Andrew McNaughton:

His Influence on Artillery and Intelligence during the First World War

by

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At the onset of the First World War, the same theories of direct and indirect artillery fire that had been used for centuries were brought into action alongside the howitzers. The idea that "the artillery must aim at maintaining the closest touch with and affording the greatest support to the infantry"[1], and that "the infantry depends on artillery to enable it to obtain superiority of fire and to close with the enemy"[2] were taken as fact. While these statements were both still technically true, the massive casualties sustained early in the war and the fatal conditions of trench warfare required that a new approach be taken towards the use of artillery in battle. Several innovations appeared during this period as a result, including: flash-spotting, muzzle velocity measurements, sound-ranging, air reconnaissance, air observation parties, and counter-battery fire planning organizations. Although some of these technologies did exist before the First World War, this would truly be their trial by fire.

Long considered the father of sound-ranging, Andrew George Latta McNaughton was born February 25th, 1887, in what is now Saskatchewan. "These were the days of Victorian certitude. The year of McNaughton's birth, 1887, was that of the Queen-Empress's Golden Jubilee. For fifty years, over territories in every quarter of the globe, Victoria had reigned; and they were largely years of peace and growing prosperity."[3] In 1905 McNaughton matriculated to McGill, at the time the "most exciting university in

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[1] General Staff, "*Artillery Notes: No.4, Artillery in Offensive Operations*" (February 1917), p. 5, from Albert Palazzo, "*The British Army's Counter-Battery Staff Office and Control of the Enemy in World War I*" The Journal of Military History (Vol. 63, No.1, Jan 1999) p.58

[2] General Staff, War Office, *Field Service Regulations*, Part 1 *Operations* (1909) (London: HMSO, 1914)p.14 from Palazzo

[3] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p. 11

Canada for science"[4], where he excelled and eventually graduated as a hydroelectrical engineer.

Gunnery however, is where McNaughton earned his reputation. To anyone in today's artillery, the name is synonymous with greatness. . "McNaughton was probably the best and most scientific gunner in an army in the world. His ideas were colossal"[5], said General Sir Frederick Pile. He joined the guns rather inauspiciously however, as an officer in the Montreal Field Battery of the non-permanent militia in 1910. He declined a regular commission because of his mother's health, but being only a part-time soldier also meant he was able to continue on with his studies at McGill as a graduate student. Here we see the origins of his scientific contributions to both warfare and intelligence.

That year, McGill ordered two "Cathode Ray Tubes by Braun" for a new lab, meant for research work in connection with very high alternating and direct voltages. At the same time, several new firms in Canada were interested in building hydroelectric power plants and transmission lines, and they sought the young scientist's expertise. They paid him well for his work, and provided him with the most up-to-date equipment, including one of the first oscillographs (An oscillograph is an instrument for measuring alternating or varying electric current in terms of current and voltage[6]) ever sent to Canada. There was no one to consult on its use, so McNaughton acquired the skills to use it on his own. This would later be invaluable when he encouraged its employment on the Western Front. His work at the same time with Cathode rays to study the problems of

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[4] Ibid. p.15
[5] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p.4
[6] http://en.wikipedia.org/wiki/Oscillograph Hawkins Electrical Guide, Theo. Audel and Co., 2nd ed. 1917, vol. 6, Chapter 63: Wave Form Measurement, p. 1858, Fig. 2607

high-voltage insulation would also lay the foundation for his post-war invention of the cathode ray direction finder.[7]

McNaughton excelled in his military career as he had in school. Promoted to Major and given command of the Montreal Field Battery, his unit was one of the first placed on active duty when the war broke out. This put an end to his civilian career in applied science, but was only the beginning of his contributions to the field. He moved with his soldiers to England and then to France, where his unit fought and he was wounded at Second Ypres. During his convalescence he continued to use his scientific background to improve the accuracy of the artillery, designing a range card (with the help of his wife, since his left arm remained motionless still) for the eighteen-pounder, containing tables which permitted moving targets of opportunity to be engaged with greater accuracy[8]. It was published under McNaughton's name in 1916, and a copy of it is now in the Artillery Museum in Shilo, Manitoba.

Despite technological advances such as these, Battery Commanders of the time still preferred to regulate their fire by observing the bursts and adjusting onto the target. But given the shortage of ammunition, owing to a lack of skilled ammunition tradesmen who were allowed to enlist without restriction until 1915, there had to be an increased emphasis placed on finding out where exactly the enemy was before firing. In McNaughton's own work, he says that "in those early days the artillery situation was not such as to inspire confidence in the minds of our infantry; picture to yourself the case of an Infantry officer pointing out a machine gun nest worrying the men in the line. The

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[7] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p. 20
[8] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p. 47

gunner admits that it is a good target, and he would like to engage, but- no ammunition"[9]. Taking into account the "corrections for the day" was another important part of conserving ammunition. The barometric pressure, the atmospheric temperature, and the direction and speed of the wind[10] were all issues that concerned McNaughton, and when they were taken into account they ensured a much great accuracy of fire. McNaughton was "one of the few fellows who carried a thermometer around" and he placed it with the ammunition so that the temperature of the shells would be allowed for; then he lay out in the opening and kept a close eye on the fall of shot, constantly adjusting, until the shells fell accurately.[11] Later in the war would see the development of a meteorological reporting network, which constantly provided gunners with information on wind direction and velocity, barometric pressure, and temperature.[12]

Observing the fall of shot, despite it's old-fashioned nature was another target of McNaughton's improvements. The pre-war system had placed some emphasis on "ground observers" to locate potential targets, but this idea was useless in trench warfare if they weren't properly sited. McNaughton began placing observation posts in covered positions along the front, as well as on any high features. He positioned the men himself, and taught them to observe flashes from guns, and to immediately send up the angle from which they had observed it. When more than one post observed the same flash, he could draw an intersection on the map and give the position of the enemy weapon to his guns[13]. He even went up in air balloons to survey the landscape for flashes and potential

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[9] A.G.L. McNaughton, "*Development of Artillery in the Great War*" Canadian Defence Quarterly (January 1929) p. 162
[10] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p. 51
[11] Ibid. p. 43
[12] Albert Palazzo, "*The British Army's Counter-Battery Staff Office and Control of the Enemy in World War I*" The Journal of Military History (Vol. 63, No.1, Jan 1999) p. 62
[13] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p. 52

targets.[14] Despite being fired on by an enemy gun, and being unable to be pulled down for fear of giving away their position, McNaughton was respected by his troops for engaging himself in the small details of how the systems were constructed and implemented.

Despite McNaughton's best efforts, "artillery intelligence was in it's infancy, and methods of co-operation between aircraft and the military command were rudimentary".[15] The two specialist organizations responsible for providing intelligence through technical means (air reconnaissance and flash-spotters) needed major improvements in both structure and scope. The information they provided was narrow, but extremely critical to the rhythm of battle. Aircraft photographs provided headquarters at all levels with the most up-to-date information on the structure of the enemy's rear defences and the dispositions of combat units there, while 'flash spotters' and 'sound rangers' provided the same information on the location of its artillery pieces for the guidance of counter-battery fire.[16]

In 1917, McNaughton was appointed "Counter-Battery Staff Officer at Canadian Corps Headquarters"[17]. Without knowing exactly what his new position was, and since the CBSO wore multiple hats, he spent some time with the French, and then with Colonel Haig at V Corps. He learned that the organization was for all practical purposes, a tactical headquarters that would be required mainly at the commencement of a battle to assure the

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[14] Bill Freeman & Richard Neilson, Far From Home – Canadians in the First World War (McGraw Hill, 1999) p.105
[15] A.G.L. McNaughton, "*Development of Artillery in the Great War*" Canadian Defence Quarterly (January 1929) p. 163
[16] John Ferris – The British Army and Signals Intelligence (Army Records Society 1992) p.3
[17] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p.35

suppression of the enemy's guns, although artillery supremacy was an on-going goal.[18] McNaughton credits his early education on counter-battery fire to Col Haig, who showed him what was currently being employed, and the strengths and weaknesses therein.

The Somme offensive of 1916 was a prime example of some of these weaknesses. The British controlled the skies, inspiring terror in the German infantrymen, who knew that the appearance of a British spotter airplane would swiftly be followed by a nerve- and body-shattering barrage of frighteningly accurate shellfire.[19] And while none disputed the importance of air reconnaissance to target acquisition and counter-battery fire, air observers had many concerns. They complained that batteries "crept up" to the targets instead of making the bold corrections requested by the pilots. Furthermore, only a few artillery commanders trusted the observers sufficiently to allow them to engage opportunity targets.[20] Observers were also beset by a number of other problems, including the virtually smokeless burst of TNT, which made registration difficult in anything but perfect weather, "wireless 'jamming' by enemy transmitters, interference due to improper allocation of wireless frequencies, improvement of enemy camouflage techniques, and the use of faked gun flashes to frustrate counter-battery work".[21] Additionally, blame for the loss of 60,000 men on the first day of fighting was placed on the gunners and their failure to destroy or suppress the enemy's batteries, despite a massive preliminary bombardment. Obviously there was a need for improved

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[18] Albert Palazzo, "*The British Army's Counter-Battery Staff Office and Control of the Enemy in World War I*" The Journal of Military History (Vol. 63, No.1, Jan 1999) p.64

[19] Michael Occleshaw, Armour Against Fate. British Military Intelligence in the First World War (London, 1989) p. 58

[20] LCol D.L. Fromow Canada's Flying Gunners: A History of the Air Observation Post of the Royal Regiment of Canadian Artillery (Air OP Pilots Association of Canada, 2002) p.20

[21] Ibid.

communications between gunners and intelligence-gathering units, and an increased focus on counter-battery fire during all stages of the battle.[22]

New technological improvements would aid in improving the situation. Stereoscopic photos were used to see through the enemy's camouflage. Flash-spotting batteries, (later called survey sections) were being used as well, staying connected through a network of telephones, and employing survey equipment such as theodolites. It was similar to the system that McNaughton had employed from his covered observation posts; if one post spotted a flash, it would take a bearing to it and report it to headquarters, which would then report the position to all the other posts, so that they could look in the same direction. At the next flash, every post would press a Morse key that lit a panel light at headquarters. The operator at headquarters, after seeing all the lights come on simultaneously, could be reasonably sure that all the posts were surveying the same target and would then get the various bearings over the phone for plotting. According to Harold Hemming, a fellow McGill graduate and Gunner serving with the British, the position of the enemy batteries could be determined to within five yards.[23] McNaughton was very confident in the system as well, believing that the technique could locate artillery positions up to 10,000 yards away, when a minimum of three posts were set up for best results.[24]

Other prominent soldiers and scientists had been working on the new skill of "sound-ranging" during this period as well, and Lawrence Bragg led the team. In 1915

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[22] Albert Palazzo, "*The British Army's Counter-Battery Staff Office and Control of the Enemy in World War I*" The Journal of Military History (Vol. 63, No.1, Jan 1999) p. 60

[23] A.G.L. McNaughton, "*Development of Artillery in the Great War*" Canadian Defence Quarterly (January 1929) p. 165

[24] J.S. Finan, W.J Hurley, *"McNaughton and Canadian Operational Research at Vimy"* from The Journal of Operational Research Society (Vol.48, No. 1, Jan 1997)p.12

Bragg had been awarded the Nobel Prize for physics, and he was assisted by the grandson of Charles Darwin, Lucien Bull, inventor of the first sound-ranging recorder, and Tommy Atkins, another expert in the field. The method they had invented could predict not only the location of the enemy guns, but what they were targeting, and with the help of a table, the nature and calibre of the weapon. The method used to acquire this useful intelligence is impressive, even by today's standards. A sound-ranging battery, made up of a headquarters and six microphones, was placed forward of the friendly lines anywhere between one and two miles, along with a listening post. When the enemy fired, the forward listener pressed a key. This key would start the recorder at headquarters, and then each microphone would pick up the sound of the report and record it at headquarters. By examining the time intervals between the microphones, the location of the source could be determined. Once the shell burst on the friendly side, it too triggered the microphones and the target could be determined. When conditions were perfect, the recording and calculating could be done in three minutes, with an accuracy of between twenty-five and one hundred yards.[25] Additionally, the time of flight and the range from origin to target were known, and as such could be used to determine the type of gun firing.[26]

There were of course flaws in this system, as there still are in today's sound-ranging technology. These included issues of winds dissipating the sounds, barometric pressure affecting the speed, and various shapes and hills on the ground causing false reflections and distortions in the data. During bombardments, there were far too many explosions and impacts to use the system at all. There were also problems exacerbated by the primitive intelligence assessment abilities of the army at this time. Organizations

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[25] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p. 73
[26] A.G.L. McNaughton, "*Development of Artillery in the Great War*" Canadian Defence Quarterly (January 1929) p. 165

were still required to record, collate, and transmit the information to the appropriate units and commanders. Regardless of these flaws, McNaughton was a man possessed, and he was filled with the motivation to erect a system similar to that of V Corps. This was timely, as preparations were underway for the storming of Vimy Ridge by the Canadian Corps.

McNaughton's system, perfected during the extensive preparatory period, was ground-breaking in more ways than technology alone. It would finally combine intelligence with targeting. Prior to the attack commencing, the enormous numbers of guns that had been massed specifically for this attack would fire at targets he selected, based on his system of intelligence. Following, the rolling barrage would be in the hands of other unit commanders. Finally, the heavy artillery not used during the barrage would be under the control of McNaughton, and would exploit targets of opportunity, enemy artillery, and the enemy's line of retreat.[27] This would be a challenging task for McNaughton, as he did not technically "command" any of the guns, but he was the targeting authority for the engagements.

It was also during the preparatory time that McNaughton proved once again how useful a background in science could be to a soldier. He brought the great sound-ranging expert team to the Canadian Corps area. The scientists brought with them many new ideas, as well as an oscillograph. This ordinarily would have been met with concern and confusion, but with McNaughton's background they were accepted into the fold, a very different reception than they had received from the British senior staff.[28] Sir Lawrence Bragg himself said that ordinarily "an almost impassable barrier had been encountered

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[27] A.G.L. McNaughton, "*Development of Artillery in the Great War*" Canadian Defence Quarterly (January 1929) p. 167

[28] Pierre Berton Vimy (McLelland and Stewart Ltd, Toronto, 1986) p. 164

between the military and scientific minds. The military thought scientists were far too visionary and gadgety to be of any help in the field".[29] But McNaughton realized their value, and used them to the utmost of their ability. His acceptance of scientific principles in warfare influenced all those who worked with him.

He further improved the accuracy of his guns using science just prior to the assault on Vimy Ridge. He was very interested in the effects of barrel wear on the accuracy of falling rounds. He hypothesized that the more a barrel was worn out, the slower it's muzzle velocity would be, which negatively affected the effective distance of rounds fired.[30] In the case of the 18-pounder for example, when firing at a range of eight thousand yards, a loss of three hundred yards could occur. In the fog of war when infantry on foot followed an artillery barrage, this could mean the unnecessary loss of Canadians lives during the assault. Notably, that was only the *average* barrel; some wore out faster than others.[31] To alleviate the potential risk to Canadian troops, McNaughton used a device known as the Boulenge electrical chronograph to measure the time it took for the shells to pass through two electrically charged wire screens. That knowledge provided him with the muzzle velocity of each weapon, and allowed the key guns used in the barrage to be calibrated prior to the commencement of the battle.[32]

Like the artillery plan, the intelligence plan for the battle of Vimy Ridge was critically important. It would be a complex plan with two main goals; the timely notification of the unit, which would have to act immediately to return fire, and the

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[29] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p. 78
[30]The Hamilton Spectator Canada Came of Age at Vimy Ridge; Conditions Were Atrocious, Casualties were Enormous, but the Conquest Led by Canada was Brilliant (The Hamilton Spectator, April 7, 2007) from the Canadian Reference Centre Database
[31] Pierre Berton Vimy (McLelland and Stewart Ltd, Toronto, 1986) p.168
[32] Ibid.

transmission of the information to adjacent and higher formations so they could plan for future actions.[33] The path was complex, with information from reconnaissance planes being passed to the batteries, the Counter-Battery Office, and the Artillery Observation Centre through the Canadian Signal Service. The reports would then be passed to balloons, flash-spotters, and sound-rangers for confirmation. Once confirmed, these reports would be passed to the heavy artillery batteries tasked with firing at on-call targets and to the Artillery Observation Centres on the flanks.[34] This all had to happen with the minimum of delay, to allow targets to be engaged in a timely manner. McNaughton claims that had the Signals Corps not been so thoroughly efficient in setting up the elaborate system of communications, the Canadian Corps would not have been successful.[35]

The critical role of the artillery counter-battery fire during the battle of Vimy Ridge and subsequent battles was obvious from the number of artillery pieces allotted to McNaughton and the Counter-Battery Office. He would have his chance to demonstrate his abilities and the abilities of his new system in the very near future, and because the Arras sector remained quiet throughout the winter of 1916-17, all arms of the Canadian army were able to spend a great deal of time preparing for the task to come. Albert Palazzo hails this winter as the critical turning point in the artillery war.[36] Numerous rehearsals were conducted where flagged sections were used to indicate the physical characteristics of the ridge, and men on horses carrying flags moved at the same pace as

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[33] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p. 79
[34] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p. 79
[35] A.G.L. McNaughton, "*Development of Artillery in the Great War*" Canadian Defence Quarterly (January 1929) p.136
[36] Albert Palazzo, "*The British Army's Counter-Battery Staff Office and Control of the Enemy in World War I*" The Journal of Military History (Vol. 63, No.1, Jan 1999) p.56

the rolling barrage would, to help commanders judge the speed of the advance. Four miles of tunnels were dug to allow the troops movement to and from the front line in relative safety. Signalers laid miles and miles of cable, so that communications and the vital picture of the ground that they provided might remain protected and effective during the battle.

The artillery support was planned in four phases. The first was a 14-day bombardment during which only half the guns would fire, so as to not alert enemy intelligence-gatherers that additional resources had been acquired for the battle. During the second phase, which took place in the week leading up to the attack, the remainder of the artillery as well as machine guns would open up on the enemy. They would not shift to targets further to the rear as they normally would have, once again to prevent the enemy from predicting their next move, but would roll immediately into the third phase which was the rolling barrage combined with McNaughton's intense counter-battery "neutralizing" program. This was meant to surprise an enemy that had just been through three week's worth of bombardment. The fourth phase was to move the batteries forward, and fire at targets of opportunity from the new position of strength.[37]

McNaughton's work in artillery intelligence at the Counter-Battery Office in the weeks leading up to the battle was very thorough as well. He had accurate maps compiled from air photographs and other means of intelligence at the disposal of the Counter-Battery Staff, all marked with the enemy's defences. "Artillery intelligence, properly compiled, would also be of enormous value to the higher command. From the dispositions of the enemy's artillery, German intentions could be deduced."[38] The time

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[37] John Swettenham, McNaughton Vol 1, 1887-1939 (Ryerson Press, Toronto, 1968) p.86
[38] Ibid. p. 74

that senior leadership spent "hanging around" in the Counter-Battery Office remaining apprised of the battle would also help increase awareness of the importance of the artillery and counter-battery fire. Through its control and use of tactical intelligence, the CBO became one of the most powerful tools in the British and Canadian war effort.[39]

While the events that took place at Vimy Ridge on the 9th of April 1917 need not be recounted in detail, it was a clear victory and an identity-building battle for Canada. It was also a test of the improved tactics and technologies of the period, which were in stark contrast to those of 1914. The field army had entered the war with 500 artillery pieces, of which only 24 had the range and weight of shell to effectively suppress enemy batteries. By the war's end this force had expanded to over 6,500 weapons, including 2,000 medium and heavy howitzers whose primary function was counter-battery fire. The pre-war artillery also neither possessed the equipment to locate hidden targets, or the ability to fire without direct observation.[40] The idea that you could locate an enemy's guns and knock them out was considered radical nonsense by old-line British Gunners until after 1917. According to these same leaders, locating enemy guns through the triangulation of muzzle flashes "took all the fun out of war"[41]. While BGen A.G.L. McNaughton could not take full credit for all of these advances in gunnery, target acquisition, intelligence-gathering, and application of scientific principles, he was a driving force who used his scientific background to influence a generation of soldiers who were still fighting the wars of the past.

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[39] Dan Jenkins, *"The Other Side of the Hill: Combat Intelligence in the Canadian Corps, 1914-1918,"* Canadian Military History, (v. 10, no. 2, Spring 2001) p.14

[40] Albert Palazzo, *"The British Army's Counter-Battery Staff Office and Control of the Enemy in World War I"* The Journal of Military History (Vol. 63, No.1, Jan 1999) p. 58

[41] Pierre Berton Vimy (McLelland and Stewart Ltd, Toronto, 1986) p.164

After the armistice, BGen A.G.L. McNaughton would become a member of the "Committee on Militia Reorganization", where he helped draft a proposal entitled "Tentative Proposal for the Incorporation of the Artillery of the Canadian Expeditionary Force into the Canadian Militia (non-permanent)"[42], which would affect the future roles and abilities of the Royal Regiment of Canadian Artillery. He would also go on to invent the precursor of radar, the Cathode Ray Finder. In 1929, he became the Chief of the General Staff at the age of fourty-two, and by 1942 he commanded the First Canadian Army. An impressive and well-respected man, his influence in Canada would continue for many years, through the world of politics and beyond. While his greatest impact on *Canada* might not have been his application of scientific principles to the rusty tactics of the First World War, his impact on the *world* of military strategy is still felt today.

[42] Col G.W.L. Nicholson The Gunners of Canada: The History of the Royal Regiment of Canadian Artillery Vol II 1919-1967 (L'Imprimerie L'Eclaireur, Quebec, 1972) p.4

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