CANADA AND CHEMICAL WARFARE
1939-1945

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By

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Dedication

In Memory of

Private VICTOR ALEXANDER BRUNDLE

40380, 2nd Bn., Northamptonshire Regiment

who died age 21 on 27 March 1918, Passchendale

Son of Charles and Sarah Elizabeth Brundle,

of 28, Cambridge Rd., Lowestoft.

Remembered with honour

ST. SEVER CEMETERY EXTENSION, ROUEN

Abstract

From 1939 to 1942 Canada, allied to the United Kingdom, prepared to defend itself against chemical attack by Nazi Germany. The Canadian preparations represented one of Canada's many contributions to the cause of the British Commonwealth, and may have been used as one method to counter British requests for additional ground troops. After the Japanese attack at Pearl Harbor, Canada became part of an alliance with the United States and the United Kingdom. Canadian chemical warfare preparations went from defensive to offensive following the attack on Pearl Harbor and the entry of the United States into the war. The chemical warfare preparations included preparation and testing of toxic gases and smokes, smoke screening and flame weapons.

One of the most important Canadian contributions to the alliance was the establishment of the Suffield Field Experimental Station in Alberta. This base was particularly useful in carrying out chemical weapon trials, during which approximately 2000 Canadian citizens and soldiers were exposed to toxic gases. At the beginning of the war chemical warfare volunteers were completely covered in protective clothing except for a patch to allow for controlled chemical burns. But by 1942 Suffield staff was given permission to rewrite the regulations for the trials, and volunteers often received significant chemical injuries, including to the eyes. It would appear that the full body of knowledge available to the wartime scientists, especially information relevant to the long-term health outcomes of exposure to vesicant agents, was not applied in the conduct of the human experimentation.

ACKNOWLEDGMENTS

This thesis represents a somewhat curious divertissement for an ex-professor of chemistry, with an abiding interest in British and Commonwealth military history! Thanks are due to a number of members of the Department of History of the University of Saskatchewan for helping to make this work possible. First I am grateful to my supervisor, Professor W. A. Waiser (Bill) who kept the focus on history when the tendency was to get excited about the arcane chemistry of chemical warfare. Also for beer and two desserts! The members of my supervisory committee, Dr. Pam Jordan and Dr. Martha Smith-Norris extended suggestions regarding the thesis. My fellow graduate students were a source of those wide ranging discussions which are such a valuable part of the intellectual experience of a University, while the Buffalo Conference in 2007 opened my eyes to the community of military historians in Western Canada.

Where next?

Never let success hide its emptiness from you, achievement its nothingness, toil its desolation. And so keep alive the incentive to push on further, that pain in the soul which drives us beyond ourselves. Whither? That I don't know. That I don't ask to know.

Dag Hammarskjöld

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Chapter 1

Chemical Warfare between the World Wars

> Chemical warfare has been branded as inhumane. Humanity is not a word to mention when discussing War. [1]

During the First World War, the combatants developed many techniques to overcome the defensive power of barbed wire, machine guns, and trench systems. These techniques included the refinement of battlefield tactics, production and use of tanks, artillery usage on an unprecedented scale (aided by sound-ranging and registered fire), tunneling and mine warfare, and the use of chemical weapons.[2] Of these military technologies, the most controversial was undoubtedly chemical warfare. The feelings of shock and outrage produced by the use of poison gas were augmented by the fact that poison gas was specifically outlawed by international law.[3] The French were the first to use tear gas to harass the enemy during the First World War.[4] The first large-scale deployment of chemical weapons occurred in the Second Battle of Ypres, April 22 1915, when the Germans attacked French, Canadian, and Algerian troops with chlorine gas discharged from cylinders. The use

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[1] National Archives of the United Kingdom (hereafter NA (UK)), War Office (hereafter WO) 188/213, Major Galwery, lecture to Staff College, Camberley, February 18 1928.

[2] P. Griffith, Battle Tactics of the Western Front (London 1994); K. Macksey, and J. Batchelor, Tank (London 1971); J. Glanfield, The Devil's Chariots: The Birth and Secret Battles of the First Tanks (Stroud 2006); M. Farndale, History of the Royal Regiment of Artillery, Western Front 1914-18 (Dorchester 1986); P. Barton, P. Doyle, and J. Vandewalle, The Tunnellers' War 1914-18 (Montreal 2004).

[3] Yale Law School, "Laws of War: Declaration on the Use of Projectiles the Object of Which is the Diffusion of Asphyxiating or Deleterious Gases", July 29 1899, The Avalon Project.

[4] L. F. Haber, The Poisonous Cloud, Chemical Warfare in the First World War (Oxford 1986), p.23.

of chemical weapons was proposed and developed by German chemist Dr. Fritz Haber.[5] The large-scale use of chemicals as weapons of war was an act of desperation by the German High Command to attempt to break the trench war stalemate on the Western Front. During the course of the First World War, approximately 150,965 tonnes of pulmonary, lachrymatory, and vesicant agents were deployed by both sides.[6]

The battlefield effects of chemical weapons were eventually limited by the development of more sophisticated protection against them. Protective clothing and efficient respirators were produced that offered better defence, even though they hindered the mobility of troops. The number of casualties from chemical weapons fell dramatically as a result. Before effective masks and respirators were introduced, the mortality rate among those on the receiving end of toxic chemicals was some 40 percent; by 1918, this had fallen to 2.5 percent, despite the introduction of more lethal chemicals such as sulphur mustard. Indeed, an overall evaluation of the effect of chemical weapons in the First World War suggests that they played a far less crucial role in the balance of military power than their notoriety would suggest. Opinion is divided over the battlefield effectiveness of gas warfare in the First World War. British official historian James Edmonds[7] observed: "Gas achieved but local success, nothing decisive; it made war uncomfortable, to no purpose," while Fritz Haber insisted "If the war had gone on until 1919 you would have won by gas alone."[8]

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[5] Fritz Haber (December 9 1868 – January 29 1934) was a German chemist, who received the Nobel Prize in Chemistry in 1918 for his process for synthesizing ammonia, important for making fertilizers and explosives. He, along with Walther Nernst, is also credited as the "father of chemical warfare" for his work in the deployment of chlorine and other war gases during the First World War. See Nobel Lectures, Chemistry 1901-1921 (Amsterdam 1966) for a biography of Fritz Haber.

[6] K. Coleman, A History of Chemical Warfare (Basingstoke 2005), p. 34. Gas casualty figures for each belligerent during the First World War.

[7] James Edward Edmonds CB, CMG (1861–1956) was a British First World War officer of the Royal Engineers who in the role of British official historian was responsible for the post-war compilation of the 28-volume History of the Great War.

[8] A. Palazzo, Seeking Victory on the Western Front, The British Army and Chemical Warfare in World War 1, (Lincoln 2000), p. 1.

Estimates of military casualties directly caused by chemical weapons during the course of the First World War suggest that for the British Army the gas mortality rate was 4.3% of total casualties.[9] The mortality rates for all other combatants were approximately the same, except for the Russian Army. It is also true that 'gas' became an important psychological weapon. Soldiers were haunted by the memory of the chemical poisoning of the early years of the war, and obsessed by the fear of becoming contaminated by the invisible agent mustard gas. Thus the use of gas caused a far greater outcry than the horrific casualties caused by machine-guns and artillery barrages. It was perhaps easier to express the horror of war by focusing on the effects of new rather than traditional weapons. Civilian reactions were perhaps coloured not just by the unusual sufferings of those wounded by the chemicals, but also by widespread apprehension regarding the future power of science and technology. On the other hand, the experience of chemical poisoning of front-line soldiers deepened their sense of hatred against the enemy. As a Canadian soldier who saw some of his comrades killed by poison gas wrote, "we who inhaled less of the filthy noxiousness grew black with a deadlier hate. Then, with what strength we could gather, did we kill and kill and kill. More, we butchered savagely." [10]

Political events after the First World War suggest that the major powers regarded poison gas as a dangerous weapon of mass destruction which had to be controlled by international agreement. For example, Article 171 of the Treaty of Versailles[11] specifically prohibited Germany from possessing chemical weapons or the materials to manufacture them. Some politicians such as

[9] J. W. Hammond, Jr., Poison Gas: The Myths versus Reality. (Connecticut 1999), pp. 33-36. Details of the various chemical warfare gases, their characteristics and medical treatment may also be found in Hammond.

[10] J. Bourke, An Intimate History of Killing: Face-to-Face Killing in Twentieth-Century Warfare, (New York 1999).

[11] "Articles 159-213 Military, Naval and Air Clauses", Article 171, Peace Treaty of Versailles.

Winston Churchill,[12] however, were calling for their further development for use by the air force. As British Secretary for War and Air in 1919, he proposed that bombs filled with chemicals be dropped by air behind enemy lines. But British air chiefs were reluctant to take up his proposal because they could not guarantee that the bombs would hit their target, revealing a continuing concern not to use poisonous bombs against civilians. In spite of various attempts to justify the use of chemical weapons on economic grounds, or as a humane weapon,[13] the attitude of soldiers and the British public was to ban their use.[14] In the words of Lord Fisher, the President of the British Board of Trade: "the public thought that poison gas was a low game and they think so still."[15]

While gas had been deemed a battlefield failure in the First World War, the possibility of the large-scale use of chemical weapons in any future war deeply concerned people during the interwar years.[16] The public outcry against the use of chemical weapons was reflected in a welter of international treaties in the aftermath of the war.[17] Earlier conventions, such as the first and second Hague Peace Conferences of 1899 and 1907, which had explicitly banned chemical weapons, had failed to prevent their use in war. Indeed, all the belligerents of the First World War, except Italy, had ratified the conditions of the Second Hague Conference on the eve of hostilities. In the post-war

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[12] Sir Winston Leonard Spencer-Churchill (November 30 1874 – January 24 1965) was a British politician known chiefly for his leadership of Great Britain during the Second World War, serving as Prime Minister of the United Kingdom from 1940 to 1945. In the First World War he served as First Lord of the Admiralty, Minister of Munitions, Secretary of State for War, and Secretary of State for Air. During the interwar years, he served as Chancellor of the Exchequer.

[13] J.B.S. Haldane, Callinicus: A Defence of Chemical Warfare, (London 1925).

[14] The Special Brigade of the British Army, which was commanded by Brigadier (later Major-General) Charles Howard Foulkes and which was responsible for British chemical warfare from 1915 until the end of the First World War, was unceremoniously disbanded in 1919 and as little acknowledgement of its existence as possible was made in later years. Buckingham Palace refused permission to publish photographs of the Royal family associated in any manner with gas warfare or even demonstrations of smoke.

[15] NA (UK), (Cabinet, hereafter CAB) 24/106, Lord Fisher "Gas warfare", May 17, 1920.

[16] These and related problems are discussed in detail in Haber, Chapter 12.

[17] For a scholarly discussion of the taboo regarding the use of chemical weapons see R. Price and N. Tannenwald, "Norms and Deterrence: The Nuclear and Chemical Weapons Taboos." in The Culture of National Security: Norms and Identity in World Politics, ed. P. J. Katzenstein New York, 1996, pp. 114-152.

period, under the guidance of British politician Lord Robert Cecil,[18] the Temporary Mixed Commission for the Reduction of Armaments[19] issued in 1924 "The Report of the Committee appointed to consider the Question of Chemical and Biological Warfare." One of the possibilities discussed in the Report was the use of aircraft to drop gas bombs, in particular mustard gas, on civilians. Bearing in mind that German airships and bombers had attacked London and other British cities during the First World War with high explosives, this possibility was quite real. By the end of the First World War, the effective use of chemical weapons had been largely confined to artillery, limiting their radius of action to the range of field guns, and having as the stage for their deployment the military (and male-dominated) battlefield. The use of aircraft to deliver chemical weapons, however, greatly increased the scale and changed the nature of the chemical battlefield.

At the 1925 Conference on the Supervision of the International Trade in Arms, the subject of chemical weapons was raised and led to the Geneva Protocol, adopted on June 17 1925. This brief document prohibited the use of chemical (and bacteriological) weapons, bound each signatory as regards other signatories (that is, it was multilateral), and urged the signatories to ratify the protocol as soon as possible. Between 1925 and 1930 many countries ratified the protocol, though they usually qualified their adherence by insisting that "the Protocol ceased to bind if any enemy fails to respect it." Spain, the United States, and Japan failed to ratify the agreement.[20] However, the nations signing the Geneva Protocol had agreed only to ban the first use of chemical weapons against one another, giving themselves a free hand to deploy them against non-signatory nations, and to respond in kind

[18] Lord Robert Cecil, 1st Viscount Cecil of Chelwood from 1868 to 1923, was a lawyer, politician and diplomat in the United Kingdom. He was one of the architects of the League of Nations and a faithful defender of it; his decades of service to that organization saw him awarded the Nobel Peace Prize in 1937.

[19] **"**Report of the Temporary Mixed Commission for the Reduction of Armaments", League of Nations Statistical and Disarmament Documents**,** Documents 1 to 8 of the 8 documents, containing the report of the temporary mixed commission for the reduction of armaments. Found at http://www.library.northwestern.edu/otcgi/digilib/llscgi60.exe

[20] Spain became a signatory on August 22 1929. Japan and the United States did not become party to the Geneva Protocol until respectively 1970 and 1975. See the Bioweapons Prevention website at http://www.bwpp.org/BWnorm/1925GenevaProtocol.html for the details.

against another signatory that had broken the agreement. Thus the Geneva Protocol was essentially a "no first use" agreement against other signatories. And the treaty was clearly Eurocentric. In the various minor wars that followed the First World War and the break-up of great empires, chemical weapons were used to deadly effect, and with little compunction, against soldiers and civilians in African and Asian countries fighting against the presence of colonial powers.

The British air force reputedly used chemical weapons (in the form of arsenic smoke) in support of the Russian White Army against the Russian Red Army in Murmansk and Archangel in the summer of 1919. There is no primary source material to support this contention.[21] The British, however, definitely wished to retain the option to employ both non-lethal tear gases and perhaps mustard gas in colonial campaigns to impede the movement and fighting power of unprotected tribesmen.[22] In the 1920s there was a general belief, which Britain shared, that the rules of war applied to only conflict "between civilized nations." It was stated explicitly in the Manual of Military Law of 1914 that "they do not apply in wars with uncivilized States and tribes." In a War Office minute of May 12 1919, Winston Churchill argued for the use of tear gas:

> I do not understand this squeamishness about the use of gas. We have definitely adopted the position at the Peace Conference of arguing in favour of the retention of gas as a permanent method of warfare. It is sheer affectation to lacerate a man with the poisonous fragment of a bursting shell and to boggle at making his eyes water by means of lachrymatory gas. I am strongly in favour of using poisoned gas against uncivilised tribes. The moral effect should be so good that the loss of life should be reduced to a minimum. It is not necessary to use only the most deadly gasses: gasses can be used which cause great inconvenience and would spread a lively terror and yet would leave no serious permanent effects on most of those affected.[23]

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[21] L. F. Haber in The Poisonous Cloud, Chemical Warfare in the First World War, (Oxford 1986), does mention the incident or incidents, but he says: "It sounds unbelievable and I have found no corroboration." P. Satia, "The Defense of Inhumanity: Air Control and the British Idea of Arabia", The American Historical Review, February 2006, includes a footnote discussing the misunderstanding of the interest of Churchill in the possible use of non-lethal gasses. Historian Anthony Clayton, writing in the Oxford History of the British Empire: vol. four: The Twentieth Century, (Oxford 1998) states that "The use of poisonous gas was never sanctioned."

[22] NA (UK) WO 32/5184.

[23] M. Gilbert, Winston S. Churchill, companion volume 4, part 1, (London 1976)

The British Cabinet was reluctant, however, to sanction the use of a weapon that had caused such suffering and public revulsion in the recent war.

The first substantiated use of chemical weapons after the First World War was during the Third Rif War in Spanish Morocco between 1921 and 1927.[24] The Spanish Army of Africa dropped chemical warfare agents in an attempt to put down the Riffian Berber rebellion led by guerrilla leader Abd el-Krim. These attacks in 1924 marked the first time mustard gas was dropped from aircraft, a year before the Geneva Protocol was signed. The gas used in these attacks was produced by the Fabrica Nacional de Productos Químicos at La Marañosa near Madrid. This plant was founded with significant assistance from Germany and especially Hugo Stoltzenberg, a chemist associated with the German government's clandestine chemical warfare activities in the early 1920s. Balfour states that "The practice of Spanish airmen was to drop gas bombs in villages where markets were being held, either the day before this gathering, or while the market was going on."[25]

Ten years after the Geneva Protocol had been signed, the use of chemical weapons on a large scale occurred once more. This took place during the Italo-Abyssinian war of 1935-1936 and constituted a blatant violation of the Geneva Protocol, as both Italy and Ethiopia were signatory states. Benito Mussolini, the fascist dictator of Italy, had long held a desire for an Italian Empire to rule beyond the Mediterranean, and often talked of building a new Roman Empire. Abyssinia was the prime candidate of this expansionist goal. It has been suggested that the Italians resolved to attack Abyssinia in order to "reclaim" the country and to avenge their defeat at Adua during the First Italo-

[24] In his recent book Deadly Embrace: Morocco and the Road to the Spanish Civil War (Oxford 2002), historian Sebastian Balfour has presented the results of five years of intensive research in public and private archives in Spain and military and diplomatic archives in Britain and France, along with the product of personal interviews of veterans and survivors of the colonial war in Morocco. One result of his research was a record of the "Secret History of Chemical Warfare against Moroccans."

[25] Balfour, Deadly Embrace: Morocco and the Road to the Spanish Civil War, p. 139.

Abyssinian War.[26] By mid-December, General De Bono was replaced by General Pietro Badoglio due to the slow, cautious nature of his advance. Emperor Haile Selassie decided to test this new general with an attack, but his forces were repulsed when Badoglio started to use poison gas.[27] Although Mussolini had ratified the Geneva Protocol in 1928, he apparently had no inhibitions about the use of poison gases against those incapable of effective gas defense. In fact, he had previously authorized the gas bombing of Libyan rebels in the late 1920s under conditions of the strictest secrecy.[28] On March 29 1936, Graziani's forces firebombed the city of Harar. Two days later the last major battle of the war, the Battle of Maychew, was fought with the Italians victorious. Haile Selassie then fled into exile in England on May 2 and Badoglio's forces took the capital, Addis Ababa on May 5. Italy annexed the country on May 7 and the Italian King Victor Emmanuel III was proclaimed Emperor on May 9 1936. Italy then merged Eritrea, Abyssinia and Somaliland into a single state known as Italian East Africa.

When Emperor Haile Selassie had protested to the League of Nations about the gas attacks on December 30 1935, chemical warfare became an international political issue.[29] After the Committee of Thirteen[30] received accounts of gas attacks in this war, supported by medical testimony, photographic evidence of mustard gas burns [31] and information about Italian shipments of gas and bombs through the Suez Canal, it was not possible to ignore the events. In the League of Nations,

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[26] A detailed analysis of the clash between Ethiopia (Abyssinia) and Fascist Italy has been presented by historian Alberto Sbacchi., Legacy of Bitterness: Ethiopia and Fascist Italy, 1935-1941, (Lawrenceville 1998).

[27] Sbacchi, Legacy of Bitterness, pp. 36-39.

[28] D. Mack Smith, Mussolini (London 1981) pp. 157;171.

[29] Haile Selassie, "Appeal to the League of Nations", June 1936.The appeal may be read at: http://www.mtholyoke.edu/acad/intrel/selassie.htm and viewed at: http://www.youtube.com/watch?v=AQJ1WfJu3fQ

[30] A body appointed by the Council of the League of Nations to examine the situation in Abyssinia.

[31] See International Committee of the Red Cross, Bernard Bridel, " Les ambulances à croix rouge du CICR sous les gaz en Ethiopie" Le Temps, August 13 2003.

Italy did not explicitly deny the use of gas but asserted the right of reprisal against Abyssinian atrocities which supposedly included the torture and decapitation of Italian prisoners, emasculation of the dead and wounded, abuse of the Red Cross emblem, and the use of "dum-dum" bullets.[32] The Geneva Protocol, however, only allowed for retaliation against a first attack with chemical weapons, not first use in retaliation for an attack with different weapons.

Estimates suggest that Italy used around 700 tons of chemical agents, mostly delivered by the Italian air force using airburst bombs and aerial spraying.[33] During those attacks, in addition to military casualties, there were civilian victims as well. Reports on the horrible consequences were mainly obtained from physicians, representatives of such organizations as the Red Cross, and journalists. John Melly, head of a field hospital of the British Red Cross in Ethiopia described that war as follows: "It is not a war, it is not even a slaughter – it is a torture of thousands of defenceless men, women and children." [34] Poisonous gases were used not only during the 1935-1936 military campaign, but also during the occupation against Ethiopian rebels.

Another nation which had territorial ambitions outside of its own borders was Japan. On September 18 1931, a small bomb exploded underneath a section of track on the South Manchuria Railroad. The Japanese Army, which under long-standing agreements policed the railroad, used this incident as a pretext for launching operations aimed at conquering all of Manchuria. The Japanese were believed to hold a wide range of war gases, including chlorine, phosgene, mustard, lewisite, adamsite, and cyanic acid. Various methods for delivery of gas munitions were reportedly developed, such as bombing and spraying from aircraft, gas shells, mines, mortars, projectors, and other

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[32] Sbacchi, pp. 63-66.

[33] "The Problem of Chemical and Biological Warfare, Vol. 1", Stockholm International Peace Research Institute, (Stockholm 1971), p. 44.

[34] Cambridge University Library, Royal Commonwealth Society Library, J.W.S. Macfie Ethiopian collection 1935-36, GBR/0115/Y304296A.

apparatus for ground contamination. Reports of Japanese gas attacks on the Chinese in 1937 and 1938 added to concern about Japanese chemical capabilities.[35] The Chinese Gas Defence Department of the Ministry of War recorded nine gas attacks in the first six months of the war.[36] The sessions of the League Assembly in the fall and winter of 1932-1933 were devoted largely to the Manchurian issue. After prolonged debate the Assembly adopted on February 24 1933 a resolution refusing to recognize Manchukuo and calling on the Japanese to retire. This resulted in the resignation (effective in two years' time) of Japan from the League of Nations.[37] The legacy of these events still affects Sino-Japanese relations even today.

In many countries during the inter-war years, governmental sensitivity to public opinion, international law, and the dubious military value of chemical weapons, all restricted further development. While in pre-1914 popular literature, the threatening aspect of science in war was of necessity speculative,[38] after 1918 the most extraordinary prophecies of future warfare could be considered to have at least some basis in reality. The British had already seen the effects of the revolution in the technology of warfare in the form of U-boats, poison gas attack, and their direct experience of aerial bombardment. It is easy to see why gas warfare and air attack became conjoined in the popular imagination in the 1920s and 1930s, as both were the newest technologies of war. In essence, if airplanes and gas warfare were so appalling in the First World War, what could advances in these technologies portend, but even more and far greater destructiveness? And who could legitimately claim to know what, if any, the eventual limits of possible advances were?

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[35] NA(UK) WO 208/3044

[36] For a more detailed discussion of the military events see the account in E. M. Spiers, Chemical Warfare, (Illinois 1986). Also see NA (UK) WO 33/1634, Nineteenth annual report of the Chemical Defence Research Department.

[37] T. W. Burkman, World Affairs, v. 158, n. 1, 1995, p. 45.

[38] The Tale of the Next Great War, 1871-1914: Fictions of Future Warfare and Battles Still-To-Come, (Ed. I. F. Clarke) (Syracuse 1995).

While the traumatic effects of the First World War affected all of Europe in profound ways, Britain, titular head of the British Commonwealth, experienced a new, previously unknown sense of vulnerability, which intruded on the interwar period. Specifically, the island nation was the victim of the first strategic bombing campaign in history. German use of airships, Gotha and later Giant bombers to strike England itself, the traditional defences provided by the English Channel and the Royal Navy notwithstanding, revealed the danger posed by the new technology of aviation. The first Battle of Britain was fought from 1915 until 1918. The psychological effect was enormous, and continued for the next two decades. Because Britain had remained sheltered behind its moat, the English Channel, for centuries, this effect was perhaps worse than it might have been for a European country with no such tradition of invulnerability.[39]

Four new major weapons had appeared in the First World War: submarines, tanks, aircraft, and gas. The use of poison gas, however, was the weapon which gave rise to the greatest popular disgust and fear. The numerous war gases ranged from lung agents like phosgene and chlorine to the blistering agent mustard gas, with chemists reputedly competing to discover even more deadly compounds. The idea of an aerial gas attack became widespread in the popular imagination during the 1920s, and especially in the early 1930s. Significantly, these two weapons, gas and airplanes, were viewed as the most difficult to defend against, and the most impersonal in their effects. British politician Stanley Baldwin, in the House of Commons on November 10 1932, prophesied: "No power on earth can protect the man in the street from being bombed. Whatever people may tell him, the

[39] P. Meilinger, "Trenchard and Morale Bombing: The Evolution of Royal Air Force Doctrine before World War II," Journal of Military History, v. 60, n. 2, April 1996, p. 247. Many English cities were bombed by German airships and bombers, including London, Portsmouth (L. F. Paige, personal communication) and Lowestoft (R. J. Freeman, personal communication). See also H. G. Castle, Fire over England: the German Air Raids of World War 1 (London 1982). Also G. W. Haddow and P. M. Grosz, The German Giants: The Story of the R-Planes 1914-1919, (London 1962); N. Hanson, First Blitz, (London 2008). It was Britain, not Germany, which carried out fire bombing and the firestorm to its logical conclusion with the "thousand bomber" raids on Cologne, Hamburg and Dresden in the next war.

bomber will always get through."[40] The crew of a bomber flying high above a city cannot distinguish between civilian and soldier, nor can a cloud of poison gas once released. Indeed, both weapons kill indiscriminately by their very nature, being weapons of mass destruction rather than targeted weapons. This imbued them both with a uniquely threatening quality, much exploited by alarmist writers of that era. In 1925 it was postulated during debate that all of London could be gassed in three hours![41] According to Harold MacMillan, "We thought of air warfare in 1938 rather as people think of nuclear warfare today."[42]

Protection from the perceived threat of gas was the most prominent feature of British civil defence preparations before the outbreak of the Second World War. Perhaps one reason for this concern was because British military authorities were knowledgeable about gas warfare and the effects of gas from the First World War experience. When Air Raid Precautions (ARP) became developed in 1935, it could draw on the expertise of the Chemical Defence Research Establishment (CDRE) at Porton Down in England, which had been at work for years studying gas problems. The Chemical Warfare Committee of the Committee of Imperial Defence had also continued to research gas warfare and issued a report entitled The Protection of the Civil Population against Gas Attacks as early as 1925.[43] Interestingly, this report helped persuade the ARP Committee that, in a future war, gas was not likely to be the first weapon used, without warning, against civilians. Nevertheless, probably because preparations for gas warfare were cheaper than the construction of huge public shelters to protect against air raids, and because of the popular fear gas provoked, it was gas warfare that was most systematically addressed by ARP planners in Britain.

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[40] The Times, November 11 1932, p.7 column B.

[41] B. D. Powers, Strategy without Slide-Rule: British Air Strategy 1914-1939 (London 1976).

[42] H. Macmillan, Winds of Change (London 1966), p. 522.

[43] T. H. O'Brien, "Civil Defence" in Sir Keith Hancock, ed., History of the Second World War: United Kingdom civil series (London 1955), p. 729.

The late 1920s also saw the publication of a number of war memoirs and presentation of theatre performances relating the horrors of the trenches in the First World War. Such famous works as Erich Maria Remarque's All Quiet on the Western Front (1929)[44] or Siegfried Sassoon's Memoirs of an Infantry Officer (1930)[45] described the violent and brutal nature of the last war. "On January 21 1929 the curtain rose on the first performance of Journey's End, the ultimate in antiwar plays, by Robert C. Sherriff, a thirty-three year old former insurance man who had served in the East Surrey Regiment's Ninth Battalion through the bloody spring of 1917. Its audiences left the Savoy Theatre stunned but primed, now, for Robert Graves's memoir Goodbye to All That."[46]

In order to dramatize the new terrors that science promised, anti-war or disarmament authors provided graphic detail of the hypothetical effects of air attack on civilians.[47] Patrick Kyba's Covenants Without the Sword: Public Opinion and British Defence Policy 1931-1935 (1983) gives excellent examples of the alarmism in the press and from politicians concerning air attack. Uri Bialer's The Shadow of the Bomber: The Fear of Air Attack and British Politics 1932-1939 (1980) is an excellent study of the effect the air threat had on inter-war domestic politics. Bialer says that the period after 1935 marked the point when the military (as opposed to the politicians) finally accepted that a devastating knock-out blow was possible, and that Germany would likely try to achieve it in a future war. By the time of the Munich crisis, all the years of warnings from the Foreign Office, the Air Ministry and others had acted to inhibit foreign policy. Hence appeasement. As Bialer concludes, the British preoccupation with air attack went "beyond the bounds of rational reflections." [48]

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[44] E. M. Remarque**,** All Quiet on the Western front; translated from the German by A. W. Wheen, (London 1920).

[45] S. Sassoon, Memoirs of an Infantry Officer, (London 1965).

[46] W. Manchester, The Last Lion: Winston Spencer Churchill; Alone: 1932-1940, (Boston 1988) p. 47.

[47] B. Newman, Armoured Doves: A Peace Book (London 1931). A science fiction novel of the future in which inventions are used to bring peace to the world.

[48] U. Bialer, The Shadow of the Bomber: The Fear of Air Attack and British Politics, 1932-1939, (London 1980).

A poison gas attack had never been experienced by the civilian population in Britain. Even during the First World War, most Britons could only read of its horrors and see the wounded victims. The information available to the public on gas warfare, therefore, was mainly from what experts told them. The influence of the unknown nature of gas on a mainly non-scientific population probably made it that much more fear-inspiring. Aviation was a reality, as could be seen by a glance at the sky, while chemical warfare was, for most, something that could only be imagined. Thus, after 1930, alarmist writers began to emphasize the weapon, gas, as much or more than the delivery system, the bomber. Gas air raids were described as:

> altogether horrible . . . much more dreadful than the air raids of the World War. They began with a nightmare of warning maroons, sirens, hooters and the shrill whistles of cyclist scouts, then swarms of frantic people running to and fro, all pride and dignity gone, seeking the nearest shelter and aid, and they ended for most of their victims in an extremity of physical suffering . . . In nearly every case the organization of refuges and gas masks broke down**.** [49]

Specifically addressing the inter-locked concepts of aviation and gas was Chemical Warfare (1930), a collection of papers from an international conference held by the Women's International League for Peace and Freedom in 1929. This collection featured typically military 'experts' writing essays on various features of the use of gas in future war.[50] As Martin Ceadel would say, by the 1930s "from 'expert optimism' of this sort, novelists took up gas warfare almost to the neglect of other types of weapons."[51] The general public also had other sources to show them what air attack would mean in a future war. By the early 1930s, reporting on real air attacks lent credibility to the imaginings of writers. Vicarious experience of modern bombing raids was provided by motion pictures of battle

[49] H. G. Wells, The Shape of Things to Come: The Ultimate Revolution, (London 1933).

[50] G. Woker, The Next War, A War of Poison Gas, (Washington 1929).

[51] M. Ceadel, "Class, Culture and Social Change: A New View of the 1930's", in Frank Gloversmith ed., Popular Fiction in the Next War, 1918-39, (Brighton 1980), pp- 161-184.

areas around the globe. Those who had no memory of First World War bombing raids could see film of more recent air strikes, and thus had photographic imagery bring home to them the potentials of air attack. The first terror bombing with modern aircraft occurred on January 29 1932, when Japanese bombers struck the Chapei sector of the Chinese city of Shanghai. "People paying their weekly visit to the cinema to watch Marlene Dietrich or Tarzan or Shirley Temple were able to see in the newsreels bombs falling and smoke rising from the ensuing explosions. It was an impressive spectacle."[52]

Italy's invasion of Abyssinia in 1935 and its policy of terror bombing and battlefield use of poison gas caused apprehension of the nightmare of another world war involving poison gas. The Spanish Civil War similarly provided moviegoers numerous newsreels of cities being bombed, especially the raids on Barcelona and Madrid in 1938. The Munich Crisis of September 1938 surely represented the zenith of the fear which had animated the conceptions of war since the 1920s. British Prime Minister Chamberlain himself fully demonstrated the profound influence that fear of air attack had over him and the nation. Addressing the House of Commons on October 3 1938, days after returning to public acclaim with "peace in our time,"[53] he referred to the anxieties the leadership had during the crisis:

> When the House met last Wednesday, we were all under the shadow of a great and imminent menace. War, in a form more stark and terrible than ever before, seemed to be staring us in the face . . . today, only a few days after, we all meet in joy and thankfulness that the prayers of millions have been answered, and a cloud of anxiety has been lifted from our hearts.[54]

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[52] J. Terraine, "Theory and Practice of Air War: the Royal Air Force," in H. Boog, ed., The Conduct of the Air War in the Second World War: An International Comparison, p.471.

[53] Great Britain, Parliamentary Debates, Vol. 339 (3 October 1938).

[54] N. Chamberlain, In Search of Peace (London, 1939), p. 203.

He praised the efforts of the four powers who met at Munich, resolving the issue by discussion and not by fighting, "and thereby they have averted a catastrophe which would have ended civilization as we have known it."[55] The public was initially overjoyed, but Churchill, participating in the House of Commons debate on the resolution "that this house approves the policy of His Majesty's Government by which war was averted in the recent crisis and supports their efforts to secure a lasting peace," charged that the Government had "sustained a total and unmitigated defeat," and that "a disaster of the first magnitude has befallen Great Britain and France."[56]

Planning for defense against chemical attack was something that both addressed the concerns of the public and was also within financial reach of the Air Raid Precautions (ARP) Department.[57] ARP had developed an inexpensive, mass-production model gas mask, and, in 1936, began producing large numbers of these masks for free public distribution. Some 30 million were thought to be needed by those within range of air attack. This number would rise to over 50 million by early 1939, when the whole of the British Isles were assumed to be subject to air attack, due to Air Staff over-estimates of the range of German aircraft. Huge stockpiles of the civilian gas masks were built up in regional storage facilities, starting in 1935. Planning on providing masks to virtually every person in England, 150,000 were made a week by January 1937, with 19,500,000 containers in storage by December 1937. Concerned that the Nazis and Italians might use chemical weapons, British war planners had also authorized the development of offensive chemical warfare munitions and delivery systems

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[55] Ibid., p.207

[56] Quote taken from The Churchill Society London at http://www.churchill-society-london.org.uk/Munich.html

[57] J. S. Meisel, "Air Raid Shelter Policy and its Critics in Britain before the Second World War", Twentieth Century British History, 1994, v. 5, n. 3, pp. 300-319. "Since war gases had been the principal focus of ARP researches, the handbooks about gas were released in short order. Anti-Gas Precautions and First Aid for Air Raid Casualties (Handbook No. 2), came out in July 1935 and sold 86,350 copies; its second edition, released in September 1936, sold 280,000 copies (First Aid and Nursing for Gas Casualties, Air Raid Precautions Handbook No. 2, 3rd edition, March 1942, Amended Reprint, London, 1942, p. iii). Personal Protection Against Gas (ARP Handbook No. 1), issued in August 1936, sold 477,000 copies in its first edition."

starting in 1937. These munitions included gas-filled artillery shells, mortar shells and aircraft sprays, all intended to make chemical weapon attacks more efficient.

By 1939 the known use of chemical weapons against civilian populations by military powers such as Italy and Japan, each possessing substantial chemical industries, and having chemical warfare schools as a component of their military establishments, was surely a reasonable source of concern to Britain and the Dominions. It seems clear that in several of the nations which would be belligerents in the Second World War, the military value of using chemical weapons against an enemy capable of counter-measures and chemical retaliation, was rightly questioned. However, in addition to the known military intentions of one's own country, there is always in war the unknown intention of the enemy. It seems that by 1939 each of the major belligerents suspected its enemies of preparing to wage chemical war. Perhaps these suspicions were based on nothing more than intelligence indicating that the nations involved were exploring retaliatory chemical warfare initiatives. But in a tense international climate many planners interpreted these actions as first-use preparations. It would have been a brave (or foolhardy) leadership which would have ignored the potential for chemical warfare by 1939, given the blatant breaches of the international protocol which had already occurred. Perhaps chemical warfare preparations were a form of insurance?

On September 1 1939, the German army invaded Poland on Hitler's orders and without a declaration of war. This action marked the beginning of the Second World War.[58] On September 3, Britain, France, Australia and New Zealand declared war on Germany. The next day, the United

[58] "When war came in 1939, it was a result of 20 years of decisions taken or not taken, not of arrangements made in 1919." M. Macmillan, Paris 1919, Six Months that Changed the World, (London 2001), pp. 493-494. See also Z. Steiner, The Lights That Failed. European International History, 1919–1933, (Oxford 2005). Also see A. Webster, "The transnational dream: politicians, diplomats and soldiers in the League of Nations' pursuit of international disarmament, 1920–1938", Contemporary European History, v. 14, n. 4, 2005, pp. 493–518; P. Clavin and J-W. Wessels, "Transnationalism and the League of Nations: understanding the work of its economic and financial organisation", Contemporary European History, v. 14, n. 4, 2005, pp. 465–492.

States made an announcement declaring its neutrality. After Parliament debated the matter, Canada declared war on Germany on September 10 1939.

Chemical warfare during the Second World War is an area of Canadian military history which has received little attention from historians. One book, Deadly Allies, Canada's Secret War 1937-1947,[59] by journalist John Bryden presents a popular account of Canadian preparations to wage both chemical and biological warfare. This study, which contains an excellent bibliography, briefly reviews many Canadian Second World War activities such as biological warfare preparations; the Habakkuk (ice ship) project; personalities and politics; research on poison gases and explosives at selected Canadian universities, the establishment of the Suffield Station; the use of human subjects for experimental purposes, the disposal of chemical warfare agents in 1946, and the intelligence activities of the USSR as revealed by the defection of Igor Gouzenko which exposed Stalin's efforts to steal nuclear secrets. But there is little examination of the wider issues related to the history of Canadian involvement in chemical warfare during the Second World War. Why, for example, did Canada become involved in such activity even though the country was a signatory to the 1925 Geneva Protocol? And how did the nature and kind of preparations change over the course of the war? These kinds of questions were not considered in this book.

Another book, The Science of War: Canadian Scientists and Allied Military Technology during the Second World War by Donald H. Avery contains a single chapter summarizing chemical warfare planning in Canada during the Second World War. This book is a well organized account of Canadian administrators and scientists, their relationships with Allied scientists, and an account of the scientific activities of the three North Atlantic nations which fought the Second World War. It describes the role which Canada played in the development of radar, RDX explosives, proximity fuses, chemical and biological warfare, and the atomic bomb. But it is not a detailed history of any

[59] J. Bryden, Deadly Allies: Canada's Secret War 1937-1947 (Toronto 1989).

one component of Canadian science during the Second World War, especially chemical warfare preparations. Again, the wider historical questions are not addressed, such as why Canada willingly participated in chemical warfare preparations.

There is one M. A. thesis, "Canada and Chemical Warfare",[60] which examines the early history of chemical warfare, the industrial basis for First World War chemical warfare (the chlor-alkali industry), the Canadian experience of chemical warfare during the First World War, Canadian policy regarding chemical warfare in the Second World War, the establishment of the Suffield Field Station, and finally, the post-Second World War efforts made by Canada to achieve chemical warfare disarmament. The thesis contains no details of the Canadian preparations and human testing programme for chemical weapons during the Second World War, or any discussion of the political factors which may have led the Mackenzie King government to participate in chemical warfare preparations from the beginning of the war. The only other Canadian thesis discussing chemical warfare is a Ph. D. thesis by Dominick Jenkins, "Poison and Justice: an Investigation into the Debate over Poison Gas after the First World War to Rethink Current Practices of Judgment in Science, Industry, and the Military."[61] This thesis examines the 1919 coalition between the U.S. Army Chemical Warfare Service, the U.S. National Research Council, the American Chemical Society, and Du Pont. This coalition prevented the U. S. General Staff from demobilizing the Chemical Warfare Service, and it reinforced the wartime establishment of a science-based chemical industry. This thesis however, has no relevance to the Canadian Second World War experience.

It would appear that there is a place for a thesis which examines the Canadian contribution to Allied chemical warfare preparations during the Second World War. This thesis will examine the

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[60] J. J. Bailliu, "Canada and Chemical Warfare", M. A. thesis, Royal Military College, 1989.

[61] D. Jenkins, "Poison and justice: an investigation into the debate over poison gas after the Great War to rethink current practices of judgement in science, industry, and the military", Ph. D thesis, Toronto 1996.

political factors which persuaded Prime Minister Mackenzie King and his Liberal government to agree to chemical warfare testing. These chemical warfare preparations included the establishment of an experimental station at Suffield, Alberta, and the industrial scale preparation of war gases, in spite of Canada being a signatory to the Geneva Protocol of 1925. Canadian support for chemical warfare also raised many policy problems during the course of the Second World War, some of them associated with the demands of Allies of greater power and industrial strength, who on occasion neglected to consult their Canadian partner. Indeed, Canadian chemical warfare policy underwent a significant change upon the entry of the United States into the Second World War and the threat to the North American continent posed by Imperial Japanese forces. The legacy of these chemical war experiments includes the Canadian volunteers who subjected themselves to painful and dangerous tests for the sake of the Allied cause. As late as May 1944 the United States Chemical Warfare Service (CWS) was known to have difficulty in carrying out casualty tests with their own soldiers. One hundred Canadian volunteers were offered for use in American chemical warfare tests.[62] However, these soldiers, now veterans in their later years of life, received no recognition for service, nor compensation for injury, until 2004. The National Defence and Canadian Forces state that:

> In February 2004, the Ministers of National Defence and Veterans Affairs announced a recognition program to offer payments to Canadian veterans who volunteered to participate in chemical-warfare experiments, mainly in the Second World War era, in Suffield, Alberta, and Ottawa. Each eligible veteran was offered a one-time, tax-free payment of $24,000 in recognition of his or her service to Canada. The amount is comparable to previous payments to Canadian veterans. This payment is in addition to pension benefits to which these veterans may be eligible.[63]

The Library and Archives Canada files which represent the primary documentation for the thesis are not readily available. A search of the Library and Archives Canada web site for records

[62] Library and Archives Canada [hereafter LAC], Minutes of the Canadian Chemical Warfare Inter Service Board, December 10, 1943 is "restricted by law." Minutes retrieved from National Archives of the United Kingdom [hereafter NA (UK)] War Office [hereafter WO] 188/812.

[63] www.forces.gc.ca/site/news-nouvelles/view-news-afficher-nouvelles-eng.asp?id=1308

dealing with chemical warfare from 1939 to 1945 retrieved 832 records, the vast majority of which are classified as "restricted by law." Thus, the problem of access to primary source material had to be confronted. The chemical warfare activities carried out in Canada were jointly prosecuted by the United Kingdom and Canada from 1940 and with the United States after Pearl Harbor. Chemical warfare records of this period are available at the National Archives of the United Kingdom (NA (UK)) and the National Archives and Records Administration (NARA) in the United States. The U. K. Archive WO188/812 (Minutes of Canadian Chemical Warfare Committee, Chemical Warfare Laboratories Advisory Committee and the Inter-service Working Committee on Chemical Warfare) and WO188/702 (Co-ordination of Research into Chemical Warfare between Britain, Canada and USA) are open. These records are a copy of the equivalent documents in the Canadian Chemical Warfare files. At NARA, in Record Group 175, the records of the CWS of the U. S. are also open, and were accessed by the author to obtain copies of much of the Canadian work on chemical warfare during the Second World War.

The preparations of Canada to wage a chemical war against both Nazi Germany and Imperial Japan, as part of a coalition during the Second World War, represents a largely unexplored area of Canadian military history. And yet, chemical warfare preparations were one of the Canadian contributions to the Second World War which were probably used by the Mackenzie King government as another means of reducing the risk of conscription that would result if large numbers of Canadian men were called upon for the land war. The Suffield Experimental Station was a major asset of the Allies, and a major Canadian war contribution. Canadian volunteers played a distinguished, and largely unknown, part in the testing of the chemical weapons of the Allied coalition which waged a bitter war in two major theatres of military action from 1939 to 1945. In the closing stages of the war in the Pacific, the coalition forces, dominated by the United States, but including Canada, contemplated unleashing a chemical war against the Japanese, especially during

the planned invasion of the Japanese home islands, in order to reduce Allied casualties. This chemical war mercifully was never fought.

Chapter 2

Canadian Chemical Warfare Preparations to December 1941.

> I think I may claim to be responsible in no small measure for the unity of Canada at this time and certainly for the united manner in which the country has entered the war at the side of Britain.
>
> Prime Minister Mackenzie King, in his diary, December 31 1939.

> *Of course*, I considered your treaties (just between us) so much toilet paper-
>
> Hermann Goering to Gustave Gilbert, at Nuremberg, 1946, in Nuremberg Evil on Trial, by James Owen.

The appalling cost of the First World War, with nearly 60,000 Canadians dead and another 173,000 wounded, left Canadians wary of further international involvement. Liberal Prime Minister Mackenzie King's general principle with respect to external affairs was that Canada should play a gradually more autonomous role, while avoiding unnecessary international commitments. King was an admirer of Great Britain and always assumed that, in the case of a major war, Canada would support Britain. But in less serious circumstances, he felt that Canada should be more independent, and in all cases, he felt that the Canadian Parliament should make the decisions. In 1927, when Canada was elected to a non-permanent seat on the Council of the League of Nations, King was suspicious, fearing this might lead to unnecessary commitments. Although not confined to Quebec, isolationism was strongest in that province which was embittered by the imposition of conscription for military service during the First World War.[1] However in the late 1930s, the looming war in

[1] D. Morton and J.L.Granatstein, Marching to Armageddon, (Toronto 1989). The Canadian Expeditionary Force of the First World War lost 60,661 dead during the war, representing 9.28% of the 619,636 who enlisted. The Canadian Expeditionary Force was comprised mostly of men who had volunteered, as conscription was not enforced until the end of the war when call-ups began in January 1918. After the Battle of Vimy Ridge Canada needed to replace casualties in its army; however, there were few volunteers available. The recruiting effort in Quebec had failed, and Canada turned to its only unused option: conscription. Almost all French-Canadians opposed conscription: they felt that they had no particular loyalty to either Britain or France. After visiting Britain for a meeting of First Ministers in May of 1917, Canadian Prime Minister Sir Robert Borden announced that he would be introducing "The Military Service Act." On July

Europe led to the realization in government circles that Canada would inevitably be drawn into another major conflict.

The Canadian government, headed by Liberal Prime Minister Mackenzie King, embarked upon the war with one supreme concern: that the war must not undermine national unity. King wanted a war of "limited liability", wherein Canada's principal contributions to the war effort would be economic and productive rather than military. This was a view shared by the Conservative opposition and its leader Dr. Robert Manion. Mackenzie King, recalling the conscription crisis of 1917, was acutely sensitive to public opinion in French-speaking Québec where conscription was unpopular, and he feared the consequences for national unity -- and his party's chances for re-election -- should heavy ground casualties force his government to enact conscription for overseas service.[2] When Canada declared war on Germany on September 10 1939, Prime Minister King promised the country -- though in essence it was a pledge to Quebec -- that there would be no conscription for overseas duty. There was, however, conscription for the defence of Canada. Mackenzie King and Ernest Lapointe,[3] Canadian Minister of Justice, worked together to bring a united Canada into the looming war through a decision of the Canadian Parliament, while also satisfying the concerns of

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6, 1917 the Act was passed, allowing Borden to conscript men across the country if he felt that it was necessary. English Canada was generally supportive of the bill; Quebec, however, was not, nor were farmers and labour groups. Bourassa voiced the opinion of many Quebec people by saying that "Canada had no business in a blatantly imperialistic European war." See the Diary of William Lyon Mackenzie King, Library and Archives Canada, online at: http://www.collectionscanada.gc.ca/king/053201/05320112_e.html

[2] J. L. Granatstein and J. M. Hitsman, Broken Promises: A History of Conscription in Canada, (Toronto 1977).

[3] Ernest Lapointe, PC (October 6, 1876 – November 26, 1941) was a Canadian politician. In 1921, William Lyon Mackenzie King appointed Lapointe to his first Cabinet as Minister of Marine and Fisheries. In 1924 he became Minister of Justice and served in that position in successive Liberal cabinets until his death in 1941. Lapointe served as King's Quebec lieutenant and was one of the most important ministers in Cabinet. Lapointe helped draft Mackenzie King's policy against conscription for overseas service in 1939 and his campaigning helped defeat the Duplessis government in 1939. See: J. MacFarlane, “Double vision: Ernest Lapointe, Mackenzie King and the Quebec voice in Canadian foreign policy, 1935-1939”, Journal of Canadian Studies, spring 1999, v. 34, n. 1, p. 93.

Québec with regard to conscription. “French Canadians were willing to allow English Canadians to volunteer, so long as the threat of conscription no longer existed.”[4]

The government of Canada, somewhat like the British and French governments in late 1939 and early 1940, was involved in a “phony war.”[5] For Canada there had been no huge mobilization of military forces,[6] material or financial resources. A plan had been made to train Commonwealth aircrew in Canada,[7] but little else had been prepared or organized. In May 1940, Germany invaded France, the Wehrmacht striking between Belgium and the carefully prepared Maginot Line[8] defences, while using a superior tactical air power doctrine. After the fall of France in the spring of 1940, Britain's strategic situation was not enviable. The British Expeditionary Force had left most of its guns and heavy equipment on the beaches of France after the Dunkirk evacuation.[9] Following the French capitulation, Nazi forces were in control of most of Europe, and Britain was facing an invasion, with Canada its only ally in the North Atlantic. On July 3, the British surrounded the French fleet at the port of Mers-el-Kebir outside Oran, Algeria and destroyed the French fleet to

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[4] Granatstein and Morton, p. 11

[5] The Phoney War (also known as the Bore War, or German Sitzkrieg) , was a phase in the early second World War from September 1939 until May 1940 marked by few military operations in Continental Europe, in the months following the German invasion of Poland and preceding the Battle of France. The great powers of Europe had declared war on one another, yet neither side had committed to launching a significant attack, and there was relatively little fighting on the ground. The British Expeditionary Force landed in France, while British children were sent to Canada or the British countryside in anticipation of attack on Britain from the air using chemical weapons.

[6] Canada's commitment to the British-French forces in Europe was limited to one division.

[7] Granatstein and Morton, p. 10. An initial small training project had been agreed upon in April, 1939, but the war intervened before the arrival of the first trainees in Canada. Later the British Commonwealth Air Training Scheme grew in size to a huge organization administered by Canada.

[8] For a fascinating virtual tour of the Maginot Line visit http://www.maginot-line.com/ The causes of the British and French military defeat are complex, and still a source of discussion for historians of that era. See J. Mosier, The Blitzkreig Myth, (New York 2003) for a recent and different analysis of the factors involved.

[9] Of the 2,794 guns the BEF had brought to France, 2,472 were left there, along with 63,879 motor vehicles out of 66,818. These figures are taken from L. F. Ellis, War in France and Flanders (London 1953), p. 327. France surrendered June 22 1940.

prevent possible seizure by Germany.[10] The world turned upside-down. Nazi leader Adolf Hitler fully expected the British to negotiate an end to resistance.[11]

As history records this did not happen. The autumn of 1940 was a daunting time for Britain. That summer the Battle of Britain had been narrowly won.[12] But in aircraft and industrial output, Britain, alone in Europe against the Axis, remained in peril, its supply lines tenuous. The dominions and colonies could offer manpower, their under-utilized industrial capacity and money, but only within limits. Another problem was the need to adjust to the reality of a different kind of war, one requiring advanced technology, new techniques of war and new weapons. In the past Canada had looked to Britain for guidance and technical assistance. Now it was Britain which needed the help of its oldest dominion. Decisions and industrial organization were now required rather than the raising of huge armies, for which in any case there were few weapons. After the long struggle of the Great Depression of the 1930s, the challenges of the Second World War accelerated Canada's ongoing, but slow, transformation into a modern urban and industrialized nation.

In addition to military manpower, a modern war demands many other resources. During the Second World War, Canada contributed food supplies, financial aid, the British Commonwealth Air

[10] At Mers-el- Kébir, 1,297 French sailors were killed and about 350 were wounded. The controversial action at Mers-el-Kébir was a tragic episode that soured Anglo-French relations for a generation. Churchill in The Second World War Volume II, (London 1949), p. 212 recounts that “two peasant families, each of whom had lost their sailor son by British fire…… Both families requested that the Union Jack should lie upon the coffins side by side with the Tricolour, and their wishes were respectfully observed.” On November 27 1942, the Nazis attempted to capture the French fleet at Toulon, an operation known as Case Anton. The French scuttled all their ships including Dunkerque and Strasbourg, as they had pledged in 1940.

[11] As did others; "Democracy is finished in England ..." Ambassador Joseph Patrick "Joe" Kennedy, Sr., Boston Sunday Globe, November 10 1940.

[12] Battle of Britain is the name given to the strategic effort by the German Luftwaffe during the Second World War to gain air superiority over RAF Fighter Command. The name derives from a June18 1940 speech in the House of Commons by Prime Minister Winston Churchill, "The Battle of France is over. I expect the Battle of Britain is about to begin..." The Royal Canadian Air Force contributed a squadron during the Battle of Britain

Training Plan,[13] ships, aircraft, tanks and eventually over a million Canadians to the Allied cause. Enemy prisoners of war found a secure location in camps in Canada.[14] Approximately 16,000 aircraft, including Lancaster and Mosquito bombers, were built in Canada. By the end of 1944, Canadian shipyards had launched naval ships, such as destroyers, frigates, corvettes, and some 345 merchant vessels. The Royal Canadian Navy was tiny in 1939, but its expansion during the war was remarkable: it enlisted 99,688 men and some 6,500 women, and it manned 471 fighting vessels of various types. Its primary task was convoy, protecting the troop and supply ships across the Atlantic. It carried an increasing proportion of this burden, fighting grim battles sometimes of several days' duration with U-boat wolf packs. From 1939 to 1945 in combination with the Royal Navy it sank or shared in sinking four hundred and ninety-one enemy submarines.[15] But perhaps no Canadian contribution to the Allied war effort was as vital as that made by the metals industries: half of Allied aluminium and ninety percent of Allied nickel was supplied from Canadian sources during the war.[16] These contributions to the cause of the Commonwealth probably all served the purpose of allowing Mackenzie King to deflect British requests for more manpower, and hence limited the possibility of conscription of Canadians for overseas service.

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[13] Granatstein and Morton p. 12. An initial small training project had been agreed upon in April, 1939, but the war intervened before the arrival of the first trainees in Canada. The new idea was to train 20-30,000 aircrews in Canada, following a suggestion of the Australian High Commissioner in London. After some consideration an angry Mackenzie King believed that this could have been used as the major Canadian contribution to the war if the British had made the proposal earlier, and would have made a Canadian expeditionary force, with all of the attendant political problems, unnecessary. It might also have reduced the anticipated financial burden for Canada of participating in the war.

[14] CBC Digital Archives Canada was home to more than 37,000 German and Italian prisoners during the Second World War. With the war raging on in Europe in 1940, Great Britain grew concerned about what would happen with their German POWs in the case of an invasion on British territory. Fearing that freed prisoners would help bolster the invading forces, the British government appealed to Canada and Australia to take custody of POWs.

[15] C. Stacey, World War II: Cost and Significance, The Canadian Encyclopaedia. Also R. Beyer, The Greatest War Stories Never Told, (New York, 2005). For its part the U. S. navy is credited with destroying 127 U-boats at sea from 1941 to 1945.

[16] R. F. Campbell, Studies In History, Economics and Public Law, No. 541, The History of Basic Metals Price Control in World War II, (New York 1948).

During the course of the Second World War Canadian scientists and engineers also contributed to the development of many weapon systems and military technologies. Among these may be noted radar, gun laying, proximity fuses, the new explosive RDX,[17] biological and toxic warfare research, atomic research and chemical warfare preparations. Perhaps one of the least known to Canadians is chemical warfare preparation and testing. British concern that German and Italian forces might use chemical weapons led the British Government to resume production of chemical weapons by 1937. In the years immediately prior to the start of the Second World War, Canada too was quite properly sensitive to the potential of chemical warfare should relations with Germany finally become hostile. Canadians were particularly apprehensive because Canadian troops had suffered during the first chemical attack with chlorine gas by the Germans at Ypres in 1915.[18] Certainly the attack would be recalled by those responsible for making decisions about Canadian military preparations for a possible future war with Germany. In 1939, at the beginning of the European phase of the Second World War, the Allies announced that they would honour the Geneva Protocol, while explicitly reserving the right to retaliate.[19] The initial phase of a war is often definitional: it may establish implicit and explicit controls and prohibitions regarding the use of certain weapons and acceptable targets.[20] In announcing that they would respect the Geneva Protocol, the Allies made a conditional pledge based upon mutual restraint. It was clear that initiation by either side would lead to retaliation.

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[17] RDX [Research Department Explosive] was first prepared in 1899. Its explosive properties were not appreciated until 1920. RDX was used widely during World War II because petroleum was not needed as a raw ingredient.

[18] "The Canadians went into this particular sector twelve thousand strong. When they were relieved five days later but two thousand remained alive. A very large portion of the ten thousand died as a result of the effects of the gas. In fact, had it not been for the presence of mind of some of the officers who ordered the men to put wet cloths over their faces and lie flat on the ground face downward, the entire force would have been annihilated." E. B. Spear, The Scientific Monthly, v. 8, n. 3, March 1919, pp. 275-283.

[19] J.R.M. Butler, Grand Strategy, Vol., 2, September 1939-June 1941, (London 1956), p. 568.

[20] R. Smoke, War: Controlling Escalation (Cambridge 1977), p. 51-52.

Gas, however, was one of the few effective defensive weapons left to Britain should invasion occur. British Prime Minister Winston Churchill had ordered that production of chemical weapons be accelerated as a matter of urgency. But the stockpile of chemical weapons in Britain was only a total of 450 tons of mustard gas and 50 tons of phosgene, only about 3 days of supply under active war usage! Canada assured Britain that it would cooperate in every way possible to help with chemical warfare preparations.[21] Given time to construct the required plants, Canada could manufacture respirators and charcoal, anti-gas ointment and clothing, along with war gases such as mustard gas and phosgene, to bolster the British supply. Canada also had huge, empty areas of land which could be used for chemical warfare experimental purposes. There were, however, many scientific, financial and engineering problems to be overcome. Canada had no production facilities for mustard gas, nor facilities for testing chemical weapons or charging munitions with gases. During the Great Depression there had been no extra money for the Canadian National Research Council which was responsible for the Canadian chemical warfare planning, nor had any more money been made available in Canada for research into war projects.

The need for coordinated efforts between Britain and Canada for defence purposes also enabled Canada to participate in the war by carrying out scientific research, which would not have happened otherwise. These collaborations set scientific research in Canada on a dramatic new path, which persisted for more than twenty-five years into the post-war era. That this became possible was due in large part to four individuals: C. J. Mackenzie,[22] General A. G. L.

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[21] Bryden**,** John, Deadly Allies, Canada's Secret War 1937-47, (Toronto, Ontario, 1989), p. 61.

[22] Chalmers Jack Mackenzie, 10 July 1888-26 February 1984. Chalmers Jack Mackenzie, C.C., C.M.G., M.C., BE, MCE, D.Sc, Lt.D, F.R.S.C. was a Canadian civil engineer, Dean of the College of Engineering at the University of Saskatchewan, chancellor of Carleton University, president of the National Research Council, first president of Atomic Energy of Canada Limited and instrumental in the development of science and engineering education in Canada. See G. Herzberg in Proceedings of the Royal Society of Canada / Series IV / Volume XXIII / 1985.

McNaughton,[23] Frederick Banting,[24] and Otto Maass,[25] all of whom had been strongly influenced by the trauma of the First World War. From 1935 through 1945 these four men were largely responsible for planning the Canadian government's scientific activities, under Cabinet War Committee (CWC) control. The formal and personal relationships that developed among these science administrators, and with Henry Tizard[26] from the U. K. and Vannevar Bush[27] in the U. S. A., made possible agreements and subsequent sharing of essential scientific information, though not without occasional problems.[28]

After the declaration of war, C. J. Mackenzie, acting on behalf of the King government asked Dr. Otto Maass, head of chemistry at McGill and a member of the National Research Council (NRC) governing council, to be responsible for establishing chemical warfare research,[29] presumably for

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[23] Andrew George Latta McNaughton, (February 25, 1887 - July 11, 1966) CH, CB, CMG, DSO, CD, PC was a Canadian army officer, politician and diplomat. In 1939 he led the Canadian army into the Second World War. The British generals frequently criticized him, and his support for voluntary enlistment rather than conscription led to conflict with James Ralston, the Minister of National Defence. McNaughton resigned his command in 1943. J. Swettenham, McNaughton, 3 vols. (Toronto 1969).

[24] Sir Frederick Grant Banting, KBE, MC, MD, FRSC (November 14, 1891 – February 21, 1941) was a Canadian medical scientist, doctor and Nobel laureate noted as one of the co-discovers of insulin. In the 1930s, Banting became alarmed by the rise of Nazi Germany and the prospect of war. He started several research efforts, including playing a major role in the creation of the first production g-suit, which was used by Royal Air Force pilots during the war. He was also involved in research in biological weapons, both in terms of countermeasures and methods for mass production of anthrax. M. Bliss, Banting: A Biography, (Toronto 1984).

[25] Otto Maass, educator, scientist (8 July 1890- 3 July 1961). Maass was educated at McGill and Harvard (Ph. D., 1919). In 1920 he joined McGill's staff and in 1923 became Macdonald Professor of Chemistry, a position he retained until 1955. He was also chairman of the McGill department of chemistry (1937-55). Other positions he held were as director general of the Pulp and Paper Research Institute of Canada (1940-55); assistant to the president, National Research Council (1940-46); director of the Directorate of Chemical Warfare and Smoke (1940-46); and chairman of various governmental committees during WWII. E. A. Flood, Biographical Memoirs of Fellows of the Royal Society vol. 9, 1963, pp 183-204.

[26] R. W. Clark, Tizard, (London 1965). See also J. G. Crowther, Statesmen of Science: Henry Thomas Tizard (London 1965), pp. 303–336.

[27] Spectrum,, Institute of Electrical and Electronics Engineers, Volume 32, Issue 7, Jul 1995, pp. 65 – 69.

[28] D. H. Avery, The Science of War: Canadian Scientists and Allied Military Technology During the Second World War, (Toronto 1998), pp. 122-129.

[29] J. Bryden, Deadly Allies, Canada's Secret war 1937-47, (Toronto 1989), p. 27.

Canadian self-protection. From his studies under Nernst[30] in Germany immediately prior to the First World War, Maass had personal experience of German chemists, and good reason to respect their scientific abilities.

The question that needs to be asked, though, is why did the Canadian government even consider chemical warfare research when it was a signatory to the Geneva Protocol on chemical weapons? Surely this reduces to a question of trust in the word of a sovereign state. How much confidence could any government now have in the word of the Axis leaders? Mussolini had used chemical weapons against the Ethiopians, even though Italy was a signatory to the Geneva Protocol. And if the Nazis had breached so many other treaties on their road to dominance, why not one more? As Adolf Hitler stated:

> I shall give a propagandist cause for starting the war, never mind whether it be true or not. The victor shall not be asked later on whether he told the truth or not. In starting and waging a war it is not right that matters but victory. Close your hearts to pity! Act brutally! Eighty million people must obtain what is their right...The stronger man is right...Be harsh and remorseless! Be steeled against all signs of compassion! [31]

Canada was more than willing to become involved in chemical warfare research and production if it helped the Allied cause. While the Geneva Protocol allowed no first use, it did permit defensive preparations and retaliation against an attack with gas, and Canadian chemical warfare preparations were largely defensive in nature during the first few years of the war.

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[30] Walter Nernst was a German chemist who is known for developing the concept of chemical affinity as embodied in the third law of thermodynamics, (for which he won the 1920 Nobel Prize in chemistry) and the Nernst equation in electrochemistry. Significantly, 3 of his graduate students were Lindemann, Maass and Tizard. Lindemann was chief scientific advisor to Winston Churchill during the war, while Tizard was a British scientist and chairman of the Aeronautical Research Committee which had instigated the development of radar. Tizard led the "Tizard Mission" to the USA in September 1940. The objective of the mission was to cooperate in science and technology with the US, which was neutral at that time. Maass became director of the Canadian Directorate of Chemical Warfare and Smoke (1941-46).

[31] Adolf Hitler to his generals at Berchtesgaden during their final pre-war conference to give them the order for the invasion of Poland. Quoted by Sir Hartley Shawcross in his indictment of the chief surviving Nazi leaders at Nuremberg. Shawcross also listed the treaties which the Nazi leaders had broken during the period of their ascendancy in Europe.

Active research in chemical warfare was being carried out in Canada as early as 1939 and was public knowledge at that time. As a December 1939 article in the Toronto Star reported:

> A German-developed antidote to phosgene, poison gas used extensively in the last war, has been brought to Toronto by a German refugee scientist, it was learned here today. Forced to leave Germany, the refugee had been working in a Nazi laboratory and carried in his head the formula for the antidote which he and other German scientists had recently developed.
>
> His arrival was welcomed in Toronto, since improvement of known methods of combating phosgene gas is one of the problems which the Banting laboratories have been carrying out as a part of their wartime duties. Canada has been allotted a large proportion of war research by the British coordinating committee, headed by Sir Edward Mellanby, and the hunt for a better antidote to phosgene was one problem given to the Banting laboratories.
>
> Now, with the aid of the latest German developments brought to this country by the refugee scientist, this particular problem is virtually completed. Anti-gas measures will also be studied in Montreal by Dr. I. N. Rabinovitch of McGill University, now in England with Sir Frederick Banting.[32]

Thus, from this one press article, anyone who could read would know the identity of the Canadian scientists working on a Canadian chemical warfare programme, and the location of the research laboratories! If necessary the enemy would even know where to find Major Rabinovitch. Clearly the British were in charge, probably due to a sense of being the head of the Commonwealth and having greater industrial capacity, while security was apparently non-existent at this point in time. This releasing of chemical warfare information through the press continued during the war. For example:

> "Somewhere in England", December 5, 1940.
>
> As part of the particularly thorough training the 2nd Canadian Division is receiving in protection against gas, a flight of Royal Canadian Air Force planes staged a "gas attack" against an entire brigade during a thirty-mile manoeuvre Two regiments from Western Quebec and one from the Prairie Provinces were slogging along narrow roads when planes dived on sections of the columns; spraying them with a harmless liquid which looked like "mustard" gas.[33]

[32] Toronto Daily Star, December 8 1939. The name of the German refugee scientist was not given.

[33] Toronto Daily Star, December 6 1940. Note that the WarMuseum.ca website yields 206 newspaper quotes regarding poison gas between 1939 and 1945.

One can only hope that this release was intentional and devised for the purpose of informing any enemy agents that the Canadian Army was well prepared for gas warfare! [34]

Many of the practical problems associated with gas warfare which were raised during the First World War still needed to be studied in an organized scientific manner, since most of the efforts of the previous war had, by necessity, been of an empirical nature. One of the most important tasks was to improve respiratory protection, particularly against toxic smokes,[35] which had been a feature of chemical warfare in the last year of the First World War. Little was known of the properties and behaviour of particulate clouds and of methods which might be used to remove them from the inhaled air. Towards the end of the First World War, activated charcoal was normally used as an adsorbent in place of the reactive chemical fillings which had been used in the early years.[36] The first supplies of respirator charcoal were made from carbonized coconut shells, but it was feared that in another major war the demand for charcoal could not be met from this imported raw material, which might also be interdicted by an enemy, and so the use of alternative sources of charcoal, such as wood, peat, coal

[34] On a more speculative note, perhaps these releases of information regarding chemical weapons were part of one of many widespread "disinformation" campaigns carried out by the British, as part of military and intelligence operations during the war? T. Holt, The Deceivers Allied Military Deception in the Second World War, (London 2007) gives a fascinating and highly detailed account of Allied deception campaigns during the Second World War. These included the development of devices that produced diesel fumes to simulate the emissions of armoured vehicles; canisters of chemicals which could produce the smell of cordite, and chemicals and equipment to emit smells which would lead the enemy to assume the use of gas, and which emulated the non-toxic effects of mustard gas including its effect on gas detectors. See NA(UK) WO 188/2085 Chemical warfare agents: fake gases for use as diversion in war; chlorinated mustard gas. Dolus an virtus, quis in hoste requirat? Virgil.

[35] The toxic smoke candle employing diphenylchlorarsine (originally a German chemical weapon), was invented by the British near the end of the First World War. To preserve the secrecy of its development it was called the "M" device. Thermal dispersion of this agent had been found by the British to be far more effective than the explosive dispersion originally used by the Germans. The irritant smokes are difficult to protect against, having the power to penetrate an otherwise efficient respirator unless it is constructed with a special smoke filter. Tests of cadmium smoke carried out in 1940 by George Wright of the University of Toronto demonstrated that cadmium smoke, which was odourless, caused fibrosis of the lungs after an estimated 24 hours following exposure. It was proposed that toxic smoke weapons employing cadmium be dropped in bomber payloads to accompany incendiaries and high explosives, to kill fire-fighters in German cities after bombing raids. This never happened.

[36] See G. Lachaux and P. G. Delhomme, La Guerre des Gaz, 1915-1918, (Paris, 2005) for an account of the development of respirators.

and coke, was examined. Eventually a process was developed using coke and this was used from 1923 for making very large quantities of high-grade charcoal for respirator containers.[37]

In the event of war, activated charcoal required for Canadian containers was supposed to be imported from Britain. But before the war began, it became evident that Canada would not be able to rely on British supplies.[38] Canada had to look at indigenous sources, including coal.[39] Through 1938 and 1939 E. A. Flood, a key figure in the Canadian chemical warfare programme,[40] visited Canadian manufacturing plants, assessing the possibilities for producing not only a suitable form of charcoal, but also other components of the respirator, so that mass production of the respirators could begin.

The chemical warfare scientists faced further problems. First, it was necessary to study the properties of the more effective chemical agents that had been used during the First World War years so that more economical and safer methods of making them could be devised.[41] Secondly, it was necessary to synthesize and test new compounds that might provide better and novel chemical warfare agents. Quite apart from any intention to use such chemical weapons offensively, this information was necessary to evaluate the threat from new chemical warfare agents and to develop adequate methods for defense. Perhaps one of the most important problems at this time was to provide protection against mustard gas. The introduction of mustard gas by the Germans in 1917 had

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[37] For details see Notes Received Royal Society of London, v. 58, n.2, 161–175, (2004).

[38] The same situation arose in Australia, which also had to produce respirator containers for gas protection using indigenous sources of charcoal. Charcoal for respirators was originally imported from Britain, Canada or India, a practice that continued until the end of 1941. The first move towards self-sufficiency was made when the Colonial Sugar Refining Company, presumably because of its experience in the manufacture of animal charcoal for the clarification of sugar solutions, was asked to consider the possibility of manufacturing activated nut charcoal.

[39] This had been done in Britain during the First World War by Sutcliffe, Speakman & Co. Ltd, of Leigh in Lancashire.

[40] In 1937 Flood had visited England and surveyed a Respirator Assembly Plant in Lancashire, learning all parts of the assembly line. He also visited British factories where chemical offensive equipment was being manufactured. On his return to Canada, the NRC set up an Associate Committee on Container Proofing and Research, the body that directed the chemical warfare program until the creation of the Directorate of Chemical Warfare and Smoke in 1941.

[41] For example, the French spared nothing in their attempts to develop mustard gas by June 1918. Their casualties multiplied at the factories, but the factories concerned were then placed under the same military discipline as the front lines!

created many new problems. One of these was due to the fact that liquid mustard gas and its vapour can produce casualties by the absorption of the agent through the skin. In addition to protection for the respiratory tract it was clear that protection for the whole body was needed. Further, mustard gas, unlike the majority of chemical agents used in the First World War, was chemically stable and consequently could cause casualties long after deployment, constituting a hazard by giving off vapour and by contact as a liquid - even as a diluted liquid.[42] Research focused on the detection of mustard gas on the terrain and military equipment, and on neutralization both on the body and on the ground. For neutralizing mustard gas on the ground, bleaching powder[43] was the reagent of choice, while to neutralize mustard on the skin Canadian chemists developed an ointment.[44] Another approach to the problem of protecting the skin was to develop permeable clothing chemically treated to inactivate mustard gas.[45] The disadvantages and discomforts of wearing impermeable oil-proofed clothing, and the consequent reduction of the efficiency of men wearing it, had become apparent during the First World War, when it was first employed as a protection against mustard gas. Investigations were

[42] Such chemical weapons are described as persistent. They can consequently be a danger to the troops who used them. Militarily they were commonly used to deny ground to an enemy. Phosgene, a common war gas is degraded in the environment by gas-phase hydrolysis, and in water is rapidly degraded to hydrochloric acid and carbon dioxide. The World Health Organization reports a persistence of mustard gas of 2 to 7 days at 15^{o} C with sun and a light breeze, and 2 to 8 weeks at –10^{o} C with snow cover.

[43] Bleaching powder is a white or nearly white powder that is usually a mixture of calcium chloride hypochlorite, CaCl (OCl); calcium hypochlorite, Ca $(OCl)_2$; and calcium chloride, $CaCl_2$. The British military used bleaching powder (water sterilizing powder) to sterilize water for drinking purposes in the field. Sometimes called chloride of lime, it can be prepared by reacting calcium hydroxide or slaked lime, Ca $(OH)_2$, with chlorine gas, Cl_2. The reaction of mustard with bleaching powder is violent, so the powder is usually dispensed as slurry with water or more commonly mixed with earth. Porton report number 2280 gives the results of a trial carried out in Southampton, Hampshire, England on the effectiveness of removing mustard contamination and vapour by merely hosing debris with water.

[44] During the course of the war a number of formulations were attempted in order to provide an ointment to neutralize mustard gas on human skin. The British and Canadian ointment contained bleaching powder in a Vaseline base. The analytical composition of the British/Canadian anti-gas ointment may be found in Analyst, 65, 1940, p. 463 (via the Royal Society for Chemistry). For tropical use the American formulation of chloramine-T in Vaseline was initially deemed superior, as the bleaching powder gave rise to intense skin irritation under tropical conditions. None of these ointments was effective. Mustard is oxidized by bleaching powder (and chloramines) into sulfoxides (which are deemed harmless) and sulfones (which possess vesicant activity) and sulphides.

[45] LAC microfilm reel C-5003, Chemical Warfare - Miscellaneous anti-gas stores – Impregnite. Also NA (UK) WO 188/738, Impregnites.

therefore made of the possibility of impregnating ordinary fabrics with chemicals which would react with vesicants before they could reach the body. Experimental work carried out along these lines during the period between the wars led to several effective processes being evolved. In one, developed in Britain, clothing was impregnated with a chemical known by the code name of "Anti-verm", which was capable of neutralising the effects of mustard gas.[46]

In the fall of 1940 British, Canadian--and American-- scientists agreed to exchange chemical warfare information through the person of Maass, who became the representative of both the British and Canadian chemical warfare programmes.[47] The choice of a Canadian scientist as the liaison between a belligerent Britain and a friendly but neutral United States was probably not accidental.

Canadian research in chemical warfare was inter-service in nature, with the Army taking the major share of administrative responsibility. In addition to the small respirator assembly plant which had operated in Ottawa before the war, the Research Establishment (Chemical Warfare) was established there in August 1941. Chemical warfare research and development was organized and coordinated by the Canadian Directorate of Chemical Warfare and Smoke (DCWS) in its own laboratories and in Canadian university laboratories. The Suffield Experimental Station, which was established in 1941, eventually became the centre of Canadian, British (and later American) field tests using mortars, artillery shells, bombs and spraying to deliver chemical agents on a large scale. Smoke and flame weapons were also developed and tested here, these latter weapons being used extensively by British and Canadian forces during the Second World War.

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[46] 2, 4-dichlorophenyl benzoylchloroimide. NA (UK) WO 188/1172-1176, WO 189/1370, WO 189/2188, WO 189/2370. During the summer of 1943-44 it was found that clothing impregnated with "Anti-verm" was literally worse than useless under tropical conditions : volunteers wearing the clothing in trials conducted in gas chambers became cyanosed owing to the absorption of the impregnating chemical or a by-product through the skin. In December 1941 the decision was made to equip Canadian troops overseas with chemically impregnated clothing for protection against mustard gas. See LAC, Chemical Warfare - Miscellaneous anti-gas stores - Impregnated clothing. See microfilm reel C-5003 and HQS 4354-23-3-1 Reel C-5009.

[47] Library and Archives Canada HQS 4354-11-1 Report of Canadian Mission, 16 October, 1940.

During the Second World War the chemical munitions produced by the Allies contained the same agents used in the First World War. These comprised choking gases such as chlorine, phosgene and chloropicrin, as well as blood gases such as hydrogen cyanide and cyanogen chloride. The vesicant or blistering agents included variants of sulphur mustard gas and its derivatives nitrogen mustard and mustard-lewisite.[48] All of these chemical weapons were produced, tested and stockpiled by Canada during the course of the Second World War.

The Cabinet War Committee (CWC) was the most important and active of the wartime committees of the Canadian Cabinet. Between the first and last meetings, the membership of the Committee altered several times, however the Prime Minister or acting Prime Minister, the Defence ministers, the ministers of Finance and Munitions and Supply were always members. The remaining members were among the most experienced ministers of the day. The first session (Meeting 'A') of the CWC took place on December 8 1939. Throughout the war the CWC would meet no less than 349 times.[49]

On September 26 1940, just two months after the Dunkirk evacuation, the topic of chemical warfare first appears in the proceedings of the CWC. This was a financial commitment of 10-15,000 dollars to make "…provision for a Canadian Chemical Warfare Defence Laboratory overseas."[50] The request for the laboratory had been made by General McNaughton, based on the assumption that the

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[48] J. W. Hammond, Jr., Poison Gas: The Myths versus Reality. (Connecticut 1999). Details of the chemical structure of the various chemical warfare gases, their characteristics and medical treatment may be found in Hammond.

[49] The first meeting of the CWC was designated 'A'; the next three were 'B', 'C' and 'D'. From that point on a numerical approach with a consolidated and detailed index and schedule of decisions was adopted. Meetings were numbered starting with one; the last, number 142, was held on May 16 1945. Two meetings took place out of sequence (283a and 286a, both on petroleum warfare development) and one meeting was not recorded (January 1940). Four meetings were of the entire Cabinet and three were Special Cabinet Committees**.** Memoranda of the meetings of the Emergency Council, September to November 1939, and the minutes and supporting documents of the Cabinet War Committee from December 1939 to May 1945 may be found in (LAC). Microfilm reels C-11789, (December 1939 to December 1940) and C-4873, (1939-1945) contain the indexes to this series which is on reels C-4654, C-4873 to C-4877. A conversion list is available in the Government Archives Division. The use of the conversion list is necessary to obtain the microfilm reel number on which the minutes or documents of a particular meeting appear.

[50] LAC, C-11789, 33, pages 6-7, paragraph 22e.

use of poison gas by the Nazis in an invasion of the British Isles was a strong possibility.[51] He wanted approval for the laboratory within the "… next few days, so that Canadians will not be caught as they were at (the) second battle of Ypres."[52] By the beginning of 1941, gas warfare seemed to occupy a more definite place in the minds of those in charge of the government. The establishment of a Canadian Chemical Warfare Defence Laboratory at an estimated expenditure of $510,000 was approved by the CWC.[53]

The first meeting of the Canadian Chemical Warfare Committee took place on October 3 1940 in the National Research Council (NRC) Building, Ottawa. This committee was originally tasked with the production of respirators, and was never intended to deal with the more extensive demands of a pending chemical war. Colonel G. P. Morrison of the Canadian Department of National Defence stressed the need for coordinating requirements for the three services, each of which could expect to be subjected to chemical attack, but under different circumstances.[54] He pointed out that the following items were being supplied to all services: anti-gas capes; ointment; eye shields; detector paper;[55] oilskin clothing for decontamination and a number of training stores. One suspects that most

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[51] General McNaughton to C. J. Mackenzie, August 6 1942; cited in Thistle, ed., The Mackenzie-McNaughton Wartime Letters, 113-14.

[52] Authorized in September 1940, the unit was a mobile field chemical laboratory including two forward sections, one medical and one chemical and designated First Canadian Chemical Defence Laboratory. In April 1943, it became the Canadian Chemical Warfare Laboratory with five officers and 11 other ranks. It included chemists, weapons officers, medical officers and technicians.

[53] On behalf on the DND the increase in expenditures was proposed by Mr. Power, at that point Associate Minister of National Defence and Minister of National Defence for Air. LAC, C-11789, January 2 1941, 56/5, sub-paragraph 18. (a).

[54] Many different military installations could be subjected to chemical attack, such as pillboxes, bunkers and tanks. Troop concentrations could be sprayed, as could cities and installations such as harbours and docks. There were hypothetical plans to attack naval vessels with toxic gases, as well as aircraft! For a fascinating account of "The Effectiveness of Mustard on Airplane Carriers" see National Archives and Record Administration of the United States [hereafter NARA] Box 154, file 461. This also contains an account of "A Study of the use of Chemicals in the defence of Oahu, Hawaii. Quoting: "An enemy is unlikely to undertake a serious air attack against Oahu by planes launched directly from his ships." May 6 1938.

[55] For early identification of mustard gas a chemical detector that would change colour on contact was developed. A dyestuff (p-nitro-phenylazo-β-naphthylamine, known as B-1) was incorporated into a cadmium lithopone/lithopone (30%)/ zinc oxide paint that was used on pillar boxes, vehicles and other equipment. B-1 was soluble in H and other

of these stores were left over from the First World War, and that little real attention had been given to the question of chemical warfare until now. But with the Nazi forces triumphant in Europe since the fall of France, Britain and Canada were ready to grasp at any weapon to stave off defeat. Subsequently the Chemical Warfare Committee underwent significant re-organization to enable it to focus on preparations to wage chemical war.

The second meeting of the Chemical Warfare Committee took place on November 27 1940, now under the chairmanship of Maass. An important new member of the committee was Mr. E. Llewellyn Davies, Superintendent of Experiments at Porton Experimental Station in England. Dr. Flood, a member of the Chemistry Division of the National Research Council and now a Captain in the Canadian Army, made reference to the minutes of a Chemical Board meeting in England[56] in which it was suggested that the production of war gases in Canada be considered. After some discussion it was decided that Canada had the capability to make diphenylcyanarsine (DC),[57] but the manufacturing and storage of this chemical agent in Canada was more problematic than for the

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persistent agents and produced a brilliant red colour. The paint changed colour from green to red in the presence of any liquid vesicant. Subsequently, booklets of detector paper and crayons were also produced and widely issued. National Archives of the United Kingdom [hereafter NA (UK)] Home Office [hereafter HO] 186/1330 and War Office [hereafter WO] 188/1029. See Military Intelligence Division (Canada) Specification CS/791, May 22 1940 for the exact composition. The influence of sulphur on the colour of aza dyes was studied in 1922 by W. R. Waldron at John Hopkins University.

[56] NA (UK), Ministry of Aviation [hereafter AVIA] 22/2271. The British War Office had prepared a pilot plant at Sutton Oak near St. Helens, Lancashire during 1936 for the preparation of thickened mustard. The total production was 50 tons/week. After the Treasury was consulted regarding the construction of two other mustard gas factories, approval was given for the construction at Kemet on Merseyside. A total of 300 tons/week was supposed to be available on the outbreak of war. See Treasury Inter-Service Committee 175th Meeting, 21 October 1938, item 11, NA (UK) T161/1327. It was not. NA (UK) Cabinet [hereafter CAB] 80/19/36: Chemical Weapons, production of: Aide-Memoire by Inter-Service Committee on Chemical Warfare, and CAB 80/19/51: Appendices I & II. Present stocks and rate of production of army and Air Force chemical weapons. The RAF was expecting to bomb Germany with chemical bombs. It never happened. Other information regarding the production of chemical weapons in the U. K. may be found online at: http://www.subbrit.org.uk/rsg/sites/r/rhydymwyn/history.html

[57] Diphenylcyanarsine is a sternutator, inhalation of which causes violent sneezing, cough, salivation, headache, and retrosternal pain; a common vomiting agent used in mob and riot control.

production of thiodiglycol.[58] Canada could however manufacture thiodiglycol for preparing sulphur mustard and store it in safety. For a fifty ton a week plant, $200,000 to $250,000 was the estimated cost, although this was not an exact figure.[59] This would cover basic machinery and installation. It was then suggested that if a thiodiglycol plant were to be considered, a one hundred ton a week plant would appear a more reasonable unit. Mr. Davies agreed with this suggestion and pointed out that fifty tons a week units were limited [the limit in size] in England in order to scatter the production capacity over a number of small units, thereby reducing air raid danger. A plant of this size could afford to be hit by a bomb without too much damage whereas a hit on a larger plant would be dangerous. But Canada was secure from air raids. It was moved by Captain Flood and seconded by Colonel Morrison that plans be put in hand immediately to obtain authority from the CWC for the erection of a thiodiglycol plant in accordance with Flood's memorandum of November 5 1940.[60] The motion was carried unanimously.

After agreeing on the placement of an order for the Canadian preparation of a small quantity of the gas diphenylcyanarsine (described in Flood's memorandum as being for "educational

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[58] The production of diphenylcyanarsine on an industrial scale is complex. The starting material is usually aniline (IUPAC phenylamine) rather than arsine and there are numerous steps to the process. The production of the more dangerous mustard gas, which was already in production in the U. K., was probably a simpler chemical task, and a more useful weapon. During 1940-1941 the output of aniline as part of the Lend-Lease programme to aid Britain and Canada grew to an annual rate of around twelve to fifteen million pounds in the U.S.A. Anilines were of importance not only in the manufacture of dyestuffs, but in the explosives industry, for rubber processing chemicals, sulfa drugs and synthetic resins. Thus aniline was probably too important a strategic material to be used to make a riot control agent during a major war!

[59] These values are inconsistent with the cost for the Kemet plant on Merseyside in England, which the War Office informed the British Treasury would cost more than £1,400,000 in 1937 in order to produce 250 tons of mustard gas. From 1940, and through the war, the £/$ rate was pegged by the British government at $4.03. Captain Flood's estimate was low by a factor of about 4-5 for a 50 ton plant! Probably he had to make up a number on the spot.

[60] LAC, H.Q. 313-62-S. This document titled Production of Gases in Canada discusses the production of mustard gas by both the Levinstein process as used by the Allies in the First World War, and the thiodiglycol (German) method. Thiodiglycol was by this time commercially available as Kromfax Solvent from the Carbide and Carbon Chemical Corporation, and was manufactured from ethylene chlorhydrin or ethylene oxide. Flood pointed out that the ethylene supplies available in Canada corresponded to a very substantial portion of possible Commonwealth supplies of mustard gas. At present it was a waste product, some 25 tons a day being wasted by the oil refineries. See Appendix A for details of the chemical processes.

purposes"), the Chairman asked Mr. Davies to explain what was being done in Great Britain to prepare for a possible chemical warfare attack and what he was seeking from Canada.

Mr. Davies said that British defensive equipment was well advanced.[61] Every civilian in England had been issued with a respirator. The best offensive advance made was in connection with aircraft spraying of mustard. They had used this at Porton, spraying mustard gas from 100 feet but using substitutes at heights up to 15,000 feet as the experimental field at Porton was only 7000 yards by 4000 yards. Military authorities had noted that "the risk of casualties (chiefly blindness) to personnel outside Porton" was too great to allow any trials with high-flying modern aircraft.[62] Experiments using aircraft at high altitudes had been carried out at the joint Franco-British experimental station and range in the Sahara at Beni Ounif.[63] After the fall of France in 1940 the use of this range was lost. Davies explained that he had come to Canada to see if he could find a replacement experimental field.[64] It would have to be 50 miles by 50 miles and free of inhabitants. He had been told that in Saskatchewan and Alberta an excellent experimental ground could be found[65] and that better data could be obtained if the ground could be sprayed with mustard from several different types of aeroplanes. Different types of gas could also be used and they could find out the

[61] Most authorities regard the British preparations for chemical warfare protection of their population as probably the most effective in the world.

[62] NA (UK)., AVIA 15/1071.

[63] In what was then a metropolitan department of France, still known today as Algeria. The area was 300 kilometres south of Oran.

[64] Interestingly, from 1940 onwards Porton was undergoing reorganization to overcome the "semi-stagnation into which the station had tended to fall in peace." See NA (UK) AVIA 22/1218, Chemical Defence Research Station, Porton, Wilts: re-organisation. Perhaps sending the Superintendent of Experiments to Canada would "kill two birds with one stone?"

[65] The sites considered were: Tracadie (New Brunswick), Northern Quebec, Northern Ontario, Brandon (Manitoba) and Maple Creek (Saskatchewan). D. J. Goodspeed, A History of the Defence Research Board of Canada (Ottawa 1958), p. 145.

dangers of these (especially arsine).[66] Maass asked Davies if he considered spraying from aircraft important, and the Committee was told that "it was a vicious weapon." But the official feeling in Great Britain regarding chemical warfare was that Britain would not use it until the Germans did.

A discussion of the staffing of the proposed experimental field, the quality of the landing ground and the necessary presence of water then followed. After discussion of the possibility of Canada manufacturing some articles rather than them all being manufactured in England, a motion by Commander Houghton (seconded by Captain Flood) was made that the Committee endorse the scheme for the proposed experimental field. The motion was carried unanimously.[67] The establishment of an experimental field in Canada would be yet another contribution to the Canadian war effort. The establishment of the experimental station at Suffield, Alberta would later be deemed to be one of the most important Canadian contributions to the chemical warfare preparations of the North Atlantic alliance during the Second World War.

The Chairman then asked Dr. Flood to discuss current problems of a technical and supply nature. The remainder of the meeting was taken up with discussions about respirator containers, air filtration units and the charcoal required for manufacturing these devices. There was a desire on the part of the Canadian government to have some articles of chemical warfare equipment manufactured in Canada rather than in England. This was consistent with Canadian concerns at that time about minimizing the financial cost to Canada, or making yet another contribution that could perhaps be used in negotiations with Britain over the provision of more troops.

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[66] Arsine gas (AsH_3) has been investigated as a CW agent, but no battlefield use has been documented. During and prior to World War II, the British studied this agent and rejected its use in the field. They concluded that arsine was more than 10 times less toxic than phosgene (CG) and was not only difficult to manufacture and liquefy but also highly flammable. It was the cause of a confused response by the British to the purchase by the Germans of all the available arsenic before the war. The Germans intensified their research into arsine weaponry after they captured a supply of British test paper for the gas! WO 193/727 Arsenic Warfare: "Arthur gas." In contrast, several arsine-derived organoarsenic compounds have been developed and used as CW agents, including lewisite (2-chlorovinyldichloroarsine), adamsite (diphenylaminearsine), diphenylchlorarsine, and diphenylcyanoarsine.

[67] This decision was the basis for the establishment of the Suffield Experimental Station.

By the beginning of 1941, gas warfare seemed to occupy a more definite place in the minds of those in charge of the Canadian government. The establishment of a Canadian Chemical Warfare Defence Laboratory at an estimated expenditure of $510,000 was approved by the CWC.[68] On January 24 1941 Mackenzie King "…referred to a recent telegram received from the Dominion Office which indicated that there was increasing evidence of Germany's intention to use gas from the air, and in the event of an invasion."[69] At the same meeting of the CWC Mr. Ralston, the Minister of Finance, stated that during his visit to England the subject of the British securing a "… large tract of land for experimental purposes in connection with gas warfare"[70] had been raised by United Kingdom officials. The British were particularly keen to investigate how mustard gas could be sprayed from aircraft, but the 7,000 acres at Porton had simply been too small and constricting. No request had been formulated in writing at that time, although some correspondence with the (Canadian) National Research Council had already taken place. The Prime Minister indicated that should a formal request be made then the Government should agree to a fifty-square-mile area at a cost of between 400,000 to 500,000 dollars. It may be assumed that the results of the second meeting of the Chemical Warfare Committee had been communicated to the CWC by now. This initial discussion was the beginning of the establishment of the Suffield Experimental Station.[71]

In earlier negotiations regarding the British Commonwealth Air Training Scheme King had observed that: "…with the concentration of Canadian energies on air training and air power and

[68] On behalf on the DND the increase in expenditures was proposed by Mr. Power, at that point Associate Minister of National Defence and Minister of National Defence for Air. LAC, C-11789, Jan. 1 1941, 56/5, paragraph 18(a).

[69] Ibid., 59, p.4-5, paragraph 11.

[70] Ibid., paragraph 12.

[71] NA (UK) AVIA 15/1071 British field Experimental Station in Canada: establishment and programme.

therefore less pressure for a large army, there would also be less risk of agitation for conscription."[72] Further, the development of the facilities would bring economic prosperity to Canada. The financing of the air training scheme had become an issue with the Canadian government probably because the cabinet leaders had become conditioned by the Great Depression, and few understood the massive expenditures required for modern warfare. In negotiations with the British, one of the conditions set by Prime Minister King for finalizing an agreement regarding air training was that a statement that the Air Training Plan had priority over all other military commitments by Canada. In spite of objections from Britain, King remained firm on his request for the priority statement, because it would help minimize the risk of conscription in Canada. These negotiations clearly demonstrate King's resolute commitment to a policy of no conscription, and a determination that Canada would not pay more than a fair share of the costs. King also wanted Canada to benefit industrially from participation in this war.[73]

Surely by consenting to the establishment of a field research station in Canada, and sharing the costs fairly, the government of Canada was once more demonstrating support for Britain-without committing any more troops for a ground war? Further, and perhaps equally important, such co-operation allowed Canada into the scientific and strategic planning establishments of Britain and, later, the United States.

Earlier, in December 1940, Maass and Porton's Davies had agreed on the choice of Suffield due to its size, greater isolation and lower cost compared to the alternative sites. The negotiations to

[72] Canada, Documents on Canadian External Relations, Volume 6, 1936-1939, (Ottawa, Queen's Printer, 1972), pp. 179-180. The agreement for the BCATP was signed December 17 1939.

[73] For an analysis of the Air Training Plan and its social impact see P. C. Conrad, "Saskatchewan in War: The Social Impact of the British Commonwealth Air Training Plan on Saskatchewan," M. A. thesis, University of Saskatchewan, 1987. J. L. Granatstein, Canada's War: The Politics of the Mackenzie King Government, 1939-1945, chapter 2 "Dealing with London" gives an account of the often tense relations between Mackenzie King and the British government with regard to finances, orders for war materiel and the sale of Canadian produce in Britain. King was adamant regarding Canadian autonomy, protecting Canadian unity and financing only a fair share of joint projects for the war effort. The problem of pressure for conscription plagued King and his Cabinet for the entire war.

formalize the chemical warfare arrangements between Britain and Canada began on 17 December 1940 and were finalized by 1 March 1941. Canadian Minister of Defence J. L. Ralston, High Commissioner for Canada Vincent Massey, Generals A. G. L. McNaughton and H. D. G. Crerar and Major I. Rabinowitch represented Canada, while Lord Weir, Director General of Chemical Defence, R. Kingan[74] of the Ministry of Supply and his deputy, James Davidson Pratt[75] represented Britain. The physical infrastructure such as residences, machine shops and laboratories needed to support the activities of the chemists, physicists and meteorologists had to be constructed.

It was at this point that Canada balked at the cost, especially when the federal treasury would be largely responsible for paying for the land, buildings, equipment and maintenance of the base. The Prime Minister confided to his diary on March 8 1941:

> I think all members of the War Committee were disgusted at the way the British came back with respect to our share of expenses on experimental chemical warfare leaving to Canada the cost of purchasing land, construction of building, and then only dividing the expenditure of maintenance, equipment, etc, this in the light of the fact that the whole business is for the United Kingdom – something that is most undesirable for us to be concerned with at all. The Cabinet were practically unanimous in sending back a reply which would let whoever sent the message see that we had resented their attitude. This it was proposed to do by refusing outright the suggestion that they had made and saying we did not feel we should be expected to meet more than 1/3 of the cost.[76]

It is important to emphasize King's words: "- something that is most undesirable for us to be concerned with at all." According to the Prime Minister, the Canadian government did not really want to engage in chemical warfare, except in a dangerous military situation and for self-defence, and

[74] Kingan, Robert (1890-1968), was a chemist who came to Porton in 1920 where he subsequently became Director of Experiments in 1936.He was appointed Chief Superintendent of the Chemical Defence Research Establishment in London in 1938. This department and his post lapsed during the war and he was then appointed Principal Technical Advisor to J. Davidson Pratt.

[75] Captain James Davidson Pratt, CBE a chemist by training, was one of the significant figures in British chemical warfare. Pratt had been a lieutenant commanding an infantry platoon in April 1915 when the first German gas attack took place. In August 1916 after recovering from wounds sustained at Hooge in 1915, he was posted to the Ministry of Munitions to be Assistant Secretary of the Chemical Warfare Committee. In 1940 he was recalled to become Controller of Chemical Defence. An account of his roles appears along with his obituary in Chemistry and Industry, Oct 21 1978.

[76] King Diary, Wednesday March 8 1941.

only considered such preparations as a means of support for Britain and perhaps as a way to deflect British requests for more troops. Even then, though, Ottawa did not want to shoulder most of the costs. Eventually agreement was reached to share the costs equally. Perhaps at this stage in the war, when the Axis forces were so successful, money no longer mattered to the same extent as in 1939?[77]

Somewhat more than one thousand square miles of prairie in Alberta were eventually chosen to provide the required experimental and training area. On April 9 1941 the Minister of National Defence submitted a draft order-in- council to the CWC providing for the lease of the land from the Alberta government. This draft order-in-council was passed at the same meeting and became P. C. 2508/41. Later in 1941 the Canadian government expropriated the Alberta ranches and homesteads contained in the area known as the Suffield Block[78] to be used for the joint Canada-United Kingdom chemical warfare experimental station. On June 11 1941 the Canadian Army became responsible for the administration of the 'Suffield Experimental Station' (SES) and within a short time Canadian scientists joined British scientists who were already present. Facilities such as laboratories, workshops, barracks and offices were built and several "…railway carloads of gases and artillery shells arrived from the United Kingdom…"[79] Although the intention was to run Suffield as a chemical warfare experimental station, a chemical warfare centre and storage depots were added in the course of time.[80]

One of the main advantages of the site was the extremes of cold and hot weather. The scientists could test the effects of gases on humans and equipment in freezing temperatures. In

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[77] "The dollar sign came off the Canadian war effort in 1940, in the sense that peacetime notions of economy and treasury control ceased to be a brake upon the effort." C. P. Stacey, Arms, Men and Governments, (Ottawa 1970), p. 50.

[78] See Environment Canada Regional Home Page: Topics, News and Publications, Prairie and Northern region, Suffield History and Status.

[79] Dinosaurs to Defence: A Story of the Suffield Block, BATUS and others (Purnell 1986).

[80] After June 12 1942 the chemical warfare centre became known as the Advanced Chemical Warfare (Offensive) Training Centre. One notes the adjective "Offensive" at this date.

conjunction with their work in India and Australia, Porton scientists were thus able to conduct trials over a very wide range of temperatures and humidity during the course of the war.

Porton officials were able to direct Suffield to carry out any specific experiments they proposed, since they were paying half of the costs of the establishment. Suffield was run essentially as a British establishment with Davies receiving direction as much from London as Ottawa, often dealing directly with his colleagues at Porton or the British Ministry of Supply. As a result, the British were free to do whatever human trials in Canada they chose "short of causing death", one author has observed.[81]

Canadian chemical warfare policy was initially restricted to a defensive programme of development, procurement and training, with each service being responsible for its own defensive training arrangements. This policy was changed in April 1941 probably due to the depressing outlook on the various war fronts, and the new possibilities which Suffield provided for Canadian chemical warfare preparations. In August 1941 two chemical warfare experimental establishments were authorized (P.C. 1/6687 of August 26 1941) and the Directorate of Chemical Warfare was established for their administration. Later in the same year the Directorate also assumed responsibility for design and research on flamethrowers and flamethrower fuels, previously a duty of the Directorate of Engineering Design. The other components of the chemical warfare organization comprised: the Canadian Chemical Warfare Inter Service Board (CCWISB) under the Chairmanship of the Director of Chemical Warfare with representatives from the three Services Staffs, the National Research Council and the United Kingdom; the field experimental station at Suffield, and the Chemical Warfare Laboratory (CWL) in Ottawa. Within this structure provision was made to promote collaboration between the three armed services. The CCWISB was the authoritative advisory body on all matters pertaining to chemical warfare. The chairman of the CCWISB was Otto Maass, who was

[81] Bryden**,** p. 171.

the director of chemical warfare and the official means of communication between the three services regarding all matters of chemical warfare, other than matters of the highest policy. These matters would be resolved between the U. K. and Canadian (and later U.S.) governments.

The laboratories and personnel at the National Research Council were taken over by the Department of National Defence in August 1941 to form the nucleus of the Research Establishment (Chemical Warfare)[82], later designated Chemical Warfare Laboratories.[83] Although vacancies on the establishment could in principle be filled by Navy, Army, Air Force or civilian personnel, in actual fact almost all the staff were members of the Army with no Navy and only one Air Force officer on strength. A few appointments were filled by civilians. Several technicians were drawn from the Canadian Women's Army Corps. Perhaps the most important contribution of the Chemical Warfare Laboratories was in the technical assistance given to Canadian industry in the manufacture of chemical warfare offensive and defensive equipment and in the critical examination of such equipment. In addition it carried out extensive development work on anti-gas equipment. A pilot plant was operated for the production of special chemicals required for chemical warfare purposes, including toxic gases. The Chemical Warfare Laboratories maintained a central information service on Chemical Warfare and related subjects, some 30,000 technical documents having been filed and indexed there.[84]

It had been clear to Canadian military planners well before the outbreak of war, that any direct military threat to the North American continent could only be confronted in cooperation with the United States. During the summer of 1938 American President Franklin Roosevelt and Prime Minister King of Canada had made public speeches regarding the two countries' military relations.

[82] P.C. 1/6687 of August 26 1941.

[83] G.O. 49 of 1942, effective December 1 1941.

[84] Chemical Warfare - Reports - Chemical Warfare Laboratories, Ottawa - Physiological section reports (See also HQS 4354-29-9-1, Reel C-5015 and HQS 4354-29-5-4, Reel C-5016). All are currently restricted by law.

On August 18 1938 at Kingston, Mr. Roosevelt declared that the United States would "not stand idly by if domination of Canadian soil is threatened."[85] In June 1940, American President Franklin Roosevelt had created the National Defense Research Committee (NDRC),[86] an emergency agency of the Council of National Defence, with instructions to "correlate and support scientific research on the mechanisms and devices of warfare ..." in all areas except aviation. The leader of the new office was Vannevar Bush, President of the Carnegie Institution, formerly Vice President of MIT, and a close associate of the most influential scientists in the United States.

> It was during the period of the 'phony war'. We were agreed that the war was bound to break out into an intense struggle, that America was sure to get into it in one way or another sooner or later, that it would be a highly technical struggle, that we were by no means prepared in this regard, and finally and most importantly, that the military system as it existed, would never fully produce the new instrumentalities which we would certainly need.[87]

Unlike today, the United States was not prepared for war. It too was a victim of the Depression.[88] Consequently, little money had been spent on military research, while the military research that was done was carried out by military personnel and was often duplicated between the different branches. The military also tended to look down on engineers and scientists.[89] NDRC committees needed

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[85] C. P. Stacey, Arms, Men and Governments, (Ottawa, 1970), p. 97.

[86] This was one of President Roosevelt's most far-reaching decisions which gave the U.S. an 18 month head start in mobilizing science for the war effort.

[87] Through his efforts and those of friends Compton, Frank Jewett and James B. Conant, President Franklin Roosevelt appointed Bush chairman of the National Defense Research Committee (NDRC) on June 27 1940 that promoted government sponsorship of private research. In 1942 the Office of Scientific Research and Development (OSRD) absorbed the NDRC and directly sponsored the development of a wide variety of scientific developments, from microwave radar to DDT, during the Second World War.

[88] See G. D. Best, Pride, Prejudice, and Politics: Roosevelt Versus Recovery, 1933-1938, (New York, 1991) for an account of the U. S. Depression years and President Roosevelt's New Deal. The American military-industrial interaction was established during the Second World War. See also http://lcweb2.loc.gov/fsowhome.html for a Library of Congress photographic collection of Depression images of America before the Second World War.

[89] This same antipathy to scientists was found in the British Army of 1914-1918. In the words of Sir Lawrence Bragg: "There was an almost impassable barrier between the military and the scientific minds. The military thought us scientists far too visionary and gadgety to be of any help in the field; the scientists could not understand why their brain waves which seemed to them such war-winners, made no appeal to the military mind."

details of aircraft armaments, gun sights, air defence radar, asdic (sonar), chemical warfare, jet engines, anti-aircraft gun laying, acoustic mines and torpedoes, proximity fuses. The best source of such information was an embattled Britain which had already started development of these technologies.

In 1939 and again in early 1940, following discussions between the British Air Ministry and the Royal Society of London, Arthur Hill, Secretary of the Royal Society, had visited Washington as the representative of Sir Henry Tizard's secret radar committee.[90] There, he gained the impression that if the British proposed a complete sharing of information, the Americans would respond in kind. This visit paved the way, in Tizard's words, for "bringing American scientists into the war before their government."[91] As America was not at war, arrangements were made through Canada. In July, following Hill's report to the Royal Society, Tizard insisted on the creation of a permanent liaison network. The British Government sent to Ottawa, as chief British scientific liaison for all North America, Ralph Howard Fowler, F. R. S.[92] Due to its proximity to the United States, and the

[90] Sir Henry Tizard's British Technical Mission arrived in Ottawa and Washington in September 1940, its famous" black box" containing the cavity magnetron, the gyro predictor gun sight, the gliding torpedo, anti-aircraft equipment, RDX explosive, and many other "most secret" technologies. At the NA (UK), the records of the British Commonwealth Scientific Office are held in NA (UK), AVIA 38 and AVIA 42 dating from 1933. David Zimmerman dates the history of this phase of Anglo-American cooperation from January 1938, if not earlier ("Churchill, Roosevelt and the Origins of Second World War Anglo-American Military-Technical Cooperation", paper delivered to the Society for the History of Technology, Uppsala, July 1992). The mission was officially affiliated to the British Supply Mission in Washington, directed by Arthur Purvis, a Canadian businessman of British birth. Tizard's group included, at different times, Col. F. C. Wallace, Capt. H. W. Faulkner, RN, Group Captain Pearce, RAF, Professor R. H. Fowler, Dr. John Cockcroft and Mr. Wood Nutt (Secretary). In Washington it was joined by Dean C. J. Mackenzie (President, Canadian NRC), Air Vice Marshal Steadman (Canada), Col. H. F. *G.* Lettsom (Canadian military attaché in Washington) and Professor A. *G.* Shenstone, then at the NRC.

[91] M. W. Kirby, Operational Research in War and Peace, The British Experience from 1930 to 1970 (London 2003), P. 90.

[92] Plummer Professor of Theoretical Physics at Cambridge, and son-in-law of Lord Rutherford. See D. J. C. Phillipson, International Scientific Liaison and the National Research Council of Canada, 1916-1974 (Ottawa, 1985).

resulting ease of sharing information between Britain and the U. S., Canada enjoyed a far closer relation to Britain during the war than did Australia.[93]

Canadian cooperation with the United States had started at an early stage of the war, even before Pearl Harbor and the U. S. entry into the war. The American liaison was a result of the 1940 Ogdensburg Agreement which established the Permanent Joint Board on Defence. The agreement authorized the exchange of liaison officers on chemical warfare and after 1941 led to "…the pooling of information…"[94] A liaison officer from the United States Army Chemical Warfare Service came to be stationed permanently at Suffield after it was established, and the Canadian Army had a liaison officer stationed permanently at Edgewood Arsenal, Maryland, during the war.[95]

During 1941, Canadian chemical warfare activities focussed on the establishment and staffing of the Anglo-Canadian testing ground at Suffield, Alberta. The majority of the scientists, technical assistants, laboratory assistants and support staff were Canadians, while some administrative positions were held by British scientists. For example, Davies was appointed superintendent of the station, probably due to his extensive experience with chemical warfare while Superintendent of Experiments at Porton in England. Perhaps the much greater experience of the British in matters of chemical warfare could also have played a part in this appointment. The station also required a staff of fifty-four Army and forty-eight Royal Canadian Air Force members.[96] In 1941, the federal government expropriated the Suffield Block, purchasing the majority of the land from the Canadian

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[93] D ea n (of the University of Saskatchewan) Mackenzie, President of the Canadian NRC, viewed the twenty-eight months between the invasion of Poland and Pearl Harbor as critical to Canada's scientific and industrial development. Sharing Britain's sophisticated and secret weaponry, ahead of the United States, gave Canada an edge it had never before (or since) enjoyed. See M. W. Thistle, ed., The Mackenzie-McNaughton Wartime Letters (Toronto p. 151).

[94] R. Ranger, "The Canadian Contribution to the Control of Chemical and Biological Warfare", Wellesley Paper 5/1976, Canadian Institute of International Affairs, 1976, p. 21.

[95] D. J. Goodspeed, A History of the Defence Research Board of Canada (Ottawa 1958), p. 138.

[96] LAC microfilm reel C-5002.

Pacific Railway and the Hudson's Bay Company, and displacing 452 residents. Experimental Station Suffield commenced operations on June 11 1941.[97] Arrangements were made with the Canadian Pacific Railway to build a spur line to the experimental station and to supply water from its sources in the town of Suffield, while the Alberta government constructed an all-weather road to the station and established telephone service.[98]

The coordination of American-British-Canadian chemical warfare planning before the United States entered the war was one of the more demanding tasks confronting Maass during 1941. There were complaints from the American Chemical Warfare Service (CWS) regarding what they saw as:

> Poor cooperation from the Canadians... These problems were soon rectified: there was an immediate improvement in the volume of chemical warfare reports and equipment moving across the border, and a representative of the CWS was appointed to Suffield.[99]

In all probability these were nothing more than the inevitable teething problems associated with the establishment of a complex - and international - operation. Further, the military of the different countries had different operational protocols; an American "get things done" philosophy versus a British "proper way to do things"? Canadian chemical warfare representatives were sent to American chemical warfare establishments to observe the operation of these plants. One result of this collaboration was the establishment of a plant at Cornwall in Ontario for the synthesis of mustard gas[100] using technical assistance and equipment from the American CWS. This plant became operational in 1942 and was able to supply both HT mustard and phosgene in tonnage quantities.[101]

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[97] LAC microfilm reel C-5003.

[98] See LAC microfilm reel C-5003.

[99] D. Avery, The Science of War: Canadian Scientists and Allied Military Technology During the Second World War, (Toronto 1998), p. 133.

[100] In his memorandum regarding the production of war gases in Canada, Flood suggests an order be placed for 5 tons of mustard gas suitable for aircraft spray (HT-V, C.S. 1324). "HT" is often called sulphur mustard even though it is a mixture of 60% HD (distilled mustard), less than 40% Agent T (bis [2-(2-chloroethylthio) ethyl] ether, and a variety of sulphur contaminants and impurities, usually poly-sulphides and dissolved iron in the form of a complex. The poly-

Collaboration between the United States of America, Britain and Canada on matters of chemical warfare probably surpassed that in any other field of defence during the course of the war. Guided by scientific training and driven by the mutual enthusiasm of practical scientists, engineers and servicemen working in a common purpose, all three countries worked together to perform numerous experiments and field tests. One project was to combine:

> true gases and aerosols or particulates, since in order to use toxic aerosols effectively, it was crucial to know the most effective size of particle for penetrating the enemy's respirators… and the amount of dosage which would be required to be lethal… and the technique for laying down such an effective dosage.[102]

On the morning of December 7 1941 Japanese carrier-based aircraft attacked the American fleet at Pearl Harbor, resulting in the U. S. Congress authorizing war on December 8 1941. On December 11 1941 the German Charge d'Affaires, Dr. Hans Thomsen, said that Germany considered itself in a state of war with the United States. America, Britain and Canada were allies in the fullest sense, and were now able to work together openly in chemical warfare preparations. On December 29 1941 the Directorate of Chemical Warfare warned that "since the possibility of the outbreak of chemical warfare in the Pacific sphere of operations would seem very likely… there is every chance

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sulphides, present to about 30% in production Levinstein mustard were known to be non-vesicant, while some thickening agents were known to be influenced by the presence of dissolved iron. Thus purification of Levinstein mustard was to be one of the objectives of Canadian chemical warfare research in the next few years. Both the Levinstein and the thiodiglycol processes were used in the Canadian mustard production programme. For a discussion of the composition of the Levinstein mustard and the nature of the polysulphide contaminant see The Polysulfides in Levinstein Process Mustard Gas, Science, New Series, v. 106, n. 2755, October 17 1947, pp. 355-359.

[101] Chemical Warfare - Offensive weapons - Production of gases in Canada. LAC Microfilm reel C-5003, file number 4354-6-5-1.

[102] D. Avery, The Science of War: Canadian Scientists and Allied Military Technology During the Second World War, (Toronto 1998), p. 133. Some toxic chemical warfare agents were not gases at ordinary temperatures. For example, some arsenical "gases" were in the form of liquids which could be dispersed as particulate clouds with droplets ranging in size from 0.1 to 10 microns by spraying or by ejection from a high explosive shell. The ability of particles to penetrate the filter of a respirator depended, in a complicated way, on a number of factors; it varied with their size and was at a maximum for particles about 0.5 microns in diameter. In other words, particles smaller or larger than this were more readily caught on the filter. In order to make the conditions under which respirators were tested as exacting as possible, it was essential to keep the particle size of all testing clouds close to the maximum penetrative power. 1 micron = 1 x 10^{-6} meter.

that it would spread to other zones."[103] Given the known use of chemical weapons by the Imperial Japanese Army against the Chinese [104] this concern with chemical warfare was fully justified:

> It is definitely confirmed that in recent operations in Malaya, the Japanese used tear gas to cover a withdrawal when confronted by a strong Australian counter attack on January 28-29 1942. The American Military Mission in Chungking, China stated that the use by the Japanese of mustard gas and Lewisite against the Chinese in recent months is confirmed. It is reliably reported that the Japanese are now equipped with frangible type gas grenades filled with hydrocyanic acid, most likely for use against tanks. The Sumitomo Chemical Company at Niihama has been manufacturing arsenical war gases for the Japanese Army since June 1940. At Himeji, Japan there is a large factory including four special buildings for filling gas shells. [105]

A request by Great Britain to the Japanese Government that neither power use toxic gases in the war did not receive a satisfactory reply.[106] In addition to the use of chemical weapons by the Japanese Army, a further factor in the probability of chemical warfare breaking out in the Pacific was the non-adherence of the United States to the 1925 Geneva Protocol.

Chemical warfare in the Far East, if it did break out, would be fought in an entirely different environment from Europe. The war in the Far East was mainly in tropical forest where the atmosphere was hot and humid. The Allies lacked any data on how mustard gas – and other toxins – would behave in such hot, humid forests, all previous experience with chemical warfare having been

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[103] LAC, HQS 4354-1-8 microfilm reel C-5002, Chemical Warfare - General - Policy - Offensive (See also HQS 4354-20-1 Reel C-5007) 1941-42.

[104] Unit 731was a covert biological and chemical warfare research and development unit of the Imperial Japanese Army that undertook human experimentation during the Second Sino-Japanese War (1937–1945) and World War II. It was responsible for some of the most notorious war crimes carried out by Japanese personnel.

[105] National Archives and Records Administration of the United States [hereafter NARA], Chemical Warfare Service [hereafter CWS] 350.05/75, Probability of use of gas by Axis Powers, B. Japan. The probability of the use of gas by Germany was reported in the same memorandum: From reliable sources it is reported that the German High Command is preparing huge quantities of gas to use in England in connection with German proposed attempted invasion.

[106] At the February 23 1942 meeting of the British sub-committee on chemical warfare held at Porton, it was revealed that the Japanese government had approached the Mexican Embassy with the message "that in the conduct of the war they would be guided by the spirit of Bushido, and would therefore not initiate the use of gas." This pledge, it was concluded, "was obviously not of a nature on which any reliance could be placed."

derived from temperate France during the First World War. It was assumed by scientists at Porton that mustard gas would probably behave the same in all climates. Later research using human testing would demonstrate that the effectiveness of mustard gas was increased tremendously by tropical conditions, due to the enhanced vapour formation under tropical conditions. Mustard vapour is a singularly effective casualty agent.[107] One task of Canadian chemical warfare scientists from 1942 onward was to help to obtain data about the behaviour of mustard gas and vapour under tropical conditions.

[107] NARA, CWS memorandum to Joint Committee on New Weapons, December 6 1943.

Chapter 3

"Of Deaths Put on by Cunning and Forced Cause."
Chemical Warfare Preparation and Its Consequences, 1942-45

> let me speak to the yet unknowing world
> How these things came about: so shall you hear
> Of carnal, bloody, and unnatural acts,
> Of accidental judgements, casual slaughters,
> Of deaths put on by cunning and forced cause,
>
> Horatio's speech in the last act of Hamlet.

After the Japanese entry into the war in December 1941, the Atlantic alliance of America, Britain and Canada[1] had two enemies to fight and two widely different environments in which to prepare to wage chemical war. Canada not only wished to assist Britain in the event of a German invasion or chemical attack, but also had an enemy of its own to defend against on the Pacific coast. The year 1942 saw the Canadian Army expand to its peak during the war. Japan's entry into the war also caused the expansion of home defence formations. Additional units were mobilized for coast defence along with three home defence divisions. Throughout the early months of 1942 the Cabinet War Committee and the Canadian Chiefs of Staff also had to reassess the Canadian chemical warfare policy. It was decided that the Directorate of Chemical Warfare and Smoke[2] (DCWS) would coordinate the industrial scale production of chemical warfare agents, concentrating on mustard gas.

[1] The Allies of the Second World War were the countries officially opposed to the Axis powers during the Second World War. Within the ranks of the Allied powers, the British Empire, the Union of Soviet Socialist Republics, and the United States of America were known as "The Big Three."

[2] It became too difficult to operate a full-scale military program within the National Research Council (NRC). To facilitate the operation, the Army created the Directorate of Chemical Warfare and Smoke (DCWS) in 1941. This directorate took over responsibility of the activities of the NRC Associate Committee on Container Proofing and Research, the body that had been directing the chemical warfare program since before the war.

The intention was that Canadian forces should have sufficient chemical weapons to launch retaliatory attacks in either the European or Pacific theatres of war.[3] Provision was also made to provide all Canadian forces with protective equipment and respirators.[4]

In early 1942 the Canadian national policy regarding chemical warfare was still one of strict retaliation - no first use. But based on the experience of the First World War, effective chemical warfare retaliation had to be initiated virtually as soon as the enemy used this weapon. There was also the question of whether a gas attack against Canadians was to be construed to mean gas attack against Canadian servicemen anywhere, or attack against the Canadian homeland itself? On January 7 1942, the Canadian Chemical Warfare Inter Services Board (CCWISB) proposed the following policy:

> In view of the information contained in present Intelligence reports, there seems to be likelihood that chemical warfare will be used. As insurance against this contingency, and so we may be in a position to retaliate, the Board recommends that the manufacture of chemical warfare agents be initiated in Canada and particularly the manufacture of mustard gas…..the Board further recommends that equipment for charging chemical warfare projectiles and other weapons be obtained and installed for operations of a charging plant on a small scale in Canada.[5]

After due consideration and discussion, the proposed CCWISB policy was adopted as Canadian national policy by the Canadian government. This policy only allowed the construction of plants for the production of chemical warfare agents, and the machinery for the charging of munitions. There was no mention of deployment of any chemical weapons on Canadian soil or overseas. Subsequently, Inter-Services Staff discussions were held at Suffield on March 21 and 22 1942 resulting in recommendations to the Chief of the General Staff regarding the fact that the use of poison gas by Japan against China had been confirmed and that chemical warfare action was believed imminent.

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[3] Library and Archives Canada, [hereafter LAC] microfilm reels C-5012 and 5013 Chemical Warfare-Offensive weapons.

[4] LAC Head Quarters Section [hereafter HQS] 4354-5-2 microfilm reel C-5003 Chemical Warfare - Miscellaneous anti-gas stores - Impregnated clothing (See also HQS 4354-23-3-1 Reel C-5009).

[5] LAC Chemical Warfare - General – Most secret policy 1943-1945, HQS 4354-20-1, 1 April 1944, Part 1, paragraph 4.

The Staff discussions led to the conclusion that a Canadian chemical warfare policy based on offensive action was now required "…to provide realism in chemical warfare plans, procurement and training."[6] On June 11 1942 the Minister of National Defence submitted proposals intended to increase the production of war gases, build additional storage facilities for the chemical agents and assemble the end-use chemical munitions. The new expenditures proposed totalled $12,397,500. These proposals were deferred until they had been examined by the Minister of Munitions and Supply.[7] At the next meeting of the CWC, the Minister of National Defence, Mr. J. L. Ralston, stated that: "The Army Staff felt that Canada should be prepared to take the offensive in chemical warfare when the need arose."[8] He then proceeded to recommend a programme intended for Canadian needs, with the provision of chemical warfare reserves for the United Kingdom as a secondary objective.

For some members of Cabinet, the Minister of Finance Mr. Ilsley in particular, Canada was being drawn by its allies into a policy which did not serve the best interests of the country. Others believed that Canada should not resort to chemical warfare unless Canadians were attacked first. Prime Minister King agreed with Ilsley and felt that Canada should be prepared for chemical warfare, but the Canadian programme should not go beyond Canada's own requirements.[9] On June 12 1942 the Minister of National Defence informed the Chief of the General Staff that his proposals for chemical warfare submitted on June 7-10 had been approved by the CWC with the "…proviso that it is only intended to provide for supplies for our own possible needs and not to provide reserves for export to other countries."

> I opposed any expenditure of money for making this stuff to be used in the same way that we were making munitions to be sent abroad, but agreed to have materials

[6] Ibíd., Part I, Appendix II, paragraph 3.

[7] LAC, C-5002, CWC meeting of 11 June 1942, paragraphs 22-24.

[8] Ibíd., Meeting of 12 June 1942.

[9] Ibíd., paragraphs 26-29.

> supplied in case use of similar materials would be made against our people, as is possible on the Pacific coast and elsewhere.[10]

The new policy proposed "…the initiative in offensive chemical warfare action against any enemy move towards a possible attack in force against this Continent…"[11] Offensive chemical warfare actions in the defence of Canada and contiguous territories were to be restricted by two considerations. One was that the strategic advantage for such action should be in favour of the Allies. The other was that consultations with the United Nations[12] took place before a decision for use was taken.[13] Chemical warfare was a "slippery slope" and Mackenzie King, while wanting Canada to help, did not want to become too deeply involved.

The potential for offensive chemical warfare was constrained by the availability of an adequate supply of chemical weapons, if they were to be used on a large and sustained scale. Thus any offensive use of chemical weapons demanded the production of sufficient stocks of chemical agents and their subsequent bulk storage near chemical weapon filling depots. The two Canadian filling depots were at Cornwall for eastern Canada and at Suffield for western Canada. It was believed that a reserve of some 10 kilotons of mustard gas could be created by December 11 1943, with 5 kilotons ready by December 1942.[14] Stocks of phosgene, hydrogen cyanide and lachrymators were also required. Chlorine and adamsite (DM) were available on a small scale for training

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[10] King Diary, June 12 1942, paragraph 3.

[11] LAC, C-5002, CWC meeting of 11 June 1942, paragraph 1.

[12] The term United Nations ("Here, where the sword united nations drew" from Byron's Childe Harold's Pilgrimage) was decided by Franklin D. Roosevelt and Winston Churchill during World War II, to refer to the Allies. Its first formal use was in the January 1 1942 Declaration by the United Nations, which committed the Allies to the principles of the Atlantic Charter and pledged them not to seek a separate peace with the Axis powers. Thereafter, the Allies used the term "United Nations Fighting Forces" to refer to their alliance.

[13] Ibid., paragraph 2.

[14] Ibid., paragraph 7.

purposes. (Details of the industrial production of phosgene and mustard, the main war gases prepared during the Second World War, may be found in Appendix A.)

Of greater difficulty than the provision of chemical agents and the filling of munitions, was a political decision whether the Canadian forces should make a first strike with chemical weapons against a Japanese landing on the coast of British Columbia, in spite of the Canadian adherence to the 1925 Geneva Protocol. There was a substantial basis for Canadian concern regarding the possibility of a landing and the need to resort to chemical weapons.[15] The Japanese occupied the islands of Attu and Kiska[16] in June 1942, a garrison which the Americans and Canadians had to eliminate before the Japanese tried to use the islands as a staging area for an assault on the coast of British Columbia. The Aleutians would be the site of the only land battles in North America in the Second World War. Fortunately, the remote location and the appalling weather made resupply of the Japanese garrison difficult, while the Americans and Canadians were able to send thousands of troops to attack the Japanese[17] and remove what was seen as a threat to both Canada and the West coast of the United States.

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[15] The Allies suffered many disastrous defeats in the first six months of the war. In January 1942, Japan invaded Burma, the Dutch East Indies, New Guinea, the Solomon Islands and they captured Manila, Kuala Lumpur and Rabaul. After being driven out of Malaya, Allied forces in Singapore attempted to resist the Japanese during the battle of Singapore but surrendered to the Japanese on February 15, 1942; about 130,000 Indian, British, Australian and Dutch personnel became prisoners of war. Japanese aircraft all but eliminated Allied air power in South-East Asia and were making attacks on northern Australia, beginning with a psychologically devastating (but militarily insignificant) attack on the city of Darwin on February 19, which killed at least 243 people. See H. A. Gailey, The War in the Pacific: From Pearl Harbor to Tokyo Bay, (New York 1995). Also T. Hall, Darwin 1942, Australia Darkest Hour, (London 1980).

[16] Kiska (Qisxa in Aleut) is an island in the Rat Islands group of the Aleutian Islands of Alaska located at 52.1° N, 177.6° E. It is about 22 miles (35 km) long and varies in width from 1.5 to 6 miles (2.4–9.7 km).

[17] On August 15-16 1943, an invasion force consisting of 34,426 Allied troops, including 5,300 Canadians (the 6th and 7th Infantry Divisions which landed on the 16th), 95 ships (including three battleships and a heavy cruiser), and 168 aircraft landed on Kiska, only to find the island completely abandoned. The battle was significant in that large numbers of conscripts had been included in the 13th Canadian Brigade. The Japanese garrison of 5,183 troops had been evacuated from the island on July 23 under the cover of fog. Despite massive US air power, the evacuation went unnoticed. There were seventeen Americans and four Canadians killed from either friendly fire or booby traps, fifty more were wounded as a result of friendly fire or booby traps, and an additional 130 men came down with trench foot. The Japanese occupation of Attu and Kiska may have been a feint for the Midway operation, with little value other than the tactical goal of drawing the US Pacific Fleet into a major surface engagement. Historians J. Parshall, and A. Tully in their book Shattered Sword: The Untold Story of the Battle of Midway, (Washington 2005) present an alternative interpretation. The military

Using chemical weapons in retaliation against a German or Japanese gas attack had been official allied policy since early 1942. But American, British and Canadian chemical warfare planners were going further, and considering the use of chemical weapons in an offensive campaign in the Pacific theatre. Under the terms of the Geneva Protocol, the Allies could have initiated chemical warfare in the Pacific, arguing that it was in retaliation for the Japanese use of chemical weapons against the Chinese, who were now our allies. Thus an offensive chemical warfare policy against Japan would be justifiable under international law. [18]

The guidelines for retaliatory attack were altered by the Combined Chiefs of Staff (CCOS) on 31 December 1942 with Canadian interests supposedly being subsumed as part of the British Commonwealth. The Canadian government not unreasonably raised objections to what was a bilateral decision by the U. S. and the U. K. and which had the potential to involve Canada in a chemical war without the Canadian government having given consideration or consent.[19] Major-General Pope,[20] head of the Canadian Joint Staff Mission, criticized the CCOS decision:

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importance of this difficult-to-supply frozen island was questionable, but the psychological impact upon the Americans of losing U.S. territory was tangible. S. E. Morison, History of United States Naval Operations in World War II vol. 7 Aleutians, Gilberts and Marshalls, June 1942-April 1944, (Illinois 2001). See also LAC microfilm reel T-17904 Kiska operations.

[18] In 1938, three years before the Pacific War with Japan began, Antony Eden (later British foreign secretary and prime minister) was already emphasising the importance of 'effectively asserting white-race authority in the Far East'. The racial double standard in imperial politics was clearly demonstrated at the Versailles conference which followed the First World War in 1919. While the Americans and the British affirmed their commitment to the new movements for national self-determination in Europe, they rebuffed Japan's attempt to include a clause on racial equality in the covenant of the new League of Nations (M. Macmillan, Paris 1919, Six Months that Changed the World, (London 2001) p.95). The racial dimension made the Japanese a very different enemy from the Germans. The Japanese posed not just a military threat to the old imperial order, but a political challenge to white power that could encourage Asian nationalism. Hence racial factors were almost certainly involved in decisions regarding possible offensive chemical warfare and Japan.

[19] National Archives of the United Kingdom [hereafter NA (UK)] Cabinet [hereafter CAB] 122, War Cabinet and Cabinet Office: British Joint Staff Mission and British Joint Services Mission: Washington Office Records, 22 July 1943.

[20] M. Pope, Soldiers and Politicians, (Toronto 1962). For a fascinating analysis of politico-military matters which includes a short account of M. Pope and the Ottawa scene, see D. Morton, Military Leadership and Change in the 1990's, XIII Annual CDA Institute Seminar.

> Canada as a separate country[21] having signed and ratified an international treaty prohibiting the use of gas as a method of warfare finds herself unable to express her adherence to this statement of policy as presently defined.[22]

Perhaps this objection by Canada of exclusion from the decision-making process may have been a case of self-esteem by a young nation only recently independent. But perhaps not. Following the strong statement made by Prime Minister Churchill to Nazi Germany,[23] and the equally strong warning issued by President Roosevelt to the Japanese,[24] the Canadian Chiefs of Staff wanted Canada to "be in a position to employ gas as an offensive weapon immediately such a measure becomes necessary."[25] This request was not well received by the Canadian Cabinet War Committee (CWC). Major General J. C. Murchie however was insistent that chemical weapons be stored and ready to use against a possible Japanese invasion of British Columbia. Effective operational use of gas was believed to require at least forty eight hours warning so that Army, Naval and Air Forces would have time to prepare to attack enemy forces "by means of vesicant air spray….when he is seeking to

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[21] Canada was an independent nation within the British Commonwealth of Nations by the Statute of Westminster 1931. The text of the document may be found at: http://www.gov.ns.ca/legislature/legc/westmins.htm

[22] NA (UK) CAB 122/1323 British Joint Staff Mission and British Joint Services Mission: Washington Office Records Memorandum by the Canadian Joint Staff Mission, September 9 1943. A similar situation is described by Pope regarding a Deployment of Forces table forming part of the Arnold-Portal-Towers Memorandum of Agreement (on Air matters) which laid down proposed strengths for air forces stationed in Canada, without any reference having been made to any Canadian representatives! Marshal of the R. A. F. Slessor and two Americans arranged the entire affair! Pope, p. 197.

[23] "I wish now to make it plain that we shall treat the unprovoked use of poison gas against our Russian ally exactly as if it were used against ourselves, and, if we are satisfied that this new outrage has been committed by Hitler, we will use our great and growing air superiority in the west to carry gas warfare on the largest possible scale far and wide against military objectives in Germany." Winston Churchill quoted in Time, May 18 1942.

[24] "From time to time since the present war began there have been reports that one or more of the Axis powers were seriously contemplating use of poisonous or noxious gases or other inhumane devices of warfare. I have been loath to believe that any Nation, even our present enemies, could or would be willing to loose upon mankind such terrible and inhumane weapons…. Use of such weapons has been outlawed by the general opinion of civilized mankind…I state categorically that we shall under no circumstances resort to the use of such weapons unless they are first used by our enemies. As President of the United States and as Commander in Chief of the American armed forces, I want to make clear beyond all doubt to any of our enemies contemplating a resort to such desperate and barbarous methods that acts of this nature committed against any one of the United Nations will be regarded as having been committed against the United States itself and will be treated accordingly. …" Franklin D. Roosevelt, Statement Warning the Axis Against Using Poison Gas, June 8 1943, The American Presidency Project UC Santa Barbara.

[25] LAC Privy Council Office [hereafter PCO], volume 38, D-19-A-2, Major General J. C. Murchie, Vice Chief of the General Staff, to R. L. Ralston, June 29 1942.

consolidate beach head positions and before his main force has been tactically deployed."[26] The CWC was reluctant to accept Murchie's proposal regarding immediate deployment of chemical weapons to the Pacific coast. It did, however, accept his recommendations that the demands of Suffield staff for equipment, materials and people be given the highest priority. Further, it was agreed that all three services use the offensive chemical warfare training facilities at Suffield.[27] Canada was being drawn closer towards a chemical war.

It is likely that the CWC believed that if chemical weapons were actually deployed in a potential theatre of war, namely the west coast of Canada, it meant committing Canada to a chemical war. King recorded:

> There was further discussion on chemical warfare. Ilsley, St. Laurent and myself all strongly insisted on not permitting gas to be used by Canadians offensively until it was quite clear it had been used in that way by an enemy who might be attacking us. In other words, if the Japanese use it against China or the British, we would be free to use it in protecting ourselves and using it offensively if they attack Canada. On the other hand, it should not be used against the Japanese if they did not use it themselves, even should Hitler use it in Europe and Britain use it against Hitler. In other words, we insisted strongly that Canada on no grounds be made the occasion of resort to the use of gas; [28]

The retention of the chemical weapons at Suffield and Cornwall acted as a safeguard against escalation of the chemical war. The Canadian government and the CWC still had reservations about the use of chemical weapons, even at this difficult point in the war,[29] not only due to Canadian

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[26] Ibid.

[27] After June 12 1942 the Chemical Warfare Centre at Suffield became known as the Advanced Chemical Warfare (Offensive) Training Centre.

[28] King Diary, Wednesday July 8 1942, paragraph 5.

[29] An extract from the report on the war situation for the period 19 February to 15 June 1942 submitted to the CWC by the Chiefs of Staff gives an idea of the repellent nature of the war news at that time: "Germany has successfully over-run the Kerch peninsula…opening the way into the Caucasus… The Libyan situation is somewhat confused…. Malta is under constant air attack… the submarine menace in the Western Atlantic has been successful to a degree which constitutes a serious threat to the Atlantic supply route…the fall of Singapore, the liquidation of the Dutch Indies, the invasion of Burma and the Japanese occupation of the Mandated Islands have placed Japan in a strong position…The Japanese have obtained a foothold in the Outer Aleutians. The war has moved closer to Canada on both coasts." LAC, C-5002, HQS 5199, June 15 1942, Chiefs of Staff Committee.

acceptance of the Geneva protocol, but also a genuine repugnance on the part of King and other members of the CWC. King's diary is instructive;

> I was astonished to hear MacDonald say that he regarded gas simply as a weapon and saw no reason why it should not be used just the same as guns, shells or bombs. I pointed out there was a real difference; that the physical wounds resulting from metal and the like were capable of being healed and healed quickly, but that gas tended to occasion disease that would last for a long time and would spread in waves to innocent people away beyond that of other forms of destruction. [30]

Canada would not use these weapons, except as a last resort, and then only after due consideration by the CWC. King continued:

> I asked pointedly if it was not the case that the military authorities in our Defence Department had felt that our coast line was very large, full of inlets, and that B. C. itself full of defiles; that we had not the men to protect us and that the planting of gas bombs would be a substitute for manpower. I said that we should not allow the military authorities to take any action on their own; that the War Committee itself would have to be "satisfied" in the first instance that we were acting in accord with the United States in any resort to the use of gas and that we were in agreement with both the President and Churchill about its use in the right way at the right time if that became necessary. [31]

This approach could be regarded as analogous to that of governments in the late twentieth century retaining operational control of nuclear weapons. In most nuclear armed countries the use of nuclear force can only be authorized by the government.

An amendment to the CCOS statement was requested by Canada, requiring that Commonwealth governments involved in the use of chemical weapons give their consent before a retaliatory attack be launched. After extensive consultations between representatives of the three governments in Washington, the understanding reached was that:

> it was morally certain that the Commonwealth concerned would most certainly see eye to eye with the U. S. and British governments as to the necessity in any

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[30] King Diary, Wednesday July 8 1942, paragraph 5.

[31] Ibid. The population of Canada in 1942 was 11,654,000.

> given set of circumstances of resorting to gas warfare and would answer with the utmost promptitude any request put to them for their concurrence.[32]

Canadian political sensitivities were apparently adequately addressed by this alteration to the CCOS statement. The wording gave ample scope for the Mackenzie King government to avoid a decision to allow deployment of chemical weapons on Canadian soil, and by implication give approval for their immediate use if Imperial Japanese forces were to land on the North American mainland. This approach could probably be described as "masterful inactivity." Or perhaps to paraphrase Mackenzie King, "chemical warfare if necessary, but not necessarily chemical warfare!"

Work began at Suffield Experimental Station to prepare Canadian troops for chemical warfare and to further develop chemical weapons. The recently created United States – Canadian Chemical Warfare Advisory Committee (US-CCWAC, which interestingly enough did not include the British in the title, even though E. L. Davies was a representative), provided a forum for coordinating gas storage and production between Canada and the United States. Perhaps the crucial Canadian interest was in ensuring that Canada received the consideration due an independent country. The major players were the British and Americans, each of whom was more vulnerable to chemical warfare than was Canada. Britain was in thrall to possible Nazi chemical attack on the home island, while American combat forces were exposed to possible chemical attack in the Pacific theatre of operations, if the Japanese used chemical weapons. A sustained chemical attack on Canada, however, was probably a military absurdity, given the vast and empty land area, and the limited range of existing enemy aircraft.[33]

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[32] M. A. Pope, Soldiers and Politicians, (Toronto 1962), pp.182-208.

[33] There were however a number of attempts to attack the U. S. and Canadian west coasts during the Second World War. See B. Webber, Silent Siege: Japanese Attacks Against North America in World War II, (Washington 1984) and R.C. Mikesh, Japan's World War II Balloon Bomb Attacks on North America, (Smithsonian 1973).

The initial and most crucial meeting of the US-CCWAC was held on September 24 1943 at Edgewood, Maryland in the office of the Chief of the U. S. Chemical Warfare Service, with Major General William N. Porter chairing the meeting. By this time significant U. S. resources had become available with which to develop chemical warfare materials.[34] The Canadian representatives on the Committee were Dr. O. Maass, E. L. Davies of Porton and Suffield, Major J. C. Beeman of the Canadian Joint Staff (Army), Major J. Morris, representative of the Chemical Warfare Headquarters, and Lt. Colonel E. A. Flood. Significantly the American service was represented by a General Officer, while the senior Canadian officer was only a Lt.-Colonel. The industrial resources of the U.S. were of course far greater than those of Canada, and the amount of chemical warfare munitions available to the U. S. was vastly superior.[35]

The purpose of the meeting was to appoint technical subcommittees to assume responsibility for sixteen projects which included gas warfare and spray (Levinstein H purification and thickening

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[34] The United States was probably fully occupied fighting the war in the Pacific before this time. Until the Battle of Midway June 4-5 1942, the Imperial Japanese forces enjoyed an unbroken string of success. On March 2-4 1943 the U. S. achieved victory in the Battle of the Bismarck Sea. The Aleutian Islands were occupied by U. S. and Canadian troops May 31 1943 while on November 20 1943 U. S. troops invaded Tarawa in the Gilbert Islands where they learned of the obdurate resistance of which the Japanese were capable using caves and tunnels. In the Far East the allies found that Japanese fortifications were resistant to anything except a direct hit from a bomb or large naval gun. In one incident in 1944, where 684 rounds of 3.7-inch howitzer shells and 670 rounds of 25-pdr shells landed in an area 250 yards square, the Japanese suffered only two confirmed dead and minor damage on a few communication bunkers; there was no material damage on the main combat bunkers (J. Ellis, The Sharp End of War: The fighting man in World War II, London 1980). The allies found that individual guns fired at point blank range were much more effective - the trick was getting the guns in place! Increased American interest in chemical weapons for overcoming Japanese field fortifications dated from that time.

[35] On June 9 1944 a U. S. study was undertaken "to determine whether or not gas should be used" in the invasion and "if so, when its use should be initiated." At the time the study was made, the U. S. was producing poison gas at a prodigious rate. On hand by the end of 1945 were more than 4.4 million gas artillery shells, 1 million mortar rounds, 1.25 million aerial gas bombs, and 112,000 canisters for spraying gas from low-flying planes. T. B. Allen and N. Polmar, "Gassing Japan", The Quarterly Journal of Military History, v. 10, n. 1, pp. 38-43. Details of the Japanese production of CW agents may be obtained at http://cgsc.cdmhost.com/cgi-bin/showfile.exe?CISOROOT=/p4013coll8&CISOPTR=1581&filename=1570.pdf which accesses a declassified report of Japanese production techniques and production values. The total Japanese production of persistent agents from 1930 to 1945 was only 4991 metric tons! Major –General K. Akiyama stated that "the Japanese not only feared recourse to gas but believed that it would be used on a large scale to hasten the end of the war. The Japanese, he explained, were particularly concerned lest the Americans spray their rice fields with mustard or lewisite or, worst of all, arsenic trichloride. Those tactics, he asserted, would have been as effective as dropping the atomic bomb." Cited in E. M. Spiers, Chemical Warfare, (Illinois 1986).

of vesicants),[36] gas masks, definition of vesicant casualties, smoke generation, protective ointments, and flame throwers. The committee as a whole was to consider the effects of terrain, specifically jungle and tropical conditions; methods of field sampling, and tests to determine the efficiency of chemical warfare gases and smokes under extremely cold conditions.[37] After the island operations in the Pacific revealed the ferocity of the Japanese defences and the high human cost of overcoming them, U. S. military interest in chemical warfare increased, in spite of President Roosevelt having condemned the use of chemical weapons earlier.

Before 1939 practically all experimental work on gas warfare in the British Commonwealth had been carried out at the Chemical Defence Experimental Station at Porton, near Salisbury, England, apart from some experiments carried out in Rawalpindi in north-west India.[38] Consequently relatively little had been known about the effects of war gases on the human body under tropical conditions. The startling discovery was made that under tropical conditions, mustard gas was at least four times as effective as it was in the temperate English climate. Sensitive areas of the human body[39]

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[36] The purification of Levinstein mustard gas was one of the important responsibilities of the Canadian Directorate of Chemical Warfare and Smoke (DCWS). In an assessment of the purification of mustard gas for chemical warfare operations, Lt. Col. Flood provided the following suggestions for methods of treatment: addition of inhibitors (hexamine), vacuum distillation, flash distillation (developed by Dr. A. R. Gordon of the University of Toronto), steam distillation and solvent (pentane) extraction. The two most promising processes for improving Levinstein mustard were deemed to be steam distillation and solvent (pentane) extraction. Economics probably disposed of most of the remainder. As steam distillation of mustard also required a ceramic tower and packing, and a silver condenser to handle the corrosive mustard, one assumes that the Minister of Finance voted no! Purification was required to allow its use in medium or heavy-walled shell or bombs without elaborate anti-corrosion varnishing techniques, thus allowing tropical storage for up to 3 months for the charged weapon. Of course the mustard for service use must have the economical minimum of physiologically inert material!

[37] LAC Chemical Warfare - Correspondence - United States-Canada Chemical Warfare Advisory Committee is currently restricted by law. The memoranda and minutes of the Advisory Committee were found in NA (UK) as WO 188/702, Co-ordination of research into chemical warfare between Britain, Canada and USA.

[38] NA (UK) WO 188/640 and 641, sub series within WO 188, Chemical Research Department, India, Periodical reports.

[39] Injuries to the scrotum and penis were especially common and painful under conditions of high temperature and humidity. Investigation, handling and dressing of the areas produced intense and crippling pain. General relief from prolonged pain and discomfort necessitated the use of morphia (1/4 grain under the tongue for 4 nights). Full details of the tests and results, including photographs of the soldiers tested may be found in Report No. 265 of the C. D. R. E. of India, retrieved from NARA RG 175, Box 154. It has been demonstrated that 80% of sulphur mustard applied to the skin evaporates, 10% remains in the skin and 10% gets absorbed systemically (Renshaw, 1946). It can penetrate the skin by contact with either the liquid or vapour. The rate of penetration is proportional to dose, temperature and humidity.

exposed for one minute to a concentration of mustard-gas vapour below 100 milligrams per cubic meter were seriously burnt. Such extreme sensitivity was associated with temperatures greater than 90 degrees Fahrenheit and relative humidity greater than 80 per cent. Under these conditions comparatively small doses of mustard gas produced an unusually sudden onset of disability; skin burns developed more rapidly, with the result that men became casualties in a shorter time. Therapeutic agents for mustard gas were found to be virtually useless, unless applied at once, which would be almost impossible under battlefield conditions. Most anti-gas ointments fell into this category.[40] It was found that the large amount of data accumulated in temperate zones would have to be checked and completely revised if vesicant gases were to be used in the tropics, and that much more research would be needed before chemical warfare could be undertaken in the tropics with any confidence.

While it is probable that an increased effectiveness of mustard gas in the tropics was anticipated by physiologists (though the full extent of its intensified action almost certainly was not), the discovery of the ease with which it was dispersed in the jungle apparently came as a complete surprise. Wind speeds at ground level in the jungle are usually only a small fraction of those immediately above the tree tops, but for a given ground wind speed in the jungle the rate of dispersion of mustard gas vapour was found to be several times greater than it would have been for the same ground wind speed in the open. These two factors combined to intensify the effectiveness of

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[40] United States-Canada Chemical Warfare Advisory Committee: Summary statement on Protective Ointments, NARA RG 175, Box 138. Extensive testing was carried at Edgewood Arsenal in the U.S.A. to develop protective ointments after July 1943, when Medical Research of the Office of Scientific Research stated that M-4 ointment containing 15% chloramine-T was not a suitable protecting agent. Impregnite S-330 was found to be far superior to any material tested at that time. The basic constituents of this prophylactic ointment were guanidine carbonate (or nitrate) and benzil. Lt.-Col. Flood, representing Canada presented a report by D. J. G. Malloch regarding the Canadian perspective on the use of anti-gas ointment. "It is a cardinal point in Canadian policy that an effective ointment should be available at all times…the ointment would accordingly be required for the decontamination of many instruments, as well as for clothing and personal decontamination." Further details of the performance and testing of the various ointments may be found in LAC HQS S. 4354-29-16-1. For work on protection against lewisite and other arsenicals carried out by Canadian scientists see L.Young, "Canadian Researches on BAL (British Anti-Lewisite)", Science, New Series, v. 103, n. 2676, 1946, pp. 439-440.

mustard gas in the jungle: for a given concentration it was more toxic, and for a given wind velocity it spread more rapidly. It was concluded that, under similar conditions in tropical areas, the degree of disability inflicted on occupying troops by the use of mustard gas in all probability would be much greater than with a corresponding amount of high explosive. In order to test this conclusion and develop modified defence procedures, equipment and prophylactics for tropical use, further trials were clearly needed with air weapons and spray attacks with mustard gas on troops on beaches, tropical island fringes and in jungle forest. But by the end of 1943, those in charge of chemical-warfare tests had good reason to believe that mustard gas could be far more useful in the Pacific than it had been on the European battlegrounds of the First World War.[41]

In this same document it was stated that "the 125-ton per week of HT or 100-ton per week of TGH which Canada can produce is available to this country [i.e. the United States]. Additional material could probably be made available to this country from the United Kingdom." The supplies of chemical warfare agents were now regarded as a communal Allied resource.[42]

In addition to responsibility for the preparation and loading of toxic gases into munitions, the Directorate of Chemical Warfare and Smoke (D. C. W. S.) was also responsible for research into smoke and flame weapons. Smoke weapons were studied extensively by a sub-committee of the US-

[41] A discussion of the work of Gorrill in Australia regarding the enhanced blistering effect of vesicants under tropical conditions may be found in the minutes of the US-CCWAC January 5 1944. Found in NA (UK) WO 188/702. At the US-CCWAC Subcommittee on Levinstein H Purification meeting of December 15 1943 it was recommended that for air burst munitions, where it is necessary to use thickened charging, a purified H, TGH, or HT be used, and in addition the interior of the munitions had to be coated to avoid corrosion during storage. The corrosion of light case bombs and land mines filled with mustard was found to present serious problems, as these munitions would not stand the pressure development resulting from the decomposition of the mustard filling. They could only be filled with stabilised mustard (usually stabilised with hexamine) or purified mustard, and then only if used within approximately two weeks of charging! This implied that if chemical munitions of these natures were to be used in the Pacific theatre, the chemical agents would either have to be prepared in-theatre (probably in Australia) or shipped there to filling depots in bulk containers. Pressure development was found to be greatly accelerated when containers and filled bombs sent from Britain were transferred from the holds of refrigerated ships to the tropical temperatures. There were instances of filled munitions bursting in Australia. The Australians eventually obtained filled bombs with satisfactory performance under tropical conditions from the United States.

[42] US-CCWAC Subcommittee on Levinstein H Purification, 15 December 1943: restricted by law in LAC. Found in NA (UK) WO 188/702.

CCWAC and tested in field trials at Suffield. Smoke may be used for many purposes in military actions. Smoke may be used for defensive and offensive screening of troop formations; large area smoke screens[43] may provide concealment for ship anchorages, potential ground targets, including airfields, main supply routes, bridge and river crossings, and in amphibious and beachhead operations. Coloured smokes may be used to mark targets for artillery and air attacks, or to coordinate such attacks; signalling the direction of advance to friendly troops and allowing recognition of armoured fighting vehicles (A. F. V.'s) from the air. Toxic smokes would be used to incapacitate or kill enemy troops if able to penetrate the respirators. The types of weapon considered the most suitable for laying down a smoke screen or throwing up coloured smoke signals included static and mobile generators, hand grenades, mortar bombs and 25 pr. shells. Up until the latter part of 1942 there had been no Army requirement in Canada for the production of coloured smoke weapons, and, therefore the manufacture of such equipment had not been initiated.[44] It was felt that by using the British designs and filling methods there would be no major difficulty should the production of such weapons in Canada be required. British experience in the use of coloured smoke had been gained in the fighting in the Middle East. By 1943, however, the Canadian D. C. W. S. believed that German progress in the field of smoke weaponry was more advanced than that of the Allies. The Canadian Chiefs of Staff ordered a major series of field trials with smoke at Suffield, using smoke generators, mortars, smoke shells and grenades.[45] As Suffield did not have a sufficient

[43] These are termed smoke curtain installations (SCI). LAC, HQS 4354-24-7-1 Chemical Warfare - Offensive weapons - Smoke curtain installations (SCI).

[44] Many difficulties in manufacture of coloured smoke munitions are revealed. For example: "recent tests on the 60mm. coloured shell, T8, have been encouraging, however most of the first shell filled under a pressure of less than 25 tons dead load have exploded in the mortar." Also "the only manufacturing problem concerned with coloured smokes at the present time is that of obtaining raw materials of uniform particle size and density." NARA RG175 Box 138 October 19 1943, Smoke Generation.

[45] LAC Chemical Warfare - Canadian Chemical Warfare Inter-Service Board minutes, Microfilm reel C-5006 is "restricted by law." The file used was retrieved from NARA RG 175, Box 138 Office of the Chief of Chemical Warfare, Chemical Warfare Intelligence Bulletin No. 24, German Combat Smoke Tactics.

quantity of smoke bombs, mortar shells and smoke generators available, the American C.W.S. supplied some munitions from Edgewood Arsenal for the trials.[46] Recommendations were subsequently made regarding combinations of colours to be avoided in any signalling code.[47]

The First Canadian Army used extensive tactical smoke screening for the first time near Calais, at Cap Gris Nez on September 23 1944 during Operation Undergo.[48] This smoke screen lasted for six days, pausing only for air bombardment, using up 147 tons of smoke generators. After this experience the Canadian Army used tactical smoke screening on an ever increasing scale.[49] The Canadians did have flame warfare Technical Staff, but did not have smoke units as such, and as a rule obtained their supporting smoke detachments from the smoke companies of the British Pioneer Corps (Royal Pioneer Corps in 1946).[50] A typical operation, such as Operation Switchback[51] during the clearing of the Scheldt Estuary west of Antwerp which lasted from October 9 to November 3 1944, employed a total of 356 tons of smoke generators. Borrowing detachments and equipment from the British was not a satisfactory solution for the Canadians. One proposal for the formation of a Smoke

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[46] LAC HQS 4354-32-1 Report of Smoke Weapons in Canada, February 2, 1943 is "restricted by law." The equivalent data may be found in NARA RG175, Box 138 October 19 1943 Smoke Generation.

[47] Orange and red; blue and violet were pairs of colours deemed difficult to resolve from the air at altitudes of 7,500 feet even with good visibility. These pairs were thus to be avoided. NARA RG175, Box 138 October 19 1943 Smoke Generation-Colored Manufacturing Problems Concerned with Smoke. This reference also contains details of coloured smoke compositions and a table of coloured smoke projectiles and generators and coloured flares.

[48] Operation Undergo -The Capture of Calais & Cap Gris Nez in: J. T. Copp, Cinderella Army: The Canadians in North-West Europe 1944-1945, (Toronto 2006), pp.75-82.

[49] LAC Microfilm Reel C-5010 Chemical Warfare - Offensive equipment - Smoke - Area screening

[50] Major E. H. Rhodes-Wood, A War History of the Royal Pioneer Corps, 1939-1945, (Aldershot 1960).

[51] J. T. Copp, Cinderella Army: The Canadians in North-West Europe 1944-1945, (Toronto 2006), pp. 88-117.

Company using the Besler smoke generator[52] was made, but the end of the war prevented further development of this concept.

Flame weapons were becoming important for Canadian troops on the battlefields of Sicily and Italy, and would become even more important during the battles in Western Europe[53] and in the Pacific campaigns.[54] The British and Canadians fielded the Wasp (a Universal Carrier or Bren Gun Carrier mounting a flame-thrower) beginning in mid 1944. The inception of the Wasp began as early as 1940 when the British decided to develop a flame-thrower that could be mounted on a Universal Carrier. The gas-pressure-operated Canadian Ronson flame-thrower was selected. Canadian development dated back to August 1942, when an order for 1,300 Ronson flame throwers was placed in Canada and subsequently an increase in range was demanded, from approximately 50 yards to 100 yards. Development was carried out simultaneously in Canada and the United Kingdom and two approaches were explored: the modification of the mechanical equipment and the development of special fuels. It was decided to focus on special fuels since work started in the United States indicated great promise. Good results were obtained with rubber mixture, but this work was dropped because of

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[52] For a photograph of the Besler smoke generator (and an Esso generator) and an account of its employment in battle, see Col. M. E. Barker, "Smoke in Defense", U. S. Coast Artillery Journal, January-February 1945, Volume LXXXVIII, Number 1, (U. S. Chemical Warfare Service).

[53] See J. T. Copp, Cinderella Army: The Canadians in North-West Europe 1944-1945, (Toronto 2006), P.108 for an example of the activities of Chemical Warfare Officers in laying a smokescreen, and for use of the Wasp flame weapon.

[54] The flamethrower was tested in action against the French in February 1915 in the Verdun sector, but was more famously used against British troops at Hooge, near Ypres, on the night of 29-30 July the same year. After the First World War, the flamethrower was quickly discarded, since most armies considered it to have been a specialized device for the peculiar conditions obtaining in the trench warfare in Flanders. It reappeared in Italian hands in the Abyssinian campaign of 1935, when a tank-mounted flamethrower was employed, and also in small numbers in the Spanish Civil War. They can be vehicle mounted, as on a tank, or carried by infantry. The British Commonwealth and the United States were the most prolific users of vehicle mounted flame weapons; the British and Canadians fielded the Wasp at the infantry battalion level, beginning in mid 1944, and, eventually, incorporated them in infantry battalions. Early tank-mounted flamethrower vehicles included the 'Badger' (a converted Ram tank) and the 'Oke', used first at Dieppe (the Oke was a Churchill tank fitted with a flame gun). The most famous flame tank was the Churchill Crocodile. Flamethrowers were reportedly devastating to enemy morale, and were noted for their, "good moral effect, knocks out the [enemy's] will to fight," and how it was "very effective and terrifying when properly used." Battle Experience Questionnaires, Captain J.C. Watt, LAC RG 24, Vol. 10450, 173; A/Major Harold Mortimer Cunningham, LAC RG 24, Vol. 10450, 188.

the supply situation after the Japanese capture of Malaya. A thickener known as Napalm A[55] was obtained from the United States and tried in Canada. In spite of some difficulty with stability, the range requirement was met. The United Kingdom meanwhile concentrated on Fuel Research Aluminium Stearate (FRAS)[56] mixtures, peptized with xylenols. Enquiries made in Canada revealed that difficulty would be experienced in obtaining the materials for FRAS type fuels and in view of other advantages lying with napalm, it was concluded that this thickener was best suited for Canadian requirements, and a decision was made to standardise on this fuel. However the manufacturers experienced difficulty in producing stable napalm, which held up supplies to Canada. It subsequently proved possible to obtain sufficient materials for FRAS, given priority of supply for the materials, and quantities of this fuel were eventually prepared, with tests being carried out at Suffield to compare the Canadian product with the equivalent British mixtures. The Canadian work was accelerated after the November 1943 establishment of the US-CCWAC Subcommittee on Flamethrowers.

In addition to the technology of chemical munitions development, there was a human cost associated with Canadian chemical warfare preparations. The British and Canadians had recruited

[55]Napalm is actually the thickener, which when mixed with gasoline or other petroleum-based fuel, makes a sticky incendiary gel. Gasoline or fuel oil was selected as the most readily available flammable fuels for flame weapons. Developed in the U.S. by a team of Harvard chemists led by Louis Fieser, its name is a combination of the names of its original ingredients, coprecipitated aluminium salts of naphthenic and palmitic acids. These were added to the flammable substance to cause it to gel. Because of gasoline's instability, volatility, and its rapid burning and self-consumption, its effectiveness as a flamethrower fuel was limited to within 30 yards. Napalm, through its unique properties, extended the effective range of flamethrowers to 150 yards. The agent developed in Britain for "gelling" gasoline (FRAS) proved difficult to use under front-line conditions in the tropics. The Australian army made a granular powder-essentially basic aluminium oleate-which the Australian army found highly successful. "Geletrol", as it was called, had the advantage of being easily mixed in the field.

[56] Fuel Research Aluminium Stearate or F. R. A. S. was a development of the British Petroleum Warfare Department. See NA (UK) AVIA 22/2303 for an account of these researches. For a detailed comparison of the differences and advantages of the two thickening agents, Napalm A and FRAS, see NA (UK) WO 188/702 Minutes of the US-CCWAC Meeting, January 5 1944 a. Criteria of the Ideal F/T Fuel and b. Comparison of Napalm Thickened Fuels and F. R. A. S.

soldiers to act as "observers"[57] in chemical-warfare tests early in the Second World War. Most of the initial experiments were designed to test protective equipment such as respirators, clothing, and ointments, as Britain and Canada prepared for a German gas threat that never materialized. In most tests only a patch of exposed flesh was subjected to testing with mustard agent. However, in 1942 after repeated requests from Porton staff in England, the Canadian staff at Suffield rewrote and relaxed the regulations[58] and, as a result, volunteers in normal (non-impregnated) army uniform were sprayed with mustard gas from aircraft in a series of experiments at Suffield. These spray tests were to investigate the dropping of mustard from high altitude,[59] a mode of delivery which required the thickening of the vesicant to avoid evaporation during the fall from great heights, and to test mustard-filled bombs. Clearly such use of chemical weapons can only be regarded as an offensive war technique. After a trial in the summer of 1942, "eight people were hospital cases, six of whom were really bad." The trial was deemed to have been a "success from the offensive point of view. The results from aircraft spray were not as good as was hoped for. Mr. Davies said that the only other hopeful way was the 50- lb. bomb."[60] More tests were deemed essential. Some 160 men were sprayed in another trial later that same summer.[61]

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[57] In the somewhat quaint parlance of First World War Porton, human guinea pigs were termed observers, as they literally observed and recorded the effects of poison gases on themselves! This term which tends to "sanitize" the nature of the poison gas experiments on humans, was retained by Porton for many years. An observer was the same as a volunteer in Canada.

[58] A list of Amendments to The Regulations Governing Use of Subjects in Physiological Tests may be found in LAC HQS 4354-9-12.

[59] These tests were carried out after repeated requests from Porton in England. War experience in North Africa, with exposure to German anti-aircraft fire, had made it clear to the British that low altitude spraying of mustard was likely to be "non-habit forming." NA (UK) AVIA 15/1071 Experimental Establishments: British Field Experimental Station in Canada: establishment and programme, 1941-42.

[60] Deadly Allies, p. 170.

[61] NA (UK) AVIA 15/896. "Abstract and appreciation of Suffield reports 39 and 47 on mustard spray; March 10 1943."

One description may suffice to give an impression of the nature of these tests, and the physical results:[62]

> 532492 Private Chartland, H Dress: winter underwear (long limbed)
> Observer No. B8-F. E. No. 68 Part III May 6/42
> Issue shirts.
> Battle dress (non impregnated).
> Drill order; steel helmet, respirator at the gas position, sprayed with mustard spray from 1600 feet (low spray). Wind speed 10 m. p. h.
> Facing down wind,
> After contamination, transported by truck to a point 3 miles away where he lay about 21/2 hours. On second and third day, marched 35 miles. Fourth and fifth day, digging in. Sixth day – attacking a control company, marched 12 miles. Seventh day – defending. Eighth and ninth day – marched 30 miles.
> Examination: A large number of sharp erythema involving the left shoulder. A number of small vesicles developed within this area. The right shoulder was similarly involved. Both arms and buttocks showed scattered small areas of mild erythema. After 8 days, the shoulder lesions were seen to be healing normally with prominent amount of pigmentation and a number of healed lesions were apparent on the upper arms.
> Non-casualty (Class III). [63]

The same report contained details of similar tests on several other soldiers. Two of the other soldiers were Class I casualties with periods of disablement of 14 days. Further, mustard gas was well known to cause blindness, either temporary or permanent.[64] A memorandum[65] of June 23 1943 contained the following:

> Attached correspondence from the Experimental Station, Suffield requests re-examination on 29 observers who developed eye lesions as the result of mustard

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[62] LAC HQS 4354-31-1 DCWS. Lantern slides of these soldiers after the trials were forwarded to Research and Development Division at Edgewood Arsenal in Maryland in 1946. Presumably they are still there or at NARA.

[63] LAC Chemical Warfare - Correspondence - United States-Canada Chemical Warfare Advisory Committee is still "restricted by law." These data were obtained from NARA RG 175 Box 138 United States-Canada Chemical Warfare Advisory Committee, Definition of vesicant casualties. The classification of casualties due to chemical burns may be summarized as follows: Class I: a casualty under any circumstances, regardless of how willing the man is to continue his duties; Class II: "Just not a casualty" mobility of one or more limbs is limited…. Would become a casualty if required to do any work involving strenuous exercise; Class III: Not a casualty, although burns may be prominent and several in number; Class IV: Not a casualty.

[64] Gassed by John Singer Sargent is the often-quoted example of the effects of mustard gas in blinding British soldiers in the First World War.

[65] LAC, HQS 4354-26-10-1

> gas spray trials within the past few months. It is proposed that special examination be conducted by Capt. H. Macrae, R. C. A. M. C., ophthalmologist, now attached to Camp Borden Military Hospital.

These ophthalmic casualties were the results from Field Experiment 68, "The Casualty Producing Power of Mustard Spray on Troops," the subjects of which had been hospitalized from five to twenty-one days.[66]

The minutes of the US-CCWAC at Edgewood, May 15-16, 1944, Item B1 deals in part with a Suffield project which was "in progress", using unthickened mustard to spray from 600, 400 and ("if necessary and advisable") 200 feet on to men equipped with respirators, ointment and normal clothing. Suffield staff expressed the view that trials over observers in impermeable clothing with windows [cut in the clothing] were "completely unsatisfactory." It was stated that in such a trial, they would be concerned "not with g/m^2 placed on the ground nor with vapour concentrations as U. S. views suggest but with the number of men placed in hospital."[67]

Not surprisingly, the military found great difficulty in obtaining a steady supply of volunteers, as demonstrated by the following memorandum of May 24 1943 addressed to The Secretary of the Department of National Defence,[68] signed by Brigadier F. M. W. Harvey of Military District 3.

> Physiological Subjects:
> 1. It is requested that Para 2 C (ii) be amended so as to require all Physiological Subjects for the Experimental Station, Suffield to be obtained from Pacific Command.
> 2. Increasing difficulty has been experienced in securing Physiological Subjects from Military Districts 10, 12 and 13, as there are no sources of trained troops or of troops who have not yet completed training.

In Appendix "C" of the Regulations Governing Use of Subjects in Physiological Tests, (Information for the use of officers only in enlisting volunteers), it is stated that "all tests are carried

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[66] Bryden, Deadly Allies, P. 170.

[67] Underlining added by author. LAC Chemical Warfare - Correspondence - Reports - United States-United Kingdom-Canada Chemical Warfare Advisory Committee is still "restricted by law." Details of these discussions were retrieved from NA (UK) WO 188/702.

[68] LAC HQS 4354-9-12, May 24 1943.

out under very careful medical supervision and under scientifically controlled conditions and consequently NO permanent injury is likely to occur."[69] The capitalization was present in the report.

The appalling effects of a massive dose of mustard gas on the human body were demonstrated by an accident which occurred on September 10 1943 involving a young man only identified as Lieutenant "A." He arranged a demonstration of gas for his platoon as part of the day's training programme. He obtained from the local Home Guard some lachrymatory smoke, some ordinary smoke and two mustard gas bombs, which had apparently been given to the Home Guard by a Royal Artillery Regiment about 6 months previously when they had left the area. At 1600 hours when demonstrating one of the gas bombs, he ignited it, but it did not explode. Some 15 minutes later he approached it and kicked it. It then exploded, and he was seen by witnesses to be drenched from head to foot with liquid. He immersed his face in water and applied anti-gas ointment to his face and hands, and then wiped his face and hands with a towel. He subsequently put on a complete change of clothing. He was admitted to hospital, feeling and looking perfectly well, at about 1700 hours on the

[69] LAC HQS 4354-9-12 dated June 5 1945. Chemical Warfare - Experimental Station, Suffield - Physiological subjects – General is still "restricted by law." The reports used here were retrieved from NA (UK) WO 188/812, Minutes of Canadian Chemical Warfare Committee, Chemical Warfare Laboratories Advisory Committee and the Inter-service Working Committee on Chemical Warfare. The claim that "NO permanent injury is likely to occur" is open to serious criticism. Apart from the battlefield results of the First World War, and Porton experiments carried out before 1939, the Chemical Warfare Laboratories Advisory Committee Report of April 28 1944 (CWL-26-2-1) (also "restricted by law") contains a damaging admission based on the work of Fisher, Aldous and Marvel (8/3/44) "The Effects of Mustard Gas on Respiration and Cell Division in the Yeast Cell" that "there is some evidence that the change persists through several generations." Surely this may be construed as an indication that genetic change which "may persist through several generations" is one effect of mustard gas? Yeast cells are commonly used in biochemistry as models for tissues in higher organisms. Note also that at least 37 peer reviewed journal articles were published in 1946 alone on chemical warfare agents, including several dealing with the mutagenicity of mustards and chromosomal rearrangements. See as one example: C. Auerbach and J. M. Robson, "Tests of chemical substances for mutagenic action", Proceedings of the Royal Society of Edinburgh, 1947, v. 62, pp. 284-291. Much of this research was performed during the war years and only released after the war. The summary to the paper by Auerbach and Robson contains a statement: "This work was carried out during the years 1941 to 1944……it was completed in December 1943 when a report was sent in to the Ministry of Supply. Publication was held up owing to the security ban on work with war gases." It would appear that the full body of knowledge available to the wartime scientists, especially information relevant to potential long-term health outcomes of exposure to vesicant agents, was not applied in the conduct of the human experimentation. The Chemical Warfare Laboratories (CWL) maintained a central information service on chemical warfare and related subjects, some 30,000 technical documents having been filed and indexed there. It would be interesting to examine the technical records of the CWL – if available - and determine which wartime reports within the archives contain material relating to chromosomal damage.

same day. After treatment with anti-gas ointment in the hospital (some 15 tubes were used), by 1830 hours he began to have a frequent dry, racking cough and very frequent bouts of vomiting. Each bout was followed by cyanosis of the face and neck. At 2030 hours he was evacuated by ambulance to a Canadian General Hospital-6 1/2 hours after gassing. Some 4 pages of medical description of his unhappy demise, after the passage of 174 hours of systemic breakdown, follow. An autopsy revealed, among other fascinating details, that "the skin of the upper and lower extremities, trunk and abdomen could be wiped off by the gloved hand…. The picture so far [of the condition of his kidneys] is compatible with an acute chemical nephrosis." The comment section of the report stated that "it is regretted that the blood studies were not more complete and more frequent; but it is to be noted, with interest, that the patient showed no diarrhoea, but rather a marked obstipation."

The report further stated "in spite of four years of war and an immense amount of military training there still exists in many places a lamentable ignorance of: (a) the gases themselves and (b) what to do when an accident occurs." In the conclusions section of this report, the statement was made "If this unfortunate officer had been wearing a respirator when the explosion occurred and had immediately stripped off his clothes to the bare skin, he would be alive today." However, the manual Gas Training 1942 – page 62, Para IV explicitly states:

> Precautions when demonstrating mustard gas in pint pots or bottles, steel 1 litre. – when demonstrating the gas, undue precautions on the part of the demonstrator are to be avoided as likely to teach a false lesson; he will therefore, wear no protective equipment apart from eyeshields and application of gas ointment. All ranks present will wear eyeshields.

The author of the formal report, Major A. R. Gordon, R. C. A. M. C., stated that "para 4 should be deleted and the following substituted:

> Precautions when demonstrating explosive blister gas weapons:
> when demonstrating the gas the demonstrator will adjust his facepiece [of his respirator] if it is necessary to approach the bomb for any reason after it has been ignited. If, through an accident, he becomes splashed with blister gas, he will immediately strip to the skin, wash his eyes as taught, for 10 minutes, and proceed

> with Personal Decontamination. This last may be done for him by an assistant, if possible, while the eyes are being washed. All ranks present will wear eyeshields.

This would appear to be an excellent case of perfect hindsight. [70]

Eventually, the Allies began emphasizing field tests that would help them decide whether to initiate offensive gas warfare on the tropical islands of the Pacific Theatre. This decision arose after the American invasion of Betio in the Pacific campaign.[71] The collaboration of the United States, Great Britain and Canada included sharing data from test sites in Australia, India, Suffield, San Jose Island[72] and Bushnell, Florida on the testing and development of chemical weapons. Field data were to be analyzed by the tri-partite Advisory Committee on the Effectiveness of Gas Warfare Materiel in the Tropics.[73]

In the closing months of the war against Japan, the use of chemical warfare against the Japanese homeland was reconsidered. After the German surrender, Britain was no longer a reciprocal hostage to chemical warfare. Gen. William Porter, head of the U.S. Chemical Warfare Service, had reviewed the appalling casualty figures for Iwo Jima and Okinawa and the anticipated cost of the planned invasion of Japan. He concluded there was a better way to overcome the resistance of

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[70] LAC, HQS 4354-29-17-2. For another detailed description of the effects of mustard on an unfortunate family in England see: "A Fatal Case of Mustard Gas Poisoning", F. Bedo Hobbs, M.D., M.R.C.P., D.P.H. Medical Superintendent, Farnham County Hospital, British Medical Journal, September 2 1944.

[71] Betio is an island at the extreme southwest of South Tarawa. The island is most well known as being the scene of the Battle of Tarawa, fought from November 20 to November 23, 1943. It was the first offensive in the central Pacific region. Although the United State's forces were ten times larger than the defending garrison, the Japanese were able to inflict substantial damage upon the U.S. force, including 990 killed and 2296 wounded in the U. S. Marine Corps. These heavy casualties sparked off a storm of protest in the United States, where the high losses could not be understood for such a tiny and seemingly unimportant island in the middle of nowhere. The losses at Tarawa may be explained by the difficulty of coordinating combined amphibious operations, one of the most demanding of military operations. At the time, Tarawa was the most heavily defended atoll invaded by Allied forces in the Pacific. In subsequent island battles the casualties became much worse as mainland Japan was approached. J. H. Alexander, Utmost Savagery: The Three Days of Tarawa, (Naval Institute Press 1995).

[72] San Jose Island, the second largest island of the Las Perlas group in Panama Bay. The recovery and destruction of old chemical weapons from the Allied tests in San Jose is a current source of controversy between Panama, Canada, the U. K. and the U. S. A.

[73] Minutes of meetings of the Advisory Committee on the Effectiveness of Gas Warfare Materiel in the Tropics, March 4, 1944; May 17, 1944; July 19, 1944; and December 7, 1944, found in NARA, RG 175, 290/3/28/142.

Japanese field fortifications. General Porter believed he could kill or incapacitate Japanese soldiers by filling their bunkers and tunnels with mustard gas, phosgene, and other chemical agents. He estimated that the entire Japanese garrison on Tarawa, an atoll that included Betio Island, could have been eliminated with as little as 900 tons of mustard gas, compared to the 3,000 tons of high explosives that had been used, with such little effect.[74] To prove his theory, Porter wanted to conduct chemical warfare experiments in a tropical setting, and military planners quickly seized on San Jose as the perfect location for testing. The island was uninhabited and relatively isolated, yet close enough to mainland Panama, some 60 miles away, to be easily resupplied.[75]

Porter then turned to his colleagues in Canada for assistance. By this point in the war Canadian political leaders probably had to consider what contribution they were willing to make to the final defeat of Japan. With a general election in the immediate future, Canadian Prime Minister King was thinking of the manpower issue and its effects on the prospects for Liberal party re-election. His observations in his diary are cogent:

> I said that Council would recall that when we were deciding on a question of war policy generally and particularly in reference to the Japanese war at the time of the Quebec Conference, it had been agreed in the Cabinet that there should be no conscription for the Army to go to Japan.
> ….. Crerar spoke very strongly against any army going to Japan. He was taken up sharply by Mackenzie, who said that this would be ruinous on the Pacific coast. I pointed out that Mackenzie had misunderstood Crerar, that what he was arguing was not against our making a real contribution as between the different forces but the wisdom of an army force of a size which would necessitate conscription or

[74] NARA RG 175, box 157, 470.6

[75] On December 20, 1943, the US Consul proposed to conduct "certain chemical warfare tests under existing jungle conditions" for 60-day renewable periods on San José Island. The agreement had to be made with both the government of Panama and the island's private owners, a Panama City firm called Huertematte & Co. A rental fee of $15,000 a year was agreed. The United States also sought Panama's consent to build trails and wharves and to incorporate the agreement into the 1942 base agreement signed the year before. The project formally began on January 6, 1944; two days after Panama gave permission to the United States to conduct "chemical warfare tests" on the island. Within days hundreds of Army engineers arrived on the island to clear roads and an airstrip and build the many buildings for operations and housing the project would use. More than 400 enlisted men were stationed on the island by mid-1945, as well as nearly 200 officers and civilians from the United States, Panama and other countries. Many of the Army troops were Puerto Rican soldiers. L. P. Brophy, and G. J. B. Fisher, The Chemical Warfare Service: Organizing for War, (Washington 1959), p. 136.

> which would not be needed for the effort against Japan….. Are not all at this table agreed that there shall not be conscription for the Japanese war?[76]
>
> In this case, I feel that the justice of the whole situation is entirely on our side. Our men have fought for 2 ½ years before the Americans were in the war at all. There is no reason on earth why we should be sending large additional numbers to the Pacific.[77]

As always the problem would be with men for the infantry. Chemical warfare testing and supplies seemed to represent a safe Canadian contribution to the war in the Pacific. Canada had developed a fifty-pound mustard gas cluster bomb, which the U.S. military believed might offer the cheapest and best method of dispersing the chemical. The goals of the San Jose Project and a related test program at Bushnell, Florida,[78] were laid out in a 1943 report by the Canadian Chemical Warfare Inter-service Board. The project would determine just how much gas was needed to produce casualties in tropical terrain ranging from swamp to thick jungle. Scientists also wanted to study how humidity and temperature affected the potency of mustard gas. Canadian and U.S. scientists were interested in two factors they believed made mustard gas ideal for use on the Japanese. The first was that soldiers fighting in the hot Pacific climate tended to wear lighter clothes and expose more skin than did those on European battlefields, giving them less protection against chemicals. In addition, there was a high

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[76] King Diary, April 3 1945. As was the case throughout the war, the question of conscription was paramount and politically something which could not be dealt with. King stated that "it was desirable to keep out of (any) statement either the word conscription or the word volunteer. It had been suggested we might use the term elect to serve in the Japanese war." At some point Macdonald stated that the contribution would have to be "indefinite."

[77] King Diary, April 4 1945. King was also quite confident that the Canadian people would not countenance Canadian men helping Britain in the reconquest of her colonial empire in the Far East. He was probably correct.

[78] From November 1943 to October 1945 the Chemical Warfare Service Mobile Unit, a satellite unit of Dugway Proving Ground, Utah, conducted operations at Bushnell Army Air Field, Bushnell, Florida. Although Bushnell A A Field provided storage and handling facilities to support the test operations, the testing was done in the Withlacoochee Forest 13 miles SE of Bushnell. The first phase of work at the test area consisted of 23 tests of non-persistent gas, primarily phosgene. The second phase, beginning January, 1944 consisted of 358 tests of seven types of mustard gas agents using bombs, rockets, mortars, cluster bombs, land mines, spray tanks and "Comings Candles." Tests included both aerial and static tests. Canvas, rubber products and clothing were placed at test sites and farm animals in cages and large animals were staked at test sites. This is some of the densest swamp in Florida, with a few hummocks of high and dry ground. It is also directly above the Floridan Aquifer, the source of drinking water for millions of Floridians.

probability of secondary infections in the tropics. It might take months for the blisters caused by mustard gas to heal.

> It is well known that the slightest scratch or skin injury rapidly becomes infected unless great care is taken. It is probable that any injury produced by mustard gas would be similarly infected, thus delaying healing, and increasing hospitalization.[79]

With Canada and Britain agreeing to participate in the project, one of Porter's senior officers, Brig. Gen. Alden Waitt, went to Ottawa in January 1944 to outline the American plan.[80] Waitt was particularly interested in the Canadian cluster bomb which was to be tested on San Jose. He believed the weapon offered great potential for saturating the jungle with chemicals. "We are very interested in contaminating large areas of ground for a very long time," he told his Canadian counterparts.[81]

The U.S.-led test program, employing 400 soldiers and scientists working at a newly constructed base on the island, began in May 1944. The Canadians were aware that the Americans had difficulty in carrying out casualty tests on their own soldiers and offered one hundred Canadian soldiers as "volunteers."[82] The experiments covered a wide range of scenarios. Soldiers wearing backpacks with spray cylinders[83] projected cyanogen chloride (CK) or hydrogen cyanide (AC) gas into bunkers built to simulate Japanese fortifications, where unprotected goats were tethered to wooden stakes and exposed to the gases. The goats all died. Another experiment used goats to test the relative merits of Japanese and American gas masks. Exposed to CK or AC, an unprotected animal

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[79] Minutes of the 27th Meeting of the Canadian Chemical Warfare Inter-service Board, December 10 1943.

[80] By early 1944 the end of the European war was in sight. The invasion of Normandy was scheduled for June 1944.

[81] Remarks to the Canadian Chemical Warfare Inter-service Board, Brig. Gen. Alden Waitt, January 13 1944.

[82] LAC, Canadian Chemical Warfare Inter Service Board, December 10 1943 is "restricted by law." Minutes retrieved from NA (UK) WO 188/812.

[83] Jet, Anti-Tank, Mark 1. See NA (UK) AVIA 15/896 for a photograph of this weapon for use against the Japanese. Cyanogen chloride is a highly toxic blood agent, as is hydrogen cyanide. Hydrogen cyanide (under the brand name Zyklon B) was perhaps most infamously employed by the Nazi regime in the Second World War. This is also the poison that Adolf Hitler used to commit suicide on April 30 1945.

and the animal wearing a Japanese mask quickly died. Unfortunately one goat wearing a Japanese small canister mask survived while another wearing an American M1XA2 mask died![84] Throughout the experiments, scientists sampled the atmosphere inside the bunkers and concluded that total dosages of CK sufficient to "break through" all types of Japanese canisters and deliver lethal dosages of CK for man were obtained in all the trials.

American and Canadian aircraft dropped mustard gas bombs on specific ground targets, after which troops clad in protective clothing were ordered to march through the contaminated area. The U. S. soldiers were exposed only if fully protected, except for patches cut out of the protective suits to expose their skin to the gas. In August 1944, the experiments took a strange turn. The scientists wanted to determine if different races would react differently to mustard gas. Military officials believed the skin of non-whites might be tougher than that of Caucasians and better able to resist the effects of mustard.[85] If that were proven, then non-white troops would be used during gas attacks. Because African-Americans were not allowed in front-line combat units at the time, it was decided to conduct tests on Hispanics. Between August 9 and August 15 1944, several tests were done to "determine if any difference existed in the sensitivity of Puerto Rican and continental U.S. troops to H [mustard] gas," according to a San Jose report. [86] A preliminary experiment involved exposing ten soldiers from each group. That was followed by a test involving forty-five Puerto Ricans and forty-

[84] LAC 4354-31-2: 15th communiqué from San Jose to Mr. E. Ll. Davies from Lt. Col. Walter Sommerville. The death of the goat wearing the American mask was attributed to a "leaking facepiece." Perhaps goats were not intended to wear gasmasks? In a later experiment the goat with the American mask survived.

[85] Interestingly enough, the British had already carried out similar tests in British India before the Second World War. In 1934 an experiment was carried out with 60 Indian and British soldiers. Further, the British were interested to find out if the susceptibility of the Europeans to gas was correlated with length of service in India. NA (UK) WO 188/640 and 641, Periodical reports, 1935-1940, reports 13-17 of the Chemical Defense Research Department (India).

[86] Minutes of meeting of the Advisory Committee on the Effectiveness of Gas Warfare Materiel in the Tropics, December 7, 1944, in NARA, RG 175, 290/3/28/142.

four Caucasians. Mustard was put on the forearms of the soldiers, who were then observed for three days. The tests showed no difference. Both groups suffered equally and their skin was burned.

Early in 1945 the San Jose experiments gained new importance as more senior officers in the U.S. military began considering the use of chemical weapons against the Japanese, especially after the death of President Roosevelt on April 12 1945. Although none of the Allied nations wanted to be the first to use chemicals, U.S. casualty figures from the invasions of Pacific islands were extremely high and Japanese resistance had stiffened as the Allies drew closer to the home islands.[87] "You can cook them better with Gas" the Chicago Tribune announced on March 11 1945.[88] An Army project, SPHINX, tested gas against fortified cave defenses, leading General Porter to conclude that gas was the "most effective weapon for the penetration and reduction of caves and underground fortifications."[89] Even more appalling was the prospect revealed in a recently declassified plan to mount a massive poison-gas attack on Japan which would start with the drenching of much of Tokyo with gas. The other twenty-four target cities were to includeYokohama, Osaka, Kobe, Nagoya, and Kyoto.

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[87] Comparative casualty data from Pacific islands invaded are: Biak Island 2,500; Peleliu 10,000; Iwo Jima 26,000; Okinawa 39,000. These totals include killed and wounded. Most of the Japanese soldiers were killed. As the Allies came closer to mainland Japan, the casualty total increased. More people are believed to have died during the Battle of Okinawa than all those killed during the atomic bombings of Hiroshima and Nagasaki. Casualties totalled more than 38,000 Americans wounded and 12,000 killed or missing, more than 107,000 Japanese and Okinawa conscripts killed, and perhaps 100,000 Okinawa civilians who perished in the battle. In the two month battle for Okinawa, the Japanese flew 1,900 kamikaze missions, sinking dozens of Allied ships and killing more than 5,000 U.S. sailors. Although Allied land forces were entirely composed of U.S. units, the British Pacific Fleet (BPF; known to the U.S. Navy as Task Force 57) provided about 21% of Allied naval air power. The fleet was a combined British Commonwealth carrier group with British, Canadian, New Zealand and Australian ships and personnel. Their mission was to neutralize Japanese airfields in the Sakishima Islands and provide air cover against Japanese kamikaze attacks. For details see: D. M. Giangreco, "Casualty Projections for the U.S. Invasions of Japan, 1945-1946: Planning and Policy Implications", The Journal of Military History, v. 61, n. 3. (1997), pp. 521-581.

[88] Editorial Chicago Tribune, March 11 1945. The editorial supported its position with a short review of the history of gas warfare, and presented the opinion of a number of historians who claimed that the Germans could have won the First World War if they had exploited the tactical surprise which they gained through the initial use of chlorine gas at Second Ypres in April 1915. Which they did not! Such speculations are fascinating, but perhaps not history?

[89] "Project SPHINX: the question of the use of gas in the planned invasion of Japan", John Ellis van Courtland Moon, Journal of Strategic Studies, v. 12, n. 3, 1989, pp. 303–323.

> The plan was to launch the gas attack on Tokyo at eight o'clock in the morning when the greatest number of people would be concentrated in the city. …….Mustard gas …. Would be used against Yawata, Wakamatsu, and Kokura, a highly industrialized area….Liquid mustard gas was particularly selected for those cities because it is readily absorbed by wood which is almost impracticable to decontaminate. And since most Japanese cities are congested predominately with structures which are low and wooden….[90]

This report proposed the killing of enemy civilians on a scale unprecedented in the Second World War. Thus Canadian support of chemical warfare in the Pacific, as a means of reducing Canadian commitments in that theatre, might have led to an unforeseen involvement with a mass killing of civilians beyond anything previously seen in the Second World War. But all of these considerations were rendered moot in August 1945, when the atomic bombs dropped on Hiroshima and Nagasaki bringing the Second World War to a close. Racism was clearly a factor in the decision making for the Pacific war. This was demonstrated by the words of Mackenzie King:

> It is fortunate that the use of the bomb should have been upon the Japanese rather than the white races of Europe.[91]

[90] T. B. Allen and N. Polmar, "Gassing Japan", The Quarterly Journal of Military History, v. 10, n. 1,1997, pp. 38-43. Lest the reader believes that the British were more humane regarding the potential gassing of Japan, NA (UK) CAB 80/85/84 Employment of Chemical Warfare in the War against Japan, Interim Report by the Inter-Services Committee on Chemical Warfare, July 27 1944 may serve as a corrective.

[91] King Diary, Monday August 6 1945. Further, "The only language [the Japanese] seems to understand is the one we have been using to bombard them. When you have to deal with a beast you have to treat him as a beast. It is most regrettable but nevertheless true." Taken from a letter by President Truman, justifying the decision to drop the atomic bombs on Hiroshima and Nagasaki. The fact that Japan was always the target, and that Nazi Germany was not considered, demonstrates a potent double standard in Anglo-American foreign policy. And the basis of that double standard was the issue of race. To the Allies, Germany was a fellow white power with which they had temporarily fallen out. But Japan was an enemy alien, a nation apart. That was why the architects of the Holocaust in Europe were never mentioned as candidates for a bombing such as Hiroshima. Instead, the atomic bomb was aimed solely at the Japanese. They were considered legitimate targets because the Western powers considered them to be a lower race.

Chapter 4

Conclusions

> To us of this day, the result of this part of the war seems a foregone conclusion. It was far from being so; and very far from being so regarded by our forefathers.[1]

During the course of the Second World War Canadian defence research scientists collaborated with the United Kingdom on many war technologies including radar, gun laying, explosives, proximity fuses, nuclear research, biological and chemical warfare, ballistics and aviation medicine. From 1939 to 1942 Canada, allied to the United Kingdom, prepared to defend itself against chemical attack by Nazi Germany. The Canadian chemical war preparations represented one of Canada's many contributions to the cause of the Commonwealth and may have been used in an analogous manner to the British Commonwealth Air Training Plan, to deflect pressure from Britain for large numbers of ground troops, a request which was politically impossible for Canada to fill. The conclusions regarding Canadian defence science and Allied military technology are summarized by Stacey. He states that it was a contribution – a share, and necessarily in most cases not a major share, in a great and complicated joint effort. He further points out that many Canadian projects were closely related to British ones and were essentially adaptations or developments of ideas or devices on which much British work had already been done. [2]

After the Japanese attack at Pearl Harbor, Canada became part of a coalition with the United States and the United Kingdom.[3] This alliance not only prepared for defensive chemical war, but was

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[1] F. Parkman, Montcalm and Wolfe, vol. 1 (Boston 1914), p. 3.

[2] C. P. Stacey, Arms, Men and Government, the War Policy of Canada, 1939-1945, (Ottawa 1970) p. 512.

[3] Through the United Kingdom and the overseas Empire, Australia, New Zealand and India were also involved in chemical warfare research. The reach of Porton was world wide.

prepared to use chemical weapons to attack the Japanese if they landed on the North American west coast. Canadian offensive chemical warfare preparations included preparation and testing of toxic gases and smokes, smoke screening and flame weapons. The chemical weapons produced in Canada were essentially the same as those constructed by the British and the Americans. Smoke screening and flame weapons were widely employed by Canadian troops in all active theatres of operations during the course of the Second World War. Poison gases were never used by Canada during this war. Canadian preparations for offensive gas warfare were principally directed against the Japanese.

One of the most important Canadian contributions to the alliance was the establishment of the Suffield Field Experimental Station in Alberta. This base was particularly useful in carrying out chemical weapon trials, in which approximately 2000 Canadian soldiers were exposed to mustard gas.[4] Many were sprayed with this gas from aircraft. At the beginning of the war Canadian chemical warfare volunteers (observers to the British) were completely covered in protective clothing except for a patch to allow for controlled mustard burns. But by 1942 Suffield staff had rewritten the regulations for the trials, and volunteers often received significant chemical injuries, including to the eyes and genital region. Records of these weapons trials on Canadian soldiers are difficult to obtain in Canada, most being restricted by law. Many records, however, are available through the National Archives of the United Kingdom (NA (UK)), and the National Archives and Records Administration of the United States (NARA). The continued release of previously unavailable records, especially in the United Kingdom,[5] suggests that a continuation of the study of Canadian chemical warfare activities during the Second World War may prove fruitful. For example, animals were used extensively in chemical warfare trials at Suffield, yet no records are to be found at Library and

[4] Library and Archives Canada [hereafter LAC], file 4354-26-10-1
[5] Records of the Chemical Defense Research Establishment (CDRE) at Porton in the United Kingdom have recently become available at NA (UK), as a result of legal action in the U. K.

Archives Canada (LAC)) relating to such trials. Inquiries to senior veterinary scientists[6] throughout Canada, and a comprehensive examination of all veterinary journals in North America from 1940 to 1968 produced no records of the use, and subsequent euthanization, of animals during chemical warfare trials in Canada. However the records of the NA (UK) list files dealing with chemical warfare and animals, including photographs.[7] Interviews with veterans of the chemical warfare trials were not attempted, due to a pending class action lawsuit against the Canadian government.[8]

The military usefulness of poison gases such as mustard is, surely, due to the reality that they damage or kill human beings. The most effective way to find out how these chemicals damage people is to expose men to them under warlike conditions in experiments. The scientific argument may be that the data obtained in these trials could not have been obtained in any other manner, which may be true. It is also true that the experiments carried out at Suffield - and elsewhere - by the Canadians and their allies did extend the understanding of the military value of several poison gases and developed techniques to deliver them on a battlefield. The full price however was paid by the Canadian volunteers, who in many cases were subjected to severe pain and damage, and in some cases may have suffered chronic illnesses later in life as a result of chemical testing. Surely, by the beginning of the war, the British scientists at Porton must have known that mustard gas could cause chronic lung diseases such as bronchitis, especially as the British government was paying pensions for gassed soldiers from the First World War.

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[6] For example, Dr. J. M. Stookey, University of Saskatchewan; Dr. E. Olfert, University of Saskatchewan; Dr. D. MacDonald, historian of Alberta Veterinary Medical Association and Dr. I. Barker, Guelph University. The Manager, Communications and Member Services of the Alberta Veterinary Medical Association informed the author that of the veterinarians who have published historical information, three are deceased. Further, prior to the establishment of the Western College of Veterinarian Medicine at the University of Saskatchewan, all veterinary graduates achieved their DVM degrees from Guelph, except a few who came from the United States. The Royal Canadian Army Veterinary Corp was disbanded in 1940, before significant chemical warfare experimentation took place.

[7] WO 188/1256 Organisation of veterinary gas service: chemical warfare and animals.

[8] http://www.merchantlaw.com/backgnd.pdf

Canadian scientists were aware of the possibility of mustard exerting a mutagenic effect on cells early in the war. This is another area of Canadian chemical warfare testing which should be pursued, as the Canadian Chemical Warfare Laboratories were the repository of much of the Allied chemical warfare scientific research during the Second World War, and may contain scientific data published after the war in the open literature. Such data would confirm that the directors of the Canadian Chemical Warfare Service should have been aware of the possibility of long-term harm to Canadian soldiers used in the tests.

The appalling and unforgivable experiments perpetrated by Nazi doctors and scientists – and the conveniently forgotten equivalents carried out by Japanese scientists in China[9] – in the extermination camps during the Second World War led to the Nuremberg Code[10], the first major attempt to establish a universal set of ethics to control human experimentation. The details of the Nazi experiments were revealed during the war crimes trials and, fortunately for them, the Allies were not required to reveal their own chemical warfare experiments to a horrified world in a similar manner. Perhaps the reluctance of governments to release the details surrounding their chemical warfare tests gives an indication of how controversial and disturbing such experiments are perceived to be today? However the ethics of the chemical warfare experiments must surely be judged by the standards and circumstances of the time. A destructive and total war was being waged, and the Allies faced a very dangerous threat from the Nazis and the Imperial Japanese. Few even today would argue that war and peace are the same - wartime is different. What needed to be done to protect the nation, had to be done. Many probably regarded ethics as a nicety at the time. After all, is war not a

[9] For an introduction to this subject see: S. H. Harris, "The American Cover-up of Japanese Human Biological Warfare Experiments, 1945-1948", in R. M. MacLeod, ed., Science and the Pacific War, (New York 2000) pp. 253-269. Japan paid nearly $3 million to China after poisonous gas from old Japanese chemical weapons killed one man and injured dozens in August 2003. The poisonous gas was left in barrels in China by the Japanese Imperial Army after World War II. Japan is working to remove from China all remaining 700,000 chemical weapons (Tokyo October 20 2003).

[10] "Trials of War Criminals before the Nuremberg Military Tribunals under Control Council Law No. 10", v. 2, pp. 181-182. (Washington 1949).

murderous and immoral activity? Most Canadians would surely believe that whatever the rights or wrongs of the decisions to carry out chemical warfare experiments with fellow Canadians who volunteered, any one of the subjects who subsequently received injuries of a long-term nature from the tests should be adequately compensated for their injuries. The impression one receives concerning such compensation in Canada is that it has been a long and uphill fight.[11]

The Second World War turned out to be the unfought chemical war for Canada and its allies. Apart from a disastrous release of mustard gas at Bari in Italy in December 1943 as a result of a German air raid, there was virtually no battlefield release of poison gas during the Second World War.[12] The largest use of poison gas must have been the Nazi use of Zyklon B (HCN) to murder large numbers of human beings in extermination camps. On two occasions during the latter part of the war serious consideration was given by Allied war leaders for the use of poison gas against the enemy. After the Normandy landings in 1944 the Nazi military bombarded south-east England, London and Antwerp with the first of the "vengeance weapons" the V-1.[13] In July 1944, Prime Minister Churchill, anxious to retaliate against the German V-1 (and later V-2) attacks, directed his military advisers to

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[11] See http://www.vac-acc.gc.ca/general/sub.cfm?source=department/press/chem_dnd_back for the Canadian government approach to the situation. Similar programmes exist in Australia and the U. K. The Canadian government is currently being sued by veterans exposed to chemical agents: See http://www.cbc.ca/canada/saskatchewan/story/2006/11/09/chemical.html for the case of a Saskatchewan veteran.

[12] On December 2 1943, the port of Bari was crowded with 30 Allied ships. An air raid was carried out by Nazi German bombers. In the attack, 20 German Junkers Ju 88 bombers achieving complete surprise, bombed Allied shipping and personnel operating in support of the Allied Italian campaign, sinking 17 cargo and transport ships in Bari harbour. Of the ships destroyed, the John Harvey was carrying a cargo of about 100 thousand kilograms of mustard-gas bombs. Much of the mustard gas was released into the water and some of it dissolved in the floating oil. There were over 1,000 military and merchant marine casualties, some 800 were admitted to local hospitals. 628 suffered from the mustard gas, of whom, 69 died within two weeks. Medical treatment was handicapped by a lack of awareness of the presence of the mustard gas bombs. After the attack, Allied leaders, including Eisenhower, Roosevelt, and Churchill ordered that the full story of the disaster be kept secret. The U.S. records of the attack were declassified in 1959 but the episode remained obscure until 1967. In 1986 the British government admitted to Bari raid survivors that they had been exposed to mustard gas and amended their pension payments accordingly. R. Atkinson, The Day of Battle: The War in Sicily and Italy, 1943-1944. (Henry Holt 2007).

[13] Between June 1944 and March 29 1945, the V-1 was fired at targets in south-eastern England and Belgium, specifically London and Antwerp. On June13 1944, the first V-1 struck London next to the railway bridge on Grove Road, Mile End. Eight civilians were killed in the blast. The V-1 was the first cruise missile.

evaluate dispassionately "the question of poison gas."[14] Churchill warned that "We could drench the cities of the Ruhr and many other cities in Germany in such a way that most of the population would require medical attention."[15] The Chiefs of Staff advised against initiating chemical war. Churchill grudgingly gave way, commenting: "clearly I cannot make head against the parsons and the warriors at the same time."[16] As the Nazi military had discovered two nerve agents before the war, and stockpiled munitions filled with tabun, of which the Allies were unaware, the decision was perhaps fortuitous![17]

In the final months of the war against Japan, the case for using chemical weapons was reopened by the American CWS and General William N. Porter.[18] Because of its predictable wind patterns and several other factors, Japan was particularly vulnerable to gas attack. Such attacks would neutralize the Japanese tendency to fight from caves - caves would only increase the soldiers' exposure to gas. Although chemical warfare had been outlawed by the Geneva Protocol, neither the United States nor Japan was a signatory at the time. While the United States under President Roosevelt had promised never to initiate gas warfare, Japan had used gas against the Chinese earlier in the war. By the summer of 1945, however, President Roosevelt was dead and the war in Europe was over. A new and inexperienced president had to make a decision with respect to an invasion of

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[14] Winston S. Churchill to the COS, July 6 1944, National Archives of the United Kingdom [hereafter NA (UK)], Premiers Office [hereafter PREM] 3/89.
[15] Ibid.,

[16] Ibid., Churchill to General Ismay, July 29 1944.

[17] Tabun and sarin were two nerve agents available to the Nazis. Only tabun was produced in quantity by the end of the war. These chemicals are liquid at room temperature and are a class of phosphorus-containing organic chemicals (organophosphates) that disrupt the mechanism by which nerves transfer messages to organs. The disruption is caused by blocking acetylcholinesterase, an enzyme that normally relaxes the activity of acetylcholine, a neurotransmitter. Allied respirators would have offered little if any protection against these agents.

[18] National Archives and Records Administration of the United States [hereafter NARA], Memorandum, Major General William N. Porter to Director, New Development Division, Subject: The Use of Gas against Caves, July 13 1945, Operations Planning Division 385, Chemical Warfare Planning, Box 120. See also "Project SPHINX: The Question of the Use of Gas in the Planned Invasion of Japan", John Ellis van Courtland Moon, The Journal of Strategic Studies, v. 12, n. 3, 1989, pp. 303–323.

Japan. The use of chemical weapons during such an invasion was one of several equally repellent options, including eventually, the use of the atomic bomb.[19] Canadian chemical weapons represented an apparently safe Canadian contribution to the war in the Pacific. Canada had developed a fifty-pound mustard gas cluster bomb, which the U.S. military believed would offer the cheapest and best method of dispersing the chemical. It is unlikely that the use of chemical weapons would have remained restricted to tactical purposes in the event of an invasion of Japan. If cities had been fortified and turned into battlefields, it is likely that they too would have been gassed, with appalling casualties.[20] Canada would then have been associated with the mass killing of civilians, in the eyes of a critical posterity. Such a chemical Armageddon, thankfully, never took place.

In October 1945 George Merck, a consultant of the American Secretary of War, had prepared a summary of the research involved in the American combined biological/chemical warfare programme operated by the U. S. Chemical Warfare Service.[21] It contained only a passing reference to the Canadian (and British) contributions to chemical (and bacteriological) warfare preparations, a fact which angered the Canadian chairman of the Directorate of Chemical Warfare and Smoke, Otto Maass. He felt that the Americans were taking all the credit and ignoring the Canadian contribution. In spite of all protests by Maass, the Americans informed him that the Canadians (and the British) could say whatever they wanted, but the Americans were using the Merck report.[22] Maass was clearly a scientist and never a politician! The final decision regarding public release of information regarding

[19] One of the great historiographical arguments of modern America concerns generally the defeat of Japan and specifically the use of the atomic bombs. The first (plutonium) atomic bomb in history was detonated at the Alamogordo Test Range on July 16 1945. It was not certain that this weapon would work until this test had been carried out. The first uranium bomb was ready for use against Japan in August 1945. The military planners of the invasion of Japan took no note of the bomb in their plans. J. R. Skates, The Invasion of Japan Alternatives to the Bomb, (South Carolina 1994).

[20] T. B. Allen and N. Polmar, " Gassing Japan", The Quarterly Journal of Military History, v. 10, n. 1, 1997, pp. 38-43.

[21] NARA Merck report, RG165, Entry 488, Box 182.

[22] J. Bryden, Deadly Allies: Canada's Secret War 1937-1947, p. 233-234, (Toronto 1989).

Canadian chemical warfare (and biological warfare) lay with Mackenzie King and the Cabinet War Committee. Given the distaste of King and his political associates for chemical warfare, it was not surprising that little information was released to the public. In all probability King and his advisors were content to allow the entire Canadian chemical (and bacteriological) warfare programme to disappear into the mists of time. Most Canadian chemical weapons were dumped in the oceans on both the east and west coasts of Canada, where they are currently a source of considerable environmental concern.[23] This was common practice after both of the wars.[24]

By 1947 the Defence Research Station at Suffield had become the responsibility of the Canadian Defence Research Board.[25] The Allied chemical warfare communities which were at that time concerned with investigating the German nerve agents recognized the need for continued cooperation, especially as the "cold war" developed.[26] A formalized tripartite co-ordination of research in chemical warfare began in 1947. Human testing of chemical weapons such as the nerve agents sarin and VX gas continued well into the 1960s, and dangerous defoliation agents were tested at Canadian Forces Base Gagetown from 1956 to 1967. These tests left Canada with large stockpiles

[23] See the Proceedings of the Standing Senate Committee on Fisheries and Oceans Issue 13 – Evidence, Ottawa, September 30 2003 for a discussion of the dumping of munitions. In February 1946, a barge containing 2,800 tons of mustard gas and 10,219, 45-gallon drums was scuttled off of Sable Island. Access to Information requests identified the location as 42 degrees, 50 minutes north by 60 degrees, 12 minutes west — only 30 kilometres from a present-day oil exploration site. Secrecy about the existence and disposal of chemical weapons is still strong in Canada. In 1984, following reports of injuries and death of members of a Danish fishing crew who had been exposed to mustard gas from leaking grenades that were hauled up in their nets off the coast of Denmark, Canada's Department of Transport Deputy Minister Withers asked National Defence to investigate if this could ever be a problem for our country's fishermen. One reply from DND stated, "No such items were known to have been disposed of by Canada."

[24] From the time of the First World War until 1972 it was thought that the vastness of ocean waters would absorb chemical agents that might leak from chemical munitions and render the chemical compounds harmless through dilution and chemical reactions. However, public concerns about human health and environmental risks, and the economic effects of potential damage to marine resources, in addition to increasing access to even deep ocean waters for resource exploitation led to a statutory prohibition on the disposal of chemical weapons in the ocean in 1972. This of course does not address the problem of munitions which have already been disposed to the oceans. The lack of coordinates for most of the disposal sites, and the possibility that ocean currents may have moved weapons beyond these areas, makes finding the weapons difficult at best, if not impracticable in many cases.

[25] Dinosaurs to Defence: A Story of the Suffield Block, BATUS and others (London 1986)

[26] The Cold War was the period of conflict, tension and competition between the United States and the Soviet Union and their respective allies from the mid-1940s until the early 1990s.

of chemical weapons. Canada eventually abandoned the use of lethal chemical weapons, and developed methods to safely destroy them. It presently assists other nations with constructing facilities to safely destroy their chemical arsenals.[27] Canada ratified the Chemical Weapons Convention on September 26 1995. However, its government still employs riot control agents which are classified as chemical weapons.

[27] http://www.opcw.org/pressreleases/2006/PR48_2006.html

APPENDIX A **Industrial manufacture of mustard gas**

If mustard gas is to be used as a war gas, the preparation must obviously be on a very large scale. Mustard gas may be prepared industrially by several processes, all of which are based on one of two basic methods: Meyer's and Guthrie's. The various stages of manufacture by Meyer's process, which is often referred to as “the German process," as it was largely employed during the First World War by Germany, may be schematically expressed as follows:

(*a*) Preparation of Ethylene :

$$C_2H_5OH = H_2O + CH_2 = CH_2.$$

(*b*) Preparation of Ethylene Chlorohydrin :

$$Ca(ClO)_2 + H_2O + CO_2 = CaCO_3 + 2HClO$$
$$CH_2 = CH_2 + HClO = Cl.CH_2.CH_2.OH$$

(*c*) Preparation of Thiodiglycol :

$$\begin{matrix} OH\text{–}CH_2\text{–}CH_2\text{–}Cl \\ OH\text{–}CH_2\text{–}CH_2\text{–}Cl \end{matrix} + \begin{matrix} Na \\ Na \end{matrix}\!\!\rangle S = 2\,NaCl + S\langle\!\!\begin{matrix} CH_2\text{–}CH_2\text{–}OH \\ CH_2\text{–}CH_2\text{–}OH \end{matrix}$$

Clearly if ethylene gas were available as a by-product of the petroleum industry, as it was in Canada during the Second World War, the process would be greatly simplified as step (a) would be eliminated and ethanol, which had significant strategic value would not have to be used.

(*d*) Preparation of Dichloroethyl Sulphide :

$$S\langle\!\!\begin{matrix} CH_2\text{–}CH_2\text{–}OH \\ CH_2\text{–}CH_2\text{–}OH \end{matrix} + 2\,HCl = 2\,H_2O + S\langle\!\!\begin{matrix} CH_2\text{–}CH_2Cl \\ CH_2\text{–}CH_2Cl \end{matrix}$$

Guthrie's method, which was used by the Allies during the First World War, and is, therefore, referred to as “the Allied process," consists simply in acting on sulphur chloride with ethylene:

$$2\ CH_2{=}CH_2 + SCl_2 = S\begin{matrix}CH_2{-}CH_2Cl\\ CH_2{-}CH_2Cl\end{matrix}$$

$$\text{or else :}\quad 2\ CH_2{=}CH_2 + S_2Cl_2 = S\begin{matrix}CH_2{-}CH_2Cl\\ CH_2{-}CH_2Cl\end{matrix} + S$$

Meyer's Method*:*

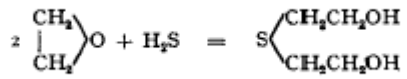
Preparation of Ethylene Chlorohydrin

This reaction is carried out in large cylindrical iron pans, lined with lead and coated externally with cork. 5 cu. m. (1,100 gallons) of water and bleaching powder equivalent to 500 kg of active chlorine is placed in this vessel and while stirring well a current of carbon dioxide is introduced in order to liberate part of the hypochlorous acid. After about 20 minutes, ethylene instead of carbon dioxide is introduced to saturation point and finally carbon dioxide and ethylene simultaneously until all the hypochlorite has reacted. The reaction should be carried out at as low a temperature as possible, between 5° and 10° C , the reaction mixture being cooled by circulating a cooling mixture through coils. After the ethylene has been absorbed, the reaction products are pumped through a filter-press to remove the calcium carbonate and the filtrate, which contains from 10 to 12% ethylene chlorohydrin, is distilled in steam so as to obtain a solution containing 18-20% of the chlorohydrin.

Preparation of Thiodiglycol

The theoretical quantity of sodium sulphide is added to the chlorohydrin solution, prepared as already described, and the mixture heated to about 90° to 100° C, the product being drawn over into an evaporator and again heated to remove all the water. The thiodiglycol formed is filtered, and distilled in vacuum.

NOTE. According to Nenitzescu, the preparation of thiodiglycol may be carried out by reacting ethylene oxide with hydrogen sulphide at 40° to 60°C in presence of a small quantity of thiodiglycol which acts as a solvent for the two gases.



This method gives a yield of 90%.

Preparation of Dichloroethyl Sulphide

The chlorination of thiodiglycol is carried out in cylindrical cast-iron pans, 2.5 m. in height and 2.8 m. in diameter, lead-lined and jacketed so that the reaction mass may be heated and cooled. The hydrochloric acid necessary for the chlorination is first passed through sulphuric acid and then introduced into the thiodiglycol as slowly as possible so as to obtain complete absorption. During the reaction the temperature is held at about 50° C. Two layers form in the pan, a heavy oily one consisting of a solution of dichloroethyl sulphide in thiodiglycol and an upper one consisting of an aqueous solution of hydrochloric acid. At the end of the reaction, the oily layer is drawn over into a lead-lined iron vessel fitted with lead coils for heating and a condenser, also constructed of lead, connected to a vacuum pump. The water is removed by distillation under reduced pressure (60-70 mm.) and the residual liquid then treated in a mixer with suitable solvents.

Guthrie's Method (the Allied Process).

This method, comparatively simple for preparing small quantities of dichloroethyl sulphide in the laboratory, presented considerable technical difficulties when first used on the industrial scale. These were later overcome by the efforts of British and American chemists. Compared with the Meyer process, the Guthrie method allows the product to be prepared more rapidly and in better yield, but it requires careful control during the course of the reaction. Several systems of manufacture were proposed and actually employed during the First World War for the preparation of dichloroethyl

sulphide by this process. The most successful procedure in practice was that of Levinstein[1] which was used by the Allies. Hence the term 'Levinstein Mustard'.

The preparation of dichloroethyl sulphide by this method was carried out in a cylindrical vessel of sheet steel or cast-iron, lead-lined and jacketed, of about 100 cm. diameter and 130 cm. in height, fitted with an agitator. This vessel has a lid through which a pipe passes to within a short distance of the bottom in order to introduce the ethylene

Sufficient sulphur monochloride to cover the end of the tube is first placed in the vessel and then ethylene is bubbled in, so arranging the speed of its introduction and the cooling that the temperature of the reaction mixture remains at 30° to 35° C. Meanwhile more sulphur monochloride is added in small portions. Employing 430 kg of ethylene, which needs 750 kg of sulphur chloride, the reaction is completed in about 20 hours.

Appendix B The Chemistry of Mustard Damage and the Nature of Ointments.

Mustard gas is the organic compound described with the condensed formula $(ClCH_2CH_2)_2S$. It has several other names both chemical and trivial. Mustard gas may be synthesized by a number of methods including treating sulfur dichloride with ethylene (the Levinstein process, as described in Appendix A). This method results in a product contaminated by polysulphides.

$$SCl_2 + 2\ C_2H_4 \rightarrow (ClCH_2CH_2)_2S \qquad \text{Equation 1.}$$

Although the compound is commonly known as "mustard gas", it is a viscous liquid at ambient temperatures. The pure compound has a melting point of 14°C (57°F) and decomposes before boiling at about 218 °C (423 °F). If it is to be distilled the process requires reduced pressure (vacuum distillation). Mustard readily eliminates chloride ion by intramolecular nucleophilic substitution to

[1] Dr. Herbert Levinstein, president of the British Institute of Chemical Engineers. Levinstein was considered the Empire's leading expert on war gases. Although entering late into the field of chemical warfare production, Doctor Herbert Levinstein, Professor A. G. Green, and their collaborators of the firm of Levinstein Limited were able to rapidly develop a successful industrial mustard gas process which was of considerable assistance to Britain and America during the First World War.

form a cyclic sulfonium ion. This very reactive intermediate tends to bond to the guanine nucleotide in DNA strands, which is detrimental to cellular health. This alkylation leads to either cellular death or perhaps cancer. Mustard gas is sparingly soluble in water but is very soluble in fat and oils, contributing to its rapid absorption into human skin.

The British and Canadian ointments were an attempt to destroy the mustard by chemical reaction with the strong base and oxidizing agent bleaching powder (or chloramine-T) dispersed in Vaseline™, when the mustard was on the skin. They were ineffective as some of the mustard had usually penetrated and reacted with human skin before any ointment could be applied. The American ointment Impregnite S-330 containing guanidine carbonate (or nitrate) was probably an attempt to make reactive NH_2 groups of the guanidine moieties available for the mustard to react with, instead of reacting with the base groups on DNA molecules. Perhaps the guanidine could be regarded as a cutaneous chemical scavenger for mustard? Figure 2 shows a schematic model of guanidine carbonate (CAS 593-85-1). Six base groups would be available for reacting, while the carbonate would be able to react with the HCl produced by the mustard. Guanidine is formed in urine as a normal product of protein metabolism in the body, by the oxidation of guanine.

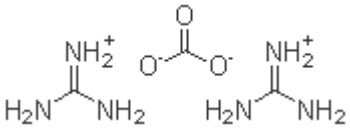
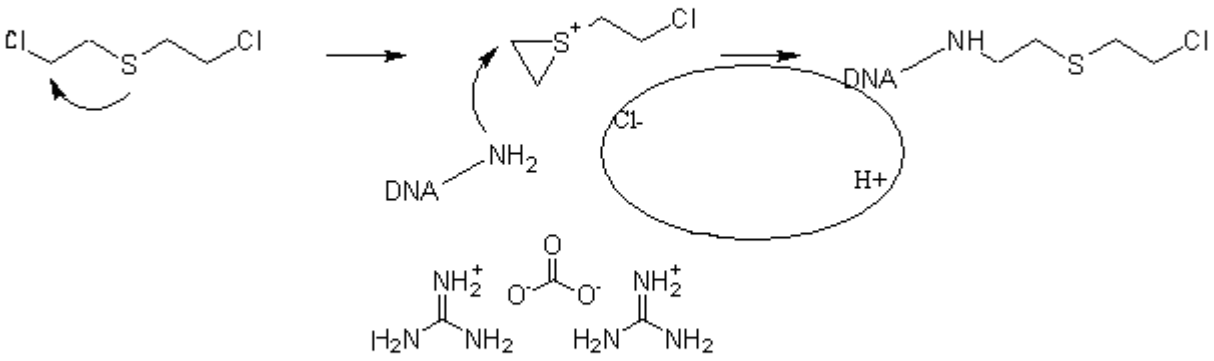


Figure 2 Guanidine carbonate (Taken from ChemBlink)

Figure 3 Mechanism of formation of mustard gas-guanine adduct and hydrochloric acid. Guanidine as a potential reactant for the mustard is also shown.



In the wider sense, compounds with the structural element BCH_2CH_2X, where B is any leaving group and X is a Lewis base are known as mustards. Such compounds can form cyclic "onium" ions (sulfonium, ammoniums, etc.) that are good alkylating agents. Examples are bis (2-chloroethyl) ether, the (2-haloethyl) amines (nitrogen mustards), and sulfur sesquimustard, which has two β-chloroethyl thioether groups (ClH_2C-CH_2-S-) connected by an ethylene (-CH_2CH_2-) group. These compounds have a similar ability to alkylate DNA, but their physical properties, e.g. melting point, vary.

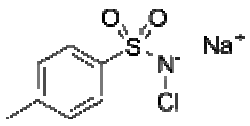


Figure 4 shows Chloramine-T which was used in an early American anti-mustard gas ointment dispersed in vanishing cream. One Japanese decontamination ointment also used chloramine-T

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Box 154 Report No. 265 CDREI; CWS 350.05/75; Box 120 OPD 385; Box 138, USCCWAC; Box 138 OCCW, Chemical Warfare Intelligence Bulletin No. 24; Box 138 US-CCWAC: Summary statement on Protective Ointments; Box 157, CWS 470.6; Box 138 CWS 350.05/75; Box 138 290/3/28/142 Several “Minutes of meetings of the Advisory Committee on the Effectiveness of Gas Warfare Materiel in the Tropics.”

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