Canadian Contributions to the Manhattan Project and Early Nuclear Research

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Abstract: During the second world war, Canada made several important contributions to the wartime work of the Manhattan Project. The three main contributions were: establishing a domestic nuclear research laboratory in Montreal to investigate heavy water reactors, creating supply chains to provide uranium oxide, heavy water and polonium to the Manhattan Project, and the direct contributions of several Canadians living in the United States. These wartime efforts helped establish a legacy of nuclear research in Canada which has persisted to the present day.

I. INTRODUCTION

To an outside observer, it may seem strange that Canada has a large fleet of domestically designed nuclear reactors, joining a small club of global powers who have achieved such a technological feat. This is no accident, rather the result of a long history of nuclear research, reaching back to the start of the 20th century, and a remarkable partnership between the allied nations to develop a nuclear weapon to end the second world war. Canadians made three major contributions in support of this mission: the establishment of nuclear research facilities in Canada, the delivery of critical raw materials to the Manhattan Project facilities in the US, and the direct involvement of several Canadians in the work performed at Manhattan Project facilities in the US. The following sections will briefly outline Canada’s contribution to these efforts.

II. CANADA’S DOMESTIC RESEARCH

II.A. Pre-war years

Canada, and in particular the city of Montreal, played an important part in the very early history of nuclear research when Ernest Rutherford accepted a position at McGill University from 1899 to 1907. His research at McGill on the transmutations of radioactive elements earned Rutherford the 1908 Nobel Prize in Chemistry. Otto Hahn, who would play a pivotal role in the discovery of fission in 1938, joined Rutherford for a time at McGill and investigated radiation emitted from thorium.

Following the discovery of fission and the possibility of a nuclear chain reaction, Craig Laurence, a scientist at the National Research Council of Canada (NRC), attempted to construct a nuclear reactor using natural uranium and a carbon moderator, beginning work in March 1940. The Eldorado mining company was able to provide a half ton of uranium oxide and he purchased ten tons of “relatively pure” calcined coke to act as a moderator. Working in the basement of the Sussex Drive headquarters of the NRC, Laurence arranged the materials shown in Figure 1. The goal of the experiment was not to achieve a sustained reaction, but rather to investigate the potential for releasing atomic energy and estimate the size of a critical reactor. This early effort predated similar experiments which Enrico Fermi performed at Columbia University. News of Laurence’s work at the NRC led to some degree of collaboration between the teams in 1941.

II.B. The heavy water war

On March 12 1940, two aircraft took off from Oslo, one heading to Amsterdam, the other to Scotland. The former was forced to land by the Luftwaffe, while the latter continued on with its cargo of a French officer and almost the entire world’s supply of heavy water (D₂O). Earlier that year, three researchers at the Collège de France, Frédéric Joliot, Hans Halban and Lew Kowarski, had identified
this substance as an ideal moderator for nuclear chain reactions and had submitted several patents related to the release of nuclear energy. The heavy water made its way to Paris, but before major research could be performed the city was overrun by advancing German forces. The three scientists and the precious raw materials were rushed to the port city of Bordeaux. There, Halban and Kowarski, along with the heavy water and a few grams of uranium, boarded the SS Broompark and set sail for England on 17 June 1940. Joliot remained behind in France to support his wife, who was ill and became an active member of the French resistance. A further 8 tons of uranium oxide was exfiltrated to Morocco by the resistance, where it remained beyond the reach of Germany for the duration of the war.

The origins of Canada’s wartime nuclear research can be traced back to this episode. The 185 liters of heavy water would be at the center of nuclear research in Canada until 1944. While in England, Halban and Kowarski worked at Cambridge to continue the research which the war had interrupted. They performed experiments using their natural uranium samples and heavy water and were able to demonstrate the feasibility of a divergent chain reaction in uranium, however they had far too little material to begin assembling a working reactor.

Seventy months earlier, in early 1940, two other refugee-scientists, Rudolf Peierls and Otto Frisch, identified a fast neutron chain reaction in $^{235}\text{U}$ as a practical means of developing a nuclear weapon. This discovery initiated the MAUD committee in Britain, which investigated the possibility of using nuclear energy for both weapons and civilian power production. Both Halban and Kowarski were members of a technical sub-committee, as they were foreign nationals and could not be full MAUD committee members. On the 30th of August 1941 Churchill approved the ‘Tube Alloys’ project to begin work on an atomic bomb. Early on, North America had been identified as an ideal location for the British project due to its distance from the war, its proximity to Canadian sources of uranium, and the potential for collaboration with the American scientific effort. However, due to the international makeup of the British scientific mission, security concerns precluded establishing a British research project in the United States. The British then proposed establishing a nuclear research facility in Canada, meeting with the president of the National Research Council of Canada, Dr. C. J. Mackenzie, in August 1942. Mackenzie recognized the importance of this effort to both the war effort and the potential to get in “on the ground floor of a great technological process”. Though the National Research Council’s headquarters were located in the national capital, Ottawa, the new nuclear laboratory was chosen to be located in Montreal due to its modern airport, large universities, and distance from the many foreign embassies in Ottawa. In the autumn of 1942, Halban and the well traveled heavy water arrived in Canada to establish the Montreal laboratory.

II.C. The Montreal Laboratory

The first set of researchers, including Halban, arrived in Montreal on the 24th of September 1942. As the leading authority on heavy water moderated nuclear reactions, Halban was chosen as the director for the research group. They initially rented a large house on Simpson Street, and all available space was quickly converted into offices for the researchers. The University of Montreal offered a wing of their newly completed medical building, and this would become the home of the Montreal Laboratory for the duration of the project. Absent from the initial team was Kowarski, who remained in Cambridge. Though he had worked productively with Halban for many years as a colleague, Kowarski rejected the possibility of being his subordinate in Montreal. A photograph of the main researchers at the Montreal Laboratory is shown in Figure 2, and maps showing important locations for Canadian wartime nuclear research are given in Figure 3.

Soon after the laboratory was set up, however, the project almost collapsed. In December 1942, the United States ceased almost all cooperation with the British on matters other than isotope separation. This cooling of relations happened after Fermi’s graphite moderated reactor worked, so the heavy water research efforts of Montreal were less critical to the success of the Manhattan project. Without access to heavy water or uranium, the work of the Montreal Laboratory was limited to small-scale investigations using only the heavy water evacuated from France.

Despite the temporary freeze in communication, many useful research efforts were undertaken in 1943-1944. Many technical reports were published and shared with the Manhattan Project, mostly on topics related to neutronics. These reports are still available at Los Alamos, from the National Security Research Center archives. Additionally, the work that Halban and Kowarski had undertaken in Cambridge was continued to further investigate the properties of a homogeneous reactor using a slurry of uranium and heavy water. Experiments on a carbon-moderated pile were also performed.

During this time, a French scientist working in Montreal, Bertrand Goldschmidt, who had previously worked with Seaborg and others on problems of plutonium separation at the Metallurgical Laboratory in Chicago, returned

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1 One of these patents “Perfectionnement aux charges explosives”, described the design of a nuclear weapon. 2 Another one was “Perfectionnement aux charges explosives”, which covered the design of a nuclear weapon.
to visit his friends at that lab. Having never handed in his badge, his friends let him “borrow” four micrograms of plutonium and a small quantity of fission products from which he was able to extract a further three micrograms of plutonium. These allowed Goldschmidt to begin studying plutonium and methods of separating plutonium from other fission products while working in Montreal.

Despite the progress made at the Montreal Laboratory, the lack of cooperation between the Canadian/British and American efforts had to be addressed in order for the Canadian effort to continue. In August 1943, the three national leaders, Winston Churchill, Franklin D. Roosevelt and Canada’s Prime Minister William Lyon Mackenzie King, met at the citadel in Quebec City to coordinate the war effort. Among the many pressing topics to be resolved at this conference, an agreement on nuclear research was reached to allow full cooperation in the field of scientific research, and sufficient communication in more applied fields to, “quickly bring the project to fruition.” Additionally, the three governments agreed never to use nuclear weapons against each other, never to use them against third parties without the others consent and not to communicate information on nuclear research to third parties without mutual consent.

An additional requirement of the improved cooperation between the Montreal Laboratory and the Manhattan Project was a change of leadership. Though Hans Halban had lead the laboratory since its inception, he was not a natural leader, and Gen. Groves insisted that a British scientist lead the Montreal laboratory. So, in April 1944, John Cockcroft, a British scientist who had already made important wartime contributions to the radar project, arrived in Montreal to assume the leadership of the laboratory and begin a new, more active phase of research.

II.D. Move to Chalk River

With a clear plan to build a heavy water reactor, the Montreal laboratory needed a larger site to build the plant and the required laboratories. The requirements for the site were similar to those of Los Alamos, in particular, a remote location was desired, but with good access to transportation in order to bring in supplies. Additionally, abundant supplies of freshwater were needed to cool the
reactor. A site on the Ottawa River, almost 200 km upstream from the national capital was chosen. The new town of Deep River was established nearby in order to provide housing for the staff and scientists. Unlike the somewhat organic growth of Los Alamos, a professor of urban planning at the University of Montreal led the design of the new town.\cite{2}

The site for the town and laboratory was chosen in mid July 1944, and construction of the laboratory was begun by the crown corporation Defense Industries Limited.\cite{2} The main focus of the laboratory was to begin construction of the heavy water reactor, termed the National Research eXperimental reactor (NRX). It was to have a 10 MW power output,\cite{21} and produce 7 g / day Pu and 0.5 g / day $^{233}$U, as well as other isotopes for research and medical applications. The design of the reactor was complex, with aluminum sheathed fuel, cooled by purified river water flowing through annular channels around the clad fuel. These assemblies were immersed in the heavy water moderator. The shielding surrounding the calandria contained channels where rods of thorium could be exposed to the intense neutron flux to allow the production of $^{233}$U. A view of the reactor building is shown in Figure 4b.\footnote{\textcopyright 2021-2022.}

This design presented significant technical challenges, and it was proposed that a simple Zero Energy Experimental Pile (ZEEP) be constructed to test optimal arrangements of fuel and moderator. A drawing of this reactor is shown in Figure 4a.\footnote{\textcopyright 2021-2022.} This reactor diverted 5 tons of D$_2$O and 3.5 tons of uranium metal from the main reactor,\cite{21} but due to the lengthy design and construction timelines for the NRX reactor, this did not slow down the overall program. Lew Kowarski arrived from Cambridge, ready to lead work on this new reactor now that Halban was no longer the lab director.\footnote{\textcopyright 2021-2022.} On Sept 5 1945, ZEEP was the first reactor outside the United States to become critical.\cite{2} ZEEP went critical two days after Japan’s official surrender and the end of the Second World War. The UK then focused on its own domestic nuclear program at Harwell, and John Cockcroft was recalled to England to lead these efforts. He was succeed by W. B. Lewis as the director of the laboratory. Lewis would continue to serve in various senior leadership roles at the laboratory until 1973\cite{22} overseeing the completion of the wartime projects and leading Canadian research efforts in the nuclear era.

II.E. Post-war efforts

Due to the complexity of the reactor design and the lack of wartime pressures on its development, it took a further year after the end of the war for the main reactor, named NRX, to go critical, which it did on July 22 1946.\footnote{\textcopyright 2021-2022.}

A parallel research effort to the development of the reactors was developing facilities to process the irradiated fuel to obtain $^{239}$Pu and $^{233}$U from the irradiated uranium and thorium, respectively.\cite{2} Despite the cooperation between the Montreal Laboratory and the Manhattan Project on reactor design and materials, research relating to chemical
(a) Zero Energy Experimental Pile (ZEEP): The first reactor to go critical outside the U. S.

(b) Chalk River in 1954. The low white building in the foreground contained ZEEP. The adjacent large brick building contained the NRX reactor. The NRU reactor, a post-war project, is under construction.

Figure 4: The early reactors at Chalk River

separation was strictly controlled by the Americans. Scientists at the Montreal laboratory had to develop their own processes to separate the desired isotopes from the highly radioactive fuel. They developed a process which used triethylene glycol dichloride to separate out the $^{239}\text{Pu}$, and a different process was used for $^{233}\text{U}$ separation. The production of $^{239}\text{Pu}$ began in August 1949 and of $^{233}\text{U}$ on January 1951.

II.F. Security

The Canadian efforts in support of the Manhattan Project in Montreal and Chalk River were targets for Soviet espionage, as were the British and Americans efforts. Bruno Pontecorvo and Alan Nunn May were the primary sources, but the technical information they revealed was somewhat removed from the design efforts at Los Alamos, and therefore of lower value. A much more significant impact came with the defection of Igor Gouzenko from the Soviet embassy in Ottawa on September 5, 1945 – three days after the end of the war. This became known as the “Gouzenko Affair.” The facts surrounding the defection became known following the defection through a Royal Commission established by Prime Minister Mackenzie King. Gouzenko’s own autobiographical account, and a film of the same name. A more complete account became possible in 2003 when the Canadian Security Intelligence Service and MI5 declassified the files, and the collapse of the Soviet Union provided insight into the ramifications for the Soviets.

Igor Gouzenko was a cipher clerk for the GRU (Soviet foreign military intelligence) working at the Soviet embassy in Ottawa from June 1943 until his defection in September 1945. He was responsible for encrypting and decrypting communications between Ottawa and Moscow, giving him access to all aspects of Soviet intelligence gathering. Gouzenko and his wife made the decision to defect about a year before the end of the war when he received news that he was to be transferred home to Moscow. The loss of a much more comfortable and free life they had grown accustomed to, as well as the possibility of more severe punishments for those called home, led him to begin collecting documentation that he could use to confirm his value as a defector. His recall was postponed for a year due to the difficulty of replacing him, giving him time to collect 250 pages of documentation to support his disclosures. He was aware that Victor Kravchenko, a previous defector without hard evidence, had difficulty convincing the FBI of his veracity. Initially, he was rebuffed by the Ottawa Journal newspaper and the Department of Justice. After a bizarre sequence of events with NKVD agents ransacking the Gouzenkos apartment, the Ottawa police assisted them in making contact with the Royal Canadian Mounted Police. The initial reaction from the Canadian authorities, including the Prime Minister, was not welcoming, as they feared the potential damage to relations with the Soviet Union, which was still formally a wartime ally. Eventu-
ally, the Canadians decided to debrief Gouzenko, and by September 12 had contacted the FBI leading Director, J. Edgar Hoover, to send a letter to the White House with the revelation that “the obtaining of complete information regarding the atomic bomb the Number One project of Soviet espionage.” The supporting documentation described the theft of a sample of $^{233}$U by Alan Nunn May, which had been hand delivered to Lavrentiy Beria and a Soviet spy at high levels in the U.S. State Department who became mistakenly identified as Alger Hiss.

The impact of these revelations in Ottawa, Washington, and London were significant. It led to arrests, convictions, and a concerted effort to uncover the full extent of Soviet espionage that revealed Klaus Fuchs, the Rosenbergs, and ultimately the McCarthy hearings. It marked the beginning of the transformation of the Soviet Union from wartime ally to geopolitical adversary. The implications of a breach of this magnitude in the Soviet Union were also substantial – the Soviets were very quickly and completely informed of what Gouzenko had revealed, through a highly placed Soviet spy in British counterintelligence, Kim Philby. Ironically, the Soviet espionage efforts targeting Canada had not been successful in revealing information of direct relevance to weapons design. The most significant asset was Nunn May, who had been recruited while he was in the UK. John Cockcroft, who was leading Chalk River at the time, was shocked when he learned on September 10, 1945 that Nunn May was a spy. In 1947 he was among the scientists signing a petition advocating a reduction in the 10 year sentence Nunn May received, although he later expressed regret for that act. Bruno Pontecorvo has long been suspected of being a Soviet spy, possibly revealing details of the design of the NRX reactor. He maintained he had never worked on weapons nor transmitted secrets but his defection to Russia following his return to the UK suggests otherwise. Efforts to recruit Canadian sources were generally not so successful, as the scientists targeted for their communist sympathies were either distant from the Manhattan Project activities or unwilling to transfer information that was not already available to the Soviets.

**III. RAW MATERIALS**

III.A. Uranium mining and milling

The town of Port Hope sits on the shores of lake Ontario, 100 km east of Toronto. Today, this small town is home to a large uranium fuel production facility for Canada’s CANDU reactor fleet. In the late 1930’s, however, this was one of the few facilities in the world that could process pitchblende ore into uranium oxide, and it would play an important role in supplying the Manhattan Project with raw materials. In 1932, a rich deposit of pitchblende was discovered on the shores of Great Bear Lake in the Northwest Territories, and was mined by Eldorado Gold Mines, Ltd. The commercial interest in this mine was not the uranium, but rather the radium contained in the ore. The refinery in Port Hope was built to extract the radium, beginning operations in 1933. Due to the outbreak of the war and the challenges of obtaining supplies to operate a mine in the arctic, mining operations ceased in July 1940. In 1941, the company was approached by a member of the American advisory committee on uranium, Dr. Lyman Briggs, who wished to purchase uranium oxide, which had been a byproduct of the radium extraction. Subsequent purchase orders for uranium oxide from the United States led to the Great Bear Lake mine reopening, resuming operations in August 1942. As the strategic importance of uranium was becoming clearer to those in the industry, Canadian Minster of Munitions C. D. Howe purchased a majority share in Eldorado in 1943 for the British and Canadian governments to keep prices under control.

Canada was not the only source of uranium to the Manhattan project. The Union Minière du Haut Katanga had been producing radium from its particularity rich deposits of pitchblende in the Shinkolobwe mine in the Belgian Congo. They had supplied the team at the Collège de France with the uranium they subsequently hid from the Germans. In 1940, as war in Belgium seemed likely, the director of the company, M. Edgar Sengier, had all available ore in the Belgian Congo shipped to New York. This ore was sold to the US government. However, as shipments from Great Bear Lake had yet to pick up, the processing facilities in Port Hope were available to process the pitchblende ore into uranium oxide. Port Hope refined all 1200 tons of the Congolese ores. Subsequent shipments of ore arrived from the Belgian Congo during the war and were refined both at Port Hope and by the Vitro Manufacturing Company in Pennsylvania. A list of the sources of uranium ores used by the Manhattan Project is shown in Figure 5. The uranium oxide from all sources was combined together for subsequent processing, so it is impossible to trace the exact fate of the ores processed in Canada, but for the first three years of the Manhattan Project, ores processed at Port Hope made up the majority of the uranium oxide used in the Manhattan Project. It is very likely that some significant part of the uranium refined to pure $^{235}$U for the Little Boy weapon, as well as the uranium which fueled the research reactors and Hanford reactors, passed through Port Hope. A more detailed analysis of the flow of materials through the Manhattan Project suggests that the majority of the uranium extracted from Great Bear Lake would have been used in research reactors rather than as inputs to the isotope...
III.B. Heavy Water

The uranium mining and milling operations were not Canada’s only contribution of raw materials to the Manhattan Project. The Consolidated Mining and Smelting ammonia plant in Trail, British Columbia was modified to produce heavy water, in addition to its normal output of fertilizer. Trail is situated on the Columbia River in a region with huge potential for hydroelectric power, a location geographically similar to the heavy water facility in Norway. The Corra Linn Dam on the nearby Kootenay River provided the power required for ammonia production. The American government negotiated directly with Consolidated Mining and Smelting to modify the plant and purchased its entire output. The first deliveries of heavy water began on 16 June 1943 at a rate of 35 lb / month and full production of 1000 lbs / month was achieved December 1944. The US also established heavy water plants at Morgantown, WV Ordnance Works; Wabash River, IA Ordnance Works; and Alabama Ordnance works, but the plant at Trail was the first to begin operations.

III.C. Polonium

A final strategic material for the Manhattan Project, which Canada was able to supply, was polonium. This was used to create neutron sources used in the initiators for both the uranium and plutonium weapons. Two Montreal Laboratory scientists Fritz Paneth and Bertrand Goldschmidt met with Manhattan Project scientists to discuss methods of extracting polonium from lead dioxide. Several tons of lead dioxide were stored at the Port Hope refinery, a byproduct of the uranium milling activities. This “radioactive lead” was purchased from Eldorado and shipped to Monsanto facilities in Dayton, Ohio, where it supplemented polonium produced by irradiated bismuth. The majority of the polonium used by the Manhattan Project was eventually produced from the irradiated bismuth, but Port Hope provided an important source of polonium in the early days when it was less clear that the bismuth process would work.

IV. CANADIANS IN THE MANHATTAN PROJECT

In addition to Canada’s domestic wartime research and raw materials production, several Canadian-born scientists worked directly for the Manhattan Project. Generally, these scientists were graduate students or professors at American universities at the outbreak of the war. In the pre-war years, opportunities for graduate degrees in Canada were limited, so it was common for students to pursue their studies in the US or UK. Table 1 shows a list of all the wartime members of Los Alamos who had Canadian heritage. A selection of Canadian scientists who had a particularly significant contribution to the Manhattan Project are discussed in greater detail in the following sections, and their portraits are shown in Figure 6.

In addition to the Canadians who worked on the Manhattan project, several foreign scientists transferred from the Montreal Laboratory to Los Alamos near the end of the war. Notable among them were Georg Placzek and Bengt Carlson. Placzek was a Czech scientist who worked with Bohr in Copenhagen, moving to Columbia University where he collaborated with Fermi on reactor design. He then arrived in Montreal to lead the Theoretical Physics Division, where he published prolifically on neutronics. Placzek arrived in Los Alamos in mid 1945 and was made group leader of T-8 “Composite Weapons”. Bengt Carlson was a Swedish physicist who worked for the Montreal Laboratory in 1943. Like Placzek, he arrived in Los Alamos in 1945 and worked in the Czech scientist’s group. Carlson remained at Los Alamos until his retirement in 1976. Carlson was heavily involved in the development of computational physics at Los Alamos and made significant contributions to the field of neutron-
With the measured values, enhancing the confidence in T Division’s calculations.

Lester Winsberg F-Division
John H. Williams P-Division
Roger B. Sutton R-Division
Louis Slotin G-Division
Manuel Schwartz T-Division
Charles Edward Runyan X-Division
Hyman Rudoff CM-Division
Robert Christy T-Division
J. Carson Mark T-Division
Hugh G. Bryce X-Division
Roy W. Goranson X-Division
John Gaston Fox T-Division
Hyman Rudoff CM-Division
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Lester Winsberg F-Division

Christy’s ‘pre-shot’ predictions agreed very closely with the measured values, enhancing the confidence in T Division’s calculations.

IV.A. Robert Christy

Robert Christy was a scientist at the Metallurgical laboratory in Chicago and at Los Alamos. He made important contributions to the design of the implosion weapon. Christy was born in Vancouver, British Columbia in 1916 and studied at the University of British Columbia before beginning a Ph.D. program at Berkeley under the mentorship of J. Robert Oppenheimer.

After graduate school, he joined the faculty of Illinois Tech and then joined the Metallurgical laboratory in the University of Chicago in 1942. Christy assisted in machining the graphite for the pile and was present during the startup of the CP-1 reactor.

In early 1943, Oppenheimer recruited Christy to come and work in Los Alamos, arriving around March, accompanied by his wife. The couple initially shared an apartment in Pojoaque with Richard Feynman. Christy worked in the Theoretical (T) division, and his experience making calculations on fast neutron systems was first used to estimate the critical mass of the homogeneous $^{235}\text{U}$ reactor, named the “water boiler.”

When the reactor was assembled, Christy’s ‘pre-shot’ predictions agreed very closely with the measured values, enhancing the confidence in T Division’s calculations.

Christy also made important contributions to the design of the trinity “gadget” and this is the subject of another paper in this special issue.

IV.B. Louis Slotin

Louis Slotin was a scientist who worked at Los Alamos during the war, but is more well known for his involvement in a criticality accident in the post-war years.

Slotin was born in 1910 in Winnipeg, Manitoba and educated at the University of Manitoba. He then traveled to England to attend King’s College London, where he earned both a Ph.D. and the title of King’s College amateur bantam-weight boxing championship in 1936. He began work at the University of Chicago in 1937, working on a cyclotron. He joined the Metallurgical Laboratory when it was established at the University of Chicago, and, according to university records, he was also present during the first run of the CP-1 reactor. Slotin arrived in Los Alamos in Dec 1944, having previously worked at Oak Ridge. Slotin’s high tolerance for personal risk was demonstrated during his time at Oak Ridge. On a Friday afternoon, Slotin wanted to make repairs to an experiment, which was at the bottom of a tank of water used as a biological shield for a reactor. Over the weekend, Slotin independently decided to swim in the reactor pool and make the repairs underwater. Experiments were able to proceed on Monday, but Slotin’s lax attitude to experimental safety would lead to tragedy as he continued his Manhattan Project work at Los Alamos.

At Los Alamos, he participated in assembling plutonium weapons and lead the assembly efforts for the core of the trinity device. He became the lead for all Plutonium experiments and was group leader for M-2, ‘Critical Assemblies’. His expertise in working with such assemblies led to the criticality accident which claimed his life on 21 May 1946. Slotin was performing an experiment where he used a screwdriver to lower a beryllium hemisphere onto a 6.19 kg sphere of nickel plated plutonium in order to demonstrate concepts of criticality, including neutron reflection. As the beryllium was lowered, Slotin’s grip on the screwdriver slipped and the two hemispherical beryllium reflectors closed. Though Slotin acted quickly, separating the assembly and using his body to shield others in the room, he had already received a lethal dose of radiation. Other observers also received significant doses of radiation, though they all recovered. Slotin died nine days later, on 30 May. Gen. Groves arranged a special military flight to bring Slotin’s parents to his bedside before he died. Before his death, Gen. Groves also sent Slotin a letter commending him for his “bravery and quick action which saved the lives of seven co-workers.”

IV.C. Walter Zinn

Walter Zinn was not a scientist at Los Alamos, but was a key figure in the Metallurgical Laboratory in Chicago, and later became the first director of Argonne National Laboratory. Born in 1906 in Berlin, Zinn attended Queen’s university for his undergraduate degree, and received a Ph.D. from Columbia in 1934. He worked with

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* Renamed Kitchener during WWI, for patriotic reasons during the war.
Leo Szilard and Enrico Fermi at Columbia on their early work on fission, and moved to Chicago to work with Fermi on the development of CP-1, the world’s first nuclear reactor. Zinn was present at the start up of CP-1 and he had the most important job of the several Canadians present for this historic event. He was the ‘axe man’ responsible for cutting the rope which kept a spring-loaded rod of cadmium out of the reactor in the event of an uncontrolled reaction. In 1946, when the Manhattan Project was transferred to the Atomic Energy Commission, Zinn remained in the US as the first director of Argonne, though was considered, alongside W. B. Lewis, as a replacement for Cockcroft as the director of the Montreal Laboratory.

IV.D. J. Carson Mark

Carson Mark was a Canadian scientist who worked at the Montreal Laboratory for the majority of the war, but moved to Los Alamos with other commonwealth scientists in the spring 1945. Carson Mark was born in 1913 in Lindsay, Ontario, educated at the University of Western Ontario, and received a Ph.D. from the University of Toronto in 1935. In 1947, he became division leader for T-Division, a position he kept until his retirement in 1973. During his time at the Montreal Laboratory, he published several technical reports, including work on neutron flux near plane surfaces, as well as applying the spherical harmonic methods to transport problems. At Los Alamos, Carson led T Division through the period where thermonuclear weapons were developed. As division leader, he was effective at the challenge of managing the strong personalities in the division. He also was able to:

- encourage free scientific pursuits in areas which were only indirectly related to the tasks of the laboratory, and he supported theoretical physics and applied mathematics in the best sense;

creating a tradition of scientific excellence that has continued to the present day.

V. CONCLUSION

During the second world war Canada made three significant contributions to the work of the Manhattan Project: a domestic nuclear research program, the production of essential raw materials, and the contributions of Canadian scientists working directly for the Manhattan project. In addition to helping advance the world-changing research efforts of the Manhattan Project, the foresight of Canadian scientific leaders such as C. J. Mackenzie, placed Canada among the global leaders in nuclear research following the war. This legacy of excellence in nuclear research, continues to this day at “Canadian Nuclear Laboratories” the modern incarnation of the Montreal Laboratory. In the 79 years since Hans Halban arrived in Montreal, Canada has developed a large fleet of domestically designed CANDU heavy-water moderated power reactors which are able to meet a significant fraction of the nation’s power requirements. This impressive technological achievement is the legacy of a remarkable collaboration among wartime allies to harness cutting edge scientific advancements to bring the war to a swift and successful close.

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Figure 6: Notable Canadians working in the Manhattan Project

(a) Robert Christy
(b) Louis Slotin
(c) Walter Zinn
(d) Carson Mark