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# A Nightmare Revisited

## The Restoration of the Canadian War Museum's 8.8 cm Flak Gun

Michael H. Miller

*"Talk about tense. To be hit with a projectile from an 88 mm usually means the end of a Sherman. The speed at which it travels and its size will make it penetrate our armour and destroy everything inside, including the crew."<sup>1</sup>*

### Introduction

The German 8.8 cm *Flugabwehrkanone (flak)* gun is one of the most famous weapons of the Second World War. It was greatly feared by Allied soldiers and airmen alike. Just as every tank they encountered was a Tiger, so too was every German gun an "88." In December 1998, the Canadian War Museum set out to restore the 88 in the museum's collection and return to public view one of the few such artifacts in Canada. The museum's gun was in extremely poor condition, and needed major work. Its components had been disassembled before it had come to the museum and had obviously been at the mercy of the elements for many years. In order to return this complicated weapon as close as possible to its original specifications, an enormous amount of technical information had to be amassed. Some of this should be of interest to readers of this journal, both as an account of a gun that wreaked havoc amongst Canadian soldiers in the Second World War, and as an insight into the nature of museum restoration procedures.

The Friends of the Canadian War Museum raised \$10,000 for the gun's restoration, and without their funding the project could not have been undertaken. Several companies bid on the project and Musetek Ltd. won the contract. Work commenced during the second week of January 1999 and the gun's restoration was completed by the first week of April 1999. The following



article will be divided into three sections: 1) the history and development of the 8.8 cm; 2) the process of identifying the particular gun owned by the CWM, and 3) the story of the gun's restoration.

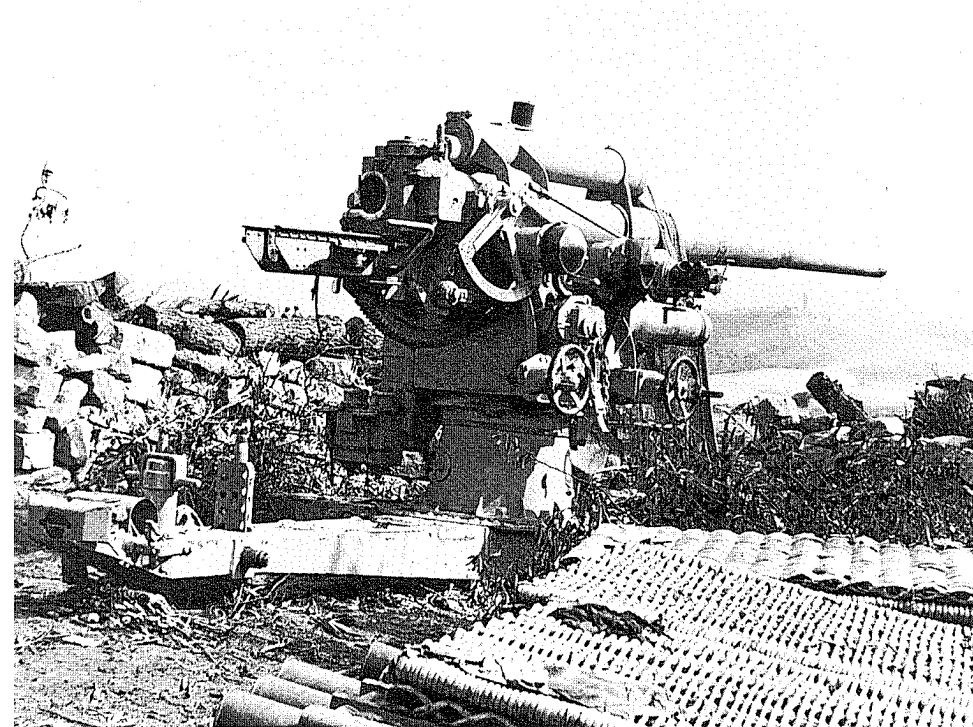
### History and Development

The German 8.8 cm Flak is the best known artillery piece of the Second World War. To the Allied troops who faced it, this weapon was known simply as the "88," the effectiveness of which attained almost mythic proportions. The 88 owed its fame partly to the efforts of German propagandists, but the real key was its operational effectiveness, which inspired fear and respect in all Allied troops who faced it. George Blackburn in his book, *The Guns of Normandy*, confirms that Canadian troops feared "the enemy's long-barrelled 88s – deadly accurate and lethal to Allied tanks at more than two thousand yards."<sup>2</sup>

Despite this praise, the 88 was not quite the "super gun" of Allied mythology. It was originally designed as an anti-aircraft (AA) weapon and later proved effective in other roles, most especially in its anti-tank (AT) variant. Yet, as an anti-aircraft weapon it was no better than its Allied contemporaries, the British 3.7-inch AA and the American 90 mm AA guns, both of which actually had slightly better ballistic and performance data.<sup>3</sup> The 88 succeeded because the Germans produced them in greater numbers from the outset of the war, and because the German



Photo by H.G. Aikman, NAC PA 174425



CWM AN 19900215-004

**Top:** A German 88 mm anti-aircraft battery captured by Canadian troops near Boulogne, France, Septemeber 1944.

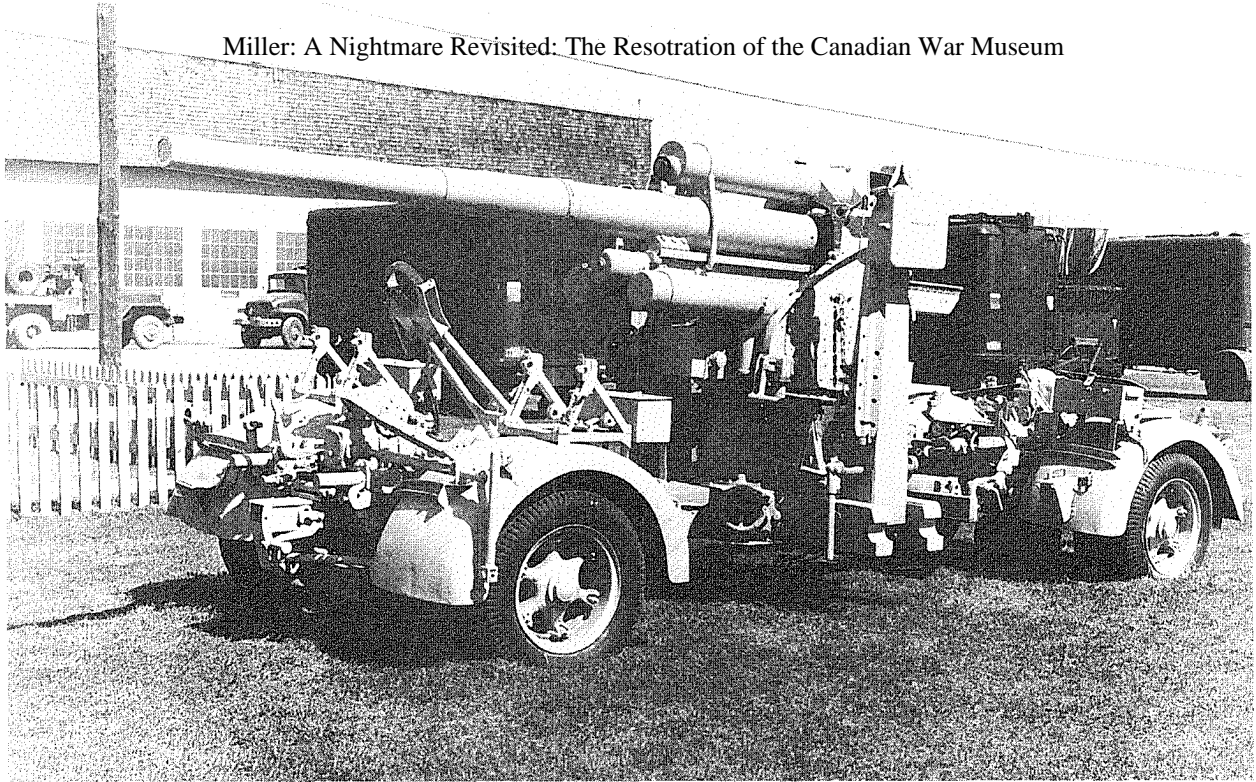
**Left:** A German 88 overlooking the road to Campobasso near Montecorvino, Italy, October 1943.

military fully understood the weapon's versatility, and employed it in a dual role.

With its baptism of fire during the Spanish Civil War (1936-39), the Germans realized the 88's potential as a multi-role weapon. Initially intended to serve in an anti-aircraft capacity, the 88 was also turned against infantry and armoured vehicle targets with great success. The Germans immediately set about incorporating telescopic sights for engaging ground targets, and began supplying the gun with armour-piercing

ammunition. The 88 would gain its lasting fame in this anti-tank role. George Blackburn recalled that,

The 88 mm is a superior weapon mainly because of its multiple role as an anti-aircraft, anti-tank, and mobile-assault gun. As a field gun, it is distinctly inferior to the 25-pounder because of its crest-clearance problems arising from its high muzzle velocity and flat trajectory, which force many of its shells to be fired as erratic air bursts. Clearly, it is as an anti-tank gun that it has earned its deadly reputation."<sup>4</sup>



NAC C 4761

A captured German Flak 18 88 mm anti-aircraft gun at the Royal Canadian School of Artillery, Petawawa, Ontario, ca.1945-46.

Due to restrictions imposed on Germany by the Treaty of Versailles of 1919, many German military engineers and designers worked outside of Germany. In the 1920s, the major armaments manufacturer, Krupp, sent a group of engineers to work for the Swedish firm Bofors. In 1929, this group began to design an anti-aircraft gun based on a 20 lb 8.8 cm projectile. In 1931, they took the drawings and blueprints back to Germany where the government promptly approved production. It entered service in 1933, the first model being known as the Flak 18.

This first-generation gun was a sophisticated weapon for its time. The breech operated semi-automatically for both opening and closing, using a series of springs, giving a constant action independent of the length of recoil or charge used. However, this made for a more complicated breech mechanism. The barrel design was a single tube construction housed within a jacket. The barrel, recoil cylinder, and recuperating cylinder were all housed together in a cradle. This cradle assembly was mounted on a pedestal, which in turn was attached to a crucible platform. Between the cradle and the pedestal two spring equilibrators were mounted. These large springs allowed the heavy barrel to be raised and lowered with the use of only a hand crank. The crucible platform had two fixed and two folding outriggers or legs. At the end of each outrigger was a levelling

jack. A pair of levelling jacks was also mounted under the centre pedestal. The entire platform, or gun carriage, was carried on two sets of bogies (wheel-assemblies), one set at the front, the other at the rear. By means of hand winches, the carriage could be lowered to the ground and the bogies unshackled and removed.

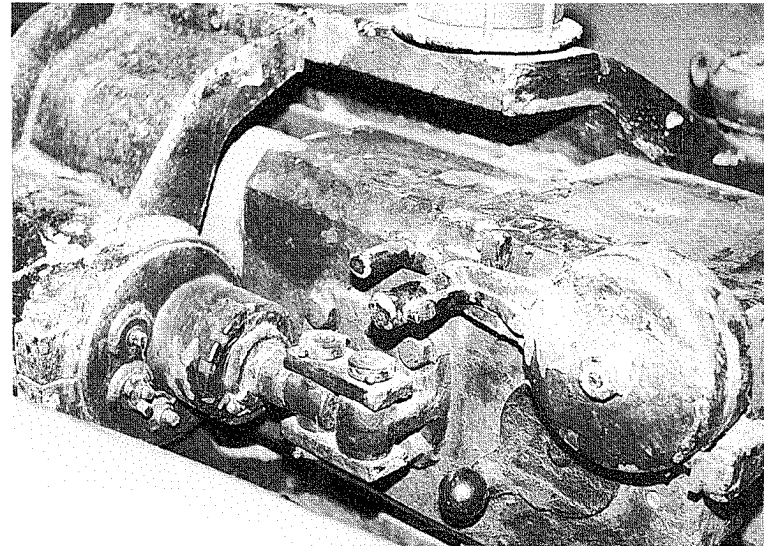
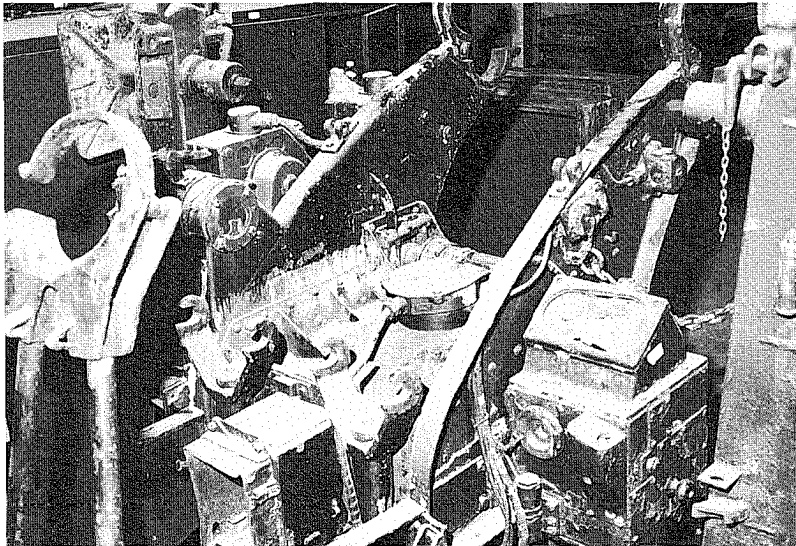
From its inception, the 8.8 cm Flak 18 was designed to serve as part of a battery of anti-aircraft guns. Each gun platform had a series of electrical connections that allowed data transmitted from the battery commander's predictor (data transmitter) to reach each gun's predictor system (receiver). The gun layers then adjusted the weapon accordingly. This predictor system was an electro-mechanical device known as the *Übertragung 30*. One of several options for the Flak 18 was an automatic rammer that took full advantage of the gun's semi-automatic breech. When used as an anti-aircraft gun, the Flak 18 was capable of firing 20 rounds per minute. Mounted to the left of the breech was a mechanical fuze setter. There were both single and double fuze setters, the double being used if a battery commander ordered a high rate of fire. A very popular feature with the gun crews was the armoured shield. As Werner Muller states in his book, *The 88 mm Flak*, "shields were issued particularly to those units that had the task of protecting front line troops,"<sup>5</sup> and provided

protection against shrapnel and small arms fire, thereby having a positive effect on crew morale.<sup>6</sup>

After field trials and practical experience, the Germans introduced several operational and manufacturing design changes. The platform and bogie wheels were re-designed for easier field use. The front and rear bogie wheels were made identical and therefore interchangeable. The front and rear outriggers were also made identical and a barrel support was placed on both ends. With this design, the gun could be towed facing either

commander's predictor, the other mechanically linked to the gun.<sup>7</sup> The crew simply adjusted the controls until the gun's pointers matched those of the predictor. This system, called *Übertragung 37*, gave finer gun control and was easier to maintain. Guns built with it were designated Flak 37.

These three variants, Flak 18, 36, and 37, constituted the bulk of the 88's produced. However, the Germans introduced a further modification, the 8.8 cm Flak 41, in 1943. This



Components of the Canadian War Museum 88 prior to restoration: **Above left:** The pedestal assembly - virtually every moving component was firmly rusted and seized. **Above right:** The breech mechanism of the gun. **Opposite:** The barrel assembly. (Photos courtesy of author)

direction. To facilitate easier manufacturing, the original octagon shape of the pedestal was changed to a square. The biggest change in the design was the switch from a one-piece barrel to a three-piece barrel within a jacket, which had several advantages. Most importantly, steel of a lesser grade could now be used in the portions of the barrel which did not wear heavily. In addition, the new barrels were easier to maintain and repair in the field. This version of the 8.8 cm Flak reached operational units in 1937, under the designation Flak 36.

The German military realized shortly after the Flak 18 entered service that improvement to the predictor system was necessary. The *Übertragung 30* was difficult to maintain and use effectively. By 1939, a new predictor system had been perfected and tested. With the new system the gun had two sets of dials, one operated electrically from the data transmitted by the

was a vastly different gun than its predecessors, with an improved mount and better ballistics, and represented the pinnacle of 8.8 cm Flak development. Another version, the Pak 43 (*Panzer-Abwehrkanone*) was developed specifically as an anti-tank gun with no anti-aircraft capacity. There were also two 8.8 cm tank guns used in Panzer VI (Tiger) tanks and other armoured fighting vehicles. The first, the KwK 36 (*Kampfwagen-Kanone*), was based on the Flak 36, and the other, the KwK 43, was derived from the Pak 43.

These 8.8 cm variants were all accurate, fearsome weapons, and when the tank gun versions were installed in Tiger tanks, they became even more infamous. As one source noted: "No German weapon was held in greater awe by allied fighting men and none provoked more profanity than the mighty 88."<sup>8</sup> The success of the design is shown by the fact that a variant

of the Flak 41 remained in service in the Czechoslovakian army until the early 1960s.<sup>9</sup> Fear of the German 88 led most Allied tank crews to be certain that every AT round fired in their direction came from an 88, although post-battle research has revealed that in fact most fell victim to the smaller Pak 40 75 mm gun.<sup>10</sup>

### Identification

Before commencing restoration work on the CWM's 88, its specific variant had to be correctly identified. The CWM possessed very little documentation concerning this particular artifact. The gun, lying disassembled in rusted components, had been transferred from the Canadian Forces in the mid-1970s. The CWM assigned it an accession number upon receipt, and then put the pieces into storage, where they lay for almost a quarter century.

The process of identification seemed simple enough, but appearances proved deceiving. The CWM 88 was compared with photographs of similar guns in various publications. However, many photograph captions did not identify the model type and, to compound the problem, several publications identified the same photograph of an 88 as different model types. Positive identification required full comparisons of all the various models.

A visual check of the weapon's base and pedestal quickly eliminated some variants. The base was not the low compact version of the 8.8 cm Flak 41, nor was it the low-wheeled carriage of the 8.8 cm Pak guns. This left only the Flak 18, 36, or 37. Nonetheless, at this point identification became much more difficult. The differences between these models, especially the Flak 36 and 37, were not distinct in most photographs.

The *Handbook of German Military Forces* notes the following: "the 8.8 cm Flak 36 differs from the Flak 18 in having a slightly different

mount, while the 8.8 cm Flak 37 is identical with the Flak 36 except for a slightly different data transmission system."<sup>11</sup> Such distinctions contained the key to the puzzle. The British War Office's *Technical Intelligence Summary No. 134*,

dated 10 July 1944, detailed the visual differences between the Flak 18 and Flak 36, making it clear that the museum's gun was not a Flak 18.<sup>12</sup> The field was thus narrowed to the Flak 36 or the Flak 37. Close inspection of the data transmission (predictor) system finally identified the CWM's 88. The *Übertragung 30* was a circular unit containing three concentric rings of electric light bulbs and two mechanically-operated pointers. The *Übertragung 37*, the improved system, consisted of two dials contained in a rectangular box, each dial having a mechanical pointer mounted in its centre. The museum's gun was fitted with the rectangular *Übertragung 37*, and therefore could only have been a Flak 37.

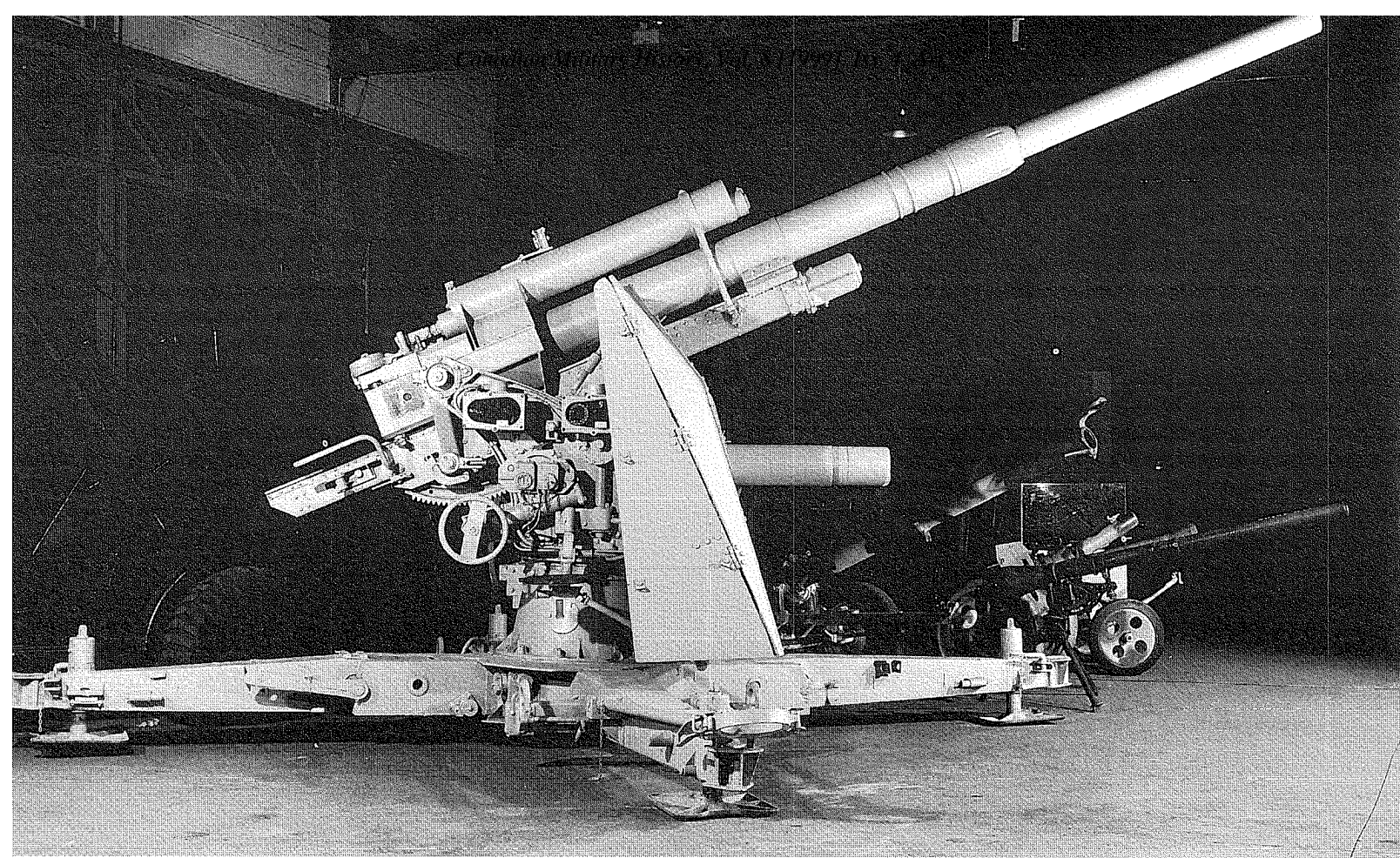
### Restoration

The restoration project was a great challenge. Budget limitations meant that the gun could not be completely disassembled, yet the CWM wanted a finished product that would be far more than a mere clean-up and paint job. I agreed that Musetek Ltd. could restore the major functions of the gun to an operable

condition. This meant that, the CWM's Flak 37 would traverse, the barrel would elevate and depress, and the breech would open and close reliably. Having established the project's deliverables, I commenced the restoration.

I had earlier written a condition report on the gun as part of the bidding process. This report carefully examined the state of the gun and identified problem areas. As thorough as I believed this report to have been, additional problems continued to arise throughout the project, adding to the challenge of completing the project on time and within budget. As many as six layers of paint covered the original finish,





The restored 8.8 cm Flak 37 on display at the Canadian War Museum.

while extensive corrosion hid many small problems, such as seized bearings and damaged parts. Ironically, the fact that gun was already disassembled into its major parts now saved time. However, the parts were extremely heavy and awkward to manoeuvre, necessitating a forklift to move parts from one work area to another. The combined weight of the barrel and recoil assembly was close to 4,000 pounds, the mount and pedestal assembly 8,500 pounds. Even the two equilibrator springs weighed 400 pounds each.<sup>13</sup>

Second World War American technical manuals in the CWM library which detailed captured enemy equipment assisted in the restoration. One was a comprehensive manual on the Flak 18 published in 1943 which, though not a perfect match, had detailed diagrams and photos of the gun disassembly and weapon components.

First I worked on the barrel and recoil assemblies, which I kept secured on their cradle. I hoped to find traces of the original paint and markings on the barrel. In particular, I sought the exact colour of the original paint and symbols

such as "kill" rings on the barrel or unit markings on the recuperator. In order to ensure that samples of the original paint would not be lost, the paint was painstakingly removed layer by layer. Success rewarded the effort: under six layers of paint lay the original colour and primer. The primer was a lead-based red oxide and the paint was a dark yellow. In the early years of the war, it was common for many German factories to use a grey paint (RAL 7021) as a colour coat over the red oxide primer. However, by mid-1943 Germany was beset by shortages of raw materials and the selection of available paint colours had dwindled. It appears that most heavy equipment leaving German factories thereafter were finished in a dark yellow (RAL 7028) over the red oxide primer. The paint on the museum's Flak 37 appears to be this dark yellow. The colour actually looks like a shade of tan, but the Germans designated it *dunkelgelb*, for "dark yellow."<sup>14</sup> There was not enough original paint to restore, so I saved a patch of the original paint and stripped the barrel-assembly down to bare metal.

While working on the barrel-assembly over a period of weeks, I found that the breech block

was firmly rusted in place and, where there was no rust, the original grease had turned into a glue-like substance that was difficult to remove. After many applications of penetrating oil under pressure, the grease and rust began to dissolve. Using an aluminum block and bronze hammers, so as not to mar the original steel, I finally forced the breech block to move. Several more days of applying oil and pressure were necessary before the breech opened fully and could be removed. I then proceeded to disassemble it and return it to working condition.

The pedestal assembly was next. Before work could commence, a large tent of polyethylene had to be constructed around it. This precaution was necessary to contain the dust and residue that would be created by the abrasive stripping procedure. Any components that could be removed from the pedestal assembly were taken to another work area. Other parts and critical areas were covered and protected from abrasive materials and dust. Unfortunately, the folding legs of the pedestal assembly were rusted and seized in the upright position. With enough penetrating oil and downward pressure the legs were eventually lowered.

The next major hurdle to overcome was the elevation mechanism mounted in the pedestal. So many layers of paint had been applied over the years that the drain holes built into the top of the pedestal had been blocked. These blocked drains allowed water to accumulate around the elevation pinion and its bearings. The entire assembly was rusted and seized. Much to my dismay, I discovered that the entire elevation gearing assembly had to be removed in order to gain access to the elevation pinion. Doing so lengthened considerably the total time spent on the project. Once the pinion and bearings could be removed, I discovered that the bearings were not restorable. However, there was a silver lining to this dark cloud. While cleaning the bearings, I found their manufacturing marks. SKF, an industrial firm that still exists, manufactured these pieces. I went to a local bearing store with the faintest of hopes of finding a match, and, unbelievably, the store not only carried the correct size, but the bearings I needed were still manufactured by SKF. They fit perfectly.

The only parts of the pedestal assembly I could not restore were the three predictor units. Since they are coated with radium they are

radioactive, and hence can only be worked on by technicians licensed through the Atomic Energy Control Board. There was no budget for this. Nevertheless, I refinished their housings and replaced their broken glass covers with acrylic. The predictors will be restored at a later date.

The CWM was fortunate to have a shield for the Flak 37, because after the war such shields were often used as scrap metal. The shield, like the gun barrel, had at least six layers of paint, but the flat plate portions were in fair condition. However, the hinges for the shield's wings and the rods connecting the shield to the pedestal were in such terrible shape that I had to fabricate new pieces and weld the rods back together. This, too, took more time than originally estimated.

At this point, the major components had been stripped of old paint and corrosion. The gun was now ready for its first coats of new primer and paint. A clean polyethylene tent was constructed in which to do the job. I selected an automotive paint because of its durability and the relative ease of matching the original colour. The most challenging parts of the project were now behind me. The artifact was taking on new life and, for the first time in more than 50 years, the CWM's Flak 37 was looking factory fresh.

The components now had to be reassembled into the completed gun. This job required six technicians and a forklift. The first step was to set the equilibrators back into place. Once in place, the equilibrators had to be secured until they could be connected to the cradle and barrel assembly, which in turn were placed onto the pedestal. The cradle trunnions could not be dropped straight down into the pedestal mount. Instead, they had to be lifted to the proper height and moved into place laterally. After several abortive attempts, the trunnions were finally placed into the mounts, which were then bolted shut. The artifact was now beginning to look like the famous German 88. But much work remained. A gun barrel as heavy as that of the 88 will not elevate without the assistance of the spring equilibrators, but I quickly discovered that the equilibrators could not be connected to the cradle until the barrel was at its maximum elevation of 85 degrees. The end of the barrel was strapped to the forklift, and, while the forks were slowly raised, a technician cranked the elevation handwheel to match the speed.



Before fastening the shield to the pedestal the full function of the traverse and elevation had to be tested. The traverse operated beautifully. In fact, unless the pedestal was perfectly level, the barrel would traverse on its own in the direction the pedestal was leaning. The elevation was not quite as smooth. After so many years of corrosion and lack of use, the equilibrator springs needed several full elevations to function as intended. We then attached the shield. Although heavy and awkward, it was re-attached in only an hour.

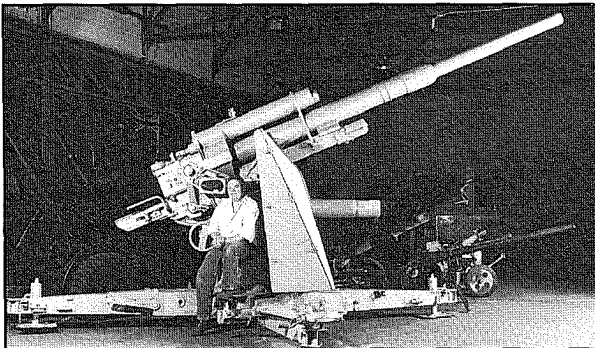
Over the next several days I re-installed and tested the breech assembly, bolted on the predictors, positioned the operators' seats, and re-attached many of the small items. The museum's Flak 37 now looked almost as formidable as it did when it left the factory.

There is an interesting footnote to this project. As we removed layers of old paint, we uncovered production codes, stamped into each separate component of the gun. Once deciphered, these three-letter codes showed that every major component, and most of the sub-assemblies, were manufactured in different factories, spread throughout much of Germany and Austria. The separate components were shipped to a single location for final assembly. The barrel and breech assemblies were of particular interest. The production code of *byl* designated assemblies that were manufactured in Graz, Austria by *Maschinenfabrik Andritz A.G.* This company still exists at its original Second World War location. A stamp bearing "1944" was discovered on the equilibrators, meaning there is a good chance the CWM's gun was produced in that year, although, many of the Flak 37's components were in fact interchangeable with the earlier Flak 18 and the Flak 36.

I was frankly extremely pleased with the outcome of this fascinating project. Since its restoration, the Canadian War Museum's 88 has been a star attraction for visitors to the museum's Technology Gallery at Vimy House, a vivid, tactile reminder of the formidable nature of the weaponry that Canadian soldiers faced during the Second World War.

### Notes

1. David Marshall of the South Alberta Regiment describing an incident of 1 March 1945, quoted in Donald E. Graves, *South Albertas: a Canadian Regiment at War* (Toronto: Robin Brass Studio, 1998), p.284.
2. George G. Blackburn, *The Guns of Normandy* (Toronto: McClelland & Stewart Ltd., 1995), p.313.
3. Ian V. Hogg, *German Artillery of World War Two* (London: Arms and Armour Press, 1975), p.162.
4. Blackburn, p.213.
5. Werner Muller, *The 88 mm Flak* (West Chester, Pennsylvania: Schiffer Military History, 1991), p.32.
6. Muller, p.18.
7. Hogg, p.164.
8. *The Tools of War 1939/45 and Chronology of Important Events* (Canada: Reader's Digest Association Ltd., 1969), p.43
9. Hogg, p.171.
10. Graves, p.101.
11. U.S. War Department, *Handbook of German Military Forces* (Baton Rouge: Louisiana State University Press, 1990), pp.349-350.
12. War Office Technical Intelligence Summary No.134 (London: War office, 1944), Section 7. (copy held in CWM Library).
13. U.S. War Department, *German 88-mm Antiaircraft Gun Materiel* TM E9-369A (Washington: Publications Division - Raritan Arsenal, 1943), pp.4-6.
14. Paul A. Owen, "Sorting Out Late WW II German Paint Schemes," December 1998, an article based upon German High Command (OKH) orders on paint finish, to be found at <http://www.track-link.net/articles/reference/notgrey.html>.



Michael Miller is president of Musetek Ltd., a company which provides exhibition and restoration services to a variety of museums and other clients. He has been closely associated with the CWM over the years. He would like to thank the following for their assistance: The Friends of the Canadian War Museum; Mr. Bruno Friesen, of Ottawa; Mr. Don Holmes, of Ottawa; Mr. Thomas Kohler, of Graz, Austria.