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# "A Unique Art"

## Canadian Anti-Gas Respirator Production in the Second World War

Andrew Iarocci

The anti-gas respirator (gas mask) is a ubiquitous artifact of 20th century total war. Introduced in 1915, respirators dramatically transformed the appearance of soldiers, replacing the last trace of a man's unique identity with a ghoulish facade that quickly became a perennial favourite of war artists and illustrators. Throughout the 90 years since the First World War, anti-gas equipment has remained a vital part of every soldier's kit just as

it has persisted as a versatile prop in popular culture. Surplus respirators can found everywhere from the Star Wars trilogy (as alien costume props) to Earth Day marches (as symbols of protest against air pollution).

This article considers the Canadian development and manufacture of Mark IV anti-gas respirators prior to and during the Second World War, tracing the genesis of an artifact from the drawing board to the soldier's kit. The Mark IV pattern, originally developed in Britain in the 1920s, was the standard respirator in Empire and Commonwealth service throughout much of the Second World War. Beginning in the early 1930s, Canadian army officers realized the urgent requirement for modern anti-gas equipment, but they did not wish to depend upon Britain for future supplies. As such, the Canadian army joined forces with domestic industry to develop a homegrown manufacturing capability where none had existed before. Ultimately, the Mark IV development history sheds light not only on an important chemical warfare artifact, but also more generally on the manufacturing infrastructure that was developed in Canada at the eleventh hour to meet the massive output requirements of the Second World War. In this respect, the respirator case study shares much in common with more complex

objects, such as the Canadian Military Pattern trucks that were built en masse at Windsor and Oshawa according to British War Office specifications. The respirators, like

**Abstract:** Total war in the 20th century witnessed an ever increasing complexity in soldiers' weapons and equipment. Although the state was responsible for procuring war material, the design and development process was often a joint venture between government and private industry. This article considers that relationship in the material-cultural context of Canadian anti-gas respirator manufacture prior to and during the Second World War. Because domestic industries had no experience with military-grade respirators, it was necessary to spend heavily on product development. The government not only avoided sharing this cost with manufacturers, but also refused any definite contracts, thanks to Depression-era budget constraints. Only when the threat of war grew more certain in the late 1930s did eleventh-hour public expenditure stimulate the full development of manufacturing capacity. By 1940-41, domestic industry was able to manufacture enough anti-gas equipment for the Canadian forces, as well as supply various components to allied forces.

**Résumé :** Au vingtième siècle, la guerre totale fut marquée par la complexification grandissante de l'équipement et des armes des combattants. En dépit de la responsabilité gouvernementale de fournir ce matériel de guerre, le processus de sa création et de son développement a souvent été le fruit d'une association du gouvernement et de l'industrie privée. Le présent article analyse cette relation dans le contexte de la culture matérielle liée à la production canadienne de masques à gaz, avant et pendant la Seconde Guerre mondiale. Comme les entreprises du pays n'avaient aucune expérience dans la fabrication de ce type d'appareil respiratoire utilisé comme arme, son développement a nécessité d'importants investissements. Or, le gouvernement a non seulement évité d'en partager les coûts avec les manufacturiers, mais il a aussi refusé tout contrat précis s'y rattachant, prétextant les contraintes budgétaires de l'époque de la Dépression. Il fallut attendre que la menace d'une guerre certaine s'accroît, à la fin des années 1930, pour que des fonds publics soient dégagés à la dernière minute et assurent la pleine capacité de production de l'industrie. Dès 1940 et 1941, les manufactures du pays furent donc en mesure de fabriquer assez d'équipement contre les gaz pour les Forces canadiennes et d'autres composantes pour leurs alliés.

the trucks, were not fashioned out of thin air. Rather, they were the products of joint efforts across the Dominion, coordinated at virtually the last minute to manufacture serviceable equipment on a grand scale.

### Anti-Gas Respirators in British Empire Service, 1915-43

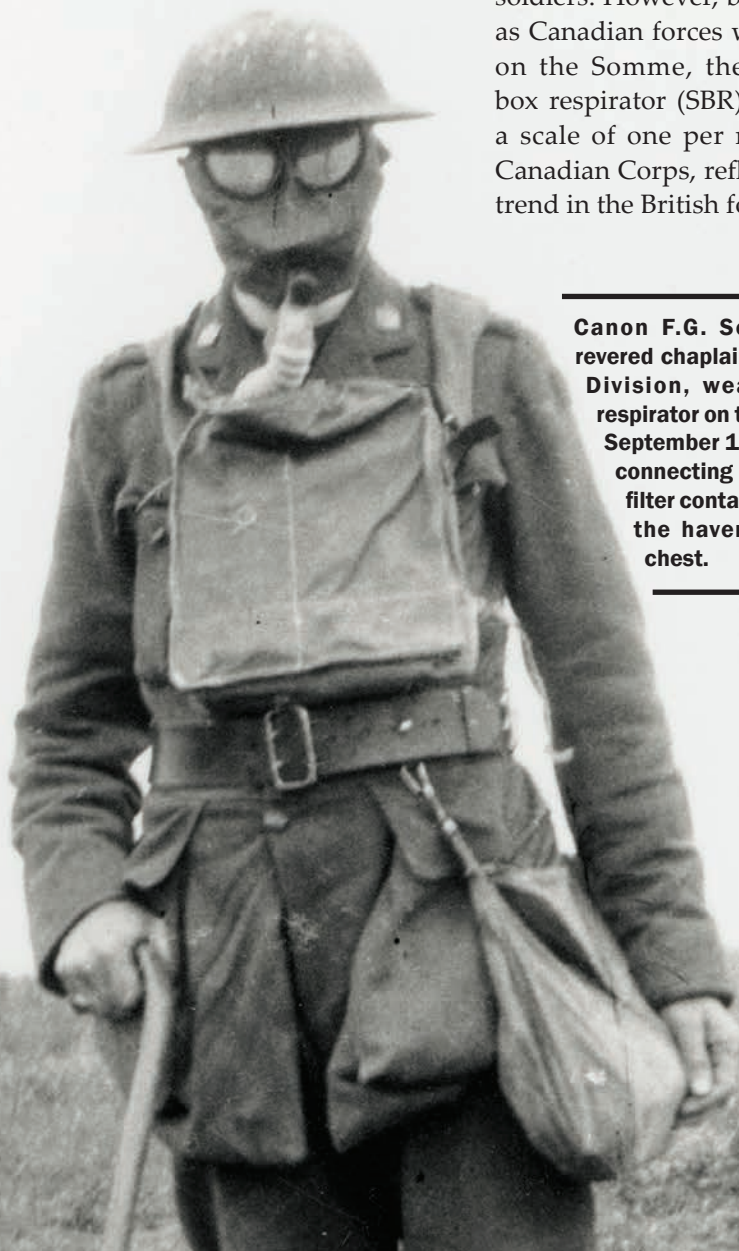
The Great War witnessed a steady evolution in anti-gas equipment, beginning with the Second Battle of Ypres in April 1915. The earliest form of protection issued to hard pressed British and Canadian troops at that time was a simple wade of cotton, held between the teeth, beneath a cloth mask impregnated with an anti-gas solution and tied over the nose and mouth. As soon as the chlorine attack became a matter of public knowledge, the War Office issued a general appeal for large quantities of these primitive masks, with instructions that they be sent in batches of 100 or more to the Chief Ordnance Officer at the Royal Army Clothing Department.<sup>1</sup> It was not long, however, before mask designs reached a level of sophistication that exceeded the sewing capabilities of various patriotic associations and other local groups.

By May 1915, most soldiers in the 1st Canadian Division had received the simple cotton respirators. At the same time, these were supplemented with the smoke helmet (also known as the hypo helmet), an impregnated bag that covered the entire head, and featured transparent mica or acetoid eye pieces. By August, every man in the division should have received a cotton respirator and a smoke helmet, while certain specialist troops in the division, such as machine gun crews,

were equipped with an even newer style of respirator known as the tube helmet. The tube helmet differed from the earlier smoke helmet in that it was fitted with a valve tube through which the soldier could exhale – a feature that helped eliminate carbon dioxide build-up inside the hood. (When inhaling, a soldier's breath was filtered through the fabric of the hood itself, which was chemically treated in the same manner as earlier types.) Improved tube helmets, which were impregnated with an upgraded solution that offered protection against phosgene, were designated as "P" (phenate) helmets.<sup>2</sup> Canadian soldiers were each supposed to carry one smoke helmet and one tube helmet as of October 1915.<sup>3</sup>

Beginning in February 1916, P helmets were gradually replaced by PH (phenate-hexamine) helmets, offering improved protection against phosgene. It appears that artillerymen were among the first soldiers to receive PH helmets in Canadian service, followed by a general issue to all trades and ranks that spring.

As the PH helmet was entering general service, an entirely novel pattern of anti-gas respirator, the large-box type (LBR), was introduced to British forces. Like the tube helmets, the LBRs were at first provided only to specialist personnel such as gunners, trench mortar and machine gun crews, and field ambulance men, in part because the new apparatus was considered too bulky for already overburdened infantry soldiers. However, by October 1916, as Canadian forces went into action on the Somme, the newer small-box respirator (SBR) was issued on a scale of one per man across the Canadian Corps, reflecting a similar trend in the British forces. Each man



**Canon F.G. Scott, the highly revered chaplain to 1st Canadian Division, wears a small-box respirator on the Western Front, September 1917. Note how the connecting tube leads to the filter container carried within the haversack on Scott's chest.**





**An NCO checks the fit of small-box respirators during anti-gas training somewhere on the Western Front.**

also continued to carry a PH helmet and one pair of anti-gas goggles as precautionary measures.

The face piece of the SBR was made of a rubberized canvas material similar to the type used in some German masks. In contrast with German models, which featured a directly mounted charcoal filter canister, the box respirator face piece was connected to a corrugated tube, which in turn mated up with the filter element – known at the time as a “tower” and later as a “container.” The tower was supported inside the khaki canvas respirator haversack, which was carried on the soldier’s chest. While the German pattern of mask was more compact, British authorities considered the box respirator to be a superior design. The weight of the filter was supported by the haversack, and thus did not pull the face piece away from the soldier’s forehead and cheeks. This problem with the German design allowed traces of gas to seep in behind the face piece. There is some evidence

that German soldiers, not realizing that the seal between face piece and skin had been broken, assumed incorrectly that the filter itself was chemically inefficient, thereby losing confidence in their masks. Interestingly, cultural determinism crept into British intelligence estimates, which suggested that “the British soldier, being more of an individualist [than the German], can better understand the seclusion imposed by wearing a mask,” and was thus a more effective operator in a chemical warfare environment.<sup>4</sup> This dubious theory was probably never tested.

Much of the credit for the British development of the box-type respirator went to the soldier-scientist E.F. Harrison. An accomplished pharmaceutical research chemist in civil life, Harrison joined the Sportsmen’s Battalion as an unlikely 47-year-old private in 1915.<sup>5</sup> After the German chlorine attack against the Ypres salient that April, he transferred to the Royal Engineers, where his

peacetime skills could be applied to more productive ends. Harrison quickly distinguished himself as an inventor of anti-gas equipment, and was promoted to the rank of lieutenant-colonel in 1917. He later became the controller of chemical warfare, a post which ultimately cost him his life. One week before the war ended, Harrison succumbed to pneumonia aggravated by repeated exposure to a deadly mélange of chemicals during his respirator experiments. In 1921 a monument was unveiled in his honour in the Hall of the Pharmaceutical Society, at Bloomsbury Square. Newspaper reports lauded Harrison as man whose invention “saved the British Army.”<sup>6</sup>

Although specific materials and construction were improved considerably, the basic scheme of the box respirator remained unchanged in British Empire and Commonwealth forces until the middle years of the Second World War. Indeed, Major John Ambrose Sadd, Harrison’s co-

inventor of the original box respirator in 1916, claimed patent rights for the Mark IV series employed during the 1930s and 1940s.<sup>7</sup> Like the SBR, the Mark IV comprised a face piece, connecting tube, and container. The face piece was fashioned of molded vulcanized rubber with separate glass eye piece discs. On early models, both the face piece and the corrugated rubber connecting tube were covered in khaki stockinet fabric. The purpose of the stockinet is unclear, but it was later discontinued, possibly for economic reasons, or because, as a porous fabric, it was difficult to decontaminate. The filter container, of ribbed sheet metal, incorporated a simple male fitting which mated with the lower female end of the connecting tube. Like the SBR, the Mark IV respirator was carried in a khaki haversack. When not required, the haversack could be slung over the shoulder. According to tactical circumstances, the haversack was to be worn on the chest in the ready position. In the event of a gas

alarm, the face piece was pulled from the top of the haversack and fitted to the soldier's head. The container rested in the bottom of the haversack, as with the SBR.

In common with most other pieces of military kit, the Mark IV respirator was followed by several variants and sub-variants (Table A). By way of summary, the Mark IV Special series incorporated an aperture on the left cheek that was fitted with a replaceable plastic cap for fitting a microphone. Some versions also had provision for wearing eye glasses beneath the face piece.<sup>8</sup> A later variant, the Mark V, was introduced just as the Second World War broke out.<sup>9</sup> In place of a pre-fitted aperture, the Mark V incorporated a one-inch cylindrical boss on the left cheek of the face piece. If required, the boss could be punched out and fitted with a plug for a microphone.<sup>10</sup> A second important difference between

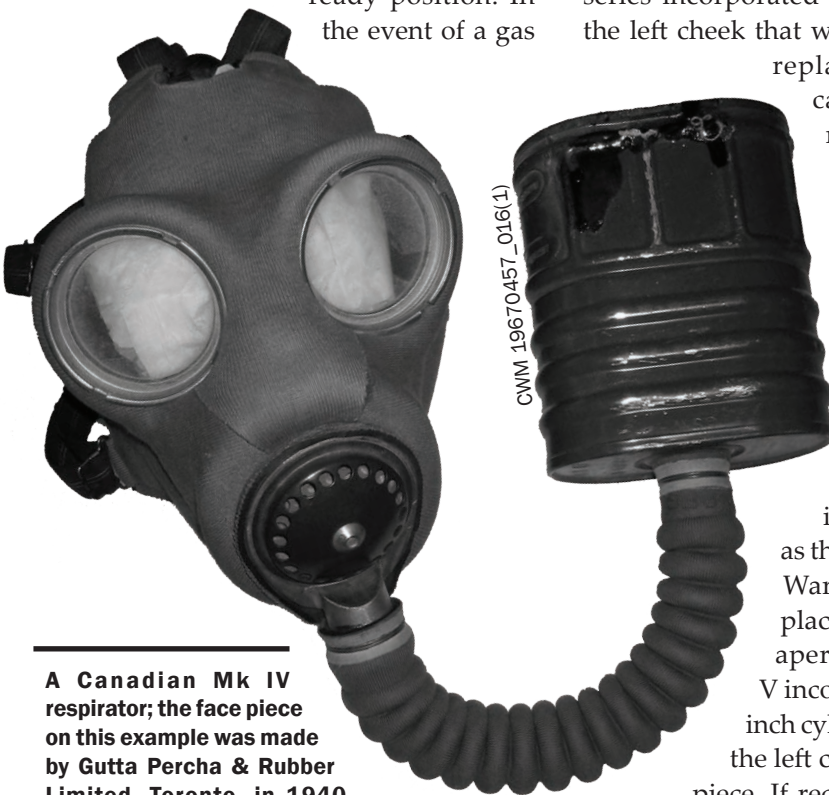
the Mark IV and Mark V respirators can be seen in their manufacture techniques, at least within a Canadian context. In Canada, the face piece for the Mark IV was crafted in hand molds, while the Mark V face piece was made in machine press molds. Different types of rubber were employed in each case. Shortly after the outbreak of war, it cost the Canadian government about \$7.65 for each Mark IV respirator, including the haversack and anti-dimming compound for the eye pieces. A Mark V cost about one dollar less.<sup>11</sup>

The Mark IV respirators and subsequent variants were issued to army, navy, and air force personnel, with the exception that a longer connecting tube was fitted to naval and air force models. This modification permitted the haversack to be worn on the sailor or airman/woman's back when the respirator was deployed, as it was not practical for specialists and technicians to carry the haversack on their chests while working on machinery or in the tight quarters of a ship or aircraft. In February 1943, however, the number of extended tubes issued to RCAF personnel was reduced as a rubber saving measure.<sup>12</sup> It is uncertain if the RCN similarly restricted the issue of the longer connecting tubes.

Beginning in late 1942 or early 1943 an improved respirator

**Table A – Mark IV and V Respirator Variants**

Designation	Key Features	Purpose
Mark IV, early issue	Made of red rubber, covered with khaki stockinet; eye pieces permanently installed	General issue
Mark IV, later issue	Made of black rubber, sometimes with stockinet; eye pieces removable; improved voice-mitter	General issue, priority given to officers and NCOs because of improved voice-mitter
Mark IV Special T	Similar to later issue Mark IV, but with modifications to the temples	For personnel wearing eye glasses
Mark IV Special T Mic	As above, but fitted with the capped aperture for a microphone plug	For signals personnel
Mark V	As above, without stockinet, featuring molded cheek boss for fitting microphone plug, suited for personnel wearing eye glasses	For signals personnel and those wearing eye glasses
Mark IVA and Mark VA	As with the Mark IV and V series, but fitted with longer connecting tubes	For naval and air force technicians and specialist personnel
Based on "Respirators, Anti-Gas," App A, 5 March 1940, HQ 56-23 (vol 14), Vol 5921, RG 24.		



**A Canadian Mk IV respirator; the face piece on this example was made by Gutta Percha & Rubber Limited, Toronto, in 1940. Note that both the face piece and the connecting tube are covered with khaki stockinet.**



was introduced in British and Commonwealth service, known prosaically as the "respirator, anti-gas, light," or more simply, the light respirator. Although beyond the scope of this article, the light respirator employed a face piece similar to the Mark IV series, except that it dispensed entirely with the connecting hose. Instead, a cylindrical container not unlike the German pattern was screwed directly to the left cheek of the face piece. The entire assembly was carried in the rectangular Mark I or II light haversacks.<sup>13</sup> This model is mentioned here because its introduction influenced the issue of Mark IV series respirators and containers later in the war.

### Gas in the Interwar Years

The Canadian military neglected its chemical warfare capabilities and defensive measures during the 1920s, despite the general belief that gas would almost certainly be used in the next major conflict.<sup>14</sup> George Witten, a newspaperman and South African war veteran who narrowly survived four years overseas during the Great War, wrote in 1926 that gas was not only the most humane weapon

available, but also the most efficient. Witten himself had been injured on four occasions – by small arms fire, shellfire, mine detonation, and gas. While the gassing incapacitated him just as fully as the other injuries, Witten claimed that gassing was far less painful, and produced fewer long-term disabilities. Without citing any evidence, he applied this general conclusion to many other gas victims, claiming further that gas was the "most effective" weapon known. This was questionable at best; although heavily employed between 1915 and 1918 on the Western Front, few battlefield victories were solely attributable to gas. Yet if Witten predicted incorrectly that gas was to be crowned king of the battlefield, his warning that troops must be equipped and trained to deal with



**A Canadian Mk IV Special T Mic respirator; the face piece on this example was made by the B.F. Goodrich Company, Kitchener, 1941. Note the removable plastic cap on the cheek for fitting a microphone plug as required.**

it was undoubtedly well advised.<sup>15</sup>

Witten was partly vindicated during the 1930s as chemical weapons were in fact employed in limited wars around the world, including the Italian campaign in Ethiopia and the Japanese war against China. These cases of gas warfare, combined with the increasing long-range capabilities of heavy bombers, spread fears that civilians would be targeted in massive chemical offensives from the air. Horrifying, if also hypothetical, reports on the destructive capacity of gas fed the hysteria. As an American military chemist noted in 1937, the matter of chemical warfare "has been the happy hunting ground for sensational newspaper and magazine

**Sailors wearing respirator haversacks line up for a refill. As naval personnel, these men have probably been issued Mark IVA or VA respirators, which featured a longer connecting tube than the standard Mark IV or V. This feature permitted the haversack to be carried in knapsack-fashion while the sailor was wearing his mask in the close confines of a ship. The air force also used this type in large numbers.**



W.E. Storey Collection

writers whose imaginations have furnished lurid pictures of whole populations being wiped out at a single blow with poison gas dropped from airplanes."<sup>16</sup> Some gas experts – and others who claimed to be – insisted that while gas would be used in future wars, its potential impact was very much exaggerated in most accounts.<sup>17</sup> Yet even if gas was not to be a decisive weapon or an instrument of Armageddon, any army not prepared to confront it was sure to suffer.

### Making Respirators in Canada

Canadian authorities did not wait for the outbreak of another global war to take action on the gas front. Although the Dominion government was not yet prepared to commit substantial resources to defence research and development in the midst of a crippling depression, the potential for conflict was enough for policy-makers to explore Canada's ability to manufacture its own military equipment.<sup>18</sup> In June 1932, Major G.P. Morrison, an artillery officer posted to Petawawa Camp, made an exploratory visit to the Safety Supply Company, a Toronto wholesaler and manufacturer of mining and industrial safety equipment. The company's manager, R.C. Fuller, had taken an interest in the manufacture of anti-gas respirators for industrial applications, but his company had not yet developed any prototype for military use. Part of the problem was that Canadian rubber companies possessed neither the tooling for molding masks, nor the mixing recipe and vulcanizing technique for producing service-grade rubber; such trade secrets were closely guarded by the well-established British manufacturers of respirator components.<sup>19</sup> Indeed, British companies such as Siebe Gorman, a well known maker of



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**Private Arnold Todd, of the Algonquin Regiment, models his Mark IV respirator at Port Arthur, Ontario, February 1941. Todd, who survived the Northwest Europe campaign of 1944-45, had this photograph taken so that his family could see his appearance in fighting equipment and respirator. Note that the Mark IV respirator is worn in the same fashion as the earlier small-box respirator.**

diving equipment, had been selling military style respirators on the international market since 1918, a practice that was encouraged by His Majesty's government in order to keep the industry viable in the event of a national emergency. In 1936, the Bata Company, then based in Czechoslovakia, purchased licensing rights from the British for the Mark IV-style respirator. (Like Canada, the Czech government was tooling up for a possible war with Germany.) Fatra, a Bata subsidiary, manufactured complete masks based on the British pattern. According to a 1942 Bata report, Fatra achieved an almost unbelievable production capacity of 25,000 masks per day before the war. Many Fatra respirators were even sold back to the British.<sup>20</sup> While Canada could also import respirators to fill immediate requirements for the mid 1930s, officials at the Department of National Defence (DND) ultimately wanted to develop a domestic manufacturing capacity not unlike the Bata/Fatra model in Czechoslovakia.<sup>21</sup>

To assist Fuller in his efforts to develop a manufacturing scheme for the standard Mk IV respirator, Morrison arranged to loan him the molds for the respirator valve and face piece. It would be up to the Safety Supply Company to determine the rubber recipe and vulcanization process. Progress was slow, as Fuller experienced difficulty finding a plant capable of replicating and molding the correct grade of rubber. Fuller finally reached an agreement with the Stokes Rubber Company of Welland, Ontario, but Stokes had little to show for its efforts in January 1933 when Morrison again touched base with him. As Fuller explained, Stokes felt that the molding process should more fully incorporate machine press molds, in place of hand molding.<sup>22</sup> Morrison countered that a complete set of press molds would be too expensive to create, and that they would do a poor job of shaping



the complex features of the face piece. In either case, upon visiting Stokes's Welland plant in February, Morrison deemed the facility entirely unsuited for large scale face piece manufacturing.<sup>23</sup>

Another year passed before Safety Supply once again explored the matter of face piece manufacture, this time in conjunction with the B.F. Goodrich Company of Kitchener, Ontario. In addition to the face piece, Morrison now also expressed an interest in making the corrugated rubber connecting tube that joined the face piece to the container (filter element or canister). But again, since no hose molds existed in Canada, it was left up to the manufacturer to come up with a procedure that would meet specifications.<sup>24</sup> As far as the face pieces were concerned,

Fuller reported in May 1934 that a couple of examples had finally been completed by Goodrich, and were to be submitted to DND for inspection.<sup>25</sup>

In the meantime, impatient military officials had contacted the chief inspector of arms and ammunition (CIAA) at Dominion Arsenals in Quebec to determine if the Mark IV respirator face pieces could be manufactured in the DA workshops by government employees.<sup>26</sup> Given that Fuller had managed to deliver the Goodrich face pieces at the eleventh hour, Lieutenant-Colonel N.O. Carr (then serving as GSO I artillery), intervened, suggesting that individual components of the Mark IV respirator, such as the face pieces, should be produced by private companies, only to undergo final assembly at Dominion Arsenals.

Such an arrangement would not only distribute the economic fruits of government contracts more broadly around the country, but by virtue of geographic dispersal, would also protect war production capacity against the threat of sabotage or enemy attacks. It would also free plant capacity in government facilities such as Dominion Arsenals. For the moment, however, manufacturing experiments would be limited to the respirators and connecting tubes. Due to some complexities in the container construction, these would have to wait until a later date for exploration.<sup>27</sup>

The prototype masks from Goodrich were by no means free of defects, but they were good enough to warrant continued cooperation from DND. To this end, Morrison provided

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**Five members of the Women's Royal Canadian Naval Service (WRENS) sport what appear to be Mark IVA Special T Mic respirators. This variant of the Mark IV featured a capped aperture for fitting a microphone to the left cheek, as well as a lengthened connected tube, so that the mask could be worn with the haversack carried at the lower side or on the back. Such respirators were issued mainly to naval or air force personnel. Note that the women have stencilled their names on the haversack straps.**

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the Kitchener office with additional specifications pertaining to the face piece, connecting tube, as well as the khaki stockinet material that was used to cover both components. The complexity of the manufacturing process is evident in the fact that about 100 engineering drawings were necessary to illustrate all of the components for the face piece and hose. Further development work at Goodrich was delayed when Safety Supply misplaced some of these drawings.<sup>28</sup> Canadian military officials had little choice but to remain polite, since Safety Supply and Goodrich were undertaking the development work at their own expense. Without any government funding, there was minimal incentive for the companies to hurry along their efforts to develop a product for which there was, as of yet, no certain mass demand.

In face of limited Canadian manufacturing capacity, the government had two short term options. The first was to purchase masks from the British, as had been the usual practice since the Great War. The second was to make funding available for serious research and development in Canadian industry.<sup>29</sup> Lieutenant-Colonel George Pearkes, then serving as a general staff officer for the director of military training and staff duties, estimated in 1934 that if somewhere between \$10,000 and \$15,000 worth funding was provided during 1935-36, "the production of a Canadian respirator, less container, will be an accomplished fact."<sup>30</sup> The catch was that the Canadian army needed new masks immediately. At the time there were only 1,449 serviceable masks in the country, far too few to equip the Permanent Force, let alone provide for anti-gas training in the Militia. Although somewhere between 700 and 2,500 new masks were needed in the short run to make up for shortfalls, Pearkes recommended that purchases be delayed if it meant saving funds for

research and development. Major-General A.G.L. McNaughton, in the post of chief of the general staff (CGS), agreed with Pearkes. The draft budget estimates for 1935-36 included \$15,000 for the domestic manufacture of respirators. Ultimately, \$10,000 was approved for that fiscal year.<sup>31</sup>

The new funding stimulated development work at Goodrich in Kitchener, and also attracted the interest of Gutta Percha & Rubber Limited, a Toronto-based company. (Safety Supply seems by then to have fallen by the wayside as a redundant middleman.) A technical representative from Gutta Percha was confident that his outfit would be able to meet the rubber specifications; he even suggested that recently developed synthetic materials might be used.<sup>32</sup> Government inspection visits to the Goodrich and Gutta Percha plants revealed each to be excellently equipped with the necessary machinery and laboratory equipment. At present, these facilities were dedicated largely to the production of rubber footwear, but there was no technical reason why they could not switch over to respirators, once the details of the rubber compounds and molding techniques were worked out.<sup>33</sup>

Goodrich and Gutta Percha continued with limited experiments throughout the winter of 1935, but failed to achieve satisfactory results. Neither company, according to a key April 1936 defence memorandum, had quite mastered the molding or vulcanizing techniques. Major Morrison, the artillery officer who had originally visited the Safety Supply Company four years earlier, recognized that unless the government offered the companies a true incentive to invest more research time and effort in the respirator problem, it was unlikely that a solution could be found in the near future. Accordingly, Morrison suggested that the director of contracts approach both companies with pricing requests for masks by

batches of 100 and 1,000 pieces. At the same time, detailed arrangements for final assembly operations at Dominion Arsenals should be made with the CIAA.<sup>34</sup>

It is unclear if the director of contracts did in fact immediately approach the companies with pricing requests, but Morrison's recommendation vis-à-vis Dominion Arsenals was indeed pursued throughout the summer of 1936. As late as August, however, the superintendent of Dominion Arsenals reported that smaller components and hardware required to complete the face piece assembly (outlet valves, head harness components, eye pieces, and the corrugated connecting tube) could not be procured from any local companies.<sup>35</sup> Military authorities would have to cast a wider net across the country to secure all of the parts necessary for final assembly at the Dominion Arsenals plant. Within a couple of months, Colonel Carr, now director of mechanization and artillery (DMA), reported that sources and price quotes for all of the necessary face piece components had been secured. All together, at least eight different companies were required to supply everything required. It only remained for General McNaughton (now president of the National Research Council) to approve the rubber samples used in face pieces and outlet valves.<sup>36</sup> Testing in this respect continued throughout the winter of 1936-37. In January 1937, initial limited orders for most of the essential components had been placed (excepting filter containers, which remained to be developed). Major-General Clyde Caldwell, the master-general of ordnance (MGO), anticipated that 1,000 masks would be completed within four months. The War Office had promised to send along specifications for the containers so that these could also be sourced in Canada, but in the meantime, 3,550 pieces were ordered from Britain.<sup>37</sup> With the threat of war on the horizon,



**Above: J.L. Ilsley, minister of finance, visits the B.F. Goodrich Company in Kitchener, Ontario in April 1944.**

**Right: Employees at the B.F. Goodrich plant put nails into Hitler's coffin for this 1942 publicity photograph.**



efforts to procure mass quantities of materiel now accelerated. Of the \$96,500 allocated for anti-gas equipment during the 1937-38 fiscal year, Colonel Carr recommended that \$52,500 be applied to the purchase of 25,000 containers from the War Office and \$44,000 to buy 6,000 complete face pieces, including their canvas haversacks, from Canadian sources.<sup>38</sup>

Just three years short of war, Canada approached self-sufficiency in basic anti-gas equipment. There were still, however, many wrinkles to iron out at all stages in the supply chain, including rubber finishing and container development. As of early 1937, Goodrich remained the only Canadian company capable of manufacturing serviceable face pieces; Gutta Percha, the Toronto-based rubber company, was still working to make the grade.<sup>39</sup> Yet even the Goodrich face pieces were not perfect. In February 1937, an early sampling of 340 face pieces from the

Kitchener plant was inspected. Only 125 of these passed. Flaws included defective eye sockets, porosity, and uneven rubber thickness.<sup>40</sup> Minor flaws continued to surface throughout 1937, although some of these related to smaller components and hardware items rather than the face piece itself.<sup>41</sup> In particular, the domestic glass industry experienced some difficulty manufacturing eye pieces of sufficient quality to meet government specifications.<sup>42</sup>

Technical problems, unfortunately, were not the only barriers to a viable domestic manufacturing program in 1937. That June, the government stalled on approval for a relatively large order of 11,000 masks demanded by the CGS for the 1937-38 fiscal year. As DMA, Colonel Carr warned in a scathing memorandum that any further delays in the program would "seriously embarrass all concerned, and will almost certainly result in failure to

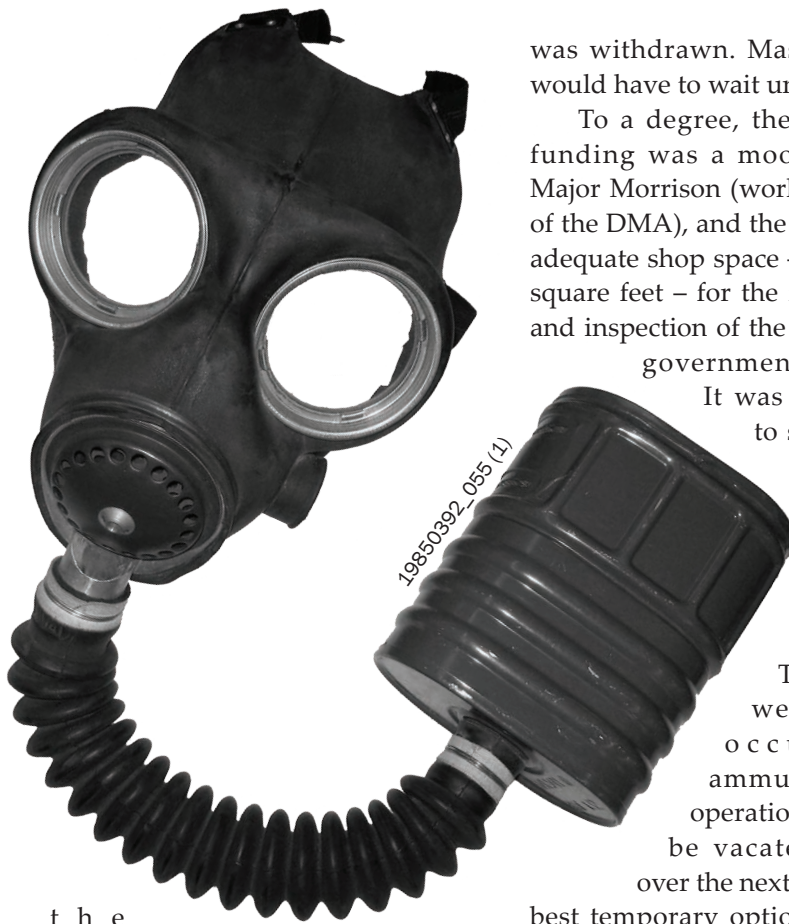
secure the required quantities this year."<sup>43</sup> Carr underscored the quality control issues that slowed even the completion of small batch orders for 1,000 masks. If domestic industry was to meet the rigorous inspection standards that were required for anti-gas equipment, it must have the opportunity to fill larger volume orders sooner rather than later. As Carr further explained:

Respirator production is, in many respects, a unique art. The preservation of the art against the day when large quantities might be required at short notice is a problem which should receive every consideration... If production ceases, as is presently the case, there is great risk of losing those skilled operators already trained.<sup>44</sup>

In other words, if Canadian companies did not exercise their present capabilities to manufacture



**A Canadian Mark V respirator; the facepiece on this example was made by the B.F. Goodrich Company, Kitchener, 1941. Note the molded boss on the cheek for fitting a microphone plug as required. The khaki stockinet normally used in earlier production has been eliminated entirely from the manufacture of the face piece and connecting tube in this case.**



t h e  
precision

components required for respirators, their employees would lose the hard won skills developed over long months of trial and error. When the matter was brought to the attention of the deputy minister of defence, Léo La Flèche, he recommended that enough respirators be ordered to fill immediate current manufacturing capacity.<sup>45</sup> Now that Gutta Percha was capable of turning out serviceable face pieces, it seemed possible that Canadian industry might complete a maximum of between 10,000 and 12,500 masks by the end of fiscal; given the limited scale of testing facilities available, the lower figure was more realistic. Yet just when it appeared that production was really about to get underway, the estimated \$32,000 required to complete the order

was withdrawn. Mass production would have to wait until 1938.<sup>46</sup>

To a degree, the provision of funding was a moot point until Major Morrison (working on behalf of the DMA), and the CIAA secured adequate shop space – at least 3,000 square feet – for the final assembly and inspection of the respirators by government employees.

It was first planned to set up shop in the Dominion Arsenal buildings at Cove Fields, Quebec.

These premises were presently occupied by ammunition filling operations, but would be vacated sometime over the next year. The next best temporary option was to rent space somewhere in Quebec City. A number of sites were considered,

including a Ste. Anne Street building formerly occupied by *L'Action catholique* newspaper.<sup>47</sup> Ultimately, none of these proved satisfactory, either because the buildings were not sufficiently modern, or the rent was deemed too high. Finally, in May 1938, the director of equipment and ordnance services (DEOS) secured authority to lease 3,800 square feet on the fourth floor of a Rue Varennes building.<sup>48</sup> Much of the assembly and inspection work of finished product was to be carried out by young female employees. At the outset of production, it was estimated that the assembly and inspection of 1,000 respirators would require "700 girl hours."<sup>49</sup>

With Hitler's grip already tightening on Germany's neighbours, Canada's respirator production program was only just kicking into gear. Immediate respirator requirements for 1938-39 were pegged at 11,000 for the Militia, 600 for the Royal Canadian Navy, and 4,505 for the Royal Canadian Air

**Table B – Canadian Respirator Component Manufacturers**

Manufacturer	Components Supplied
Coulter Copper & Brass Company, Toronto	eye piece retaining rings, valve guards, fasteners
Gutta Percha & Rubber Company, Toronto	face pieces, eye piece washers
Dominion Steel & Coal Corp., Montreal	binding wire
St. Lawrence Steel & Wire Co., Gananoque	harness buckles and loops
B.F. Goodrich Rubber Company, Kitchener	face pieces, connecting tubes, outlet valves, harness pads
Canadian Die Casters, Galt	valve holders
W.E. Phillips Company, Oshawa	eye piece discs
Penmans Limited, Montreal	khaki stockinette
Dominion Rubber Company, Montreal	eye piece washers, rubber tape
Woods Manufacturing Co. Limited, Welland	haversacks
Belding Corticelli, Montreal	elastic harness webbing
Russell Manufacturing Company	elastic harness webbing
Duplicate Safety Glass Co. of Canada, Oshawa	eye piece discs
Aluminum Company of Canada, Montreal	valve holders
Byers Company Limited, Toronto	harness buckles and loops

Force.<sup>50</sup> By mid-1938, production finally began to move forward, with more than a dozen outfits providing components for the finished product (Table B).<sup>51</sup> Notably, the British War Office had by then taken a favourable view of the Canadian-manufactured face pieces.<sup>52</sup>

Throughout 1938-39, the number of contractors involved with respirator production increased, while some existing contractors began work on additional items. For example, when it was anticipated that new machine press moulds were to arrive from Britain for the manufacture of the Mark V respirator, DND officials planned to let contracts for face pieces to the Dominion Rubber Company.<sup>53</sup> As well, several other companies won contracts for accessories such as the haversacks; these included: S.S. Holden Limited (Ottawa) and J.E. Lortie (Montreal). Ultimately, project officers at DND preferred that more rather than fewer companies be involved in production. As Colonel Carr noted in April 1939, contracts should be "spread over as many firms as practicable in order to obtain as many potential sources of supply as possible in the event of an emergency programme having to be put into operation."<sup>54</sup>

Given the contemporary sensational media reporting on gas warfare, it is not surprising that the press began to take a special interest in Canadian preparations. When *The Toronto Star Weekly* first requested photographs of the Canadian respirators and production facilities in late 1937, the paper was put off by defence officials. This had less to do with secrecy than the fact that no production facilities yet existed; any report on Canada's homegrown respirator industry would have been entirely underwhelming.<sup>55</sup> Undeterred, the *Star Weekly* approached Gutta Percha, one of the Toronto-based manufacturers involved with the

program. The paper's editor believed, mistakenly, that the respirators were being manufactured somewhere in Toronto, and he wanted details and photographs. Gutta Percha's general manager, F.A. Warren, evaded repeated information requests, before writing to La Flèche in desperation. Perhaps, Warren suggested, it would be better to issue a guarded statement to the press rather than fend off repeated inquiries.<sup>56</sup> Ottawa relented, and Colonel Carr drew up a release the next day. In essence, it underscored the challenges of coordinating Canadian industry to meet the precision manufacturing requirements for respirators. Carr also noted that the Canadian Mark IV measured up well against the British version (which had already been in production for many years), for approximately the same cost.<sup>57</sup> With the production program well underway by early 1939, requirements for the 1939-40 fiscal year were projected at 11,600 respirators

for all three services.<sup>58</sup> Changing circumstances soon dictated that this quantity be increased by a considerable margin.

## Containers

The last remaining obstacle to Canadian self-sufficiency was the Type E container which served as the filter for the Mark IV system. It appears that Canadians did not embark upon detailed investigation of the domestic manufacture of the Type E-series containers until 1938-39.<sup>59</sup>



An illustration from a 1939 training manual shows the new Mark V respirator with its haversack.





W.E. Storey collection

Compared with the face piece development, however, the containers were relatively straightforward, given that there were only four principal components required: the canister, filling materials, compression springs, and inlet valve. On the eve of war, three of these four components were already being manufactured in Canada. Ontario Metal Specialties (Bronte, Ontario) was the first company to produce the canister, although General Steel Wares later produced very large quantities. Steele Brothers (Guelph) turned out the springs, while Seiberling Rubber Company (Toronto) handled the inlet valves. The filling materials, which were responsible for neutralizing any war gases inhaled through the container, were still imported from Britain at this time, at least in part because the formula was a strictly guarded War Office secret. The containers were assembled and filled at the National Research Council Annex, at the corner of Sussex and John Streets in Ottawa, apparently due to space limitations at the respirator assembly

**A Type E “green dot” container designed to offer improved protection against cyanogen chloride and hydrogen cyanide. The dime-sized green dot is clearly visible on the top right side, partly over top of the “GSW” stamping. GSW stands for General Steel Wares, a Canadian company that manufactured a variety of metal products for Canada’s military forces, especially ammunition boxes, steel helmets, and canisters for respirator containers. This particular canister was made at GSW’s MacDonald Plant in Toronto.**

shop in Quebec.<sup>60</sup> (See Table C for details on containers.)

Late in the war, chemical warfare experts determined that the conventional Type E filter did not afford sufficient protection against certain agents. One of these, cyanogen chloride (known as CK or CNCl) was an especially toxic blood agent. Another was prussic acid (AC or HCN), more properly known as hydrogen cyanide, and now infamous for its widespread use in Nazi death camps. Although Allied intelligence reports doubted that the Germans were apt to use CK “in any wholesale manner in the immediate future,” chemical warfare experts felt that RAF and RCAF personnel who, after 1943, were still equipped with the Mark IV and V series respirators (as opposed to the new light respirator) might need extra protection.<sup>61</sup> One option was to treat ordinary Type E containers with a solvent called pyridine. Another option was to retrofit Mark IV and V respirators with the Type E “green dot” high performance container, a new variant that offered better protection than the old Type E, and so called because a

small green dot was painted on the top of the container.<sup>62</sup> Late in the war, Lieutenant-Colonel E.A. Flood, the superintendent of Canada’s Chemical Warfare Laboratories, doubted that the current threat was severe enough to warrant wholesale pyridine treatment. Given that the 70,000 green dot containers held in reserve for the Canadian Army were no longer required (because of the general issue of the light respirator to the Canadian Army Overseas after 1943), these were made available to the RCAF. Meanwhile, the Canadian Army retained a reserve of 100,000 Mark II green dot containers for the light respirator.<sup>63</sup>

## Conclusion

On the eve of war Canada’s domestic manufacturing capacity was firmly grounded in the chemical warfare sector. The Canadian government felt secure enough with this knowledge to refuse offers to purchase British-made respirators in the dark summer of 1939.<sup>64</sup> On the contrary, Canada would soon be in a position to export chemical warfare equipment to friendly countries, some of which had already made enquiries.<sup>65</sup> By the summer of 1940, Colonel Morrison, still working for the DMA, was striving for an output rate of 6,000 respirators per week. To help meet this demand, companies like B.F. Goodrich were turning out face pieces 24 hours a day.<sup>66</sup> By early 1941, Canada had produced in excess of 250,000 respirators (excluding naval and air force contracts), and was now in a position to export surplus output to allies.<sup>67</sup> Taking the Type E container

**Table C – Container Variants**

Type	Colour	Purpose
Type A	dull blue	For training only
Type E Marks I, II, IV	brown / red oxide	For operational use in Canada only
Type E Mark V	brown / red oxide	For operational use overseas, included an improved inlet valve

as an example, Canada had turned out more than 600,000 pieces by the end of 1941, of which 175,000 were supplied to South African troops and nearly 60,000 to New Zealanders.<sup>68</sup> This great production capacity was the glad consequence of several years of challenging developmental work undertaken by Canadian industries and a small group of army officers. Besides respirators, there were many other items in Canadian service that followed similarly complex development paths from the drawing board to the shop floor to the soldier's kit.

At the outset of the Second World War, Allied intelligence estimates suggested that if German forces did resort to gas, they were likely to employ tactics similar to those of the 1918 spring counteroffensives. This meant that persistent agents, such as Yellow Cross, would be used to neutralize strong points, create physical barriers, or simply immobilize basic defences. As the British braced for what seemed a likely German invasion of the home islands in 1940, it was anticipated that aircraft would serve as the primary mode of delivery.<sup>69</sup> British assumptions regarding the potential tactical employment of gas by German forces were essentially rational, given the information available at the time and the experience of the First World War. What if there had been such an attack? Speaking to the Canadian Institute of Chemistry at Hamilton, Ontario in June 1942, Lieutenant-Colonel Flood, the superintendent of Canada's Chemical Warfare Laboratories, noted that well trained soldiers equipped with anti-gas respirators and protective clothing would be more or less invulnerable to gas tactics. Indeed, it would probably be easier to prevent casualties by gas than by shot or shell.<sup>70</sup>

At the time of Flood's speech before the Institute of Chemistry, Canadian soldiers were indeed well kitted out with anti-gas respirators

and other protective equipment, but it had been a close call. As late as Christmas 1939, it appears that there were not enough respirators to go around to all Canadian soldiers stationed in Britain.<sup>71</sup> As with other war supplies, this state of affairs gradually changed for the better over the next year. Canada not only produced enough equipment for its own forces, but was also able to supply other Allied nations with anti-gas components. This manufacturing program represented only one small component of Canada's larger military output. It also underscored the reality, all too often overlooked in macro-level study of military logistics and the Second World War *Materialschlacht*, that the ability to produce sophisticated equipment does not simply exist in nature, but more often than not, is the result of years of frustrating trial, error, negotiation, and false starts.

### Notes

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1. "Murderous Gases – War Office Appeal," April 1915, GAQ 9-37, Library and Archives Canada (LAC) RG 24 Vol.1837.
2. Tim Cook, *No Place to Run: The Canadian Corps and Gas Warfare in the First World War* (Vancouver: University of British Columbia Press, 1999), p.42. Cook provides detailed discussion of the physiological implications of these hood-type respirators. For illustrations, see Simon Jones, *World War I Gas Warfare Tactics and Equipment* (Oxford: Osprey, 2007).
3. "Gas Protection," GAQ 9-37.
4. "Memorandum, German Respirators, 1917," GAQ 9-37.
5. On the Sportsmen's Battalion, see Michael Foley, *Hard as Nails: The Sportsmen's Battalion of World War One* (Stroud: Spellmount, 2007).
6. "Gas-Mask Inventor," *The Daily Mail*, 28 October 1921. See also "Treasures of the Royal Pharmaceutical Society's Collections," *The Pharmaceutical Journal*, 278, no.28 (April 2007), p.508.
7. Sudd's patent claims appear on drawings dating from 1942-43. See "Chemical Warfare Facepieces, Production Generally," LAC RG 24 vol.81 HQ 173-4-2 (vol.2).

8. Refer to "Chemical Warfare Facepieces, Production Generally," LAC RG 24 vol.81 HQ 1173-4-2 (vol.2).
9. See Memorandum by Morrison, 19 September 1939, LAC RG 24 vol.5920 HQ 56-23 (vol.9).
10. MGO to CMHQ London, 16 February 1940, HQ 56-23 (vol.13), LAC RG 24 vol.5921; CMHQ London to NDHQ, 19 April 1940, HQ 56-23 (vol.14), LAC RG 24 vol.5921.
11. Morrison to War Supply Board, 5 December 1939, LAC RG 24 HQ 56-23 (vol.13).
12. According to the RCAF order, only personnel in the following trades would require the extended connecting tubes: armourers (bombs and guns), flight mechanics (airframe and engine), mechanical transport mechanics, all wireless and telephone operators, teleprinter operators, armament assistants, torpedo technicians, all aircrew personnel, medical personnel, and balloon operators and riggers. About 43,300 personnel acted in these trades in Canada at the time. As such, approximately 99,000 respirators with the shorter tubes would be required for use by personnel in other trades. The order apparently did not apply to RCAF personnel overseas. See Memorandum, RCAF Respirator Requirement, 25 February 1943, 5 March 1943, 8 March 1943, 452-7-4, LAC RG 24 vol.5432, Series E-1-b.
13. For drill and training details on the light respirator, see *Gas Training* (War Office, 1951), pp.12-20.
14. See Cook, pp.222-25 on the early postwar years in Canada.
15. George Witten, "Humanizing War," 22 December 1926, 529-30, periodical clipping found in GAQ 9-37. Details of Witten's Canadian military service can be traced only up to January 1915, when he was discharged from the CEF in order to accept a commission in the British Army. See George Witten, Vol.10514-57, RG 150, LAC.
16. Augusting M. Prentiss, *Chemicals in War: A Treatise on Chemical Warfare* (New York: McGraw-Hill, 1937), vii-viii.
17. "Scientist Debunks Poison Gas Fiction," *The Ottawa Journal*, 30 December 1935.
18. This applied not only to anti-gas equipment, but to other types of materiel, including wheeled transport vehicles, which had been undergoing trials since the 1920s.
19. The War Office did not specify or possess the formula. It was up to the rubber company to devise a formula that met government specifications. Once these were satisfied, the manufacturer retained ownership of the formula. Of course, the Canadian government did have the option of purchasing respirators directly from British manufacturers, but this would defeat the purpose of developing a domestic capability. See Morrison to NDHQ, 4 October 1934, HQ 56-23 (vol.1), LAC RG 24 vol.5918.



20. Thomas Bata to Department of Munitions and Supply, 9 January 1942, 1173-4-2 (vol.1), LAC RG 24 vol.81.
  21. Morrison report, 21 June 1932; Morrison to N.O. Carr, 24 July 1932, HQ 56-23 (vol.1).
  22. It appears that hand molding continued in Canada throughout production of the Mark IV. The new Mark V, however, was probably manufactured entirely on machine press molds, which were probably received from Britain sometime in 1939. See Memorandum, Carr to DEOS, 18 December 1936, File 56-23 (vol.4), LAC RG 24 vol.5919, and Director of Contracts to Dominion Rubber Company, 30 November 1938, File 56-23 (vol.7), LAC RG 24 vol.5920.
  23. "Visit to the Stokes Rubber Company," February 1933, HQ 56-23 (vol.1).
  24. Carr to Morrison, 22 March 1934, HQ 56-23 (vol.1).
  25. Fuller to La Flèche, 23 May 1934, HQ 56-23 (vol.1).
  26. Dewar to CIAA, 11 January 1934, HQ 56-23 (vol.1).
  27. Memorandum, Carr to CGS, 24 October 1934, HQ 56-23 (vol.1).
  28. Morrison to NDHQ, 4 October 1934; Memorandum, Inspector Artillery Stores, 2 October 1934; Safety Supply Company to DND, 3 December 1934, HQ 56-23 (vol.1).
  29. It is unclear if the Canadians considered buying licenses directly from British manufacturers. Yet even if the rubber recipes could have been purchased, Canadian plants still lacked the skilled workers to mould the masks. As later development work would prove, Canadian industry was also ill equipped to provide smaller components for the respirators, such as the glass eye pieces.
  30. Pearkes to CGS, Memorandum on respirators, HQ 56-23 (vol.1). On Pearkes's role with the in training and staff duties, see Reginald H. Roy, *For Most Conspicuous Bravery* (Vancouver: University of British Columbia Press, 1977), pp.115-34.
  31. Pearkes to CGS, 4 December 1934; Carr to CGS, 11 April 1935, HQ 56-23 (vol.1).
  32. Morrison to GSO (1) Artillery, 14 March 1934, HQ 56-23 (vol.1). The Americans were developing synthetic rubber that was gas and oil resistant, and there is evidence that the Soviets were doing the same.
  33. Morrison tour report, 13 May 1935, HQ 56-23 (vol.1).
  34. Memorandum to Director of Mechanization and Artillery, 21 April 1936, HQ 56-23 (vol.2), LAC RG 24 vol.5918.
  35. Dominion Arsenal to DND, 13 August 1936, HQ 56-23 (vol.2).
  36. Table of Components for Face Piece No. 4 for Immediate Order from the Trade in Canada, October 1936; La Flèche to McNaughton, 15 August 1936, HQ 56-23 (vol.3), LAC RG 24 vol.5918.
  37. Memorandum to La Flèche, 18 January 1937, HQ 56-23 (vol.3).
  38. Memorandum to Director of Equipment and Ordnance Services, 20 January 1937, HQ 56-23 (vol.3).
  39. Carr to Master General of Ordnance, 20 April 1937, HQ 56-23 (vol.3).
  40. Memorandum to Director of Mechanization and Artillery, 25 February 1937, HQ 56-23 (vol.3).
  41. See, for example, Morrison to Director of Mechanization and Artillery, 17 November 1937, HQ 56-23 (vol.5), LAC RG 24 vol.5919. This file goes into considerable detail on all of the various technical deficiencies.
  42. Memorandum by Morrison, 5 June 1937, HQ 56-23 (vol.5).
  43. Carr to Master General of Ordnance, 23 June 1937, HQ 56-23 (vol.5).
  44. Ibid.
  45. Memorandum to Director of Engineering and Ordnance Services, 17 July 1937, HQ 56-23 (vol.5). It appears that production of Mk II elongated naval pattern connecting tubes also began at this time, with an initial quantity of about 500.
  46. Pricing of components for Mark IV and IVa respirators; Morrison to DEOS, 20 July 1937; DEOS to Carr, 23 August 1937, HQ 56-23 (vol.5).
  47. Cayouette to Department of Public Works, 30 December 1937, HQ 56-23 (vol.6), LAC RG 24 vol.5919.
  48. DEOS to CIAA, 5 May 1938, HQ 56-23 (vol.6).
  49. Morrison to DEOS, 6 March 1937, HQ 56-23 (vol.7).
  50. Carr Memorandum, 7 May 1938, HQ 56-23 (vol.6).
  51. List of Canadian Manufacturers of Components, HQ 56-23 (vol.6); Suppliers of Components for Canadian-Made Respirators, July 1939, HQ 56-23 (vol.8).
  52. High Commissioner to La Flèche, 10 June 1938, HQ 56-23 (vol.6).
  53. Dominion Rubber Company ended up manufacturing Mark IV face pieces before the Mark V molds were available. See Minister of National Defence to Governor General in Council, 9 June 1939, HQ 56-23 (vol.9). It also seems that Dunlop Rubber Company and Kaufman Rubber Company manufactured face pieces and connecting tubes after the war broke out. See MGO to Director of Contracts, HQ 56-23 (vol.9), Vol.5920; Kaufman Rubber Company to DND, 12 September 1939, HQ 56-23 (vol.12), LAC RG 24 vol.5921.
  54. Carr to Director of Contracts, 27 April 1939, HQ 56-23 (vol.9).
  55. Thompson to La Flèche, 14 January 1938; Caldwell to La Flèche, 26 January 1938, HQ 56-23 (vol.5).
  56. Warren to La Flèche, 18 March 1938, HQ 56-23 (vol.6).
  57. Press Release, 19 March 1938, HQ 56-23 (vol.6). It is worth noting that as of mid 1938, DND had no involvement in the production of civilian respirators.
- It is not yet clear when these were first manufactured in Canada. See La Flèche to Gutta Percha, 14 June 1938, HQ 56-23 (vol.6).
58. Bode to CIAA, 19 April 1939, HQ 56-23 (vol.8), LAC RG 24 vol.5920.
  59. NRC to Director of Contracts, 15 December 1938, HQ 56-23 (vol.7).
  60. Suppliers of Components for Canadian-Made Respirators, July 1939; Memorandum, Director of Contracts, 10 July 1939, HQ 56-23 (vol.8); CIAA to DND, 31 May 1938, HQ 56-23 (vol.11), LAC RG 24 vol.5920.
  61. An RCAF order of March 1943 shows that only RCAF personnel serving in Canada were to be equipped with the light respirator. Those proceeding overseas were issued the older Mark IV or V types. Perhaps this was a measure to maintain the newer type of mask under Canadian inventory control as much as possible. See Memorandum, RCAF Respirator Requirements, 13 March 1945, 452-7-4, LAC RG 24 vol.5432.
  62. Memorandum, Pyradine Treatment of Type E Containers, 20 January 1945, 452-7-4.
  63. Flood to Director of Chemical Warfare and Smoke, 5 February 1945; Containers, Type E, Mark VI, Green Dot, Status of Supply, 4 May 1945, 452-7-4.
  64. Toronto Board of Trade to Ian Mackenzie, 3 July 1939, HQ 56-23 (vol.8); Memorandum from Morrison, 13 September 1939, HQ 56-23 (vol.10), LAC RG 24 vol.5920.
  65. New Zealand was among the first, in February 1939. See Wilgress to LaFlèche, 27 February 1939, HQ 56-23 (vol.10).
  66. Morrison Memorandum, 17 July 1940; Stafford to Department of Munitions and Supply, 12 June 1940, HQ 56-23 (vol.15), LAC RG 24 vol.5921.
  67. Morrison Memorandum, 3 March 1941, HQ 56-23 (vol.16), LAC RG 24 vol.5921.
  68. Inspection Report: Respirator Anti-Gas Containers, 6 December 1941, HQ 56-29-1 (vol.1), LAC RG 24 vol.5922.
  69. "C.W. Counter Measures Against Invasion," GAQ 9-37.
  70. 'Defence Against Gas,' Lieutenant-Colonel E.A. Flood, 1 June 1942, HQ 1173-1-8, LAC RG 24 vol.81.
  71. DesRosieres to War Supply Board, 18 December 1939, HQ 56-23 (vol.13).

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