THE GILLIS REPORT

AUSTRALIAN FIELD TRIALS WITH MUSTARD GAS 1942-1945

PEACE RESEARCH CENTRE • THE AUSTRALIAN NATIONAL UNIVERSITY

PeaceDoc No.1

THE GILLIS REPORT

AUSTRALIAN FIELD TRIALS WITH MUSTARD GAS
1942-1945

With a Preface by Shirley Freeman

Printed and published in Australia
at The Australian National University

Copyright © Department of Defence 1985

The book is copyright. Apart from any fair dealing for the purposes of private study, research, criticism, or review permitted under the Copyright Act, no part may be reproduced by any process without written permission. Inquiries should be made to the publisher.

National Library of Australia
Cataloguing-in-Publication entry

[Australian field trials with mustard gas, 1942-1945]. The Gillis report, Australian field trials with mustard gas, 1942-1945.

ISBN 0 7315 1322 3.

1.Mustard gas. 2.Gases, Asphyxiating and poisonous - Australia - War use. 3.World War, 1939-1945 - Australia - Chemical warfare. I. Gillis, Richard G. II.Australian National University. Peace Research Centre. III.Title: Australian field trials with mustard gas, 1942-1945. (Series : Peacedoc series ; no. 1).

358.340994

Unless otherwise stated, publications of the Peace Research Centre are presented without endorsement as contributions to the public record and debate. Authors are responsible for their own analysis and conclusions.

Designed by ANU Graphic Design.
Printed by ANU Central Printery.
Published by:
Peace Research Centre
Research School of Pacific Studies
The Australian National University.

THE PEACEDOC SERIES

The Peace Research Centre's PeaceDoc series is designed to reproduce important documents relating to peace and security issues.

Such documents might otherwise remain obscure, be difficult to find or stay permanently out of print.

PEACEDOC EDITOR'S NOTE

The Gillis manuscript was published by the Australian Department of Defence in 1985 and was tabled in Parliament by the Minister for Defence in March 1987.

In order to improve readability and remove inconsistencies we have carried out some minor editing. These changes are indicated in the text.- by square brackets where additions have been made and by triple full-stops where excisions were necessary. Punctuation changes have not been identified. Military ranks, which were abbreviated in the original, have been written in full, to facilitate understanding by a generation not as familiar with them as Dr Gillis and his colleagues. Finally, the footnoting system has been systematised and footnotes placed at the end of each chapter for accessibility. Otherwise the manuscript remains as close to the original as possible. Page numbers of material not in the original document are in brackets.

The Peace Research Centre is grateful to the Department of Defence for permission to republish the Gillis report and for the Department's cooperation during the publication process. In particular, the Centre wishes to thank the Materials Research Laboratory (Melbourne), the Campbell Park Library of the Defence Department (Canberra), and the Australian War Memorial for their assistance in locating original photographs.

I would like to thank Alistair Sands and Christine Wilson, Research Assistants, for their assistance in bringing this first PeaceDoc to fruition, and Karen Bowland and Carol Staples, who patiently typed and corrected the text.

Trevor Findlay
Canberra 1992

PREFACE

Shirley Freeman[1]

The Australian Armed Forces carried out field trials with mustard gas during the period 1942-45. Those were dark days for Australia. The armies of Japan had occupied most of Southeast Asia; in the west they had advanced almost to the borders of India, and in the south Indonesia and parts of Papua New Guinea had fallen to them. The Philippines and most of the Pacific Islands west of Hawaii were likewise occupied.

It was known that Japan had used chemical weapons in China. As early as 1937 there were reports of the use of mustard and probably phosgene from the Shanghai front. In 1941 the Australian war correspondent Wilfred Burchett sent photographs to London of badly injured Chinese soldiers in the Chungking hospital. They had been gassed with a mixture of mustard and lewisite on the Ichang front. British intelligence reports stated: 'Lethal chemicals definitely appeared on the battlefield in the summer of 1941 and were used extensively wherever the Chinese were applying pressure and the Japanese wanted to conserve manpower. Ichang and Chungshe received the bulk of the attacks, the effects of which were studied by American observers'. After the attack on Pearl Harbour it became apparent that the Japanese had fielded chemical weapons in the southeast Asian area. Over the war years captured Japanese munitions were examined; in Australia this work was done by the 2/1st CW Laboratory, under Captain J. C. McAllester. In 1944 this laboratory issued more than 50 reports on captured Japanese CW equipment. Captured equipment was also examined at the Munitions Supply Laboratories at Maribyrnong. Both offensive equipment and protective equipment, such as respirators and overgarments were seen. A shell captured in the New Guinea campaign was found to contain mustard and lewisite, and glass grenades containing hydrogen cyanide or phosgene were found in the Solomons. British and American reports of cyanide grenades in Malaya and Guadalcanal were also available to Australia. A toxic smoke generator was found in a munitions dump at Soputa in 1942, and was found to contain diphenyl cyanarsine, a vomiting agent. It was considered likely that Allied troops would have to face CW attacks, and mustard seemed the likely agent.

Mustard and lewisite are blister agents which cause burns which resemble thermal burns. There is usually a delay of some hours after exposure before mustard burns appear; lewisite in contact with skin causes immediate pain. If soldiers are protected with respirators the burns heal over a period of weeks or months, apparently without ill effect. However if mustard is inhaled lung damage results and death may follow. Victims may live in pain for months before finally succumbing. Mustard is an alkylating agent which combines with the nucleic acids (DNA) which form the genetic code. Whether this effect is responsible for the blistering is not known, however it is probably the basis of the drop in the number of white blood cells that follows intoxication with mustard. It is potentially carcinogenic, and studies of the workers in Japan who made mustard during the war under appalling conditions suggest that they suffered a rate of lung cancer in excess of that found in the unexposed population. A study of exposed

workers in the UK also showed an excess of lung cancer, but not of skin cancer, although they had received skin burns. Other studies have not shown such a correlation, so one must suppose that cancer is a rare consequence of heavy exposure. Mustard is not a gas, but a liquid with the consistency of light oil. It evaporates, and burns may be due to exposure either to the liquid or the vapour. Lewisite is more volatile than mustard, and would probably have dispersed very rapidly in the tropical climate. Hydrogen cyanide would have been a gas at the prevailing temperature, and would also have dispersed rapidly. The glass grenades filled with cyanide appear to have been designed as antitank weapons, and might have been effective if the cyanide were dispersed inside the tank. Cyanide combines with the respiratory pigments inside all cells, preventing oxygen transport.

Many people remembered the casualties and the suffering caused by chemical warfare in World War I; it was essential that soldiers fighting in the Pacific region should be protected against its effects. Chemical weapons caused about one million casualties in World War I; some ten per cent of these died. Memories of the suffering of these men persist in Australia to this day, and chemical warfare is still regarded with particular repugnance.

It might also have been necessary for the Allies to retaliate in kind. Australia was a party to the Geneva Protocol which banned the use of chemical weapons, but at that time had reserved the right to retaliate. Neither the United States nor Japan had ratified the Protocol. It was considered during the war that the Allies would probably use gas warfare in retaliation, and that the US might initiate gas warfare on a limited scale after the European war if Allied lives were likely to be saved by such action. In March 1943, General MacArthur issued a Chemical Warfare plan for the Pacific area. The use of toxic chemicals would be initiated only on his direct orders; until then, chemical weapons would not be issued to combat units but would be held in reserve on the Australian continent. Some chemical weapons were held by Australian forces, but the greater part of those located in Australia were under direct American control. The chemicals were not made in Australia, although this was contemplated at one stage. Mustard and phosgene were imported from England, and American stocks of mustard came from the US. In the event chemical warfare was not used by either side, and after the war the stocks were destroyed by burning and by dumping at sea. Australia is fortunate in that the continental shelf does not extend for many miles to seaward, and most of the mustard seems to have been dumped in very deep water. Mustard that was dumped in the Baltic Sea, and near Okinawa, poses an ongoing problem to fishermen who from time to time dredge up live munitions.

Experience with mustard in World War I might not have been relevant to the more mobile war in the Pacific region, and it was also possible that tropical conditions might cause logistic problems not encountered before. Thus the mustard trials were carried out against the background of a perceived threat, and some anxiety as to how chemical weapons might behave in the tropical environment.

We must all be indebted to Dr Gillis for the collection and editing of the accounts of these trials that follow. They are vivid and personal, and make it possible for us to understand something of the tensions and fears of wartime. Chemical warfare was not

used in World War II; however this could not be known at the time. The dedication and courage of the people involved in the trials gave the Forces the knowledge that could well have been critical in withstanding a chemical attack. Gas is a horror weapon. In conventional war soldiers are trained to keep their heads down and return fire. Gas defeats their normal precautions and leads to chaos and panic. Only training and experience can overcome this, and make it possible for men to continue their mission. The Australian field trials must therefore be seen as a necessary part of our effort to defend our country against an invader who was perilously close. The service men and women who took part in these trials have largely been forgotten by history, the report that follows may help to set the record straight and give these people something of the recognition they deserve.

The trials were carried out by Australian servicemen and women under the direction of a team of British and Australian scientists and medical officers. Jack Legge describes how the team was put together and how they set up the unit to study the effects of mustard. They depended initially on information available from the Chemical Defence Establishment at Porton, England. It was soon apparent that the British experience was not relevant to Australian conditions. Later in the trials there was American involvement, however the work was essentially a British/Australian effort. All personnel endured hardships and most if not all sustained mustard burns. The scope of the trials may be seen from the 'Programme for Australian Field Experimental Station 1944-45', which appears at pages 50-55. Broadly speaking the trials encompassed medical and protective trials and weapons testing. In every area the European experience was found to differ markedly from that found in tropical Australia. Some of these differences could have been critical. Thus Jack Legge found that the chemical used to impregnate clothing in order to make it resistant to mustard caused casualties in the hot climate. The chemical was absorbed by the soldiers and converted the haemoglobin in their blood to methaemoglobin, which is unable to carry oxygen. Had this clothing not been tested before issue massive numbers of casualties might have resulted. The trials also showed that mustard was much more aggressive in the hot climate and it was estimated that burns were some four times worse than those that would have been expected from a similar dose of mustard in a temperate climate. The medical aspects of the trials were reported after the war in two articles in the *British Medical Journal.* [2]

The meteorological conditions, both under the jungle canopy and in open areas, affected the dispersal of mustard by shells and bombs. These latter studies were important not only from the point of view of possible retaliation, but also to predict what concentrations the enemy might be likely to achieve in the theatre of use.

Many reasons have been suggested for the failure of the combatants to use chemical warfare in World War II. The reasons are probably complex, but the fear of retaliation in kind must have been important. International law relating to chemical warfare goes back to the Hague Conventions of 1899 and 1907. Use in World War I, in breach of these Conventions, led to the drafting of the Geneva Protocol of 1925, which banned the use in war of chemical and biological weapons. This protocol attracted many signatories, but most entered a reservation to the effect that they retained the right to use

chemicals in retaliation. The United States signed the protocol but did not ratify it until 1976. However, the prohibition of use has been considered by many to amount to customary international law. The large scale use of chemical weapons by Iraq in the recent Gulf War was consequently a breach both of the protocol and of customary law.

Iraq used mustard and the extremely lethal nerve agents that were developed by Germany towards the end of World War II. Iranian casualties from mustard numbered many thousands. Burns and deaths followed the pattern of World War I, and should provide a sharp reminder that the trials in Australia in the forties are still relevant in today's world. Chemical disarmament, as envisaged by the Chemical Weapons Convention which is under negotiation in Geneva, will be multilateral and verifiable. The provisions of the convention are sweeping, and it has not yet proved possible to frame them in a way that is acceptable to all nations. It must however be realised that until we have such a Convention in place it will be prudent for states to maintain an effective defensive posture. Since World War II Australia has maintained a small unit at the Materials Research Laboratory which studies defensive (protective) aspects of chemical warfare. The scientists engaged on this work are the successors of the scientists of the forties, who in addition to the trials now reported carried out much research relevant to the military needs of the time.

The Australian mustard trials are a lesson of history. We should remember them and the dedicated people who carried them out.

Melbourne 1991

NOTES

[1] Shirley Freeman is a former senior principal research scientist with the Materials Research Laboratory (MRL), Melbourne, and was for many years principal scientific adviser to the Australian delegation to the Conference on Disarmament in Geneva. She was awarded the Order of Australia in 1989 for public service. She was the Peace Research Centre's 1990 Elizabeth Poppleton Visiting Fellow.

[2] D. C. Sinclair, 'Clinical features of mustard gas poisoning in man', *British Medical Journal*, 7 August 1948, vol ii, p.290, and D. C. Sinclair, 'Disability produced by exposure of skin to mustard gas vapour', *British Medical Journal*, 11 February 1950, vol i, p.346.

The Secretary
Department of Defence

Sir,

I was engaged in December 1982 by the then Department of Defence Support as a consultant with the purpose of producing a public record of Australia's activities in chemical warfare field trials during World War II. My active involvement in this editorial work ceased in early 1984. Officers of your Department have since attended to final editing and production of this document.

I now have the honour of presenting this report for your consideration and trust it meets with your requirements.

(R. G. Gillis, Ph.D., FRACI)
4: iv: 85

AUSTRALIAN FIELD TRIALS WITH MUSTARD GAS, 1942-1945

The events described in this publication took place more than 40 years ago, so that the number of persons with first-hand knowledge of them is diminishing. The Department of Defence Support (now Defence) engaged Dr R. G. Gillis as a consultant to prepare this document in order to record this piece of oral history. What follows are anecdotal, personal accounts of events edited by a scientist who was also personally involved. This collection has been produced as a contribution to our national history, from a time of great stress to the nation. It complements, rather than reiterates, what is available from archival sources.

AUSTRALIAN FIELD TRIALS WITH MUSTARD GAS

1942 - 1945

Editor: R. G. Gillis, Ph.D., FRACI

Men marched asleep. Many had lost their boots,
But limped on, blood-shod. All went lame, all blind;
Drunk with fatigue; deaf even to the hoots
Of gas-shells dropping softly behind.

Gas! Gas! Quick, boys - An ecstasy of fumbling,
Fitting the clumsy helmets just in time,
But someone still was yelling out and stumbling
And floundering like a man in fire or lime -
Dim through the misty panes and thick green light,
As under a green sea I saw him drowning.

In all my dreams before my helpless sight
He plunges at me, guttering, choking, drowning.

From 'Dulce et decorum est' by Wilfred Owen, 1893-1918.

FOREWORD

Mustard Gas In The First World War

Mustard gas, though not used as a weapon until quite late in World War I, had been known to chemists for more than fifty years. A paper in the *Journal of the Chemical Society* in 1859 described its blistering effect on human skin, while later in 1884 the noted German chemist Victor Meyer again drew attention to this vesicant property. In 1916, French chemists, sifting through chemicals that might be suitable as weapons, took a hard look at mustard gas. They were aware of both its toxic and vesicant properties but as it seemed less toxic than phosgene and prussic acid, gases already in use, they decided not to go ahead with its manufacture.

Eventually the Germans, who had launched the first cloud-gas attack in the early months of 1915, felt that mustard gas was worth a try; in July 1917 they shelled the British at Cambrai with high-explosive shell and two types of chemical shell - one containing diphosgene and one mustard gas. The HE and diphosgene, included to mask the mustard gas attack, failed in this; within two days chemists in Britain had identified samples collected in the field. And though British and French troops lacked protection against skin blistering, at least they knew they were under threat from a novel and effective weapon.

Suddenly the attack on the Cambrai Salient had brought a new dimension to chemical warfare. Less persistent gases, whether lethal like phosgene or merely lachrymatory, would be dispersed by wind within a few hours or destroyed by rain. But mustard gas, a liquid with a high boiling point (219°C) would linger in the shelled area for days or even weeks if the weather were cool. Troops were constantly at risk; the vapour is toxic at levels too low to detect by smell, so that men would not know when to don respirators, while the liquid lurking in shell holes or puddles, little affected by heavy rain, could inflict third degree burns that would put men in hospital for weeks or months. A low death toll but a high casualty rate meant that many troops had to leave their normal tasks and help to move gas-wounded to casualty clearing stations. Nor were humans the only casualties. Horses, so vital in bringing up supplies, became crippled from walking across contaminated ground, so rations, stores and ammunition had to wait on motor transport not always available or adequate in that muddy and battered terrain. Thus a successful mustard gas attack tended to paralyse enemy activity and to shatter morale, for the troops would never be sure when they could eat, drink, sleep or even sit down safely.

In introducing mustard gas as a weapon, the Germans showed a logical and practical approach. Their chemical industry was far ahead of any other in Europe; they had factories built, manned and on stream, while the allies had not even devised a manufacturing process. Not until June 1918, eleven months after Germany had first attacked with mustard shell, were the French able to return the attack. Due to delays in adopting an economical process, the British were even later; finally on the night of 26 September 1918 they fired 10,000 shells with devastating effect. Prisoners reported on battalions losing a quarter of their strength, of batteries out of action for days and of

divisions relieved after only a few days' action. A notable victim of a later attack was Adolf Hitler, who stated in an interview many years afterwards: 'The end of it came on 14 October 1918 when with many of my comrades I was knocked out by the new mustard gas which the British were using for the first time'.

Why then did the Germans fail when they had first use of a weapon as demoralising as mustard gas? C. H. Foulkes,[1] Gas Adviser to the Commander-in-Chief Allied Forces, gives several reasons. German stocks of mustard gas were low due to their slow and costly process of manufacture. Instead of waiting until they had built up huge stocks of mustard shell and then launching a massive surprise attack, their first attack was somewhat experimental. As a result the Allies, alert to the threat, were able to take countermeasures. Also the Germans would not risk storing gas shell at the battery positions where it would have been used swiftly and effectively when the allied troops were assembling for attack. But the British and French attacked with thousands of mustard shell launched as rapidly as possible, thus building up crash concentrations of gas which penetrated the German respirators, causing the troops to lose confidence in them.

A despatch from a German war correspondent vividly catches the confusion and misery of life during a gas attack:

> A salvo of gas shells whistles over, bursting 100 metres away with a weak explosion. Gas! In a trice the masks are on and nosebags filled with moist hay are drawn over the horses' mouth and nostrils. We wait until a few more salvoes arrive and then continue our route through the poisonous cloud. The eyepieces become misty and breathing becomes difficult and we cannot see our way. And then gas! The mask makes freedom of movement impossible with its horrible pressure on the face and the eyepieces besmirched with mud and gore. Rifles full of water. The ground on which one seeks a foothold, a sliding morass. Impossible to eat! And day and night the same!

Today's critics of the Australian mustard gas trials held during the forties tend to look back on them as a useless, even a sadistic exercise, where an obsolete chemical weapon caused unnecessary pain to unwitting victims. But people of the twenties and thirties thought rather differently. With still vivid memories of mustard gas attacks in 1918 they were quite certain that it would be one of the major weapons if war broke out again. Statistically mustard shell proved five times as effective as explosive shell; had the war continued through 1919, both sides planned to use even more chemical shell and fewer HE [High Explosive]. Nearer to home, Munitions Supply Laboratories (one of MRL's [Materials Research Laboratories] early titles) during the twenties added a fourth section to its establishment of Chemistry, Physics and Metallurgy sections, that of Chemical Defence, whose scientists were to keep abreast of new developments in chemical weapons.

Also the mood of those times is also clear from the many books on civil defence published in the late thirties.[2] Air raid shelters had to be 'splinter proof, blast proof and gas proof' and frequently most of the text is devoted to protection against mustard gas.

Shelter doors [were to be bedded] onto draught strips or other soft seals so that no poisonous vapour [could] enter. Cracked plaster was to be repaired and sealed with varnished brown paper. Gas blankets were to be kept wet with decontaminating fluid; a tray of fresh bleaching powder placed at the shelter entrance to neutralise mustard gas on shoes; shelter 'leakage time' was to be determined by placing amylacetate outside and measuring the time elapsed before the vapour could be smelt inside. Keyholes and waste pipes were plugged with putty, chimneys stuffed with sandbags. If many people occupied the shelter, ventilating air was pumped in through beds of charcoal, maintaining a positive air pressure so that leakage would be outwards rather than inwards.

It is not surprising then that the British and Australian armies, expecting this weapon to be used, conditioned by experience with it in Europe, and knowing that Japan had used it against China in 1937, would be anxious to assess how it performed in the tropics where higher temperatures, less air movement and a vastly different terrain could enhance its effectiveness and aggravate the problems of protecting troops. Hence the Trials.

NOTES

1. C. H. Foulkes, *Gas! The Story of the Special Brigade*, Edinburgh and London: William Blackwood and Sons Ltd, 1934.

2. H. M. Hyde and G. R. F. Nuttal, *Air Defence and the Civil Population*, London: The Cresset Press Ltd, 1938.

CONTENTS

MAPS AND ILLUSTRATIONS

ACKNOWLEDGEMENTS

This account of the trials could not have been put together without assistance from the staff at Materials Research Laboratories [*sic*]. I am specially indebted to Mrs E. King and her staff of the Typing Pool, to Mrs Rene Higgins and her colleagues in Word Processing, to Mr Max Butler for the figures and maps, and also to the Library staff.

Group Captain A. M. Stewart (RAAF ret.) formerly of D. Arm. [Directorate of Armoury], who was on flying duties at the time of the trials read a late draft of the manuscript and made helpful suggestions.

INTRODUCTION

The Australian Mustard Gas Trials held during World War II received no publicity at that time, and now there are very few people who remember them. From time to time statements are made in the media about these trials, and returned servicemen ask questions of the Minister for Defence. Defence staff then have to study the records to try to put together information for answering Parliamentary Questions. Most of the records have been declassified, but they are not easy to find. The general outlines have been available since the 1950s in Professor Mellor's Chapter in the Official War History.[1] The medical results were also published in medical journals over thirty years ago.[2]

Media reaction to chemical warfare trials is usually emotional, in the daily press, in weekly magazines and in some television programs. Such reports are generally handled by people with no knowledge of scientific method, of chemistry, physics or biology. The so-called investigative reporters often do not investigate but merely repeat hearsay.

Because of these aspects it was decided to produce an unclassified narrative account of what did happen and why, and for this to be available to the public. As I am one of the few people who were involved and knew all of the main participants, I was asked to undertake the task. In addition, I am now retired and have the time and interest to attempt it.

Participants were contacted and asked whether they were prepared to talk with me with a tape recorder running. If they agreed, then a visit was arranged and the interview was recorded. Tapes were then transcribed and returned to the participants for corrections and additions.

Not all of the people on the original list responded, but from time to time during the interviews, people would ask 'Why don't you talk to So and So?' If a name came up more than once it was added to the list. In a few cases, people were contacted by writing or by telephone and no formal interview was held. As shown in the Appendix, sixteen people participated. Finally, corrected transcripts were assembled into a logical order to produce a consolidated statement.

Individual accounts have been fragmented as little as possible, so that there is occasional repetition and the order is not strictly chronological. Individual memories do not always agree on the order in which some events occurred. In such cases no attempt has been made to force agreement.

With regard to media reports, the term 'guinea pigs' is quite inappropriate when referring to volunteer human subjects. Guinea pigs or other laboratory animals are involuntary participants in experiments, and are frequently sacrificed at the end of the experiment so that the effect on particular organs can be determined.

In these trials the subjects were volunteers and they were told beforehand why the trials were being held. The main objectives were to find out how mustard gas affected troops under tropical conditions, the level of contamination that would make them ineffective

as soldiers, the deficiencies of protective equipment and how to improve methods of treatment of casualties. The volunteers co-operated willingly and deserve better recognition for their participation than they have received to date. Nobody died as a result of the experiments. Although they suffered very severe skin burns, every effort was made to ensure that they did not suffer any damage to their eyes, or their lungs.

In the following account I have tried to make it clear when I am expressing my own opinions by saying 'I'. When referring to comments by others, I have indicated that I am quoting them. All units are in the old measures, pounds, feet, inches, etc. Any attempt to convert them to metric equivalents would be self-defeating.

R. G. GILLIS

NOTES

1. D. P. Mellor, 'Chemical Warfare', Chapter 17 in *The Role of Science and Industry*, vol.5 of *Australia in the War of 1939-1945*, Australian War Memorial, Canberra, 1958, p.368.

2. See D. C. Sinclair: 'The Clinical Reaction of the Skin to Mustard Gas Vapour', Brit J Derm and Syph [*British Journal of Dermatology and Syphilology*], 61, 113, 1949; 'Treatment of Skin Lesions Caused by Mustard Gas', Brit Med J [*British Medical Journal*], i, 476, 1949; 'Disability Produced by Exposure of Skin to Mustard Gas Vapour', Brit Med J [*British Medical Journal*], i, 346, [11 February] 1950; 'The Clinical Features of Mustard Gas Poisoning in Man', Brit Med J [*British Medical Journal*], ii, 290, [7 August] 1948.

PROLOGUE

The use of chemical warfare in World War I produced a lasting revulsion among most ordinary people. Its military effects were so obvious that a great deal of scientific and technical effort in Europe and North America was spent in developing protective systems (respirators, special clothing, shelters) in case the opposition might use it in a later war.

In Australia it was a little different. The chemical industry here was only developing. It was originally based on the mining (explosives for blasting), extractive (oil from shale, iron and steel, coke ovens and towns gas), and food industries (sugar, fermentation etc.) and could not have supported production of chemical warfare agents. Indeed when this was suggested about 1915, the foresight of Mr A. E. Leighton[1] ensured that we did not divert our limited resources to making mustard and other gases. Instead Australian chemists and chemical engineers were sent to [the] UK to provide technical staff to assist British munitions production. When they returned after 1919 they formed the basis of the growing chemical industry here.

Protection for soldiers and civilians was not forgotten. The Chemical Defence Board was established to ensure that local industry was able to make the rubbers, fabrics and other materials for respirators and protective clothing. Its Secretary was Mr P. R. Weldon, who formed a small group at Munitions Supply Laboratories that developed the expertise to assist manufacturers of components and to inspect finished products. When war was anticipated in 1938, this group was expanded. Respirator production began at the Laboratories; later it was transferred to an annexe in the Melbourne suburb of Brunswick which was operated for the Department of Munitions by Hilton Hosiery Ltd.

Sometime in 1942 after the fall of Singapore, Major F. S. Gorrill[2] RMC [Royal Medical Corps] arrived in Australia. Gorrill was a man of considerable ability and drive. He had a science degree with a chemistry major, then qualified in medicine, and he had experience in chemical defence at the British research establishment at Porton. There is no available record of his instructions, but it is believed that they were to train Australian military medicos in the treatment of gas casualties and to find out if the protective equipment on hand (either of British origin or made in Australia to British specifications) was effective under Australian conditions. Mr Weldon and the Chemical Defence Board gave him every assistance and Gorrill began to put together a team of service medicos and civilian scientists.

NOTES

1. Leighton was an English chemist/chemical engineer who was trained at Woolwich Arsenal. After helping India to set up munitions factories he came to Australia about 1912 to do the same here. Leighton became one of the 'grand old men' of the Australian chemical industry and remained here in Government service until his death in 1962.

2. After the war Gorrill became a director of an English pharmaceutical company, and died during a visit to South Africa.

CHAPTER 1

Putting the Team Together: Recollections of Jack Legge

Jack Legge[1] recalls:

My introduction to chemical warfare research as a physiologist came when I received a letter from Charles H. Kellaway, then Director of Army Pathology, a part-time post which he held at the same time as being Director of the Walter and Eliza Hall Institute [in Melbourne]. He knew me since I'd worked in his lab about five years earlier during the 1936-37 university vacation and from my work with Lemberg[2] in Sydney. Kellaway was also on the National Health and Medical Research Council [NHMRC], from which I received my research grant. He suggested that I should stop what work I was doing at that stage, some of it only peripherally related to the war effort, such as TNT toxicity and the role which local anaesthetics like procaine may have in reversing the effects of sulphanilamides, to take up work which he thought of greater importance.

I came to Melbourne and was interviewed by the then Major F. S. Gorrill who had, I think, been brought out by LHQ [Land Head Quarters] to train medical officers in the treatment of gas casualties. After some hesitation, Gorrill included me among the civilian members of a team which consisted of two Americans, and four medical officers of the Australian Armed Services: Major Andrew Abbie and Captain Peter Parsons of the AIF, Trevor McLean of the Navy, and Flight Lieutenant Don Hamilton, RAAF.

Abbie had previously been a senior lecturer in anatomy at the Sydney Medical School and finished up as Professor of Anatomy in Adelaide. I imagine that Kellaway suggested to P. R. Weldon that the Munitions Supply Laboratories [MSL] should get some chemical warfare physiologists to work in tandem with the medical officers on any research aspects which might arise. Kellaway, after all, had been in England when World War I started, he knew all the English physiologists well and was no doubt very well aware of the great contributions they had made, not only to the defensive and offensive aspects of gas warfare but also to the functioning of the human organism under the stresses of aerial and submarine warfare. Kellaway selected the four civilians, Dr E. R. Trethewie, who was a research worker supported by the NHMRC, as were Ennor and myself, while A. B. Corkhill was Director of the Baker Institute. He, the fourth civilian, had done some excellent physiological work in the late '20s and '30s, mainly on insulin, and indeed you might say Ennor was his chief trainee. Ennor had started as a technician in the animal house and did a diploma and then a degree.[3] Gorrill ran a course for, I think, somewhere between six to twelve weeks ... which started at 0800 [hours]. On the night before, he had read up the classified reports from World War I, the interregnum reports from Porton,[4] together with a number of American reports that we had and lectured to us for an hour or so from 8 to 9, ... after which we performed toxicological tests on the various CW agents then thought likely to be used.

This was done at Melbourne University in laboratories in the physiology school. Professor R. D. Wright[5] then held the chair of physiology, I think may also have been on the Chemical Defence Board, but he was himself more interested in the questions of high altitude flying and had built an excellent low pressure chamber, in which I believe he flaked out at one stage due to oxygen lack. Gorrill had organised an extremely good course, we had histological teaching from the technician who was associated with Willis, the noted pathologist at the Alfred Hospital. Willis was a world figure in the identification of various tumours. We were taught how to fix, section, stain and examine bits of material from dead animals within half an hour by a rapid method. Gorrill, who was quite a remarkable man, had developed a certain mistrust of chemists from his experience at Porton and he felt that the pathological details of animals killed would give us better evidence of the nature and concentrations of the agents to which they had been subjected. Gorrill believed that everyone should be able to do two jobs so that, although Ennor and myself were not medically qualified, nonetheless we had to understand what had to be done for treating casualties. Equally he insisted I should learn the various procedures for analysing these gases.

The course included a period of some weeks at Bonegilla, where we went through a primitive form of military exercises at which point Dr Corkhill, who wasn't a fit man, dropped out, so now the civilians were three. A number of trials were done with the volunteers from the armed forces on decontamination of droplets of mustard and lewisite, and we prepared them. We had a small one cubic metre lead-lined gas chamber, where we learnt to expose animals and observe the course of the illness and later we did the postmortems. About this time Gorrill announced that we would go to Townsville, and do some field experiments under tropical conditions. In this I think he was supported by Weldon. So, a 20 cubic metre, double-walled, masonite-lined[6] box was constructed on a 3 ton truck. It was painted inside with some sort of anti-gas varnish that Porton had told MSL was a gas paint and it had a small port through which we could insert mustard gas and remove samples.

So, the Unit borrowed a lot of equipment from Professor Wright and made their way up in various bits and pieces to Townsville. To my great chagrin, I was delayed due to chicken pox. I arrived a week or so late, after they had themselves set up, to find Dr Trethewie wearing dark glasses and returning to Melbourne. He had apparently become sensitive to exposure to mustard gas. He told me that there had been an accident to a number of members of the team and, on arriving at the Unit, I found that Jim Lincoln, Reg Taylor, the RAAF meteorologist and Don Hamilton, the medical officer who was a flight lieutenant in the RAAF, very seriously injured, faces red, swollen eyes shut. They had been vomiting for about a day at this stage and they were quite severely burned with mustard. Most of the MOs [Medical Officers] were, I think, away on an artillery shoot with CW shell but there may have been one MO there. We treated the victims as well as we could, doing virtually nothing except making them as comfortable as possible and tried to reconstruct the causes of the accident.

So far as we could determine, it turned out that, rather against instructions, the MO had allowed the others to go in to find out why we could find no mustard in the gas

chamber by the usual analytical methods, after quite considerable amounts, some ten to fifteen grams according to my recollection, had been introduced into the chamber. They may have thought, at first, that the sampling tube had broken or something like this, but they only stayed a relatively short time within the chamber. However, during this period the temperature must have increased and they may have got themselves very hot and sweaty which, we showed later, greatly increases the sensitivity of the skin to mustard. I think both the doors into the chamber were left open, but there would have been little ventilation. The other members of the team soon returned and we continued with the reconstruction. Apparently, the anti-gas paint or varnish absorbed mustard gas extremely well at the low temperature of the chamber when it was introduced at 0900-1000 h[ours] and desorbed it again as the temperature increased during the day.

This may have accounted for our accidental casualties, but didn't make it any easier to put up and maintain a stable concentration of mustard in the chamber. This we generally did by attempting to strike an equilibrium between the desorption and the absorption processes, arranging relatively short exposures of the individuals so the temperatures wouldn't be greatly disturbed, and using higher concentrations so that it was a little easier to be certain of the analytical data.

The main conclusion from these experiments was that mustard gas was perhaps eight times more dangerous in the tropics than had been suspected from experiments in temperate climates.

Most of the original data had been gathered in Europe; they had, however, attempted to imitate hot climates at Porton. The experiments used volunteers who got hot and sweaty while working. They didn't seem to me to do it very well. They had one wearing underpants which had been treated by an otherwise excellent method, N-chloro-2, 4-dichlorobenzanilide, which was the British 'Anti-Verm' [anti-mustard gas agent for impregnating under garments] while this volunteer stoked a furnace for some hours, without receiving mustard burns. Well, it turned out under our conditions that this material did protect, but its life in the tropics wasn't as great as experiment in temperate climates had suggested. The other thing that we found was that treatment with anti-gas ointment containing 'Anti-Verm' had to be carried out much more rapidly after droplet contamination than had been believed. It was thus evident that protection against liquid or vapour exposure was far more difficult in the tropics and that we had, in the three injured members of the team, an example of the consequences of exposure of unprotected men to mustard gas vapour.

I should perhaps say a word or two about the volunteers. The first lot I think were from the 6th Division back from the Middle East and my recollection is that many of them were a bit sick of drilling, cleaning, webbing and polishing their boots. They were only too happy to volunteer for experiments in the tropics. I think, as time went on, the grapevine probably told them what these experiments were. This was enough to get the first lot of volunteers. I have been asked on other occasions as to whether they were tricked. I would deny that. They were asked to volunteer, they volunteered. When they arrived, the purpose of the experiment was clearly explained to them. It was pointed out that the members of the unit, all of whom had

experiments on themselves, because if they got sensitive they were of no more value and they'd have to be sent home.

In addition, the members of the unit were by no means as tough or fit or as well trained as the troops were, [so] that we would be unlikely to imitate action conditions. We therefore proposed to ask them - after they had been burned and after their armpits, elbows, knees and groins were sore - we wanted them to go on marching carrying their packs for a certain period each day because we wished to know how long they could remain effective soldiers. Gorrill now recalled that one of the tests in an officers' training school in England, during the 1940s, was that the trainees were marched into a dense cloud of nose gas that impaired visibility. They were not allowed to put their respirators on and any man that fell out onto the road was automatically failed in the course. As well, experiments at Porton, which we confirmed later, also suggested that during exposure to tear gas, one is temporarily annoyed by pain and photophobia and then you reach a period where your eyes feel like sand, but you are still able to continue working with quite a high concentration of tear gas, so again one doesn't have to give in. You can still fire a weapon and be effective.

So the troops, in my opinion, were thoroughly well informed, they had a complete explanation of our role. It was explained [that] if there were any who wished to pull out at this juncture, i.e. before the experiment, they could; but to my recollection none did. In fact, if I could anticipate, there was one case where a man not up to active service was not burned as severely as he wished to be. He felt he had been let down and he made the error of exaggerating his burns, in order to get, not compensation or anything, but just some respect for his efforts. It was a sad case, in which no action was taken. The volunteers were told therefore that after exposure they would be asked to march to and from their barracks with pack and weapons. If, at any stage, they were unable to continue, we would be happy to hospitalise them. But until this point was reached they were to make do with no more than elementary first aid. I think that both the official reports and the films that were made show how whole-heartedly the volunteers entered into the spirit of the investigation.

Now, back to the gas chamber. I don't recall much about the field trials, but we already had enough experience with the gas chamber to know that it was virtually useless for fine quantitative work. But on the day before our return to Melbourne we were asked by Porton to see whether 40, 60 and 80 percent peroxide did any good against lewisite drops - and so the six of us who then remained sat there for one or two minutes while we allowed the lewisite to eat into our forearms. After one minute the peroxide did a little good, after two minutes it was quite hopeless, so we all went down with third degree burns on our arms. It was quite a painful episode but you forgot these things. Soon after we arrived back in Melbourne, Gorrill managed to take over the old Chemistry Laboratory in the University.

Professor Hartung had put up a new chemistry building in 1938 and the old one had been taken over by Donald Thompson, the anthropologist. Gorrill felt that our experiments were more important than Donald's canoes, which were shunted away to a corner of the old first year laboratory. And we got down to planning the second

to a corner of the old first year laboratory. And we got down to planning the second season. The first season had lasted about six weeks from the end of 1942 to the beginning of 1943. We now had to get used to spending a longer period in the hot climate in North Queensland and then winter in Melbourne. Gorrill, no doubt encouraged by Weldon, had realised that he now found himself in charge of quite a powerful research team. It was hoped that this might be expanded. Weldon supported him, and the English, deeply disturbed by our findings, agreed to send out a number of additional scientists from the English CW establishment to work with us on the second hot season. We then started to build a stainless steel gas chamber, 100 cubic metres capacity, and we were advised by Walter Bassett, the refrigeration engineer, as to how we could control temperature and humidity independently. Unfortunately it didn't look as though we could do this without making use of a canvas cover over it, because once the sun hit it, very few refrigerators could cope with the extra heat load. So the apparatus had an external sweating surface, with stirrup pumps and a team of riggers to supply water and cool the canvas awning, while the 3½ horse power motor dealt with the heat generated inside. Small neoprene gaskets were used between the five or six segments and after one or two tests in Melbourne, we found that the mustard could be put up and almost quantitatively recovered from it.

* * * * * *

Now I should just make a couple of points about our plans for the second season. It was obvious that we had to fill in all the gaps in our spectrum of conditions under which they [the volunteers] were exposed to mustard. We also planned more trials of the lifetime of British protective clothing in the tropics because by now we thoroughly distrusted the data from overseas. The four additions to the team were: David Sinclair, an anatomist who'd worked with Gorrill at Porton, arrived to become second in command of the research establishment; three others also came from Porton: Clifford Purkiss, a chemist, George Owen who was an expert on protective clothing and the preparation and impregnation of the 'Anti-Verm' onto the clothing, and Frank Pasquill, a meteorologist. We also accumulated more members of the Australian Women Army Services and a few drivers and support staff. Sinclair trained a girl to carry out his haematological investigations. Sinclair had recalled that Shaw Dunn, an English pathologist, had measured a drop in white cells after individuals had been exposed to mustard gas and was determined to look into this again. At that stage, in [the] winter of 1943, he must have mentioned the problem to me, since I remember ordering some folic acid to see if that did any good in animal experiments in alleviating the effects of mustard.

At that stage, as a result of my work with Lemberg before the war, I had some familiarity with drugs which caused blood disorders. Among those that cause methaemoglobinaemia, in which the blood pigment won't carry oxygen, are compounds that can form ortho- and para-quinones. The English 'Anti-Verm', no doubt due to economy, was only substituted with two chlorine atoms in the two and four positions in the aniline part of the molecule. Therefore position '6' was vacant, leading to the possibility of an ortho-quinoneimine and thus a potential methaemoglobin former. With this possibility in mind, I made sure to take up [to

Queensland] a spectroscope, although I did kill one rat by ointment inunction without observing any abnormal blood pigment.

We were away for the second season a bit longer, probably for three months at Innisfail. The site, on the banks of the river, was very nice. We set up our gas chamber and at this stage we collected a large number of wild goats. We were going to expose them, because a goat had been chosen in the majority of English experiments because its respiration rate was much closer to that of man. We know that this is important in the history of chemical warfare as Barcroft's famous experiments show.[7]

The first extraordinary discovery we made was when we got a paratrooper battalion who wore the British protective clothing as part of our user trials while they moved out on what was called a 'doover' (a manoeuvre), which was intended to include a four day march in the jungle...as well as night exercises. They all put on these clothes and we happily went back to the Unit. However, late that night, I think about ten or eleven o'clock, we received an extraordinary call from the Commanding Officer of the paratroops saying his men were collapsing. I went up with Sinclair, carrying my spectroscope, because I had suspected that this might happen. The men indeed were quite leaden in colour. They had, as I later showed, up to 30 percent of the oxygen-carrying capacity for blood blocked off because the iron in [their] haemoglobin was now in the ferric form. As was to be expected, they recovered after getting out of the clothing. Then what really followed was what I have always regarded as the best work I've ever done on the back verandah of a house. I used the Porton bubbler in order to extract the urine collected from the men who had been wearing the clothing, and isolated hippuric acid. This was evidence that the 'Anti-Verm' had been absorbed through the skin and then hydrolysed in the body to [become] 2,4-dichloroaniline and benzoic acid.

I think I was discussing the assault course earlier. After the first expedition we weren't convinced that simply marching to and fro was a rigorous enough test of the extent to which the people had been injured. I cannot remember whether Ennor or Gorrill came to this conclusion first, perhaps the former who was able to talk to the volunteers with less 'rank'. We therefore designed a most vicious assault course, which was designed to rub off blisters and abrade injured skin. I think I was responsible for the liana vine hazard. The course was set up on the Innisfail showground, and we continued our open discussion with the troops, just as we had previously. They willingly accepted the assault course and we felt that we had now really provided a complete set of field trials which were rigorous as possible, short of actually sending the volunteers into the manoeuvres preceding action.

I remember one example, which I think has been filmed, where we dropped the 65 lb light-case mustard bomb on an area of jungle. The volunteers, wearing protective clothing - at this time probably the US-issue, impregnated with CC2, also an N-chloro derivative[8] - had gone through [the mustard-affected area] as they had been trained at the jungle training school. One bloke actually sat in a puddle of liquid mustard against which, of course...no amount of permeable protective clothing offered protection. A number of them were really quite severely burned. Half the area of

the buttocks were blistered, for example. Another chap was blistered from hand to elbow. And at this stage, Gorrill had managed to get in some high-ranking medical officers in the forces to visit the unit. These volunteers were paraded before the medical officers before they were about to go on the assault course. The visitors were asked, 'What would you do with these men?' They all recommended, 'Hospitalisation at once. They are quite incapable of doing anything'. The volunteers then pulled up their pants and went over to the assault course and marched off. One man, whose arms were severely blistered and whose wife, I believe, had run off with someone, went over the rope crossing. I remember the blisters bursting as he went over, showering him with serum.

This really pointed up an issue which I think, in the end, came to be quite important. That is, granted our acceptance of the courage of the volunteers, it meant first of all that if they were brave in action, the figure we originally set for exposure to withstand in the tropics as eight times as dangerous as that in temperature [*sic*] climates was immediately divided by four. So for really determined troops, we were much nearer old-style figures. It was still, as far as damage to skin [was concerned], certainly more dangerous than in a temperate climate. And this immediately presented a problem. Medical officers who were in fighting units had the basic job of keeping the unit in effective action; it was not to put people in hospital, as in civilian life. Yet we found that they would grossly over-estimate the incapacity of their charges. This obviously called for a different attitude.

But it also meant that, and here I'm only guessing, that members of the military establishment might have doubted if their troops might be perhaps as hardy as were our volunteers during experiment, and would have very great reluctance to subject troops who might be ignorant of gas warfare to the risks of the damage that they had seen. I have only got one bit of additional evidence here coming from the year we had a trial on Brook Island. We bombed it in order to compare the effectiveness of the HE and mustard. We didn't, of course, expose humans initially on the island; we put goats on it. Only after all the bombs had been exploded did a group of volunteers, wearing US protective clothing, follow primarily to see how well a person could wear a respirator, because this is a question which is by no means as easy as one might think. After three days, all of our jaws were extremely sore.

But, back to the trial, no sooner had the mustard gas bombs been dropped than members of the unit landed on the island in order to measure the concentration at the various sampling sites, which we had determined earlier.

Now the set of samplers had to be replaced to measure the decay of the mustard under these conditions. We had, at that time, the two American MOs who had been part of the original CW school. They refused to land on the island. Gorrill said later that he'd like to have shot them, but just arranged to have them sent to New Guinea in disgrace. After all, during the island trial, the girls in the unit all sampled with everybody else. I might say that this behaviour was not at all typical of all Americans with the unit. We were extremely well-served by Howard Skipper[9] - a remarkable chap with whom I frequently disagreed on the role of Roosevelt - who has since become quite distinguished for work in cancer chemotherapy in the US. It

was he, I think, who made sure we got the Liberator bombers at one stage of our trial. Skipper was an enormous help and always very glad to see old team members who visited the States.

The result of the island trials was therefore to show that mustard was far more dangerous than HE, results we confirmed in other experiments...we tried, such as simulated artillery or mortar attack on goats in Japanese-style bunkers. The second season in the tropics was without doubt noted for more novel findings than was the first. We then returned to Melbourne and planned further expansion. A large station was to be built at Proserpine and a complete army establishment accumulated to look after it. More scientists were brought out from England, including Dr R. H. S. Thompson, who had helped to discover British anti-lewisite, and the gas chamber was shifted to Proserpine.

So far as the physiological work was involved, Sinclair was particularly interested in questions of treatment. I mentioned earlier an experiment in which the troops had gone over the assault course in which one of them had sat in a pool of mustard and got a burnt bum. Superimposed on this trial was, I think, a treatment trial, that Sinclair had designed, in which we subdivided the group into those with no treatment and clean clothes, treatment and clean clothes, and those that wore dirty clothes and received no treatment. I don't think that we were able to show that treatment had any noticeable effect.

In the third season Sinclair was interested in cleaning up his analysis of the injury side and the treatment side of the injuries. I've forgotten what Thompson was doing. Supported by both Ennor and Gorrill, I was principally interested in completing the exposures under the range of conditions in which we could get reliable quantitative data, and in expressing the degree of damage in a semi-quantitative fashion, according to Sinclair's method. We were able to complete our series of experiments to obtain a sufficient range of various temperatures and humidities; the volunteers exercising or not exercising during exposure, with the repair of their lesions taking place under various climatic conditions. I then settled down to try to reduce these to a multiple correlation between dose, environmental conditions during exposure and recovery, and final invalidity, [to be] published in one report. I found that significant effects were produced by the temperature and also the wetted area, a term due [sic] to Gagge from the Yale research school, and one that could be derived from the physiology of a human, and the temperature, and the relative humidity and his degree of exercise at the time of exposure. It turned out that a significant effect was produced by the temperature to which the burned individual is subjected after he'd been exposed. Hot and wet conditions caused a greater invalidity. We found that we had been able to push the experiments rather close to conditions we felt might have had lethal consequences.

I must say that initially the whole emphasis was on defence against chemical warfare should the Japanese first use it. But, of course, this inevitably raises the question of retaliation and both the British, the Americans and the Australians were, I think, prepared to retaliate should the Japanese have decided to use chemical weapons on any scale. Some attention was certainly paid to the possible uses of mustard gas as

an offensive weapon. I think the opinion of the Unit was [that] it would be very useful; qualified by a 'caveat emptor' as to the expectation that untrained troops would behave as courageously as had our volunteers. In our experiments we believed we had bracketed the concentrations which were highly significant. In my own opinion it was the very courage of our volunteers that made everyone hesitate, quite apart from the moral issues involved. Chemical warfare just slows everything down anyway and the effort of training considerable bodies of troops to be as confident as members of the Unit, or volunteers, was forbidding. Most wanted to wait until the Japanese started it before reaching a final decision, unlike of course the case of the atom bomb. So in fact, I'm very pleased that it was never used.

I think there may be one other reason why they didn't use CW. There is quite good evidence now, in a book by a man called Gabriel Kolko, 'Allied Diplomacy 1943-45'[10] which suggested the Americans really wished to win the Pacific War on their own. They weren't terribly anxious for the British Navy to help them and of course they left the Australian troops to island-hop while they went ahead. It has since occurred to me that they were not anxious, at this stage, to make use of a weapon which they felt the Australians might handle well, but which mightn't be accepted so favourably by their own troops.

One final note, which should be recalled. Sinclair wrote up his treatment trials in the medical journals and certainly confirmed the drop in the white cells after exposure. So far as I'm aware, these experiments were almost the only good thing apart from the use of alkyl phosphofluoridates as insecticides that came out of chemical warfare.

Well, at the end of our third tropical period the Board decided to send both Ennor and me overseas to visit overseas chemical warfare establishments, where I was anxious to get criticism of my calculations. I can't say I got much, either positive or negative, but I happened to be in Canada when the atom bomb was dropped on Hiroshima and a few days later I was in Baltimore when the Pacific War ended. I returned home via [the] UK, Poole and India, where I saw the British continuing their work on defoliants at their Cannanore experimental station.

After that I think I was anxious to get out of the Defence Establishment, as soon as possible, because there are natural restrictions on one's liberties in this occupation. I had been very happy to cooperate while the war was being won, but I was anxious to try to do something to build the peace and I thought it would be better to leave the Department. I think this was the attitude of many. I would say perhaps, in conclusion, that my experience does show that it is difficult in a long period of peace to get research work of the highest quality going on under secret auspices. I think it is desirable, as far as possible, that people who are continuing to work on defensive projects such as chemical defence, are given the freedom to subject their work to open criticism and I think in this way the defence capacity of the country would be looked after better than it was, for example, at Porton in between the last two wars.

NOTES

1. After the war, Legge spent two years in the UK, then joined staff of the Biochemistry Department, University of Melbourne and was a Reader when he retired.

2. Dr R. Lemberg, originally from Breslau and Heidelberg (Germany), was a biochemist and world authority on bile pigments who worked at the Royal North Shore Hospital, Sydney.

3. After the war, Ennor became Professor of Biochemistry at the Australian National University, and later was Permanent Head and Secretary of the Commonwealth Department of Science and Education. He died shortly after retirement.

4. The UK Chemical Defence Research Establishment is at Porton Down near Salisbury in south-west England. It is often simply referred to as 'Porton'.

5. At the time of writing (late 1983) he had become Sir Douglas Wright, Chancellor of the University of Melbourne.

6. 'Masonite' was a post war development. The material used was probably 'Celotex', a building board made from sugar cane waste.

7. The 100th Anniversary of Barcroft's birth was celebrated by a volume - in the Brownless Library, University of Melbourne - in which the introduction describes his demonstration that hydrogen cyanide was an ineffective chemical warfare agent, an experiment which impaired his health for a period.

8. CC2, the compound which the Americans used to treat their underwear, had all three positions in the ring chlorinated so that no quinones could be formed and methaemoglobinaemia could not occur. 'Anti-Verm' was incorporated in the British A/G ointment; it was unstable and [an] irritant as well as being ineffective. The Americans did not incorporate CC2 into ointments and a different N-chloro compound, S-330, was used in their M5 ointment. It was not as irritant [*sic*] as the British ointment but not much more effective against mustard.

9. Skipper later became Director of the Kettering-Meyer Laboratories and Professor of Experimental Pathology at the University of Alabama, Birmingham, Alabama.

[10. Gabriel Kolko, *The Politics of War: Allied Diplomacy and the World Crisis of 1943-1945*, London: Weidenfeld and Nicholson, 1968.]

CHAPTER 2

Army Engineers and the 2/1 Mobile Anti-Gas Laboratory

This section is based on an account written for the *History of the Royal Australian Engineers* by J. C. McAllester,[1] who was trained as a chemical engineer. After the war, he worked in both industry and government, becoming Acting Director of Commonwealth Serum Laboratories in 1961. Later he became an executive director of Glaxo Australia and later still General Manager of G. N. Raymond Ltd. He is currently Chairman of three proprietary companies in technical fields.

Australian Army Engineers' Participation

Up to the end of 1941 the field experience gained by mobile antigas laboratories in the Middle East and India was limited because the Germans and the Italians appeared not to have intentions to use CW offensively. However, it could not be assumed that the Japanese would adopt the same policy, so provision was made for a 'chemical adviser' to be appointed to the staff of the senior engineer officer at Army Headquarters. The officer appointed, Major D. O. Shields, was highly qualified, holding the degrees of M.Sc., Ph.D. and M.B., B.S. He had served in the 1st AIF, and was Medical Officer for Industrial Hygiene in the Victorian Health Department.

In 1941 chemical warfare companies, Royal Australian Engineers, were added to the order of battle, one company to a corps or higher formation. Five were raised in nucleus form: the 1st in Northern Command, the 3rd in Eastern Command, and the 5th in Western Command, followed by the 2nd in Eastern Command and the 4th in Southern Command (3rd Military District). It was planned to bring them to full establishment if offensive CW became necessary, equipping them with 4.2 inch mortars, for which ammunition charged with mustard gas was available from the United Kingdom. The ammunition duly arrived, the first consignment being unloaded at Williamstown [Victoria] and escorted by the 4th CW Company to the ammunition depot at Hume outside Albury.

Meanwhile Major Shields directed his attention to two aspects of preparedness - the ability of the Army to identify enemy CW equipment, and the assessment of the importance of defensive and protective equipment in tropical conditions. He proposed the establishment of a mobile anti-gas laboratory on the British Army pattern, and a research and experimental section. His proposals were supported by an advisory mission from Britain which visited Australia in 1942. The initial officer appointments were made in October 1942. Captain J. C. McAllester, who had been a company commander in the 2/14 battalion and was at the time GS03 (CW) at Headquarters 7 Division, was appointed to command the 2/1 Australian Mobile Anti-Gas Laboratory, and Lieutenant J. R. B. Neil was transferred from the Directorate of Artillery at LHQ to assist him. Later Lieutenant C. H. Bull from 12 Field Regiment and Lieutenant F. A. Goldstone from the RAE [Royal Australian Engineers] Training Centre were appointed

to the Laboratory. All these officers had university degrees in science or engineering.

In the first part of 1942 the five CW companies were concentrated at the RAE Training Centre, Kapooka. There followed a reorganization, out of which came the 1st Chemical Warfare Company and the Chemical Warfare Research and Experimental Station, RAE. The Research and Experimental Station was located at the LHQ Gas School, Bonegilla. Its officers included Lieutenant J. E. D. Kerr and Lieutenant R. G. Andrews, both professionally qualified.

The new 1st CW Company was a unit of about 175 [of] all ranks, commanded by the then Captain J. W. Woodfield, RAE. The men had received basic training as engineers. At Kapooka they were given extensive infantry and commando-type training, including jungle work, as well as the specialized training required by the unit's role. The company was well known for the long route marches which it undertook, and it was only natural that its move to Hume Camp, near Albury, later in 1942, should have been made on foot. At Hume it received its major armament, twelve of the formidable 4.2 inch mortars, which could throw a 20 pound bomb from quite a short range to as far as 3,500 yards. No manuals came with the mortars. The company devised its own by drills. There were no range tables, and the company constructed its own by firing into Lake Hume and observing the fall of shot with its own surveyors. The ammunition was high explosive: the unit's chemical ammunition was held in the Albury depot close by. The company wore the purple hexagon approved for the Anti-Gas Laboratory.

In November 1942 arrangements had been made by the General Staff at LHQ to conduct trials of chemical ammunition at Heathfield and Cape Cleveland near Townsville, and Captain McAllester was instructed to attend so that his unit might assist in the chemical assessment of future trials. This was the first trial conducted in Australia of such ammunition, and valuable experience was gained from the use of 25 pounder BE (base ejection) chemical shell, charged with BBC/V (bromobenzyl cyanide/viscous), a lachrymator. The trial was remarkable for the steadiness of the volunteers from local militia units who manned the target area in protective capes, goggles and respirators. The BE shell was fitted with airburst fuses set to operate above the target area. Fragments of shell were expected to land forward of the target area, but the behaviour of the baseplates, some of which landed among the volunteers, had not been expected by the gunners.

The second trial of 25 pounder BE chemical shell took place at Singleton, NSW, in January 1943. The 2/1 Mobile Anti-Gas Laboratory was responsible for installing equipment to sample air from the target area and to determine the concentration of toxic vapour achieved by each shoot. Fortunately the mobile ammunition workshop vehicle was delivered to the unit on 6 January: it departed for Singleton next day. The target area was wired for electrical control of sampling, and piping was installed to draw vapour samples into bottles dug in and protected from damage from shell fragments. One shoot was with shell-charged BBC and one with mustard gas, of which 100 rounds were fired. The concentration of mustard gas sampled was very low, which was disappointing because confirmation was being sought of the casualty-producing effect of 25 pounder BE shell as set out in the War Office Chemical Warfare Pocket Book.

The next trial of 25 pounder BE chemical shell, at Forbes, NSW, utilized the staff and resources of the laboratory unit and the experimental wing of the LHQ Gas School (which was to become the 1st Field Trials Company, RAE) with support from the Munitions Supply Laboratories. Vapour concentration was again unsatisfactory, though volunteers who received droplets of liquid mustard gas exhibited some blistering. An intensive investigation was carried out to ensure that more consistent results would be achieved at the next trial. To obtain higher ambient temperatures this was carried out at Lake Hiawatha, 26 miles from Grafton, NSW, in April 1943. Captain N. K. King, RE [Royal Engineers], an Australian who had been involved in CW work in the United Kingdom, was detached from LHQ to co-ordinate the trial, in which personnel of the RAAF [Royal Australian Air Force], RAA [Royal Australian Artillery], RAE [Royal Australian Engineers], RAMC [Royal Army Medical Corps] and AAMC [Australian Army Medical Corps] were engaged. Both vapour and crater samples were collected by the RAE units and analysed at a temporary laboratory in the town of Grafton.

The difficulties encountered in the trials up to this time in moving the sampling equipment, the piping and the electrical cables from one site to another, and the damage caused by shell fragments, demonstrated the need for permanent trial site facilities. It had already been decided to set up in North Queensland an establishment at which the effects of chemical agents in tropical conditions - likely to be more severe than in temperate or cold theatres of war - could be studied. This was the Australian Field Experimental Station, in which all the armed services were involved, and [personnel from] Britain as well as Australia. When in March 1943 the laboratory unit was given the task of sampling CW ammunition held in depots, it became apparent that field trial assessment would require the expansion of the 1st Field Trials Company and its location near the Field Experimental Station.

At Innisfail, the Field Experimental Station occupied a row of houses near the Johnstone River, with a large stainless steel gas chamber in one of the back yards. Trials of 25 pounder BE shell and 4.2 inch mortar bombs charged with mustard gas were conducted in tropical rainforest on the mainland near Innisfail. Aircraft weapons were tested on North Brook Island, using Vultee [Vengeance Dive Bomber] and later Beaufort bombers from Bowen, and measuring the effect on Japanese-style bunkers and foxholes manned by goats. Chemical sampling equipment was installed. Troops landed at various time intervals after bombing and with various types of protection. Other tests from Innisfail included the tolerance of man to dibutyl phthalate, which was used to suppress the vector of scrub typhus, and the effect of wearing anti-gas clothing on the ability of troops to perform normal duties and do heavy work in tropical rainforest.

About the end of 1944 the Field Experimental Station, including the 1st Field Trials Company, moved to Proserpine where it occupied substantial buildings erected to the order of the Chemical Defence Board in Melbourne.

John Anderson[2] recalls:

As people who had some background in chemistry we were asked to volunteer for chemical warfare in Australia. We formed a unit at Royal Park and we were known as

[the] 1st Australian Chemical Warfare Company. Captain Heath was our officer commanding. A number of others, qualified chemists, were made officers.

I had been a part time chemistry student working during the day in the laboratories of Robert Bryce and Co., so I knew something about dyes and basic organic chemistry, but I was just a private in the Unit and we had a number of lectures on chemistry and gas and decontamination procedures, and this was all good fun because we were right in the heart of Melbourne and we got leave passes every night. I was a lad barely 19 years old, and it was very good to get home and also to get out, as I had been isolated in the training battalion. We did not appreciate chemical warfare and its consequences until we actually had an active part in guarding a train that was taking war gas in various forms to Albury.

The wharfies at Williamstown knew all about it and they said, 'Keep clear of that stuff, it's leaking mustard'. So we had to decontaminate some of them with bleaching powder and we were on the train for the purpose of looking for any leaks and one very quickly got to recognise the smell. That was off-loaded at Albury. Whether it went any further or was actually dumped or stored around there I don't know.

And then we were moved up to general engineering training at Wagga, at Kapooka camp and we were joined by other chemical warfare units which had been formed in Sydney, that was the main unit, and there were some from Adelaide and also some from Western Australia and later on we got a few Queenslanders as well. So it formed quite a large unit, eventually, with three platoons and the officer commanding was Frank Espie. Some of the officers left the unit, because we became bogged down in a fairly intensive training program while the Army decided whether they were going to use war gases or not. We actually marched down from Wagga to Albury, trained at Albury, and got pretty fit and tough. We looked upon ourselves as an elite commando-type unit. We became quite proficient at doing things that were important. I was studying maths for chemists. It was one of the subjects I still had to complete for my diploma and I decided I had enough maths to do the surveying and to do the calibrations of the mortars and I drew up all the tables of the angles that were required for certain ranges. The job in the field was to work out the range and variance for setting up the mortars. As far as chemistry was concerned, well, I didn't do all that much chemistry from there on. I became a surveyor.

I think the point is that the range tables weren't satisfactory under Australian conditions. We were originally trained by English surveyors and I remember them saying, 'You'd better recalibrate the whole show', and we did this when we were in Albury by shooting blanks into the Hume Weir and triangulating on the splash to get the distance that one would obtain on a certain calibration and charge. At Albury we were in both Bonegilla camp and Hume camp. We then went up to the tablelands, and we were again with a general training scheme with a number of units up there just before the New Guinea campaign and some of us were sent down to Innisfail. Again that was all good fun because in Innisfail there weren't as many troops as there were in Atherton where you couldn't get near a girl at a dance, whereas I remember being in the Innisfail Town Hall on New Year's Eve [where] there was not much competition.

I remember we were stationed at the Showgrounds in Innisfail and we had all our equipment in the grandstand.

We did additional anti-gas training and we figured that there was something on in what we called a 'live shoot', that is with live ammunition. We had all this dummy stuff to practice with and I think we did a recalibration again just to make certain how this ammunition would behave. We did a shoot on the mainland and then we went out to this island off the coast from Mourilyan Harbour. Then went across to another island, which I think must have been Brook Island and dug fox holes.

I remember goats coming on the island and we were told that the goats were going to be put in the fox holes that we had dug, but I can't remember seeing the goats afterwards. We weren't on the island during either of the trials. I had done the survey and they took us off the island while just one mortar crew shot off the live stuff. Then with gas capes and ointment - all of us used every possible protection - we went back

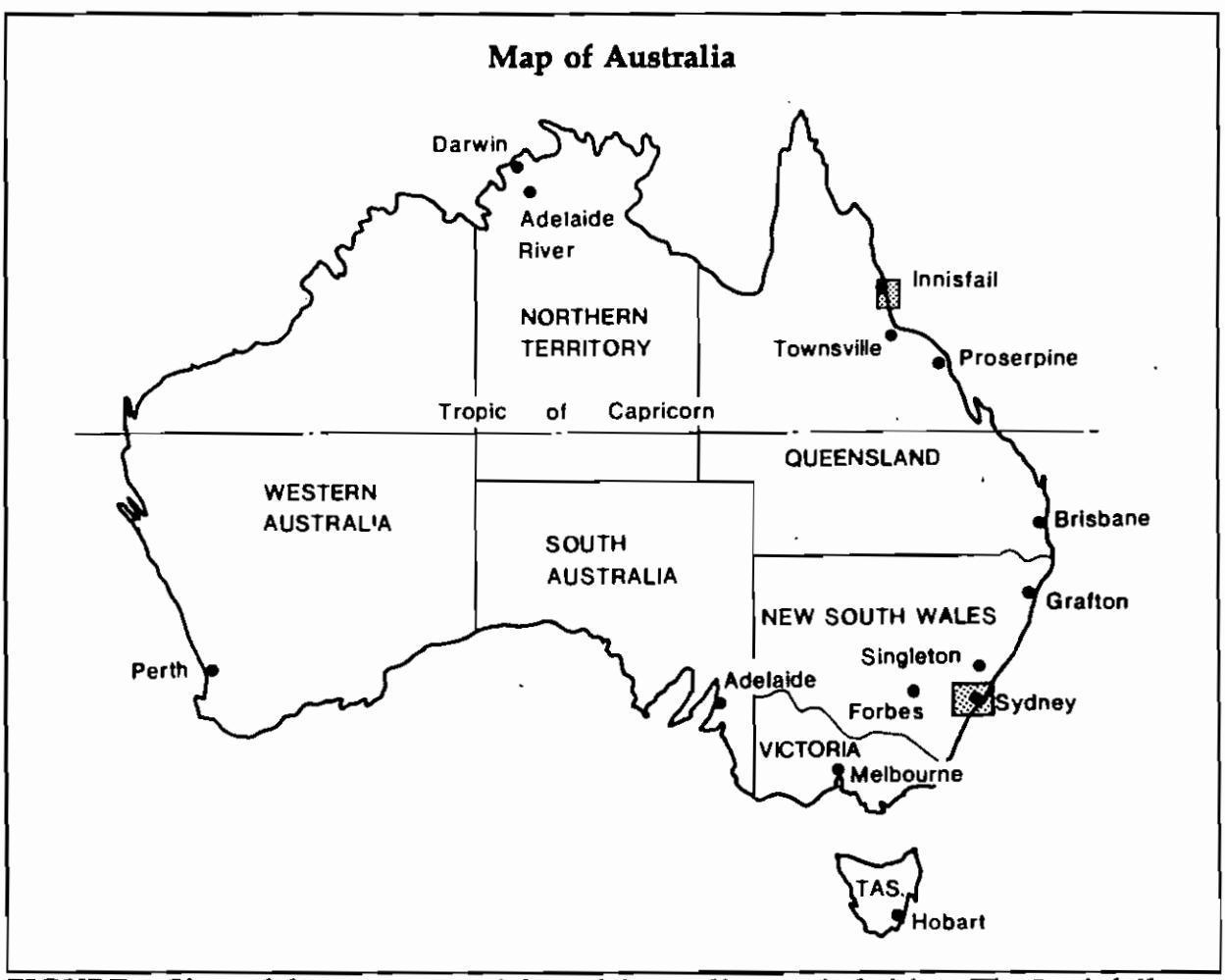
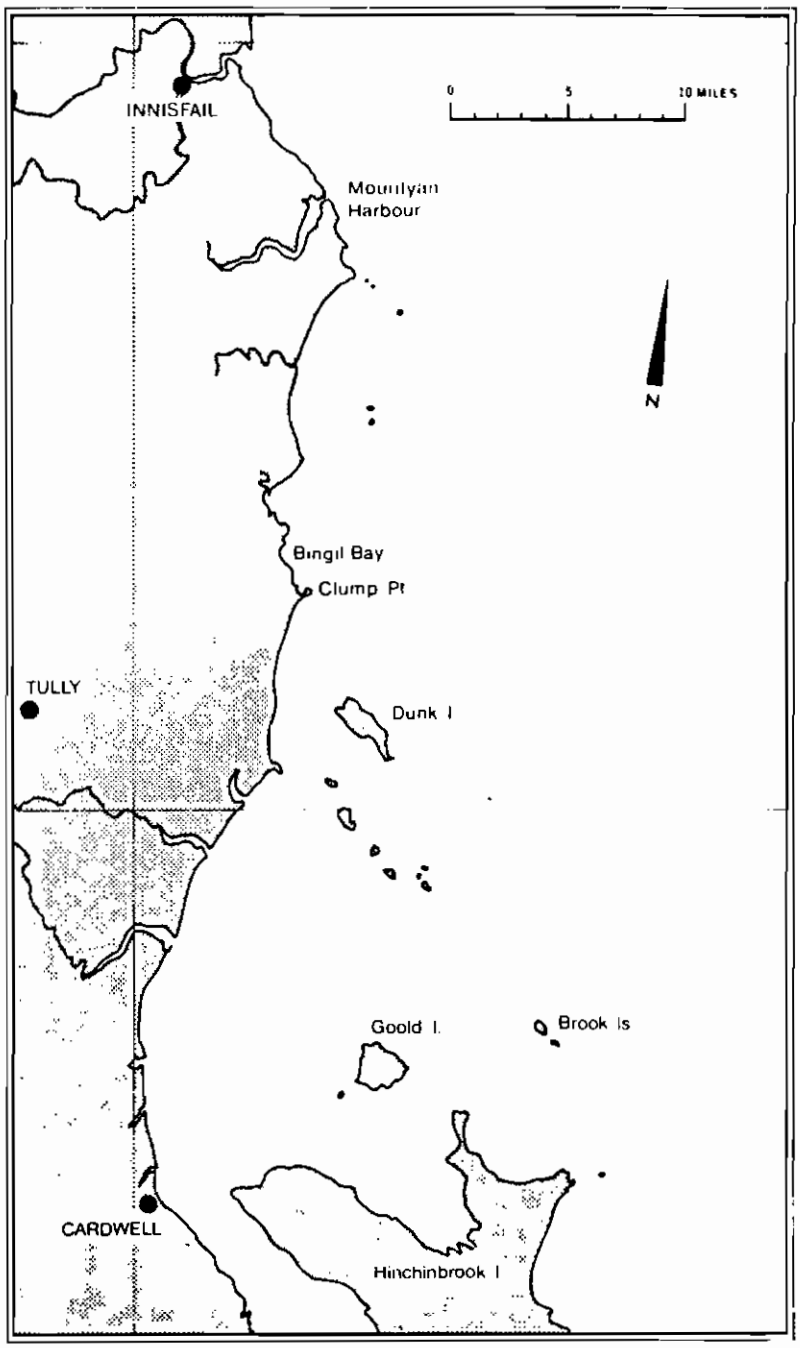


FIGURE 1. Sites of the 1942-1945 trials and Australian capital cities. The Innisfail area is enlarged in Figure la and the Blue Mountains area in Figure 3.

FIGURE 1a. Innisfail, Tully, Cardwell area



after the shoot. I myself was not burnt at all, some of my mates had minor burns, but I can't recall anyone in my unit ever suffering from gas of any form. None of our unit was asked to volunteer as live 'guinea pigs'.

The thing was, if you were promised home leave, or some special leave, you would do anything. Actually, when I joined up, I volunteered for this chemical unit partly to use my chemistry, partly because they wanted to put me into army medical. They saw no distinction between a chemist and a pharmacist.

One experience, I don't know whether it was connected with chemical warfare or not, but it was connected with an invasion of islands, was that we had to mount our mortars on landing barges and fire the mortars, while the landing barges pitched and tossed their way to the shore. And I being surveyor had a position atop the roof of the canopy taking ranges as we went in, and if they got me, there would be no brains behind the guns, as they say. But in addition, when we got closer and closer the barrel got steeper and steeper, so that the mortar bombs were going practically straight up, and even firing blanks there was a danger that you'd drop a bomb on yourself.

It may have been that they thought this would be one way of creating panic on the beach, by firing mustard gas shells, but again if this [was] going to be followed by our own troops, there would have been contamination. So that was an experiment, and the last of the experimental things that we were involved in using mortars from landing barges, because the big guns from the Navy had to lift their barrage in case they would fire on their own. If they had fairly heavy mortars in the first wave of landing barges, that would just cover right up to the beach, but we never used that in action.

In both New Guinea and Bougainville we were a high explosive unit and actually changed our name to 101st Brigade Support Company to be attached to any Brigade who wanted close support. And then we became [the] 101st Australian Heavy Mortar Company. That described our latter function as a sort of mini-artillery. The only trouble about being mini-artillery, we had to carry out our own stuff. We weren't issued with jeeps and vehicles and I've still got a crook shoulder from that.

NOTES

1. J. C. McAllester, 'Chemical Warfare', Appendix G in R. W. McNicoll, *History of The Royal Australian Engineers*, Vol.3, Corps Committee of the RAE, Canberra, 1982, p.366.

2. Anderson completed his studies after the war, worked as a dye chemist in the textile industry, and then taught Dye Chemistry at Royal Melbourne Institute of Technology, where he was a Senior Lecturer when he retired in 1982.

CHAPTER 3

An Unforeseen Problem

Reg Taylor[1] recalls:

I was trained as a meteorologist in the RAAF, and I was forecasting in Nowra, and was posted to take command of No.1 Mobile Meteorological Flight out of Townsville. Its job was to co-operate with the Army and give them whatever meteorological aid they needed. It was part Air Force, part Army unit and most of that aid was [the] provision of upper air temperatures and winds for the artillery. I got a request to go to this chemical warfare place because they wanted to get some idea of the temperature and humidities they could attain in their gas chamber and how much they could control it by watering it down the outside.

I went to see them on Wednesday, 13 January 1943. They told me what they wanted, and they had only one day in which to work. So I suggested I get inside the chamber, take the wet and dry bulb readings, every 5 minutes or so, which gave me time to work out the humidity before the next reading, and plaster wet paper around the walls to get a bigger evaporating area and see how high I could push up the humidity. The gas chamber was made of masonite, the inside of which had many many coats of duco on it and they thought it would be quite impervious to mustard gas. It had had a concentration put up in it some little time earlier and it had been thoroughly ventilated and they thought it would be quite safe. So I went in there and I started taking these readings because I had only one day in which to do it. My idea was to keep on doing it right through up to the highest temperature and then to get them to put wet bags over the outside and hose them down.

Normally you expect a symmetrical rise and fall in temperature and we were hoping to see how much that could be distorted by watering down the outside. I was only wearing shorts and boots typical for the climate, and no respirator because they did really feel that the paint was impervious to the mustard gas. But after about three quarters of an hour I started to feel a bit itchy under the chin, and I suppose, just looking back, it was just because I was hot and perspiring, but I got a bit worried and I slipped a little note under the door. They talked about it and decided I should come out and be relieved by somebody else. I told him what to do and when I had lunch with them I started feeling sick and I got my driver to take me back to the unit. When evening came I was quite sick and I remember I wasn't even able to look at the moon. That was something that they expected and apparently found significant.

I got my driver to take me back to the CW unit where they put me up for a couple of days and then decided I'd better go to an RAAF hospital, which I did and was in there for about 5 weeks.

I didn't get much blistering. These were vapour burns I got. I wasn't exposed to liquid at all and what I did do was peel. It was exactly like bad sunburn. I peeled all over,

including the palms of the hands and soles of the feet, and most of the time my eyes and scrotum were affected and the coughing was present, but it only became a real problem later. That's why I had to retire - just so weakened by the continual coughing and emphysema - and that's about it. An eye specialist first suggested that I apply to the Repat [Repatriation] people to have it accepted and they did. And later on a specialist physician made the same recommendation about my chest and that was accepted. At the end of 1981 I put in a request that my whole case should be reviewed. It took them over 15 months to make up their mind, and early this year, I was reclassified TPI [Totally and Permanently Incapacitated].

Following my accident with mustard gas in January, 1943, a spell in hospital and some sick leave, I was given a desk job at the Weather Bureau in Melbourne until late that year. During this time the Chemical Defence Board asked for a member of the British Meteorological Office to start up a Meteorology Section for their research in Australia. Frank Pasquill, who had been working at Porton, was appointed. He went on to become internationally known for his work in the field of atmospheric diffusion before his retirement about 1975. He asked for and was given the assistance of one RAAF Meteorological Officer (I applied for this job and got it) and two assistants (RAAF NCOs).

At the risk of being prolix, it is necessary here to introduce the idea of atmospheric stability. When the air is heated strongly by the ground (as on a hot, sunny day) there is a marked decrease in air temperature with height in the lower layers, leading to strong mixing and diffusion. This condition is referred to as instability. On the other hand when there is cooling from below, as on a good radiation night, the temperature in the lower layers increases with height (a so-called 'inversion') and mixing and diffusion are suppressed. In those days measurements were made of the temperature difference between two heights, initially only 10 and 110 cm.

As well as temperature differences, we also measured the ratio R, defined as that of the wind speed at 2 metres to the speed at 1 metre. Obviously, the stronger the mixing, the more nearly equal these two speeds. The measurement was supposed to be over a clipped grass surface, but in those days ideas of how much [of] this surface upwind of the anemometers was necessary were rather naive. Nowadays most people would say one to two hundred times the greatest height of observation; at that time we were satisfied with 20 yards or so, with consequent gross inconsistency in the values of R.

In late 1943 we went to Innisfail. There we measured the two stability parameters (R and temperature difference T) for their own sakes, so as to get some idea of their magnitudes in the tropics as well as to apply them to diffusion theories. Two interesting results emerged. First, it was found that inversion strengths at night over open country were weaker than was commonly found in temperate latitudes and decreases of temperature with height ('lapses') were stronger. These results were due (a) to the high water vapour content of the atmosphere, with strong absorption of long-wave outgoing radiation by night and (b) to the very strong insulation by day. Secondly, a predicted result was confirmed: because the rainforest canopy was the main site of radiation absorption by day and emission by night, inversions were found near the forest floor by day and lapses by night.

As well as the measurements of R and T, two sorts of gas trial were carried out by the Meteorology Section: measurements of gas concentration in the air from a continuous point source, and from an 'infinite' continuous cross-wind line source. Since winds in strong lapse conditions are usually light and variable in direction, the latter type of source was simulated by contaminating an arc of a circle with the centre at the sampling point and as nearly as possible symmetrical about the mean wind direction. Sulphur dioxide was used in the point source trials, mustard gas and lewisite for the line source. Both sorts of trial were made in both rainforest and open country. The use of lewisite was soon abandoned because it evaporated too quickly to be of possible use in the tropics. Methyl salicylate was sometimes used as a mustard substitute. In rainforest, where winds are extremely light and variable, the cross-wind source was simulated by a complete circle of contamination.

The results of the diffusion trials were compared with the predictions of two theories: the 'statistical' and 'mixing-length' theories. My post-war work in meteorology rarely touched on turbulent diffusion and so I cannot recall any details of these theories. I can only say that neither of them appears to form any part of present-day thinking on the subject.

As well as the trials from artificial sources, a number of meteorological assessments of various bombs were made, entirely as far as I remember, in rainforest. After dropping, the point of impact was located as quickly as possible, a ring of samplers was set up around it and the measured concentrations were compared with theory. The bombing of North Brook Island was a physiological rather than a meteorological experiment, though we did supply background met[eorological] observations at a number of stations.

I returned to Melbourne in the middle of 1944 and was replaced by another RAAF Met[eorological] officer, one Steve Lloyd. He stayed in the Weather Bureau after the war. I did meet him a couple of times later but I do not think he was ever permanently stationed in Melbourne.

Later in 1944 we returned to Innisfail and later still the unit as a whole was transferred to Proserpine. Two more men from the British Met[eorology] office were brought out. Stanley Crawford was a graduate and professional scientist, Stanley Mason was a non-graduate and, I gather, corresponded roughly to an STO [Senior Technical Officer] in CSIRO [Commonwealth Scientific and Industrial Research Organisation]. In addition the Met[eorology] Section acquired a Synoptic Section (RAAF personnel) with the duties of drawing the charts and making forecasts.

As I understand it, one of the reasons for choosing Proserpine was that it offered a number of sites on tropical open savannah woodland to complement the work done in rainforest and open country at Innisfail. There is no need to detail the work done at Proserpine because it ran very closely parallel to that done at Innisfail.

I remember in 1980 my wife and I took a holiday through Airlie Beach, which is just out of Proserpine, and I hired a Moke for the day and drove out to Gunyarra Siding and there wasn't any trace of the old station to be seen. All the bush had been cleared and it seemed to be either sown pasture, also crop growing. There were cattle alongside it.

NOTES

1. After the war, Taylor returned to work with the NSW Department of Education. In 1949 he transferred to the CSIRO Division of Meteorological Physics (later Atmospheric Physics, later still Atmospheric Research) and remained with them till he retired.

CHAPTER 4

Early Artillery Trials

Nick King[1] recalls:

I had graduated in science from Sydney University and when the war broke out, I was on a ship on my way to England to do a course at Oxford. We hadn't even reached Colombo, but I decided to go on to England. I immediately volunteered to join the AIF when I reached Australia House in London, and they said that was very good, and they would give me every assistance to get a passage back to Australia to enlist there. So I joined the British Army, and was trained as a Technical Officer (CW). It took nearly a year to get into the British Army - I had to have influence. I had started doing the course that I had left Australia to do and Sir Robert Robinson, for whom I was working at Oxford, got me into the Army.

I was eventually allotted to the No.1 Anti-Gas Laboratory (Royal Engineers), as it was called, and we left England to go to Singapore. But the Japs got there first and we went to Rawalpindi in India. I was actually doing similar trials to the Australian ones, in the south of India, when I got a cable telling me to report to Land Headquarters, Melbourne, and I never saw my unit again. I went straight to a troop ship that had 6th Division AIF on board returning from service in the Mediterranean area, and we went back to Australia. I was attached to Land Headquarters and it was from Melbourne that I started doing these trials. My memory is that it was early 1943. I joined Gorrill's team for the Forbes and Grafton trials. Then I had 5 months in Innisfail, from about 10 December, 1943 until 10 May, 1944.

I was involved in the planning, conduct and reporting of trials of 25 pounder air-burst base ejection shells charged with mustard gas (thickened) and also with innocuous materials. The trials took place at Singleton, Forbes and Grafton, all early in 1943.

Singleton was the first, and shells were fired to air-burst over a target area which consisted of a group of numbered cards which were about ½ metre square. There were about 200-400 cards in the grid. The target area was about 100 metres square. Also in the target area were dummy soldiers (like scarecrows). I don't think there were humans or animals in the target area during that shoot. There were also vapour sampling devices consisting of trains of ordinary gas bubblers (ordinary chemical glassware). These were installed and operated by remote control by the 2/1 Mobile Anti-Gas Laboratory, McAllester's unit. After the shoot the cards were collected by volunteer troops who counted and measured the spots of mustard gas and I made a map of the density of the spots. I think the guns and crews and volunteers all came from the 2/2 Field Regiment RAA. The shoot was under the direction of Colonel Wade of the Artillery School. The vapour concentrations were lower than we'd expected and the drop size was finer than in England, but that had been predicted.

The most surprising result was that some shells, and I think they were all from one batch, behaved quite unpredictably. (It was later found that the viscosity was lower than normal because if you stack the shells in the sun, the viscosity goes down as the temperature inside goes up. And also, if you stack your shells on the side, and the thickener gells, you've got a semi-solid mess which puts them off axis when they spin.) There was one batch, I remember, that was quite unpredictable. The rest were pretty good.

At Forbes the shoot was carried out on a disused airstrip. In this, human volunteers were involved; I briefed them myself and they were vetted by a medical officer. I did tell them that we were hoping to get casualties and they were happy about this. A slit trench was dug in the area, at right angles to the line of fire. About a dozen volunteers occupied this trench, and I was in it with them. After ranging carefully on a nearby target, the line of fire was switched to burst four shells simultaneously near, but not directly over, the slit trench. The idea was for the volunteers to wait until the shells had burst and then get out of the trench, wearing normal battledress with respirators, and try to place themselves in a position where they would receive some of the spray.

I was wearing impregnated battledress and some extra protection over my face, because I was involved in a lot of experiments with mustard gas and it was policy that people who were involved in trials should be protected because you become sensitised to the stuff if exposed to it repeatedly. They did get into the spray. I think on account of the sensitisation business, we never used a volunteer twice. I was protected in some ways that they were not. I think my battledress was impregnated and I think that I was wearing anti-gas ointment on my face. Certainly it was the intention that some casualties from droplets would occur, but none from vapour. Everybody was wearing gas masks. Our eyes and lungs were protected. This was explained before the men volunteered. I was present in the slit trench and wore protective clothing. Some blistering was found by the medical officers. Our results were similar to those found at Singleton. Again, the vapour concentration was found to be lower than predicted.

There was a less serious incident. After the guns had fired and before the shells arrived, an RAAF aircraft was seen approaching to land on this disused strip. Four shells landed on the strip several seconds before the plane did. The pilot put on full power and cleared out. No one registered his markings and there was no record of an RAAF plane legitimately in that area. So it was probably somebody going to see his girlfriend.

The third trial with 25 pounder charged mustard gas was near Lake Hiawatha in the Grafton area. The guns and volunteers came from the 2/6 Field Regiment. The experiment was like the Singleton one as far as I can remember. There were volunteers in the target area, presumably in slit trenches. I wasn't in the target area myself on that occasion. A further trial with 25 pounder base ejection shells was carried out between Katherine and Humpty Doo during 1943, probably August. I think the troops involved were from the 4th Field Regiment RAA (an AMF unit) and again the grid of cards and dummy soldiers were used. I don't think there were any volunteers or animals in the target area and I don't think there was any vapour sampling either. In these trials I was in charge of the technical side.

Dick Gillis[2] recalls:

I first became involved in chemical warfare in January 1939. At that time I was an honours student at the University of Sydney looking for a project, and I did not want to work on natural products which was the standard sort of thing which was done then. Dr Frank Lions offered me a project, to work on the preparation of thiodiglycol from ethylene oxide and hydrogen sulphide. He knew the war was coming and thought that something in the chemical warfare area would be worthwhile; I was also to make some analogues of mustard gas.

This project was terminated for two reasons. Firstly, Donald Othmer, from the Brooklyn Polytechnic, published his work on the reaction,[3] and I also must have made some satisfactory analogues because I was burned. So the project was terminated and I transferred to work with Professor John Campbell Earl. Earl also knew the war was coming. He was a member of the Chemical Defence Board's Chemical Sub-Committee, and knew the sort of things that would be required by the military when the war broke out. So he had people working on synthetic Vitamin C, ethyl aniline, which was used for making a compound for stabilizing cordite and, in the CW area, a dye called Ingredient B1, which was used in a detector for mustard gas. It is a brown substance which goes bright red in contact with mustard, but also with some other chemicals.

As a result of this work, I was offered a position at the Munitions Supply Laboratories [MSL], as it was then called, and started work there in May, 1940. My first task was the treating of respirator charcoal with silver to make it effective against arsine, which military intelligence indicated the Germans were preparing to use on a large scale. I was also loaned to ICI at their Yarraville [Victoria] plant to work on improving the production of bleaching powder which was needed as a decontaminant for mustard gas. Later, I transferred to the toxic laboratory in the new building at MSL.

The job there was preparing ammunition for the trials. Also the RAAF had a considerable amount of mustard gas in large drums, stored in tunnels in the old single-line railway from Sydney to Lithgow. One of my jobs was to take samples from these drums, bring them back to Maribyrnong, analyse them and see that they still conformed to specification. The Army had their own system for checking their stocks and this was done by McAllester's Mobile Chemical Warfare Laboratory. Mustard gas was thickened with chlorinated natural rubber. It was made viscous so that when a shell exploded in the air, the droplets that would reach the ground would be reasonably large, sufficient enough to cause casualties. Unthickened mustard would simply disperse as a very fine mist. It wouldn't get to the ground. The Japanese had captured most of the sources of natural rubber and chlorinated natural rubber became in short supply. We began to need substitutes, and this was where perspex first became used. It was a poly (methyl methacrylate) and this was used to provide a viscosity of about 6 poises. This viscosity was specified because it was known to be suitable in Europe. But, we soon found that in the much higher temperatures that you get in North Australia generally, this was not at all satisfactory.

One of the things that we tried to do in the toxic laboratory was to modify the existing thickener with chlorinated rubber by adding perspex and other things. Mostly we were interested in base ejection shells. The 25 pounder gun howitzer that we used took a shell about 80 mm diameter and this was hollow and filled with viscous liquid. The base was screwed in and held on about 1½ threads. There was a filling hole in the centre of the base. This had a plug that was held with more threads than 1½. The idea was that with a time fuse, the burster would go off while the shell was in the air, and the liquid would push the base out of the shell and it would then rain down with drops of the size that would cause casualties.

One of the things that we did was to add dyes to the mustard gas. And we had cards (sometimes called 'jump cards') which were coated with absorbent paper. You'd get a circular mark and from measuring the diameter of the stain on the paper, you could estimate or determine the size of the drop. These were calibrated in the laboratory beforehand. We also prepared special fillings for 4.2 inch mortars. These were used in the trials at Innisfail several times. Some were filled with methyl salicylate which was dyed. This was in order to determine how much was left in the trees when the bomb came down through the canopy of the jungle - how much actually got to the ground. Some of these trials were done with simulants which were non-toxic. For the Grafton trials, where shells were fired so they burst when they hit the ground, we added an oil-soluble copper compound to the mustard, and soil samples were taken in which they determined [if] copper [were present]. As there was no copper in the soil near the lake, this enabled us to determine how much mustard went into the ground and how far it was spread around the crater. My activities were mainly involved in preparing ammunition for the trials, and the only trials which I personally attended were Innisfail in January 1944, and Grafton, which I think was May 1943.

Parsons[4] joined Gorrill's group about June 1942 with McLean, Abbie and Don Hamilton, who is now a medico in Sydney. They learned chemical warfare from Gorrill. Amongst the others with them were Dr Corkill [*sic*], Director of the Baker Institute (E. R. Trethewie and H. Ennor) and two American medicos, Roland Miller, who was a Yank, and George Moore from the Deep South. Parsons and the rest of this group were involved in the early work and later in the old chemistry school at Melbourne University, and in the Physiology Department.

Parsons was in the first trials at Townsville and he was also involved in the trial at Grafton, where they were in trenches and a 25 pounder gun was fired at them with air and ground burst ammunition. The trials at Grafton were at Lake Hiawatha, which is quite near the coast and about 15 miles from Grafton itself. One man who had a mustard gas vapour burn on the scrotum was told to stay in bed at the camp, near the lake, but he didn't do that. He got a lift into Grafton to see a girl and then had to walk back to the camp, which was about 15 miles. The next day he was incapable of movement and it was deemed that it was a self-inflicted wound because he had not done what he was told. It may be worth noting that the resident medico at Grafton Hospital was a nephew of Ion Idriess, the author. Parsons recalls the incident at Townsville when Trethewie, Taylor and Lincoln were burned by the mustard gas, which desorbed from the walls of the chamber and this was totally unexpected. Taylor's eyes were badly burned but he was treated by Travers who was an Air Force medico and an

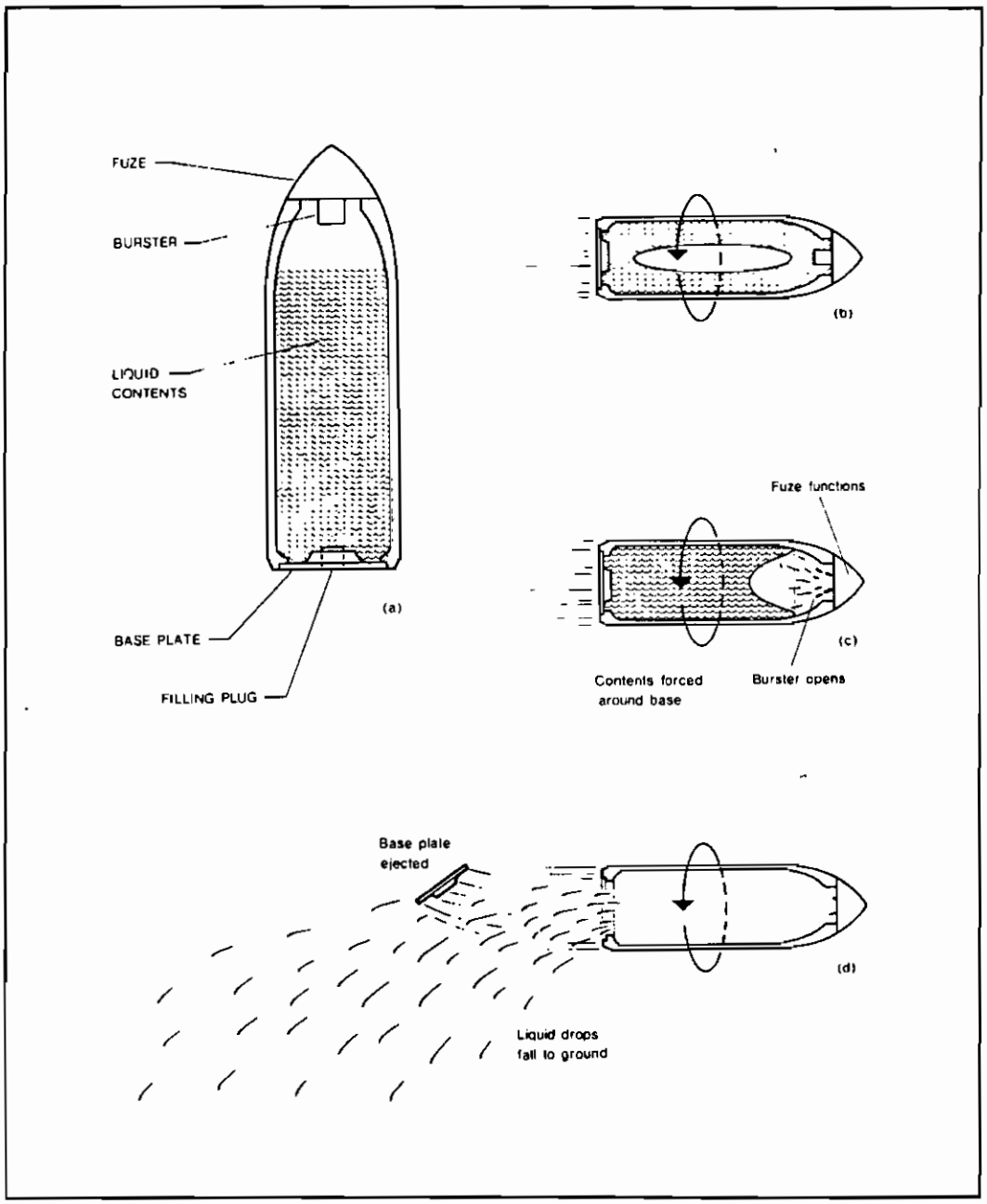


FIGURE 2 Schematic of a Base-Ejection shell in operation

a) Standing on its base
b) In flight
c) After time fuse functions and burster explodes
d) After base plate is ejected and liquid begins to fall

eye specialist. Parsons and Abbie got out of CW sometime during 1944, Parsons was with a unit on the Tablelands and then went to New Guinea.

Keith Rossi[5] recalls:

On or about 16 February 1943, F Troop, 2/2 Australian Field Regiment entrained at Newcastle and proceeded to Forbes, arriving there on the evening of the following day. The townspeople turned out in strength to welcome us as we marched from the station to the Town Hall for an official reception, and slept in the hall overnight. Next day we unloaded our vehicles, guns and equipment from the train and moved to Forbes Racecourse where we established a bivouac. Also at the Racecourse were about 30 young soldiers who, I believe, were from the Recruit Training School at Bathurst. A Meteorological Section, RAAF, was also there. The firing took place near Forbes 'aerodrome'; the target area was near the hangar, which was a large galvanised iron shed.

The troop was equipped with four 25 pounder gun/howitzers. Gun positions had been surveyed and pegged in a straight line, at various distances from the target area, before our arrival.

We may have been briefed about our task but I have no recollection of it, nor can I recall any reference to the need for secrecy. We mingled freely with the townspeople when not on duty, but they didn't talk about what we were doing. Neither did we. Over a period of, I think, about two weeks, we fired gas shells from different gun positions. A British Army Officer[6] appeared to be in charge of the operation. I have an impression that we fired shells with several different fillings; teargas and mustard gas come vaguely to mind. We certainly knew at the time as the shells were marked in the standard manner.

The volunteers wore normal drill uniforms and tin hats, with gas masks on some occasions, and on others gas capes and eye shields. For some experiments the soldiers stood in the open while we fired over, but generally they stood in trenches.

After some shoots, working parties wearing protective clothing entered the target area to decontaminate it by spreading a white powder over the ground.

Although the volunteers were camped on the racecourse near us, we did not mix much with them. I cannot recall whether the segregation was enforced, or merely the outcome of lack of common interest between us 'old' soldiers and those 'young ones'. Certainly I have no recollection of a noticeable lessening of the number of volunteers participating, nor for that matter can I recall ambulances calling at the racecourse to evacuate casualties. But I may have been socialising in Forbes when the ambulances arrived and left. I did hear afterwards that some had suffered severe burns and had spent a couple of weeks in hospital.

I am under the impression that I was the only member of F Troop to suffer burns, although some say others were burned also. It was not the done thing to complain

about one's problems, so it is quite likely that others were mildly affected by gas and said nothing about it. I certainly didn't report my minor blistering until we returned to the Regiment a couple of weeks later, when an inspecting officer stood me up for not shaving. I then went to the RMO [Regimental Medical Officer] for protection, as the area under my chin was too tender for a razor.

I was contaminated when I rode my motorcycle along a telephone cable to locate a suspected break. The cable had been broken by a bursting shell and, although I took great care that none of the liquid gas got on to my skin while I made a temporary repair, it seems that some evaporated from the hot ground and 'bathed' my face. A day or so later the area under my chin and jaw reddened and blistered slightly. Something like impetigo. So far as I am aware there have been no after-effects.

The following section consists of a taped conversation between Gillis and McAllester in which the latter reads from a letter which King wrote.

My recollection is that they were all volunteers, they weren't press ganged and that they got a little extra money and extra leave after a trial. The other thing that I'm sure about is that they wore respirators in the mustard trials.

Impregnated underwear was used for the Forbes and Grafton trials and again the whole assessment of that was in the hands of Gorrill. He also did the arrangements for obtaining the volunteers and I can't recall any problems arising with the obtaining of volunteers on target areas. I think the Forbes trial was the first one at which blisters were recorded. In general our work was concentrated on obtaining quantitative results of the mustard vapour concentration, and the way that it was operated. Gorrill tended to take the physiological assessment under his own wing and not discuss it very widely among those present at all.

Weldon was in the act in this sense too. Weldon's attitude was, the best security is for you to know nothing, and I think Gorrill took much the same attitude, and they were very very security conscious, both of them.

I'm only able to comment on the trials at Innisfail, Townsville, Singleton, Forbes and Grafton; and, as I mentioned earlier, the logistics of getting all the gear to the Grafton site and doing the analytical work was such that our unit was unable to carry out its proper function of preparing to check and identify and report on any enemy chemical equipment that was there.

So that after the Grafton trial it was decided that the experimental wing for the gas school, staffed principally by Andrews and Kerr, would move to Proserpine and form the nucleus of a larger group to do the chemical assessment of future trials.

There was never a full meeting after the trials of everyone concerned. We each put in our separate reports and Nick King coordinated the reports, and he would come back

to us and check various points but I can read out to you the comments he made on the draft I sent him for the Engineer History.

He says:

> As I feared, I have not been able to produce anything systematic. I attach a few notes on people, weapons tested and results. My memory is even hazier than I expected to find it. You seem to think I was at both Innisfail and Proserpine. In fact, I spent some months, five or six I think at Innisfail, but never even saw Proserpine. I had transferred to Air Force before Proserpine started. I was asked to organise trials of 25 pounder shell full of mustard and also with a fake mustard gas of the same viscosity, to test dispersion and ballistics. There were the early trials at Grafton, Lake Hiawatha, Forbes, on a disused airstrip, and Singleton. The 2/2 and 2/6 Field Regiments provided the guns and crews.
>
> There was also a trial at Humpty Doo in the Northern Territory, but I think possibly nearer to Katherine. The guns and crews were provided by an AMF Field Regiment, the 4th I think, but that is very hazy. Later I was attached to Gorrill's very unorthodox unit, but I had already decided that CW adventure would not result or not occur, so I applied for air crew training. This took a long time to come through, but arrived just before the transfer to Proserpine.

[In] another letter, he mentioned his memory being hazy, but when he gets back from a trip he'll seriously try to get something on paper.

Now to some things that we weren't involved in, that Nick mentioned: weapons tested at Innisfail, 25 pounder base ejection shell-charged mustard, 4.2 inch mortar shell-charged mustard, 250 lb aircraft bomb-charged mustard, and he mentions an aircraft bomb made by filling an ordinary petrol can, a standard 4 gallon tin, with mustard and attaching a flag to the handle to get some degree of aerodynamic stability. Like a drogue, you just pitched it out of the cockpit of an open aircraft. The viscosity was quite low, possibly unthickened, and at least in some cases dispersal was by impact only. And he mentions aircraft spray tank[s].

The 25 pounder shell and the mortar shell were tested in tropical rainforests on the mainland here in Australia. My memory is that the trials of the aircraft bombs and spray tanks were on North Brook Island. Japanese-style bunkers and fox holes were constructed and manned by goats. Chemical equipment was installed and that would be the equipment that we handed over to Andrews and Kerr. The island was bombed from the air with various mustard weapons, troops then landed at various times and with various types of protection, or with no specific protection other than respirators Assessment was made of the effect on animals in bunkers, the effect on troops entering the area from the landing barges and the persistence of the gas. I think I heard after had gone to the Air Force there were other trials in which troops were actually occupying bunkers on North Brook Island during the aircraft attack

He also mentions the other work on dibutyl phthalate, to repel insects. He thinks the trials of anti-mosquito preparation were limited to user tolerance, because the bug doesn't occur near Innisfail. Our other test was carried out on the effect of wearing anti-gas clothing, on the ability of troops to do normal duties and also heavy work in tropical rain forests. At least one of these trials was carried on until it was stopped by physical collapse. We recovered pretty quickly. He points out that Ron Andrews may remember that trial better than he did. I don't know why. At that time he might have been in charge.

He mentions the physiological side effects of anti-gas ointment, physiological effects of measured concentrations of mustard gas vapour. These tests were carried out in a gas chamber, not in the open. A great deal of micrometeorology was carried out in rainforests, and then he mentions the one you already have in the Engineer History. First the effects of tropical and sub-tropical conditions on viscosity and hence on dispersal and drop size was very much as predicted by Porton. The reduced viscosity of the charge had considerable and unpredicted effects on the ballistics of 25 pounder shell. One batch of shell was found to be so erratic it was not to be used. Physiological effects were enhanced to a greater exten[t] than predicted.

Well, that's the extent of Nick's comments, and I don't think that I could add to those because I just didn't have time to go on any Cooks tours. I had fairly regular contact with Travers and Danson, helping them to get equipped because he had the base lab in Brisbane and a well organized supply channel. Our main problem was keeping our mobile section supplied in New Guinea and bringing it backwards and forwards to the mainland as the Command decided, which had no relation to what we were trying to do.

The 2/2 Field Regiment certainly provided the guns at Singleton in 1943 because they were just back from Ceylon. Colonel Wade was there. It's just coming back to me, the thing that used to upset the gunners was the fact that, I think they claimed that if a shell wasn't filled right up to the plug ... it became unstable in flight and you could hear them tumbling through the air.

I remember at the end of the day at Grafton we went out to check the target area in the jeep and on the way back we did a big sweep around. We took our respirators off. Somebody said 'I can smell mustard'. Now this was 400 yards to the left of the line of fire and about half way to the target. We said 'Hell, there shouldn't be any mustard around here', so we went and had a look and we found a shell which had hit the ground and exploded. What I think happened was that they were always stored on their side and that the thickened mustard had gelled and it was sort of semi-solid in there, so when it came out of the gun it just turned around the corner like that. This was the only explanation I could think of at the time. And you don't want that sort of thing happening because it could come right around and drop on you. Nick mentions the 4th Field Regiment at Humpty Doo, but I'm almost certain ... that was to enable them to get their gunnery right.

One thing that came out of that to my knowledge was that if you store shells in bright sunlight they get so hot that the viscosity drops down to virtually nothing.

NOTES

1. King worked as a chemist for Drug Houses of Australia after the war, then for Commonwealth Serum Laboratories. Later he joined CSIRO and was in its Bushfire Research Section when he retired.

2. Gillis moved to Melbourne Technical College after the war, and taught organic chemistry there for about ten years. He returned to the Laboratories and when he retired in 1980 he was Head of Personnel Protection Group.

3. D. F. Othmer and D. O. Kern, *Industrial and Engineering Chemistry*, 32, 160, (1940).

4. Dr Parsons is still a practising physician.

5. Mr Rossi is still active on business and on Returned Services League [a]ffairs.

6. This was almost certainly Captain N. K. King, RE.

CHAPTER 5

A Contaminated Ship

... Le Fevre[1] recalls:

In the earlier months of 1939 most of the scientific people in English universities were catalogued on a Central Register from which they could be drawn in the event of war. My job would be to go to the Directorate of Scientific Research in the Air Ministry, but before doing that I had a short attachment to the Ministry of Home Security [MHS] which required me to organise and run courses for 'Gas Identification Officers' being recruited in our local areas. These were mostly civilian analysts or county analysts. For the first months of the war this was what I was doing. At Falfield near Bristol I met a whole lot of Porton people whom I later came to know quite well. The MHS attachment came to an end by about Christmas 1939 and, early in January 1940, I joined the Director of Scientific Research of the Air Ministry and found myself a member of RD Arm 6(C) (Research Development, Armament, C for Chemistry, Number 6). My task was then to go for about a fortnight to Porton, factories, etc., and another fortnight going around various Air Force Stations, back to Porton for another fortnight, and so on. I alternated in this with F.B. Kipping, the son of a professor, who was well known for his discoveries of silicones and related compounds.

At War Cabinet levels there seems to have been an opinion that a supply of chemical weapons should be sent to the Middle East and again at a later date, to the Far East. Kipping was therefore appointed as an Air Force officer and went to the Middle East to do what he could, and I was told that in due time I had to go to the Far East. After an interesting air and sea journey, I reached Singapore in June 1941.

I was met by Wing Commander Ramsay-Rae, the senior armament officer, Far East Command, with whom I worked in close association. My first duty was to consider what preparations could be made for storing chemical weapons when they did arrive. My attention was drawn to the possibility of using caves and to Mr M. W. F. Tweedie, who was the Curator of the Raffles Museum. He was a speleologist of note and he knew all about the extensive group of caves at Batu just outside Kuala Lumpur.

Most of the caves were full of bat dung, as bats had lived in them for centuries. It was necessary to clear out some of the lower caves, but there was no trouble in doing this. We gave away the bat dung to a local Malaysian as fertilizer. The clean-up took less than a week, and the first of the gas storage depots in Malaya started. The CW stores were got up there by train. I don't remember there being any mishaps or casualties.

We had very few troubles because we didn't have a great holding there. A large number of empty SCIs [Smoke Cloud Installations][2] and not very many storage drums.

There were land mines and so on and some 250 lb bombs. Anyhow, we got them all housed in the caves with a squad of airmen to guard them. I gave talks and

demonstrations about handling, decontamination, etc. This was all on too small a scale, as we realised when later we came up against real situations. Under Air Force Headquarters instructions we had decontamination squads at every aerodrome. We were responsible for all the aerodromes up the Burma Road as far as the Chinese border. There was a line of about 12 aerodromes along the Burma Road which I visited. Intelligence reports became more and more intensive about the Japanese fleets sailing around in the Gulf of Cambodia and the imminence of Japanese attacks. At the same time the people in London sent instructions that I was to try to travel into China as a university lecturer and, at RAF expense, was to clothe myself with a civilian suit, and go to Chang Sha where there were some captured Japanese chemical weapons, and try to arrange that at least one or two of these were brought back to Singapore, where there was an efficient Government Laboratory in which chemical analyses could be performed. I was just ready to do this during December 1941.

During the night of 8 December Singapore had its first air raid and bombs started falling everywhere. Such attacks were repeated daily. Japanese aircraft were almost unopposed and the British forces' withdrawal southward was accelerating. Our chemical supplies had to be brought back from Kuala Lumpur to Singapore by train, and this was accomplished, fortunately, without incident. The next problem was where to put them because nobody was prepared to take the responsibility of holding them. In the end, someone in the Navy said, 'There are lots of spare lighters which were used to unload ships, you can have about 20 of them if you like'. It was decided that the weapons would be stacked on these barges and towed around to St. John's Island East. Once upon a time there had been a leper settlement there. It was uninhabited and quite a nice place. We had about a dozen airmen to operate and guard all this with a Flight Sergeant in charge. The air raids went on and on, more ships were coming and more chemical weapons. One, the *SS Silver Larch*, arrived *during* an air raid. By this time the Japanese were more or less down at the southern tip of Malaya. They weren't on Singapore Island yet, but very close to it. Daily air raids were frightening at times. All supernumerary and unnecessary people of whom I was one, were advised to get out the best way they could. I was told to go to Sumatra. I got to Palembang on the east side of Sumatra and sought news of the *Silver Larch* and her cargo and was told that the best thing to do would be to take the train to Oosthaven, which I did. While I was there, the Japanese made a big attack on Palembang. So I was then told to go on to Batavia. There I found overcrowding and confusion. At Batavia I was told that the best thing that I could do really was to get on to an RAF auxiliary vessel called *Tung Song* which had been carrying fuel to the Andaman Islands. This I did, and we went round to Tjilatjap on the south side of Java.

During that trip the boiler started to leak and when we got to Tjilatjap, steam had to be dropped while the crew did some urgent welding on the boiler tubes. We had several hours of tension while waiting, occasionally hearing noises of aeroplanes and knowing that the Japanese were reputed to be coming across land. We picked up a whole crowd of chaps in khaki shorts who had assembled on the shore. Finally *Tung Song* had 220 men on board. It was literally covered with men, and wives or relatives of RAF personnel.

Luckily, there was one corporal medical orderly amongst these refugees and he took over dressing of wounds, boils, ulcers, cuts, etc.

The men all slept on deck; the women were given the two little cabins which normally were for the engineers. We were told that this vessel would be going towards Australia and a course was set south 28 degrees east which was held for 15 days, and fortunately we weren't seen. (That was the time when *Perth* and *Yarra* were sunk.) There was a Japanese aircraft carrier and several other major ships in those waters seeking what they could destroy. Fortunately we were not seen. We continued South 20 degrees E for many more days. That brought us into Exmouth Gulf where, according to the Captain's information, there should have been a mother ship re-fuelling British submarines. But when we got to Exmouth Gulf, there was nothing to be seen but heat haze. The mother ship had disappeared days before.

I was chemical adviser. *Tung Song* had down below several big drums of lubricating oil, plus other sorts of oil with which one might re-fuel. So all hands had to knuckle down and hike these things up by manpower and crane, and pour them through big funnels into the furnace oil tanks. I assured the captain that they would burn and thank God they did, so we were able to proceed to Fremantle. I was told to get onto *Monterey*, a US luxury ship that had brought American troops to Western Australia, and I went directly to Melbourne.

For a few nights I slept at the Ascot Vale recruit centre. I made my number with the RAAF HQ Armament Section where Lightfoot[3] had the idea that I should be retained for a little while until the first arrival of chemical weapons, when my experiences in Malaya might be of some use to Australia. So it was arranged that I would be on attachment for 3 months but what with renewals and developments, in the end I stayed a year and a half. The first questions that came my way in RAAF headquarters were again as in the Far East: 'Where could we store these weapons?' And this was when some bright spark came along and said, 'If we haven't got caves, we've got disused railway tunnels'.

The first tunnel was at Glenbrook, NSW, on the old single track line and the second one was at Clarence, further west towards Lithgow. There was also a short tunnel near Picton. We investigated caves up near Charters Towers. They weren't satisfactory because of the water supply; and then finally the last dump I had contact with was about the 87-milepost south of Darwin, on the Katherine Road.

I got back to London in December 1943 and went back to RD Arm (6) with the rank of Assistant Director. About mid-1944 I was moved, to take charge of the Chemistry Department of the RAE establishment at Farnborough, and from then on I had nothing more to do with Chemical Warfare. Then the war ended, and Sydney University made me an offer and I came back here.

Arthur Trewin[4] recalls:

Le Fevre was an Honorary Wing Commander, RAF, and I was brought in from the RAAF Armament School at Hamilton to understudy him because he was supposed to go back to [the] UK. I was picked because I had a degree majoring in chemistry and was supposed to know about these things, but I knew nothing. Within a matter of weeks, *SS Idomeneus*[5] arrived in Melbourne Harbour and we were involved with our first ever casualties in chemical warfare from the service point of view.

We were unloading the ship on a beautiful, sunny, Melbourne Sunday afternoon, with me sitting on the side of the hold watching wharf labourers unload commercial supplies which were on top of three holds of mustard gas. We found that *Idomeneus* had been in a storm somewhere. They had such a bad storm that one of the 90 gallon drums of mustard gas in the bottom hold had been pierced and leaked, and eventually it took us the best part of 4 weeks to clean it out and this meant of course that the mustard gas had been absorbed by the pitch sealing in the hold and it all had to be chipped out, by people wearing impervious clothing and respirators.

In Melbourne, on the Sunday, I suffered such bad gas poisoning that I was blind for two to three weeks and our wharf labourers had to be eventually rounded up and put into hospital. Wing Commander Le Fevre had gone off with the captain and he didn't get burned. He eventually met *Idomeneus* in Sydney. And he initiated the off-loading there. He arranged for the RAAF to unload it using new recruits, much to the objection of the wharf labourers who wanted to do it. They started to do it but they were inefficient.

Meanwhile Wing Commander Le Fevre was admitted to Concord [Repatriation Hospital] and after I had recovered from my burns I went to Sydney and supervised the unloading of the mustard gas and the cleaning of the hold and the unloading of the phosgene gas which was in a refrigerated hold. Because it was in mid-summer, as soon as we took the phosgene gas bombs out and off-loaded them into hot trucks alongside, they immediately started to leak. We had to get them all away in a hurry because they were dangerous. We sneaked off at the dead of night with this phosgene gas consignment to a big cutting at Marrangaroo.

They leaked from then on, and even the alsatians used as guard dogs were poisoned and we had to take them off. When the mustard gas was eventually off-loaded, we trained it out, also at the dead of night, and took it to Marrangaroo and put [it] in the Glenbrook tunnel.

The mustard was in Glenbrook and the phosgene was in Clarence. We deliberately put the phosgene in the open-cut area, not in the tunnel. It was too dangerous because of leakage. We also put some in the Picton Tunnel, but that was later.

Glenbrook was an old mushroom-growing tunnel, and we took it over and put in a concrete grid floor, the railway lines were still there, telephones and so on for security purposes. The gas was in the cleared area in the open-cut at one end and the camping area at the other.

I recall that when we got the phosgene off-loaded at Marrangaroo...the RAAF recruits who loaded it and off-loaded it appealed to me for leave to go to a local dance because it was Saturday. They went to a local town dance and they kept collapsing in the girls' arms. They were suffering from a cumulative effect of the phosgene gas, which they had been getting for a couple of days, but they got over it fairly quickly and there seemed to be no after-effect. It was a scare. We realised then how insidious phosgene could be.

When we were off-loading *Idomeneus* in Melbourne, from the point of view of commercial supplies, tests were carried out and we felt from the tests that things were fair enough. I got poisoned quite badly, and so were a number of wharf labourers. Wing Commander Le Fevre took over on arrival of the ship [in] Sydney and wasn't greatly perturbed about the problem that we had had so far. He did tests, and these tests, according to British standards, indicated that things were alright. So wharf labourers began to unload, but things were done so carelessly that he finally insisted that unloading be done by service personnel. In the meanwhile, he suffered burns himself, by being in the hold too much, and a number of wharf labourers were also admitted to the hospital as well, and one of them died as a consequence of his hospitalisation (not because of mustard gas, but because he tried to climb out of a bathroom window and did not know he was five floors up).

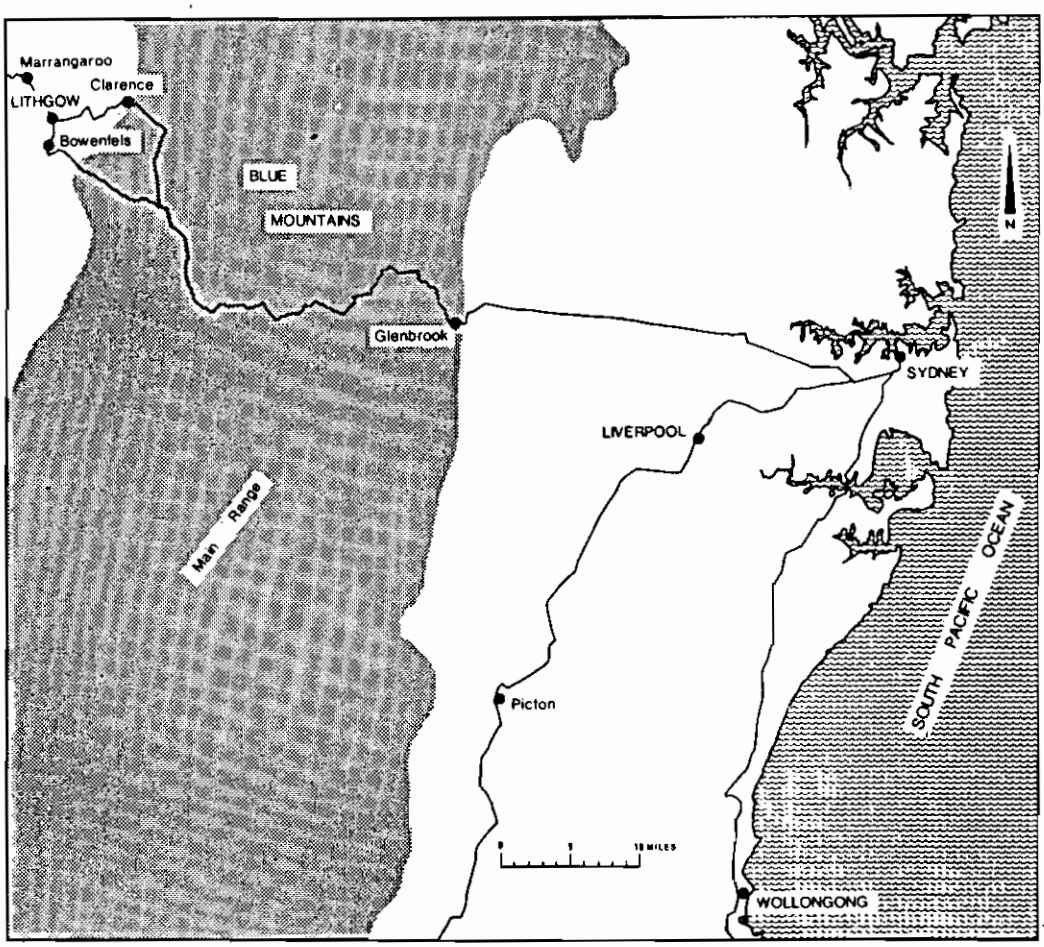
The consequence was that when we took over the unloading of *Idomeneus* with RAAF personnel dressed in impervious, impregnated clothing, under Sydney December conditions, a tremendous amount of exhaustion resulted. So that we had to lower men into the hold on ropes, because by then we were going into the third hold down, and having to bring them up on ropes when they were in the state of complete exhaustion, because they were dressed in complete impervious and impregnated clothing.

The men were in a state of collapse when we eventually discovered that the cause of everything was a 60 or a 90 gallon busted drum (I can't remember which) of mustard gas, and that this had impregnated the timber and the pitch and so on, on the floor of the hold at the bottom of the ship. We then had to start digging out with picks, taking out the soft pitch that was impregnated with the mustard gas and it took us days and days. Eventually we steamed around outside Sydney Harbour with big air sails, pulling air down in to ventilate the hold, like the miners used at Ballarat to ventilate their shafts.

Eventually we kept working on the hold and kept taking everything that could carry solvent out of the hold to clean it out. It was rather a forbidding experience, and then eventually getting these leaking containers into Glenbrook, the mustard gas going into the tunnel itself, except for the leaking containers stored at the far end, and having to be repaired. At the same time not having any competent servicemen, we had to institute training schemes to train them in...handling the gas. We had the best part of about forty servicemen working on ... transferring the mustard gas from leaky containers to serviceable ones.

And these containers had to be lined with a material to prevent anything from attacking the metal of the containers. The English ones had a special type of enamel lining, and we had the problem of not having the advantages of that kind. So they had to go into

Figure 3. Blue Mountains Storage Areas



things like 4 gallon kerosene drums and that sort of thing, which were susceptible to rust, and the old 40 gallon oil drum had no internal protection.

Up to this stage there was no preparation to receive mustard gas into the RAAF, and I think the Army had the same problems. There was no training, there was no readiness for it whatever. What I don't know personally is whether the English simply sent it out to us or whether we had asked for it.

I'm not aware of there having been an order from the Air Force for it, but it wouldn't have come from the Air Force. It would have come through the Chemical Defence Board. We still don't know what initiated the receipt of mustard gas and phosgene gas very suddenly into the Army and Air Force establishments, because they all came at the same time. There were three ships, *Idomeneus, Birchbank* and *MV Nigerstroon*. But *Idomeneus* caused the most trouble because of contamination from storm-damaged drums.

NOTES

1. Le Fevre returned to Australia after the war as Professor of Chemistry and Head of the Chemistry Department at the University of Sydney and is now retired.

2. SCI - Smoke Cloud Installation: A container which could be fitted to an aircraft. It was originally intended for laying smoke screens but was later adapted for spraying thickened mustard gas.

3. Group Captain I. J. Lightfoot RAAF was Director of Armament 1942-1945.

4. After the war, Trewin returned to teaching chemistry at Dookie Agricultural College, then at the Royal Australian Naval College at Jervis Bay, NSW, and at the Royal Naval College at Dartmouth, England. He was a Principal Lecturer at the Riverina College of Advanced Education at Wagga, NSW, when he retired.

5. Everyone associated with this ship pronounced its name 'Eye-doe-mean-us' although it should be 'Eye-doe-many-us'. Idomeneus was one of the Greek heroes in the Trojan war who came to a sticky end because he made a promise he could not keep.

CHAPTER 6

Medical

David Sinclair[1] who was Gorrill's second-in-command writes:

The volunteers were drawn from the AMF and RAAF. The majority came from units stationed on the Atherton Tableland, but many were from units in other places - I am sorry I cannot remember where. Some of the wearing trials with clothing were conducted 'on the spot' - e.g. in Atherton or in such places as 'Dead Man's Gully' (I think that was the name) between Cairns and Cooktown.

I cannot remember the wording of the appeal for volunteers, which I had no hand in drafting but I imagine it simply asked for volunteers to take part in chemical warfare experiments. When they arrived at the unit in batches of about fifty, I personally briefed them about the sort of things they would be expected to take part in. These of course varied according to the work schedule - e.g. exposure in the chamber, traversing 'jungle' contaminated with liquid mustard, etc. This briefing took place ... where they were quartered, i.e. the Showgrounds in Innisfail or in the huts which later became available for them in Innisfail or Proserpine. The necessity for a practical assessment of their injuries was explained to them and the routine to be followed was detailed. Every effort was made to enlist their interest and enthusiasm, and sweepstakes were arranged, the winner being the man who was judged to have been most severely burned; these were at first organised by the men themselves. I should like to pay tribute once again to their wholehearted willingness and determination.

After exposure, all subjects were kept at the unit for at least 21 days (or longer, if the healing time of his burns demanded it); several volunteers were thus retained for longer than this. Each man was examined daily for at least 8 days after exposure; for the next 8 days he was examined every second day, and from then until all his lesions were healed he was examined every third day. If burns were severe he might have daily examinations until 3-4 weeks after exposure, but if the burns were minimal, daily examinations were not done for the full period. Assessment cards were completed in full at each examination, and treatment cards were filled in for each day on which treatment was applied. Each subject thus had a standardized medical record extending over at least 21 days, and consisting of, on the average, 14 examination cards plus any treatment cards. Biochemical investigations were done on selected cases, and subjects who required hospital treatment were admitted to a special ward in the Innisfail Hospital under the care of at first myself and later the unit medical officer. I was responsible for the treatment schedules and for the supervision of the assessment procedures of all burns; the assessment of casualty status was a joint effort organised by Ennor, Legge, Gorrill and myself. During the assessment period the volunteers were required to take part in route marches and assault course runs.[2]

I should stress that after the war my involvement in CW research terminated, and I made no serious attempt to keep up with the literature. There have been, of course,

several books and papers on aspects of CW and BW which have taken no account of the Queensland work, but I imagine these are not relevant.

I know of nobody who developed skin cancer after having received mustard burns, but, as I have just said, I did not keep in touch with CW after the war. I did, however, meet by accident some of our volunteers, and was told of instances in which crops of boils appeared at the site of burns; I did not see these personally. In my view (for what it is worth) the mustard burn is simply a chemical burn by a slowly acting agent, and therefore cancer is no more likely to occur in such burns than in other chemical burns. The situation could be different in regard to internal organs, for mustard is absorbed through the skin, and is well known to have a direct toxic effect on bone marrow and possibly other viscera. Nevertheless I know of no such cases either.

The mustard burn is not a specific and peculiar lesion, but is simply the response of the skin to a slowly acting tissue injurant.[3] It is therefore most unlikely that any specific treatment will be found for established mustard lesions, and in consequence it is permissible to treat such burns exactly as thermal burns, according to the personal preference of the operator. Koontz,[4] as a result of animal studies, concludes that 'there is no major difference, either qualitative or quantitative, between heat burns and mustard burns of equal intensity', and points out that the same methods of treatment should therefore be applicable to both. Davis[5] concludes that 'almost any of the generally accepted technics [sic] of burn treatment' may be used for mustard burns in man.

Casualty assessment[6] has been put on a sound basis by the introduction of a series of practical tests to determine, in an objective manner, whether or not any individual is a casualty. Such tests obviate the need for depending solely upon the clinical interpretation of the lesions sustained by the men, and on the subjective impressions of the men themselves.

In order to achieve this, the subjects perform a standard exercise daily after exposure. An assault course has been designed so that, while it is severe enough to demand considerable physical effort, it is not so severe as to produce incapacitating injuries such as sprained ankles, etc.

Secondly, since the carrying of full equipment while on the march is an integral part of the duties required of the soldier in the battle zone, it is obviously important that the ability of the soldier to perform such a duty should be taken into account in the ultimate assessment. The ability or inability of the individual to perform:

a. the assault course

b. marching in full equipment in a satisfactory fashion,

may be taken as a relatively good measure of his being a casualty under battle conditions.

In a series of experiments conducted in Northern Queensland these points have been investigated, and the conclusion has been reached that the following system provides a satisfactory practical assessment of a casualty.

On arrival at the Unit each volunteer is sent over the assault course twice in order to determine his normal performance. The standard dress for the assault course consists of full battle order, less rifle. On the day following exposure and on each subsequent day until there is no further likelihood of fresh lesions appearing, each subject is sent over the assault course twice each morning. His performance is assessed both subjectively and objectively. Subjective assessment consists simply in questioning him regarding any difficulty which he might have found with the obstacles. The objective assessment consists in short notes made daily regarding his actual performance. The time taken by each subject to do each run of the assault course is recorded, but little stress is laid upon this as an index of his disability, the main criterion being his ability to finish the course in a reasonable time. The two runs which each man performs are separated by a rest period of approximately half an hour. The course, while not a particularly difficult or strenuous piece of exercise under temperate conditions, is a fairly rigorous and difficult task under conditions of high temperature and humidity.

The ability of the volunteer to march with full equipment is tested in the following manner. The volunteers are camped 1½ miles away from the point of examination. Each morning they march this distance in full webbing equipment, including haversack and water bottle, and carrying personal weapons. The time taken for this march, which is carried out over bitumen roads, is approximately half an hour. On the conclusion of the morning routine (assault course and clinical examination) volunteers return to their billet for the midday meal, and in the afternoon a similar double march of 1½ miles is made. The total distance covered daily by the volunteers in full equipment is thus 6 miles. It should be noted that whilst the completion of 6 miles marching in full equipment cannot be regarded as a severe test under temperate conditions, under tropical conditions the accomplishment of this task by volunteers suffering from the effects of exposure to mustard may entail considerable effort.

Experimental Conditions. During the period of experimental assessment all the volunteers involved live under an approximation to field conditions. No barracks or billets are available, and the men sleep either on ground sheets in the open or on bed boards in an open shed. This has an earth floor, muddy in the wet season, very dusty in the dry season. The conditions of the trials are not very far removed from those obtaining under actual battle conditions, and such dressings as the men receive, so long as they are ambulant, are carried out at a Regimental Aid Post, the resources of which approximate to those of a Field Dressing Station.

Sepsis. Because of these conditions, it might be expected that the incidence of sepsis in the lesions sustained by the volunteers would be high, but in practice very few cases of frank infection have occurred in second and third degree burns treated under these circumstances.

Abrasions. It has been noted that the skin following exposure to mustard vapour becomes extremely fragile, and areas of varying size are liable to become abraded as the result of trauma on the assault course. These lesions are superficial and heal readily.

Suspensory Bandages. The value of the sus ensory bandage in the treatment of scrotal burns cannot be too highly emphasized. In many cases, its use has enabled men who would otherwise have had to be classified as Class B to remain in Class C or even Class D.

Desquamation [process in which the outer layer of the epidermis of the skin is removed by scaling]. Little attention has previously been paid to the effects of desquamation as a casualty producer, but in this investigation it has been found that any men who were able to carry on in Class D with severe erythemas [superficial inflammation of the lymphatic vessels of the skin] or second degree burns, became so affected by moist desquamation occurring in various regions of the body that, from this cause, they had to be relegated to another class. The main regions where desquamation leads to the production of disability are the posterior axillary folds and the inner surfaces of the thighs. Men affected in these positions may be incapable of wearing equipment or of marching, and may, therefore, require to be relegated to Class C or even to Class B.

The assault course is roughly circular, which facilitates starting and timing, and is approximately 400 yards long, over level ground. There are seven obstacles, equally spaced throughout the course, arranged [so] that a group of four volunteers can be run over them at one time:

Obstacle 1. A wall 12 feet high, composed of 4 inch logs laid horizontally one immediately above the other. Climbing of this wall is facilitated by four ropes suspended from the top (Figure 8).

Obstacle 2. This consists of three hurdles, the first and third being single and the second being double, i.e. consisting of two hurdles placed one immediately after the other with a 1 foot interval between the two. The first hurdle is 4 feet high and the second and third are 3 feet 6 inches (Figure 9).

Obstacle 3. This consists of a sloping ladder (angle approximately 60 degrees) composed of logs set in a framework roughly 3 feet apart. The wall is 12 feet high, and this provides a latticed inclined plane up which the men clamber ... and then jump down (Figure 10).

Obstacle 4. This is a single hurdle 3 feet 6 inches high.

Obstacle 5. This consists of a series of parallel ropes (one for each volunteer) suspended 12 feet above the ground between poles set 25 feet apart. Access to the ropes is provided by a 'jump bar' set horizontally between the first row of uprights. From this bar the volunteers are required to jump up in order to catch the rope (Figure 11).

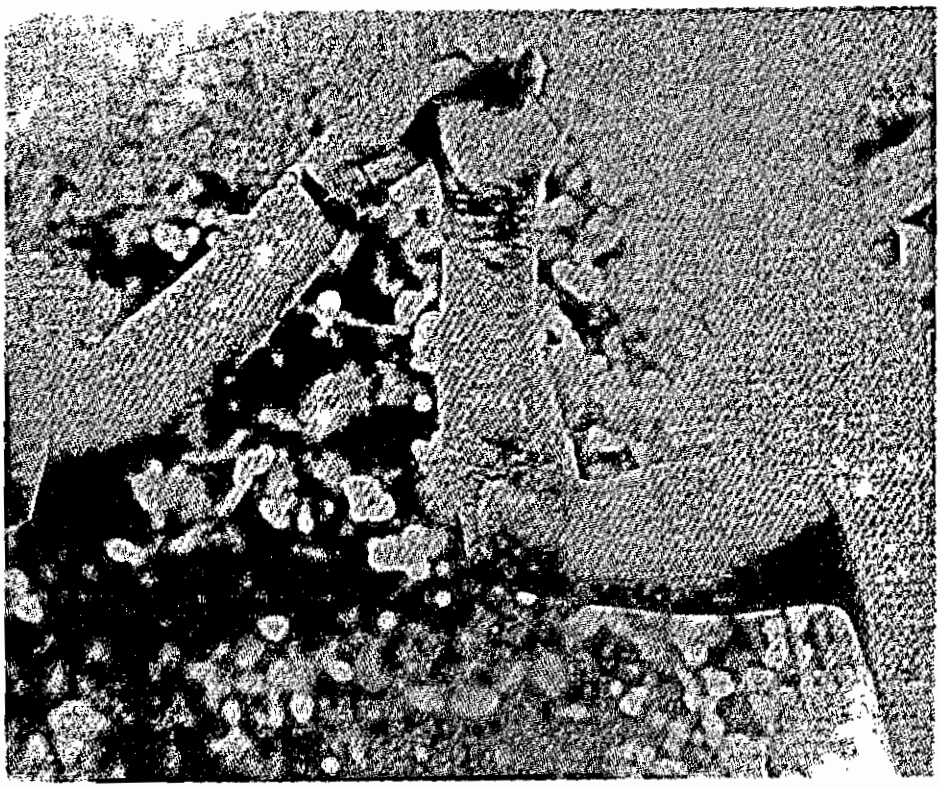


FIGURE 4. Typical blisters from Mustard Gas

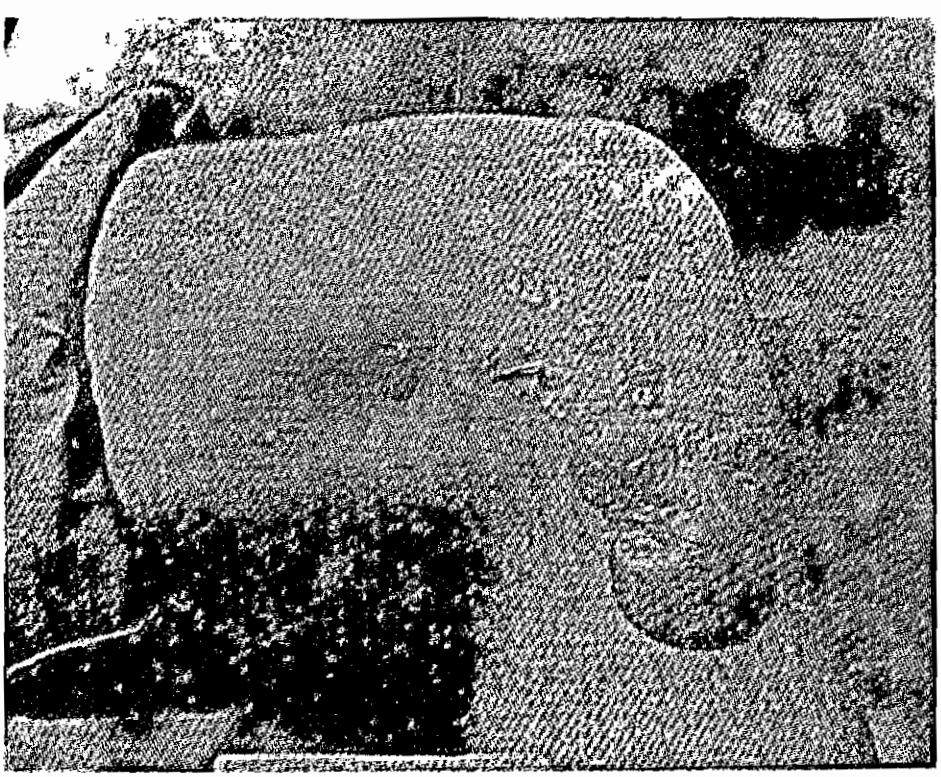


FIGURE 5. Typical blisters from Mustard Gas

FIGURE 6. The respirator protected the face, eyes, nose, mouth but not the side or back of the neck.

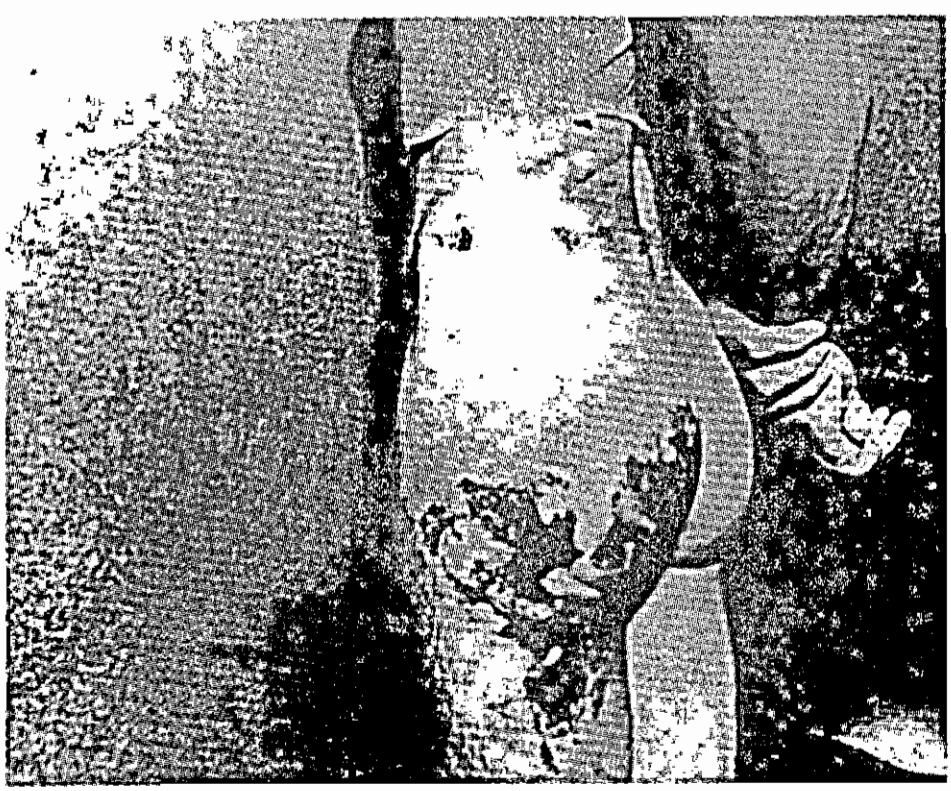


FIGURE 7. A Burned Bottom

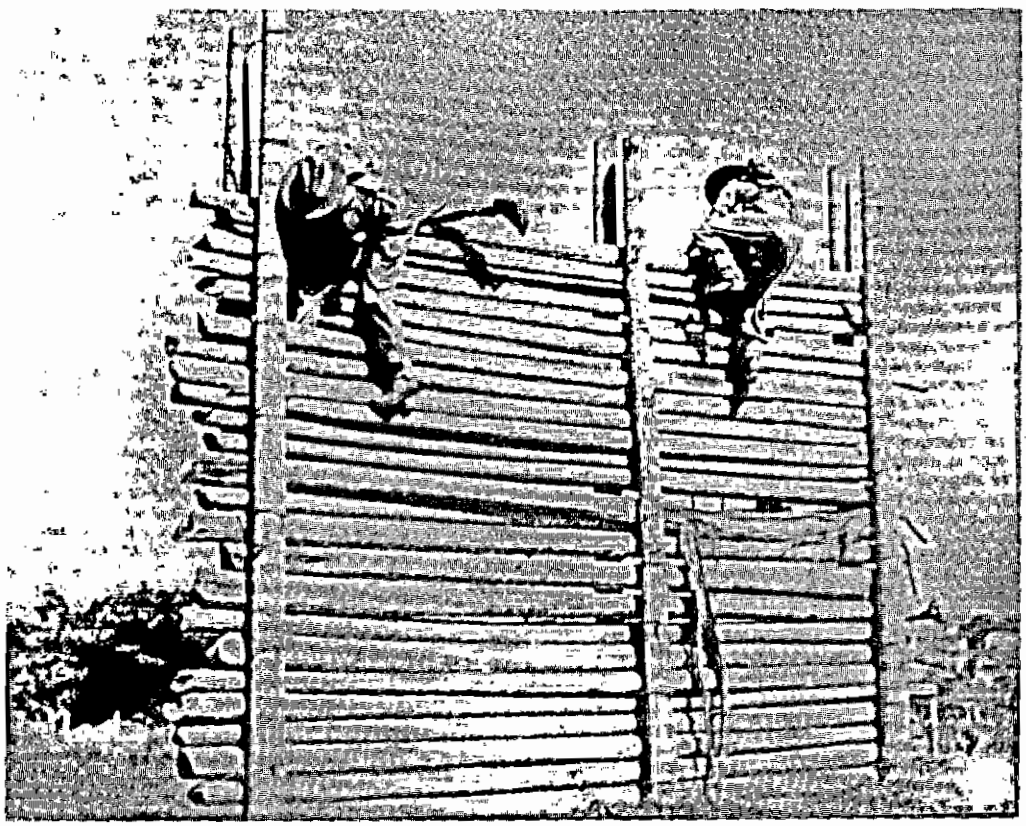


FIGURE 8. Assault Course - First obstacle. The Seventh obstacle was identical.

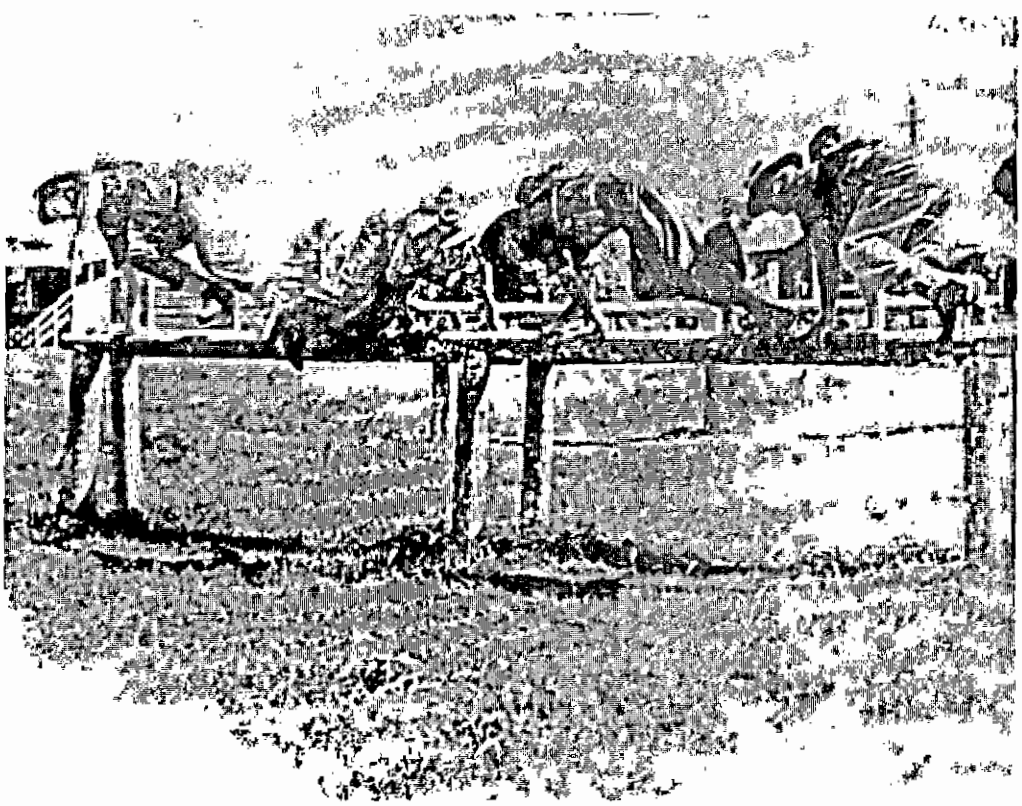


FIGURE 9. Assault Course - Second obstacle. The fourth obstacle (not shown) was a single hurdle similar to these.

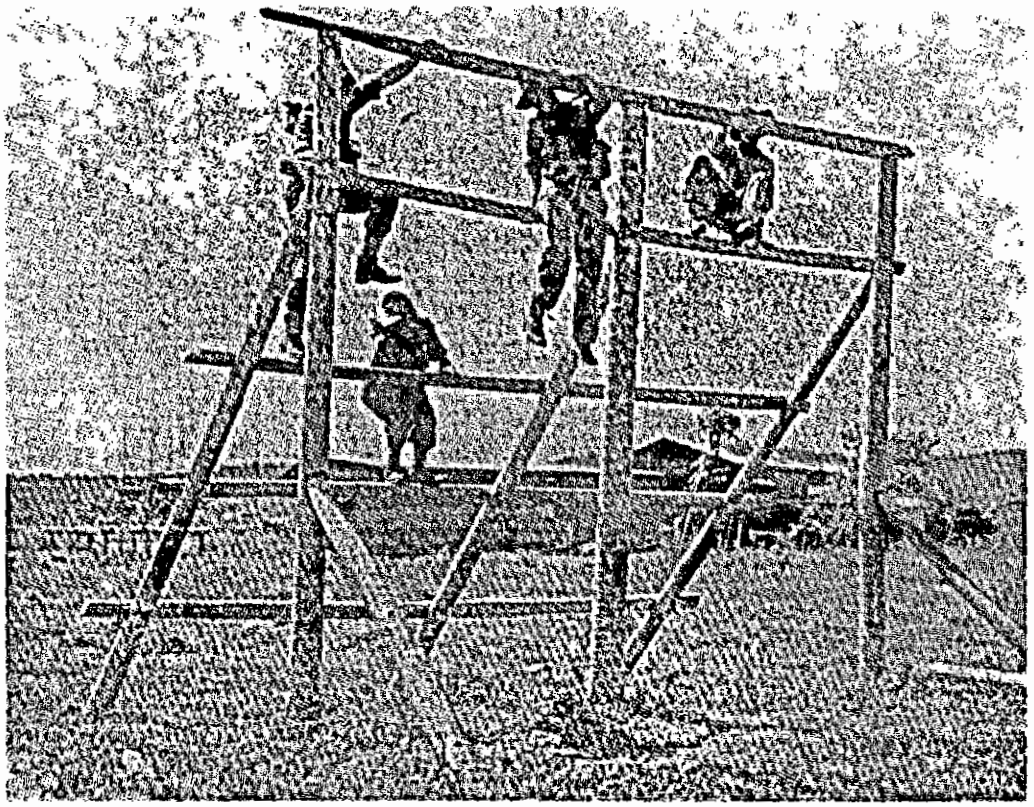


FIGURE 10. Assault Course - Third obstacle

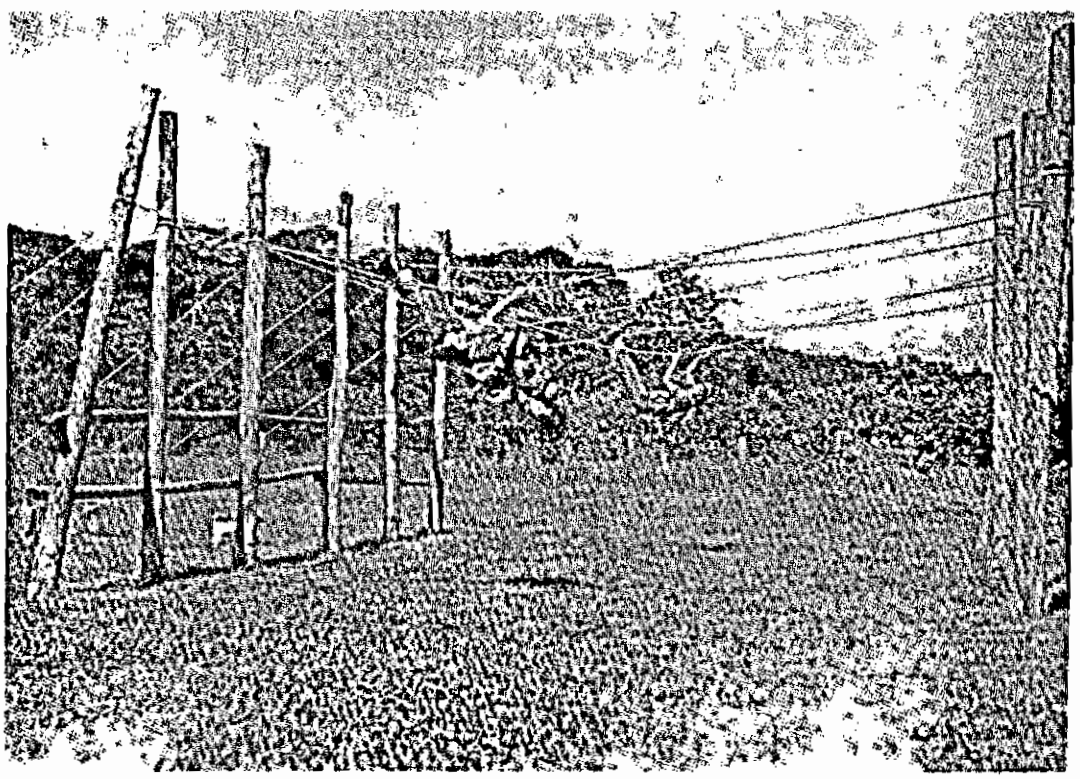


FIGURE 11. Assault Course - Fifth obstacle

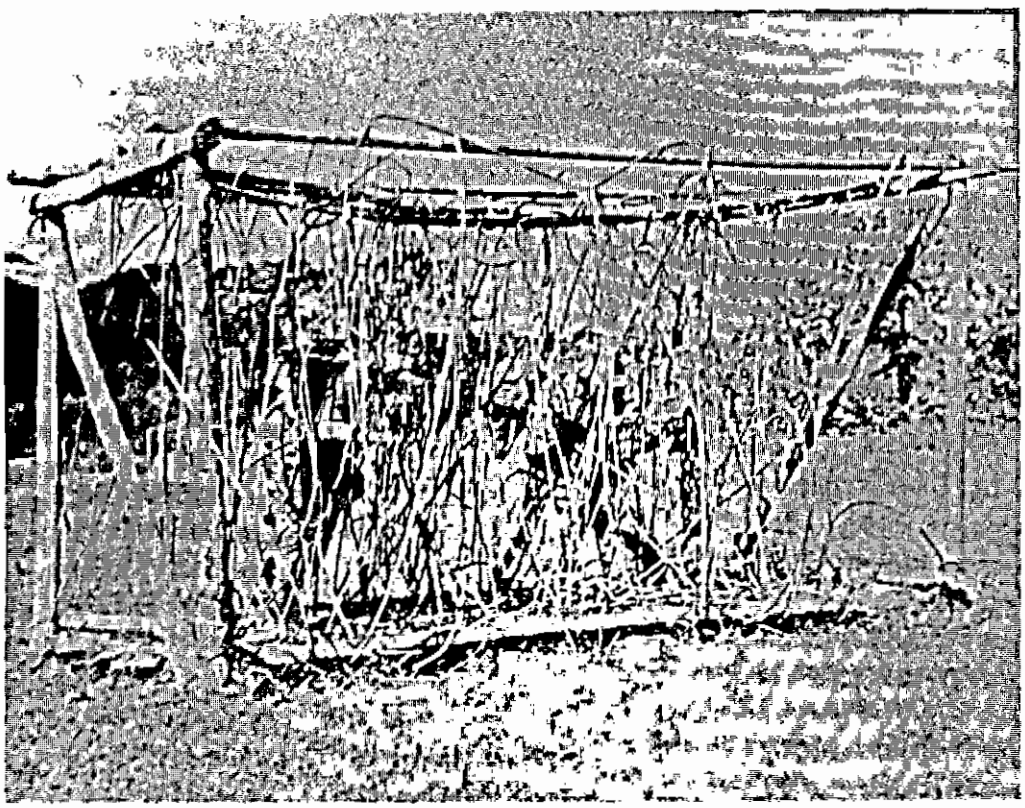


FIGURE 12. Assault Course - Sixth obstacle

Obstacle 6. This consists of a tangle of liana vine criss-crossed irregularly in several places between roof and floor of a small frame-work 8 feet high. The volunteers are required to force their way through this moderately dense tangle which is 6 feet deep (Figure 12).

Obstacle 7. This is an exact replica of Obstacle 1.

No specific instructions are given to the volunteers as to the manner in which they should negotiate these obstacles.

A casualty is defined not by the extent of his burns *per se* but by the tasks which he can or cannot perform. An A, B, C, D severity classification is adopted for general use in these trials.

A : Totally disabled - of no usefulness in the field.

B : Partially disabled - could contribute to the defence of a static position only.

C : Partially disabled - could perform some offensive operations with adequate motivation.

D : A volunteer with burns of little or no military significance.

NOTES

1. After the war, Sinclair joined the Anatomy Department at Oxford University and was later appointed Foundation Professor of Anatomy at the University of Western Australia; later he occupied the chair at Aberdeen. He resigned from this post to direct postgraduate medical studies in Western Australia, but has now retired and lives in Scotland.

[2. Details are given in References 4, 5, 6, 7, 10, 11. See p.91 below]

3. D. C. Sinclair, 'Treatment of Skin Lesions Caused by Mustard Gas', *British Medical Journal*, i, 476 , 1949.

4. A. R. Koontz, *Archives of Surgery*, 48, 284, 1948.

5. M. I. J. Davis, *Journal of American Medical Association*, 126, 209, 1944.

6. This description of casualty assessment is based on a document written by Gorrill.

CHAPTER 7

Programmes and Reports

The following are extracts from 'Programme For Australian Field Experimental Station 1944-45', dated 15 November 1944, Declassified from Secret to Unclassified, Public Release, 9 February 1982. They are included so that the reader can appreciate the range of topics studied.

SECTION I - DEFENSIVE

1. CC2 impregnated clothing

(a) Wearing trials to determine the protective life, irritancy, etc. of CC2 clothing.

(b) Life of CC2 [illegible - Ed.] impregnated clothing.

(c) Trials similar to (a) and (b) above on any new types of clothing from UK or US, e.g. lightweight CC2 clothing.

2. CC2 impregnated hoods

To determine practicability of wearing impregnated hoods. (Comparison of US and UK designs.)

3. Anti-gas Ointments

(a) Comparison between British A/G Ointment No.6 with American M5. (Trials will include: (a) determination of the best method of using A/G ointment to get maximum protection; (b) comparisons in field trials; (c) toxicity.)

(b) Life of British and American A/G ointments in storage.

(c) Comparability of A/G ointments (British and US) with camouflage ointments and mosquito repellant.

(d) Adjuvant methods of skin protection against liquid contamination.

4. **Respirators**

(a) Effect of prolonged carriage of British light respirator under jungle fighting conditions.

(i) Gain in moisture content of respirator containers and effect on gas protection.

(ii) The effect of prolonged carriage on new British design of haversack.

(iii) Effect of prolonged carriage on Canadian and US containers filled [*sic*] ASC charcoals.

(iv) Other effects of prolonged carriage.

(b) Efficiency of Mk.VI anti-dim outfit with light respirators.

(c) Efficiency of arctic non-fogging eyepieces under tropical conditions.

(d) Trials of wearing respirators in AFVs.

(e) Trials of individual face masks for AFV crews.

5. **Eyeshields**

Wearing trials to determine the disability resulting from continuous wearing of eyeshields both in the open and in jungle country. (Trials will include Mk.VI anti-dim and *ad hoc* modifications to improve performance under more severe temperature and humidity conditions than tried so far.)

6. **Impervious A/G Clothing**

(a) Trials of Canadian cape-cum-ground sheet and Australian 'Poncho'.

(b) Comparative trials of British and Canadian A/G capes.

(c) Trials of new US fabrics for efficiency and life.

7. **Foot Protection**

(a) Protective life of CC2 impregnated socks.

(b) Storage properties of fungicidal dubbin (when available).

8. Gas Proofing of Earthworks

Trials to determine any increase necessary in expenditure to penetrate Japanese earthworks of different types.

9. Decontamination

To assess value of methods of decontamination under tropical conditions.

10. Detection

(a) Pocket vapour detector.

(b) Case, War Gas, testing.

11. Trials with Japanese A/G Equipment

12. Trials with American A/G Equipment

SECTION II - WEAPONS

A. Army Weapons

15. 25 pounder shell

Trials in open country of:

(a) Mk.VIII with MM thickened charging.

(b) Mk.VI or VII with 'Monkey glanded' CR thickened charging.

16. 4.2 inch mortar bombs charged H

(a) Assessment at normal charges against jungle.

(b) Assessment in open country.

17. **3 inch mortar bombs charged H**

    (a) Assessment in jungle.

    (b) Assessment in savannah country.

18. **2 inch mortar bombs charged BBC and CN**

    Assessment trials.

19. **Jet A/T Mk.II model**

    Assessment charged AC and CG against AFVs and bunkers.

20. **Japanese AC grenades**

    Assessment against AFVs and later, bunkers.

21. **C/W Grenades**

    Assessment of British designs

    (a) discharged from rifle launcher.

    (b) thrown by hand.

22. **US Land Service Weapons**

    (a) 4.2 inch chemical mortar shell charged H.

        (i) Functioning trial against primary forest.

        (ii) Area trial if results of (i) are favourable.

    (b) Trials if required with

        (i) Artillery shell charged H.

        (ii) 7.2 inch Rocket charged H or CG.

23. **Japanese C/W Weapons**

SECTION III - PHYSIOLOGICAL AND MEDICAL

40. Effect of variations of T for a given CT of mustard gas against bare and clothed skin. (Particularly for T values less than thirty minutes.)

41. Determination of CTs for varying degrees of casualty production in varying circumstances.

42. Systemic effects of mustard gas under tropical conditions

43. Sensitivity to mustard gas

44. BAL ointment

Efficacy of BAL ointment and possible toxic effects.

45. Treatment of gas casualties

Under tropical conditions.

SECTION V - METEOROLOGICAL

57. Experimental study of atmospheric diffusion and evaporation

(a) Diffusion and evaporation in open country. (Effect of marked lapses on shallow vapour clouds.)

(b) Diffusion and evaporation in jungle. (Influence of lightest winds and reversed temperature gradient.)

(c) Special cases of diffusion. (Beach; Jungle fringe (including coastal range); Kunai grass; Tanks; Defensive positions.)

58. Collection and correlation of Meteorological data

(a) Observational work

(b) Correlation in terms of work on diffusion, etc.

(c) Forecasting of relevant factors. (Wind and temperature structure over smooth open country and jungle. Special cases above.)

59. Instruments

(a) Research and development. (Ultra sensitive anemometer for jungle work. Temperature and wind gradient apparatus (static and portable). Wind tunnel.)

(b) Maintenance. (Calibration of wind and temperature instruments.)

61. Mathematical Research

(a) Theory of diffusion and turbulence.

(b) Finite area problem.

(c) Dependence of concentration on area distribution of sources.

* * *

The following are extracts from 'Notes on Work Carried out under the Direction of the Chemical Defence Board in Australia from 25 June 1943 to 25 October 1943', Declassified from Secret to Unclassified Public Release, 9 February 1982.

The following matters have been under consideration during the past three months:

(a) 25 Pounder B.E. Shell

One hundred shell, thickened perspex, were received from Great Britain in July, and were tried in the neighbourhood of Darwin early in August. Certain shell, which had been modified in the Chemical Defence Section, Munitions Supply Laboratories, were also fired, the modifications being:

(i) Y.4 and solid perspex incorporated in a mixer.

(ii) Y.4 to which a solution of perspex in nitrobenzene had been added in the shell.

(iii) Y.4 to which a solution of perspex in benzene had been added in the shell.

(iv) Y.4 with which a solution of perspex in nitrobenzene had been incorporated in a mixer.

The results of this trial were very interesting, and showed that shell charged Y.4, to which perspex had been added, gave far better results than any previously obtained from shell charged Y.4, the outstanding performance being given by the shell received from United Kingdom; the best results from the locally modified shell were obtained from these included in group (iii) above.

Erratic ranging of the shell was again a feature of the trial.

A report on the trial at Darwin was forwarded to [the] United Kingdom on 26 September 1943.

5. PHYSIOLOGICAL INVESTIGATIONS

Lieutenant Colonel Gorrill arrived in Australia on 6 August, and was followed in a few days, firstly by Mr F. Pasquill and later by Messrs Owen and Purkis; owing to delays in transport Major Sinclair did not reach Melbourne until 21 September 1943.

On his arrival, Colonel Gorrill presented to the Chemical Defence Board the programme of work which had been outlined by United Kingdom authorities.

This programme was considered by the Chemical Defence Board, and in detail by the Experimental and Research Committee in an endeavour to outline a programme of priorities for the various items. Several items of immediate urgency are dependent on specific factors, e.g. trials of 4.2 inch mortar bombs depend on the availability of a mortar company on the mainland; trials in connection with contamination of jungle need to be carried out in the jungle, etc. On the other hand, many experiments could be undertaken in parallel. After careful consideration of all the items, it was agreed that the most important items were an appreciation of standard weapons (Army and Air Force) under jungle conditions and attack on an air strip with H.

The laboratories at the Physiological School, Melbourne University, have been completed, and the CW physiologists are in occupation. In addition to the United Kingdom personnel, there are two civilian biochemists who were trained by Colonel Gorrill earlier in the year, and ten AWAS personnel (including eight technicians and two stenographers) who have been added to the staff. Mr C. H. Purkis is training an additional number of AWAS technicians for chemical work and four Army personnel, who will be available from time to time to assist in the investigations. An additional civilian chemist, who has been appointed to the establishment, is also being trained by Mr Purkis.

The AWAS will also assist other members of the party in various aspects of the work.

Construction of the 100 cubic metre gas chamber has been completed, and its erection has been completed in the University grounds in close proximity to the laboratories. A number of trials have been run and its performance has proved to be very satisfactory.

It has now been dismantled and transhipped to Northern Queensland for use in the experimental work under tropical conditions.

Lieutenant Colonel Gorrill and Mr F. Pasquill spent a week in Northern Queensland recently to choose a site at which the experimental work would be carried out. It had been thought that Cairns would be the most promising location, but as there was no accommodation to be obtained in that town, investigation of other areas was necessary, and it was considered that Innisfail, while being satisfactory from an accommodation point of view, would offer even more suitable climatic conditions than Cairns. Arrangements were, therefore, made to take over certain houses in the area, and the selection of Innisfail was ratified by the Experimental & Research Committee at a meeting held after Lieutenant Colonel Gorrill's return to Melbourne. A train load of stores, including the chamber, has left Melbourne and it is intended that personnel will leave on 5 November 1943, and will spend approximately six months in the locality. If, however, the field experimental station at Proserpine becomes available before completion of the work at Innisfail, the outstanding work may be transferred to Proserpine (which is approximately 300 miles south of Innisfail) as this site will form the headquarters of all tropical CW activity in future.

The first half of the equipment collected by Lieutenant Colonel Gorrill arrived safely on the ship which brought Mr Pasquill to Melbourne, but the long delay in forwarding the second half of the equipment (which ... is understood to have left England in the last few weeks) has handicapped the work. A large proportion of the equipment has now been received and is on its way north.

LIAISON WITH US ARMY

Lieutenant Colonel Best, after spending a short time only in Melbourne, was transferred to Headquarters of the USAFFE.

A chemist from the US 42nd Laboratory Company was attached for some weeks to the Physiological Research Laboratories to undergo training by Mr Purkis, and it is expected that a CW officer will be attached to Lieutenant Colonel Gorrill's research team; it is expected that this officer will reach Australia early in October.

13. LIAISON WITH NEW ZEALAND

The three New Zealand Army medical officers, having completed a course of training in chemical warfare physiology, have returned to New Zealand, and arrangements were made prior to their departure for them to be kept up to date with the position of chemical warfare in Australia. This contact is maintained through the New Zealand liaison officer, who is a member of the Chemical Defence Board.

15. EXAMINATION OF ENEMY WEAPONS

A number of reports prepared by the US 42nd Laboratory Company on examination of weapons received by the Company have been forwarded to [the] UK.

17. AUSTRALIAN FIELD EXPERIMENTAL STATION

When the submission was made to [the] Defence Committee that a site at Proserpine should be set aside for a testing ground for chemical warfare weapons, the recommendation was approved in principle, and it was requested that more specific data should be provided to enable [the] Defence Committee to consider the whole project. Since then, several visits have been paid to the area by members of the Chemical Defence Board, and a detailed submission was made to [the] Chemical Defence Board on 1 September 1943. This submission was discussed at a meeting of [the] Defence Committee at which the Secretary of the Chemical Defence Board was present, and approval was given to the project in the following terms:

> The Defence Committee endorsed the recommendations of the Chemical Defence Board that a Chemical Warfare Experimental Station should be established at Proserpine, Queensland, and recommended that the Department of Munitions should undertake this as part of its chemical research activity, and make the necessary submission to War Cabinet[1]

it being considered that the establishment of a chemical warfare experimental station was desirable for the following reasons:

(1) To enable chemical warfare weapons to be tested and evaluated.

(2) To provide facilities for the physiological research that is being undertaken under the leadership of Lieutenant Colonel Gorrill.

(3) To enable operational training in the use of chemical warfare weapons to be undertaken. This applies particularly to the use of sprays and such appliances in aircraft.

It is intended to commence weapon trials as soon as the area is made available without waiting for the erection of huts; it is hoped that trials may be undertaken within the next two months. Immediately afterwards, it is proposed to second Air Force CW personnel to the area and to carry out large scale Air Force trials. It is also noted that a number of artillery shoots will be carried out in the area during the forthcoming wet season.

It is also intended that the bulk of physiological investigations will be carried out in the locality, but as it is not yet definitely known when the site will be available for use as an experimental station, Lieutenant Colonel Gorrill is commencing his work at Innisfail and will move to Proserpine on completion of jungle work, and when facilities exist for carrying out the work.

* * *

The following are extracts from a declassified report compiled in November, 1975. It summarised 27 reports which 'describe the tests and experiments carried out in the period 1943-1945 at various sites in Queensland, under the direction of Lieutenant Colonel F. S. Gorrill, C.O. Australian Chemical Warfare Research and Experimental Section'.[2]

The report which has been extracted considered the 27 reports under three headings:

(a) Experiments carried out to determine the effects on volunteers of exposure to mustard vapour and liquid contaminants.

(b) Experiments carried out to assess and compare the protection offered to volunteers against mustard gas and liquid contaminants by various ointments, respirators and impregnated clothing.

(c) Experiments relating to the offensive possibilities and limitations of chemical warfare.

The experiments encompassed a wide variety of the practical contingencies envisaged in a tropical warfare situation in which the enemy employed anti-personnel chemical agents. Mustard gas used in a tropical jungle situation produces more severe casualties than when it is employed in temperate zones, as in the First World War. For this reason and because of the threat that the Japanese might have resorted to such methods in the Second World War, the information sought was urgent and vital.

In some experiments more than one effect of chemical agents on volunteers or equipment was tested. Casualties amongst the volunteers in several cases were quite severe, requiring hospitalization for over a month.

Analysis of Reports [# designates which of the 27 reports in being referred to]

(a) Effects on volunteers of exposure to chemical warfare agents

(i) skin

Detailed observations were made of the effect of mustard vapour on the volunteers' skin in many of the experiments in the course of assessing protective measures and offensive capabilities.

#4 Thirty six men in four sample groups were exposed to various vapour dosages within the gas chamber. Some exercises were performed, and with the maximum dosage a number of the volunteers were hospitalised for periods of up to 4 weeks. Respirators to protect the eyes and lungs were worn during the experiment.

#5 This experiment specifically tested the effects of exercise during the period of exposure on the severity of the burns received. Twenty-five men in five groups exercised and rested during exposure within the jungle and the control chamber at varying dosages of mustard vapour and varying levels of temperature and humidity, as experienced in tropical areas. Temperature and the resultant perspiration were shown to be important factors: higher temperatures increased the severity of burns. Humidity was less important in affecting the severity or extent of lesions.

#6 This report deals with the effect of varying the level of exercise during exposure to mustard gas, while holding other factors constant. The volunteers, twenty-five men in five groups, worked and rested in the chamber, jungle and army bunkers exposed to various dosages of mustard gas. The main conclusion was reached that increased exercise markedly increases the severity and extent of lesions.

#7 Two sample groups totalling twenty-three volunteers, were equally contaminated, and one group washed their burns while the other did not wash for eight days, to test whether cleanliness had any effect on the development of sepsis in mustard burns. The conclusion was that cleanliness was not an important factor.

(ii) blood

#1 Ten men in the control chamber were exposed to mustard vapour to determine the effect on the time for their blood coagulation the results show that a fall in the coagulation time occurs.

#2 The white count of twelve volunteers was taken before and after exposure in the chamber. Some tentative conclusions were reached which required further testing.

#3 This report follows up #2 (above). During the attack on a small island described in #24, several groups of men were located in the jungle, 'Japanese' style bunkers and slit trenches. A significant rise in their lymphocyte count was noted, after exposure. Some of the volunteers were hospitalised for mustard burn treatment for 3½ to 4 weeks after the attack.

(iii) gastric function

#8 The experiment dealt with the problem of nausea associated with gas poisoning, which occurred despite the wearing of respirators. The conclusions reached after a large experiment with fifty-four volunteers showed that exposure to mustard gas does lead to an increase in the secretion of acid in the stomach.

(iv) environmental factors

#9 Sunlight and wind were found not to have a significant effect upon lesion severity. Two sample groups were placed in areas of equal contamination, one in the chamber and one in the jungle. It was shown however, that exercise during (but not after) exposure did worsen the lesions.

#10 This report considers the problem of classifying and assessing casualties from vesicant agents. A casualty is defined not by the extent of his burns *per se* but by the tasks which he can or cannot perform. A number of case histories are examined and an A, B, C, D severity classification is adopted for general use in chemical warfare trials.

A : Totally disabled - of no usefulness in the field.

B : Partially disabled - could contribute to the defence of a static position only.

C : Partially disabled - could perform some offensive operations with adequate motivation.

D : A volunteer with burns of little or no military significance.

NC : Non casualty.

This classification system was not used in all the reports and only the maximum casualty status is given, e.g. a volunteer may have been class A for 10 days, class B for 14 days and class D for 6 days, but he is only recorded for the period in which he was class A.

(b) Protection against chemical warfare agents

(i) ointments

Protection afforded to the hands and necks of volunteers by a number of chlorine based preparations was tested. Some of these proved unsuitable because of the irritation they caused and some because of the low prophylactic qualities they possessed.

#11 A comparative irritancy trial was held between the ointments containing S461 and S330 agents. Fifteen volunteers took part in the test, repeating applications every three hours in a testing procedure decided upon in Washington in July 1943. S461 was found to be an irritant and unsuitable for tropical use while S330 proved satisfactory.

#12 This experiment compares the irritancies and prophylactic qualities of ointments A/G No.5 and S461 under tropical conditions. Thirty six volunteers in five groups were involved. A/G No.5 was completely unsuitable, in that it failed to offer adequate protection, and while S461 provided some protection if it was applied immediately prior to exposure its extreme irritancy rendered it unsuitable.

#13 The American M5 ointment was tested for irritancy and skin decontamination as an alternative to those mentioned above in #11 and #12. The ointment proved to be non-irritant and superior to A/G No.5 and to S461 against mustard vapour if the elapsed time was more than one hour. Tests were also conducted on the ointments to assess their worth as decontaminants against drops of the chemical irritants.

(ii) clothing

Reports #16, #18 and #14 deal with the problem of toxicity of impregnated clothing, while #15, #17, #19 and #20 test the level of protection offered by such clothing and its protective life.

#16 Tests on sixteen volunteers established that the chemical AV used to impregnate clothing as a protection against mustard vapour is itself absorbed by the skin and is toxic to the wearers. Volunteers became tired, weak and unsteady and one man was hospitalised - the problem is seen to arise because of the rapid break-down of AV in the tropics, in contrast to its stability in temperate zones.

#18 This is a continuation of #16 (above) and involves the testing of two alternative impregnates, 'Ben' - 2, 4-dichlorobenzanilide and 'Impregnite B', N-chloro-2, 4, 6-trichlorobenzanilide. 'Ben' produces the same toxic effect as AV while 'Impregnate B' produces no blood changes or central effects in the wearer. Eighteen volunteers were tested.

#14 In this trial the volunteers wore underclothes to see whether the toxic effects would be lessened. Two groups of six, one with underclothing and one without, wore impregnated uniforms and exercised during the test. Subjective and objective analysis revealed little difference between the toxic effects experienced by the two groups - a rather surprising result.

#15 Chamber trials were carried out to test whether high concentrations of mustard vapour over a short time or low concentrations over a long time would be more effective in penetrating impregnated clothing. Eight volunteers were exposed to various dosage levels. The conclusion reached was that high concentrations have a greater penetrative effect.

#17 The design of clothing offering protection against mustard gas was assessed - more particularly the value of flaps on shirts, coats and trousers. Sixteen volunteers in six (not mutually exclusive) groups were exposed to concentrations of gas in the control chamber. Some of the volunteers required hospitalisation.

#19 Two American clothing impregnation processes (M1, a solvent process and M2, an aqueous process) providing protection for the wearer against mustard gas were assessed and compared for longevity under wear and wash conditions. The clothing was worn continually for a week, then washed and dried and tested at points of greatest wear and tear and sweat. The useful protective life of the clothing was determined to be 2 weeks and both methods M1 and M2 were shown to be effective. Wearing, not washing, caused the major loss in protection, in the tropical conditions (temperature 90 degree F, humidity 85 percent).

#20 In a follow up test 10 months after report #19 (above), M2 impregnated clothing was subjected to exposure to the sun and various chemicals to determine the effect of such conditions on the protective life of the clothing.

(iii) respirators

#21 The data for this test was collected during the clothing trials. Its aim was to determine the penetration of the rubber components of the British-type respirators by mustard vapour. At very high concentrations some penetration of the rubber components was noticed, and some of the volunteers developed conjunctivitis, upper respiratory tract infection and lesions. The main conclusion was that respirators offered a better protection than ointments and impregnated clothing at every dosage level.

#22 This report covers tests carried out to determine the tolerance of volunteers to the physical discomfort of wearing two types of respirators in tropical conditions while at rest and during strenuous exercise. in the first test fifteen volunteers (previously experienced with respirators) kept their respirators on except for ten minutes every four hours (for food). Their endurance range was between sixteen and thirty-six hours, the main complaints being aches, nausea and boredom. The mean endurance time was 25.4 hours.

In the second test the same fifteen volunteers were subjected to strenuous exercise - clearing a path through the jungle while wearing respirators. The endurance time range was two and a quarter hours to four and a quarter hours with a mean of 3.1 hours. The main complaint was exhaustion. The added incentive of mustard gas would probably prolong these times, especially in the first test.

(iv) footwear

#23 Boots and socks specially protected and others unprotected were tested with liquid contaminants. The general conclusion was that a combination of dubbined boots and impregnated socks provides a good protection against the hazards of liquid concentrations near bomb sites.

(c) The offensive use of Mustard Gas

Four reports, #24, #25, #26 and #27, are considered below. The first two of these detail aerial attacks on small tropical islands to assess the efficiency and spread of the contaminants. #26 is an assessment of the effectiveness of short range mortar for delivering contaminants and #27, a consideration of the hazards of traversing contaminated areas.

#24 The aim of the Brook Island trial was to determine what concentration of mustard gas was necessary to cause a high proportion of casualties against typical Japanese jungle fortifications, and how long the contamination would remain. The report is very detailed, with maps, photographs and diagrams. The experiments were carried out with both mechanical devices, volunteers and animals located in a specific target area, previously bombed by six Liberators [US bombers] which had released a total of 90 bombs. After five days the target area was declared safe for jungle traverse.

#25 In a similar test to #24 (above) Beaufort bombers dropped a total of 159 bombs on a small island. Tests were conducted on the effectiveness of impregnated clothing and the volunteers were required to perform specific tasks in the target area. Maps, photographs and case histories are included and there is a discussion on the strategy and tactics for gas bombers to adopt to maximise their effectiveness.

#26 This report covers a series of trials carried out with a 4.2 inch mortar on a very short range near Innisfail. Bunkers of the Japanese variety were used and the area was traversed at intervals to determine the continuing danger from exposure. Despite the short mortar range it was shown that the impact of the bomb sometimes prevented a good spread of contamination. Case histories are detailed and photographs included.

#27 This trial was to compare the hazards of three contaminants HT, HBD and Levinstein when used in tropical jungle conditions. Three adjacent 'lanes' of jungle were bombed to a contamination level equal to 60 tons per square mile pro rata with the three chemicals. Parties of volunteers traversed the areas one and four days after the bombing to test the level of contamination. HT was shown to be the most effective contaminant. Tests were also conducted during this trial on the ointments A/G No.5 and M5, and on the development of sepsis. Hospitalisation was necessary in several cases.

NOTES

1. During the period of the trials War Cabinet consisted Messrs. J. Curtin (Prime Minister), F. M. Forde (Army), J. B. Chifley (Treasurer), H. V. Evatt (Attorney-General), J. A. Beasley (Supply and Development), N. J. O. Makin (Navy and Munitions) and A. S. Drakeford (Air).

2. Although this summary has been declassified, some of the reports themselves are still classified because they contain information which is of operational significance.

CHAPTER 8

[The] Organisation [of the Chemical Defence Board]

A. J. Roennfeldt[1] recalls:

The Chemical Defence Board had an annual meeting through the years from 1928 to 1938 or '39. Weldon was in charge of the Chemical Defence Section at MSL and looked after the Chemical Defence Board from Maribyrnong. He continued to look after the Board when the war broke out and more frequent meetings were held. A physiological sub-committee was operating before the establishment of the Chemical Defence Board Headquarters in Collins Street [Melbourne] in 1944, where we had a meteorological sub-committee (A. Hogg, Secretary), a chemical sub-committee (J. Almond, Secretary) and a physiological sub-committee (A. Hogg, Secretary). Weldon had felt that he wanted assistance in that direction. The Chairman of the Chemical Defence Board when Weldon went overseas in 1944 was Brodribb and as the secretary of the Board I used to report direct to Brodribb. The three service DGMSs [Director General Medical Service] were on the Board. Major General Sam Burston (Army), Air Vice Marshal Daley (Air) and Surgeon Rear Admiral Pritchard (Navy). Colonel Kellaway...was the Director of the Walter and Eliza Hall Institute, and Rupert Downes was at that stage the [DGMS] Army. I went to England in May 1941, got back end of '41. In 1942 everything was in a mess and I think England realised that they didn't know enough about use of gas in the tropics and at that stage she was committed in the Middle East in any case. In 1942, and I couldn't tell you the exact time, Major F. S. Gorrill arrived in Australia. At this stage Dr Shiels (Major Shiels) was the Chemical Advisor to the Army, and in this connection the Physiological Sub-Committee came in handy because Gorrill had presumably been given instructions that he should do some trials in the tropics. So they decided that they'd recruit Legge, Ennor and also Trethewie and I think that at the beginning of 1943 they decided to do trials at Townsville.

These were definitely physiological trials and I'm certain that Kellaway and the other people on the Physiology Sub-committee had a lot to do with the setting up of those trials. In 1943 at the end of the hot season after the Townsville trials, Gorrill returned to England, and what I prefer to call the 4 x 4 situation came about. He reported back to England that mustard gas could be up to 16 times more effective in the tropics than in temperate climates. The reason was the vapour concentration was 4 times higher and because the skin was more open it was 4 times more effective for the same vapour concentration, and 4 x 4 = 16. The people in England were horrified, and it was decided that further extensive trials would have to be done in Australia. As a result, in 1943 Purkis, Pasquill, Reavell and Sinclair came to Australia. I think there were six of them. The Army got hold of an evacuated house at Innisfail and then we had the situation that the Chemical Defence Board was controlling what we might call the administrative side, with assistance from the Army in providing cooks, etc. I can't be sure what the arrangements were for volunteers, but there were a lot of volunteers at Innisfail.

These trials were carried out alongside the road where they took the sugar to Mourilyan Harbour.

There were 4.2 inch mortar trials. They fired from one side of the road, over the road into the jungle area, and people walked into the jungle afterwards to check the clothing and so on. At that stage they had the showgrounds and the volunteers camped there, and they had an assault course. They would go out with watering cans and spray mustard on the ground and [then] they would perform manoeuvres over the contaminated ground and see what was the result.

Let us go back a stage. In 1942 somebody decided they wanted chemical weapons in Australia and as a result the *Idomeneus* brought bulk mustard and loaded weapons to Australia. Some of the drums of bulk mustard leaked badly. Eric Lanfear and I went down with Arthur Trewin, to the ship when it came to Melbourne.

There were 25 pounder base ejection shell, some 6 inch naval base ejection shells and 4.2 inch mortars. I'm a bit confused about who owned them. Some of them were Army stuff. The Air Force had hundreds of 44 gallon drums of mustard which were stored in the tunnels in the old single track railway in the Blue Mountains at Glenbrook and phosgene bombs at Bowenfels.

It was only through the co-operation of the Americans that the Brook Island trials could be done because of the distance from Innisfail. We stayed overnight on one of the other small islands. On the first trial we stayed off-shore in the landing craft, full equipment on, respirators etc., waiting for the bombers to come over. I was sea-sick, and had to pull my respirator off. I remember Gorrill saying, 'The things we've done for Britain, eh Bert?' We then landed on a sandy spit on this Brook Island. We had to walk over the coral beach some 400 yards and then we went to the jungle where we set up sampling gear. We were supposed to have slept on another island and that may be where the North and the South came in. Subsequently, on the later trials (I think there were three) the teams slept on Hinchinbrook. Incidentally I went back to Brook Island, at a stage when the Army and Supply were examining the possibility of setting up an expanded Army Tropical Testing Station at Innisfail. The Headquarters was still at Innisfail but I remember that the goats used in the trial were picked up and Johnny Legge and I took the load of goats from the first trial back by landing craft to Cardwell and then by road to Innisfail.

I think the results had been sent back to England and proved to be so interesting that they decided that the facilities at Innisfail were not good enough and that they would have to have a special station built. This is how Proserpine came about. Three people constituted a sub-committee of some other committee. Don't ask me how or why they were chosen, these three were Eric Lanfear, Wing Commander Le Fevre and Squadron Leader Dwyer from the Meteorological Branch.

They toured around; it's easy enough to look at this thing with hindsight but why they ever selected the site at Proserpine, I wouldn't know. My own opinion is that meteorologically-wise it wasn't the best. Position-wise it was on the banks of a creek which periodically flooded. But it had one saving grace in that the owner or lessee of

the station (Lascelles) was a very decent scout and he was quite prepared to forgo his lease of the property that they wanted to use. They could have picked Iron Range or any other places further North except that communications in time of war would have been very bad. They could have picked places with better meterological conditions. However that's how Proserpine came about. The Chemical Defence Board made some submissions about this and I became involved because Weldon was going to join Gorrill and go to England in 1944 to put the case and discuss the results and all the rest of it. Sinclair was left in charge of the team. In 1944 it was decided that the Chemical Defence Board would be expanded and separated from Maribyrnong. Weldon would become Controller Chemical Warfare and because he was going to England there had to be an Assistant Controller, and Assistant Secretary, someone to look after things while he was away. I got the job and one of the things I was left with was to write a cabinet submission for £50,000 further expenditure on the Proserpine station.

It had been started before Weldon went off in May 1944 and I can recall going to Proserpine with Keith Laidlaw, who was Controller of Works, for the Department of Munitions as it was in those days. Keith and I went up with Major Travers. Dave Danson was [the] Army Admin[istration] man at Innisfail, quite a capable cove in my opinion.[2] A pretty able guy, but I think he wanted things done army administration-style and he had some difficulties with Gorrill and the others because, as you know, they didn't conform to the bureaucracy.

Regarding the recent situation that was discussed in the media about personnel being badly burned, of course they were badly burned but they did it in the spirit of the trials. They used to run a sweepstakes, with the man who could finally make it over the assault course being the winner. They got extra leave and an extra shilling a day. I can't tell you who paid but I think it was paid through the Chemical Defence Board.

I don't know whether Jack Legge told you about what was, I think, an outstanding piece of research work, done under extremely difficult circumstances up at Innisfail, the absorption of the chloroimides, etc. that we used for the impregnation of the protective clothing. I remember after I'd been working out on trials, Jack Legge or Sinclair looked at my ear with a spectroscope and found methaemoglobin. There were quite a lot of people adversely affected in this way due to the opening of the pores and letting the imide go into the blood stream. Jack Legge took gallons of urine and finally identified the compound in the blood stream and I consider that was a damn good piece of work which undoubtedly influenced the thinking about impregnated clothing at a very early stage.

One of the things that I was wondering about is the volunteers. My recollection is that they tried all sorts of things, wearing the underwear and protective clothing, but they always had their respirator on. So they never should have had any lung effects or eye effects.

... I have no recollection of personnel being exposed to mustard gas without respirators. On the Brook Island Trials there is no question, everyone wore respirators. You've got to remember that despite the fact that they kept their respirators on, they were not accustomed to wearing them. Nobody had any control over them as to whether they

kept them on correctly. This is the problem I've always worried about so far as these statements are concerned. It's one thing for David Sinclair, Hugh Ennor and Jack Legge to have said that, another thing to be sure they did what they were told. Let's face it, these lads didn't know too much about wearing respirators. It is quite easy to break the seal and get a little bit of fresh air.

The first Americans that I met in Australia were Colonel Copthorne and his second in charge Captain Morgan, who came to Maribyrnong from Brisbane to make contact with Weldon. Morgan and I had met in America, on the steps of Gunpowder Mess at Edgewood. Morgan, [who] came from the Deep South, said to me, 'Well, I'll say goodbye here, I don't know where we are headed for, but I don't think it's Australia'. They were at sea when the Philippines fell and he came with Copthorne to Maribyrnong to make contact with us. I must say that Copthorne saw that Weldon was a power in the Australian CW scene and he, in my opinion, played along with Weldon to the utmost when it suited him. The American CW people came to Melbourne, then moved up to Sydney then on to Brisbane.

I think it was Copthorne, sitting in Brisbane, [who was] willing to say to the Americans, 'Get involved in the Brook Island Trials'. I think it was through them that Gorrill was able to do much of his work at Innisfail. That's where he got the aircraft and some American bombs for the Brook Island Trials. As far as I recall they were all American bombs that were dropped. Innisfail had a lot of logistical support in various ways, but I don't think they subscribed any manpower other than the landing craft drivers and the pilots and crew of the aircraft, except for Captain Howard Skipper, a biochemist/physiologist.

Mrs Elsie Smelt,[3] who was P. R. Weldon's secretary, recalls:

Brodribb was the Chairman of the Chemical Defence Board and Weldon was the Secretary, and it met quite frequently, about once a month.

They had a number of sub-committees. There was a chemistry sub-committee, a physiology or medical sub-committee and they had some pretty high-powered medical people on it: Burnet, Kellaway, Travers and of course Wright. Those people were active on the committee.

I went to all the meetings to take the minutes and I was impressed by these high powered people, who were very involved in the discussions and concerned about the matter. So that when the experiments were planned, they were pretty carefully thought over, and it wasn't any hare-brained scheme that went on. I think those committees were formed after the first round of trials at Townsville. My recollection is of the committee coming in as critics of the results, rather than of the planning. My recollections are that Gorrill was sent out by the English when the war came into the Pacific, because they realised that their anti-gas equipment had never been tested in tropical conditions, and they sent him to find out if it was satisfactory under tropical

conditions. My recollection is that he arrived on the doorstep with a job to do and no one knew anything about his coming. He knew what he was going to do and went on and did it, and when they got the results which showed that the equipment was unsatisfactory, that's when the 'Secret' label was put on everything. I don't think that Gorrill had carte blanche as it were. I expect that the people at Porton would have given some indication of what he should do before he came out.

He got the group together in Melbourne. Corkhill went as far as Albury I believe. He wasn't really fit, and he came back to Melbourne. The rest of the party went to Townsville and did their first lot of trials, and the results were what really shocked them, the Brits and everyone. That's when they realised there was a big job ahead. And then Freddie Gorrill went back to England to report because it was still a UK project. We were still only working with and for [the] UK at that stage.

I think that Freddie would be ambitious to the extent that he came from a fairly humble background, and had achieved academically, but this is only an impression. If there was ambition (and all men are ambitious) he was also concerned with the project. The human forces at work were quite different then from now.

He wasn't an empire builder, he just wanted to get on with the job, and he and the other scientists worked very hard as did everyone involved in the project. Freddie was keen to finish the job and return to England.

The starting of Proserpine might suggest empire-building, but the scope of the work was enlarged when the US became involved. The first trials were really pilot runs. I don't think the UK initiated the US involvement. But when they started to build up Proserpine it was pretty much a joint effort UK, Australia and USA.

Without a doubt Mr Weldon was the cornerstone on which everything connected with chemical defence was built in Australia. He was respected by all who worked on the project. Freddie Gorrill appreciated best that Weldon was prepared to cut corners where and when required. He never took a negative attitude. The project was a big thing landing on that quiet little establishment at Maribyrnong at that time, and probably Weldon, more than the other people who were at the top, was better able to deal with it. He was prepared to say 'yes' to almost any sensible proposal that was put up to him that would advance the work and the credit for it having gone on so well was probably largely due to his being prepared to respect the job and those working in it and to give them his full support. This wasn't always appreciated.

Proserpine was much better organised than Innisfail. And they were also very unlucky at Innisfail, where they suffered a terrible summer and it rained interminably. They were absolutely stranded, all the bridges were down and phones out, they couldn't move, by road or rail, but they kept on with the job. It was done in the summer months because these presented the worst conditions under which the equipment had to be used.

I don't think the English ever appreciated just how bad things can get in North Queensland. That year at Innisfail was one of the worst. At Proserpine they didn't have

the same problem, it wasn't such a bad summer.

In regard to the risks associated with the experiments, Freddy Gorrill was a responsible person, Hugh Ennor had a great respect for Gorrill and he considered they all took risks, not stupid risks but calculated risks. My recollection is that great care was taken to ensure that no harm came to people. I remember very clearly the service people themselves having this concern about their men. I think of Carter in particular, and Le Fevre, and also Dr Maxwell always asking about the precautions that were being taken, and they read everything that came up in relation to this. In addition, as I have already said, I have a feeling Freddie Gorrill had a sense of responsibility in this matter, and he and other senior personnel took part in the trials as well as the men, although their involvement was of a different kind. I believe there was no recklessness. I think everything was planned. Plans might have had to be modified, but there was no happy-go-lucky attitude. They were hard working, responsible scientists. They weren't long-haired ratbags. Freddy graduated in Science first, and majored in Chemistry and then went on to do Medicine. He considered his scientific background was as important as his medical training in the chemical defence work he undertook.

Norman Carter[4] recalls:

This war diary is the history of the Directorate of Military Operations, Chemical Warfare Section, LHQ, that I produced just before I was demobilized and I signed it on 24 October 1945, and it summarizes really the whole gamut of what was done by the Army on Chemical Warfare in association with other Service Departments and Department of Munitions and other nations throughout the war.[5]

Mellor's chapter on the 'Role of Science and Industry' in the Official War History[6] covers the intelligence information that led us to such great activity.

The 6th Division of the AIF captured mustard gas munitions from the Italians at Bardia in late 1940 and this was the first instance during World War II that offensive chemical munitions were taken from the enemy. There were subsequent discoveries of offensive munitions which are mentioned in Mellor's chapter. There were glass grenades containing hydrogen cyanide, and there was a 75 mm shell that was filled with a mixture of mustard and lewisite.

None of these was other than captured enemy equipment. They were not associated with any obvious offensive or intentions at the time from any enemy, but the fact that the enemy had this equipment kept us going.

I think I should re-state some of my basic points of view, extracted from the history that I wrote and I earlier referred to. Under the heading 'Lessons and Recommendations: Preparedness for Gas Warfare', I said:

> Firstly in the early years of the war up to the latter part of 1942, chemical warfare was generally regarded in the AMF as of little importance and the lack of preparedness for CW in the AMF was serious at this stage.

FIGURE 13. Brook Island Beach, looking north

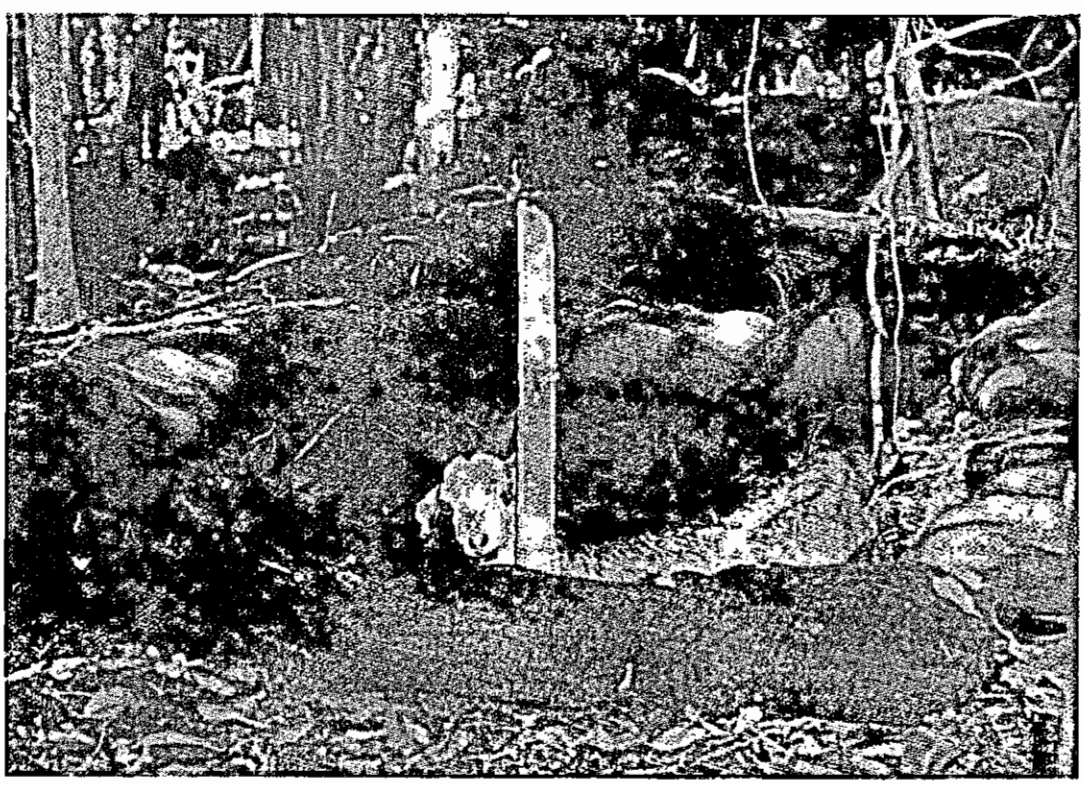


FIGURE 14. Feral goat in Japanese-style fox-hole

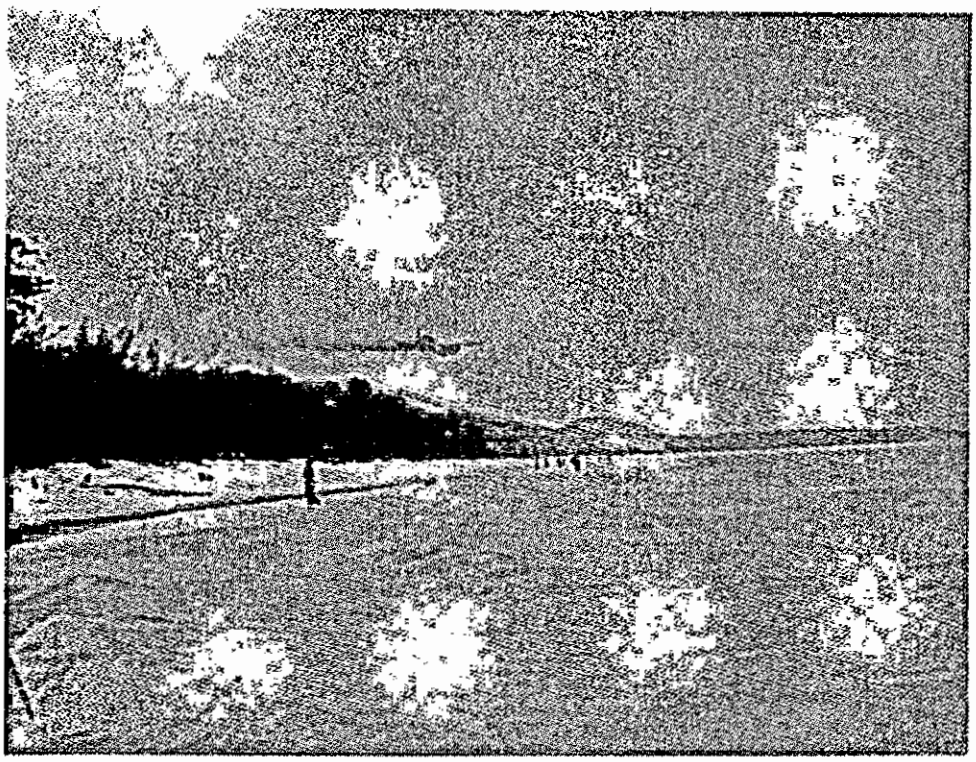


FIGURE 15. Brook Island - Aircraft spraying unthickened American mustard.

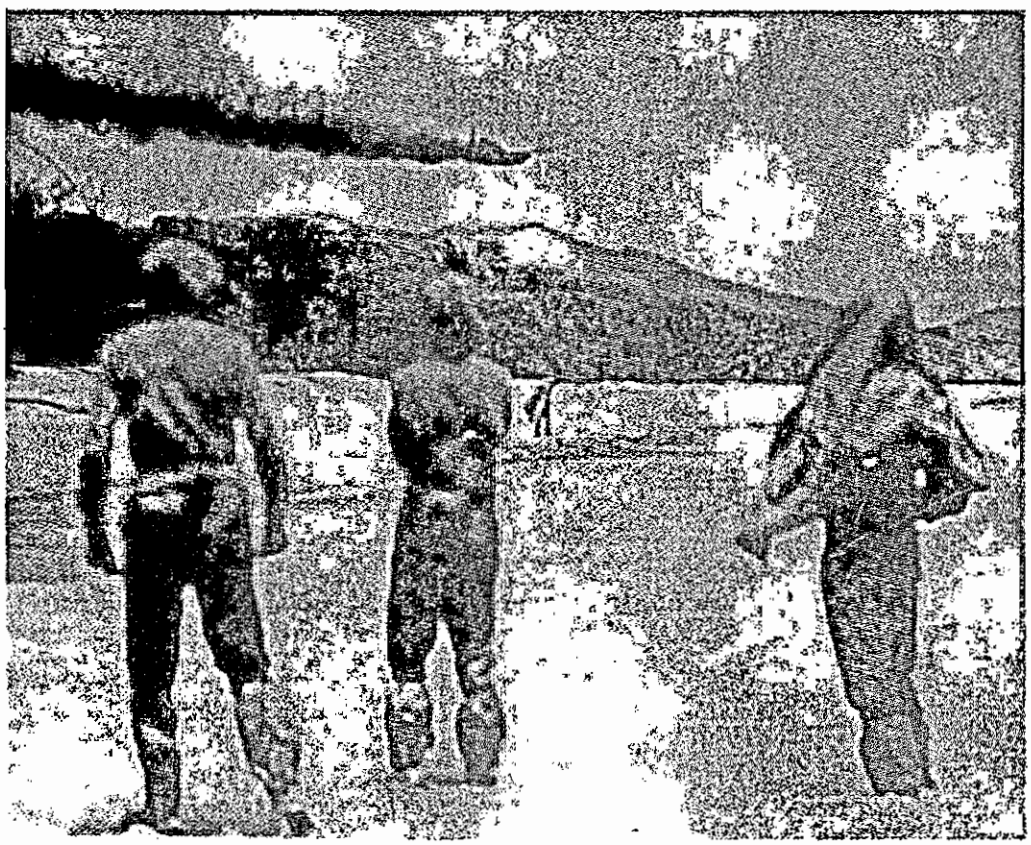


FIGURE 16. Brook Island - Aircraft spraying British mustard thickened with "Perspex".

Although such lack of preparedness was speedily rectified, the fact that gas was not used in this war could lead to the casual conclusion that preparations for gas warfare (whether defensive or offensive) have been, in the past, and would be, in the future, unjustified. However, such a conclusion would be quite erroneous. The enemy's failure to use gas at vital stages of World War II was of tremendous, perhaps critical, value to the Allies. As far as can be ascertained, such failure was due largely to the enemy's wholesome (perhaps exaggerated) respect for Allied offensive and defensive CW preparations. In this regard, it is concluded that (a) the value of a small insurance against disaster in the event of gas warfare, as opposed to complete neglect, has been clearly demonstrated in World War II; (b) the possibility will always remain that total lack of preparedness (particularly defensive) might encourage hostile use of gas by an enemy; (c) not lack of effectiveness of gas but fear of overwhelming retaliation probably kept Germany from starting chemical warfare. This also probably applied to Japan and might be true in future.

I think I'd like to add another paragraph not strictly under the heading of intelligence but under the heading of Chemical Warfare research.

The popular misconception that existed prior to and even during much of World War II, that all was known about CW agents and that no new or more effective gases than those used in World War I were likely to be found, was exploded both by the Allies and by Germany in World War II; and there have been significant developments since then. It is of great importance that in future the AMF, and all Australian services, should keep fully conversant with latest developments in CW research overseas. In this regard it is obviously highly desirable that the close and cordial liaison and respect established in this war between Australian, and UK and US Chemical Warfare authorities should continue in the future. However, of the greatest importance and complementary to the intelligence information that we gained by capturing some offensive CW weapons and equipment from the enemies, was the growing awareness emerging from Australian chemical warfare research trials that we had discovered a number of things that were of critical and indeed strategic importance not only to the Australian services but to all the Allies, with the conclusion that the effectiveness of chemical warfare in tropical areas is likely to be of a completely different order of severity from that applying in the only theatres in which chemical warfare had been employed previously. But in addition, we concluded in January 1944 that, as opposed to the effectiveness of chemical agents in tropical climates, the then existing Allied CW defensive measures (i.e. anti-gas equipment) were very nearly completely ineffective and even disabling in the tropics.

Some of the important points which emerged from the Australian investigations into CW in the tropics included the following.

(l) While the ground wind speed in covered targets such as jungle is a small fraction of the external wind speed, one-quarter to one-tenth, the rate of dispersion of gas on these targets is several times greater than would occur with the same ground speed in the open. It appears that either the accepted theory of diffusion does not apply near the ground under cover, or very large alterations are required for the parameters of the statistical

expression to make it fit diffusion over covered targets.

(2) The influence of skin condition and ambient temperature on human sensitivity to vesicant vapours have been fairly well evaluated and the dose/lesion relationship for various conditions (including tropical) is now reasonably well understood. We found that the sensitivity of human beings in the tropics to mustard gas vapour was many times their sensitivity in the northern hemisphere and outside the tropics.

(3) Measures considered necessary to protect the skin from damage by mustard in the tropics have been developed to the point where efficient protection can be provided without imposing an undue strain on the individual soldier - although the strain on supply services would admittedly be heavy. It was considered (I'm reading from a 1945 conclusion) that American impregnated clothing and their M5 anti-gas ointment provide the best available protection against mustard vapour.

(4) Another 1945 conclusion was that a completely efficient anti-gas ointment has not yet been devised but reasonably good protection could be obtained from then available types at the expense of fairly high consumption.

(5) A reliable estimate of scales of expenditure of ammunition to provide militarily effective dosages over various types of target area could be made. However there is still room for improvement in the basis used at present to calculate chemical munitions expenditure.

I'd like to refer you to various pages in Professor Mellor's report on chemical warfare[7] in his volume, 'The Role of Science and Industry' in the Official War History. Just quickly to remind you, the second paragraph on page 376, the final paragraph on page 376, second paragraph on page 377, the bottom half of page 377, which talks about the effectiveness of chemical warfare in tropical areas and that this was really discovered in Australia. Also discovered at the same time and a great worry was the ineffectiveness of protective measures as they then existed. Then it refers to the Brook Island Trial[s] in February 1944. It refers to volunteers clad in various kind[s] of British, American, Japanese and experimental impregnated and impervious clothing, jungle trained troops with a minimum of protection, and then on page 378, it refers to the emphasis placed on results obtained with volunteers. At the Innisfail trials they were hardened infantrymen, thoroughly experienced in the technique of jungle warfare. In November '44, when increased numbers of volunteers were required, RAAF servicemen in the North Eastern Area came forward and they too were chosen from men fully acclimatised to the tropics.

On page 378, the second last paragraph draws attention to the importance of the results of the Australian chemical warfare investigations being recognised by authorities in Great Britain and the United States, who suggested that further work should be carried out in Australia, both countries offering to assist and to provide technical staff and equipment. On the strength of this advice, the Defence Committee decided to transfer the CW Research and Experimental Station from Innisfail and to reform it as a nucleus

about which to create the Australian Field Experimental Station at Proserpine in Queensland. The War Cabinet approved a program of building construction designed to accommodate a technical and administrative staff estimated at 650 personnel in total. At the same time it accepted offers of technical assistance from Britain and the United States.

In September 1944 South Africa and Canada asked to have representation on the Australian Station. Australia provided civilian scientists, Army technicians and administrative personnel, an RAAF flight of 4 Beaufort bombers, meteorologists, laboratory assistants and other technicians including women of the WAAF [Women's Australian Air Force] and the WRAC [Women's Royal Army Corps]. The United Kingdom and United States provided civilian scientists, and Service chemical warfare specialists, also much of the specialised scientific equipment. In addition observers came from South Africa, Canada and New Zealand.

I think the point I am stressing is now obvious, but it should defuse some of the sensationalism in our media reports of the last few years about these trials. The CW trials were most carefully conceived, they were not undertaken without prior approvals really that led right back to the Defence Committee (that is, Chiefs of Staff) and ultimately to the War Cabinet. The questions of selection and use of volunteers were very carefully considered at the time; and the results from the use of volunteers in the trials were of immense strategic importance, a fact that I think my appreciation given to the Commander-in-Chief in February 1944 brought out. I said then that 'while in certain tactical situations in the South West Pacific Area use of gas in the attack would probably prove to be more effective than any other weapon of war, employment of chemical warfare in the South West Pacific Area would be likely to favour the defence more than the attack by generally slowing up operations'. The meaning of these important conclusions is one thing; the availability of the trial evidence that allowed these conclusions to be drawn, not merely by the Australian services but by the Allies generally, was of immense importance. These trials and their results were really very important.

I wrote in this final report under the heading 'Volunteer Observers in Australian Chemical Warfare Trials':

> throughout the CW experimental work and research undertaken in Australia during World War II, volunteers obtained from the AMF were used to assess physiologically the effects and effectiveness of chemical agents. (Refer SM25199 of 1 November 1943 and SM279 of 9 January 1945.) The morale and standard of volunteers obtained was particularly high and has been commented on favourably by all dealing with them.

That was from the history of the Directorate of Military Operations Chemical Warfare section LHQ, dated 24 October 1945.

NOTES

1. Roennfeldt remained in the Commonwealth Government Service at the Laboratories and was a divisional Superintendent when he retired.

2. About 1960 he was adjutant at Army Staff College, Queenscliff.

3. Mrs Smelt became secretary to professors at various Australian universities and now writes educational texts on spelling and English.

4. After the war, Carter rejoined CSR limited and was General Manager of the Materials and Chemicals Division of that corporation when he retired. He is now the external director of several public companies.

5. This document is now in the Australian War Memorial Archives in Canberra as A. W. M. Series 54, War of 1939-1945, Written Records Item 179/1/1, Open Access status.

6. D. P. Mellor, 'Chemical Warfare', Ch.17 in *The Role of Science and Industry*, Vol.V of *Australia in the War of 1939-1945*, Canberra: Australian War Memorial, 1958, p.368.

7. ibid.

CHAPTER 9

Innisfail and Brook Island

N. K. King recalls:

On 6 December 1943, I was still in Melbourne. By 21 January I'd been in Innisfail for quite some time, long enough to get pretty tired. I remember that I have never worked so hard in all my life as that period in Innisfail. We took no time at all off, we worked all day and every day and well into the night. We took a half day off for Christmas Day. And by 21 January one of the big North Brook Island trials was already over. That was where the Sergeant Major was given the task of carrying a goat to the highest point on the island. He was smart. He picked a nanny goat that had a kid at heel and he carried the kid. By 15 May I was in Concord 113th Australian General Hospital. I was only exhausted, there was nothing wrong with me.

An interesting thing was that one of the findings at Innisfail, [which had] nothing to do with mustard gas (or perhaps it has indirectly), was that in rainforest the normal way that turbulence changes with the progress of the day is reversed. The turbulence is greatest on a sunny afternoon, in ordinary country. In rainforest it is least on a sunny afternoon because it's the canopy that's being heated. And this finding had application in the bushfire business because the people in Western Australia do control.burning in their pine plantations. These were planted so close that there was a canopy, and there again turbulence is least on a sunny afternoon and it is greatest at midnight. Well, this affects the time at which you do your burn. You light up about 4 pm and you make sure your fires are out by midnight, because that's when the turbulence starts getting very severe.

I think there were five Brook Islands. Up to the time that I left, only North Brook Island had been used. There had, I think, only been one trial there by the time I left in May and went to hospital. As soon as I was discharged from hospital I transferred to the RAAF. I do not think that that first North Brook Island had volunteers on the island until after the bombs had been dropped. Then people went in with protective clothing on and so on. They went in on the landing barge and operated the sampling gear. The heavy mortar group provided some of the personnel who went in and did the survey. I prepared the target area and we were marooned out there by weather for several days after we were supposed to have been picked up.

I think I got the record for the greatest number of cups of tea drunk and I think it was into the low 20s. It had to have salt in it, I remember that. Certainly that crew up there knew all about salt deficiency because they put salt in their tea, after that trial, and I think Gorrill's advice was that you kept drinking salty tea until you could taste the salt. And when you could taste the salt, you'd had enough. That's a fair rule of thumb.

McAllester quotes a letter from King:

> Weapons tested at Innisfail: 25 pounder base ejection shell charged mustard, 4.2 inch mortar shell charged mustard, 250 lb aircraft bombs charged mustard. And he mentions an aircraft bomb made by filling an ordinary petrol can, a standard 4 gallon tin, with mustard and attaching a flag to the handle to get some degree of aerodynamic stability. Like a drogue, you just pitched it out of the cockpit of an open aircraft. The viscosity was quite low, possibly unthickened and at least in some cases dispersal was by impact only. And he mentions [an] aircraft spray tank. The 25 pounder shell and the mortar shell were tested in tropical rainforests on the mainland here in Australia.
>
> My memory is that the trials of the aircraft bombs and spray tanks were on North Brook Island. Japanese style bunkers and fox holes were constructed and occupied by goats. Chemical equipment was installed and that would be the equipment that McAllester handed over to Andrews and Kerr. The island was bombed from the air with various mustard weapons, troops then landed at various times and with various types of protection, or with no specific protection other than respirators. Assessment was made of the effect on animals in bunkers, the effect on troops entering the area from the landing barges and the persistence of the gas. I think I heard after I had gone to the Air Force there were other trials in which troops were actually occupying bunkers on North Brook Island during the aircraft attack.

King also mentions the work on dibutyl phthalate, to repel insects. He thinks the trials of anti-mosquito preparation were limited to user tolerance, because mosquitoes don't occur near Innisfail. Another test was carried out on the effect of wearing anti-gas clothing, on the ability of troops to do normal duties and also heavy work in tropical rainforests: 'At least one of these trials was stopped by physical collapse but we recovered pretty quickly'.

He mentions the physiological side effects of anti-gas ointment, physiological effects of measured concentrations of mustard gas vapour.

These tests were carried out in a gas chamber, not in the open. A great deal of micrometeorology was carried out in the rain forests. The effects of tropical and sub-tropical conditions on viscosity and hence on dispersal and drop size was very much as predicted by Porton. The reduced viscosity of the charge had considerable and unpredicted effects on the ballistics of 25 pounder shell. One batch of shell was found to be so erratic it was not to be used. Physiological effects were enhanced to a greater extent than predicted.

We did not have many laboratory staff at Innisfail. There were plenty who used to go to the trials and come back. None of the regular people from Maribyrnong was resident at Innisfail or Proserpine engaged in day-to-day activities. A lot of the routine mustard analyses, vapour concentrations and other things were done by girls who were Lab Assistant types but were in uniform as AWAS [Australian Women's Army Service].

There were not too many civilian scientists who were outside of the defence setup. Jack Legge and Ennor were strictly speaking civilian scientists but I honestly don't know who paid them, they may well have been paid from Chemical Defence Board.

CHAPTER 10

Proserpine

Doug Kerr, originally from New Zealand, who was working for the Shell Company in Borneo, got out before the Japanese invaded and joined the Australian Army.[1] He recalls that he came into the Engineers Camp at Liverpool, then went to the gas school at Bonegilla.

Ron Andrews was there too. We went from the gas school at Bonegilla to the Forbes trial. Ron Hamilton came in as a sapper, and he eventually went up through Sergeant to Lieutenant. He came to the gas school at the last stage of it closing down. He came with us to Melbourne University, and joined up with the Gorrill-Ennor-Legge team.

Purkis was the man in charge of the chemical section and we were running mainly the estimates of mustard gas concentration in the air.

The new gas chamber, I think, started to arrive at Melbourne University at the time I arrived and then after they had checked it out, they took it to pieces and shipped it to Innisfail. The main thing that they did in Melbourne was to get a lead on how much mustard gas they lost in the new chamber because of the high absorption in the old wooden one. It was always quite high, surprisingly high, in spite of the fact that it was made of stainless steel. You had to keep pumping the stuff in to maintain a constant concentration. And as I recall that chamber had heating, cooling and ventilation.

Ron Andrews and I were on the deck at Forbes, or back at the hotel on a double shift type of thing. We only worked an hour on and an hour off. The greatest danger was of course, getting hit by the base plates out of the shells, which was something people didn't realise at first. They fell almost straight down, and the ground crew didn't like it.

* * * * * *

At Innisfail a very stupid thing happened. Our armament expert, the British guy, James I think it was, decided to fire mortars with primary propellant only, so we got something like 50 percent of UXB's [unexploded bombs] and these were left lying around for 3 or 4 weeks, and then he had them picked up and I didn't know about this. I was sort of general rouseabout in this thing anyway and it should have been my job to dispose of them. He wanted to use this firing area again, but he didn't want to contaminate it with mustard by blowing things up, so he picked them all up and I met the truck on the way to dump them in the Mourilyan Harbour. They had active fuses in them because they hadn't been activated by sufficient charge in the tail and anyone of them could have gone off. The 152 fuse needed a reasonable setback to function.

I was in the staff car, I met the truck on the way down to Mourilyan Harbour with two of my boys sitting on the UXB's and James the armament guy in the front seat. I made them get the hell out of the truck and I went and took the truck down on my own to Mourilyan Harbour to dump them in there.

He was firing primary only because the range was so short and that's alright because he had plenty of ammunition, but they should not have been moved. They should have been exploded on the spot. He didn't want to contaminate his range because he wanted to continue firing, but if it killed a couple of guys, there would have been hell to pay.

The type of sampler that we were using was very, very fragile and with a glass U-tube. I suppose in the second half of the Innisfail trials I was spending all my time blowing because there was nobody else to do it. This was the origin of the adapted, commercially made sampler, the single bottle with a double cork in it. I designed that while I was working up there; I thought this is a silly way to be working, repairing glassware all day every day. Something more robust is required. So the first half of Innisfail, I was out in the field, the second half I was glassblowing.....and after Brook Island I don't think I had more than a third of our samplers working. Glassware of that type was not very suitable. The bottles that we developed stood up very well in the field. Dropping one of those bubblers was almost surely fatal to it. Dropping a bottle didn't do any damage most of the time. Well, Brook Island was a fairly big effort, but there was nothing very special about it. All this stuff that has been in the newspapers about criminals from Alcatraz and so on is a lot of rot... It was goats we left out. I was on the ground and there were no people left on the island when they dropped the bombs, only goats. Then we waited a reasonable time, came back afterwards and then started on our assessments.

John Anderson, who was a chemist by training and was in the first CW Company, was mixed up in that. They went in afterwards with the samplers, they also did a survey on where the bombs fell.

We had four landing craft attached to us, at Innisfail, and they were our only transport, they were what we called LCIs, Landing Craft Infantry, supposed to take 28 armed men. They were rotten sea boats but they were all right for poking around the islands. They loaded at Cardwell for the Brook Island Trials.

Howard Skipper got us our four LCI's. He had an extraordinary amount of influence in getting things. I understand that he had a paper from some General, saying that he had to be given everything he asked for. That's what he told me, anyhow.

He went up to Cairns when we were at Innisfail, and requisitioned for four LCIs. They were a bit reluctant, so he produced his bit of paper and got 4 LCIs. They were on their way down to Innisfail and the guy who rightfully had them pleaded, 'Look they are fully armed, can't you do with four unarmed ones?' And he said 'Yes' and they were swapped. They had machine guns and all the works on them you see.

* * * * * *

The Operation at Proserpine

Proserpine was designed for five hundred camp staff and 70 to 100 volunteers. Doug Kerr recalls:

We had a water supply from the lagoon five miles away, the pump was remotely controlled, and required pretty constant attention. Our electricity came mainly from the sugar mills at Proserpine, which supplied the local shire by contract. The mill had an electricity generator and we drew from that, but we did have and operated for some months, three (I think they were 2.5 kw or thereabouts) 3 phase generators which required an electrician to look after them. The sampling was done with compressed air bottles through a venturi to produce suction and we had a 2000 psi submarine compressor... I think it was diesel engine and electric motor. It was also used to blow up the bottles again. This thing wasn't a toy either, it needed attention and there was a lot of fancy equipment there. In my second year at Proserpine I was more or less equipment officer and general engineer rather than a chemical warfare officer.

We took the chamber with us to Innisfail, the first year, then it was shifted down to Proserpine. The use of Innisfail was for the rainforest, which was lacking at Proserpine. It didn't matter where you ran the gas chamber. We had an assault course and everything else there as well.

Proserpine was folded up when the war ended. A few weeks after the end of the war with Japan, all ammunition stocks, what was left in the one ton mustard container, stocks of any toxic materials, were destroyed, presumably under instructions from Headquarters in Melbourne. Nothing of a chemical warfare toxic nature was left. We took it out in the scrub and burned it. I was one of the last ones. It was rapidly disbanded. By about December 1945 there was only a skeleton crew left. Dave Danson and Bob Wilson wound the thing up completely. As far as I know there has been no proposal to reestablish it.

I have seen the site a couple of times since and there was nothing whatever left. Most of the useful stuff of course went over to Hayman Island. Water supply, and the water treatment plant.

Ian Homewood recalls:

In May '43 I was at the Grafton trial, then I went to England.

I spent a month in the States on the way through. I had to go by troop ship to San Francisco and then went across the States by train and then visited the CW Headquarters in Washington and Edgewood (Arsenal) and spent probably about a week there. So I was in the States for about 2 to 3 weeks and then I flew out from Montreal in a Liberator to Gatwick and so I probably arrived in England early in June 1943.

[Q:] Now, about the English attitude to the results that they got from Australia. My impression is from what other people have said [that] they were inclined to disbelieve them. You think that is not quite right?

[A:] My impression is that the English were surprised at the effects and that they were higher than they expected. Now in a way that could be different interpretation of the same result.

Undoubtedly, in the early trials in Australia they were getting far bigger blisters from a given dosage of mustard than when they were in the European climate. They didn't really know the main cause of the increased effects. It was not only the temperature, hence the rate of evaporation, but also, they believed, it was due to the sweatiness of the skin.

[Q:] Amongst the English people you were associated with, you mentioned Wansborough Jones and General Brunskill from the War office.

[A:] Well first of all Davidson Pratt was the big chief and his assistant secretary of the various committees was Haddon. I'd see Davidson Pratt from time to time but only when there was a meeting or when there was a specific policy matter and I would go over and talk to him; he was always extremely friendly and I never seemed to have any problem with access, but most of the time I would talk to Haddon. Davidson Pratt's 2-i-c was Childs. I would sometimes see Childs but not as much as Davidson Pratt and Haddon. Davidson Pratt was from industry and he went into the CW field at the outbreak of the war, whereas Childs and Haddon were permanent civil servants.

Then there were four groups where Haddon and Davidson Pratt were located. One was on defensive weapons or defensive equipment and one was dealing with smoke and one was dealing with CW and I used to talk to the heads of these groups at Savoy Hill House, just off the Strand.

The Army side of the chemical warfare people were either located in the War Office or in the Adelphi and the inspection people were also there. I didn't have very much to do with the RAF except when I went to some of their bases that were holding CW weapons or where they were doing Field Trials. I spent some time with them down at Larkhill, which was the Army range and also the adjoining airfield in the vicinity of Porton, where CW and smoke trials were carried out. The decision to set up an Experimental Station at Proserpine was taken in conjunction with the UK Government, who put a lot of money and equipment into it. So they must have really been on side at that time because of its importance to them.

I believe the trials at Grafton were the first trials in a semitropical environment. I don't believe at that stage San Jose (Panama) was opened and I think it is possible that the Americans may have been influenced in starting San Jose because of the results that were obtained at Proserpine. I believe we moved to Proserpine to get a more tropical environment than the Grafton area. In between, they went to Innisfail. There are people who say that Proserpine was the wrong site because there wasn't enough jungle about. I'm not prepared to get into an argument about that, but I think it is possibly true. The

Yanks met a lot of people at Proserpine. Undoubtedly there is still the minutes of the meetings that used to be held about once a month. I don't remember much about the Proserpine and the Innisfail Trials and I had left Australia by this time.

[Q:] So all that you can really give us is your feelings for what the English reactions were.

[A:] I think Australia's reputation was enhanced by the work that was done up at Proserpine and Innisfail. I think it was highly regarded not only by the people in the UK but also the people in the States. It might have had some influence on the establishment of their tropical testing stations at San Jose and Panama. It was also of great interest to the people at Dugway Proving Ground (U.S.) because they were doing similar type of work in a totally different climatic environment and they were interested in the results that we were getting in Australia compared with what they were getting in Canada. The Dugway people participated in trials at Suffield, Canada. I think the work that was done in Australia enabled me to get across with the investigation teams into Germany, consisting of primarily the British and the American team, and I think I was the first Australian to get into Germany and in fact we were in there before the end of the European war investigating the German targets. I felt very privileged to be able to do that, but I believe it is partly due to the work done in Australia and the reputation that Australia had made.

I think that if you look at the minutes of the UK Chemical Board Meetings it will be demonstrated from these, ... although they may not be as eulogistic as direct conversations I often had with senior officers, ... how important the work was to them. I believe Dr Fred Gorrill was an outstanding scientist, and I am certain he made a major contribution to the tests in Australia, but I also believe that he had high regard for the work that was done by other Australians. I know he had an extremely high regard for Hugh Ennor and Jack Legge; they were kindred spirits and made significant contribution to the science of chemical warfare.

I went round as the representative in UK with Weldon when he was over there, and I also went around on a number of visits with both Ennor and Legge when they were there. I saw more of Hugh than I did of Jack. They were held in high regard not only by Gorrill but by other various members of the British team.

NOTES

1. After the war, Kerr rejoined the international staff of Shell Oil Company and worked in Australia, Singapore, North America and again in Australia. After early retirement from Shell he worked for the Australian Commonwealth Government and retired once more in 1977.

GLOSSARY

Abbreviations

Capt.	Captain
Lt.	Lieutenant
Maj.	Major
Lt/Col.	Lieutenant Colonel
Col.	Colonel
F/Lt.	Flight Lieutenant
F/O.	Flying Officer
S/Ldr.	Squadron Leader
W/Cdr.	Wing Commander
Gp/Capt.	Group Captain
LHQ	Land Head Quarters (Army)
MO	Medical Officer
CW	Chemical Warfare
A/G	Anti-Gas
A-V and AV	'Anti-Verm' a British compound for impregnating underwear etc.
CC2	An American compound for impregnating underwear etc.
B.E. Shell	Base Ejection shell - for mode of action see Fig.2. Chemical shells were painted grey with a coloured band to indicate the type of content - yellow for vesicant, black for tear gas etc. The yellow band had a letter and number e.g. Y.4. which indicated the composition of the charging. Shells were 'charged' with liquid but 'filled' with solid, i.e. high explosive. The origin of this distinction is obscure.

H	Code letter for mustard gas, used by both British and Americans.
HT	British code for mustard gas (H) made by the Thiodiglycol process.
HD	American code for mustard gas which had been Distilled. American mustard gas made by the Levinstein process contained different impurities from HT and it was distilled to remove them.
HT/V (CR)	British code for HT mustard made Viscous (thickened) with Chlorinated Rubber.
HT/V (MM)	Mustard made Viscous with Methyl Methacrylate ('Perspex').
BAL	British Anti Lewisite. Chemical formula CH_2OH-CHSH-CH_2SH, was originally developed for treating Lewisite burns, but is now of value in treating poisoning by heavy metals, e.g. mercury.
S330	An American N-chloro compound used in A/G ointments.
CT	Concentration of vapour multiplied by Time of exposure - frequently used as a measure of exposure dose.
A/T	Anti-Tank.
BBC	Bromo Benzyl Cyanide - a tear gas. This was also thickened and charged into BE shells.
Mk	British practice was to denote development changes as Mark One, Two etc., written Mk I, Mk II, with roman numerals. American practice uses M1, M2, with arabic numerals.
25 pr	25 pounder - a standard artillery shell about 3¼ inches diameter, the BE version held about 2 pounds of HT/V.
DGMS	Director General of Medical Services - the top ranking MO [Medical Officer] in each service.

UXB	Unexploded Bomb.

[AIF	Australian Imperial Force
AMF	Australian Military Forces
HE	High Explosive
MRL	Materials Research Laboratories
MSL	Munitions Supply Laboratories
RAAF	Royal Australian Air Force]

APPENDIX 1

Listing of Those Who Participated

Mr J. H. Anderson

Mr N. L. Carter

Mr C. W. Gleeson

Mr M. I. Homewood

Dr J. E. D. Kerr

Mr N. K. King

Prof R. J. W. LeFevre

Dr J. W. Legge

Mr J. C. McAllester

Dr P. Parsons

Mr A. J. Roennfeldt

Mr. K. V. Rossi

Dr D. C. Sinclair

Mrs E. Smelt (Furlonger)

Mr R. J. Taylor

Mr A. H. Trewin

APPENDIX 2

Mustard Gas Rears Again: The Gulf War[1]

Though still kept as a standby in the arsenals of many countries, vesicant gases had not been used in anger since World War I except briefly by Italy against Ethiopia in the mid-thirties and by Japan against China a few years later. Suddenly in the eighties mustard gas again made the headlines. In November 1983 Iran advised the United Nations that Iraq had used chemical weapons in an attack on Iranian troops. Though [the] UN considered the report on several occasions, by the end of February 1984 nothing had been resolved.

Determined to thrust the issue before the world, Iran, early in March, flew about thirty casualties to hospitals in Vienna, London, Stockholm and Tokyo, where examination showed they were indeed victims of some form of chemical attack. The resulting publicity put pressure on the UN to take action.

At the end of the first week of March, the Secretary General approached ten technically-competent, mid-level nations, inviting them to each send a specialist to investigate the claims made by Iran. Four of these nations, Spain, Sweden, Switzerland and Australia, agreed to take part. Australia named Dr Peter Dunn, a superintendent at Materials Research Laboratories, Maribyrnong, Victoria, as its representative.

On Tuesday 13 March the team of specialists arrived in Teheran, where a senior officer of the Iranian Ministry of Foreign Affairs discussed the alleged use of chemical weapons. He claimed [Iranian] forces had suffered almost 2000 gas casualties and of these 30% were critical. Next, the team visited the Coroners' Mortuary where they inspected about fifty crude wooden coffins containing bodies, many badly burned, some blackened, blistered and distorted. The Spanish representative, the medical member of the team, spent some time examining the bodies.

The following day the team flew to Ahvaz in south-west Iran and from there drove to Hoveyzeh, a town being rebuilt [after] its destruction by Iraq[i] forces. Not far from there, among the bomb craters, were damaged but unexploded bombs. Some were sent back to Teheran so that the charge could be examined in detail, but one was sampled rather hazardously on the spot. Lacking a vice, one soldier secured the bomb by driving a vehicle over it so that it was jammed under a wheel; this allowed a second soldier wielding a large wrench to remove the fuse. Samples of an oily brown liquid contained in the bomb were collected and sealed.

After returning to Teheran, the specialists used the clinical laboratory at the Medical Centre where, with test papers and other techniques, they confirmed that samples taken from the bomb were mustard gas. Finally small samples of the liquid, repacked in special containers, were sent off to approved government laboratories at Spiez in Switzerland and Umea in Sweden to be identified independently by more sophisticated methods.

On Sunday 18 March it seemed the task was done, when suddenly news of a new chemical attack caused the team to return to the war zone. Casualties showed such symptoms as salivation, myosis, dizziness and respiratory paralysis, all pointing to the use of a nerve gas. Again samples were sent to Switzerland and Sweden, where analysts identified the liquid as GA or Tabun. This gas, an organo-phosphorus compound, was [invented] in Germany in the late 1930s and manufactured there towards the end of World War II.

Unanimous conclusions of the UN mission [were that]:

(a) Chemical weapons in the form of aerial bombs have been used in the areas inspected in Iran by the specialists.

(b) The types of chemical agents used were bis-(2-chloroethyl)-sulfide, also known as mustard gas, and ethyl N, N-dimethylphosphoroamidocyanidate, a nerve agent known as Tabun.

The extent to which these chemical agents have been used could not be determined within the time and resources available to us.[2]

NOTES

1. This precis is taken from 'A Journey to Iran - a Personal Account', by Peter Dunn, Materials Research Laboratories, Victoria, September 1984.

2. United Nations Security Council, Document S/16433. 'Report of the specialists appointed by the Secretary-General to investigate allegations by the Islamic Republic of Iran concerning the use of chemical weapons', 26 March 1984, New York.

REFERENCES

1. Foulkes, C.H., *Gas! The Story of the Special Brigade*, William Blackwood and Sons Ltd, Edinburgh and London, 1934.

2. Hyde, H.M. and Nuttall, G.R.F., *Air Defence and the Civil Population*, The Cresset Press Ltd, London, 1938.

3. Mellor, D.P., 'Chemical Warfare', Chapter 17 in *The Role of Science and Industry*, vol.5 of *Australia in the War of 1939-1945*, Australian War Memorial, Canberra, 1958, p.368.

4. Sinclair, D.C., 'The Clinical Reaction of the Skin to Mustard Gas Vapour', Brit J Derm and Syph [*British Journal of Dermatology and Syphilology*], 61, 113, 1949.

5. Sinclair, D.C., 'Treatment of Skin Lesions Caused by Mustard Gas', Brit Med J [*British Medical Journal*], i, 476, 1949.

6. Sinclair, D.C., 'Disability Produced by Exposure of Skin to Mustard Gas Vapour', Brit Med J [*British Medical Journal*], i, 346, [11 February] 1950.

7. Sinclair, D.C., 'The Clinical Features of Mustard Gas Poisoning in Man', Brit Med J [*British Medical Journal*], ii, 290, [7 August] 1948.

8. McAllester, J.C., 'Chemical Warfare', Appendix G in R.W. McNicoll, *History of the Royal Australian Engineers*, vol.3, Corps Committee of the RAE, Canberra, 1982, p.366.

9. Othmer, D.F., and Kern, D.O., Ind Eng Chem [*Industrial and Engineering Chemistry*], 32, 160, 1940.

10. Sinclair, D.C., 'Observations on a Series of Human Subjects Exposed to the Vapour of Mustard Gas under Tropical Conditions'. M.D. Thesis, St Andrews University, 1947.

11. Sinclair, D.C., 'A Clinical Analysis of a Series of Mustard Burns occurring under Tropical Conditions', C.D. (Australia) Report No.55, October 1944, originally classified, SECRET, Declassified February 1982.

12. Koontz, A.R., Arch Surg [*Archives of Surgery*], 48, 284, 1948.

13. Davis, M.I.J., J Am Med Assoc [*Journal of the American Medical Association*], 126, 209, 1944.

14. United Nations Security Council, Document S/16433, 'Report of the specialists appointed by the Secretary-General to investigate allegations by the Islamic Republic of Iran concerning the use of chemical weapons', 26 March 1984, New York.

15. Dunn, Peter, 'A Journey to Iran - a personal account', Materials Research Laboratories, Victoria, September 1984.

[16. Kolko, Gabriel, *The Politics of War: Allied Diplomacy and the World Crisis of 1943-1945*, Weidenfeld and Nicholson, London, 1968.]

Research School of Pacific Studies • The Australian National University • GPO Box 4, Canberra, ACT, 2601 • Telephone (06) 249 3098 • Fax (06) 249 0174