. Purlins were made up from split bamboo poles, and secured by means of metal binding strips from packing cases. The roofing was formed from "gareed" grid panels, tied on with native string, overlaid with double thickness native grass matting, and then covered with opened out cement bags of reinforced paper. The walls were similarly treated, and a pair of old gates "hung" to serve as entry. The whole was then given a good coat of bituminous emulsion and sand dashed in the wet state in a form of camouflage.

Only 1 lb. of 3-in. nails was used in the whole job, and while this shelter creaked and moved with the wind, it did duty as a cement store for the time during which it was most urgently needed.

There is probably nothing new in the foregoing, but it does show that your average Sapper is a useful sort of chap, when the question of "adaptation" comes up for early and efficient action.

TYPES OF ROAD SURFACING

A very useful pamphlet, Road Note No. 5, has been issued by the Department of Scientific and Industrial Research and may be obtained from H.M.S.O. for 1s.

It gives brief details of road construction, using Tar or Bitumen binders and the properties of these materials.

Bitumen or asphalt materials have been in use in several forms for many years and have proved their value under various conditions They are available for use in either hot, cold or emulsion form. The emulsion type is, generally speaking, not so good for roads carrying heavy traffic and it is too easily washed through the surface layer if rain occurs soon after it has been sprayed on.

Mastic asphalt has proved its value even with tank traffic.

Tar has been used for many years as a surface dressing and has proved its worth. More recently dense tar surfacing has been used on roads carrying heavy traffic and the results so far have been satisfactory. More care is required, however, both in manufacture and in laying than is the case with asphalt.

Although a tar emulsion has been prepared there is at present no standard specification for this material and no satisfactory data as to its value.

There is a very wide range of products now on the market and it is hoped that the pamphlet will be of assistance to engineers selecting the most suitable type for any particular road, taking into consideration all the local conditions, e.g., traffic density, climate and type of plant available.

MOUNTBATTEN BRIDGE, SHWELI RIVER

By LIEUT.-COLONEL P. A. EASTON, O.B.E., R.E.

MOUNTBATTEN BRIDGE was a temporary, Class 12, timber bridge built in February, 1945, by 15 Engineer Bn., I.E., under the command of C.R.E., 36 Div., for the purpose of maintaining that division on the south bank of the Shweli River.

The bridge was required in the neighbourhood of Myitson (see map), at which point the river presents a considerable obstacle ; being from 400 yds. to 500 yds. wide, with 7 ft. 6 in. banks (February level) and currents up to 3 knots. The depth is, on the average, from 4 ft. to 5 ft. with occasional 10-ft. channels, and is continually altering ; in one case some trees thrown into the river from the north bank caused a channel, 150 yds. away near the other bank, to silt up by 4 ft. in a day. The bottom is of sand or gravel, thinly overlaid with mud.

In order to secure the shortest span of bridge it was decided to build at a site some thousand yards east of the village, where an island divides the river into north and south channels, of about 200 yds. and 100 yds. width respectively. The configuration of the northern (deeper) channel was the controlling factor in detailed siting. At its narrowest point it was very deep with almost a mill race running along its northern bank ; accordingly a site was chosen near the west end of the island, where the channel was shallower and the current better distributed.

Two bridges were, therefore, required ; the northern to span a channel 540 ft. wide and of average depth 5½ ft., with one race 10 ft. deep by 40 ft. wide close to the island ; the southern to span 243 ft. with a maximum depth of only 2 ft. The division at this time was being maintained by air from Ledo, some 400 miles away. Supplies were, therefore, very limited and no bridging equipment could be flown in for the project. This fact, in conjunction with the firm nature of the bottom, pointed clearly to timber trestle or crib construction as the basis of design.

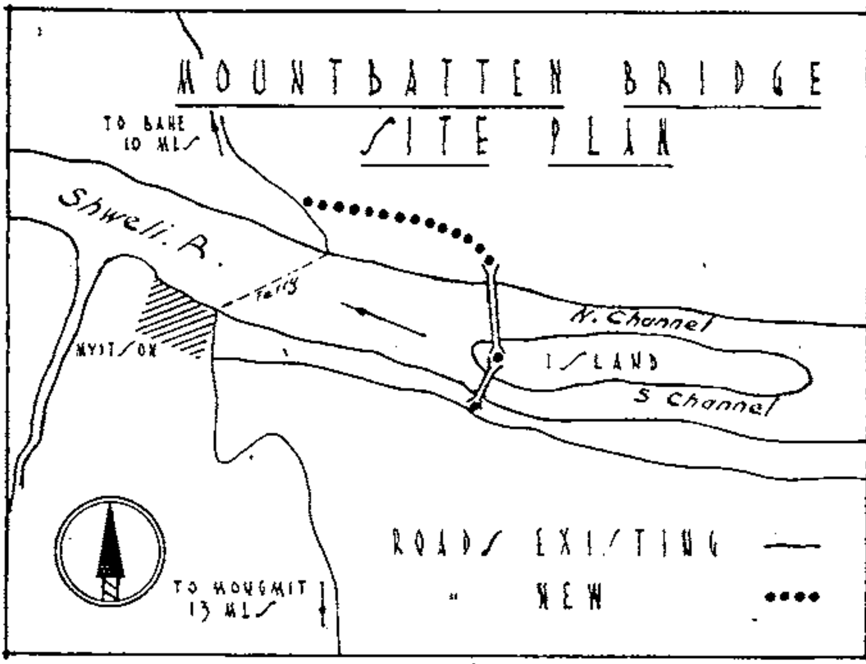
At this stage details of the bridges may be conveniently summarized.

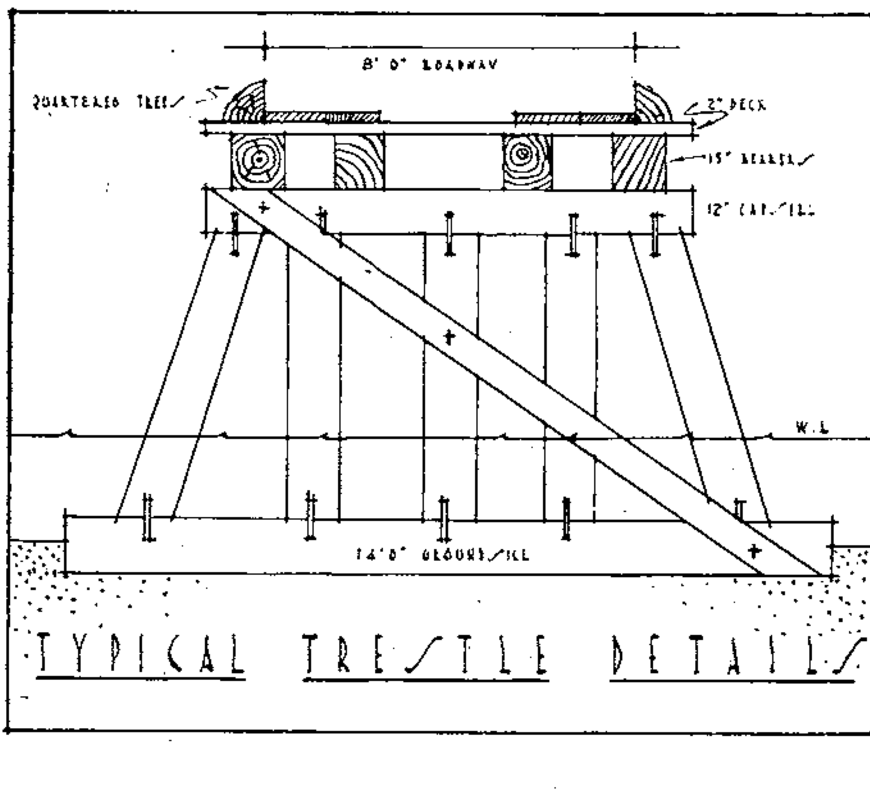
North Bridge Thirty-five single bent trestles (see diagram) at 15-ft. centres.
Four 15 in. × 15 in. bearers per bay.
Decking in 10 in. × 2 in. × 10 ft. planking.
Wearing surface (longitudinal planking), two tracks each 2 ft. 6 in. wide.

South Bridge Ten timber cribs.
Three single bent trestles. All at 18-ft. centres.
Bearers and decking as for North Bridge.

The 15 Engr. Bn. I.E. was given this job. Plant allocated was one compressor saw ; $\frac{5}{8}$-in. round steel for dogs, was available through Engineer stores channels, and teak in ample supply was growing ready to hand.

Initially two companies were put on the northern bridge and the third on the southern bridge. The job of timber felling and preparation was already in progress when the order to build was given ; but since all ripping and facing had to be done by hand, this part of the work was kept to a minimum. Trestle legs were left in the round ; capsills, bottom sills and crib timbers


MOUNTBATTEN BRIDGE
SITE PLAN
TO BAHE 10 MLS
Shweli R.
Ferry
N. Channel
ISLAND
S Channel
ROADS EXISTING
" NEW
TO MONGMIT 13 MLS


8' 0" ROADWAY
2" DECK
W.L
TYPICAL TRESTLE DETAILS

were faced top and bottom only ; bearers were squared roughly to 15 in. (teak being stronger than British Class I timber the loss in strength from rounded corners was negligible).

Crib construction, used where the water was less than 2 ft. deep, proceeded smoothly and calls for no special comment. The launching of the north channel trestles, in up to 10 ft. of water, involved some features which are worthy of record.

As a preliminary an S.W.R. cable was put across the channel, upstream of the line of bridge, from which a raft of old Japanese pontoons operated on the "flying ferry" principle. Light piles (4 in. to 6 in. diam.) were then driven on the bridge centre-line at the site of each trestle and at a distance from the centre-line of the trestle equal to half the width of its groundsill. Each successive trestle was then rolled out to the forward end of the bridge (bearers having been laid, bay by bay, as construction progressed) and was lowered down round timber skids until the groundsill was resting against the light pile. At this stage cordage slings were passed from the capsill to a party on the raft, who hauled the trestle into vertical position. Bearers were then pushed out and subsequently the trestle was anchored by 10-in. timber piles driven against the groundsill up and down stream.

It may be mentioned in passing that attempts to float trestles into position had proved extremely troublesome, owing to the weight of teak and the strength of the current. The method described above proved entirely satisfactory and work proceeded to schedule. After four days the south channel bridge was complete and the third company was employed on the island end of the north channel. Eight days after starting, Mountbatten Bridge was open to traffic.

DR. JEKYLL AND MR. HYDE

(Reprinted from the Journal of the Institution of Electrical Engineers, January, 1949.)

A student of literature recently inquired whether, for his story with the above title, Robert Louis Stevenson had obtained the names of "Jekyll" and "Hyde" from the List of Members of The Society of Telegraph Engineers. On referring to the first list, which was published in 1872, it was found that the names "Hyde, H., Col. R.E." and "Jekyll, H., Lieut. R.E." appear next to each other. Unless the arm of coincidence is a little longer than one may reasonably suppose, such strong internal evidence, supported by the date of the document, does indeed suggest that R.L.S. may have obtained the names from this source. In the same list there is a "Stevenson"—but, alas, the initials are not "R.L."

Photo 1.—All sawing was done by hand.

Mountbatten Bridge, Shweli River

THE NEW SCOTTISH H.E. PLANT AT LOCHALSH

Submitted by RICHARD COSTAIN, Ltd.

On the 21st of December, 1948, the first of the North of Scotland Hydro-Electric Board's projects was put into operation. This is the Lochalsh project, Ross-shire, the first part of the Board's Constructional Scheme No. 1 to be completed and the first of a series of 102 projects scheduled for construction by the Board under a long term hydro-electric development programme. The water power resources of 7·3 sq. miles of Ross-shire, with an average annual rainfall of 68 in., will be used to provide electricity for an area of over 100 sq. miles, which has a widely dispersed population of approximately 2,400 people.

Initially power will be supplied from this scheme to the Lochalsh district and, by means of a submarine cable, to the Island of Skye, but later distribution will be extended to the neighbouring districts of Lochcarron, Applecross, Sheildaig, Glenelg and Arnisdale. At present, temporary supplies are being given to Lochalsh and part of Skye from a 700 kw. diesel generating station at Kyle of Lochalsh.

TWO DAMS

The Lochalsh project covers the ultimate development of 4,000 kw. and involves the construction of two dams across Allt Gleann Udalain. The work has been divided into two parts, and completion of the first will bring the project into operation this year. This section provides for the construction of one dam across the Allt Gleann Udalain, about one mile up Glen Udalain, and the building of a generating station of 1,000 kw. capacity about 70 yds. south-east of Nostie Bridge. Water will be led from the dam to the generating station by a 33-in. pipeline branching into two 24-in. pipes, and the plant will operate under a maximum gross head of 478 ft. The estimated ultimate annual output of the project is 7 million units.

The second stage of the work consists of a dam across Allt Gleann Udalain farther up the valley from the first dam. The project was approved by the Secretary of State for Scotland in March, 1945, and preliminary work on the site started in 1946.

CIVIL ENGINEERING WORKS

The nearest railway access to the site is the Dingwall-Skye line of the old L.M.S. Railway with stations at Stromeferry, five miles by road from the dam, and Kyle of Lochalsh, nine miles from the dam. Between the dam and the generating station the distance by road is approximately 2½ miles.

The rock at the site of the dam is Lewisian gneiss, and excavation for the foundations of the dam, a mass concrete gravity section type with a spillweir crest level of 500 ft. O.D., was carried into sound rock with a cut-off trench on the upstream side. In order that the river flow should not affect the preliminary construction work, the Allt Gleann Udalain was temporarily diverted. Later, a temporary opening with sides tapering inwards to the downstream side was made through the body of the dam to maintain the flow of the stream during construction, which commenced in March, 1947. To facilitate work on the dam and to support the crane and light railway used to carry spoil to banks which will be submerged, a tubular gantry was erected. This spanned the gorge on the upstream side of the dam up to crest level.

The dam, which was constructed of mass concrete with no reinforcement, has an overall length of 210 ft., a height in the centre section of 53 ft. and a width at the base in the centre section of 35 ft.

It was originally proposed that the excavation for the foundations should go down to 13 ft. but in several places this was exceeded, due to poor quality rock. The concrete was a 1 : 7 mix for the main blocks with a 1 : 4 mix for the 9-in. facing. Aggregate " as dug " from the shore of the Loch was used. Very little concreting was done during the winter, and stopped when weather conditions were bad.

On the upstream side, an intake channel to the scour and draw-off pipes was excavated and the slopes of the cut in soft material were pitched with rough stone-random pitching 9 in. thick, set in cement mortar.

The energy of the water flowing over the dam is dissipated in a deep stilling pool at the toe at the deepest part of the valley. The water from the extremities of the spillweir is brought into the stilling pool in side spillway channels formed artificially with retaining walls. The bed of the side channels and much of the stilling pool is lined with concrete and the retaining walls are of mass concrete. A small concrete weir is installed at the downstream end of the stilling pool to maintain adequate depth.

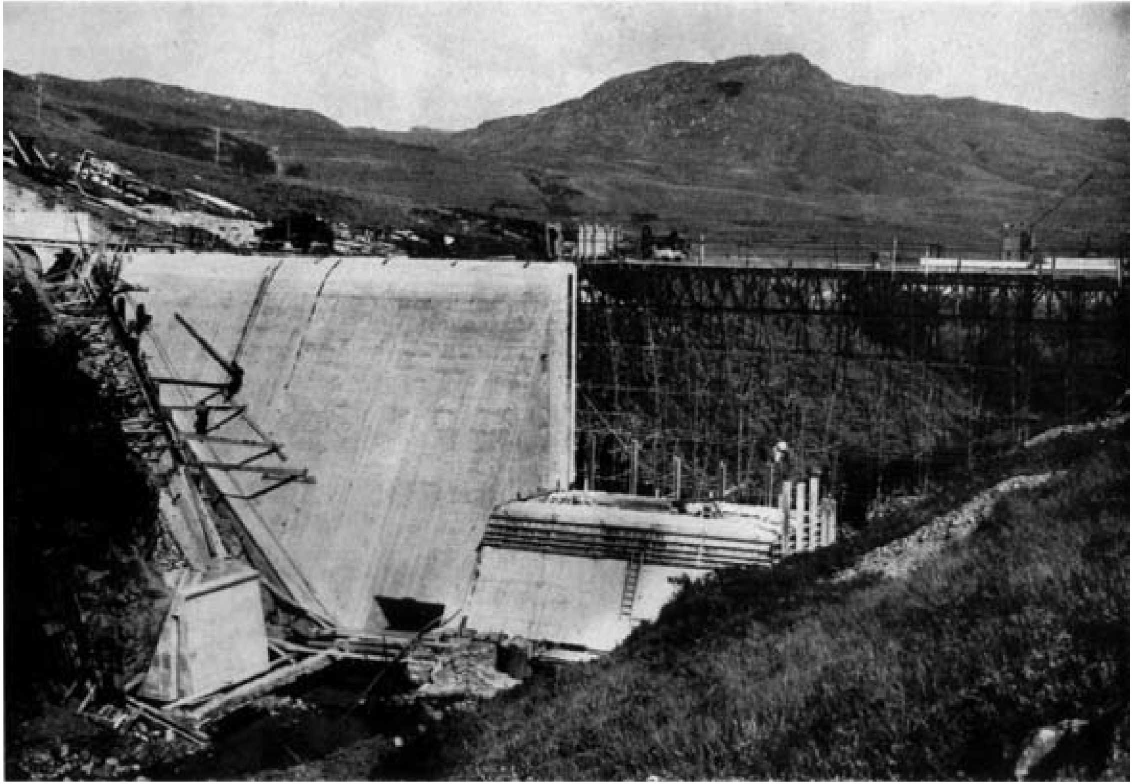
During the course of the contract there were no outstanding constructional difficulties, but the method of stringing out 24-in. and 33-in. steel pipes for the pipeline is interesting. Decauville track was laid along the route of the pipeline, but the slopes were too great to use a locomotive. An aerial ropeway, powered by a steam ploughing engine, was rigged up and this hauled the bogies by means of " tails " from the ropeway.

Labour was from time to time a problem as quite a number of men we crofters and fishermen who at awkward moments drifted off to attend t their crofts or nets.

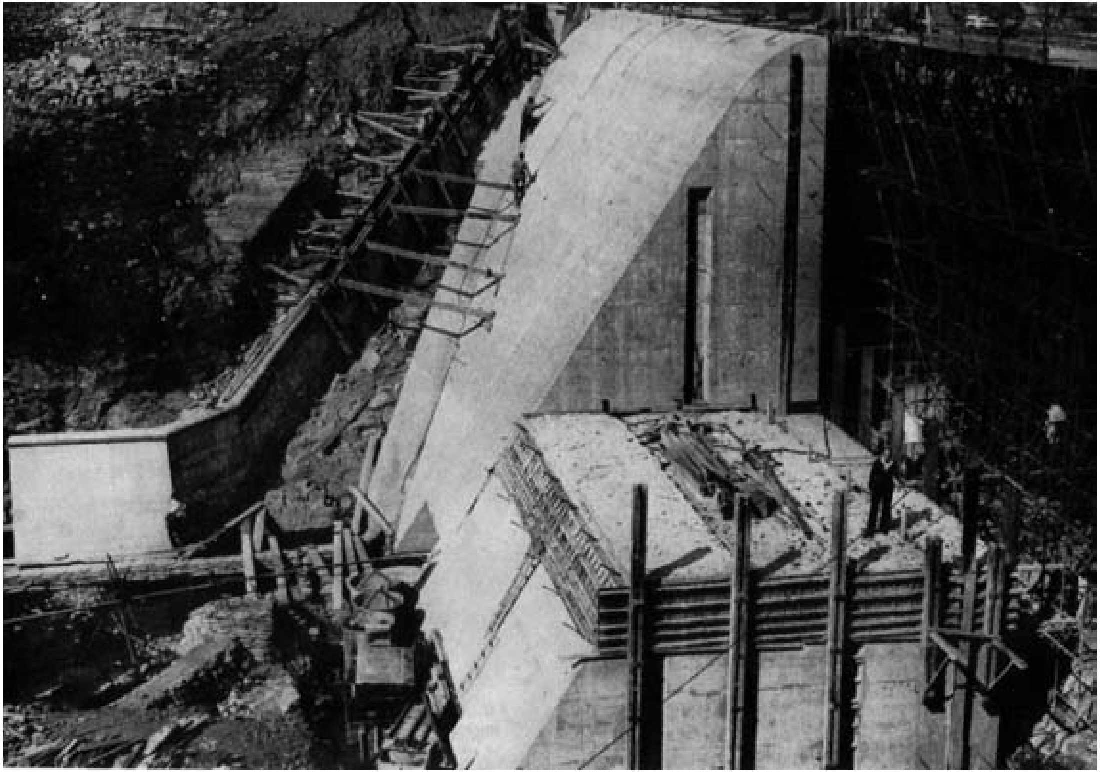
Pipe line

From the upstream face a flanged cast-iron pipe 18 in. in diameter is laid, and after passing through the dam and the valve house it discharges into the stream below the spillway channel. This pipe is fitted with two hand-operated sluice valves, 18 in. in diameter, situated in the valve house. The valve house is constructed with mass concrete walls and a reinforced concrete roof, the retaining wall of the spillway channel forming the lower part of the upstream end wall. A cast-iron draw-off pipe, 33-in. diameter, is also laid from the upstream face of the dam. This passes through the dam and valve house where it is fitted with two 33-in. diameter hand operated sluice valves and terminates where it joins the pipeline.

The pipeline, approximately 5,230 ft. long, leads the water from the dam to the generating station which overlooks Loch Alsh. It is sited on the left bank of the Allt Gleann Udalain, closely following the gorge of the river, and consists of a steel pipe carried on mild steel bearing cradles set in concrete pedestals on a continuous benching in the hillside. For approximately 2,000 ft. the pipeline consists of a single 33-in. pipe, but for the remainder of the distance to the generating station it has been divided into two pipes each 24-in. diameter. The rate of fall of the pipeline for the greater part of its journey is 1 in 113, but this fall increases sharply as it nears the generating station. Close to the generating station the pipeline passes under the road from Balmacara to Dornie, and in order that it should not interfere with the traffic on this road a temporary bridge was built to support the road while the pipe was being laid.



Mountbatten Bridge, Shweli River 2



Mountbatten Bridge, Shweli River 3

To shut off the water in the event of a burst, an automatic self-closing valve has been installed near the bifurcation point, and the pipe will be protected by anti-vacuum air release valves.

Generating Station

The generating station is built of local stone in the building tradition of the neighbourhood. Every care has been taken to ensure matching with surroundings, even to the provision of a raised flower bed at one entrance to the building.

The station is situated east of Nostie Bridge, near the Balmacara-Dornie road, and has outside dimensions of 57 ft. by 32 ft. A 12 ft. 9 in. folding steel door allows entrance for machinery. Inside, the station provides offices and storage space for the operating engineers as well as containing two sets of turbines and generators.

Owing to the absence of rock at a reasonable depth, and the unsatisfactory nature of the ground, a box of sheet steel piling has been formed to contain the whole of the foundation of the building ; the main turbine blocks, discharge ducts and the by-pass chamber being constructed above the top of the box. To give entrance to the building, which lies below the level of the main road, a curved access path has been built.

The turbines to be installed in the station are 21-in. Gilkes patent Turgo impulse types, with an output of 720 h.p. Their normal running speed will be 750 r.p.m. and 1,080 cu. ft. of water will pass through each turbine per minute. They will be coupled to Bruce Peebles 500 kv. alternators, having directly coupled exciters.

"Q" (QUARTERING) PROBLEMS IN MALAYA DURING 1947

By Major D. J. Willison, M.C., R.E.

Introduction

IN the post-war period the problem of accommodating troops in areas not previously occupied by British soldiers in peacetime has arisen in several parts of the world. The provision of the necessary accommodation as a matter of urgency at a time when the eventual size and shape of the garrison of each area was still in a constant state of flux, has given rise to many intricate problems. Rapid solutions have not been made easier by the imposition of increasingly severe measures of financial control and accounting for works services at a period when estimates could not, of necessity, be as accurate as the Treasury might require.

This article seeks to record some of the problems which beset the "Q" (Quartering) staff of H.Q. Malaya Command during 1947, together with some of the lessons learnt in the solution of those problems within the framework of Vote 10 (later renumbered Vote 8) accounting. Although the conditions of time and of the method of financial control were in some respects peculiar, the lessons learnt were for the most part standard pre-war practice. But, in common no doubt with other overseas areas, peacetime accounting was progressively imposed in Malaya without a corresponding general issue of the relevant manuals such as R.E. Services. Many of the officers concerned, both staff and R.E., had little if any previous peacetime experience of accommodation problems.

The recounting of the experiences gained by an engineer officer who was called upon to fill a "Q" (Quartering) appointment at an interesting time may therefore be of some value in showing how a number of lessons which were perhaps standard peacetime procedure were re-learnt the hard way by practical experience.

"Q" (Quartering) Plan for 1946

Before examining the quartering problems which occurred in 1947, it is necessary to give a brief résumé of the initial building plan for Malaya which was drawn up in 1946. It will be remembered that after the end of the British Military Administration, Malaya from the Straits of Johore northward to the Siamese frontier, and including the island of Penang, became the Malayan Union under a Governor located at Kuala Lumpur. Singapore Island became a separate governorship. Parallel with this civil organization, H.Q. Malaya Command at Kuala Lumpur controlled the whole of Malaya. Singapore Island came under H.Q. Singapore District.

In early 1946 it became apparent that the post-war garrison of Malaya would be of the order of one infantry division together with certain static administrative H.Q.s and units. Before 1939 no Imperial Troops were quartered on the mainland of Malaya. It was obvious therefore that a formidable building programme was required. The only assets at the disposal of the "Q" Staff were as follows. On Penang Island there still stood one permanent barracks, built to house two coastal artillery batteries, whilst on the mainland, at Taiping and Johore Bahru respectively, there were two State Force barracks each for one battalion of Asiatic troops. All three barracks were in need of major renovation and reconstruction if they were to be fit for British troops. It was also found that some temporary huts, again requiring much renovation, which the R.A.F. had built prior to 1941 at Kota Bahru, Sungei Patani and Kluang, could be fitted into the army post-war accommodation plan, and that the R.A.F. were willing to relinquish their rights to these.

In the spring of 1946 the garrison of Malaya, apart from the few troops in these barracks and huts, was accommodated in tents and requisitioned buildings. Incidents such as the mutiny by paratroopers at Muar, which led to the trial at Kluang, gave a great sense of urgency to the task of providing roofs quickly for all troops in tents. On the other hand pressure from the Civil Government, from Resident Commissioners and from a host of private individuals to release requisitioned buildings grew with every month that passed. In these circumstances a plan to provide temporary hutted accommodation for the bulk of the projected garrison and for the renovation of the existing assets to house the remainder was prepared with all possible speed. This plan was based on the assumption that the requirement was for temporary huts or "bashas", which would have to last for three years, until such time as permanent construction could be both approved as a policy for South-East Asia and completed in Malaya. It was not until late 1946 that it became clear that no permanent construction would in fact be sanctioned and that the temporary huts would have to be transformed into semi-permanent camps to last for five to ten years instead of the original three. However, in mid 1946 the War Office approved the overall project for temporary huts to last three years. Work on sites actually began in April, 1946.

Layout plans in early 1946 called first for three concentrated brigade cantonments. Later the plan crystallized into a requirement for three dispersed brigade group areas and a H.Q. and administrative installations area. This entailed the renovation of the existing accommodation assets and the construction of six new camps of battalion size and nine for supporting arms and administrative units, together with hutted accommodation for the Command and Brigade H.Qs., and for the Command administrative installations, including three large military hospitals. At this time it was still impossible to forecast which particular battalion or unit would finally occupy any particular camp. As a result it was decided to build standard "major" and "minor" unit camps to provide living accommodation for 750 and 250 men respectively at a standard establishment for officers, warrant officers, sergeants, and other ranks. The emphasis was to be on living accommodation with a basic scale of offices and stores. An estimate of the probable establishments of the various H.Qs. and administrative installations was also made on which plans were drawn up.

Work actually began in the spring of 1946. Control of the building programme was exercised by H.Q. Malaya Command at Kuala Lumpur, with three subordinate headquarters for north, central and south Malaya. The shape of all four headquarters fluctuated repeatedly in the next eighteen months, Command eventually reducing to a District in November, 1947, whilst the subordinate headquarters were in turn Divisions, Sub-Areas, and finally Sub-Districts. Throughout the period there was a Brigadier in charge of Administration at Kuala Lumpur with "Q" (Quartering) staff officers at all four headquarters. Parallel with the "Q" staff organization there was a Chief Engineer at H.Q. Malaya Command with three Cs. R.E. Works functioning alongside each subordinate headquarters, each C.R.E. controlling two or three Works Sections.

Development of the "Q" (Quartering) Plan in 1947

Financial Framework

The financial estimates prepared early in 1946 were preliminary estimates based on 14th Army wartime scales of accommodation rather than considered figures based on peacetime accommodation needs and taking into account local costs. Furthermore, the estimates were based on "standard" camps which would obviously require modification for occupation by individual units, and in certain cases, such as workshop cover, the future was so uncertain that the preparation of detailed projects was left over until a later date.

In the autumn of 1946 estimates for the financial year 1947–48 were prepared. These estimates included continuation services for all projects approved in the initial programme, certain new services for camps whose need had become apparent since the original scheme was prepared, a bid for a lump sum to cover new works within G.H.Q. and Command powers, and a sum for maintenance services. During 1947 these figures, which in due course received War Office approval, formed the financial framework in accordance with which the building programme had to be controlled.

At the same time Vote 8 W accounting for works services was enforced with increasing vigour during the year. The War Office reduced powers of administrative approval for any new service from £20,000 to £7,500 Total Civil Estimate (T.C.E.) for G.H.Q., Far East Land Forces, and from £10,000 to £4,000 for H.Q. Malaya Command. Furthermore, any alteration in the light of practical experience of the scope or cost of any one service entailed reference back to the War Office through G.H.Q., Far East Land Forces for revised administrative approval. This process might take anything from six weeks to nine months, and the effects of such delay upon the vital problem of providing roofs quickly can be readily understood.

The term T.C.E. (Total Civil Estimate) used in this article stands for the overall cost of any one project. L.C.E. (local cash expenditure) stands for the total cost (T.C.E.) of any one project less the cost of work carried out by military labour and less the cost of stores provided from military sources.

With this picture of the financial control framework in mind we can now turn to consider the main developments in 1947, the problems which arose, and the lessons learnt in their solution.

The Building Schedule

The first and basic factor effecting the building programme in Malaya was the eventual size and shape of the proposed post-war garrison. Throughout 1947 the forecast garrison was constantly changing in conformity with the numerous changes in the total allocation of troops for the Far East. The withdrawal of the British troops from Burma and Japan, the decision to station a British Gurkha Division in the Far East, and last but not least the effect of the mounting financial crisis at home upon the British manpower ceiling for the Far East, all had their effect upon the post-war garrison of Malaya.

But as already explained above, once a major building programme has actually been approved and work is in progress, no change to the scope of any individual project is possible without reference to the War Office and acceptance of the consequent delay involved. The main preoccupation of the "Q" staff was therefore to try and mould each successive "G" plan in such a way that all work in progress would both prove of value and not need to be altered in scope. For this purpose the standard camps for major and minor units proved a trump card, and it was possible by and large to continue uninterrupted with the original building plan. Pressure to alter this decision became acute at times, but, backed to the full by the Chief Engineer, the argument by the "Q" staff that changes in scope and layout would involve months of delay in replanning and reference to the War Office proved successful in preventing any major alteration in the layout of the projected garrison, despite numerous changes in the composition of that garrison.

Minor changes, however, were inevitable and the necessity for a "Q" staff table setting out the breakdown of all units and sub-units which would form the garrison of each military centre in the country became apparent at an early date. Some means was required whereby each successive change in plan could be analysed and related to the individual projects actually under construction or planned. The accommodation framework for each military centre was formed by the projects already approved both administratively and technically for that centre. The variable factors which enabled modification of the framework to fit each successive plan were first the ability to initiate new services within Sub-District powers of administrative approval (£500 T.C.E.) or to ask approval for new services within Command (£4,000 T.C.E.) or G.H.Q., FARELF (£7,500 T.C.E.) powers; secondly the ability to lease or in certain cases purchase civilian buildings, subject to War Office financial approval.

To enable Sub-District Commanders to review their "town plans" in the light of each new change in the planned order of battle, a "Q" staff table called the Building Schedule for Malaya was produced. New editions for each successive "G" plan were issued. This Schedule gave a detailed breakdown into Officers, Warrant Officers and Sergeants, and Other Ranks by nationalities (British, Indian or Locally Enlisted Personnel) for each unit, sub-unit and detachment which it was forecast would form the garrison of each town in Malaya some twelve to eighteen months ahead. On the assumption that the framework of approved projects remained unaltered, Sub-District Commanders were then able to revise their town plans for accommodating the forecast garrison by either of the two methods given above. They were also able to advise in cases where projects, which had been approved but not yet started, could now be cancelled.

The method adopted by Command H.Q. was to show on the Schedule the suggested means by which each serial should either be integrated into an existing approved project; or be covered by a new project, application for which should now be prepared; or be accommodated in leased or purchased buildings. For this reason serials included not only all the units and sub-units in each garrison but also each station's requirements of canteens, married quarters, etc. By frequent conferences Sub-District views on Command proposals contained in the Schedule were obtained and the policy recorded in the next edition of the Schedule.

It will be appreciated that the Building Schedule became the full statement of the accommodation intentions of the "Q" staff. On the one hand the Works services organization had a set plan in operation for constructing a number of projects including the major and minor unit camps for a fixed breakdown of Officers, Warrant Officers and Sergeants, and Other Ranks. On the other hand the "Q" staff were able to translate each succeeding "G" plan into the numbers and breakdown of men, married quarters, hospitals, canteens, etc., accommodation for which would be required at each military centre. By a continuous review of the whole accommodation programme, based on successive editions of the Building Schedule, readjustment in priorities could be made to meet the changing circumstances, works within G.H.Q., Command or Sub-District powers could be planned, and at the appropriate time financial estimates for works required in the financial year 1948–49 could be drawn up.

Scales of Accommodation

The original plan for the construction of a number of major and minor unit camps, which was drawn up in 1946, was based on War Accommodation Schedules as modified for the Far East. This scale of accommodation was of course very much on austerity lines and towards the end of 1946 it became apparent that in the case of the British soldiers at any rate the authorized scales were much too austere for peacetime conditions. Furthermore, by this date it had become clear that no permanent construction would ever be authorized by the War Office, and that the temporary hutted camps already in course of construction would have to be improved so that they would last for much longer than the original estimate of three years. A conference was therefore called in December, 1946, by the G.O.C.-in-C. Malaya Command to decide what should be the basic amenities to be provided for all ranks in the way of baths, showers, latrines, fans, lights, mirrors, etc., in all semi-permanent accommodation. The decisions arrived at were forwarded to G.H.Q. in Singapore and by early summer approval was given for revised scales of accommodation incorporating the majority of the recommendations made by H.Q. Malaya Command.

The repercussions of this desire to increase both the life of the camps already under construction and the permissible scale of accommodation and amenities were not slow in making themselves felt. Commanders who had attended the original conference began to insist, even before G.H.Q. approval was received, that the improved scales of amenities should be installed in all completed camps and in those actually under construction, in addition to those in the planning stage. As soon as the increases were approved by G.H.Q., commanders at all levels pressed even more strongly that all camps should be completed to the new scales, without appreciating the financial problems involved. Very soon reports began to come in that for certain projects, which had received War Office sanction, the estimates for total cost and cash expenditure would have to be raised to cover the cost of completion of the camps to the new scales. As we have already seen all increases in either L.C.E. or T.C.E. required War Office approval for any project over £7,500 T.C.E. Furthermore, it was well known that the correct procedure in such cases must be that work must either stop or be completed at a lower scale of accommodation pending the issue of revised approval. Any idea of committing the War Office to an over-expenditure and then asking for the money on the grounds that the contractor just had to be paid was naturally unpopular in the extreme.

Some very rapid thinking had to be done to sort out this complex situation which had developed piecemeal before the full implications were perceived by the "Q" staff. It was clear that the cause of the trouble lay in the fact that the scope of projects already approved had now been increased and that in some cases work was being put in hand before War Office approval had been obtained. We re-learnt by bitter experience that new scales of accommodation can only be implemented in projects which are still in the planning stage and which have not yet received formal administrative approval. For approved projects the correct method should be to ask for a new service to raise the scales of accommodation of the original project. This method takes time, especially when the cost is likely to require War Office approval, and under peace time conditions commanders cannot, therefore, hope to push such matters through at any great speed.

Due to the special circumstances of the case a solution was found to the problem. It so happened that administrative approval at a bulk T.C.E. and L.C.E. figure had been given in the summer of 1946 to what was then called the "Brigade Groups Scheme" for major and minor unit camps. As a result of the numerous changes of plan since that time, not all the individual camps were still needed nor had they in fact all been started. In view of the incessant changes of plan both as regards the garrison and the type of accommodation to be provided, it proved permissible to cover all the increased estimates on projects actually in progress under the original scheme by a switch of funds within the bulk total, with the exception of one case where work was stopped and the War Office were asked to approve an increase of £20,000 L.C.E. In the case of married quarters, seventy had been approved by the War Office, but it was found that only sixty-one could in practice be built on the approved figure for local cash expenditure. The War Office were therefore told that only sixty-one quarters were in fact being constructed so that no over-expenditure in cash would be incurred.

Labour Force

One aspect of the constant changes of the garrison during 1947, was the effect upon the direct labour force available to the Chief Engineer. The initial building programme was undertaken by a number of Indian Engineer Battalions assisted by some 9,000 Japanese Surrendered Personnel (J.S.P.). During early 1947, as the bulk of Engineer Battalions returned to India, some work was put out to contract, though the majority of projects remained in the hands of the J.S.P., under the supervision of British Works Sections and the remaining British and Indian engineer units.

In the summer of 1947 orders were received that all J.S.P. must be returned to Japan by October, 1947. It was hoped to recruit and raise pioneer labour units in Ceylon to replace them before the last J.S.P. departed. The tents and "bashas" occupied by the J.S.P. were obviously in no way suitable to house the Ceylonese and there arose the problem of producing tented accommodation with hutted ancillaries for 3,000 Ceylonese Pioneers, in three months, in the middle of the financial year.

The "Q" plan, based on engineer advice, for this building operation was as follows. It was decided to locate the Ceylonese in company or half company groups of 500 or 250 men at the various military stations in Malaya. A standard establishment was laid down for each 500 or 250 man camp. It was laid down that the cost of each camp must not exceed £7,500 T.C.E., i.e., each service would be within G.H.Q. powers of administrative approval. The Chief Engineer worked out a standard specification for tented camps covering the provision of electricity and "bithess" floors for tents; hutted ancillaries in the way of ablutions, latrines, cookhouses; and hutted dining halls which could also be used as unit canteens. G.H.Q. approval to specimen A.F.M.1428s for both types of camp was obtained, and contract documents were all prepared in the Chief Engineer's Office. Meanwhile Sub-District Commanders were told what acreage of land was required for each type of camp and what land tenure must be obtained. By the time sites were firm, C.R.E. works had received sufficient data to allow siting boards to be held. Finally approval was given for work to start, contracts were accepted and the camps were ready within three months.

To crown these intensive efforts, information was received just as the camps were being completed in October, 1947, that no Ceylonese would in fact arrive in Malaya for another two or three months and even then only in reduced numbers. This situation caused a fresh crop of difficulties. The superimposing of the Ceylonese Labour Camp projects on to the existing building programme had already caused delay in the planning of a number of other projects. The complete lack of military labour which resulted from the departure of the J.S.P. meant that work had either to stop on a number of projects or be put out to contract. This meant yet further increase in L.C.E. and delay, as the preparation of contract documents had by now become one of the principal bottlenecks in the execution of the entire building programme.

The culmination of disappointment over the slow implementation of the new scales of accommodation, coupled with a general slow-down of work due to the virtual elimination of the military labour force, caused much irritation amongst commanders at all levels. Faced with large numbers of troops still in tents and attacked on all sides by the civilian population over slowness in releasing requisitioned property, the tendency was for commanders to blame those responsible for direction and execution of the building programme, rather than to examine the causes for delay in completion dates for work in hand. Some C.Os. were most helpful and understanding, both in their appreciation of the difficulties and in the provision of unit labour to assist local G.Es. It was clear however that much could still be done by both "Q" and engineer officers to "put over" the problems which face Works Services, with particular regard to the system of financial control exercised by the War Office. One method of impressing commanders in this respect was to show them the contract documents and drawings for just one small project. In this connexion the lack of surveyors of works throughout 1947 proved one of the principal bottlenecks in the progress of the works programme during the year.

Lessons

Before going on to discuss the preparation of financial estimates and finally the land problems which are so inseparably connected with Works Services, it will be convenient to summarize at this point the main practical lessons which emerged from the development of events in 1947.

(*a*) The need for a "Q" staff table expressing the accommodation intentions of the "Q" staff on the lines suggested above.

(*b*) Once War Office approval to a series of projects has been received, the necessity for the "Q" staff to work in the closest collaboration with the "G" staff so that changes in the operational plan are made with the minimum of dislocation to approved services.

(*c*) If revised scales of accommodation are introduced, the best course of action is to complete all approved projects to the original scale while application is made for new services to raise the projects to the new approved scales.

(*d*) No commander is entitled to order work to commence until the engineer officer responsible for executing the work has in his possession the following authorities :—

   (i) A "Q" administrative approval for the scope of the work at an approved T.C.E. and L.C.E. from the appropriate H.Q.

   (ii) An "E" technical approval for the work as set out in the A.F. M.1428.

   (iii) An allotment slip from the Chief Engineer to cover the cash expenditure (L.C.E.) which has been approved for the work.

(*e*) If at any time it becomes clear that either the approved T.C.E. or L.C.E. or both are inadequate to cover the cost of the project, the correct course of action is either to stop work whilst revised approval is obtained, or better still to complete the work at a lower scale of accommodation so that it can be used until such time as the additional money to complete the project as originally planned is forthcoming.

(*f*) One final lesson was learnt as a result of the necessity for switching over from military labour to work by contract. Although the scope of the projects and therefore the Total Civil Estimates remained constant, the Local Cash Expenditure was bound to increase. Once again War Office approval was necessary to such upward revisions of cost, and once again further delays to the progress of the work actually resulted whilst financial approval was obtained. The lesson here is that as soon as it is known that a change in the military labour force is contemplated, the War Office should be asked for covering authority to raise the Local Cash Expenditure of projects which must now be completed by contract.

Financial Estimates

One theme has run through the preceding paragraphs, namely the delays involved if at any time during the financial year reference has to be made to the War Office for permission to alter either the scope, and therefore the Total Civil Estimate, or the Local Cash Expenditure of any project. The most important yearly task of the "Q" and Engineer staffs is the preparation of the financial estimates for the following year, in order that War Office financial approval may be received in time to prevent any break in continuity between the end of one financial year and the beginning of another. This meant that estimates for the period April, 1948, to April, 1949, had to be prepared in Malaya during August, 1947. Once these estimates have been dispatched, statements of case for each new service requiring War Office approval have to be prepared and submitted as soon as possible thereafter. If the figures are incorrect or if the statements of case are poorly presented, delays in the progress of work in the following year are inevitable.

The preparation of the figures for T.C.E. and L.C.E. on all new services necessitates the preparation by the "Q" staff of a full planning brief covering establishment, storage capacity, etc., on which estimates can be worked out. In the fluid conditions then current in Malaya the preparation of planning briefs looking twelve to eighteen months ahead called for foresight verging on clairvoyance on the part of the "Q" staff.

The most important task of the "Q" staff when compiling applications for approval for new services to support the estimates already submitted is to set out clearly the necessity for each service. Failure to do this in 1947–48 caused endless correspondence and delay over certain projects. Each case has to be sufficiently clear on its own merits to convince a Works Finance civil servant sitting in London that it is essential that the service should be given financial approval at this particular moment. This entails a detailed history leading up to the requirement for the project and the provision of sufficient data to show that the project cannot be constructed at some other place and cannot be deferred or merged into some other project. It is also important to include in the application full details of the land problem of the site selected. The Works Finance representatives need full assurance that the site can be held for the useful life of the buildings contemplated, and that the cost of terms of acquisition or lease are reasonable.

On the assumption that the statement of necessity is self evident, that the terms for acquiring or leasing the selected site are fair, and that the cost is reasonable in the light of earlier demands for similar services, the task of gaining administrative approval should be completed without undue correspondence and delay. The main lesson learnt during 1947 was that when, during the course of the financial year, work was held up due to delay in receiving War Office administrative approval the reason was generally found to be in the faulty presentation of the case for necessity, land or costs and not to the necessarily slow and cumbersome procedure of financial control from the War Office.

One other interesting lesson came to light during the preparation of estimates for the financial year 1948–49. Where the necessity is recognized by the Treasury that a large scale building programme has to be completed quickly, the governing factor is the ability to expend rather than the availability of money. It is then necessary to assess what is in fact the peak output of the Works Services in the financial year in terms of funds which can be physically expended on continuation of approved projects, on maintenance, and on new services. The bulk figure is of course effected by the supervisory and labour force available, by the number and capacity of contractors which can be employed without undue detriment to civilian needs, and by the output of local materials such as timber and bricks, again without undue interference with civilian supplies. This figure was computed as £2,000,000 Total Civil Estimate in Malaya. As a matter of interest, after deducting funds for continuation, services, maintenance, new services within G.H.Q. powers and pay of civilian staffs, it was found that only £600,000 worth of new construction could be undertaken in 1948–49.

Land Problems

No account of the experience gained in 1947 would be complete without reference to the extremely difficult problems which arose over land and buildings. Parallel with the "Q" and R.E. staffs in Malaya there was an Assistant Director of Claims and Hirings at Kuala Lumpur and Deputy Assistant Directors working with each of the subordinate H.Qs. Claims and Hirings are of course responsible for an enormous amount of work in connexion with claims, but it is in their capacity as agents for the Army in any matter to do with requisitioning, or derequisitioning, leases of land and buildings and direct acquisitions that we are now concerned.

Reference has already been made to the rapidly increasing pressure to release requisitioned properties. This came mainly from the Civil Government but also from a host of private individuals. Over a thousand properties were requisitioned in 1945, and the task of releasing these without having to put troops back into tents was no light one. Eventually a timed programme covering the whole Command was prepared at Command H.Q., based on the estimated completion dates of the building programme. Parallel with this plan great efforts were made to lease as many properties as possible, thus removing them from the list of requisitions.

It is on the question of leasing or purchasing building sites that the paths of Works Services and Claims and Hirings cross. A.D. Claims and Hirings, Malaya, had financial powers to sanction any lease up to £800 per annum, leases up to £1,000 per annum could be sanctioned by G.H.Q. and leases above that figure required War Office approval. No purchase of any site or building could take place without War Office approval.

In 1946 the policy laid down was that land tenure on building sites for semi-permanent construction was to be secured for a minimum of three and a maximum of five years. Within these narrow limits sites were selected in the spring and summer of 1946, in some cases without adequate guarantees from the owners, and building started. In 1947 the standard of semi-permanent accommodation was raised, and it was obvious that the life of the buildings would be much greater than five years. At the same time it began to be clear that the garrison of Malaya was likely to remain well beyond the original estimate of five years. For this reason authority was eventually given to increase leases on camp sites first to seven and then ten years, and also to purchase sites outright where possible. The quantity of work involved in sorting out the problem of land tenure for all W.D. building sites in the country in accordance with the new policy can be left to the imagination.

Space does not permit any detailed account of the activities of "Q" and Claims and Hirings during the year in this field. However, the main lessons learnt as a result of a wide variety of cases are summarized below :—

(*a*) Once a decision has been taken to locate a project in a particular area it is the responsibility of the "Q" staff on the advice of R.E. to tell Claims and Hirings what area of land is required for building. To this may be added "G" (Training) bids for training grounds.

(*b*) Claims and Hirings in conjunction with R.E. narrow the search down to one or more areas on which security of land tenure can be obtained. The "Q" staff then convene a Recce Board whose task it is to confirm the site.

(*c*) The following should be represented on the Recce Board. They should be asked to record in writing that they are satisfied that the site selected meets their particular requirements.

(i) Medical—that the site is healthy, that the source of water is suitable, and that the anti-malarial commitment is not too extensive.

(ii) Claims and Hirings—that no difficulty is likely in securing the necessary land tenure, that compensation is not likely to be excessive, and that R.E. proposals for water intake and sewage disposal will not clash with civilian interests.

(iii) Works Services—that the overall T.C.E. and L.C.E. including costs of water supply and anti-malarial work should not prove excessive, and that the site is suitable and adequate for the purpose in mind.

(iv) General—if the project is for a technical or service unit, an officer representing the head of the arm or service concerned at the H.Q. which convenes the Board should be invited to attend.

Though patently obvious, it was extraordinary on how many occasions weeks or even months of planning work were rendered useless because these precautions had not been observed, or because one or other parties to the original Recce Board had failed to study the problem fully. In the experience of the writer the repercussions of a poorly conducted Recce Board are often greater by far than of an inefficient Siting Board at a later stage in the procedure. The choice of a suitable President is obviously an important consideration.

(*d*) Under no circumstances whatsoever should work of any sort be permitted on site until a guarantee has been received from Claims and Hirings in writing that they are satisfied that the owner is prepared to lease or sell the site on terms acceptable to both parties to the transaction. Failure to obey this rule caused endless trouble and even legal action during 1947.

(*e*) Really close liaison between local commanders and the civil authorities, in this case between Sub-District Commanders and Resident Commissioners, concerning land problems is worth its weight in gold. Much time was wasted over and over again at the lower levels in selecting suitable sites for building only to have the scheme turned down by the Resident Commissioner as soon as the case reached him.

Conclusion

The control of a large scale building programme necessitates the coordination of many branches of the staff. In the first place mutual confidence and the closest co-operation between the " Q " staff and all sections of the " G " staff at all levels of headquarters is essential. Secondly there must be the closest co-operation and confidence between the " Q " staff, the Chief Engineer's Branch, Claims and Hirings and the Financial Adviser, as the principal partners concerned in the control and execution of a building programme. Co-operation and confidence can only come when each partner has acquired a thorough knowledge of the range of problems which face the other, and of the rules of procedure by which each is tied. Lastly no chance must be lost to impress upon commanders at all levels the nature of the financial controls by which Works Services and Claims and Hirings are governed. Without due appreciation by commanders of the scope and nature of War Office controls, the path of the " Q " staff officer is likely to be a hard one.

THE MOVE OF THE S.M.E. (INDIA) FROM ROORKEE AND ITS RE-ESTABLISHMENT AT KIRKEE

By LIEUT.-COLONEL SIR JOHN S. FORBES, BT., D.S.O., R.E.

BRIEF HISTORY OF THE S.M.E. PRIOR TO ITS MOVE FROM ROORKEE

THE sanction for the formation of a School of Military Engineering at Roorkee was given by the Governor General in Council on the 28th September, 1943.

Before that date, except for the very few Indian Officers who had been commissioned from the " Shop ", the technical education of R.I.E. officers had been carried out at civil Indian engineering colleges, such as the Thomason College in Roorkee and the Maclagan College in Lahore, and at R.E. O.C.T.Us. established at the Regimental Centres of the old Sapper and Miner Groups. These methods had proved inadequate and therefore it was decided to establish a fully equipped S.M.E. in India.

The task was rendered easier at Roorkee by the proximity of the Bengal S. & M. and above all by the generous decision of the U.P. Government to hand over to the S.M.E. the facilities of the Thomason College, full control of which had been given by 1945.

When the war with Japan came to an end, it was apparent that the S.M.E. must switch over to a peacetime rôle. The Corps of R.I.E. had expanded and there could be no return to the pre-war makeshift arrangements for training officers. A reorganization was accordingly carried out and an Interim Peace Establishment was finally sanctioned in July, 1946. The School as reorganized then consisted of a Headquarters, a Civil Engineering Wing, an Electrical and Mechanical Engineering Wing, a Field Engineering Wing and a Depot Battalion.

Of the above, Headquarters, the Civil Engineering and the Electrical and Mechanical Wings were in the Thomason College buildings, the Depot Battalion was also nearby in Roorkee, while the F.E. Wing was established in hutments six miles away up the Ganges Canal at Dhanauri.

About this time, i.e., in early 1946, the Thomason College also were reorganizing for peace and required the return of their college for its conversion into a University. Other factors contributing, it was clear that the S.M.E. would have to move elsewhere. Consequently steps were taken to find a new home and a preliminary reconnaissance of the present site, known as the "Harris Bridge" site, on the River Moola at Kirkee was carried out in April, 1946.

THE PLANNING OF THE NEW S.M.E.

Planning started on a note of optimism. Little did the originators foresee the unexpected obstacles that would arise and wellnigh smother the young growth of the new S.M.E.

The accommodation was planned on the interim establishment sanctioned in July, 1946, mentioned above, but allowance was made for the inclusion of a Transportation Training Wing, although this had not yet been accepted as necessary by the Government of India at this stage.

It was then proposed to phase the project as under :—

Phase "A" To be completed by 1*st October*, 1947.

(1) Rs. 5 lakhs to be spent on adapting the existing hutments of the American Special Force Defence Centre for the Civil Engineering Wing, Officers' Mess and quarters, and H.Q. & Wing offices.

(2) To build in permanent construction
- (*a*) E. & M. Wing and workshops.
- (*b*) Field Engineering Wing.
- (*c*) 50 per cent married accommodation for permanent staff.
- (*d*) I.O.R.s Institute.
- (*e*) Stores, MT Lines.

Phase "B" To be completed by 31*st March*, 1949.

This phase comprised the replacing of the inconvenient temporary accommodation in Phase A(i) by permanent construction.

Phase "C" To be completed by 31*st March*, 1952.

The provision of further residential accommodation to bring it up to full post-war scales.

At this stage it was even thought likely that the Main Block for Headquarters, the Civil Engineering Wing and the Institution of R.I.E. which would normally have come under Phase "B," might be included in Phase "A."

On the 1st June, 1946, a high ranking officer of the S.M.E. wrote "It is good to hear that at last things are moving and that the site has been acquired." Although it is realized that this sentiment referred only to the area of the Special Force Defence Centre, comprising some 350 acres, and not the full 3,500 acres eventually to be acquired, this statement tickled the sense of humour of the present writer somewhat, in view of the fact that essential portions of the site were not actually acquired till March, 1948.

The chief cause of optimism was the hope that the S.M.E. Project would be financed from a Capital Grant for large projects which the Q.M.G. was then expecting from the Defence Dept. However, this hope soon faded and it was apparent that a mere Rs. 5 lakhs would be available up to 31st March, 1947. The same officer quoted above was now "filled with the deepest gloom" and had visions of tented accommodation for students for several years, no married quarters for anyone, and only the barest accommodation for offices, permanent staff and a few classrooms in the first "Phase."

It was still envisaged that the second phase would commence in the Financial year 1947–48 and that a sufficient amount of this phase would be complete to open up courses in the Field Engineering Wing by 1st January, 1948, and the E. & M. Wing and the Civil Engineering Wing by 1st April, 1948.

By February, 1947, the phasing was fixed as follows :—

Phase I Rs. 5 Lakhs (1946–47).	Conversion of existing hutted accommodation to house Headquarters and the Civil Engineering Wing temporarily and provision of tented accommodation for officers and other ranks.
Phase II Rs. 124 Lakhs (1947–48).	(*a*) Acquisition of the whole land required for the project. (*b*) The E. & M. Wing and workshops. (*c*) The Field Engineering Wing. (*d*) 50 per cent married accommodation for officers and other ranks. (*e*) Necessary external services including arboriculture.

Phase III Rs. 120 Lakhs (Later).	Provision of the Main Building to house Headquarters and the Civil Engineering Wing, the Institution of R.I.E. and the completion of permanent living accommodation to full scale.

Phase II was well on by this time and detailed planning and drawings, acceptance of necessity and administrative approval were duly given, but allotment of funds was awaited.

By April, 1947, however, the rapid political changes leading up to Partition were in full swing, and the Government and Defence Department were in no mood to give decisions on such minor items as a new S.M.E. In consequence little progress was made.

Plans for the Actual Move to Kirkee

By this time the S.M.E. authorities were getting seriously worried. It appeared that they would have to vacate the Thomason College by October and that there might not be anything to open up with in Kirkee. It had been decided to close down instruction at Roorkee on 1st June, pack and move to Kirkee by 1st October, and open up courses again by 1st January, 1948, in the Field Engineering Wing. The closing down was fixed but the re-opening was by no means certain.

Staff

The problem of staff was also beginning to be worrying. The plans for replacing British Officers by Indian were being hurried on faster than any planning authorities had thought possible. It now appeared likely that between the closing and re-opening of the School all junior British Instructors would go as well as some of the senior ones. At the same time replacements would have to be found for the civilian staff of the Thomason College, who supplied the bulk of our instruction in the E. & M. and Civil Engineering Wings. In fact the continuity of teaching tradition in the S.M.E. was threatened with extinction.

Equipment

The S.M.E. had relied to a very large extent on the Thomason College for the instructional equipment in the E. & M. and Civil Engineering Wings. Steps had been taken to draw up new equipment tables to include replacements for this equipment and to arrange for its provisioning direct to the S.M.E. on arrival at Kirkee. However, the wheels were grinding all too slowly and the new equipment tables showed no signs of having been approved by G.H.Q. by May, 1947.

The S.M.E. oracle now expressed extreme gloom at all these delays. If it had been realized then how very much worse things were to become there probably would have been a suicide !

Preparation for the Move

During June and July packing up was the order of the day. The F.E. Wing was to move first and provide an advance party in Kirkee. It was more and more apparent that there would be very little on the ground at Kirkee by 1st October.

There was still no money allotted for Phase II and Phase I work had not yet been completed. In addition a spring storm had unroofed most of the hutted accommodation that did exist. However, preparation for the move proceeded slowly but surely with Independence and Partition just round the corner.

It was at this time—the end of July—that the present writer arrived at Roorkee from England as O.C., Field Engineering Wing. The wing was fifty per cent packed up.

On 5th August the first railway wagons were loaded. It was planned to load and dispatch three wagons a day but owing to erratic receipts of wagons it did not work out quite like this. However, the move had started!

Independence Day and Partition

The 15th August was Independence Day, and the terms for Partition and also the new terms of Service for British Officers were published about this date. All this involved many shocks to the S.M.E.

First of all came the news that neither the Deputy Commandant nor the O.C., E. & M. Wing, who were on leave in the U.K., would be returning. Then the Commandant was removed to be Chief Engineer, Southern Command. Also, as anticipated, the large majority of British Instructors opted to cease service in India. A mere sprinkling volunteered to serve on, mostly for three months but a few for a year.

A few days later the results of the disturbances in the Punjab began to be felt at Roorkee, and the flow of rolling stock ceased. An Advance Party consisting of the writer, one other officer, and a V.C.O. and Havildar of the Bridging School left for Kirkee on the 19th August to prepare the way and receive the flow of wagon-loads. The Assistant Commandant was now in charge of operations in Roorkee and he was to dispatch a more complete Advance Party on demand when Kirkee was ready for them.

Progress of the Move

To add to the rolling stock difficulty, Roorkee and the Punjab and United Provinces were the victims of unprecedented floods, and the roads and railways were breached in several places during September. The result was that Roorkee was completely cut off from the outer world. Demands from Kirkee for a further advance party were not received and many other important letters and signals were completely lost. However, eventually the flow of wagons was resumed.

In the meantime, in Kirkee the advance party had acquired some permanent staff by claiming Maharatta personnel from the Royal Bombay Engineer Centre, to replace their P.M.s who had gone to Pakistan. With the help of these men and other working parties from the R.B.E.C. and from 624 Army Gp. Engineers in Kirkee the unloading and preparation of the new S.M.E. site progressed.

On arrival, as expected, very little was ready at the new site. No allotment of funds for Phase II had been received. It had been heard unofficially that the new Government would confirm the sanctions given by the previous Government and that Rs. 50 Lakhs would be allotted for expenditure up to the 31st March, 1948, but this allotment did not reach Southern Command in sufficiently concrete form for expenditure to be incurred until 5th November.

In the meantime during September and October the last Rs. 41,000 of the Rs. 5 Lakhs of Phase I were spent on reconditioning single officers' accommodation including the officers' mess. A few T.G. Sheds were in course of erection on a "no cost basis" by 624 Army Gp. Engineers. These were for storage of equipment and were part of Phase II, but no floors or racks could be provided until Phase II money was forthcoming.

The accommodation available in September was :—

(i) Hutted office accommodation—just adequate.
(ii) Hutted barracks for 200 men (remainder to be in tents till Phase III).
(iii) 89 Single Officers and Officers' Mess Quarters under repairs and renewals.
(iv) Inadequate temporary storage accommodation.
(v) Temporary classrooms for C.E. and F.E. Wings awaiting money for their necessary alterations.

There were no married quarters for officers, I.O.Rs. or civilians on the establishment and none obtainable in Kirkee or Poona. In fact, the married personnel of the S.M.E. were definitely " not wanted " by the local sub-area, who had told A.H.Q. as much. It was evidently accepted that all the married quarters the S.M.E. could expect would be provided by the project itself, which unfortunately was already six months behind schedule.

The Completion of the Move

The S.M.E. remained split from August to December with the Asst. Comdt. in charge at Roorkee endeavouring to complete the move and the Advance Party slowly building up in strength, unloading equipment as it arrived, and preparing the existing accommodation for the arrival of the main body. After the two major interruptions in traffic due to the Punjab riots and the floods, the flow of wagons was resumed. A party about one hundred strong with four officers left Roorkee on 19th September and arrived in Kirkee on the 22nd, Headquarters remained in the North. The main body which had been planned to move on 7th October did not obtain a train till 2nd December. On 2nd November all non-volunteer British Officers left Roorkee for Deolali to join their boats. This included the Asst. Comdt., Q.M. and many other key Officers for whom there was no replacement.

The O.C. Civil Engineering Wing was now left in command at Roorkee and continued the battle to get a train. Eventually, after many false starts, the main body left Roorkee on 2nd December and arrived in Kirkee on 5th December. This left a road convoy to follow, which arrived on 20th December.

The state of the S.M.E. staff was now precarious. The Commandant, Dep. Comdt., Asst. Comdt., O.C. E. & M. Wing had all gone without a handover and the officer strength was sixteen out of an establishment of forty-seven, and many of these were due for release. The writer, who now became Officiating Commandant, had been given the task of resuming instruction in the Field Engineering Wing on the 1st January and the Civil Engineering Wing on 1st April.

Progress of Phase II of the S.M.E. Project

The first allotment of funds for Phase II of this project eventually arrived on 5th November, 1947. Some contracts went out to tender at once and synchronizing with the arrival of the main body from Roorkee the first sod of the E. & M. Wing workshops was turned on 3rd December.

Owing to the lateness of the allotment of funds, it was difficult to spend all the money in the remaining three months of the year. However, this was accomplished by pushing through the purchase of all the land to be acquired which absorbed Rs. 27 Lakhs, and by purchasing stores, in addition to expenditure on the commencement of five contracts, viz. :—

(1) E. & M. Wing workshops.
(2) 29 V.C.Os. Married Quarters.
(3) 56 I.O.Rs. Married Quarters.
(4) Completion of T.E.O's. stores and construction of stores on the Bridging Hard and Explosive stores.
(5) Construction of the F.E. Wing Main Block and
(6) Some external services.

Resumption of Courses of Instruction

As already mentioned, in the original plan for the move of the S.M.E. it was intended to start instruction in the F.E. Wing on 1st January, 1948, in the Civil Engineering Wing on the 1st April and in the new E. & M. Wing by the 1st June.

By October, 1947, it was evident that the state of equipment and accommodation were adequate to expect to start the first two wings up to time, but the critical factors were the timely posting of the requisite staff and the punctual arrival of the main body of the S.M.E.

The E. & M. Wing was a different problem altogether. There was nothing on the ground. The allotment of funds for Phase II of the project was still in the balance and in addition most of our machinery and equipment had been left *in situ* at the Thomason College and replacements had been planned from E.S.Ds. Unfortunately all the Static machinery in the country was in the Mayo Road Depot in Lahore and it was impossible to issue any of this until adjustment had been made between India and Pakistan. It was therefore impossible to give a firm date for starting E. & M. Instruction.

The position as regards staff remained acute and it was rendered more so by the commencement of operations in Kashmir. India had asked for twelve volunteers from the U.K. to fill certain instructors' appointments at the S.M.E. for one year or three years. A few of these were filled by officers already in India, but there were no fresh offers from the U.K. In addition there were many civilian professors' and lecturers' vacancies to fill in the Civil and E. & M. Wings.

Eventually sufficient instructors were posted in time to start an R.I.E., V.C.O's. and N.C.O's. F.E. Course on 16th February, only six weeks behind schedule, closely followed by an All Arms Officers' F.E. Course. Even then the Depot Wing and Headquarters were woefully shorthanded at a time when extra work was required in those departments to reorganize the stores, train new permanent staff and generally to remake the new S.M.E. and the necessary amenities. Not the least of our worries was finding married quarters for all categories of permanent staff in Poona, Kirkee and Dighi, which were seven, three-and-a-half and three miles away respectively. However, the F.E. Wing was now functioning and the Civil Engineering Wing was also approaching working order. In fact it would have been possible to start some courses for M.E.S. Personnel on 1st April as planned, if candidates had been forthcoming.

The 1948–49 Budget

The Defence Department in India was much in the limelight when the first Indian Budget was published because it appeared that it was responsible for seventy-five per cent of the Central Government's expenditure. The immediate result as far as the S.M.E. was concerned was a visit from the Commander-in-Chief closely followed by the Army Standing Establishments Committee.

The S.M.E. had been on an interim establishment for several years and a proposed Peace Establishment was submitted in the middle of April for introduction by the 1st July, 1948. The Establishment committee came to examine this. At the time of writing the fate of both the Peace Establishment and Phase III was in the balance.

As a result of the C.-in-C's. visit on 15th April, Phase III was divided into two parts. Roughly those essential items which remained to be constructed over and above Phase II were in the first part, and the items which were needed to replace temporary hutting formed the second part. It is hoped that both parts will survive. The planning of the new S.M.E. had been thorough, on an adequate though not over-generous scale. It is the first project of any magnitude to be carried out in India since the war, and it would be a great pity if it is not completed according to the original planning. As it is, the Transportation Training Wing has been temporarily shelved by the Defence Department.

Present Situation

At the time of writing—early June, 1948—the first batch of twenty-six I.E.M.E., Y.Os. had just arrived for their basic engineering course and they were to be followed by a similar number of R.I.E., Y.Os. on 16th June. Both courses are roughly two years and each syllabus coincides to a large degree. A Supplementary course of R.I.E. officers was to commence in September lasting ten months. After two years it was expected that the S.M.E. will be teaching 250 officer students and in addition many M.E.S. and a few other rank students.

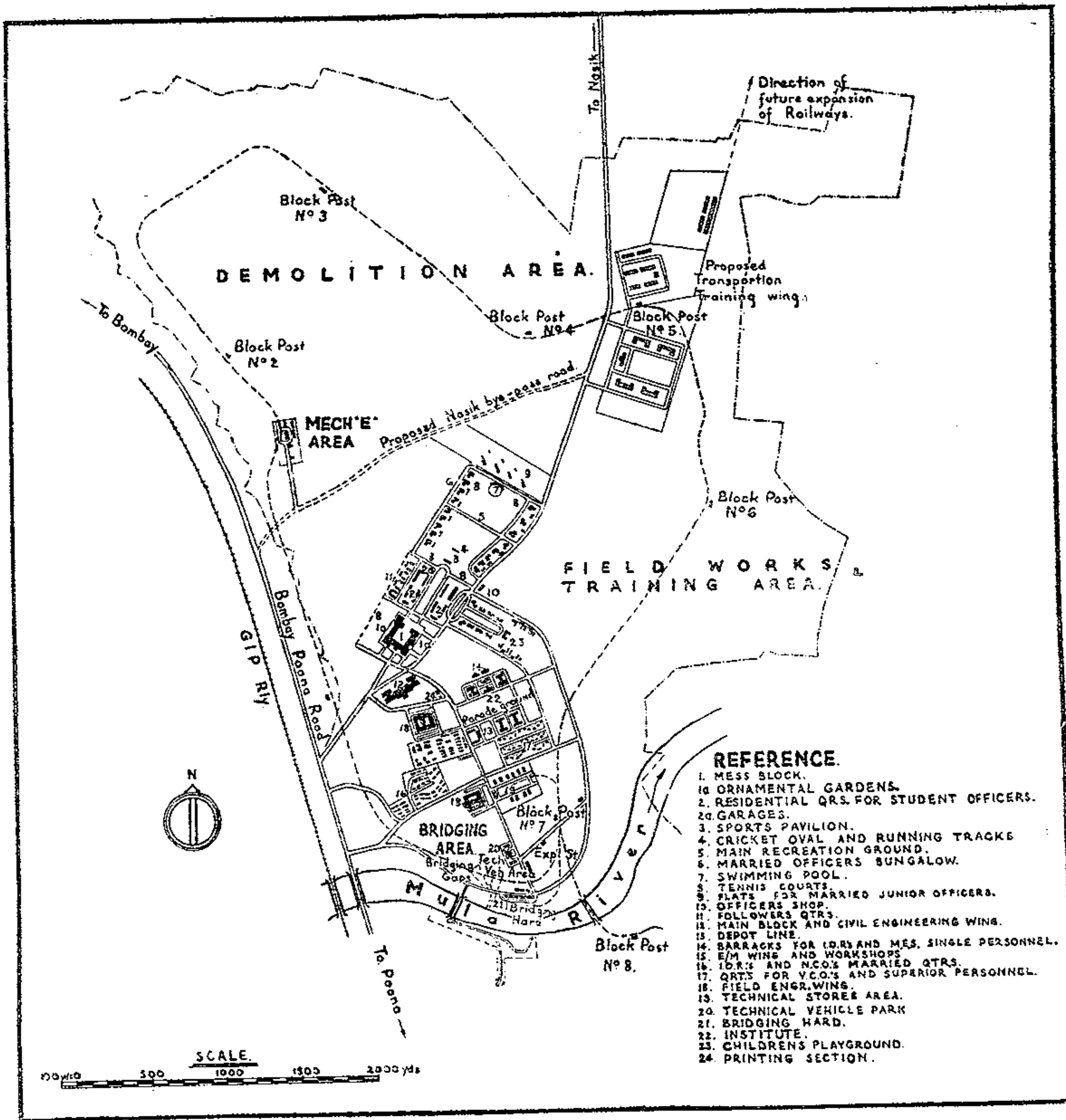
The new Workshops were to be completed by October and the E. & M. main block some six months later. The F.E. Block should be completed by Christmas. The Civil Engineering Wing was creditably improvised in temporary hutments. Some married quarters for V.C.Os., I.O.Rs., and subordinate civilian staff were to be completed by September. Unfortunately no married officers' quarters were then under construction, but six bungalows and twenty flats should be completed by next June.

Amenities are few at present. Hockey and football grounds have been constructed, but more are required. Squash and tennis courts and cricket grounds are included in Phase III. In the meantime the S.M.E. are building three tennis courts with their own resources. A swimming pool is also included in Phase III, but this at present is a mere dream of the future.

The brightest spot is a Sailing Club which is rapidly becoming popular. The School acquired four Dublin Water Wagtails from the old Royal Connaught Yacht Club when it sold up in late 1947. These boats are now in daily use on the "Home" reach of the S.M.E. near Harris Bridge. It is hoped to acquire more of these boats from the Gunners at Kharakvasla Lake, who are moving to make room for the National War Academy. The S.M.E. recently took three crews to Kharakvasla to race against three Gunners crews and they were the first three to pass the finishing line.

Conclusion

The S.M.E. in India has survived a very severe transplanting in a time of extreme financial drought. The first shower of rupees which fell on 5th November, 1947, just saved its life. There was also just sufficient continuity amongst the members of its staff to allow its growth from the same roots. It has now taken firm hold and is growing well, but it needs to be provided with the best instructors India can produce. If it receives its full allotment of funds to complete it to its original plan, it will be a great asset to India. It is a magnificent site and is capable of endless development.



PROPOSED LAYOUT FOR S.M.E. AT KIRKEE.

ADVERTISING THE CORPS

By MAJOR-GENERAL H. L. PRITCHARD, C.B., C.M.G., D.S.O.

AN anonymous writer calling himself "Chiliarch" has contributed, under the above heading, an exceedingly well thought-out and interesting article on this subject to the December number of the *R.E. Journal*. May I be allowed to make a very few remarks on this article.

"Chiliarch" tells us that, "a very senior, distinguished and successful commander," on two occasions paid the Corps a wonderful compliment on their achievements in war and chided us for not advertising ourselves enough. "Chiliarch" then proceeds to give absolutely unanswerable arguments for the C.R.E. of a division in war holding the rank of temporary full colonel. Later on in his article he refers to the subject of advertisement. I would like to refer to these two points, namely, the C.R.E. of a division being a temporary full colonel in war, and secondly to advertising.

As I have said one cannot improve upon his arguments for the C.R.E. of a division being a temporary full colonel in war, but in carrying out that recommendation one must beware of a few pitfalls. Two world wars have conclusively proved the necessity for youth or comparative youth in various appointments in war.

In the second world war perhaps even younger men were appointed than in the first world war to posts as company commander, battalion commander, brigade commander, divisional commander and to analogous appointments in all arms of the service. Of course the limit of youth increased as each step in rank was reached, but all were comparatively young for their appointments. The same must, of course, apply to the C.R.E. of a division. One can remember the spectacle of a man full of ripe experience and sound judgment completely out of action in war owing to his age having failed to stand the strain of the pace and physical and nervous exhaustion. Secondly, the normal age of a lieut.-colonel, who is at present a C.R.E. of a division in peace, may be considered as the upper limit of age for that appointment in war. It would therefore, not be wise to take existing full colonels in peace and appoint them to Cs.R.E. of divisions in war. On the contrary if existing lieut.-colonels in peace, who are Cs.R.E. of divisions, should be immediately upgraded to temporary full colonel even then war may perhaps soon weed out a few of them.

It might be very difficult and might meet treasury opposition to give temporary rank of full colonel to lieut.-colonels in peace, but provided we secure the temporary rank immediately on the outbreak of war, it is doubtful whether we should press for the temporary rank in peace. In considering a career in the army one must consider the average period a man serves in war and in peace. One must give a proportion of officers a reasonable chance of serving for forty years and reaching a very senior rank. A large number of men at the age of sixty, of forty years' service, have served in two world wars but even so they have only done ten years of war and thirty years of peace. During peace there are positive advantages in having men of ripe experience and sound judgment in all ranks, the older ones can stand the strain of peace but not of war. That is why I say that peace-time full colonels should not be appointed as Cs.R.E. of divisions, but such appointments should be filled from peace-time lieut.-colonels.

Now as to the subject of advertising the Corps. I imagine that the very senior, distinguished and successful commander used the word, "advertising," because he wished to express in one word the necessity for educating commanders and staffs and officers in other branches of the Army in the achievements of the Corps of Royal Engineers and their methods of accomplishing those achievements, their organization and system of command and administration and training.

I submit that the Corps has played its part in such education by telling the story of its achievements and how they did them and it remains for commanders and staffs and officers of other arms to play their part in studying the history that has been written and the methods employed. For many years now the *R.E. Journal* has been a first-class production. It is read by several civil engineers with great interest and also by men who have been Territorial or temporary R.E. The article entitled, "Seven Bridges," in the December, 1948, number is an outstanding description of the achievements of the Corps. But how many, if any, commanders, staff officers and officers of other branches read it? Volumes of history have been written, e.g., *The Military Engineer in India*, *The Indian Sappers and Miners*, *The R.E. in Egypt and the Sudan*, *The History of the Corps of Royal Engineers*, in three volumes, from 1066 to 1914 and *The History of the Corps* 1914–37, which is about to be published in three volumes. The *History of the Royal Engineers* in the war 1939–45, is also being written (it will be a marvellous record). Many R.E. officers have produced other books and writings telling of the achievements of the Corps and how they were done. The story of such achievements and the method of accomplishing them has been fully and on the whole not badly told. The story itself stands out as a wonderful one as the very senior, distinguished and successful commander has most handsomely admitted. I say, therefore, that the R.E. have played their part in providing the material for education and that it is up to the other officers of the Army to do their part in studying how to make the best use of the R.E. for the benefit of the whole Army.

I respectfully submit that it is in the power of the C.I.G.S. to ensure that commanders and staff officers, in particular, and some officers of other branches study the accounts which the R.E. have written of their achievements, their organization and methods of command and administration and training. It would be presumptuous of the author of these remarks to presume to advise the C.I.G.S. upon this matter, though he believes that several R.E. senior officers could make valuable suggestions to him on that point, if he wishes to receive them.

EDITOR'S NOTE

Lieut.-Col. M. C. A. Henniker, D.S.O., O.B.E., M.C., R.E., has requested that it be made known that he is not the author of the original article, as many officers have written to him on the assumption that he is.

THE RIGHT TYPE OF R.E. OFFICER AND HOW TO GET HIM

By " CENTURION "

I HAVE much appreciated the articles which have appeared under the title " The Right Type of R.E. Officer." Apart from anything else, they have helped me to sort and focus ideas which have been in my own mind. I do not suppose that my conclusions will be universally palatable but I should like to give them, as briefly as I can.

Nowadays no one can hope to have an expert knowledge in all the fields of Sapper activity. The tendency is for each field to become more and more complicated and hence to demand a high degree of specialization for its mastery. The Corps must have its experts and it becomes increasingly necessary for them to devote all their energies to mastering but a limited part of the realm of Sapper work. We must accept that in future the expert, if he really is to be an expert, cannot be expected to be an all-rounder as well, a point which will be amplified later.

Equally with the expert, we must have the jack-of-all-trades who must have sufficient knowledge in all fields to be able to use the experts. This, by the way, is not merely a pious hope—it can and must be done, or there would never be a fully competent Chief Engineer! The tendency is for the expert, whom I take leave to nickname " Percy," to become more and more a consultant, while the jack-of-all-trades, " Jack," remains the executant, in a manner of which I will give an illustration.

A formation, such as a Corps, can be likened to a large firm having its own engineer (the C.E.). The firm may decide to build its own airfield, and the engineer, not being a specialist in airfields, makes use of a consultant (the S.O.R.E. Airfields) who produces working plans and specifications. The job is then given to contractors (say a field regiment) who carry out the work in accordance with the plans, etc., given them. The contractor himself (the C.R.E., Field Regiment) is not required to produce designs involving *detailed* technical knowledge, though he must, of course, be able to understand the specifications sufficiently to ensure that the completed work conforms to them. He must have, in fact, a broad engineering knowledge and the ability to organize and command, in its widest sense, his resources.

Similarly, if the firm want to build a sewage works or expand their power station they will again put the matter in the hands of their engineer who will, no doubt, again use the appropriate consultant. He may often, however, use the same contractors as before ; in fact he should very seldom need to look further than to a general utility-contractor, but I do not propose to enter here into the question of specialized contractors (i.e., specialized units).

These examples of the general system could be multiplied many times and they add up to this—that we require two types of officer, Percy and Jack. The function of Percy is to plan, design and advise, while Jack commands the resources in men, machines and materials and gets the work done. Percy, be it noted, commands, at most, a small office staff and maybe a recce party.

Here it is unfortunately necessary to expand a little on the subject of command since I fear it is not always seen in the right perspective. It cannot be assumed—as unfortunately it is far too generally assumed—that anyone can command solely by virtue of being an officer, or even by virtue of being a regular officer. It is very far from being as easy as that ; there is a technique of command just as much as there is a technique of doing anything else worth while. It is compounded of many things including enthusiasm, determination, tolerance and a genuine interest in human beings, and it requires a mind which is sensitive to, and receptive of, the day to day human experiences of life. Because some people command well the fatal mistake is often made of assuming that it must be simple. It is curious that this should be so, because the same people who make it do not fall into the error of assuming that perfection of performance in other directions is due to the fact that there is nothing difficult in achieving it. An analogy can be drawn between the function of command and mountaineering. The mountaineer must first have the basic qualities and love ("liking" is too weak a word) for that pursuit but does not expect these alone to bring him success. We also do not expect him to be even a merely competent performer until he has trained himself in mind and body and learnt a wealth of mountain lore. He will not conquer a difficult peak until he has scaled smaller ones, learning all the time and spending many an evening thinking over the day's experiences so as to improve his technique. Good mountaineers, even potential ones, are comparatively rare, and we need not expect all officers to be first-class commanders.

Now the "system" of Percys and Jacks is already very widely applied, and I believe we can and should make it of general application, and that every officer should become, at a comparatively early stage in his career, either a Percy or a Jack. A prospective Percy, when, say, a junior captain, should be told : "You will never be expected to be a regimental commander. You are more cut out to be an expert in such-and-such a field (or fields). You will be given opportunity to learn all there is to know about it, and subsequently you will have to keep your knowledge up to date." A prospective Jack, on the other hand, will be told: "You will not be expected to know all the details in any field but you must have a wide engineering knowledge and unlimited 'engineering horse-sense.' In addition you must make yourself into a first-class regimental commander. You will be given the necessary opportunities."

The idea of so clear-cut a distinction between Percys and Jacks may upset some but it is, I am convinced, the only way by which we will acquire experts who really are experts, and Commanders, R.E., who are thoroughly competent.

In passing let me say that I view with suspicion the expression "Jack of all trades and master of ONE." He need not be master of any in the sense implied if he can use the appropriate Percy. Let the missing "N" be restored, for only so will Jack preserve a really balanced view—and he will need it because it is "Jack," not "Percy," who must be at the top. (I am reminded of the sad story of a subaltern who received a long-awaited visit from a senior officer from whom he hoped to obtain much needed help, and even, perhaps, some encouragement. Alas, the first thing they encountered was a smoking fireplace and all he actually obtained was an hour's dissertation on fireplaces; all aspects, historical, constructional and even artistic, were dealt with.)

The excellent article by "That Ould Brigader" as well as dealing with the right type of R.E. Officer also touched on how to get him, and since the answer to the latter is as vital as that to the former I also propose to say something about it. How are we in fact to attract both Percys and Jacks ?

It is hardly necessary to say that the recruitment of officers to the Corps is governed by the general status of the Corps in the eyes of the Army and the world in general, a subject on which I need say no more than that I agree with every word written by "Chiliarch" in his article "Advertising the Corps." There are, however, some particular points which I would mention.

Let us consider Percy first, as on the face of it his prospects seem not so encouraging. He can never be a C.R.E. (reserving that term, as it should be, for a regimental commander) or a C.E. He might easily, however, reach Colonel, S.O.R.E., and I do not think he should expect to become a General or even a Brigadier. He will, however, have compensations (e.g., good chances of a technical civil job on retirement), and thorough specialization at an early age would attract those with appropriate bents. We all know the officer who is highly technically-minded but perhaps not very effective with troops, such as one I knew who confessed he was " not interested in men, only in metals." I am not suggesting that one with a real talent for command cannot also have a strong technical bent, though I do think that the former is sufficiently rare to make the owner's best employment, in the interests of the Corps, a " Jack." However, the point is that, in my opinion, specialised employment (without the strains as well as the joys of command) is nowadays sufficiently attractive to provide an adequate supply of Percys. Further, it should be noted that certain bents can, within the Army, only be exercised by joining the Corps ; we are not in such instances competing for candidates with other arms.

Jack, though superficially better placed, is in fact, much more difficult to attract. He has to be finally two things, a general-utility engineer and also an able regimental commander, and he was told " make yourself " the latter in order that he should have no illusions about the effort and hard thinking required. Now, anyone who feels the urge to become a commander may hesitate, even though he may have a taste for engineering, before he embarks on so formidable a task as becoming a Sapper commander. He may well ask himself whether he would not do better in an arm where by becoming a commander only he might rise both further and faster. I think that if he could assess the units of " talent-effort " demanded of a C.R.E., as compared with a similar assessment for a contemporary Brigadier of another arm he would certainly ask that question.

I have two suggestions to offer concerning the attraction of Jacks, the prospective Commanders, R.E.

(*a*) Their promotion prospects must be improved *vis-à-vis* their contemporaries in other arms, and in this connexion I cannot possibly do better than refer again to what " Chiliarch " wrote about the rank of C.R.E.

(*b*) Corps pay is essential, and this goes for Percys too. To be a fully competent Sapper, either a Percy or a Jack, does require a more than usually able and resilient brain, and the owners of such " goods " need its recognition by tangible reward. If it is not to be had they may be expected to go to some other market where, even if payment offered is the same, their goods are more easily marketed.

In making these suggestions I am not taking a purely Corps point of view ; I can qualify them with the words : ". . . if the Army is to expect the same standard of service from its Sappers as it enjoyed in the past."

I finish with an assurance that the views which I express are not merely those of a " needy knife- (or axe-) grinder." Such a pseudonym would be inappropriate, and I have chosen one which I hope " Chiliarch " will take as a compliment.

THE ORDNANCE SURVEY IN THE NEAR EAST

By Lieut.-Colonel H. E. M. Newman, R.E.

Part I

IT is common knowledge that officers and men of the Ordnance Survey have served professionally outside Great Britain in many of the British Dependencies. In these circumstances the department is not normally responsible for the work executed, nor for the publication of any map resulting from the work. It may therefore be of interest to recount the story of two of the rare instances in which the Ordnance Survey was responsible for a party of surveyors working outside Great Britain, and for the publication of the resultant map, particularly in view of the fact that the parties were sent to work on foreign soil. The surveys in question were of Jerusalem and Sinai, the former of which throughout the nineteenth century lay within the sovereignty of the Sultan of Turkey. The accounts which follow are derived from a research carried out between the wars using the official files and some private correspondence which were amongst the archives of the Department.

1. Jerusalem (1864–5)

The survey of Jerusalem originated officially in a petition from Dean Stanley of Westminster, representing a Committee which included the Bishop of London, to Lord de Grey and Ripon, the Secretary of State for War, on 15th April, 1864. It might have been supposed that Archaeology and Biblical History would alone have justified such a survey, and it is surprising to discover these aspects rated as of secondary importance, especially since controversy had lately been rife concerning the topography of the city and the sites of Biblical events. The principal motives as outlined in the petition were water supply and drainage, their lack, and the impossibility of improvement until the provision of a survey such as had been found indispensable at home under similar circumstances. In spite of thus apparently treading on the toes of the Turkish authorities, inactive though they were, it was evidently considered politic in Victorian England to place cleanliness before godliness when courting official blessing, but, be that as it may, the interest subsequently developed was almost entirely scientific.

Colonel Sir Henry James, then Director General, had estimated the cost of carrying out the proposals at £500 ; other amounts were suggested as from time to time the proposals were varied, but this was the sum decided upon and subscribed. At that time it was requested that the subscriber's identity should remain " a profound secret." Two years later, when the Preface to the Notes on the survey was being compiled, the Secretary of the Palestine Exploration Fund, Mr. G. Grove, wrote asking that mention in it might be made of the share which that Association had had in the survey, and that the money had been given by Miss Burdett Coutts at the instance of a leading member of the Committee.

At first there was no mention of an officer. Then the Horse Guards insisted that one should be sent, but to this the War Office no more than agreed that "there may be an engineer officer who would like to undertake this interesting work without remuneration getting leave to travel." In the final event the officer was allowed two months of each of the financial years covered by his absence to count as ordinary leave on full pay. The rest of the time he received only regimental pay from the War Office, while the men's pay was charged as a repayment service to the survey as well as the engraving and other work done. Captain Parsons, R.E., was first approached, but, being disinclined to incur the expenditure involved, this officer proposed Lieut. C. W. Wilson, R.E., a senior subaltern of judgment and discretion, who had spent four years on the American Boundary Commission, and who possessed a taste for archaeological pursuits. Wilson, who later became Colonel Sir Charles Wilson, Director General of the Ordnance Survey, accepted the appointment.

Provision for an officer did not appear in the first estimate of £500, and the threatened increase in expense which this might have entailed bred a certain amount of ill feeling. Mr. James Fergusson, a member of the originating committee, had given lectures at the Royal Institution and written books challenging most of the traditional sites in Jerusalem, and many people had adopted his opinions. According to Sir Henry James these were due to his ignorance of Saracenic architecture, to acceptance of dimensions given by Josephus in his History of the Jews which had been transcribed faultily into more modern units, and to an ambition to be original in his views. Although Sir Henry James contrived that Wilson and Fergusson should meet and discuss these matters, yet he was persistent in cautioning Wilson to preserve an unbiased mind in drawing his conclusions both before the party sailed and later when Fergusson himself went to Jerusalem. To return to the point, Fergusson was perturbed that the committee's money should be under the direct control of the Director General, particularly on account of the latter's refusal to guarantee that the £500 would not be exceeded. Probably dismay that the committee should lose control of the survey and men as well as the money added to an exasperation which became manifest very soon afterwards. Sir Henry's reasoned reply that the conditions and cost of living in Jerusalem being an unknown quantity, and no sound basis for his estimate, was sufficiently convincing to persuade the Dean to give Lord de Grey a written guarantee for any excess incurred, but, just a month before the party was due to sail, Sir Henry wrote again to Fergusson asking him what concessions the P. & O. had granted for the passages of the five or six sappers, and requesting that the £500 should be placed by Dean Stanley to the credit of the Executive Officer's (Colonel Cameron) personal account at Messrs. Cox and Co. This provoked an immediate antagonism. A minor reason was that, in addition to the appointment of an officer, the sappers should be also augmented from four to five or six. The Director General maintained that he was responsible under orders from Lord de Grey for the work of the survey but declined to guarantee its cost, so that we have Fergusson on the one hand refusing to concede complete financial control, and the Director General on the other hand threatening eventually to forbid the party to sail unless complete technical, economic, and administrative command were given him. The Dean was away at Lausanne. The Director General submitted an official draft for the Secretary of State's signature requesting the Dean to pay over the money, and at last on 24th August, Sir Henry wrote to Fergusson to say that all outstanding matters were settled, and to ask him for any special points for inclusion in the final instructions for the survey. The reply from Fergusson curtly expressed his disinclination to interfere, unaware as he was of the way matters had been settled without his assent. Nevertheless, a copy of the original prospectus on which the subscription was raised arrived from him on 9th September, three days before the party was due to sail, which date was governed by the consideration that October would be a reasonably cool month to begin the work, which it was hoped would easily be finished before the next hot weather began.

Preliminary arrangements included correspondence with the Turkish Government to provide protection and assistance, and with the British Consuls in Jaffa and Jerusalem to prepare accommodation and for the hiring of such labour as might be required. Negotiations with the P. & O. obtained concessional rates for the party ; the single fares from Southampton to Alexandria being granted at £10 per head. Details of former surveys were collected, including maps from the Hydrographer at the Admiralty, one by Pierotti, one by Van de Velde, and a survey made by Lieut. Symonds in 1841. The only item of stores which appears specially to have been purchased was a small barometer from Negretti, graduated in feet as well as in inches, to measure down to a depression of 1,500 ft. for comparing the Dead Sea and Mediterranean levels.

The party which left Southampton on 12th September consisted of :— Captain C. W. Wilson, R.E. (promoted since his original appointment) ; Sergt. J. McDonald, R.E. ; L/Cpl. F. Ferris, R.E. ; L/Cpl. J. McKeith, R.E. ; Sapper J. Davison, R.E. ; Sapper T. Wishart, R.E.

Their instructions are summarized as follows :—

1. Two styles of maps were required ; one on a scale of 1/2,500 was to be contoured at 10 ft. vertical intervals covering an area measuring 1½ miles from north to south and 1 mile from east to west, to include the city ; the second at a scale of 1/10,000 to extend 3 miles north and south and 2½ miles east and west with levels along the principal valleys and heights.

2. The plan of the city was to be a block plan, except for public buildings which, outside and inside where permitted, were to be surveyed with as much detail as possible and plotted on the 1/500 scale.

3. The base line was to be ½ to ¾-mile long, measured three times with a standard chain which was to be checked between reference marks laid down on the ground with a levelling staff, and a suitably level site for the base, it was suggested, might lie to the north of the city.

4. The triangulation was to cover the whole area, with the city's principal minarets and domes intersected.

5. A bench mark, to be cut at or near the Fountain of Nehemiah, was to be the datum for the system of levels, and an aneroid reconnaissance was to decide whether this should be arbitrarily called 100 or 200 ft. Bench marks were to be cut at the corners of the city walls, at the city gates, and on churches and other public buildings where permitted. The summit levels in the city and of the surrounding hills were to be accurately determined.

6. Although not specified in the Committee's requirements, it was highly desirable if time would allow to cover the whole area surveyed with contours at 25 or even 50-ft. vertical intervals.

7. The whole area required was to be plotted on the 1/2,500 scale in six sheets and then reduced to 1/10,000.

8. A table giving the Pole Star's position at greatest elongation at eight-day intervals was supplied for the determination of an azimuth, which was then to be used to determine the local magnetic variation by prismatic compass.

9. A skeleton plan on thick paper on the 1/10,000 scale was to be made and on it were to be accurately sketched the topographical features.

10. The dip and strike of the sedimentary rocks were to be plotted on a tracing and two geological sections across the city given on the 1/10,000 scale. Every strata bed was to be measured and numbered and its composition stated, and a specimen of each together with any fossils discovered were to be brought home.

11. A suggestion was made that some official at Jaffa might be found who would undertake barometric readings, thrice daily, so to determine by a series of simultaneous observations in Jerusalem and at the Dead Sea an approximate figure for their comparative heights.

12. For archaeological purposes the ground north of the city was to be examined for ruins of ancient walls, and, in the city, buildings were to be examined for possible remains of pre-existing buildings.

13. Quite independently from the survey a series of photographs of the principal buildings was to be taken. The Director General undertook to pay the cost of the chemicals himself should the survey estimate be exceeded.

14. The party was to be in a position to return to Southampton not later than the end of February, 1865, and every endeavour was to be made to finish even sooner than that.

15. Details were given regarding pay and accounts, statements of which, as well as progress reports, had to be sent home fortnightly. There were warnings against offending the prejudices of the several religious sects to be found in the city, against the men exposing themselves to night dews, or to sunshine without their muslin cap covers, or to working without previously "taking some coffee and bread or biscuit," and lastly a prevision that further funds might eventually be subscribed to enable a line of levels to be run from Jaffa to the Dead Sea.

The party reached Alexandria on the morning of 26th September, just missing the French boat to Jaffa, but they benefited by being allowed to remain the next three days on their old ship the S.S. *Ripon*, which was detained in port, avoiding thereby the high cost of living on shore. The Austrian vessel on which they embarked on the 29th was delayed by the strength of an adverse sirocco so that they did not arrive at Jaffa till after sunset on the 30th. Consequently the excellent intention of making Ramleh on the day of landing was frustrated, and Wilson, finding the Consul absent, eventually met a German who took the party to the Latin Convent where they were given shelter for the night. The next evening, Saturday, they were entertained at another Latin Convent at Ramleh, but they had found the march over the plains so hot that they lay quietly all Sunday and accomplished the final ten-hour stage to Jerusalem by night. They were fortunate in their accommodation. Through the kindness of the Prussian Consul they were enabled to hire three rooms, one for Wilson, one for the men, and one as an office, at the Prussian Hospice, which, being a government institution, provided them with a living at about 2s. 0d. a day as opposed to what would have been 6s. 0d. a day outside.

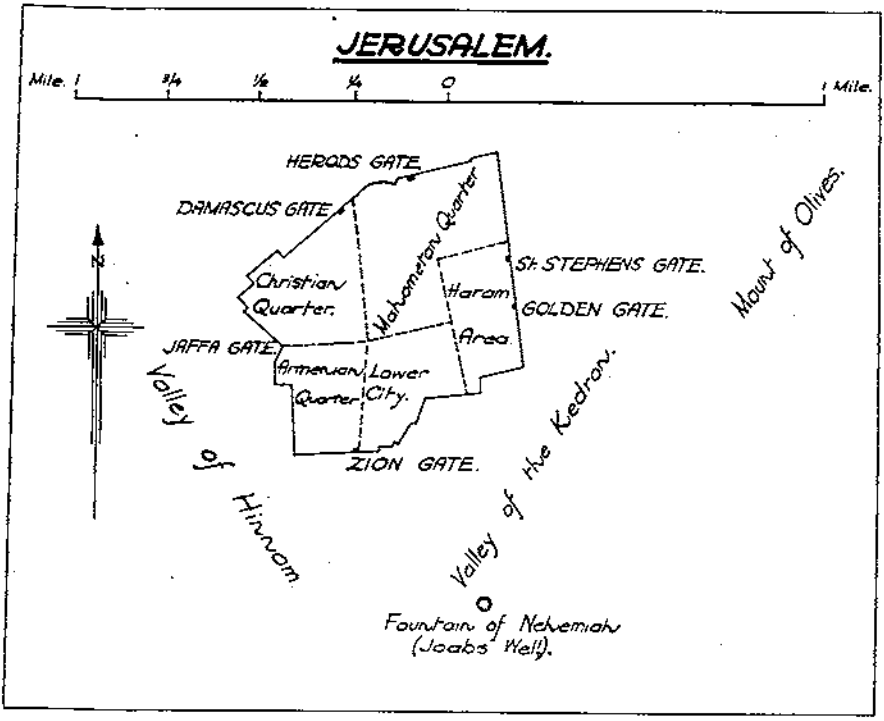
The men found the physical exercise very hard after life at Southampton. The most salient features of their new surroundings were the still great heat and the rough rocky nature of the countryside, to which the pre-existing plans of the city's environs gave no clue. These plans represented the town area itself very fairly, although Pierotti's came in for severe criticism when the archaeological exploration of subterranean passages came to be made.

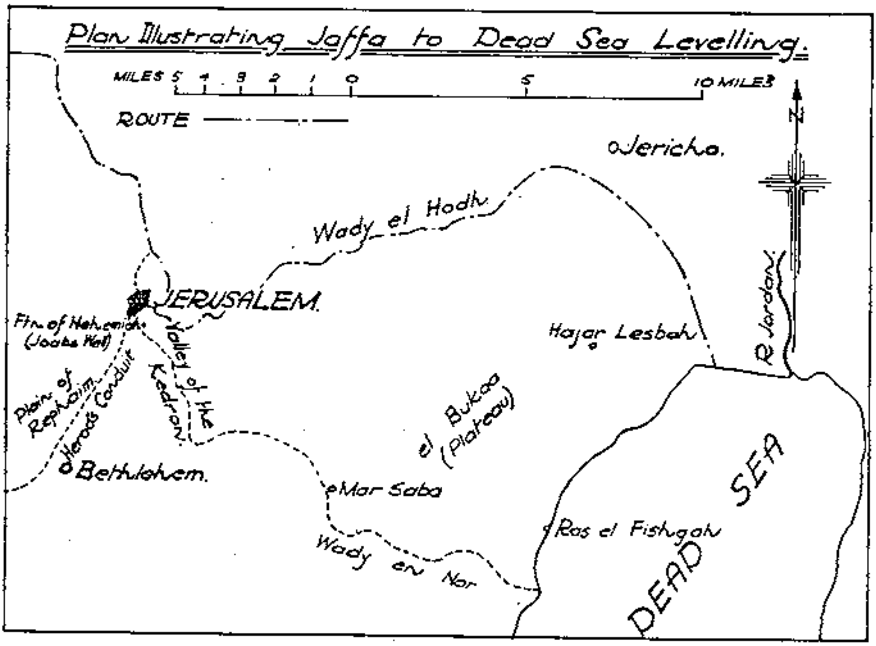
The roads were mere bridle paths winding up the dry beds of watercourses or around the spurs of the hills. The valleys were filled with loose stones from what, before the breaking up of the country, had been walls separating fields and vineyards. The city itself was indescribably filthy. There was no sanitation. Mosquitoes, fleas and vermin of all sorts made night horrible. There was some difficulty in procuring timber for poles, owing to there being none in the country but what came from Trieste. They had to pay a fabulous sum for their drawing table. Wilson found Izzet Pasha, the Turkish Governor, very civilly disposed ; and that he was willing to do his utmost to further the progress of the survey, but it was necessary to proceed with tact and care for it was impossible at the beginning of the work to know how the various classes of the inhabitants would react to the constant trespass.

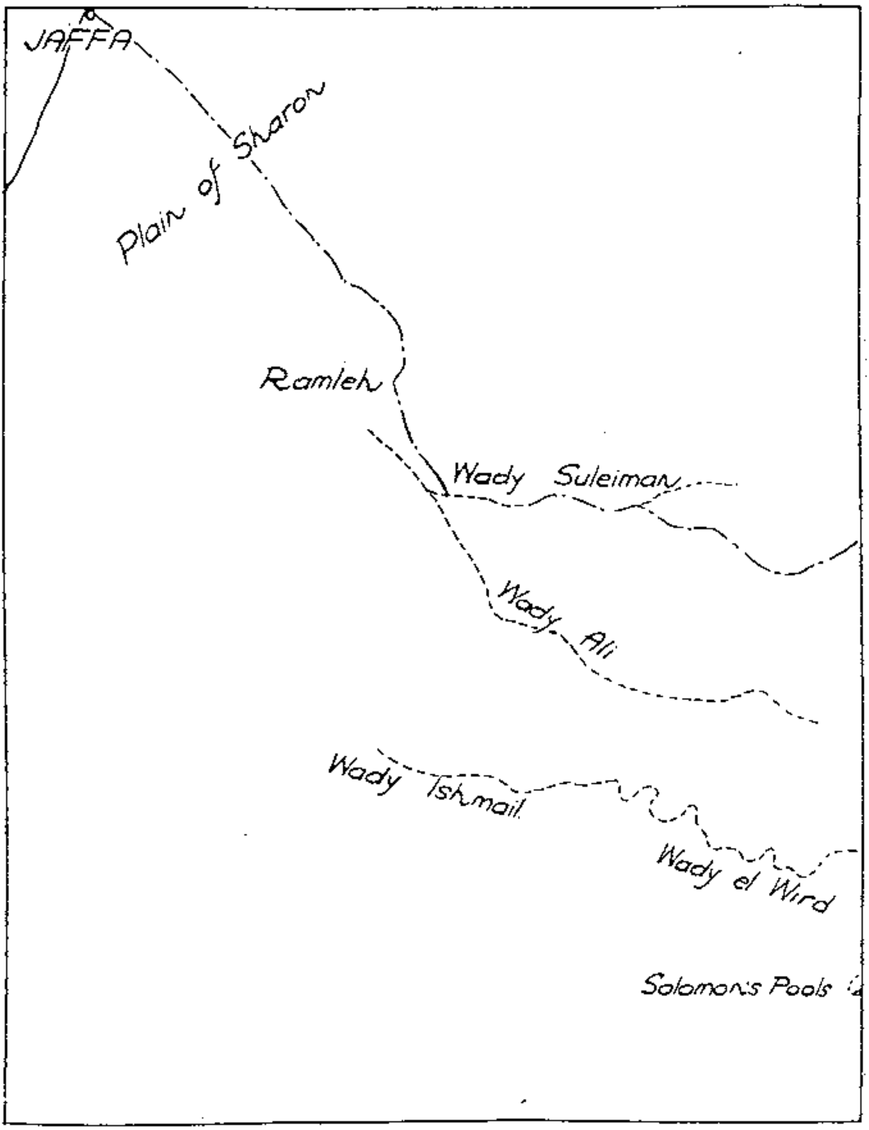
By 13th October a base had been measured north-west of the town, although no subsequent use was made of it, for, in the published Notes on the Survey, it is recorded that the ground on this side was too rough and timbered for such a purpose, and that "the base adopted for the calculations was measured on the Plain of Rephaim, to the south-west of the city." The three measurements of the finally accepted base chained to within half a link over a length of 3,875 ft. By then also, the whole area had been cut up into triangles, with posts erected at the various stations. On 14th October observations were due to begin and levelling on the day after that, when three of the triangles to the north of the city had already been surveyed. The angles of the triangulation were all measured with a 7-in. theodolite, and the chain survey of the whole area, which was plotted at Jerusalem so that tracings could be taken on to the ground for examination, had its longer and more difficult lines laid down with a 5-in. theodolite. A traverse survey was made of the city and Haram area with a 5-in. theodolite.

Labour was very expensive, especially where the knowledge of a little English was necessary. The labourers employed were Nubians and Arabs. The former came from a Moslem class living in poor houses attached to the mosques in the Haram, and they were particularly useful during the survey of that part of the city in reconciling the inmates of the Haram, always fanatically resentful of interference. Indeed an interpreter and police had to be engaged during its survey, but, actually, very little trouble occurred. Non-fanatical opinion suspected at first that "Perfidious Albion" was scheming again, and some feared that the survey was the harbinger of increased taxation. There was a reluctance amongst members of the Jewish community, living in that quarter called by Josephus the Lower City, to allow Wilson access to the interiors of their private houses. This was countered through the influence of Sir Moses Montefiore who wrote recommending and explaining the mission to the Natrum Baṣhi.

Towards the end of October Fergusson arrived at Jerusalem. According to Sir Henry James he had given out prior to his departure that the survey was under his direction and that he was going out to join it. He and Wilson explored quite a number of the celebrated localities, and the latter was, at any rate temporarily, converted to some unorthodox opinions. It does not appear that the bias long survived Fergusson's departure. The importance of his visit rather lies in the introduction it gave Wilson to the archaeological topography of the place, and in arousing a train of thought which led to many interesting investigations and discoveries all detailed at length in the published notes to the survey, and which in the end supplied abundant evidence in support of the authenticity of tradition. These investigations, many of them underground, Wilson carried out by himself to prevent taking the men away from the actual work of the survey.


JERUSALEM.
Mile. 1 3/4 1/2 1/4 0 1 Mile.
HERODS GATE.
DAMASCUS GATE.
Christian Quarter.
Mahometan Quarter
Haram Area.
St. STEPHENS GATE.
GOLDEN GATE.
Mount of Olives.
JAFFA GATE.
Armenian Quarter
Lower City.
ZION GATE.
Valley of Hinnom
Valley of the Kedron.
Fountain of Nehemiah (Joabs' Well).
N


Plan Illustrating Jaffa to Dead Sea Levelling.
MILES 5 4 3 2 1 0 5 10 MILES
ROUTE
Jericho.
Wady el Hodh
JERUSALEM.
Ftn. of Nehemiah (Joabs Well)
Valley of the Kedron.
Plain of Rephaim
Herods Conduit
Bethlehem.
Hajar Lesbah
R. Jordan.
el Bukaa (Plateau)
Mar Saba
Wady en Nar
Ras el Fishgah
DEAD SEA
N


JAFFA
Plain of Sharon
Ramleh
Wady Suleiman
Wady Ali
Wady Ishmail
Wady el Wird
Solomon's Pools

By November some rain had fallen, and the improvement in the climate made it no longer necessary to cease work in the middle of the day. But it caused an outbreak of fever in the city and Sapper Wishart was down for a day with a slight attack.

It was just about then that the first serious proposal arose, at the instance of the Royal Society, to run a line of levels between the Mediterranean and the Dead Sea. In addition it was mooted that pendulum observations should be made at each end of the line in order to provide data for the determination of the mean density of the earth. There was a pendulum apparatus at Kew available but a man would have to have been trained in that special class of work and sent out with it, and the Director General in view of the funds available, and of their purpose, believed from the first that nothing would come of it. However, so far as the levelling went this proposal initiated the project which was eventually carried through. Sir Henry James suggested that the Royal Society should approach the Lords of the Treasury, who in view of the exceptionally favourable moment, might very likely grant the necessary funds, but the Royal Society would make no move without the Government being previously sounded, lest they should incur a rebuff.

Wilson was considering the question too. On 2nd December he wrote outlining his proposals. He was somewhat despondent at the poor progress made by the survey, the country proving to be more rough and troublesome than at first supposed, and began to fear that from the £500 there would be none to spare for other purposes such as the line of levels. " For the latter operation we should require an escort of Bashis, tents, and a small train of mules to carry our luggage and water, of which there is little on the way." He strongly urged using two instruments simultaneously so that errors could be checked step by step instead of after a whole operation using one instrument levelling in both directions. The party would consist of the five sappers only, detailed as two observers, two stavemen and one chainman, providing thereby data for a section and sketch of the route. He was rash enough to guarantee the cost at less than £100, and proposed early March as the best time before the great rush of pilgrims, when dragomen and mules would be at a premium, and before the hot weather would have begun in earnest when the Dead Sea neighbourhood would have become stifling. A quick decision was essential in any case, in order that instruments could be dispatched to arrive before the survey finished.

Wilson's detailed estimate followed ten days later and his first guaranteed sum was doubled. He suggested two possible routes from Jerusalem to the Dead Sea ; the shorter by the Valley of the Kedron to Mar Saba and thence by El Bukaa to the Dead Sea near Hajar Lesbah ; the more " interesting " by the Wady el-Hodh to Jericho and thence to the mouth of the River Jordan, " which would also give me an opportunity of examining and sketching the ruins on the plains of Jericho "—certainly " interesting " but outside his official terms of reference. The time was estimated at twenty-one days, and the costs at £93 or £110, according to which route was used, to which should be added another £100 to cover the levelling from Jerusalem to Jaffa—say £200 in all. Dr. Zimpel, a German, had recently carried a line of levels from Jaffa to Jerusalem by the Wadies Ishmail and el-Wird, prospecting for a railway, but Wilson proposed going by either the Wady Ali or the Wady Suleiman.

The Director General had acted upon the original guarantee of £100, and had written on 27th December to Dr. Falconer, F.R.S., palaeontologist and former East India Company's servant, and to Lord Wrottesley, asking that the Royal Society, if it would devote this sum from the Government grant as Dr. Falconer had already hoped it might without difficulty, should place it to Colonel Cameron's account at the bank. On the 29th he had to write again to these gentlemen apologizing and doubling the amount and urging that they should write to the Treasury and say they were willing to pay half the cost when "the matter might still be arranged." He then wrote a letter to *The Times* purporting to be a progress report of the survey "for the information of those who had contributed to the fund" (precisely one individual), quoted extracts of Wilson's letters descriptive of his archaeological discoveries and announcing the urgent desirability of the levelling project. "The cost of this would be about £200, and I am not without hope that it may be obtained from some source." This letter provoked a great deal of interest and correspondence from the public. One outcome was an offer of the £200 from Messrs. Moxon & Co., publishers, "on the only and simple condition that we be allowed to publish Captain Wilson's history of his explorations." Wilson accepted the offer, provided the Director General approved, and provided the notes to be published were only those unconnected with the Jerusalem neighbourhood itself which were to be published as a companion to the plans. There is no record of this £200 being subscribed or used.

At the beginning of January, 1865, Wilson was positive that the survey could not be finished by the middle of February. "There is much more work in it than we ever expected, and the contouring promises to be a very heavy piece of work. From Joab's Well to the south-west angle of the city wall there is a rise of 545 ft. and from thence to the northern point of the special sheet a rise of 150 ft. more, making about 70 contours to be run over ground naturally very rough and made still worse by the network of garden and vineyard walls which covers it in all directions . . . The weather has been favourable thus far, but we have the latter rain still before us. This has, however, been very much exaggerated as I find they have been reading their rain gauge a great deal too high, counting the quarters as whole inches, so that the total rainfall as given in books should be divided by four . . . The expense of the survey averages about £11 a week and at this rate there will be money enough for three months more work."

Wilson's letter of 23rd January described a new difficulty "the impossibility of keeping the same labourers ; as soon as a man learns enough to be really useful he gets tired of the hard work and leaves, so that we have to begin again on a new subject. I am beginning to be afraid that the cost of the survey will exceed the estimate . . ."

A rather belated hint, about contouring "precipitous portions of the ground, a few lines of levels down which with the contours sketched in is all that will be required for that part of the work," was sent on 2nd February. By 3rd February Wilson was able to report that the detail survey would be completed in one more week, that concentrated upon contouring they could dispense with hired labour which would reduce the weekly cost, although nothing could be expected to remain from the £500. No news of the Dead Sea levelling had reached him but he hoped if possible to do it during March and carry on with the contouring during April "when the longer days will hasten on the work considerably ; the shortness of the days and the necessity of being inside the gates soon after sunset has been a serious drawback . . . Bad weather has set in the last few days but we have plenty of work to get on with indoors at present."

His letter of the 22nd February anticipates full completion after seven weeks and money sufficient for more than two months. "I leave tomorrow on a trip of four or five days to explore the different gorges to the Dead Sea ;

the ignorance on the subject here is beyond belief . . . I have not yet received your orders for commencing this work, but will have all ready to start on the 5th of next month after the arrival of next mail." Wilson's letters are all mainly concerned with his archaeological experiences, but, since the results of these are recorded at length in the published notes on the survey, repetition of them here, however interesting, would be redundant.

It is recorded that the Haram area was instrumentally contoured and that for the rest of the work a 5-in. theodolite was used.

On the 14th January the Royal Geographical Society subscribed £100 towards the cost of the levelling. On the 18th the Government Grant Committee of the Royal Society voted their £100, less than a fortnight after which Dr. Falconer, one of the principal agents in carrying the matter through, died. Owing to mismanagement this money did not become lodged at the bank until 27th January, and the sending out of levelling instruments and instructions dependent upon shipping arrangements was delayed until 2nd February. Another sum of money received was £10 10s. 0d. from Sir Moses Montefiore towards Captain Wilson's expenses, to be devoted to the costs of exploration, and a further £10 10s. 0d. was promised for the levelling, contingent upon other subscriptions, by a Mr. John Watson, Civil Engineer, who owned property on the Bethlehem road, but there is no record of its receipt. On the subject of subscriptions it has been nowhere publicly recorded that Wilson's father gave him £150 to assist in the payment of his expenses, without which sum, having regard to the oriental capacity for absorbing bakshish, and the restriction on Wilson's official emoluments, it is probable that but little of the archaeological research work could have been accomplished.

The instructions on the levelling included the following points :—

1. A double line of levels to be run from the lowest bench mark cut during the survey in the valley of the Kedron by the direct route, Mar Saba, and the Wady-en-Nar, to Ras el Fishkhah on the Dead Sea, and afterwards on the homeward journey from Jerusalem to Jaffa. (It is odd to find such details normally dependent upon reconnaissance being dictated from an English armchair. Compliance was found to be impossible.)

2. The two independent levellers to close from time to time on common points to give frequent checks.

3. Bench marks to be cut on rocks and permanent objects, and their positions surveyed by a double traverse during their selection and description. A sketch plan of the ground about the route to be made if time permits.

4. Indications of any maximum and minimum water level in the Dead Sea to be recorded.

5. Permission accorded to a return from the Dead Sea via Jericho should funds permit.

6. Levels to be reduced to mean sea level of the Mediterranean.

A week after these instructions were dispatched the Director General sent news of yet more work impending. Sir Moses Montefiore with his friend Dr. Hodgkin, had called upon him about " an examination of the country round Jerusalem for the purpose of ascertaining what supplies of water are available and could be brought to the city." He would call a meeting of the Syrian Improvement Committee and was sure that £100 would be voted for this purpose, otherwise he would guarantee that amount personally. The Committee actually made the grant on 16th February. The work would be done after the return from the Dead Sea " and I " (the Director General) "certainly think it would be well to have a line of levels run through Bethlehem to Solomon's Pools and connect it with the levels of Jerusalem . . . Under Solomon or Herod they had the will and the power to make the cisterns for storing the water of winter available for the whole year and to collect it from every source . . ." Incidentally he sent out a dozen yards of magnesium wire for the photography of interiors, a novel process at that time.

A few days later his instructions betray a complete change of mind. He had read Dr. Whitty's report on the Jerusalem water supply and had spoken with Sir John McNeale on the same subject, thereby coming to the conclusion that all this levelling would be superfluous. He ordered merely the connecting of Sir John's bench mark at the Jaffa Gate with the city levels recently established. To carry out this and some minor requirements of Dr. Hodgkin was estimated to cost £50 and the Syrian Improvement Committee were asked to devote the balance of the £100 granted towards Wilson's exploration expenses, but to this they would not assent. However, there was a discrepancy between Dr. Whitty's and Sir John McNeale's results, attributed by the Director General to an error in the levels of the former, but which the secretary of the Syrian Improvement Committee, the Rev. Herman Schmettan, was anxious to have settled once and for all, so Wilson's final orders on the subject were dispatched on 3rd March. According to these :—

1. A line of levels was to be run from Jerusalem to the Pools of Solomon.

2. Herod's Conduit, 187 ft. above the level of Solomon's Conduit, so far as discernible, was to be traced back to its source.

3. If it were possible to find a point near Bethlehem, and one or two others, to connect the castle (?) with the Pools of Solomon he was to do so by triangulation.

4. Lastly "I wish you to make a traverse survey from Jerusalem along Herod's Conduit to the Pool fixing as many objects as possible by observations on either side."

There was also a postscript which reads as follows :—

"CUBIT"

"Mr. Critchlow. who built the English Church at Jerusalem says the people there have a cubit in use as a common measure. If so, I shall be glad if you would purchase one for me to take the exact length of it."

(The cubit did not appear among the standards of length in the Bar Room Museum as it stood in Southampton before the blitz !)

Sir Henry James was approached by the Rev. W. Douglas Vecht to search for the Ark of the Covenant, which tradition relates to have been concealed by Jeremiah amongst the underground vaults of the Temple before the Chaldean army under Nebuchadnezzar sacked the city, since when it has never been seen. Needless to say the reply was that the plan of the city was the first object of the survey and that any such discovery would be merely incidental.

To return to Wilson, his next letter home is dated 7th March. "A long succession of westerly gales during the last three weeks stopped all communication between Alexandria and Jaffa so that your letters and instructions for the Dead Sea levelling only reached me two days ago. We start on the 9th, but I have had some difficulty in arranging for the transport of the party, a sudden influx of travellers having raised the price of everything and obliged me to pay much higher than I expected ; if we only had tents of our own we could afford to laugh at the Dragomen but having nothing of that kind are completely at their mercy. I have been down the three principal routes from Jerusalem to the Dead Sea and find we shall have to carry the line of levels via Jericho and the Wady el Hodh, the other routes being impracticable . . ." Nobody believed he could explore down the Kedron Gorge below Mar Saba, partly because of its roughness and partly because Taamri Bedouins, encamped an hour's journey below that place, were at variance with the Turkish Government. He was determined, however, and found for a companion Professor Fraas of Stuttgart. Beyond Mar Saba the dragomen and small escort refused to go, fearing bloodshed, so the two Europeans engaged two Bedouins as guides, sent off one with the horses to meet them where he could, and entered the gorge by being lowered through a trap door from a convent. The gorge there and for about a mile further was walled in with precipitous rock 300 ft. high, after traversing which they regained their horses and rode along a well-beaten track. "In a few minutes we came upon the Taamri outposts; it was a regular Roderick Dhu scene, and we were soon surrounded by a number of wild looking fellows who came pouring down from the hills; a few words from our guides seemed to make it all right and we went through a long course of hand shaking and salaaming . . . I was very pleased with the Bedouins; it is the only place I have been to without being troubled with demands for bakshish." That route was abandoned because the stream made its final descent over an unscalable cliff. The second day he explored the ordinary route from Mar Saba to the sea but found it also unsuitable for levelling as it passed over a succession of spurs and hills and uneven ground. Hence the adoption of the third route through Jericho which maintained a steady gradient the whole way.

For the first time since the work started he strikes a cheerful note as regards progress. "This (contouring) is getting on much better than I expected and I am glad to say we have got the worst part finished, where the ground was so wooded as to necessitate the frequent removal of the instrument." The levelling to Solomon's Pools "would not take long or be a very expensive work as the men could be lodged in the convent at Bethlehem, and work both ways from there."

On 3rd April Wilson reports, "I hope by the end of this month nearly everything will be completed, but we have unfortunately lost the use of one man, Davison, latterly, and I am afraid he will never be able to do much work again in this country as the Jerusalem fever has got hold of him." Previously his plans for the Dead Sea levelling, following his original proposals, had included the leaving of one of the men, who had had an attack of fever and ague, to take care of the office and continue with the hill sketching whilst they were away. Presumably this referred to the same man. "The expenses of the Dead Sea levelling," he writes, "have been greater than I expected but I hope the portion to Jaffa will be under the estimate as we shall not require an escort and may get the transport done at a cheaper rate after the travellers leave, but without tents or camp gear I am entirely at the mercy of the dragomen who have made a sort of combination against me . . . Prince Arthur was out here last week accompanied by Elphinstone and Mr. Jolly. I showed them our plans and what we were doing which they seemed greatly interested in . . . The city is now very crowded with pilgrims of all nations which has put me to a great deal of inconvenience as every available lodging is crowded to excess . . . Good drainage would be more beneficial than any amount of water, the street in front of the hotel I live at is literally nothing more than a huge cesspit though one of the principal thoroughfares of the city." The fever is scarcely surprising.

By 22nd April he envisaged another three weeks work and the possibility of beginning the levelling to the Pools about the 15th May. Yet again were plans frustrated, for, on the 20th April, the Director General had written to the P. & O. requesting berths at reduced rates to be granted for the party's homecoming about the middle of May. The survey is a record of inevitable postponements due to inexperience of work under the conditions obtaining, and to the slowness of communication, but Wilson's forecasts persist in optimism right to the end.

The next we hear of him is the 13th May, when the survey is nearly complete and the examination due to finish next week. " There then will only remain the two cross geological sections which will not take very long. I hope to commence levelling to the Pools some day between the 22nd and 26th and then to go on to Jaffa where I expect to embark by the mail of the 14th June. I find that at the end of April there was a balance of £34 remaining of the £500 which will be enough to cover all expenses here and on the way home . . . The heat is getting very great now and will give us some trouble on our homeward work ; we shall be able to do nothing in the middle of the day and shall have little shade in the plain of Sharon. Nearly all the pilgrims have left and few travellers arrive so the city has again an empty desolate appearance."

Between this and 18th June there is no first-hand news of the survey. On that day he wrote from Alexandria, " We arrived here yesterday and I find we shall have to remain till the 24th or 26th as the mail has broken down on the other side of the Isthmus and the steamer here has to wait for it . . . I was very glad to get out of Jerusalem as the health of all the men was suffering, and I was not able to do as much as I could have wished towards the work at Solomon's Pools in consequence. To have done the thing thoroughly would have been another week's work which I do not think the men would have stood. The cholera is now at Alexandria."

They arrived home on 10th July, and a fortnight later a letter appeared in *The Times* which nearly completes the story. After announcing the party's arrival and the work of compiling the results for publication which had meanwhile been sanctioned by the Treasury, Sir Henry James announced the result of the levelling, which of course was not computable until the final closing of the line of levels at Jaffa. " The depression of the surface of the Dead Sea on the 12th March, 1865, was found to be 1292 ft., but from the line of drift wood observed along the border of the Dead Sea it was found that the level of the water at some period of the year, probably during the winter freshets, stands 2 ft. 6 in. higher, which would make the least depression 1289·5 ft. Captain Wilson also learned from inquiry amongst the Bedouin, and from European residents in Palestine, that during the early summer the level of the Dead Sea is lower by at least 6 ft. ; this would make the greatest depression to be as near as possible 1298 ft. Most of the previous observations for determining the relative level of the two seas gave most discordant results. The Dead Sea was found by one to be 710 ft. above the level of the Mediterranean, by another to be 710 ft. lower, and by another to be 1446 ft. lower, but the most recent, before that now given, by the Duc de Luynes and Lieutenant Vignes of the French Navy agrees with our result in a very remarkable manner, considering that the results were obtained by barometric observation, the depression given by them being 1286 on the 7th June, 1864, which at most differs only 12 ft. from the truth if we suppose the Dead Sea was then at its lowest . . . It may interest those who have subscribed to the fund for paying for the survey and levelling to know that my estimate for the survey was £500, and the cost £519 10s. 1d. ; the estimate for the levelling was £200 and the cost £214 15s. 6d. and that this small excess was caused by the unexpected detention of the party at Alexandria for a fortnight in consequence of an accident to the mail steamer in the Red Sea."

As regards the levelling to the Pools of Solomon and the inquiry into the water supply, the estimate was £50 and the cost £52 7s. 11d.

In due course the survey was published. There are three sections to this :—

1. The maps and the plans of the principal public buildings.

2. Captain Wilson's notes consisting of a short description of the survey and a long dissertation on his archaeological discoveries ; a preface by Sir Henry James enunciating his opinions on tradition and historical sites ; numerous diagrams showing details of buildings and the surveys of the Dead Sea and Solomon's Pools levelling routes—all in one volume entitled *Ordnance Survey of Jerusalem—Notes.*

3. The photographs of public buildings and features of particular interest reproduced by zincography.

The Palestine Exploration Fund organized further expeditions during ensuing winters, and the first (1865–6) was under the charge of Captain Wilson. But these have nothing to do with the Ordnance Survey, excepting that there is a record of a Corporal Hancock working in Jerusalem between March and June, 1867. Lieut. Warren, R.E., presumably in charge of the exploration for that year, was in administrative, but apparently not in technical command of him. The Corporal's job comprised the completion of the contouring around Jerusalem and the plumbing of the city walls, the cost of which was in the neighbourhood of £105. The origin of this sum is not divulged. The outcome of this work was that in February, 1868, Sir Henry James announced the production of models of the city and its environs on both the 1/2,500 and the 1/10,000 scales, one style of which was coloured geologically. These were at the time very well received amongst educational establishments and museums.

Lieut. Warren visited the Dead Sea that autumn and reported an error in the magnetic bearing as shown on the plans, whereby he encountered difficulty in finding Wilson's terminal bench mark. There is no mention of the amount of the correction which had to be applied, but on 6th December, 1867, Wilson writes from Ordnance Survey Office, Inverness : " I have sent Parsons some corrections made by Warren in the Jerusalem work, and there are others (in the underground work) of which I have not yet received the plans. When I do so they will be forwarded at once. I am not surprised at there being many errors as I had no plan to lay the work down upon till we reached England, and seldom had any assistance working in the dark, the Sappers being of course fully occupied above ground. You will be glad to hear that Warren speaks in the highest manner of the survey itself, which, by the minute manner in which he is now going into everything, is being tried more severely than I expect most English Parish Plans are " : which note of confidence provides a suitable point at which to close this part of the story.

(*To be continued.*)

THE CARIBOO TRAIL

By BRIGADIER G. MACLEOD ROSS, M.C., M.ENG., M.INST.C.E.

IT is now nearly ninety years since a vast storehouse of treasure was located, hidden away in the streams, valleys, and mountains of Canada's North West. The emergence of this treasure into the civilization of that day was made possible by the building of a road.

In 1861, largely owing to the lack of speedy communications, it was the custom to trust the man on the spot. This habit of delegation produced men possessing both vision and the ability to act. In the vast area, then referred to as New Caledonia, authority was represented by a Scotsman, James Douglas. He read the signs aright, engineered a road, and brought out the treasure.

During the past year we travelled Canada's Number One Highway from Vancouver B.C. to Jasper, Alberta. Four p.m. on an August afternoon found us at Yale B.C., which marks the western end of the Fraser Canyon, and therefore the easterly limit of navigation.

Yale in 1858 was one of a chain of Hudson Bay Company posts—Lytton, Yale, Langley, Queenborough—the collecting and connecting stations for the fur trade with the markets of the world. When we intruded upon the still solitude of Yale it must have been almost as quiet and deserted as it was early in 1858 when the chief trader had just reported to Victoria scales of yellow, the size of a pin head, which he was finding in his frying pan whenever he washed it out with the grey sand from the bars of the river.

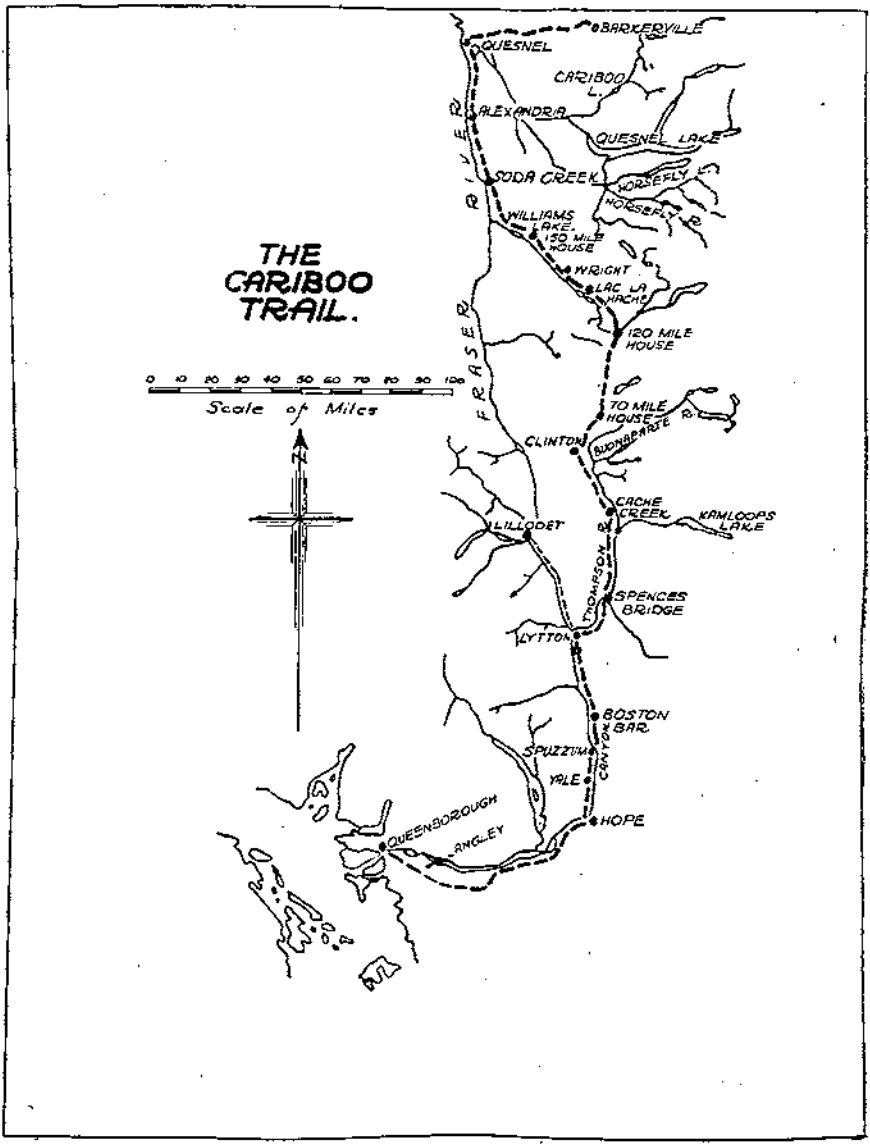
We were accommodated and ate. Then made our way down the terraced side of the valley, past the whistle stop, to a grassy plateau. From here we were assailed by a magnificent gorge of sheer-sided rock, through which boiled the milky glacier-fed waters of the Fraser.

Where the gorge bent left-handed out of sight it was possible to discern huge rocks protruding from the stream like teeth. As a backdrop, there mounted to the low clouds a gigantic slope of hemlock, the colour of the Black Watch tartan. In all this time we had seen only three persons, and two of them now stood, far below us, on a grey sand bar, casting a line into the fast moving water.

We turned from the lovely wildness of this picture in greys and blues and black greens, and sought to return uphill. And then, on a bank, secured from the doubtful publicity of the Highway, we came upon one of the five bronze tablets to be found in the Province, which open the door to memories of the past.

FORT YALE

> "Here began the Cariboo Wagon Road which extended 400 miles northward to the gold mines of Cariboo. Built 1862–5. In the golden days of Cariboo over this great highway passed thousands of miners and millions of treasure."


THE CARIBOO TRAIL.
0 10 20 30 40 50 60 70 80 90 100
Scale of Miles
N
BARKERVILLE
QUESNEL
CARIBOO L.
ALEXANDRIA
QUESNEL LAKE
SODA CREEK
HORSEFLY L.
HORSEFLY R.
WILLIAMS LAKE.
150 MILE HOUSE
WRIGHT
LAC LA HACHE
120 MILE HOUSE
FRASER RIVER
70 MILE HOUSE
BUONAPARTE R.
CLINTON
CACHE CREEK
KAMLOOPS LAKE
LILLOOET
THOMPSON R.
SPENCES BRIDGE
LYTTON
BOSTON BAR
SPUZZUM
CANYON
YALE
HOPE
QUEENSBOROUGH
LANGLEY

Time rolls back nearly ninety years. It is spring, 1858. New Caledonia is an undeveloped, uncharted tract. James Douglas "governs" both the Colony of Vancouver Island and the "Company." Fur is king, the sole horizon of the few inhabitants. A small detachment of the Corps of Royal Engineers has recently been landed to undertake a boundary survey under Colonel Moody, with Captains Grant* and Parsons.

Into this peaceful, unconscious, and severely limited scene is suddenly projected a new and all compelling incentive—gold. No modern means of intercommunication could embellish the reports on such a subject as could the tales by word of mouth in 1858. Almost overnight Victoria is besieged by ships bearing a vast prospecting polyglot, quiescent since the '49 in San Francisco. By the end of this fateful year 10,000 men were washing gold in the sand bars adjacent to Yale. The population of Yale became 800 and every second shack was a saloon. Meals of bacon, salmon, and bread and coffee were served at a dollar a head. And all the courage, determination, energy and lawlessness which the lure of gold can engender was present in crescendo.

The authorities acted with a speed unknown in these days when radio has been debauched to concentrate instead of delegate authority to proconsuls. By June, Revenue Officers and Justices of the Peace had been appointed at Yale and elsewhere. On 2nd September the Colony of British Columbia was chartered, and ten days later Governor Douglas is addressing the inhabitants of Yale, having landed from Captain Gus Wright's *Enterprise.* "Our gracious Queen commands me to allow you to dig for gold in Her Dominion."

By 10th November a mail service had been established at 5 cents a letter, and Hicks, the Revenue Officer at Yale, was apologizing for the rain blots on his report and bemoaning the non-arrival of sealing wax and a seal. Two murders had already been committed nearby, and one, Foster, had been apprehended smuggling liquor. Trouble with the Indians was reported. They saw the knell of their trapping. That notorious Californian, Ned McGowan, uncrowned king of Hill's Bar, 1½ miles below Yale, was flouting the Queen's representatives on a scale which made the authorities recall the Oregon Boundary dispute. So James Douglas again visited Yale, supported by Sappers and Marines, and quickly restored order. Colonel Moody preached a sermon that Sunday to forty people in the Yale Court House, and before the Governor left the diplomatic McGowan had entertained him to a champagne dinner. As the year closed $500,000 worth of gold had been taken from the Fraser.

But by 1869 washing for gold dust in the Fraser River bars was fast becoming uneconomical. The more adventurous prospectors had already pushed upstream in efforts to locate the lode. In doing so they had had to brave unassisted the rapids of the Fraser Canyon and the precipitous rock faces of its sides. Thick hemlock forest, fogs, where the old hand listened for the fall of the stone he had thrown ahead of him, and nightmare struggles along sheer black rock faces on swaying contraptions styled "Jacob's ladders." All these hazards were endured, and interposed themselves in the ever lengthening distance from the comparative civilization of Yale.

Giving little thought as to how they would get their gold back, still less as to how they might subsist, the adventurous pressed on from Lillooet and Clinton. Leaving the river they plodded on via Lac le Hache to rejoin it at William's Lake. Then Horse Fly Creek, near Lake Quesnel, yielded 100 ounces in a week and the fever began to mount again, causing a mad rush northwards so that by the fall of 1859 there were 1,000 miners around Lake Quesnel.

* The father of the late Maj.-Gen. Sir Philip Grant, K.C.B., C.M.G.

The spring of 1860 saw Yale and Hope deserted and all the time tales of fantastic finds filtered back through the almost impenetrable curtain of natural obstacles. Quarter pound nuggets above Lake Cariboo. Lightning Creek—$100,000 in three weeks. William's Creek—40 lb. per day per claim, and $50,000 in six weeks from another creek.

But none of these fabulous strikes did anything material to ease the mounting problem of supply. Flour was costing $300 per barrel, and boots $50 a pair way up at the end of the line. Evacuating the gold to security and a market was taking a high toll, for the Fraser Canyon rapids were much more dangerous to descend than to face. Holdups became the profession of those too slim to brave the dangers of prospecting. It was at this juncture that Governor Douglas took the immortal decision to build a wagon track to get the gold out.

By 1862 contracts had been let and work begun. The road should run from Yale, the head of navigation, to William's Creek. It would be 18 ft. wide and 385 miles long. In those dim and circumscribed days enthusiasm could effervesce to such an extent as to hail it as the "Appian Way of British Columbia."

The names of many of the giants of those days are immortalized in place names along its length. The Royal Engineers built the first 6 miles out of Yale and later the 9 miles north from Cook's Ferry, now Spence's Bridge.

Thomas Spence took the section into Spuzzum and from Boston Bar to Lytton. Joseph W. Trutch drove the line from Spuzzum to Boston Bar and in 1863 built the Alexandria Bridge at Spuzzum in replacement of Franklin Way's effort of 1858. A year later Spence bridged Cook's Ferry over the Thompson River, which took on the name of Spence's Bridge. Oppenheimer and Walter Moberly worked from Lytton to Cook's Ferry. The versatile Gus Wright, skipper of the *Enterprise*, had undertaken the portion from Clinton to Alexandria, nearly 200 miles from Yale. The *Enterprise* covered the 20 odd miles of Fraser River from Alexandria to Quesnel, and in 1864 Wright built the road on to Cottonwood. The final 25 miles to Barkerville were completed in 1865 by Munro.

In three years, at a cost of $2 million, the road had been put through. Judge Murphy, himself a child of the road, having been born at 141 Mile House, has given a vivid picture of the metamorphosis of scene the road effected. Men on foot and in bull teamed covered wagons. Men beside mule pack strings with the white bell mare in the lead, aperajoes on their backs fastened with the famous diamond hitch and loading 300 to 400 lb. One optimist introduced twenty-one camels into the service, but their stench caused such havoc among the horses that they, together with some steam tractors, were acknowledged a failure. Finally came the Concord stage coaches with bright red bodies latticed with curving lines of white. The deep black leather boot in front, the iron safe, the leather thorobraces, and the yellow wheels picked out in black. With teams of four to six horses they ran 8 miles in the hour, and Barnards Express did the stages from Yale to Barkerville in four days.

The standard of living at the upper reaches of the road can be gauged from the following: Pianos were transported from Quesnel to Barkerville at $1 per lb. Champagne cost two ounces of gold per pint. The German hurdy-gurdy girls charged $10 a dance. Regarding the last, the bard of the locality, who always seems to have been Scots, records:

> "They danced 'a nicht in dresses licht
> Fra' late until the early O
> But O, their hearts were hard as flint
> Which vexed the laddies sairly O."

As for the dividend, it is estimated that, during the years 1859 to 1871, $25 million of gold were taken over the Cariboo Trail.

We shall be advised to leave the story of the road in its hey-day, with " Cariboo like a land of old, the land of Eldorado." Gold is a fickle will o' the wisp, especially placer gold, for with the supply line established, placer gold gave out, and the population diminished as speedily as it had been attracted. Rather let us turn our gaze to the final lines on the solid and lovely tablet which seems a part of the halcyon days of Yale.

> " In the golden days of Cariboo over this great highway passed thousands of miners and millions of treasure."

Yale sleeps on. The scenic treasures sleep on. And so does the modern counterpart of James Douglas. For the present is ripe for a display of that vision and business sense which will realign and resurface the Number One Highway of Canada to convert it into a modern Cariboo Trail.

For those who have already prospected, the nuggets of Canada's scenic treasure are legion. The magnificent Fraser Canyon. The scarps and screes above the green Thompson River near Gladwyn. The first glimpse of Kamloops Lake seen from the west. The azure blue of Shuswap Lake seen in the long flat rays of a setting sun over a field of stubble. The lovely bends of the pearl grey Columbia River with the hemlocks paddling their toes in its icy stream. The wild grandeur as the Kicking Horse Pass approaches Wapta Falls. The eerie alpine stillness of an early morning below Laggan. Pink rock faces, snow flecked high above. The Transcontinental, with headlight burning brightly for the spiral tunnels, puffing pompously up the grade. A mountie leading a young boy. A female bear sitting at the receipt of custom. A timber wolf disturbed at breakfast. The faerie stillness of placid Lake Louise beneath the high snows of Mount Stephen glacier. The elusive valley of the Bow seen from Banff. The cool serenity of Bow Lake supporting its towering glacier. The wild abandon of the Sunwapta Pass. The cavernous green of the Columbia icefield. The milky new fledged Athabasca threading circuitous paths through deltaed shoals pink with fireweed. Mount Edith Cavell in shadow and a shaft of sunlight flooding the sheer white precipice of Angel Glacier. All these and many more are the treasures to be discovered on the Number One Highway. But as conditions stand they await the modern James Douglas to open a trail to this Eldorado. And as an afterthought, it was not so surprising to stumble upon the footprints of the Royal Engineers so far from home.

A GARRISON ENGINEER IN SOUTHERN IRELAND

By Major D. G. B. Boyd, R.E.

IT is not often that a garrison engineer gets mixed up in Southern Irish politics. However, in the summer of 1938 it was my fortune, or perhaps misfortune, to become involved in a labour dispute on Bere Island, which lies in Bantry Bay, in the south-western corner of Eire. This island was an outstation of the South Irish Coast Defences, which had its Headquarters on Spike Island in Cork Harbour. The South Irish Coast Defences were technically under Western Command, but led a fairly free existence, owing to the distance and lack of communications in those days. The strategic importance of Bere Island, as a convoy collecting station on the Western Approaches, has often been mentioned, and the handover of this island with the other defences in Cork Harbour to the Irish army, was at the time bitterly opposed by Mr. Churchill in the House of Commons. The following story concerns the last days of the British garrison in 1938.

In April, 1938, it became apparent that the directly employed Irish labour on Bere Island were dissatisfied with the rates of pay for skilled and unskilled labour, and spurred on by agitators on the island and the mainland were threatening to come out on strike. My C.R.E. sent for me and said that an ugly situation seemed to be developing, and that I was the only officer in Fort Camden he could spare at the time. I was to go down to Bere Island, and settle the matter as quickly as possible. So I gave up my ideas of taking out the local black-eyed Cork beauties, and beating up the oyster bar in Cork with Seamus and Malcolm, and instead set out for the relatively unknown outstation in the deep south-west.

West Cork is one of the most beautiful districts in the world. It was then, as it is to-day, a tourists' paradise. The colour of the sea is often Mediterranean blue, and rich tropical flowers and plants flourish along the coastal strip, and in the numerous islands off the coast. High mountains protect this veritable riviera from the cold northern winds sweeping over the "Windy Gap" pass between Killarney and the Kenmare River.

At the top of Bantry Bay, sheltered by the mountains, lies the town of Glengariff, dominated in those days by the far famed "Aunty May," proprietress of Roche's Hotel. She and her family were ever the hosts of the Royal Navy and the Bere Island Garrison, and an eager welcome always awaited us. Her hospitality was often returned by the Navy, who in their destroyers braved the dangerous shallows and anchored in the lagoon below the hotel. "Aunty May" used to come aboard, take on her share of gin, and then invited her hosts to come ashore with her, and explore her bar in the hotel. "Explore" is the word for it, for the bar was surrounded by shelves containing trophies from all over the world, including freshly painted lifebuoys "lost at sea" by the visiting destroyers. Alas, "Aunty May" and her hotel bar are no longer one of the sights of Ireland, but her kindness and humour will be remembered by many a British serving man.

I came to Castletown Berehaven when the sun was shining and cloud shadows were moving across the surrounding hills. It was a peaceful setting, the only evidence of British power being a visiting destroyer of the home fleet anchored in the haven. A small W.D. launch bore me to the island, and I travelled in company with the protestant padre from Castletown, who remarked on my steel helmet and gas mask, and said that they would probably be needed before the summer was out. He thought there might be some stone throwing by the villagers, as they were in an ugly mood, and he personally felt that there might be some justice behind their complaints. We stepped ashore at last, and were met by the Garrison Engineer's Staff and a handful of rather surly looking civilians, the latter evidently intent on having a good look at the newcomer. The padre said he thought I should hide my gas mask and steel helmet, as it might give them the impression that I was afraid of them!

And so I came ashore. I soon found that all the civilian labour was on strike, not merely talking about striking. In a short time I discovered rude messages written on my door in chalk, including a threat to cut off the water supply of the garrison, which had its source outside the British perimeter, and flowed through land occupied by gentry called "pipe line tenants," who had been threatened with dire consequences if they did not break the rising main. However, the lure of constant payment for the useless rocky land through which the pipe line passed, proved stronger than their patriotic instincts, and this problem seemed to solve itself.

Very soon after arrival I received a deputation from the strikers. The leader was a ruffianly looking fellow, a dark southern Irishman with troubled eyes, who said that every man had refused to work for the pay they were getting, and implied that if the British authorities did not do something about it, not only would the British garrison be hard put to maintain themselves, but hinted darkly that quite a lot of people might get hurt. So I said that as far as the pay was concerned, the labour office in Bantry felt it was already above the rate prevailing elsewhere in Cork, and that if they liked to stop work, they could only blame themselves if they were short of money for the next few months. I also said that there were many soldiers in Fort Camden who would be only too pleased to have some practical trade training, and that they could be sent down to the island. If that happened, the Sappers might stay there indefinitely, and then the strikers would have to find work elsewhere. In fact I did not feel like taking them back at all, even if they were willing to work for us. I was considerably helped in taking this line, by having an interview with the manager of the labour office in Bantry, which included the swopping of alcohol and stories. He was an ex-officer of the Munster Fusiliers, and naturally was on our side.

And so the strike dragged on, and most of the tradesmen sent down from Fort Camden had a glorious summer repainting buildings, renovating officers' and sergeants' messes, and repairing the one road in the island. The strikers looked on sullenly, and occasionally I had a drink in one of the village pubs, and asked them how their money was holding out. The ex-officer of the Munster Fusiliers had seen to it that they didn't get any dole. Far from anything violent happening, they merely confined themselves to writing messages on garage doors. One of the best ones was "Beware of Easter Lily, strikers respect no boys life." We altered that to "nobody's life," as presumably intended, and left it there—Chinese like—to remind them of their bad manners.

Towards the end of the summer the strike ended through lack of solidarity between the labourers, but its end coincided with the handover of the defences to the Irish Army, and the labourers discovered that their new masters were disinclined to maintain even the wages provided by the British. Drastic cuts were made in the garrison, and the Fort put on a care and maintenance basis. Thus ended the last British–Irish labour dispute in Southern Ireland.

The handover to the Irish Army received little publicity in the British press, but was an occasion of mutual goodwill between the two garrisons. Negotiations commenced in Spike Island and lasted three months. Gradually the British garrison thinned out, and as they left the Irish Army took over the manning of the defences. Many conferences were held, assisted by a liberal supply of whisky provided by Western Command, and details were generally left to the soldiers on the spot. Tea cups replaced cups and saucers in the mess, but the solitary cups contained a brew of whisky, instead of tea. On Bere Island we negotiated the sale of R.E. stores in a similar setting, and the War Office minimum price for their sale was the subject of near-oriental bargaining. I think we eventually closed at thirty-five per cent of catalogue price—five per cent below the War Office minimum, but there were various concessions made on the Irish side, who offered us £10 late at night for a useless stone-crusher, which to my knowledge hadn't crushed stone for many a day. Co-operation reached its height at the time of Munich when the depleted British garrison received the code word to put the defences in a state of readiness. By this time all the guns and ammunition had been taken over by the Irish Army, and the main British garrison consisted of sapper tradesmen and a small number of gunners. It was finally agreed, the Irish Army omitting wisely to inform their Government, that the best thing to do would be for us to take back and man the guns and searchlights as best we could, while they took on the administration of the whole garrison. And so, for the first time, and not to re-occur since, the British and Irish armies acting together prepared to defend the Western Approaches to the British Isles.

The final ceremony was the hoisting of the Irish flag on the island, while the rear parties of the British garrison embarked on the waiting destroyer, and the guard of honour, acting under orders shouted in Irish, smartly presented arms.

SAPPER OFFICERS IN THE PENINSULAR WAR

The following extract from a Journal kept during the Peninsular War has been sent by G. E. G. Webber, Esq., of Winnipeg, Canada, who served with the Royal Engineers during the 1939–45 war. It gives an interesting record of two Sapper Officers, Colonel Squire and Captain Goldfinch.

Lieut.-Col. J. Squire was originally commissioned as a 2nd Lieut. in the Royal Artillery on 27th April, 1796, but was transferred with a number of other R.A. officers to the R.E. on 1st January, 1797. He saw war service in Holland in 1799, Egypt 1801, Buenos Aires 1806–08, Sweden 1808, Peninsula 1808–09, Walcheren 1809 and the Peninsula again 1810–12, dying, as stated, from fatigue at Trujillo on 19th May, 1812.

Captain H. Goldfinch, who is also mentioned, was originally commissioned as a 2nd Lieut. in the Royal Artillery on 1st March, 1798, and was transferred to the Royal Engineers on 24th June, 1798. He saw service at Copenhagen in 1807 and in the Peninsula from 1809 to 1813, and was present at the battles of Talavera, Busaco, Vittoria, Nives, Orthes and Toulouse. He was promoted Major-General in November, 1841, and Lieut.-General in November, 1851, and was awarded a K.C.B.

Notes on an extract from the journal of Captain William Webber of the Royal Horse Artillery who was serving in Lieut.-Gen. Sir Rowland Hill's Corps in Spain, 1812.

The localities mentioned are shown on the 1/250,000 sheet of Spain called Caceres, No. S 3640. The army was on the march which drove the French temporarily out of Madrid in 1812.

The artillery left Puerto de Santa Cruz on 15th September, 1812, at five in the morning and marched for Trujillo. The extract from Captain Webber's journal after arrival at Trujillo is as follows :—

"Maxwell and myself, after the weather had cleared up a little, went up to the Castle, now in ruins. Our first object was to see the tomb of Col. Squire of the Engineers who died here from excessive fatigue in May last. We found it and seeing the stone work with the inscription on it corroborated the noble and generous conduct of the French officers who were here soon after the place was evacuated by our troops. The Alcadez told us the story and as it reflects so highly on the honour of our enemies I must give it. Col. Squire was a most meritorious officer and had received his last two advances in rank from his distinguished conduct on several occasions, particularly during the late siege of Badajos, in consequence of which and Lord Wellington's notice in his despatches, he obtained the rank of Lieut.-Col. by Brevet, but unfortunately died before the letter announcing his promotion reached him. The high respect every officer felt anxious to pay to his memory induced Col. Dixon of the Artillery who was then here to make every exertion to finish the tomb before the British troops had orders to march, which was every hour expected. However, he could not complete it and left the large stone which was to be placed over it with the Alcadez with strict injunctions to finish it.

"A few hours after the French entered the town and the Alcadez fearing he might suffer if detected in doing anything for us resolved on trusting to the generosity of the French Commander and immediately made him acquainted with all the circumstances. The officer, whose name I have not been able to learn, not only permitted the Alcadez to do as he had been desired but rendered him every assistance as to money and otherwise to have it completed immediately with directions that he should be informed when it was so: which being done, he assembled all the French officers and formed a procession and the road to the grave was lined with his men after which the stone was placed in a most solemn manner. Such conduct is noble and notwithstanding the character given (deservedly) to French troops, we often hear of the humanity and generosity of some of them to our officers who may be their prisoners. The tomb is plain and the stone bears the following inscription 'Lieut.-Col. Squire of the Royal Engineers died the 19th May, 1812.'"

The journal mentioned is in my possession and covers the period 28th August, 1812, to 16th June, 1813. The original was in poor condition and some time before 1900 was copied by a member of the family. It is this copy which I have. The journal breaks off in the middle of a sentence.

On 9th September, 1812, Captain Webber notes that he rode from Don Benito to Villa Neuva with Captain Goldfinch of the Engineers. On 27th October, he mentions crossing the Tagus River at Aranjues. The bridge had been built by Captain Goldfinch. The next day he mentions seeing Captain Goldfinch engaged in mining a bridge over the Jarama River.

MEMOIRS

LIEUT.-COLONEL W. A. HARRISON, R.E.

WILLIAM ALBERT HARRISON was the son of Sir Henry Harrison of the Bengal Civil Service and was born on 9th September, 1867. He was commissioned into the Corps in March, 1887, from the "Shop" and on completion of the S.M.E. Course he was posted to the M.W.D. at Calcutta in 1889. At the end of that year he was transferred to the 2nd Coy. of the Bengal Sappers and Miners for the Chin-Lushai Expedition.

On his return to India the following year he was posted to Simla and then served at Jullundur, Calcutta, Jubbulpore and Darjeeling till November, 1893, when he went to Rangoon and was employed on the construction of the King's Bank Battery on the Rangoon River.

In March, 1894, he returned to the U.K. and was then posted to the Ordnance Survey at Redhill, where he was employed on the large scale survey of London and later the revision of the Kent and Sussex areas. He was promoted Captain in December, 1897.

In May, 1898, he volunteered for service with the Field Survey Section detailed to survey the Shantung Peninsula round Wei-hai-wei. Returning to England in October, 1899, he was posted to Aldershot as D.O. R.E., but in August, 1900, he was ordered out to China again as a Special Service Officer and was attached to Brig.-Gen. Reid's Brigade at Taku for the attack on Shankaiwan. Owing to the amount of engineering work to be done, Harrison was employed throughout as an Engineer Officer and not in his official capacity as a Special Service Officer.

Harrison returned home later in 1901 and was then asked to form a Colonial Survey Section. Owing to his health he did not wish to do this, but was persuaded to start the section and to begin work at Mauritius, until he could be replaced.

While he was in Mauritius he became engaged to Miss Rose Parnell, who was visiting a friend in the island, and they were married at home in June, 1903. She died in 1919 after sixteen years of happy married life.

In November, 1903, Harrison was selected as one of the first officers to be sent out to Japan to learn the language. At that time officers sent on language courses had to pay for their passages out to Japan, but if at the end of fifteen months they passed the exam they received £100 for the oral exam, £100 for the written exam and £85 towards their passage money. Harrison did very well to pass the oral exam with 85 per cent and the written with 76 per cent marks and so obtained all the awards.

On his return to the U.K. he was posted as Staff Officer to the Chief Engineer Western Command, having been promoted Major in 1905, and in October, 1907, he was appointed as Secretary of the R.E. Institute, as it was then called. At that time the appointment was held by a serving officer. In 1910 it was decided that the appointment of Secretary should be held by a retired officer and Harrison decided to retire in order to retain the job, as his wife's health was bad and he did not wish to go on foreign service again.

During his tour of office, Major Harrison pressed for the proper formation of an R.E. Museum. Although previously there had been a small museum of sorts no one had taken any real interest in it. It had been moved on more than one occasion and there had never been any Curator in charge of it. In consequence the exhibits had not been properly cared for and many items disappeared. Harrison succeeded in persuading the authorities of the need for a proper Museum with a full time Curator. The old Model Room, which had been used for band concerts, lectures, etc., was now allotted specifically for the Museum and the reappropriation for this purpose was approved by the Army Council in 1909. Over £1,000 was spent on altering the building and providing show cases, etc., and the Museum was formally opened in 1912 in the form in which it is now known. Thanks to untiring efforts on Harrison's part he persuaded a very large number of officers to present or loan a great number of very valuable exhibits. He himself gave many items, including a very large proportion of the excellent collection of medals. The Corps owes a great debt of gratitude to Harrison for all his work in this connexion.

In July, 1914, just before the start of World War I, Harrison was sent to Ireland as Assistant Cable Censor, but in October, 1914, he was ordered to go to the R.E. Record Section with 3rd Echelon in France. His predecessor there had broken down from overstrain and the records were in chaos. He got the records into good order and was complimented on his work by Colonel B. R. Ward, O. i/c R.E. Records. He was mentioned three times in despatches and promoted Temporary Lieut.-Colonel in 1915.

In 1917 he asked to be allowed to return home on account of his wife's ill health and was posted as Asst. C.E., Southern Command. He later joined the Ordnance Survey at Southampton where he was in charge of Survey Stores for all the Armies.

In 1919, when his wife died, he asked to be allowed to terminate his services and the following year he went on a trip to Australia. In August, 1921, he married the widow of Dr. C. Terrey of Sydney and then decided to make his home in Australia, where he had a very happy married life for over twenty-five years.

Colonel Harrison still took a great interest in the Corps and especially in the R.E. Museum and kept in constant touch with the Institution. In 1946, he had a very serious illness, but made a wonderful recovery and later, during his convalescence, he wrote an account of the start of the R.E. Museum, which expands to some extent an article he published in the *R.E. Journal* in 1912. It is a most valuable historical record. He also sent a very interesting account of his service, from which this memoir has been compiled.

From his mother's family, the à Becketts of *Punch*, he inherited a great artistic sense and was quite a good water-colour painter and also excelled in the very varied arts of etching and scene painting.

In spite of marrying for the second time at the age of fifty-two, he lived to celebrate his Silver Wedding in 1946 and died on 8th October, 1948, at the age of eighty-one, being survived by his widow, who had nursed him so devotedly through his last illness.

C. F. A-C. writes "Harrison inherited a good deal of his father's ability. He was a devout, practising Roman Catholic, and this aspect of his life he also derived from his father, who went over to Rome as a result of the Oxford movement, and might, if he had not "verted," have been a "squarson." Harrison had a good natural voice, and sometimes sang at concerts in Indian. He could do that, for Europeans, very rare thing, he could sing like an Indian, or I believe, like a Japanese. He certainly had a good ear for the niceties of sound. He also had a good talent for draughtsmanship.

He was never happier than when he was Secretary of the R.E. Institute. Here, he was in his element, and, as mentioned above, he took an unfailing interest in the R.E. Museum, to which, amongst other relics, he presented the original map used by Wellington for indicating the position to be held by the British Army at Waterloo. He maintained his interest in Army history to the end of his life. He kept up with his old friends and followed that excellent piece of advice, given by Oliver Wendell Holmes, "that one should keep one's friendships in good repair."

C.C.P.

Lieut-Colonel WA Harrison RE

Major-General HBH Wright CB CMG

MAJOR-GENERAL H. B. H. WRIGHT, C.B., C.M.G.

AS one who was privileged, both in General Staff and Corps capacities, to be intimately associated with Major-General Wright during World War I welcome this opportunity of paying a respectful tribute to a chief whose sterling worth has been inadequately recognized.

To him in the rôles first of Chief Engineer, and later of Engineer-in-Chief to our Forces in the Near East between 1914 and 1919, rather than to any other individual, it is fair to assign the military culmination of the work of the many Royal Engineer officers who had played such an important part in the regeneration of Egypt.

Henry Broke Hagströmer Wright was born on 1st February, 1864, and was the son of the Rev. C. H. H. Wright and brother of Sir Almroth Wright the celebrated bacteriologist. He was commissioned into the Royal Engineers as a Lieutenant on 15th February, 1884, and after completing the usual course at the S.M.E., he was posted to the 4 Coy. Q.O. S. & M. in Burma in 1886, where he remained till 1890, being employed for the latter part of the time on special Intelligence duties in Upper Burma. He was awarded the Indian General Service Medal (1854–95) with three clasps ("Burma 1885–87," "Burma 1887–89" and "Chin-Lushai 1889–90"). He was twice mentioned in despatches.

In April, 1890, the company returned to Bangalore, but in the winter of 1891 they were back again in Burma and employed on the construction of a road towards Manipur. In 1892 he was in command of the company and was employed in the Chin Hills, where they remained till 1894 when they returned once more to Bangalore.

After a spell of leave in the U.K. from November, 1894, to December, 1895, he returned to Bangalore as O.C. 4 Coy. Q.O. S. & M. and in 1897 was employed with the Tirah Field Force and the following year with the Malakand Force receiving the Indian General Service Medal (1895–1907) with three clasps ("Punjab Frontier, 1897–98", "Samana 1897" and "Tirah 1897–98"), and was mentioned in despatches.

In the Tirah Expeditionary Force, Wright's company of Madras Sappers and Miners was the only regular S. & M. unit in the 2 Division which did most of the fighting and penetrated farthest into Tirah.

There was little engineering work but plenty of pioneer work, i.e., roads, temporary bridges, building sangars and other field defences, demolition of towers and defensible buildings, etc. The one and only permanent bridge constructed was a steel-wire suspension bridge over the Bara River. This bridge was designed by Wright and built by his company.

In 1899 he returned to the U.K. and was posted as O.C. 1st Telegraph Division at Aldershot, proceeding to South Africa with 2nd Telegraph Division in 1900 and becoming Asst. Director of Army Telegraphs in Natal in 1901. He was awarded the Queen's South African Medal with three clasps and the King's Medal with two clasps, and was mentioned in despatches.

From 1902 to 1908 he served as O.C. 1st Telegraph Division and as O.C. 1st Airline Telegraph Coy. at Aldershot. He was then appointed as C.R.E. Bermuda, where he remained till he took over the appointment of C.R.E. 3rd Division at Bulford in 1911.

H.C.S., who served under Wright at Aldershot, writes :—

"While serving with him, I spent some of the happiest times I have had while in the service and was taught a great many valuable things. My main recollections of public interest were that he was responsible for the design and introduction of the last pattern of horse-drawn cable wagon, which frequently saved the situation for us in the 1914–18 War, and also the 'D' type of field telephone, acknowledged at that time as about the best in the world.

"I have always regretted that I never had the opportunity of meeting him again, as our ways were always so far apart."

In October, 1913, he was placed on the "Unemployed List," but in August, 1914, Colonel Wright was sent out as Chief Engineer of the Troops in Egypt. His command consisted solely of one Field Company and a slender organization for peacetime barrack maintenance.

Colonel Wright, with a breadth and depth of vision rare at the time, foresaw an accurate picture of future events. He immediately, and on his own initiative, entered into the closest relations with the Egyptian Civil Administrations, thereby laying the foundations of the vast "Works" organization which was later to use to the full the resources of Egypt.

He was fortunate in finding the Egyptian State Railways, the State Telegraph Service and the (Civil) Delta Light Railways under the management of retired Royal Engineer officers; the Egyptian Survey Department under a worthy disciple of its Royal Engineer founder; the Irrigation Service with a live tradition of its distinguished Royal Engineer forebears; and the Ministry of Public Works controlled by a British Secretary of State ready to co-operate in every way.

The first spectacular result of this co-operation was the flooding of the old Pelusiac Channel of the Nile, dry since before the Christian Era, by the admission of salt water from the Suez Canal (to which the consent of the very conservative French Management was reluctantly given) thereby forming inundations to the east of the Canal which reduced the length vulnerable to Turkish attack by 25 per cent.

Colonel Wright at once obtained the full confidence of Maj.-Gen. Sir John Maxwell, who succeeded to the Command in Egypt shortly after the outbreak of war. He had a very heavy task in providing accommodation for the vast numbers of troops passing through Egypt in transit as well as those of the Garrison itself. In addition there were the operational needs during the Turkish attack early in 1915, various small campaigns in the Western Desert as well as the requirements for the Gallipoli Campaign. Nor were the inherent complications lessened by the political requirement of observing the theoretical neutrality of Egypt in the early days of the War.

In 1915–16, steering his way tactfully through the situation produced by the co-existence in the one small country of the trinity of High Commands (Force in Egypt, Mediterranean Expeditionary Force and Levant Base), Wright emerged as Brigadier-General (and later as Major-General) Engineer-in-Chief, Egyptian Expeditionary Force, with the additional task of implementing the decision to construct a triple "Maginot Pattern" line of passive defence on the 110-mile length of the Suez Canal.

Though always questioning the soundness of this strategy he entered loyally into the preliminaries for its construction, and by his sound common sense succeeded in bringing some of the original fantastic ideas within the bounds of possibility, the execution of the work being in the hands of officers sent especially from France for the purpose.

Before the defence line was completed came the decision to defend Egypt on the more advanced line of El Arish, 120 miles out on the Mediterranean Coast of the Sinai Desert, in furtherance of which it devolved on Brig.-Gen. Wright to originate and "Father" the construction of the double line of standard gauge railway; the wire roads; the 12-in. water pipe-line with complicated filtering plant and Suez Canal crossing; and the conversion of the small Suez Canal outpost of El Quantara into a commodious seaport for ocean going vessels.

The railway swing bridge crossing the Canal at this point was a later achievement of the Railway Administration, ingeniously contrived from "scrap" materials in the country and described by the again protesting French Canal authorities as a "*macedoine de ponts.*"

These projects, though surpassed in several places during the second World War, were hitherto unheard of in magnitude and difficulty, which was not lessened by the justifiable surmise that the advance, once initiated, would not stop on the El Arish line and that it was consequently necessary to make long-term Engineer preparations for the more ambitious operations which later were duly undertaken.

With all these works well on the way there came a time when the characteristic blunt directness of Maj.-Gen. Wright's advice ceased to find favour with the High Command with the result that his star suffered temporary eclipse and he returned to England.

However, as a result of a change in the High Command after the unsuccessful second battle of Gaza no time was lost in recalling him in June, 1916, as Engineer-in-Chief, to the augmented Expeditionary Force, now consisting of two Army Corps, a Mounted Corps, several strong non-divisional formations and several subsidiary commands. In this appointment he remained until after the final complete victory.

As well as being General Allenby's esteemed Engineer Adviser he was respected and trusted by the whole of his heterogeneous team consisting, in addition to Royal Engineers, of the Engineers of all parts of the British Commonwealth ; from India, Australia, New Zealand, Canada and South Africa as well as some from Egypt ; all welded into one efficient team.

A factor which contributed to his success was his ability to decentralize ; to give clear precise instructions and leave the man on the spot to carry them out, giving him every "headquarters" assistance and such credit as accrued, while being willing to take full responsibility for shortcomings. The writer was fortunate to have been, for a time, one of these "men on the spot."

A man of few words, his outwardly somewhat hard manner was but a mask which scarcely concealed the understanding and sympathy beneath. His dry sense of humour carried him through many difficulties. He was never content with less than the best from those surrounding him and when, as was usual, he got the best, he could be relied on to utilize it to the full and give it due credit.

He was awarded the C.M.G. in 1915 and the C.B. in 1917, as well as the Order of the Nile and the Grand Order of the Crown of Rumania, and was mentioned in despatches on four occasions.

He returned home from Egypt in July, 1919, and retired the following March, settling down at Seaton, Devonshire, where he was most interested in his garden, especially in growing apples. He was also very keen on golf.

In June, 1896, he married Helen, the daughter of Sir John Kirk, G.C.M.G., K.C.B., who survives him, as do their two daughters.

He died on the 21st September, 1948, at the age of eighty-four.

R.E.M.R.

LIEUT.-COLONEL J. R. GARWOOD, D.S.O., R.E.

JOHN REGINALD GARWOOD was born at Meerut on 24th November, 1873. He was the second son of Colonel J. F. Garwood, R.E., and like his elder brother Fred was educated at Marlborough and the " Shop." He passed out second of his term, and was commissioned on 10th February, 1893. As a young man he was a keen footballer and played in the scrum for the once famous Marlborough Nomads.

Garwood was one of the old " subminers," and was very sad when submarine mining ceased to be a Corps activity. When serving at Trincomali he sited and constructed the well-known camp at Diyatalawa, which was first used for Boer prisoners. A little later he was in India, but came back to Gosport in 1912 to command the 4th (Fortress) Coy. and to be Chief Instructor at the School of Electric Lighting, a job after his own heart. When war came in 1914 he was employed for the first year in training Territorials in coast defence, and in November, 1915, went to Salonica, where he was staff officer to George Walker then C.E. XII Corps. He was responsible for the construction of an excellent base camp at Summer Hill outside Salonica.

He was awarded the D.S.O. in 1917, and in 1918, owing to ill health, returned to Gosport where he became C.R.E.

Garwood had married Winifred Lloyd in 1912, and they had two daughters. When the war was over he decided to retire, and to devote his energies to the paper-making business owned by his father-in-law. This he did for seven years until Mr. Frank Lloyd died, when it was thought best to dispose of a concern, which was large and flourishing.

Mrs. Garwood had inherited the Coombe House estate near Croydon from her father, and after the settlement of his affairs, Garwood and his family decided to live at Coombe Farm, where he started amateur farming, and to offer the use of Coombe House to the Corps, so that R.E. families in need of rest or change could spend a few weeks there in comfortable country surroundings. This very generous offer was most gratefully accepted, and Sir Bindon and Lady Blood took a personal interest in the project. Many R.E. officers and their families will remember with gratitude a pleasant stay in such delightful conditions. This happy state of affairs continued until the second World War, when the place being in a target area had to be closed. No fewer than 457 guests had been entertained during the period that Coombe House was open.

For the last twenty years of his life Garwood suffered from indifferent health, and much of each winter was spent abroad. When war came he felt that intensive farming would be the best contribution which he could make to the war effort, and accordingly developed a dairy herd and cultivated for the time being part of an adjoining park and golf course. In 1944 a flying bomb seriously damaged his home, and this restricted his activities, but by no means his interests.

Garwood had somewhat of a specialist's mind. He would be prepared to work all night at a task which interested him, but found it hard not to be bored with routine. He was a kindly, generous soul, somewhat shy and reserved, and always keenly interested in Corps matters. He was a great reader, especially of Service biographies, and helped to start the Air Cadets organization in Croydon.

A.G.B.B.

BOOK REVIEWS

THE INDIAN SAPPERS AND MINERS

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

(Published by The Institution of Royal Engineers. Price 25s.)

Many famous men, Sappers and others, stalk through the pages of Lieut.-Col. Sandes' new book—*The Indian Sappers and Miners*. We see Bindon Blood as a major in the Second Afghan War and Hunter-Weston as a subaltern in the Miranzai Expedition of 1891. We meet Lawrence, Lake, Napier, Roberts, Kitchener and many others; and we read of dozens of officers whom many of us have known in the flesh or as legendary figures of the Corps. Here we see in black and white the exploits for which they won their fame.

The stories are told most graphically. The author is clearly absorbed in his work, and the interest he takes in the people and events of which he writes adds to the pleasure in reading of them. British Officers and N.C.Os., Indian Officers (or V.C.Os. as they were later called) and sepoys all receive a fair and just place in this book. It is thus a mirror of army life and not merely a history. The author's light touch recalls those happy days of soldiering in India. It is a pity, though, that lack of space has prohibited an account of the many fields of sport in which sappers have taken part and often excelled.

It is quite astonishing how many people have been traced by the author. Hundreds of officers, retired and serving, will find their names in the Index; and, unless human nature has ceased to run true to form, they will be irresistibly compelled to see what they have done to deserve it. It will be surprising if many of them find fault with what the author writes; for innumerable references have been consulted. Many facts, which I can check by personal knowledge, I find completely accurate. From this I deduce, perhaps illogically, that the rest is accurate too. It is a monumental work.

To quote the Foreword by Lieut.-General Sir Ronald Charles: "In recording the development of the engineer arm of the Indian Army the author has traced its evolution against a background of nearly two centuries of warfare both in and outside India."

Beginning in 1759, two years after the Battle of Plassey, the author shows us the first Pioneer units, formed of volunteers from European regiments assisted usually by Lascars. The author quotes a Captain Munro, H.M. 73rd Regt., in an account of the Pioneers in the campaign in Southern India. He describes camp life during the early Mysore Wars. The Sapper officer of to-day will be interested to learn that two hundred years ago, according to Munro, "it would be absurd for a captain to think of taking the field without being attended by the following enormous retinue, viz. dubash (butler) cook and boy; and as in these times, bullocks are not to be had, he must assemble fifteen or twenty coolies to carry his baggage, whom with a horse-keeper and grass cutter and sometimes a dulcinea and her servants complete his train, having occasionally the assistance of a barber, washerman and ironer, in common with the other officers of his regiment . . .

His tent is furnished with a good large bed, mattress, pillows, etc., a few camp stools and chairs, a folding table, a pair of shades for his candles, and six or seven trunks with table equipage; his stocks of linens (at least twenty-four suits); some dozens of wine, brandy and gin; tea, sugar and biscuit; a hamper of live poultry and his milch-goat . . . ." From such a beginning the author follows the story of the Engineer arm up to 1939.

It is interesting to note that an unsuccessful attempt was made in 1776 to recruit a company of German military artificers. After many vicissitudes, which must have been heart-breaking to those concerned, there were established the three Corps of Sappers and Miners; and the author discusses the vexed question of seniority with an impartiality that should satisfy the most ardent partisan.

He describes the achievements of the Sappers and Miners in Burma, Ceylon, Malaya, Afghanistan and Tibet; in China and in the Sikh Wars. Two chapters are devoted to the Mutiny. It will come as a surprise to some readers to find the part played in the last century by the Sappers and Miners in the Middle East: in Persia in 1819, 1856 and 1857; in Abyssinia in 1867; in Malta in 1878, Cyprus in 1882 and at the Battle of Tel-el-Kebir. The present century is not the only one in which the British lion has had to show its teeth.

There is a long and detailed account of almost all the North-West Frontier expeditions from 1849 to 1908, and of many North-East Frontier expeditions. Four chapters are devoted to operations between 1918 and 1939 on the North-West and North-East Frontiers, and in Afghanistan, Iraq and Iran.

The most important section of the book is perhaps the six chapters on the 1914–1918 War. The Sappers and Miners fought in all theatres. Events are vividly described and the atmosphere cunningly captured: the cold of the French winter of 1914; the excitement of a lonely reconnaissance in No-man's Land; the flies in Mesopotamia; the exhilaration in pursuit of the Turks into Syria; or the humour of the soldiery. The author had what is now called "an unlucky war." Yet he writes without rancour of the operations ending in the surrender of Kut; and his strictures on the handling of the campaign by the Indian Government are restrained. All through this and other campaigns the author gives a fair and balanced background against which to paint the detailed picture of the Sappers' work.

Every campaign can be followed on adequate maps (47 all told) interspersed in the letterpress, and there are three small-scale maps in a folder at the end. There are many interesting illustrations. The book is well printed and excellently produced. The Index is good. The 726 pages do credit to the Institution of Royal Engineers as publishers no less than to the author. The Corps may well be proud of this book. It is a fitting tribute to its magnificent work in India.

How then should this book be rated? As a military history it is accurate and readable. Its great length makes it rather a mouthful to read from cover to cover. Having done so, however, I must confess that I thoroughly enjoyed it. Though its chief value is as a book of reference, one can dip into it when one has an hour to spare and read with enjoyment of the people and places one knows. There should be a copy on the shelves of every Mess Library.

Copies may be obtained from the Secretary, Institution of R.E. for 25s., or at the special reduced rate of 10s. for members of the Sappers and Miners, or of the Institution of R.E.

M.C.A.H.

DESIGN FOR WELDING

By F. KOENIGSBERGER

(Published by Longmans, Green & Co. Price 18s.)

The author of this book has very clearly set out the advantages and the disadvantages of welding, and very rightly thinks that each problem should be considered on its merits. When considering the technical and economic aspects of whether or not fabricated welded construction is the most advantageous, the mechanical properties of the metal and the varying problems likely to be encountered in the manufacturing process, together with costs of production must be known. These problems are freely discussed, together with the economic aspect. The reasons why difficulties are experienced when welding high tensile steels, and the tendency for the formation of cracks are explained at length. In dealing with structural steelwork, examples show that weight for weight, welded structures can be designed having approximately twice the load carrying capacity of the normal rolled sections.

The chapter on welded joints clearly describes the various types of welds. Examples of weld failures are given. Various figures and diagrams of butt and fillet welds are shown, giving ultimate stresses for alternating and pulsating loads (2,000,000 cycles or more) as found by different research workers. Stress calculations for butt welds, parallel fillet welds, etc., under bending, tension, and shear have been set out at great length and amply illustrated by diagrams. Joints by the arc welding and resistance welding processes are dealt with separately, and very thoroughly.

In the general design principles for welded construction, the author has given a graphic method of determining the stresses and metal thicknesses, etc. He has dealt very fully with the question of ribs in a structure, and has illustrated by graphs and calculations the conditions of stiffness and strength for various designs. In designing welded structures, emphasis is laid on the provision of adequate accessibility. If the welder can " get at " the structure, he can produce sound welds which will meet the requirements of the designers' specifications. Inaccessibility may be dangerous and lead to bad welds and possible failure of the structure.

In the chapter dealing with detail design of part assemblies, there are several useful examples with illustrations and calculations. The use of intermittent welding on stiffeners or ribs is well explained, together with details showing how bosses for bearings, etc., can be rigidly and accurately located. There are many typical examples of welded structures. The example of a lattice construction for a 10 Ton Crane Bridge is particularly clear, and a table showing the procedure for calculating various sections and the resulting stresses in the lattice girder are given. A very good example of welded construction is also clearly shown in the section of a milling machine. Here the design has been carefully considered in that the main body and smaller portions are fabricated, whilst the saddle is a casting. Other typical examples are a 100,000 kw. alternator stator, a diesel engine cylinder block, and the design and calculations for Pressure Vessels.

In the final chapter, Drawing Office Practice is commented on ; one illustrated example shows how various components are flame cut to facilitate assembly work. The advantages of multi-run welds over the single run weld are given and residual stresses, heat treatment, soaking times and cooling processes together with other items which may appear on the drawing and specification are fully described. The relations of the D.O. with the Planning and Inspection Depts. have been fully commented upon.

In conclusion it is considered that *Design for Welding* is a most useful book for the " Designer," " Draughtsman," and the " Man in the Works."

C.S.B.

PRODUCTION ENGINEERING

By J. S. MURPHY, A.I.I.A.

(Published by The Louis Cassier Co. Ltd. for *Machine Shop Magazine*. Price 12s. 6d.)

In this book the author shows, from a practical aspect, how the basic principles of planning and organization should be applied to engineering production.

Though intended for study by engineers employed in factories making articles for industrial markets, the methods of planning and controlling production that he advocates are equally applicable to Army workshops of all kinds and sizes and are, therefore, of interest to officers of all ranks employed on work of this kind, whether in an executive or administrative capacity.

The systems described are of a general kind and not restricted to any particular class of product or type of factory, nor does the author go into details of business administration or labour management. The aim is to achieve the maximum economy of time, labour and materials by the application of a simple but systematic routine to a flexible organization that can be adapted to meet changing conditions and requirements, factors inseparable from any engineering work in the Army.

The close relationship between Service and Civilian problems and the methods of solving them is frequently, if unintentionally, brought out in this book. For instance, the necessity for close and continuous co-operation between the executive and administrative branches and for the rapid dissemination of accurate and up-to-date information are specially stressed. The author's plea that, " the purpose of a record is not for someone to gather a lot of information and sit on it ; the purpose is to be able to provide information immediately to anyone who may require it," should strike a chord of sympathy in the hearts of most military readers ; it also tends to refute the tradition that, in actual practice, business methods are necessarily more efficient than those of the Army.

The line of reasoning on which the recommended procedure is based is comparable to that of a military appreciation in that the object, factors and methods proposed are clearly set out ; the object, however, does not, as one might expect, always appear at the beginning but sometimes in the middle or at the end of the appreciation. Apart from this, the methods advocated are described in sufficient detail for them to be put into practice, are well illustrated by photographs and diagrams and, where appropriate, supported by examples taken from production methods in actual use.

The author develops his theme by considering the successive stages through which an item passes from the original idea to the completed product, each stage being dealt with as a separate function in the order in which it would arise in practice.

All classes of production work are taken into account, including quantity production, either by batch or by mechanized line flow methods, experimental and jobbing work and the manufacture of jigs, tools and fixtures needed for special purposes. The distribution of labour to the various tasks according to skill, the selection of tools and materials best suited to the purpose and the comparative merits of different manufacturing processes, are fully considered at every stage.

There are ten chapters in all, of which the first eight describe the main features affecting production engineering such as programme planning, design, the organization of stores, drawing and clerical offices, process layout and workshop organization, including maintenance of plant and the internal transport of stores and products. The two remaining chapters deal briefly with time and motion study and with estimating and costing, both rather involved and specialized subjects; their value to the average workshop officer lies mainly in the guidance they give in training unskilled workers and in economizing time, effort and materials.

A list of relevant textbooks is given at the end of each chapter and there is a short index.

This is essentially a practical book which fills a gap not covered by the average textbook and can be recommended to any who may be concerned with the operation or management of engineering workshops, whether engaged in production or repair work.

C.D.A.F.

STRAIGHT ON FOR TOKYO

By Lieut.-Col. O. G. W. White, D.S.O.

(Gale and Polden Ltd., Aldershot. Price 15s. 0d.)

Lieut.-Col. White writes with authority on the work and play of the 2nd Battalion The Dorsetshire Regiment between 1939 and 1948; for he was born in the regiment, the son of a company commander, and he commanded it for three years of war and peace. He describes in *Straight on for Tokyo* the Battalion's part in the B.E.F. operations of 1939–40, their stay in England during the Battle of Britain, their journey to India, their training there before going into battle at Kohima in 1944, the jungle war, the occupation of Japan, and the disbanding of the Battalion in 1948.

Anyone who served in the Battalion will be interested. There is, in great detail, what was done and by whom. The book will appeal also to those who served in the 5th Brigade and in the 2nd Division (particularly 208 Fd. Coy., R.E.). It gives a good idea of life in a battalion on active service: the triumphs, the failures, the irritations and the minor incidents that are the lot of the regimental soldier. And one sees how tradition and discipline enabled the Fifty-Fourth to make the best of everything, whether it was a battle, at gymkhana or a ceremonial parade in Tokyo.

It would be wrong to commend this book without stint, for it has blemishes. The "big picture," although usually given, is not described sufficiently lucidly for the uninitiated to follow. The maps are dotted about the book and there is no reference to the appropriate one at the head of each chapter. The author was not present at the battles of 1940 in France and Belgium, and his account reads like a citation with too many catch-phrases. The description of the jungle, on page 77, may be an apt simile for those who saw it, but it gives no idea (except that the ground was not flat) to those who did not.

The part of the book that will appeal most to the general reader is the description of Japan and the problems of the occupation forces there. It gives one a thrill of pride to read of the example set by the 2nd Dorsets, and the splendid way they represented their King and Country there.

The fact is that a writer cannot please everyone: the lance-corporal of "A" Company and the reader who has never heard of "A" Company. The author has, quite rightly, chosen to interest that fine body of West-countrymen who made the story that he here records. And if you buy the book you should bear this in mind.

M.C.A.H.

TROOPSHIP

By Lieut.-Col. R. A. Chell, D.S.O., O.B.E., M.C.

(Published by Gale & Polden Ltd. Price 6s. 0d.)

Nearly everyone in the Army travelled at some time during the war in a troopship, and most of them were very glad when the journey was completed.

In the early days of the war the O.C. troops and most of his staff were selected for each voyage from the troops on board, but in 1942 it was decided to appoint permanent O.C. troops and staff to the troopships doing long distance voyages. The greatest credit must be given to these officers and O.Rs. who carried on with their difficult jobs year in year out.

This book gives a good idea of how one O.C. troops carried out his duties over a period of some three years, during many voyages to all parts and with troops of all kinds, including American as well as British. It shows the steps taken, under very difficult circumstances, to keep the troops occupied and happy and at the same time, while always alert for attack from the air or underwater, to prevent unnecessary or false alarms.

C.C.P.

DOWSING

By W. H. Trinder

(Published by the British Society of Dowsers, York House, Portugal Street, London, W.C.2. Price 10s. 0d., or 7s. 6d. to Members of the Society.)

Two books on dowsing have been received for review. This is perhaps one of the most controversial subjects of any and it is, therefore, good for everyone to learn as much as possible of the details of the subject when published by such a reliable source as the Society itself, which was formed in 1933, with Colonel A. H. Bell, D.S.O. (late R.E.) as its President, which position he still retains.

Perhaps one of the most interesting statements in Trinder's book is contained in the Foreword, where it is stated that, after three years of research work with very delicate electrical instruments, it has been found that when passing over subterranean water or other substances, holding a rod, in almost every case a change of muscle tone was indicated by the instruments, although in some cases it was not sufficiently strong to move the rod. They add " We have found that the simpler dowsing phenomena, the location of underground streams, ore bodies or conductors above ground exhibit a similar pattern. So it is perhaps not to be greatly wondered at that some high frequency radiation may be the cause of all such phenomena."

The book starts by describing the different types of instruments, how to use them and how to assess location, depth and quantity. Different metals, etc., will make a pendulum rotate a different number of times, and these numbers are used as serial numbers to decide on the nature of the metal located. Trinder gives a warning here that ground which has once contained a metal, which has later been removed, will still give off rays and so lead to the assumption that the metal is still there. Musical notes and colours also give off rays and can be compared.

There is an interesting chapter on " Dowsing and Horticulture " in which is explained how the reaction of a pendulum over different types of soil can be compared with its reaction over various plants or seeds. When reactions are similar the soil is most suitable for that particular plant.

Then we come to a chapter on "Dowsing from Photographs or Maps" and no clear explanation is given of these reactions. Trinder assumes that the natural ray is transferred to the photograph or map, but as the print of the photograph or the map which is used has probably never been near the place of the original ray this is difficult to accept.

With the exception of this chapter the book gives a very clear and straightforward description of what Dowsing can be expected to do. For anyone who is not an ardent adherer to the faith it is perhaps a pity that the chapter on photographs and maps has been included as it introduces another side which cannot be explained by the scientific theory of the "ray," on which the rest of the book is based. Henry de France in his book *The Elements of Dowsing*, reviewed below, treats this practice as a psychic reaction and it is perhaps better left at that. C.C.P.

THE ELEMENTS OF DOWSING

By Henry de France, translated by Colonel A. H. Bell

(Published by Bell & Sons, Ltd., London. Price 6s. 0d.)

This book covers much the same ground as Trinder's book, reviewed above, but includes the additional subjects of Alimentary Radiesthesia and Medical Radiesthesia. In the former case the reaction of the pendulum is tested over food and the reaction when the hand is placed between the food and the pendulum. From these reactions the effect of the food or drink on the individual can be ascertained.

In the medical case the pendulum will give different results over healthy and unhealthy parts of the body, or specimens from the body, and by carrying out similar tests with various remedies one can tell which is most likely to have the best effect.

The examination of maps and photographs using a pendulum he calls "Teleradiesthesia" or "Superpendulism." He explains, that although many people have the power to get results, this procedure is quite distinct from ordinary Dowsing, or "Radiesthesia" as he calls it. The latter is a matter of working by the senses, whereas Teleradiesthesia he says can be compared to intuition. It might be in the interests of Dowsing if this distinction could be clearly maintained in all cases and if all dowsers carefully avoided any suggestion that the location of water or minerals could be assessed by the same methods off a map as on the ground. C.C.P.

PRACTICAL FIVE-FIGURE MATHEMATICAL TABLES

By C. Attwood, B.Sc., B.Sc.(Eng.), A.M.I.E.E.

(Macmillan & Co., Ltd., London. 3s. 0d.)

This publication contains the usual tables and some very clear and concise notes on the use of the tables.

The compiler has taken particular care to check and where necessary recalculate the mean proportional parts included in the tables for interpolating between successive entries. M.P.Ps. are printed in red where they are to be deducted. There is a table in the notes showing the maximum possible error for forward interpolation in the use of any table.

The volume is well and clearly printed and bound in limp cloth.

For the range it covers this is a compilation to be much recommended.

E.M.E.C.

PREJUDICE AND JUDGEMENT

By P. J. Grigg

(Jonathan Cape, 30 Bedford Square, London. Price 16s. 0d.)

Military readers will like many things in *Prejudice and Judgement*, the autobiography of Sir James Grigg, late Secretary of State for War. They will like his portraits of the political figures of the last thirty years. As private secretary to five Chancellors of the Exchequer he had a unique view. He not only saw politicians, as others do, on the stage ; word perfect, and made up. He also saw them at rehearsals ; fumbling in gesture and shaky in their lines. One feels that the author could have told us more. Perhaps long years of the Civil Service bred in him a caution against committing all his opinions to writing. It would be fun to hear him on the same personalities in an expansive mood at the dinner table.

It is also interesting to read of the methods of the great. Most officers would, themselves, like to be great. Many might say " I'd like to see a really big man do his job ; to learn from him." Here one sees many in action. But they are all different. There is no sealed pattern for greatness.

There are pen-pictures of six great soldiers—Alanbrooke, Montgomery, Alexander, Paget, Giffard and Dill. These have appeared as articles in the *Sunday Times*. With the exceptions of Giffard and Dill, about whom most of us know too little, there is nothing much new here.

We are told a lot about Churchill ; as Chancellor of the Exchequer, " in the wilderness," and as Prime Minister. We see him as his private secretary saw him ; and as the Secretary of State for War saw him. We get glimpses of him in many moods : angry, artful, flippant, buoyant, and in his great historic attitudes. It is a fascinating picture and, in some ways, the best part of the book.

We are told a tremendous amount about the national finances between the wars ; too much, in fact, unless one is a financier. And there are interesting chapters on the author's early life ; in the army in World War I ; and in India.

We also learn a deal about Sir James Grigg. Most officers who were in touch with rank-and-file opinion at the time will agree that he was widely known and disliked by many when War Minister. I have heard it said that it was antipathy to Grigg that turned the army vote to Labour in 1945. When you read this book you wonder why. Could it be that his command of the written word made him prefer it to the spoken word : that he would write rather than speak ; or send a letter rather than pay a visit ? This is conjecture. However, whatever you may think you will see in this book a capable but homely person who served his country with fidelity and distinction.

This book, then, lends itself to " skipping," and that is the way to read it—but it should be read. M.C.A.H.

CEMENTONE NO. 2 WATERPROOFING POWDER

(Published by J. Freeman Sons & Co., Ltd., Wandsworth, London, S.W.18.)

This small pamphlet of twelve pages gives very clear and useful data on the best methods of using this material for all types of waterproofing of buildings. It has a large number of very good illustrations showing how the work should be done. The pamphlet should be read by anyone having to carry out this type of work so as to ensure successful results. Copies may be obtained free of cost on application to the publishers as shown above. C.C.P.

TECHNICAL NOTES

FLAME CLEANING STEELWORK BEFORE PAINTING

(*The Railway Gazette*, dated 25th June, 1948)

A report on the advantages of removing scale and other deposits from steelwork by oxy-acetylene flame before painting, has recently been made to the American Railway Engineering Association. This interesting article extracts some of the cardinal points of the report.

Flame cleaning is now proving more economical than sand blasting, especially for jobs out on the line, as the plant can be handled and transported much more easily than the heavy compressors and sand needed for sand blasting. There is also a considerable saving in time.

The primary condition for effective cleaning of steelwork by this method is quick and intense heat ensuring that the scale and other surface material shall expand rapidly as opposed to the parent material and separate from it. A slow heat causes fusion instead of separation. An oxy-acetylene flame is generally used. It is recommended that painting should follow flame cleaning as closely as possible so that the metal does not cool off and gather moisture and rust.

With the thought of advancing the knowledge of this practice, the report is summarized in the American publication *Railway Engineering and Maintenance* of May, 1948.

WIND TUNNEL FOR SUSPENSION BRIDGE MODELS

(*The Engineer*, dated 29th October, 1948)

An investigation of the aerodynamic oscillations of suspension bridges was begun early in 1946 with the object of providing guidance in the construction of the Severn suspension bridge. The serious study of aerodynamic oscillations of bridges dates from 1940, after the disaster of the Tacoma Narrows bridge in the U.S.A., and intensive American researches into this subject have made notable advances and have cleared much obscurity from a very complex problem.

Persistent and dangerous oscillations of suspension bridges in wind are due to adverse interaction between the forces due to inertia, gravity, stiffness and wind. In this respect they resemble wing flutter on aeroplanes. However, the bridge problem presents special features which are discussed in this article. The experimental methods employed are also given, together with a description and photographs of the wind tunnel and model Severn bridge used at a recent demonstration.

MECHANISED CARGO HANDLING

(*Modern Transport*, dated 9th October, 1948)

An interesting example of the multitudinous ways in which mechanized handling aids can be applied to transport purposes has recently been introduced at London Docks. In recognizing the necessity for the seasonal tomato and new potato traffic from the Channel Islands to reach their markets in and around London, as quickly as possible, a noteworthy advance in the technique of handling this traffic and also general cargo has been achieved.

Certain alterations were made to the layout of an additional berth, and fork trucks and pallets were introduced. It is understood that four such trucks in conjunction with twenty to thirty pallets have unloaded, on one occasion, 26,000 trays of tomatoes in 6½ working hours. One or more of these trucks are kept in reserve in case of emergencies.

This article continues to describe how the discharge is effected and how the cargo is cleared from the port area. The ready co-operation of the P.L.A. in providing suitable loading platforms and ample space for road vehicles has gone a long way in assisting this effort to promote a quicker turn round of vessels and delivery of goods to vehicles. This is a welcome step forward towards the solution of port problems, which are always very much in the news.

SWING BRIDGE RENEWAL ON THE CHICAGO AND NORTH WESTERN RAILWAY

(*The Railway Gazette*, dated 12th November, 1948)

This article describes how a 162-ft. deck, lattice girder, swing span over the Sheboygan river in Wisconsin was replaced by a plate-girder span weighing 140 tons and was ready for rail traffic in nine hours.

The C. & N.W. Railway decided some time ago to replace the single-line swing span, and although it was realized that there was no necessity for a swing span at this point, it was considered advisable for the new span to be easily convertible to a swing bridge should it become necessary at some future time.

The new span was designed, therefore, as a plate girder, deck structure 162 ft. long, with the girders 7 ft. apart, and their middle three-fifths 7 ft. 6 in. deep, and the remaining one-fifth at each end tapered ; the whole capable of central and end support. The span was conveyed from the shops on two 200-ton flat trucks, with a dummy in-between and one at each end, five trucks in all. The description of the change-over is accompanied by two very good photographs of the actual work.

ALUMINIUM BRIDGE AT SUNDERLAND DOCKS

(*The Engineer*, dated 3rd December, 1948)

Although aluminium alloys have been used for bridge construction before, the first bascule bridge in the world to be built of aluminium alloy was officially declared open at Sunderland Docks on 26th November by the Minister of Transport.

This new structure replaces a swing bridge and is part of the scheme for the improvement of the Port of Sunderland to enable it to cope with greatly increased volume of general cargo traffic.

The Hendon Dock Bridge, as it is known, is of no great size. It derives its peculiar interest from the fact that its moving parts are made of aluminium alloy. The article is illustrated by engravings and also gives the dimensions and other relevant particulars of the structure.

The operating machinery is designed to raise and hold the bridge in any position against a wind load of 15 ft. per sq. ft. The bridge carries a 9 ft. roadway, with a single railway track and two 4 ft. 9 in. footpaths. The overall saving in weight when compared with a similar mild steel bridge is of the order of 50 per cent, but the article gives no price comparison.

DETERIORATION OF STRUCTURES OF TIMBER, METAL, AND CONCRETE EXPOSED TO THE ACTION OF SEA-WATER

NINETEENTH REPORT OF THE COMMITTEE OF THE INSTITUTION OF CIVIL ENGINEERS

Timber, on account of its suitability for fabricating field structures and its availability close to most sites of operation, is a very popular medium for many military works. It is no less popular with some marine organisms, which, equally with the engineer, regard immersed piles as a means of support. For jetties and piers therefore, if more than a limited life is required, some regard must be paid to the resistant properties of the timber available and to measures which can be taken to protect it against attack.

Research into this question has been carried out over a number of years by a committee of the Institution of Civil Engineers, and the findings from trials on timber to date are published in the nineteenth report. From observations made, marine animals that attack timber, such as Teredo, are found to be more active in tropical and sub-tropical sea-water. Oak, elm and softwoods exposed in these conditions may be destroyed in a few years, although some species of softwoods are suitable for use in northern waters.

Timber immersed in fresh water, water of low salinity, or water chemically contaminated, is free from attack and its life is dependent only on its resistance to fungal decay. Fungus does not attack timber that is continuously immersed.

Some species of timber such as greenheart, turpentine and jarrah are stated as naturally resistant to attack by marine organisms. But under service conditions unless such timbers are available in the area, unsuitable species may have to be used, and if a reasonable expectancy of life is required, special preservative treatment must be relied upon. The report gives the results obtained by the use of various types of preservatives and reaches the general conclusion that the most satisfactory type at the present stage of knowledge is coal-tar creosote. Of the other preservatives tried, "Celcure," a proprietary substance containing potassium dichromate, copper sulphate and chromium acetate, has also indicated satisfactory resistant properties under test at Singapore.

Generally the resistant properties of the timber is dependent on the degree of penetration of the preservative and creosoting under pressure is in most cases the only satisfactory answer. Ordinary surface applications of creosote may add to the appearance of the structure but will do little to provide a durable resistant surface and may be quickly removed by sea action.

Some timbers possess the quality of absorbing creosote readily through the surface and these species will therefore be preferred when naturally resistant timbers are not available. Absorption of the order of 5 lb. or more per cu. ft. appears necessary to get a good degree of protection and absorption may be assisted by incising the surface of the timber. It is noted that some widely used timbers such as Douglas Fir are not resistant to marine borers and at the same time offer considerable resistance to penetration of creosote, although incising helps.

A point of interest brought out in the report is that round piles respond more readily to treatment than square timber, due to the ability of the outer belt of softwood to absorb preservative. This property is somewhat lost in square timber, due to the exposure of the less absorbative heartwood in cutting. Square timber offers greater facility for jointing, but the use of steel grid connectors simplifies the connection of round timber and may therefore commend its use on account of its suitability for preservative treatment.

Cutting or boring after treatment provides an entry point for marine borers to the untreated interior of the timber and should be avoided.

A card index system for timber identification is under preparation and it is intended that cards for each timber species will contain information as to its resistance to marine borers and its suitability for preservative treatment.

AIR POWER AS AFFECTED BY AIRDROME CONSTRUCTION

BRIG.-GEN. S. D. STURGIS, JR., U.S. Army

(*Military Engineer*, August and September, 1948)

PART I

This is the first of two articles stressing the importance of keeping aircraft design in step with aerodrome construction. The operations in the Pacific during the last war furnish an excellent example of how the airfield engineers were able to construct airfields in the combat zones with sufficient speed and in adequate numbers, capable of supporting the types of operational aircraft then in use. This article sets out to show how; despite much talk of long-range push-button warfare, a future war is likely once again to develop into a struggle for air bases. The early steps especially, may well comprise a world-wide struggle for aircraft bases within practicable operating distance of the enemy's war potential. There is no doubt that the side which can first construct all-weather, well dispersed airfields and maintain local fighter superiority in these regions will win. Thus the problem of airfield construction assumes such vital importance.

PART 2

This article discusses the present position in which the design of aeroplanes and the design of airfields has become out of balance, as aeroplane design has reached a stage in which aeroplanes cannot be supported on the ground without an enormous constructional effort. One of the fundamental reasons for this is that just as the Civil Engineer often has only the interest of the layman in aeronautics, the converse is also true. Both types of engineers must be more aware of each other's problems.

The author shows graphically how weights and tyre pressures have increased enormously since the war. The stage has been reached when to consider the building of a road as the same as building an airfield is a dangerous cliché. Airfield construction with 70 ton wheel loads, such as with the B.36, is more like providing continuous footings for a house. A 20 in. concrete slab is necessary. Multiple wheel loading is a possible answer to help the airfield engineer, but even this solution does not reduce the effort required in the construction of flexible pavements such as Pierced Steel Plank, or bituminous surfacing, on crushed rock, as it does for concrete. It becomes most important therefore that sites with as much strength as possible in the subsoil should be chosen. This is illustrated graphically.

It is also shown graphically how increase in tyre pressure also adds greatly to the construction effort required for flexible pavements. This trend is especially noticeable in fighters. The development of tracked landing gear is the most promising solution, if plane performance thereby is not too greatly handicapped. Although it is essential to keep air power and construction power in balance, it is up to the engineers to see that the performance of aeroplanes is not seriously handicapped by having to have disproportionately large landing gear.