A SYSTEM OF CHANGE: INNOVATION FROM THE BOTTOM IN THE BRITISH ARMY, 1914-1918

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ABSTRACT

This research is about innovation. Using the example of the British Army, which underwent great changes during the First World War, I focus on the role of soldiers and civilian in its process of adaptation to the new tools of warfare. Innovation was not a process forced from the top of the Army or produced solely by officers. Change came from a complex interaction between soldiers, army institutions, and civilians at home. Technology was the topic of this interaction: soldiers used technology to lobby for change and improve their effectiveness on the battlefield, civilians used it to help and participate to the war, while institutions transformed their own structures to adapt to the fast-paced changes, providing a common place to absorb and redistribute innovation.

I try to break the common narrative that portrays the inventor producing a weapon, a committee of the army adopting it, and the weapon changing warfare. Ideas surfaced from a complex environment that looked for solutions in a constant dialogue between the experience of the battlefield, the personal competencies of soldiers and civilians, and the necessities of the British Army to simplify, streamline, and standardize.

To Jacqueline.

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I could never delude myself thinking that this work is the result only of my mind. The paths of life that led me to this point are as full of serendipity as everyone else's and I am thankful of the opportunity to write down here my gratitude to the people that most influenced my studies.

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brightest star in my life. Her contribution in this research is substantial. Not only did she provide most of the happiness of my past years, but also her support, corrections, insights and questions which enriched these pages in a way that is impossible to overstate.

TABLE OF CONTENTS.

LIST OF FIGURES

ACRONYMS

BEF	British Expeditionary Force
CEF	Canadian Expeditionary Force
CDS	Stationery Service (old initials)
CO	Commanding Officer
GHQ	General Headquarters
GSO	General Staff Officer
HMSO	Her Majesty Stationery Office
HQ	Headquarters
IGC	Inspector General of Communications
NCO	Noncommissioned Officer
OP	Observation Point
RE	Royal Engineers
RFC	Royal Flying Corps
RUSI	Royal United Service Institute
SS	Stationery Service
SWP	Special Works Parks
WO	War Office

INTRODUCTION

The First World War was an industrial conflict. Technology always had a strong impact on war, but in the trenches of the western front this influence became domination. Soldiers were ruled by technology, subjugated by the destructiveness of modern weapons, constrained deep down in their trenches. The enemy was no longer the biggest fear on the battlefield, it was artillery. While the small silhouettes on the other side of no-man's land hid in their own trenches, the artillery shells imposed a constant, unrelenting, and overwhelming presence on the life of the soldiers on the frontline. However, modern technology was not autonomously projecting its influence over the course of the war like a *deus-ex-machina* of an ancient Greek tragedy. It was the men using them who made the difference, working tirelessly for four years to master these new tools.

The Great War therefore carried the apparent contradiction of having technology that dominated and at the same time empowered men. In a shallow but common and inaccurate simplification, the powerless soldier was in the trenches and the empowered —and dominating— officer was comfortably in the rear lines. The decisions of staff officers detached from reality but commanding a massive amount of firepower determined the life or death of privates in the frontline. According to this interpretation, new technology and tactics came from the top, pushing ideas down in the throats of unwilling testers. The reality was quite different; this study tries to widen the perspective showing how the push for innovation was not as unidirectional and top-down as we would expect from the hierarchical structure of the army.

Considering the sudden shock of the armies to the full extent of the power of modern weapons, the First World War represents a great opportunity to see how social groups respond to innovation. Many of the pre-existent and well-established habits and doctrines became useless. For example, the pride of the Cavalry Corps was shattered by its obsolescence, threatening its own existence, while airplanes and tanks created new tactics. [1] Therefore, throughout the war the armies had to adapt and evolve to a new warfare or face defeat. While the final decisions rested in the hands of the top officers and their governments, they were not the only people to direct the change. Soldiers on the battlefield and civilians at home tinkered, invented, reflected, and eventually lobbied to direct innovation in the way they thought would lead to survival and victory.

The British Army offers a good example through which to understand this dynamic. While the structure of the army represented well the highly stratified nature of the English society, the British Army had to react more vigorously to the initial shock of 1914. Of the triad of armies that fought on the western front, which was not the only battlefield of the war but arguably was the one with a higher density of technology, initially the British Army was the least prepared. Indeed, at the beginning of the conflict, in comparison to the behemoths of the French and German armies, the small English contingent of professional soldiers was unfit for the vast scale of operations. The gap in weaponry was not substantial, yet in the first years the British Army remained on the sidelines, following closely the development of the French and German armies but not

[1] Lori A. Henning, *Harnessing the Airplane: American and British Cavalry Responses to a New Technology, 1903-1939* (Norman, OK: University of Oklahoma Press, 2019).

leading innovation. By 1917 however the army had caught up with the other two and had started to lead on important innovations such as tanks and air domination. In 1918 the British soldier could be proud of his army, which was at least comparable with the French one, possibly better. In the preceding years, conscription, developments in training, and a change in its vision of the role and autonomy of the soldiers on the battlefield transformed the whole structure of the army. The environment of this change is the topic of this research.

How armies evolve under the pressure of circumstances is a topic that has already interested historians. The twentieth century exposed armies to a continual stream of technological innovations, highlighting the importance of adaptation to success on the battlefield. Meir Finkel explored this topic in *On Flexibility*. Two words are at the center of his research: surprise and recovery; new technology brought by the enemy onto the battlefield constitutes the surprising element that unbalances the conflict and places pressure on old doctrines; an army's success or failure to recover from the crisis depended on its flexibility. Finkel showed that prediction is a chimera: it was not the finnicky foresight of theorists that made armies successful on the battlefield, but their ability to react quickly to problems. The "development of cognitive flexibility" in the ranks of an army is therefore a fundamental factor in success.[2]

Today, how armies should adapt to a new situation is still an important question. Facing a crisis of identity in today's asymmetric wars, the U.S. Army had to understand

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[2] Meir Finkel and Moshe Tlamim, *On* Flexibility*: Recovery from Technological and Doctrinal Surprise on the Battlefield.* (Stanford, Calif.: Stanford Security Studies, 2011).

how to deal with the complicated scenarios in Iraq and Afghanistan. James A. Russell showed how units on the ground responded to challenges unforeseen by the doctrinal framework. These units improved their effectiveness throughout their deployments with an empirical approach. Tactical adaptation and flexibility in the organizational structure of the units were fundamental in overcoming the problems. Russell adopted a bottom-up perspective, showing the role of the soldiers on the battlefield when the theoretical foundations of the army are not functional to the task.[3]

The armies' challenges with innovation during the Great War attracted the attention of some historians, even if not as many as one would expect from the amount of historiography on the conflict. Williamson Murray for example dedicated an excellent chapter of his study *Military Adaptation in War to the First World War*, condensing with great acumen the main problems that armies faced. For him the greatest problem was that the European armies did not cultivate the "intellectual side of their profession." In other words, the armies were not institutions that allowed a systematic learning from the experience of the battlefield. Murray highlighted how the German Army was an exception. When a more dynamic Ludendorff took the place of the lackluster Falkenhayn at the lead of the army in 1916, the well-organized German system allowed a "revolution in tactics." While the shift in leadership surely explains much of this change, Murray focused too much on the importance of the leader without considering the natural time necessary for adjustment to a new situation. It is interesting to observe in this regard that

[3] James A. Russell, *Innovation, Transformation, and War: Counterinsurgency Operations in Anbar and Ninewa, Iraq, 2005-2007* (Stanford, Calif: Stanford Security Studies, 2011).

the French, English, and even the Italian army had a similar cycle of crisis and reform. This common sequence indicates perhaps that all these armies needed an adjustment time in order to adapt to modern warfare.[4]

Moving away from an analysis of grand strategy and towards the minutiae of warfare, Anthony Saunders dedicated most of his historical research to the technical aspects of the First World War's warfare. While this perspective could seem too narrow an approach to the problem, a service more for war enthusiasts than for scholars, it actually takes research into a different approach from the bottom-up. Indeed, Saunders demonstrated multiple times how many foundational technologies such as hand grenades came from the trenches. At the same time, his knowledge on patents allowed him to explore the underworld of civilian inventors that tried to contribute to the solution of trench warfare, showing how limiting it would be to focus only on the armies to understand the changes in warfare during the conflict.[5]

Concentrating only on the leadership or on the singular technological inventions are not the only approaches. Robin Prior and Trevor Wilson opened a previously ignored path with their seminal *Command on the Western Front*. Using the military career of Sir Henry Rawlinson as a case study, they explained the importance of the contribution of the intermediate commanders who led divisions, corps and armies. Throughout the war, Rawlinson led at all these levels with various degrees of success. The authors' final

[4] Williamson Murray, *Military Adaptation in War* (Institute for Defense Analyses, 2009).

[5] Anthony Saunders, *Weapons of the Trench War, 1914-1918* (Stroud: Sutton, 1999); Anthony Saunders, *Dominating the Enemy: War in the Trenches, 1914-1918* (Stroud: Sutton, 2000); Anthony Saunders, *Reinventing Warfare 1914-18: Novel Munitions and Tactics of Trench Warfare.* (London: Bloomsbury Publishing, 2011).

judgement on his qualities seems a little harsh. They described him as an untalented general who stumbled too often in learning how to lead in a modern war. In the very last sentence of their book, however, they underline how he provided “a command structure that would facilitate his technical experts and his ranks and file” to win the war. The army as a system needed not to be pedantically guided but to be empowered with a well-organized structure, leaving it free to adapt to the ever-changing situation on the battlefield.[6]

Michel Goya agreed with this analysis in his impressive *Flesh and Steel*, recently translated into English. He focused on the French Army and illustrated the long and tortuous path that it took from the lack of experience and organization of the pre-war years to the effective tactics and doctrines developed at the end of the conflict. The most important factor for the triumph of the army was the presence of experts in managing the different stages of innovation. Eventually one of these experts, General Foch, took the commanding seat, signaling the acceptance in the French Army of these figures as leaders. Goya however warned us that the “notion of a centralized control of change is largely an illusion.” Indeed, innovation was never a straight-forward process, it was inherently messy and convoluted.[7]

This characteristic confusion during the process of innovation is now commonly accepted by the experts, who look at the army not simply as a highly hierarchical and

[6] Robin Prior and Trevor Wilson, *Command on the Western Front: The Military Career of Sir Henry Rawlinson, 1914-18* (Oxford, UK ; Cambridge, Mass., USA: Basil Blackwell, 1992).

[7] Michel Goya, *La chair et l’acier. L’armée française et l’invention de la guerre moderne (1914-1918)* (Paris: Tallandier, 2004).

therefore cleanly organized institution, but more like a society or an economic enterprise. It is not surprising therefore that the latest research developments on innovation during the First World War borrow from the tools of management studies. Regarding the British Army during the First World War, Robert Foley and Aimée Fox are the most important representatives of this school of study. Foley analyzed the differences between the German and the British armies, focusing on the different learning styles: while the first had a more formal and standardized process, the second based the transfer of knowledge more on the social connections inside the army. Fox explored this research vein in her excellent *Learning to Fight*, showing in length the importance of these horizontal connections between mid-level officers in the learning process throughout the war.[8]

As these two historians demonstrated, the institution of the British Army was not an abstract concept. The social connections and interactions between its officers were an important vector for the distribution of new knowledge in the army. However, there are two main questions still unanswered. The first is the origin of this knowledge, the second is the role of the millions of soldiers, both on the frontline and behind the line, and of the civilians who actively participated to the process of innovation. Indeed, it is very limiting to think that innovation came only either from the top or mid-level officers. A great deal of the expertise accumulated in the trenches made it into manuals, training, and doctrine

[8] Robert T. Foley, "A Case Study in Horizontal Military Innovation: The German Army, 1916–1918," *Journal of Strategic Studies* 35, no. 6 (December 2012): 799–827, https://doi.org/10.1080/01402390.2012.669737; Robert T. Foley, "Dumb Donkeys or Cunning Foxes? Learning in the British and German Armies during the Great War," *International Affairs* 90, no. 2 (2014): 279–298, https://doi.org/10.1111/1468-2346.12109; Aimée Fox-Godden, *Learning to Fight: Military Innovation and Change in the British Army, 1914-1918*, Cambridge Military Histories (Cambridge, United Kingdom ; New York, NY: Cambridge University Press, 2018).

coming from the bottom up. This movement of knowledge from practice on the battlefield to general adoption as a tactic or doctrine is the topic of this research. Analyzing the recent war in Iraq, Russell defined this process of adoption as "organizational innovation," a term that functions very well for the contemporary U.S. Army, which is strong from a century of continual adaptations to modern warfare, but that does not fit well for the much more organic and messy process of change in the British Army during the Great War.[9] In this case the word "assimilation" is better, describing how the changes in the bureaucracy of the army also transformed its ability to collect, retain, and implement innovation.

It is important to notice that the focus of this study is not military effectiveness, which requires a comparison with the enemy's ability and a general judgment on the quality of change.[10] While in this case the process ended positively and the bottom-up pressure to innovate contributed to the final victory, to focus on effectiveness could be a temptation for discarding the many tortuous processes that went against the grain of the institutions, sometimes failing to become officially accepted despite their continual and successful use in the trenches. Efficiency for most of the war was not a word that described well the process of innovation.

The environment of change is at the center of this study, with attention to the movement of knowledge from the bottom up. It would be, however, very limiting to think that knowledge started always and only in the trenches and at the lower ranks. Therefore,

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[9] Russell, *Innovation, Transformation, and War*, 191.

[10] For the reader interested on this topic: Allan Reed Millett and Williamson Murray, eds., *Military Effectiveness*, New Edition, vol. 1: The First World War (Cambridge: Cambridge University Press, 2010).

my approach to “bottom-up” is not to look at the rank of the inventors, but at the ideas’ direction of movement. This perspective allowed me to follow throughout the war innovation born outside of the official channels and its often-long transformation and process of officialization. At the same time, focusing on the direction of change freed me to look at different levels of decision-making power: from a private in the trenches to staff officers, knowledge from the bottom often meant to fight for an idea, lobbying it to their superiors in the hopes that it would eventually become official. This wider perspective also pushed my research in various directions, looking to official institutions such as schools and the Royal Engineers, to the participation of soldiers to grand projects such as the constant updating of maps and intelligence collection, to a wider world of influencers that contributed a continual stream of ideas, to the innovation of weapons and tactics.

For all the above-mentioned reasons, I am trying to expand the excellent research of Fox and Foley. Management studies are powerful in explaining how the organization of a system — being a business company or an army — influences innovation. The relationships and connections between managers and workers can help the business to flourish or ruin it. From this perspective, in an army the managers would be the officers, and therefore the workers would be the soldiers. This parallel between businesses and armies has fundamental limitations. Foley and Fox showed that it works well if the goal is to highlight the connections between the officers and the horizontal movement of ideas. It has the positive effect of expanding the common view of an army as a solely hierarchical organization in which innovation follows only the institutional channels.

The limits of this perspective became clear when I started to expand the concept of innovation. I started to see the problems of defining sharp borders to separate institutional change from organic innovation. Soldiers are not only the workers of the army business, they are also the customers, because they are the ones who receive and use the latest weapons and tactics. In addition, it would be difficult to even define the business-equivalent role of civilians that interacted with the armies to suggest innovations. To add even more complication, soldiers often did not feel to be part of the system of change. Instead, as is the case with customers, they had a fundamental role in the process of innovation. Customers not only define the success or the failure of a product, but also often redefine the use of a product in a way not imagined by the inventors and the producers. In a similar way, soldiers were the judges of the effectiveness of a weapon or tactic and pushed the boundaries of technologies, as we will see with maps.

The choice of focusing on technology came about because during the Great War to change technology meant to change warfare. From the every-day problem of sniping to the most brutal close-combat interactions with the enemy, soldiers not only tried to adapt their actions to war technology, but also to modify that technology in pursuit of survival or victory. Therefore, technology was the connecting link between soldiers (and civilians at home) and their desire to change. It was their opportunity to influence the direction of the war.

I use a broad definition of technology. I move away from the common mistake of focusing only on the high-tech or expensive tools, because these needed great investments and were therefore the kind of change that is pushed from the top. The case of the tank is a good example of this top-down influence. Soldiers in the trenches and civilians at home rarely had access to great sums of money, and therefore often had to adapt with less glaring ideas. In addition, I do not want to limit technology to objects: innovation included ancient-old tools such as the knife, techniques such as camouflage, or new doctrines such as sniping. Sometimes it was the idea of a single individual such as Nissen, who developed a revolutionary method to build barracks cheaply and fast, while other times it was a general change in mindset, like in the case of the evolution of the significance of maps during the war, for which it is almost impossible to pinpoint to a singular origin and required the participation of almost all the army.

The British Army demonstrated a good capacity of assimilation of new knowledge, but the changes required trials, errors, and time. The case studies of this research suggest a rough chronology of the different stages of transformation. The first stage was shock: the violent summer of 1914 represented a seminal moment that dismantled old theories and well-established doctrines: the British Army, like the French and the German ones, was taken by surprise when modern weapons demonstrated their destructive power.

When in the late autumn of the first year of war the soldiers settled down in trenches, the units discovered to their dismay that old manuals and techniques were mostly useless in this new scenario. Therefore, 1915 was a year of experimentation: battles such as Loos for the British and Artois for the French were the places where commanders tried new ideas. However, their men in the trenches did not wait for solutions from the top and tested new weapons such as hand grenades, trench mortars, and sniper rifles. The industrial production was overburdened by the incredible request of resources of modern warfare; the bureaucratic machine of the army was still unable to manage the new organization necessary for static warfare, so great changes were difficult to implement. The British soldiers therefore took the initiative.

The great innovating event of 1916 was not the battle of the Somme, which usually takes most of the space in the narrative of this year. Instead it was the Military Act of January, when the Parliament instituted conscription. Lord Kitchener's campaign for volunteer enlistment already inflated the ranks of the army in 1915, but conscription maintained the flood of untrained men. To transform this multitude of recruits into soldiers the British Army needed to rethink their training system, while the sheer number of new men increased the requests of services, putting under stress units that would become fundamental for the transfer of knowledge such as the Stationery Service. This pressure inspired simplification of procedures, clarification of methodologies, and streamlining of communication protocols with the rest of the army. In short, the hardship made the organization of the army more efficient and at the same time promoted flexibility and adaptation. The last two years of the war stabilized the growth of the previous year, allowing the army to withstand the challenges offered by the enemy and develop tools and doctrines that would eventually lead to the solution of the stalemate.

The British Army could take on the challenges of the First World War because it was able to respond with flexibility and bureaucracy. The novelty of trench warfare compelled adaptation, demolishing many preconceptions and making space for new ideas. Far from being stiff and unresponsive, the structure of the army allowed its men to lobby for their plans and designs. The army permitted a localization of the developments with Army and Corp schools, which promoted in relative autonomy new tactics and doctrines. While this distribution of responsibilities can seem chaotic and inefficient, it empowered the men on the ground, the only experts on the new trench warfare, to accumulate knowledge and test new ideas. It also meant that the General Headquarters (GHQ) in France exercised restraint on its centralizing and regulatory power, an important attitude that other armies did not take. The Italian Army for example maintained under Cadorna a very resistive stance against the ideas from the combat units, which hindered the army's efficiency. Only with the defeat of Caporetto, the dismissal of Cadorna, and the subsequent reforms did the Italian Army acquire the necessary flexibility to defeat the Austro-Hungarian opponent.[11]

Together with flexibility, an effective bureaucracy was necessary to succeed. Bureaucracy created a path for the best ideas coming from the frontline to surface and be distributed to the whole army. For this step, administration was an almost surprising ally. Throughout the war experts increased their authority on their specialized topics, but the dialogue between these experts and the War Office or the GHQ in France needed an official venue. In the last year of the war, this came through the Stationery Service (SS), the creation of a minor bureaucrat, Captain Partridge, who slowly but surely increased the responsibilities, the influence, and the capabilities of this unit. Indeed, starting as a small

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[11] John Gooch, *The Italian Army and the First World War*, Armies of the Great War (Cambridge: Cambridge University Press, 2014); Vanda Wilcox, *Morale and the Italian Army during the First World War*, Cambridge Military Histories (Cambridge, United Kingdom: Cambridge University Press, 2016).

printing warehouse, the SS at the end of the war was the authority responsible for the acquisition, printing, and distribution of knowledge for the entire army.

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This study follows a loose path from the general to the specific. In chapter 1, I describe the world of trench warfare and the evolution of this weapon system. Trenches were not only a frustrating delay towards modern warfare but an environment that stimulated change. This perspective allows us to better understand not only the complexities of trench warfare, but also its continual evolution throughout the conflict. Indeed, the shape of the trenches changed because the troops on the battlefield refined their understanding of the weapons and tools they were using. Therefore, trenches are a good acid test to understand how the experience on the battlefield transformed how the war was fought. Trenches are also a good start for an analysis of the agency over innovation, showing how decision-makers were not the sole influencers. Far from proposing theories, GHQ was more a collector and analyzer of information from the frontline, transforming the successful practices on the battlefield into general doctrines for the whole army. Soldiers on the battlefield were the real source of change and among them experts pushed new ideas such as camouflage.

In chapter 2, I analyze one of the most consequential tools of the war: maps. Low-tech and far from being a new invention, maps became the connective link between any action of the army on the battlefield. In a war where the control over the territory had become an obsessive and dominating character, maps allowed a scientific approach to warfare that was based on precise data. The survey of a territory had long been one of the most important actions that nations employed to control their lands; it was indeed one of the best tools to centralize the power through bureaucracy. It is therefore difficult to think of the map survey that the British army did in France as a bottom-up project. However, it is an error to describe map making only as the action of few, super specialized units, because while the barebones of the maps was an institutional effort, the population of these maps with the most important data such as all the details of the enemy position was a collective endeavor of a multitude of observers, snipers, and aviators. In addition, the competition over the control of the landscape was driven by a steady flow of new techniques for the interpretation of aerial photographs, a completely new discipline that developed organically on the frontline. Therefore, using the examples of map-making I explain how official projects expressed not only the will of the decision-makers, but also the agency of the lower ranks of the army.

Chapter 3 describes the official hubs of knowledge, research centers that were places of innovation. I employ four examples: to represent the schools I use the 2nd Army Trench Mortar School; the other examples are all from the Royal Engineers: the Special Works Park (SWP), which was a unit that developed camouflage material and ideas for the British Army throughout the war; the case of the design of the Nissen huts; and the development of sound ranging for the detection of enemy's artillery batteries. These examples were officially recognized by the army and therefore the members of these units rarely had to fight for the acceptance of their ideas. However, the trench mortar school and the SWP are good examples of how these institutions were not solely research centers: indeed, they acted more like sponges, collecting information from the trenches and filtering it out for the whole army. They were also training facilities and their officers became established experts in their fields. When the army eventually needed to solidify ideas born in the trenches with the production of official manuals, these experts were the obvious choice for writing them.

Not all experts had an officially sanctioned role in the innovation process and many were not even experts, as I explain in chapter 4. Many tinkered on new weapons, in the hope that their idea would help the soldiers in the trenches. Some silly gadgets reached the trenches with terrible consequences. Some devices had very intricate paths despite their clear usefulness; others, like the trench knife, were almost universally used but were never made official gear by the British Army. This chapter explores the confusing, indirect, and often irrational relationship between ideas and bureaucracy. With hindsight it is easy to focus on only the successful stories, sometimes even making their path to adoption more straightforward that it was. However, at the time no one had a perfectly clear idea of which new weapons and tools would be successful and influential on the battlefield and which would be utter failures. The social context of innovation often was this middle world of ideas, hanging between the will and understanding of the institutions and the theories and hopes of civilian and soldier inventors.

Chapter 5 illustrates what possibly is one of the clearest examples of how soldiers in the trenches adopted new ideas and how these new ideas slowly climbed up the ranks of the British Army, eventually becoming a doctrine. While sharpshooting had long been common on the battlefield, modern sniping was a trench invention. Its usefulness in modern warfare allowed snipers to acquire slowly but steadily an official status, but GHQ perceived their complex and highly specialized knowledge as merely specific to trench warfare. When in the last year of the war the armies finally found a solution to the gridlock, the sniping school had to work hard to show their usefulness outside the trenches. They lobbied for official equipment, then for an official role, then to create schools, and eventually for the acceptance of their doctrine in the army. Their continual fight for validation is a clear example of the pressure of ideas from below and of the difficulties that these ideas encountered on their path to acceptance.

In chapter 6, I recount the story of the Stationery Service, the unit that from a very humble beginning became by the end of the war the neural system of the collection and distribution of knowledge in the British Army. To illustrate the movement of the ideas from the bottom-up without analyzing the role of this unit would illustrate the innovation process as a mere monologue of the inventors, oversimplifying the complexity of the dialogue with the institutions. Bureaucracy was fundamental in innovation for two reasons: first, a take-in system allowed ideas to flow upward; second, a centralized system could re-organize these ideas, make them clear, and distribute them to the rest of the army. For these reasons the Stationery Service needed a technical proficiency in printing and publishing together with an official recognition and power of control over the process of publication. The case of the Stationery Service also represents an additional evidence that change came from the bottom. Indeed, the unit had to lobby continually for its position in the army: their important role was not an idea of the War Office or of the GHQ, but the child of the constant work and promotion of expert bureaucrats.

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This study uses a wide variety of sources. Official histories, units' war diaries, and manuals were the easiest to handle. They helped to delineate the stories of important units such as the Royal Engineers, schools, and the Stationery Service; manuals offered the final, distilled record of the experience on the battlefield and therefore I had to interpret their findings in search of the origin of this knowledge. Unfortunately, the official manuals do not offer any clue on the name of their authors. Personal memoirs and diaries published after the war helped fill in the gaps. In the only circumstance I could find in which their identity surfaced from other sources (the manual Scouting and Patrolling, written by Frederick M. Crum) the author was a practical expert who spent much time and energies to promote ideas developed in the trenches. Diaries also revealed the experience of the army around new concepts and tools and providing examples of how men on the battlefield perceived innovation. Not everyone had the necessary connections to publish their memoirs. However, a small universe of articles from official military journals and magazines for the public often offered slices of memories of the war.

Many memories disappeared in the past decades with the departure of the last veterans of the war. However, this emotional connection has not completely evaporated. In the laborious attempt to illustrate the relationship between soldiers and the terrific technology of war, I used the impressive array of oral interviews of veterans offered by the Imperial War Museum. The sound of their voices, slowed down by the weight of years and by the burden of their memories, should remind us that technology and warfare was not affecting the abstract soldier, but actual people.

CHAPTER 1. AN ENVIRONMENT OF CHANGE: THE EVOLVING TRENCH WARFARE

Trenches were the environment that pushed the armies to change. Therefore, to understand innovation we need to understand how the weapon system of trenches evolved throughout the war together with the evolution in warfare. In this chapter, after a brief look at the historiography, I explain how the shape of the trenches changed during the war, and I describe the actors who influenced this change.

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Why trenches are so unappealing to the historian is an interesting question. No scholar who deals with the Great War can avoid the topic, nor has anyone avoided the topic completely; yet, except for a few specialists, the majority have treated trenches as a nuisance that locked down armies and impeded the return of maneuver warfare. This opinion on trenches is an understandable perspective because it was also the perception of the generals and soldiers at the time. For the soldiers, the trench was the misery of the claustrophobic and uncomfortable life below the ground, for the generals, it caused frustration at every attempt to break through the enemy defenses. However, to think about trenches only as a nuisance misses a fundamental point: trenches were a weapon system that developed throughout the conflict and forced the armies to evolve, specialize, and manage the integration of different roles on the battlefield. Therefore, the environment of trench warfare was probably the most important factor in forcing the adaptation of the old armies to the modern tools of war of the twentieth century.

Literature focused on soldiers' experiences of the trenches, both in well-known literary successes such as Remarque's *All Quiet on the Western Front* or Jünger's *Storm of Steel*, and in the numerous collections of published diaries and memoirs, a genre that recently saw a rebirth due to the interest of the public on the wave of the war's centenary. Historians, too, have focused mainly on the every-day life in the trenches, often using the horrors of trench warfare to denounce the irrational immorality of war; Jay Winter and John Ellis are good examples of this category.[12]

The four-year-long sequence of frustrations in looking for a breakthrough and the fight for a solution to the gridlock have been another common topic for military historians: some, such as Timothy Travers, focused on the strategic dimension, while others dug deep in the development of new tactics, like Bruce Gudmundsson.[13] The excellent work of Paddy Griffith, *Battle Tactics of the Western Front: The British Army's Art of Attack, 1916-18*, touched both worlds, linking masterfully the emergency of new tactics and technologies with the complex necessities of their strategic implementation.[14]

Most of these historians, however, only touched on the details of trench warfare, an understandable but problematic oversight, because trench warfare was fought on details. The 'minutiae' of the development of fundamental tools such as hand-grenades

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[12] John Ellis, *Eye-Deep in Hell: Trench Warfare in World War I*, 1st American ed (New York: Pantheon Books, 1976); Paul Fussell and J. M. Winter, *The Great War and Modern Memory* (Oxford: Oxford University Press, 2013).

[13] Bruce I. Gudmundsson, *Stormtroop Tactics: Innovation in the German Army, 1914-1918* (New York: Praeger, 1989); Timothy Travers, *How the War Was Won: Command and Technology in the British Army on the Western Front, 1917-1918* (London; New York: Routledge, 1992).

[14] Paddy Griffith, *Battle Tactics of the Western Front: The British Army's Art of Attack, 1916 - 1918* (New Haven: Yale University Press, 1996).

emerged in the work of weapon enthusiasts, yet few scholars devoted time to analyzing them. Among them Anthony Saunders relentlessly investigated the details of trench life and tools.[15]

While scholars dedicated attention to the study of the doctrine and technology, fundamental factors to understand the practical reality of trenches, there are few works on the actual development of the trench system. We find information on the structure of a trench, how was to live in the dugouts, even on the different shapes of pillboxes. Scholarship analyzed how trenches made aggression impersonal and ritualized.[16] However few books address the evolution of the shape and organization of trenches as a weapon. Some of these works are targeted for military history enthusiasts, but usually texts are more descriptive rather than an analysis.[17]

One exception is Nicholas Murray, who did exhaustive research on the development of the trenches as a reaction to the new technologies of the late nineteenth century. His work is detailed and illuminating, showing how trench systems in 1914 were not a new and surprising evolution of warfare. This book should be on the short list of texts for whomever wants to understand the origins of trench warfare for anyone seeking to understand. The author ended his research in 1914, a choice that surely made sense and

[15] Saunders, *Weapons of the Trench War, 1914-1918*; Saunders, *Dominating the Enemy*; Anthony Saunders, *Reinventing Warfare 1914-18: Novel Munitions and Tactics of Trench Warfare.* (London: Bloomsbury Publishing, 2011).

[16] Tony Ashworth, *Trench Warfare, 1914-1918. The Live and Let Live System* (London: Macmillan, 1980).

[17] A laudable example of general overview of trench warfare is the work of Stephen Bull, both in Gary Sheffield, ed., *War on the Western Front* (Oxford, U.K. ; New York, NY, USA: Osprey Pub, 2007) and in his own work; Stephen Bull, *Trench: A History of Trench Warfare on the Western Front* (Oxford; New York: Osprey Publishing, 2014).

gave the book a well-defined *raison-d'etre*, but unfortunately for us, it leaves out the important analysis of the developments during the war.[18]

Indeed, Murray left the reader hungry: he served a rich appetizer but left the kitchen right when the customer would have appreciated the main course. How and why the trenches evolved during the war remains a topic that still deserves its own book. G.C. Wynne in 1940 addressed the evolution of the trench system in an almost forgotten book published with the incredibly unfortunate title of *If Germany Attacks*. Published over several years in the *Army Quarterly* as a series of articles warning of a war to come, the analysis of the book is extremely detailed and solidly based on an extensive research of British and German documents. However, it is an eighty-year-old study that would benefit from the subsequent extensive historiography.[19] Much more recently, Martin Samuels did a good analysis of the evolution of trenches during the Great War, but his focus is mainly on a comparison between the British and German military efficiency and structure of command.[20]

The German side of the question has been explored in one of the Leavenworth papers by Timothy T. Lupfer, who studied the change in tactics and the evolution of doctrine during the war.[21] Jonathan Krause partially filled the gap, explaining the early

[18] Nicholas Murray, *The Rocky Road to the Great War: The Evolution of Trench Warfare to 1914*, First Edition (Washington, D.C: Potomac Books, 2013).

[19] Graeme Chamley Wynne, *If Germany Attacks. The Battle in Depth in the West* (London: Faber & Faber, 1940).

[20] Martin Samuels, *Command or Control?: Command, Training, and Tactics in the British and German Armies, 1888-1918* (London ; Portland, OR: Frank Cass, 1995).

[21] Timothy T. Lupfer, *The Dynamics of Doctrine: The Changes in German Tactical Doctrine During the First World War (Leavenworth Papers).* (Combat Studies Institute, U.S. Army Command and General Staff College, 1981).

stages of the learning process. Indeed, he showed how the experience of the second battle of Artois in the early summer of 1915 forced both armies to re-think the structure of their trench systems and the methodologies of attack, factors that had major impacts on the subsequent, and much more studied, years of the war. In addition, he studied the actions of the French Army, which unfortunately too often remains out of the spotlight in the Anglophone historiography.[22]

While these authors investigated general doctrines, we still need a deep understanding of the evolution of the actual trench system and not only of the doctrines built around them. The common view is that Germans developed a more complex system of trenches early in 1915, refined the system in 1916, perfected it with the Siegfried Line — baptized "Hindenburg Line" by the Entente— in 1917, and demolished the system with the new tactics of their assault troops at the end of the war. The development of the trenches, therefore, was a forced sequence of steps. We are back to the perception of a war in which the actors are passive victims of a system that is imposed on them by fate.

To think that it was indeed an obvious path is similar to considering all the studies on Vauban or on medieval castles silly and unnecessary, because the evolution of fortresses was simply an automatic response to new tactics and technologies. The reality is that trenches were —and still are— weapons: they not only saved men, helping them survive the terrible destructiveness of modern artillery and automatic fire, but they also killed the enemy, funneling the attackers in well devised death traps. Men on the

[22] Jonathan Krause, *Early Trench Tactics in the French Army: The Second Battle of Artois, May-June 1915*, Ashgate Studies in First World War History (Farnham, Surrey ; Burlington, VT: Ashgate, 2013).

battlefield used this weapon very effectively and improved it throughout the war. Therefore, the weapon of trenches developed as did artillery, airplanes, and tanks throughout the war.

Although soldiers built trenches with dirt and a shovel, they were actually also a product of concrete, metal, and state-of-the-art engineering. They even outlived the Great War. During the Second World War, Moscow, Stalingrad, and Kursk on the eastern front illustrated clearly how the grind of a static warfare did not die with the First World War. Even outside of the brutality of the Russian front other examples such as Tarawa and Okinawa in the Pacific can show how costly were attacks on strongly defended positions, even in a time when tanks and more powerful airplanes well re-established mobile warfare.

Why have historians overlooked trenches? The common perception of trenches is that they were an impediment to a 'normal' development of war, which is often considered a synonym of 'conquest of territory.' This is an illogical analysis that undermines well-established doctrines such as strategic bombing, which destroys the enemy but does not conquer ground. If anything, trench warfare has the quality of highlighting the illogical immorality of war. The evident examples of the First World War's battles make it difficult to justify the number of casualties sustained just to conquer few feet of land. Another explanation resides in the level of technical understanding necessary to analyze trench warfare. The degree of specialization in the details of soldiers' trench making in the Great War implies that the historian needs an equal specialization to decode the peculiar environment of the trench warfare.

Moving from considering the trenches as a simple 'environmental factor' to seeing them as an actual weapon is important because otherwise we risk misunderstanding the whole war. The trenches were not an odd parenthesis in the normality of the war of movement, but an integral part of the evolution of modern warfare. The armies in 1914 were not structured in accordance with the power of their weapons and trench warfare was the environment that forced them to change. Understanding the evolution of the powerful weapon system of the trenches is, therefore, central in understanding the evolution of modern warfare. Technology and weapon systems, as the creation of new weapons, or the finding of new uses for old ones, is in this regard as important as the strategic vision of the generals. However, technology is not another abstract influencer, and troops on the ground used practical experience to interact with their tools of war and influence the changes of the system of defense. Soldiers were the ones who kept the continual work of refining and adding improvements. Taking this perspective, we can see how the trench system was a stratified, collective expression of the imagination, study, and effort of soldiers and officers on the battlefield.

The Evolution of The Trench System.

When the war broke out in August of 1914, the British Army, like the other armies on both sides, was focused on the attack as the only way to ensure a decisive success. With the hindsight of the bloodbaths of 1914-1915 it is easy to see how this was a shortsighted understanding of the modern tools of warfare. The error seems even bigger if we take into consideration not only that modern weapons clearly demonstrated their power in the Russo-Japanese war of 1904, but also that most of the armies seemed to recognize the importance of field fortifications. The proof is that every major nation that participated in the war, except France, issued entrenching tools to every soldier. However, the lessons of the Russo-Japanese war were only partially interiorized and theory had yet to clash with practice.[23]

Indeed, the theory was not wrong: the pre-war official manuals demonstrate how precise was the knowledge of the power of field defenses. In 1908, the Royal Engineers published a manual of field works with tests of the effectiveness of trenches against artillery. The manual noted how "…field gun shells are not intended to destroy earthworks. Against deep trenches, with low, flat parapet, field artillery has but little effect." The manual is almost two hundred pages long, heavily dependent on illustrations, and full of detailed accounts of a number of field defenses. Of course, trenches are well described and comprise a substantial part of it. What is described in these pages are not foxholes, but systems of defenses that encompass barbed wire, with designs that had been highly successful in the Russo-Japanese War.[24]

Being that the knowledge of effective trench systems and the experience of previous wars was already there, one would be tempted to fault the myopic vision of the British Army in 1914, but we should also understand that to entrench is frequently a declaration of failure. It is astonishing how well the armies and the nations behind them absorbed the shock of the exceptional number of casualties in the summer and early

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[23] Murray, *The Rocky Road to the Great War*, 214–18.
[24] *Military Engineering. (Part I): Field Defences, 1908* (London, 1908), 8.

autumn of 1914, but war had already been a very deadly affair for at least a century, arguably for more. Not so far back in time, the Franco-Prussian War in Europe and the American Civil War on the other side of the Atlantic demonstrated the dangerous mix of modern nationalism and industrial production. Therefore, it should not surprise that it took four months of slaughter to definitively establish that the only way to survive was to be well covered below the parapet.

In January of 1915, the frontline was well defined between the North Sea and Switzerland. A continuous boundary of no-man's land delimited by opposite-facing trenches inaugurated the static warfare of the western front. The Germans often occupied the higher ground, and surely this was the case when they faced the British Army. This advantage, in addition to a heavier artillery and the distribution to the infantry of the infamous *minenwerfer*, quickly spread the opinion that the Germans had a better grasp on trench warfare.

Even privates in the British Army had a clear opinion in this regard. E. A. Clarke remembered that, "the Germans had the technique of trench warfare, we were just learning. They had everything ready for trench fighting." The impression would have been legitimate, considering also that, as Clarke remembered, being in the lower ground not only allowed the enemy to check every movement on the British line, but created incredible problems of drainage, often putting the bottom of the trench under a foot of water.[25]

[25] "Private Papers of E. A. Clarke," Imperial War Museum.

If Germans had the advantage, it does not mean, that as Clarke said, “they had everything ready.” Krause described how, although unsuccessful, the 1915 French offensive in Artois scared the German Headquarters enough to inspire a complete revision of the trench system. A simple line of trenches was effective against previous tactics, but the French tested new attack techniques. One was a well-planned and violent use of artillery, with the first use of a rolling barrage, an advanced technique that precisely timed a movement forward of the bombardment to allow the troops to follow closely. The plan fell short, quite literally, because the artillery was not able to follow the unexpected success of the attacking troops. The French troops had gained ground so fast that even their reinforcements could not follow up.[26]

The battle confirmed the firm grasp of modern guns on the field, both in attack and in defense. Thousands of French poilus payed the price of an evolution in doctrine that was inherently too slow. The French generals did not acknowledge fast enough that the advantages in organization, control, and morale of compact units —a dogma in infantry doctrine at the time— could not compete with the dangers that it created: indeed, they offered the perfect targets for the German guns. Despite its final failure, the offensive in Artois had been a partial success: the highly organized and concentrated initial bombardment dismantled the first line, and the Germans had to scramble to contain the flood. In the winter and early spring of 1915, the French Army pushed not only in Artois, but also in Champagne and on the salient of St. Mihiel; it was a series of very aggressive offensives that ultimately failed at great expense. Both the French and the

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[26] Krause, *Early Trench Tactics in the French Army*, 5–6.

German armies learned costly lessons that would shape not only future tactics, but also the practical implementation of the trench system in the years to come.

All these lessons eventually reached the British Army as well. The Stationary Service printed and distributed two pamphlets: the *CDS 303 Experience Gained In the Winter Battle in Champagne*, the translation of a captured German document issued by the Chief of the General Staff of the Army the 13th May of 1915, and the *SS 23 Preliminary Deductions for Instruction, from Recent Engagements*, issued by the French General Staff at General Headquarters in June 1915. Both documents were translated and printed in November the same year. They offer a very interesting dual perspective on the crucial lessons of the previous months.[27]

The French pamphlet begins with two general lessons: the importance of an "elaborate, though vigorously conducted preparation, and "the perfecting of the organization of our own defences…an object to be pursued without intermission and must never be regarded as achieved or even as adequate." In 1915, trench warfare was an antonym of improvisation, and even the attacker had to constantly maintain a defensive attitude, continually improving the trenches, which were never safe enough and needed constant repair and maintenance.[28]

These general rules are then followed by six points of explanation: two are dedicated to the planning of the attack, which has to be supported by a reserve "as close

[27] "C.D.S 303 - Experiences Gained in the Winter Battle in Champagne from the Point of View of the Organization of the Enemy's Lines of Defence and the Means of Combating an Attempt to Pierce Our Line," 1915, Imperial War Museum; "S.S. 23 - Preliminary Deductions for Instruction from Recent Engagements," 1915, Imperial War Museum.

[28] "S.S. 23 - Preliminary Deductions for Instruction from Recent Engagements."

as possible to the front," and has to be organized as a series of simultaneous and coordinated assaults on a broad front, "with the object of forcing the enemy to disintegrate his resources." The other four points explain the structure of the enemy's trenches. These were lightly garrisoned and defended mainly by a great number of fortified machineguns. The enemy organized a series of strong points of defense designed to resist attacks from any direction and keep a "stubborn resistance" even when surrounded. The analysis then explains the importance of communication trenches to link the different sections of the line and the necessity to organize the defense system around the barbed wire, planning for stopping the attackers with flank fire, therefore preventing the encirclement of positions. Lastly the document notes that the Germans reinforced the cellars [of houses and farms] with concrete, digging underground shelters underneath them. The last rule admonishes that "Army and Corps Commanders will be responsible for seeing personally that these various hints are borne in mind, no less on the defensive than in the offensive."[29]

The German pamphlet is organized in a similar fashion, showing that it is an old habit for armies to appreciate bullet points. The reader that expects a positive evaluation of the experience acquired — the 1915 battles are indeed often represented as German victories — would be surprised to find a generally negative tone; only the German artillery is spared from a general critique of the behavior of the army in the battle.[30]

[29] "S.S. 23 - Preliminary Deductions for Instruction from Recent Engagements."

[30] "C.D.S 303 - Experiences Gained in the Winter Battle in Champagne from the Point of View of the Organization of the Enemy's Lines of Defence and the Means of Combating an Attempt to Pierce Our Line."

The document is split in two main sections: preliminary remarks and instructions. The first two points of the preliminary remarks analyze the French attack tactics. Some were successful, such as the “irresistible artillery preparation, defying all description,” others less effective, such as the infantry attacks, that despite the fact they “were carried out with courage and devotion” were focused on too narrow fronts and in dense formations, not using a “system of successive lines of attack.” This comment should be read as ‘they did not use the terrain properly during the attack.’

When the document focuses on the German side of the battle it becomes even more interesting. This part is all devoted to artillery. The first observation describes the power of the French artillery against the position of the German trenches. Clarke, like the British in general and many historians, consider the competent choice of trench positions by the Germans as one of the most important advantages they had. The German Army’s choice should have been the result of their deeper understanding of trench warfare and their better strategic vision. However, if we read the German analysis of the battle, it was actually not so perfect after all.

> The chief German trenches were, in order to obtain good command, generally sited on the forward slopes of the crest fairly high up, a fact which was of great assistance to the French artillery observers. The hostile artillery soon reduced our trenches to a condition in which they were little more than a mass of ruins, offering not a vestige of shelter. Successive attempts made by us during the night to repair the damage were rendered almost impossible by the massed fire of Minenwerfer [sic], rifle grenades and infantry; these attempts were responsible for our heavy losses, which were caused almost exclusively by artillery fire. Our losses were so serious that in many cases every living thing was annihilated, and

> all the obstacles completely destroyed, thus enabling the enemy's infantry to penetrate our positions with ease.[31]

This document illustrates the grim reality of trench warfare on the side of the defender, a side that English-speaking historians and public memory tend to under-represent in their studies. Memory focuses more on the slaughter of the first day of attack in the Somme battle, when British soldiers were mowed down by machinegun fire coming from positions that planners considered obliterated by the preparatory artillery attack. This perspective hides the tragic reality of the poor German soldiers on the other side, vaporized or buried alive by enemy artillery in the previous days. So much for the advantage of the defender and for the good position of the German trenches. The reality is that, as a war of attrition, the casualties were enormous on both sides in almost every battle.

The second lesson that the Germans learned in Champagne was that neither the French nor the German artillery could stop each other's activity. The German General Staff was not even sure how to solve the problem: "It is for consideration whether this want of success must be accepted as inevitable, or whether the difficulties can be overcome by continuing the training of the artillery aviators." We can answer the question for them, because counter-battery would become, in the subsequent years, a fundamental aspect of trench warfare. Indeed, the role of the aviation as the eyes of the

[31] "C.D.S 303 - Experiences Gained in the Winter Battle in Champagne from the Point of View of the Organization of the Enemy's Lines of Defence and the Means of Combating an Attempt to Pierce Our Line," 1.

artillery would increase to the point that the control of the sky would become of the utmost strategic and tactical importance.

The third lesson learned regarded the strategic importance of advantageous observation points, which in Champagne had become the main focus of contentious fights, raged violently in the stubborn attempt to conquer or maintain important sections of the line. These contended spots were the ones that granted visual control on the rest of the landscape, not because the army could fire upon the enemy from these, but because artillery observers could direct the fire of faraway artillery batteries from these locations.

These were the lessons learned, but the substantial part of the document describes the practical responses to adopt. The Germans codified them in the second section of the document, titled "instructions". It consists of twenty-six points organized by topic. They describe in detail the role of the artillery, the usefulness of the *minenwerfer* —the very effective German trench mortar— and of hand grenades, the difficulty of communication in trench warfare and the necessity of a well-planned net of telephonic lines, the necessity of providing for every fire trench a deep and safe dugout to prevent the annihilation of the troops by artillery. Every one of these points and more are illustrated with detail and conciseness, clearly tailored for an effective distribution of knowledge to all the army.

There is, however, a specific point that deserves special attention, a real doctrine that is overlooked in the schematic description of the trench warfare commonly used, even by historians.

> As the result of these conditions and local needs, we have learnt by experiment and experience that what was required was not one or even

> several lines of fixed defences, but rather a fortified zone which permitted a certain liberty of action, so that the best use could be made of all the advantages offered by the configuration of the ground, and all the disadvantages could as far as possible be overcome.[32]

This paragraph explains how it was necessary to go beyond a fixed paradigm of first and second line of defense. In a counter-intuitive way, trench warfare, despite being fixed on a very narrow and apparently immoveable area, was flexible in structure. It was necessarily a continuous adaptation to the moves and countermoves of the enemy, especially during an extended operation. Therefore, the author of the document stressed the importance of breaking the concept of lines of defenses and move to the one of "fortified zone." However, this does not imply that there is no main line of defense, but only "to see better and to enable one to orient oneself, and also in order to have a clear idea at what point the tactical key of the position is to be found," as it is explained subsequently in the document. This fortified zone was organized in depth, with an observation line thinly manned in the front and a support line in the back, but the army could not afford to consider the line as fixed and had to be ready constantly to reinforce the points that had become weak.

Under this doctrine, the trench effectively ceased to be considered as a tool and became a weapon system. This weapon was planned and organized at high level in the army, but it was managed by the troops on the ground. It was not only a matter of stating the obvious reality of the presence of troops in the trenches. The document is clear in describing this situation: "After the line has been broken through, it is impossible to grasp

[32] "C.D.S 303 - Experiences Gained in the Winter Battle in Champagne from the Point of View of the Organization of the Enemy's Lines of Defence and the Means of Combating an Attempt to Pierce Our Line," 2.

at once the whole plan of the complicated network of our own and the enemy's trenches," the result of this confusion was that the artillery could not organize effective fire without the risk of killing the defending troops. The solution was the distribution of a vast number of *minenwerfer* and aerial torpedoes – which today we would call infantry heavy mortars. These impressive weapons allowed the infantry to rain destruction on the enemy by themselves, reducing the dependency of the 'local troops' from external support. In this doctrine we can see the first steps towards one of the most important results of the war: the downward sharing of the army decision making process.

These two documents illustrate the lesson learned by the continuous streak of failures of 1915. The British and French attacks could not pierce the enemy's lines but, as we read, even from the German side it would be difficult to define these battles as victories. In addition, they help to explain the subsequent failures of 1916, and in particular the British battle of the Somme. These documents certified that artillery was the only solution to trench warfare and illustrated how its devastating power could demolish soldiers' morale and reduce defensive positions to an unrecognizable rubble.

Under this perspective, the long and thorough preparatory bombardment at the start of the Somme was the result of a planning that used good standards of learning and improving from experience. Instead, it failed. Why? There were some fundamental details that surface in the German report cited above. With the advantage of hindsight, it is easier for us to understand their importance, which was still unclear at the time. The first and more obvious is that from the experience of 1915 it became clear that deep and well-fortified dugouts where the troops could survive the devastating power of modern artillery were needed. The second is a detail easy to overlook. The Germans understood that to stop an attack more important than rifle fire from infantry, was flanking fire from machineguns and obstacles placed to stop the infantry attacks. “It is impossible to have too many of these works,” commented the author. However, they were also fragile because “obstacles, as we have learnt by experience, are completely destroyed by methodical artillery fire.”[33]

After these remarks it would be difficult to explain why in the first day of the Somme many soldiers found themselves at the mercy of enemy’s machineguns and artillery in front of their barbed wire, which stubbornly resisted days of bombardment. Part of the problem was the chronic lack of heavy artillery, but the German document suggests that other reasons can be added to the explanation. The wire entanglements changed shape after Artois because “they should … be concealed from view, divided into parallel lines and their height kept as low as possible; further, they should be provided with iron posts, with base pieces and securely anchored, and obstacles which can be rapidly placed in position should be held in readiness.” The adoption of these improvements after the experiences of 1915 made the artillery much less effective in clearing the path at the Somme. It is clear how much easier is to break a wooden post instead of a metal one. To see again an advantage of artillery against the barbed wire we need to wait until a new and more sensitive fuse was available in late 1916 and moreover in 1917; before this fuse the only method to cut barbed wire was to use shrapnel

[33] “C.D.S 303 - Experiences Gained in the Winter Battle in Champagne from the Point of View of the Organization of the Enemy’s Lines of Defence and the Means of Combating an Attempt to Pierce Our Line,” 3.

ammunition. Therefore, at the Somme the old fuse, so effective against the entanglements in Artois, had a hard time to compete against the metal posts.[34] We can see how trench warfare gave an advantage to the defender, not only on the battlefield, but also at the drawing board. The experience of past battles gave the defender solutions that were easier to implement. To invent, produce, and distribute a new and much more advanced fuse was indeed much more complicated than to modify the geometry of the barbed wire.

The in-depth defense implemented by the Germans after 1915 soon became the standard on the frontline, even on the opposite side. In early 1916, a scientific and extensive explanation both of the general and specific implementation of trench building was codified in a pamphlet, printed in more than one hundred thousand copies, and widely distributed under the name *Notes on Trench Warfare for Infantry Officers; Compiled by the General Staff*. The audience of this one-hundred-pages booklet was the officer on the ground, who is now officially recognized to be the one that must take the decisions not only of how to entrench the troops, but even where to do it.[35]

The choice of the positioning of the trenches was especially important because failing to recognize even the smallest detail could jeopardize the men in the trenches. The wrong positioning could offer to the enemy a good observation, or sniping, point or expose the trenches to a very dangerous enfilade fire. The importance of this decision is clearly stated in the textbook as the final point of the section "Deliberate Siting of

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[34] "S.S. 139-5 - Artillery Notes. No. 5: Wire Cutting by Artillery," 1916, 2, Imperial War Museum; "S.S. 139-4 - Artillery Notes. No. 4: Artillery in Offensive Operations," 1917, 8, Imperial War Museum.

[35] *Notes for Infantry Officers on Trench Warfare 1916, Compiled by the General Staff* (London: HMSO, 1916).

Trenches" in the second chapter, dedicated to the "Siting and Construction of the Trenches." It is partly a warning for the officers, but also a statement of their importance as actual decision makers on a greater scale. "The satisfactory siting of a trench line constructed in these circumstances will largely depend on the power possessed by the officers on the spot to recognise during the various stages of a battle the minor features of real tactical importance. The ability to recognise these is only acquired by previous training, and is a quality which every officer must study to possess." Knowledge is the key to dominating the landscape.

The pamphlet, however, starts with a less practical chapter on the "Special Characteristics of Trench Warfare." The British Army's desire to solve the gridlock is clear: "trench fighting is only a phase of war." A section on "the offensive spirit in trench warfare" ensured that officers did not forget that their experience of war in the trenches was supposedly a temporary anomaly. The rest of the book is a practical manual of field entrenchment, no doubt at the time much more useful to the officer in the first line than the hopeful wishes for an open warfare. No aspect of trench building or organization of the troops in the line is missing: sanitation, accommodation of troops, training in trench making at night, communications, duties, and routines are all described. This 'defense extravaganza' is counterbalanced only meagerly by the last chapter "Notes on the Attack in Trench Warfare."

At the end of the pamphlet, thirty pages of diagrams and schemes provide not only a visual aid in the study and comprehension of the book, but also blueprints for designing the trenches on the field. Browsing the diagrams, the amount of details could impress the reader, but this bounty of illustrations was apparently not enough. In December of 1916, the General Staff printed another pamphlet. This new booklet did not have a single word outside captions and contents and was entirely composed of seventy-six illustrations and diagrams.[36]

The amount of details shows how the top of the army controlled the bottom: army rules, standards, and drills indeed de-facto inhibit the agency of the single soldiers and officers. This case is, however, quite the opposite. The schematics are often accompanied not only by comments such as "diagrammatic, it should be not too straight," "plan depends on the ground," or "if possible," but sometimes show multiple options for the same project. There are, for example, six different styles of communication trenches, thirteen different traces for the main trenches, and seventeen pages on barbed wiring, full of a myriad of different schemes. This manual was offering the 'Lego bricks' to the officers, and they had to choose the scheme, adapt it to the ground, and implement its construction with the material available and techniques allowed by the circumstances. This revision shows the results of the evolution of trench warfare: the complication of the labyrinthic nature of such environment made impossible to control every aspect of the war from the army leadership and therefore the decision-making trickled down to the lower ranks.

The tendency to a devolution surfaces again in another official publication of 1916, *SS 112 Consolidation of Trenches, Localities and Craters after Assault and*

[36] *Notes for Infantry Officers on Trench Warfare, Revised Diagrams, December 1916* (London, 1916).

Capture, With a Note on Rapid Wiring. As the above publications, this too was printed in more than one hundred thousand copies and distributed not only to the BEF, but also to the Canadian Expeditionary Force (CEF).[37] This manual was more specifically focused on the fortification of a location after its conquest, and therefore more succinct than the general manual. Parts of its text are direct quotes of the general text, and one of these is the part that highlights the importance of the knowledge and adaptation of the officers on the ground in understanding where to place the new trenches. This detail on one hand shows the standardization of the army's literature, but on the other shows how important it was for the General Staff to ingrain this concept in the ranks.

This manual starts with a surprising comment: "the capture of a system of hostile trenches is an easy matter compared with the difficulty of retaining it." Considering the difficulties of the attack in trench warfare and the impressive sequence of disasters of the previous two years, it seems a little overstated. The irony is even more bitter when we notice that the manual was printed in August, just a month after the iconic tragedy of the first day of the Somme. We should however consider the true meaning of the words.

Attack, in 1916, meant to conquer after a meticulous destruction by the artillery. The infantry — if they succeeded — often occupied trenches that were only a small resemblance of what were before the artillery did its job. In addition, as we have read before, the new and more complex trench system formed an in-depth fortified zone,

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[37] "Constructing Barbed Wire Defences | Wartime Canada," accessed March 1, 2020, https://wartimecanada.ca/document/world-war-i/training-manuals/constructing-barbed-wire-defences. The presence of a copy of the same manual at the State Library Victoria in Australia suggests that it was distributed to the whole commonwhealt. http://search.slv.vic.gov.au/primo-explore/fulldisplay?vid=MAIN&docid=SLV_VOYAGER223961.

planned and made to offer as much defense from one direction and as least possible from the other. The troops who survived the attack, exhausted and cut off from reinforcements, often needed to dig as fast as possible to resist to the inevitable counterattack, facing the enemy in unsafe positions.

The manual tried to help the troops on the ground by highlighting problems and providing solutions, while establishing the fundamental primary objectives of securing the freshly conquered terrain in a delicate moment of the operation, one that could not have been planned precisely beforehand. However, if not planned, it could at least have been thoroughly thought-out. The manual suggested that speed was the main key to success. Therefore, it was necessary to decide in advance "which points required attention." For this purpose, maps and airplane photographs were tools that offered great accuracy and added important information to that acquired from good observation on the frontline.

Therefore, the main points that made an attack successful were planning, speed, and adaptation. The first objective was not the re-creation of the trench system, but the occupation and fortification of single strong points positioned in a way that allowed soldiers to mutually support each other with machinegun fire provided by the Lewis Gun teams. The second objective was to secure the communication with the rear. The third phase called for filling the old trenches "within bombing distance of the points occupied" to eliminate any cover for the enemy, while new strong points were created in the rear of the first points to further reinforce the position. Only later, would these points have been connected and the trench system recreated. The manual dedicated special attention and specific instructions to naturally occurring strong points such as woods, towns, and mine craters, providing the officers on the ground with the tools to imagine the new defenses.

The attack, therefore, was not a matter of arriving in the enemy's trenches, freeing them from any resisting force, and simply 'turning the weapon against the enemy.' It was a much more organic and long-lasting process that offered time for the enemy to re-take the position with a fast counterattack, without the need of a prolonged planning. This was the theory, because German counterattacks at the Somme and after were apparently often ineffective.[38] The important point, however, is that there is an evolution in the doctrine of trench warfare from rigid concepts of attack and defense to new, more adaptive ones that slowly surrendered the tactical responsibility to the officers and troops on the field.

From the perspective of the 'failures' and stalemate of the frontline in 1916, with the slaughters of Verdun and the Somme, it would be hard to define what is described in this pamphlet as a successful strategy. However, success is such a volatile word in warfare: while we can read the manual as a manifestation of the frustration of the attack against well-planned trenches, we can also glimpse the next steps of the evolution on a path to adaptation and improvisation that would eventually break trench warfare in 1918.

In 1917, two main factors influenced trench warfare: the strategic retreat to the Siegfried line — commonly known by the Allies as the Hindenburg line, and the evolution of the platoon tactics. The titanic effort to build a supposedly impenetrable line of defense produced what we can consider the state of the art of the trench system in the

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[38] Griffith, *Battle Tactics of the Western Front*, 75–76.

war. Fields of barbed wire occupied miles of terrains with geometric shapes, protecting a network of strong points with concrete bunkers, pillboxes, and virtually indestructible shelters deep underground. The risky operation was the direct result of the failure of Falkenhayn's strategy at Verdun and of an overall overextension of the German Army.

The gigantic fortification set the standard for the years to come and after the war it was extensively investigated by American engineers.[39] Indeed, even during the war, this was another important result of the strategic retreat: the Germans could not destroy all evidence of their defense systems and left many details intact to the enemy, allowing a deep investigation of their techniques. Officers interested in camouflaging, aerial photography, and field fortifications could freely check their previous interpretations with the real objects. For an intelligence officer specialized in analysis of aerial photographs, for example, it meant that he could take a field trip to investigate all the "doubtful points;" it was a practice that was officially encouraged in the booklet *SS 550 Notes on the Interpretation of Aeroplane Photographs*, published in March of 1917. "A great deal of the patience and care taken in the study of aeroplane photographs is wasted unless verification of doubtful points is obtained from the inspection of captured trenches." Even inspection was not enough apparently, and the manual suggested making a model of the fortification "before the machine guns or trench mortars have been removed and the emplacements dismantled." As we will see in chapter 6, at this point of the war, the

[39] Pillsbury, G. B. "TECHNICAL ENGINEERING DETAILS OF THE HINDENBURG LINE IN THE SECTOR OF ATTACK OF THE II ARMY CORPS." *Professional Memoirs, Corps of Engineers, United States Army, and Engineer Department at Large* 11, no. 56 (1919): 150-74. http://www.jstor.org/stable/44535346. Bond, Aubrey H. "REINFORCED CONCRETE SHELTERS OF GERMAN HINDENBURG LINE." *Professional Memoirs, Corps of Engineers, United States Army, and Engineer Department at Large* 11, no. 57 (1919): 312-24. http://www.jstor.org/stable/44535053.

British Army had organized a system for the collection and redistribution of the experience accumulated on the battlefield through printed material. The recording of enemy structures with models is a proof of the level of sophistication that the army reached in the collection of information.[40]

This investigation of old German trenches, together with a study of the lines captured in the Messines Ridge, helped the British to understand the extent of their artillery's effects, and showed how extensive the use of reinforced concrete in the German trenches was. The British Army aptly copied the German plans and adopted the new techniques in their own manuals. This improvement, however, created new complications: it not only overstressed the already busy work of the Royal Engineers but also required specialized knowledge, which was not always available. Unskilled soldiers without pre-war experience in building with concrete were, for example, prone to over-use reinforcement, a counter-intuitive problem that split the structure in separated layers of concrete and weakened the structure against artillery shells. However big the problems, the German designs were tested, building errors corrected, and procedures established and published in a Fieldworks Note at the end of 1917.[41]

The new platoon tactics, an often-underestimated revolution in the infantry warfare of 1917, were even more important and impactful on the trench system — and on the evolution of warfare — than the creation of the 'perfect system' of defense of the

[40] "S.S. 550 - Notes on the Interpretation of Aeroplane Photographs," March 1917, Imperial War Museum.

[41] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, vol. 9, Work of the Royal Engineers in the European War, 1914-19. (Chatham, Kent, 1921), 158–67; Jim Beach, *Haig's Intelligence: GHQ and the German Army, 1916-1918* (Cambridge: Cambridge University Press, 2013), 42.

Siegfried line. The new platoon tactics were a significant change, much more than the utilization of new technologies such as the tank. Despite the long-time implications of armored warfare, in the short-term, the creation of an autonomous and effective small unit of men armed with grenades and Lewis guns was truly one of the key factors in breaking the gridlock of the trenches.[42]

The results of this innovation are visible in two manuals, *SS 202 The Organization of Shell hole Defences* of December 1917, and the *SS 196 Diagrams of Field Defences of March 1918*. The first is clearly the result of the experience gained in the Third Battle of Ypres, which we can recognize not only from the date of publication, but also from the attention with which the author described how to properly drain shell holes, a detail that had become of fundamental importance in the muddy and wet nightmare of the Ypres sector. As interesting as the details of the actual implementation of such shell holes can be, what catches the attention is the new concept of independent strongholds organized "in depth, arranged chequerwise [like a checkboard] so as to bring as much mutually supporting fire to bear as possible." However, the author also stressed that "no standard method of organizing their defense can be laid down," a constant theme of these manuals as we have already seen and which reveals the continuous struggle between adaptation and army rules.

The concept of strongholds was not new to the trench system: the Germans already adopted it after the experience of 1915. What is new is the scale of operation:

[42] On the topic of warfare innovation the reader will find me much like-minded to the thesis of Griffith than on the ones of Travers. Travers, *How the War Was Won*; Griffith, *Battle Tactics of the Western Front*.

before 1917, a strong point was a decently sized location such as a village or farm, a wood, or a particularly important slope; these positions were defended by regiments or even divisions. The manual of 1917 illustrates strong points for platoons, small points where a couple or even a single Lewis gun and few men could hold the enemy at bay. These shell holes did not need much work to be used and could be made a little more comfortable and, more importantly, less visible using simple materials and a few hours of work.

Adaptation was the key element of shell hole entrenchments for the simple fact that the position of these holes of course was not planned. However, shell holes were ubiquitous as a natural occurrence of the battled landscape. Therefore, the problem was not to find them, but to carefully choose the best ones. Factors in the choice were livability — a position completely flooded would have not been a strong one — and above all concealment, because the strength of these strongpoints was their blending with the surroundings to surprise the attacking enemy.

The main characteristic of this new tactic was that these groups of shell holes, connected by small communication trenches, did not work as a solid line of defense anymore, but as a collection of independent fortifications that supported each other, forming an adaptable and somewhat flexible line of defense. The importance of the new concept of the platoon in this evolution is clear, because these small strong points would have been indeed manned by single units or even fractions of them. The autonomy of the new platoon, both in decision-making and in firepower — every platoon had a Lewis light machine gun —, allowed a solution to the rigid system of the first and second line of defense.

The weather and nature of the Ypres sector were a strong influence in pushing for this solution: the rain and the high water table tormented Allied soldiers from 1914, often obliging the troops to build up the trenches with sandbags instead of digging them down. The solution of these shell hole fortifications however was not restricted to the Belgian sector but generalized for the whole trench system.

The second manual, the *SS 196* of March 1918, shows us the last doctrine on fortifications before the final crumbling of the trench system on the western front. I hope that after this short analysis it is clear that what seems to be an odd and abrupt end to a system that locked in place millions of men for three full years, was instead a much more organic and natural evolution. The manual almost foretold the future: "no defences in themselves can withstand a determined attack for more than a certain time; all that can be expected of them is that they will enable a few men to delay the enemy." The solution is "several zones of defence disposed in depth, each of which will take the form of a network of posts and localities sited for mutual support in considerable depth." Closer to the enemy was a line of observation "consisting of a series of groups of shell holes or of defended posts," all surrounded by barbed wire. Behind them, a series of traversed works behind a continuous line of barbed wire. This is the last remnant of the original trench system of 1915, a continual fortification line. Behind, the main defense would be a system of "defended localities and posts, organized in depth, with the ground between them swept by flanking and crossfire to break up the enemy's attack and provide supporting points for our own counter-attacks."[43]

The implications of this new system during the Kaiserschlacht in the spring of 1918 is outside of our scope, but it is important to note that just before this offensive the British Army developed a method that was adaptable, flexible, and somewhat moveable. While the creation and maintaining of the old trench system required a long period of preparation — to build the Siegfried line the Germans required months of work and a titanic logistic effort —, connecting shell holes and creating defensive posts needed only a few hours and had the important quality of being naturally suited for delaying an enemy's attack. This was more than useful in the spring of 1918 during the long struggle against the relentless assaults of the elite German storm divisions.

At the end of the war, the practice of trench warfare had changed much from 1914. Most importantly, the system of trenches forced the armies to modify their structure, the training of their men, and to adopt a more flexible chain of command. This was also the analysis of the experts at the end of the war. In a conference published in May 1922 in the *RUSI Journal*, Colonel Harvey, the Chief Engineer at Aldershot, explained the effects of the war on field engineering. In his lecture, he gave a detailed picture of the incredible quantity of small changes that had been necessary to adapt to the new warfare: the necessity of increased knowledge on fortifications required by all the corps, but especially by the infantry. Expertise in all but the most technical kind of

[43] "S.S. 196 Diagrams of Field Defences," 1918, Imperial War Museum.

fortifications, in addition to rudimentary demolition skills, had become necessary even outside the Royal Engineers Corp. In addition, the design of trenches had changed, simplifying where possible but adding a much more complex organization to the system of defense.[44]

Harvey's lecture started with his general analysis, well exposed in bullet points following the correct etiquette of an army man: "A: It crystallised military thought on the subject which was half formed before the War into definite opinion. B: It demanded various modifications in the details and designs of works in the field and the addition of some new subjects; *but* [highlight of the author] without seriously changing the general principles laid down before the War." Harvey's view is interesting, moreover because the whole philosophy of defense strategy changed throughout the war. The commentary brings us back where we started, highlighting how the experts had grasped the fundamentals of the trench system after the Russo-Japanese war of 1904. However, the devil is in the details in trench warfare and the way of using trenches changed radically throughout the war.

Indeed, in his lecture Harvey illustrated how the priorities of work changed during the war, therefore showing how the understanding of the key points of a system of defense changed too, because the most important fortifications have to be laid first:

1914. *First*, clear your field of fire.
Second, excavation (fire trenches).

[44] Colonel R. N. Harvey, "The Effect of the War on Field Engineering," *The Journal of the Royal United Service Institution* LXVII, no. 466 (May 1922): 193–218.

Third, entanglements with wire.
Fourth, communication (trenches).

1918. *First*, you choose your field of fire.
Second, site machine guns well.
Third, entanglements with wire.
Fourth, the trenches, dig like H..uns.[Huns][45]

These are two very different philosophies: in 1914 the focus was on rifle fire (that is the reason behind the intensive clearing of the field of fire from obstacles that impeded the aiming), entanglements, and then establishing a solid communication with the chain of command. In 1918, the focus was on adaptation and firepower: choose your ground well, place the machineguns, defend the line with barbed wire, and only at this point dig up the trenches for the rest of the men. This new set of priorities was not only British, but it was also a lesson that had been learned on the other side of no-man's land. In a publication issued in the Spring of 1917, the German General Staff described in detail the newly built Siegfried Line. Given the titanic effort necessary to build this line of defense, not everything was supposed to be ready for the German troops taking possession of their assigned sectors. The defense system, however, was considered safe, because the most vital components of the defense line were ready when the retreating divisions arrived to occupy the positions: the German engineers had laid down the barbed wire entanglements in front of the first and second line and erected "the bulk of the concrete structures (dug-outs, machine gun emplacements, artillery O.P.'s, flanking positions)." The actual trenches of the intermediate and second line position were only marked out on the

[45] Colonel R. N. Harvey, 202.

ground, and the material necessary for their construction was ready for the infantry to use when they arrived.[46]

Harvey's analysis highlights one of the problems of trench warfare: its details were incredibly important. The practice of trench making did not change much if we consider how trenches were dug up and shaped, but the doctrine behind these details was substantially different from the one at the start of the war. Barbed wire, dug-outs, and machine guns were the same or very similar to the ones of 1914, but their use and their role in the general system of defense changed greatly.

If we need a less British-centric confirmation of the evolution of the trench system, we can find it in an article with the title *Evolution de la Fortification de Campagne au Cours de la Derniere Guerre* by Captain Botte, published on the *Revue Militaire Générale* in 1921, translated and republished the same year in the *Royal Engineers Journal* and one year later in the U.S.A. by *The Military Engineer*. After an introduction of the pre-war theories, Botte acknowledged that defense in depth was necessary by 1915. 1916 was the year of the hard lessons (not the Somme, but Verdun) that shattered the idea of the infrangible nature of one line and allowed the lessons of 1915 to sink in. 1917 saw the introduction of tanks on the allied side and a ubiquitous use of smoke and gas shells on the German side. However, Botte underlines that:

> The great discovery of August, 1917, was the combat group, the practical value of making the automatic arms protected by a few men the backbone of the defence, since experience had proved that the section commander alone could exercise command, and then perhaps not over the whole of his section; it was the commander of the combat group only who

[46] "S.S. 745 - Description of the Siegfried Line," 1918, Imperial War Museum.

> could effectively command, hence the combat group became the elementary cell of the defensive organization.[47]

Trench warfare, therefore, was the reason behind the devolution of control from the top to the bottom of the armies, the stress that pushed a revolution in organization and a fundamental change in operational philosophy.

The Agents of Change.

This brief overview of the evolution of trench warfare will give us the foundation to attack the core problem. Who or what drove this change? Clearly, there is no easy answer. Changes in technology, advancements in tactics and logistics, and the development of aerial photography were all factors that contributed to the evolution and eventual dissolution of the weapon system of the trenches.

These could appear as 'external' factors that happened in a deterministic fashion, a little like the action of the gods in Greek mythology. Indeed, we often simplify our understanding of complex technological change with expressions such as 'a new item appeared in the market,' when in reality there is no Prometheus giving the knowledge and marvel of new technology, but a complex system of developers, producers, and planners that interacts with analysts, customers, and the market itself.

In the case of the evolution of the shape of the trenches, there were four different influencing factors: the strategic direction of the army; army institutions and middle men (officers in contact both with the staff and with the troops); and the common soldier on

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[47] Capitaine Botte, "The Evolution of Field Fortifications During the Late War," *The Military Engineer* 14, no. 74 (1922): 82–85.

the battlefield were the 'human factors.' To these first three, we need to add the technological component of the new inventions and weapons. If it is somewhat odd to give agency to objects, it is not a new technique in historical research. Historians of technology in the past thirty years used the tools of the actor network theory with important results.[48] New weapons meant new possibilities, empowering soldiers or inhibiting old ways. Surely, the true agency should fall on the actual utilizer of the tool, the soldier, but artificially giving the power of change to the object itself helps us to better understand the complicated system of change and its influencing factors. Here however, we will focus on the human side of the change, leaving a more detailed description of the interaction between the human agents with technology for chapter 4.

War Office.

If one lesson becomes apparent from our brief history of change in trench warfare, it should be that the leaders of the French, German, and British armies were not blind to the necessity to adapt and evolve. A stream of official publications modified the doctrines, sometimes only a few months apart. And yet, reading the pamphlets of the British Army, theory appears to always be lagging behind, answering to practical problems instead of imagining and projecting the army into the future. It is perhaps an unfair assessment, probably influenced by the value we now give to predicting and developing the future of warfare, a lesson that we learned from the impressive research in

[48] Actor Network Theory is a child of 1980's French social sciences; probably the most famous scholar contributing to its birth was Bruno Latour. As most theoretical frameworks, it can be abstract, somewhat convoluted, and sometimes too reliant on quantitative analysis, especially for the more literary minds of historians. However, its contribution in developing our understanding of the processes of technological innovation are clear, in particular for its addition of non-human actors as influencers of systems of change.

doctrine that mostly the German Army, but not only, made in the interwar period. In addition, doctrine was not always lagging behind: Captain Botte, for example, remembered in his article that some lessons learned on the ground were difficult to accept from some troops such as infantry and sappers who, strongly opinionated from their own experiences on the battlefield, sometimes opposed new changes when they had just mastered the old techniques.[49]

However, there is some truth in this impression of a theory that was always behind the reality of the battlefront: on one side the theory of the attack, the one that is supposed to plan the future of warfare, suffered against the very balanced nature of the conflict. This was a war that did not allow final breakthroughs, and this equilibrium constituted a great advantage for the defender, always able to find an answer to previous problems. The attacker, therefore, needed to be two steps ahead, imagining how to overcome solutions that were not yet implemented.

On the other side, the very experience that came from the frontline was creating this lag. The proliferation of pamphlets demonstrates how commanders were paying much attention to what happened in the frontline, but also created a sort of prevalence of tactics against strategies. These pamphlets are indeed overflowing with technical details, practical solutions to the every-day struggles in the trench warfare. The necessary attention to the continual innovations on the battlefield could easily lead to a short-sighted attitude and to a pedantic mindset. The danger was apparent to the authors of the

[49] Capitaine Botte, "The Evolution of Field Fortifications During the Late War."

pamphlets, who often reminded readers to keep an open mind and to adapt the final decisions to the specific situations. This is an important point that was acknowledged and led to a change in the structure of these manuals throughout the war, as we will see in chapter 6.

Another problem of these publications is that they were distributed *en masse*. In general, such sharing was a positive thing that created an environment in which unique solutions could become general techniques, but these pamphlets often communicated the solution to the enemy. The evidence is in the substantial number of technical and tactical manuals translated from the German, printed, and distributed by the Stationary Service to the British troops. This unwanted and unintended exchange sometimes produced almost comical results, such as the note “For official use only. Not to be taken into front trenches,” all in bold capitals on the cover of the pamphlet *SS 112 Consolidation of Trenches, Localities, and Craters after Assault and Capture, with a Note on Rapid Wiring*; the army printed one hundred twenty thousand copies of this manual on how to make trenches and then required the readers to keep it secret and to not bring it on site! The Army and even a number of privately published manuals and memoirs contributed to the spreading of knowledge, manuals that went freely on the market and could be easy prey for any spy, professional or amateur alike.

Lobbyists and Institutions.

People on the ground participated in innovation, because their lives depended on the very details that made the success or the failure of trench warfare. For example, the sniper expert Captain Prichard was directly interested in the shape of trenches. Indeed, the trench system was his hunting ground. What was even more important, even for him, was that the shape of the trenches saved lives, if done properly. At the beginning of trench warfare, however, the concept of a well-made trench differed from the official directives of the army, and Prichard remembered how "the parapets were made of sandbags beaten down with spades, and it is not too much to say that along many of them a mouse could not move without being observed by the most moderate-sighted German sniper." In this case, precision was a problem that was enhanced by the very nature of the army regulations, made to maintain everything in perfect shape. Prichard suggested to "hang as many rags as possible upon our wire, and wherever else they could in the region of our parapet." It was an easy solution to a dangerous problem because the constant flapping around of the rags in the wind distracted the eyes of the enemy's snipers.

However, Prichard also noted that the enemy was way ahead on the problem, and that to increase the confusing and irregular shape of their trenches, the Germans used sandbags that were "red, green, striped, blue, dazzling our eyes." Understanding the usefulness of inhomogeneity of standards, the enemy issued the systemic solution of producing randomly colored sandbags.[50]

The detail of the colored sandbags also appears in a long and detailed lecture that an anonymous "British Officer Skilled in Landscape Gardening" published in 1917 in the journal of the U.S.A. Engineer School *Professional Memoirs* (in 1920, this journal changed its name to *Military Engineer)*. From later comments of the author, we know

[50] H. Hesketh-Prichard, *Sniping in France* (London: Hutchinson & Co., 1920), 34–35.

that the anonymous British officer was Alister Mackenzie, a famous golf course architect who at the beginning of the war focused his attention on the study of entrenchments.

Mackenzie noted that "in the winter of 1914-15 that sandbags of various colors would be a great advantage," and the suggestion was to have sandbags of the primary colors arranged "without the smallest suspicion of regularity." The architect, however, gave a different interpretation of the paternity of the idea: "some months after it was suggested in this country, the Germans adopted colored sandbags." He did not think that there was a direct connection, but that it was caused by a shortage of jute and the subsequent use of assorted textile to substitute it. Whatever the cause, Mackenzie reported that everyone he had talked with described how effective it was and that "the change in the alteration of these breastworks by the use of colored sandbags was almost magical in its results." It is interesting to note that the Germans had a much more practical approach to the theoretical problem of the tidiness of the trench shapes: in a manual published in Berlin in 1916 and translated and reprinted in London in the spring of 1917 there is no indication of the usefulness of messy parapets, only that "too much attention to keeping trenches neat and tidy is forbidden. The labour necessary for this is better devoted to new work."[51] However, we are not really interested in understanding who had the idea first. The important fact here is that already in 1915 trenches had become a topic of study outside of the official channels.[52] Why should that not have

[51] "Manual of Position Warfare for All Arms. Part I: The Construction of Field Positions (Stellungsbau)," 1917: 6. Imperial War Museum.

[52] "Entrenchment and Camouflage," *Professional Memoirs, Corps of Engineers, United States Army, and Engineer Department at Large* 9, no. 47 (1917): 618–19.

been? The problem of the visibility of the trenches was one that haunted the life of every soldier on the frontline: trenches showed the artillery (and the snipers) where to shoot.

There is no mention of the problem of breastworks in an article that Mackenzie published in the spring of 1915 in the popular British magazine *Country Life*. It should not come to surprise because it was a short piece on the importance of imitating nature when building trenches. The article is curiously positioned between one section of the magazine with suggestions for your garden such as “The right place for Wichuratana Roses” and an illustrated gallery of elegant country mansions. This piece offers a double irony: on one side, it was talking about trench warfare in a gardening section, while trenches had such a horrible implication on the rural landscape of France and Belgium; on the other, the publication exposed the explanation of how to hide from the enemy in plain sight in a fashionable and widespread magazine, well-illustrated by photographs.

However, the author clearly explained his motivations in the conclusion of the article itself, stating that “it is not simply with a view to pushing my own ideas, but in the hope that my suggestions may give rise to improvements in our present methods, that I have written this article.” If we consider the social structure of British society, we can assume that the target of the magazine would have been the well-off citizen, landowner, educated, and well-connected, the ruling class of which top officers were proud members. The scientific approach of Mackenzie, corroborated by explanatory pictures of tests made with some troops, together with his already established fame as a golf course architect, renowned for having dedicated his professional life to integrate as much as possible the golf courses into the landscape, could have reached the right ears through the pages of the posh magazine. Mackenzie, despite being an officer, was lobbying the Army using an unofficial path that could bypass the long and perilous routes of military bureaucracy. He had the meanings and the personal connections to do that, and the professional expertise to be convincing.

The problem was that the listeners were not always willing to be convinced. Mackenzie, apparently, was not lucky. At the end of a lecture published in 1917, there is a transcription of the section in which he answered a number of questions from the public. Someone asked if most of his suggestions were not in the pamphlet *Notes for Infantry Officers on Trench Warfare* of March 1916, to which he answered:

> Most of the important points were mentioned by me 12 or 18 months previous to the publication of the pamphlet referred to. For example, at an early part of the war, I bombarded the authorities with memoranda, diagraphs and photographs illustrating the importance of the irregular parapet (I have photographs in my possession of trenches made in 1914 illustrating this principle, and constructed in an irregular series of salients and re-entrants). Little if any notice was taken of these ideas; finally in desperation I published an article on the subject, this article, I hear, was reproduced and extensively discussed in America, shortly afterwards (whether a coincident or not, I do not know) the Germans adopted an irregular parapet.[53]

Mackenzie did not directly try to divert from the 'correct' path, but after spending much energy in trying to convince people through the normal channels, he decided to catch their attention somewhere else. Curiously, he did not even seem troubled by the idea that the people that he finally convinced could have been the enemy. In his

[53] "Entrenchment and Camouflage," 633.

explanation, all he cares about is that the necessary changes were institutionalized in the official pamphlet.

Surely personalities such as Mackenzie and Prichard contributed to the change of the design of the trenches, however, it should be clear that they did not drive the change alone. Yet, they are good examples of the middlemen that influenced the British Army. Not only did they eventually convince the top of the Army that these details were indeed important, but they also relentlessly lectured and talked with fellow officers and soldiers on the ground, asking questions, exchanging ideas, and suggesting changes.

A major step in the diffusion of these ideas was their publication in an official pamphlet. To publish only techniques coming from the practice on the battlefield, however, was problematic, because it only acknowledged the fait accompli. An important innovation was the creation of institutions inside the army to test and develop new techniques, a story that we will follow in chapter 3. While trench making was tested directly on the ground — with the hundreds of miles of trench needed it would have been superfluous otherwise —, camouflage required a different approach. Camouflage needed to function in its first use on the battlefield, otherwise it would have been pointless; therefore the British Army, taking inspiration from the French, organized a section of experts to ideate, test, and eventually share new methods to hide anything and everything from the curious eye of the enemy.

Camouflage was not new, and surely it was not an original invention: we only need to search on a grass field to find how nature expressed itself in a variety of shapes and colors to blend in for safety. In the late 19th century, the concept was addressed from different directions: natural studies mixed with art and the new printing techniques. This diverse universe of knowledge created the opportunities for the development of camouflage during the war.

Artistic and scientific attitudes mixed together in the person of Abbott H. Thayer for example. Well before the start of the war he studied the important role of color in nature and used his artistic talent to develop a series of techniques to mimic nature's successes. He first described two important axioms: countershading and disruption of the shape. Countershading was the adoption of lighter colors at the bottom of a round object to flatten it out: in normal light, the top of an object is lighter in color, and the bottom darker; inverting this common paradigm helped bugs and other creatures to distort the perception of their hunters. The disruption of the shape suggested that with the use of contrasting colors in random shapes, an object's profile could be broken down, making it more difficult to recognize. Both these theories were amply used during the war on almost everything, from big cruiser to field artillery or even personal equipment such as steel helmets.[54]

Mackenzie too used these two principles, translating them into his artistic kingdom of earthworks. Countershading helped him to recognize that the parapet of the trenches should have had a gentle curve, built as random as possible avoiding measuring and precision, and possibly be disrupted with grass; when the use of sandbags was necessary, he suggested to randomly throw white ones to the bottom of the parapet to

[54] Roy R. Behrens, "The Theories of Abbott H. Thayer: Father of Camouflage," *Leonardo* 21, no. 3 (1988): 291, https://doi.org/10.2307/1578658.

make it lighter in color. The other problem, the artificial shape of trenches, could be solved by not only avoiding angles and linear progression of the trenches — a principle that eventually made it way to the official pamphlets of trench making — but also by disrupting the vertical shape of the parapet itself, adding divots and small bumps. These features could also add the nice result of protecting the head of the soldiers shooting from the parapet.

The theories of Thayer were part of a general advancement in knowledge of the second half of the nineteenth century. Science increased our understanding of how light and shapes work in our perceptions. The example of impressionism and pointillism in art are manifestations of a better understanding of color theory. The world, in this time, was discovering new chemical paints, photography, and printing technologies. Perception and images were studied in art and advertising. Therefore, in 1914 soldiers and officers in all armies had the tools to understand the importance of perception in a battlefield where soldiers rarely saw the enemy at short distance and where optics played a major role in controlling the landscape.[55] Concealment had become a clear factor in war. The sudden change in color of the uniforms of many armies in the decade before the war certainly suggests that the message already arrived at the top of the armies. The French Army, which stubbornly maintained a vividly colored uniform, was rapidly brought to reason by

[55] Mary Virginia Orna, *The Chemical History of Color*, SpringerBriefs in Molecular Science. History of Chemistry (Berlin; New York: Springer, 2013); Michel Frizot, ed., *A New History of Photography* (Köln: Könemann, 1998).

the horrible performance of their red trousers and blue coats on the battlefield and eventually adopted a pale blue uniform.[56]

Considering the general interest and the growing experience on the topic, why was there no directive or official publication in England at the start of the war? The British Army did not print anything until December 1916, when the Stationery Service distributed the *SS 528 Notes on Camouflage*. The answer to this delay is, quite simply, that it required time to build up the specific knowledge and test it.

The French Army in early 1915 was the first to start experimenting on camouflage in an organized way, hence the French word was adopted in English. Even in this case, soldiers started to innovate on the battlefield and the army followed up. Artists led the way because they were, like Thayer, the ones trained to think about perception. In 1914, a French artist serving in the artillery, Guirand de Scevola, tried to hide the guns of his battery under sheets of painted canvas. The French Army recognized the possibilities and asked him to find other artists to create a detachment, a think-tank. The successes of a small group inspired the creation of more teams and already in the fall of the same year Scevola was directing a brand-new service, jumping from private to lieutenant.[57]

The British Army soon followed and asked a well-established member of the Royal Academy, Solomon. J. Solomon, to go to France to investigate. Not only was he a well-connected member of the London society, but he had also already shown interest in

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[56] Murray, *The Rocky Road to the Great War*, 230.

[57] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:107–8; Guy Hartcup, *Camouflage: A History of Concealment and Deception in War* (New York: Scribner's, 1980), 16–17.

the matter. Thereafter, a British section called Special Works Park (SWP) was created in France, in Wimereux, with five artists under the direction of a R.E. officer managing several specialized carpenters coming from England. We will analyze the story of the Special Works Park in more details in chapter 3.

The ubiquitous eye of the enemy, projected behind the line from the new discipline of aerial photography, constantly increased their importance, and the work was continuous and restless. Their main task at the beginning was the creation of camouflaged observation posts. In 1916, camouflage was still a special work, as the *SS 528* illustrates. This is not yet a complete manual for camouflaging, but a collection of instructions and suggestions to help the SWP to fulfill as fast as possible the orders from the frontline. For the most part, it resembles a catalog of products for a trench customer. To train officers on the topic, in August of 1916, Wimereux started to host two-day schools for officers, invited many others to visit the place, and maintained close touch with the sniping schools.[58]

Throughout the war, the number of requests increased, and three new "Depots" were created, allowing the fulfillment of the new and much more resource-demanding task of creating camouflage for the artillery batteries. In 1918, the nature of camouflage was very different from the one of merely two years before: The SWP had a testing ground, developed under the pressure to find the most effective ways to hide from the sky, and a new manual, printed and distributed in ten thousand copies, demonstrating the

[58] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:112.

maturity of a discipline that was no longer ‘special’, but a constant element of modern warfare.

This new pamphlet, *S.S. 206 The Principles and Practice of Camouflage* of March 1918, is different from the previous one because this time its main purpose is not to show a catalog of products, but to share knowledge. Its densely packed twenty-five pages are divided in three main sections, followed by illustrated plates: Principles of Camouflage, Practice of Camouflage, and Camouflage Demands. The last section, one and a half pages long, is the last relic of the *SS 528*, reducing to the bare minimum the suggestions on how to ask for special jobs. The other two chapters are a short essay to teach the mindset necessary and the basic materials and techniques to camouflage anything, from the observation post to the heavy gun.

The French continued their development of camouflage in parallel. There were exchanges of experiences and sometimes officers from both sides visited each other’s schools. However, the exchanges, oddly enough, became rarer instead of intensifying. One explanation could be that on one hand, the workload increased at a much greater speed than the acquisition of new workers, on the other, what was at the start a highly experimental work became a well-established practice of war, codified in doctrines and technical manuals. In addition, the British caught up, making the presence of French specialists in the British workshops unnecessary.

At the end of the war, the new pictorial style of manuals, an important development in education tools that happened in the last two years of the war, was well established both in the British and French Armies. The manual *L’Instruction sur le*

Camouflage of April 1918 was in two volumes; the second one provided all the plates, but the thirty pages of photographs illustrate instructions better than any verbal description of the state of the discipline. The booklet also highlighted the important connection between camouflage and photography with its first page, which explains the rendition of color in the different photographic plates.

This manual closed the circle: from the inventiveness of single soldiers, camouflage grew to a discipline that needed an institution, and eventually went back to the troops as it became an aspect so fundamental in modern warfare, that every soldier had to deal with it in a way or another. Artillerymen concealed their guns into pits covered by net, observers climbed into fake trees or lay behind fake dead horses, and soldiers defended positions in shell holes carefully improved to be effective without showing their presence.

Conclusions.

It is interesting that historians have not paid enough attention to the evolution of the design of trenches during the war. The problem of understanding this evolution remains, in my opinion, still in need of comprehensive analysis. This chapter is not the place, and surely there is not enough space here to attempt it.

On one hand, many scholars wrote about life in the trenches, with all the unpleasantness connected to the experience of living on a static frontline deep underground: bad food, lice, and general discomfort have their deserved space in the literature. On the other hand, the trenches remain similar to a monster with its own will and agency. It is understandable, because historians followed the experience of the soldiers who, from their narrow perspective inside the labyrinth, had difficulties in understanding the evolution of the system they were living in.

However, soldiers both on the frontline and at home were the main contributors to the changes because they lived in this absurd world and interacted with it daily. These small changes seemed uninfluential, but together amounted to a general overhaul of the trench system. However, soldiers were only one of the many influencers: the War Office was another important one because it eventually institutionalized a channel to absorb and theorize the knowledge produced on the ground. Even inanimate objects such as weapons ‘participated’ to the evolution, providing opportunities, creating problems, and channeling soldiers in the search for the necessary solutions. Environmental factors such as the geological nature of the ground contributed too, for example, impeding the troops from digging down due to the presence of water near the surface or working against any deception such as the white, chalky ground that highlighted all the edges of the trenches of the Somme.

That so many different factors contributed to the development of the trench complicates our understanding of the process of innovation. This problem however allows us to embrace the chaotic nature of change during the war and to acknowledge how innovation is often messy and disorganized, especially in war.

CHAPTER 2. MAPPING THE FIRST WORLD WAR: THE EMPOWERING DEVELOPMENT OF MAP MAKING

During the First World War maps became a fundamental technology that permeated all levels of the armies, allowing for techniques and tactics of such complexity that would have been unthinkable at the start of the conflict. Analyzing the role of maps in the British Army during the war, in this chapter I advance three main arguments: first, that maps were not used only as an instrument for the artillery, but they became an integral part of every aspect of warfare; second, that maps became a mindset, a language to understand, rationalize, and share any kind of information; third and most important, that we need to re-think the concept of the map-maker, breaking the solidified perception that this was the job of the professional surveyor, on the contrary within this role we should include the multitude of soldiers who collected information recording it as coordinates, scribbling it on their personal maps, or analyzing photos and precisely documenting the results.

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The very nature of trench warfare enormously enhanced the importance of understanding and controlling the landscape. Maps became a primary instrument to achieve this goal, allowing the sharing of information collected in a great variety of ways. From the interrogation of captured enemies to the analysis of aerial photographs taken during dangerous missions over enemy territory, none of this information could retain any importance if not pin-pointed to a map coordinate. During the war the increasing importance of maps is glaringly evident from the exponential expansion of their production and distribution. Consequently, the training on map reading increased, extending down even to the humble private. Some roles required more education on the topic, so specialized schools such as the ones for snipers and observers dedicated ample time to instructing the men on how to interpret maps. Manuals for self-improvement and teaching were printed and distributed widely, taking advantage of the increased literacy of the populations.

Maps had become a universal medium, and Private Walter Hare used maps to connect with his parents. “Oh, I shouldn’t have this map on me - he said - take care of this will you, until I come back. Stay where you are, I am going a little bit further … I will pick it up when I’ll come back.” Hare waited for the officer alone with the map in the middle of no man’s land. They had ventured out of the trenches to find the location of an enemy machine gun that was causing some trouble. “He never came back, and I don’t know what happened to him.” Hare kept the map, breaking the strict rules on the matter. Many years later, already old, he confessed to the interviewer from the Imperial War Museum who was recording his voice that he still had it at home as a memory of the war. When he returned home on furlough he brought the map with him and gave it to his parents: “it was a map with all the places I have been to up to then, you see, so mother and father could see where we were being operating and when they see on the news [or the radio] … talked about them, they would know … that I have been there.” Hare’s family became part of an ongoing communication through maps that shared information on the battlefields. Even if they could probably only recognize town names and link them to the generic news that censorship filtered to the general public, they had in their hands an object that was so important that an officer had taken care to protect it from the eyes of the enemy.[59]

Map reading became almost a universally necessary ability of the soldiers because the increasing complexity of warfare required maps to rationalize and understand the landscape. Concentrating on the concept of map reading — the ability to understand symbols on a map and link them to the features of the territory that they represent — holds the risk of minimizing the agency of the soldiers, making them passive receptors of information laid out for them by professional surveyors. Surely the maps were mostly (but not in all cases as we will see later) made by highly skilled technicians that utilized all the techniques refined in peacetime to create precise records of the parcels of land, but these maps, printed by professional typographers and distributed to the soldiers, became objects of continual interaction: new information was collected and organized using these maps, which then were constantly updated thanks to these new data. The map reader thus became map maker, taking part actively in the universal effort of representing the landscape in a precise and useful way. Under this optic I describe maps as a new language through which soldiers of different units and with various degrees of knowledge talked to each other, describing how to move in the congested web of roads of the second lines, where to find drinkable water in a certain area, and where to locate the enemy's machine gun, dangerously camouflaged to the eye.

[59] "Hare, Walter (Oral history)." Imperial War Museums. Accessed October 27, 2016. http://www.iwm.org.uk/collections/item/object/80011195.

All the armies utilized maps, on both sides of no man's land. The precision required by modern warfare channeled the efforts in ways that produced very similar results.[60] The educational effort of the armies was similar for the different countries, and in the case of the Entente — the coalition comprised of Great Britain, France, and Russia, eventually joined by Italy, the U.S.A., and all of the nations that fought against the Central Powers — translation of manuals helped in spreading good innovations and techniques, and the necessity of coordination eventually pushed for a shared symbology and scale of the maps. In this chapter, however, I will use the British Army as a case study, taking advantage of the great number of documents available.

Despite the ubiquity of maps, this topic seems oddly uninteresting for First World War scholars, probably because of the apparent distance from the action of the mapmakers and the technicality of their job; in addition, precise maps seem an obvious corollary of every war: the importance of geography in warfare is, and was at the time, a truism. To take a famous example, Napoleon was notoriously obsessed with maps and mapping. Some scholars, however, took the challenge. Terrence J. Finnegan contributed to the topic of photography and aerial reconnaissance, which became central in the process of map making, with his excellent *Shooting the Front*: the author deeply investigated the organization, technology, methods, and challenges that characterized the continual research for information that extended the battlefield vertically over the trenches.[61] Michael Heffernan looked at the influence that the Royal Geographical

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[60] Peter Chasseaud, "German Maps and Survey on the Western Front, 1914-1918," *The Cartographic Journal* 38, no. 2(2001): 119-34

[61] Terrence J. Finnegan, *Shooting the Front: Allied Aerial Reconnaissance in the First World War*, paperback ed. (Stroud, Gloucestershire, United Kingdom: Spellmount, 2014).

Society had in providing good strategic maps to the army and the role that geographers played in influencing the strategic vision of the British Command.[62] Peter Doyle and Matthew Bennet offered an interesting contribution on the role of the terrain evaluation in trench-making. The authors explained how the geology of the terrain greatly influenced the strength or weakness of the trenches and described the role that topographers and geologists had in influencing their placement.[63]

The greatest contribution to the topic comes from Peter Chasseaud. His interest in trench maps followed him in his long career dedicated to the study of military cartography, which included an exploration of German mapmaking and its great contributions in optical technology and trigonometrical techniques.[64] His most important work on the topic is *Artillery's Astrologers: a History of British Survey & Mapping on the Western Front 1914–1918*,[65] in which he detailed the history of the British Ordnance Survey from the perspective of the topographers and explained their role in tandem with the artillery.

Chasseaud's attention to the artillery is understandable, because ultimately it was the artillery that dominated the battlefield of the First World War. One might argue that the whole development of military aviation, aerial photography, and precise mapping began for the sole purpose of artillery effectiveness. The little army of cartographers of

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[62] Michael Heffernan, "Geography, Cartography and Military Intelligence: The Royal Geographical Society and the First World War," *Transactions of the Institute of British Geographers* 21, no. 3 (1996): 504-33.

[63] Peter Doyle and Matthew R. Bennett, "Military Geography: The Influence of Terrain in the Outcome of the Gallipoli Campaign, 1915," *The Geographical Journal* 165, no. I (1999): 12-36.

[64]Chasseaud, "German Maps and Survey on the Western Front, 1914-1918."

[65] Peter Chasseaud, *Artillery's Astrologers: A History of British Survey & Mapping on the Western Front 1914 - 1918* (Lewes: Mapbooks, 1999).

the British Ordnance Survey whose story Chasseaud recounted in high detail worked closely with the batteries. Precision was fundamental when dealing with artillery, because an error could not only impair its destructive power, but might also put in grave danger the artillery's own infantry. For this reason the field survey companies and their skilled men were responsible for the three fundamental points that guaranteed, as much as possible, good results. These three points were the position of the battery, the bearing of the target, and the range of the target, which is its distance from the battery itself.

The members of the field survey companies however were not commanding the batteries, they were only providing the preliminary instruments. So, every time that a battery took a new position they went in situ and registered accurately the new location, then gave a specific direction of fire that would serve as a reference for future targeting, and finally provided an artillery board for the unit. These artillery boards were "flat rigid surface[s] on which the required positions are accurately plotted, and permitting of the accurate measurement of angles and distances." They were usually made of zinc sheets mounted on a wooden base: they were not made of simple paper because the change in humidity stretched or contracted the fibers of paper and added dangerous error. A series of arcs with the battery at the center helped to measure the distance and direction of a specific target. There was no need to have the whole detailed map on the board, and usually the enemy's trenches were more than enough, but later in the war it became common to cut actual maps into squares and glue them on the grid of the board, a process that helped with measurement and confined the error due to the stretching of the paper map to small areas.[66]

I argue however that to confine our interest in maps and map making to solely the artillery is to close our eyes to a world as ubiquitous as it was important for the understanding of the life and actions of the soldiers of the First World War. To comprehend the hidden half of the question we need to consider what a map was at the time. At the start of the war all maps fell under the category of skeleton map, that is a map that merely shows the geographical features such as roads, houses, contour lines (the parallel curves that indicate the elevation or depression of the terrain), woods, rivers, and all the characteristics of the represented landscape. In a war of movement — the one that the armies expected at the start of the war — no other kind of map is needed. The maps were indeed only an instrument to understand the landscape, plan operations, give and understand orders, and basically to not get lost. But at the end of the conflict on the western front, after four years of attritional war that had been fought mostly in the same areas and with a very ‘static’ definition of maneuver and conquest, the number of different kinds of maps printed was impressive. Surely many of these types of maps were still dedicated to artillerymen: enemy battery position maps and barrage maps are probably the best examples, with their clear explanation of the objectives or of the plan for creeping barrages precisely timed to precede the wave of attacking men. This was a task of incredible importance where the competency of topographers with theodolites —

[66] *Maps and Artillery Boards: Reprinted from Pamphlet Issued by the British General Staff December, 1916* (Washington D.C.: Army War College, 1917), 18.

a surveying instrument with a telescope — was fundamental in guaranteeing the precision necessary to be effective and also, importantly, to avoid friendly fire. But a great number of maps were not dedicated at all to the artillery: all of the logistics maps that made possible the high level of organization necessary on the second line for example fall into this group. Dump maps helped in organizing the distribution of ammunition, water supply maps illustrated to the commanders where to fill the reserves and satisfy their soldiers' thirst, hospital maps allowed a better movement of the wounded, while bridge strength maps helped to plan the movements of heavy artillery, tanks, and truck traffic in general.

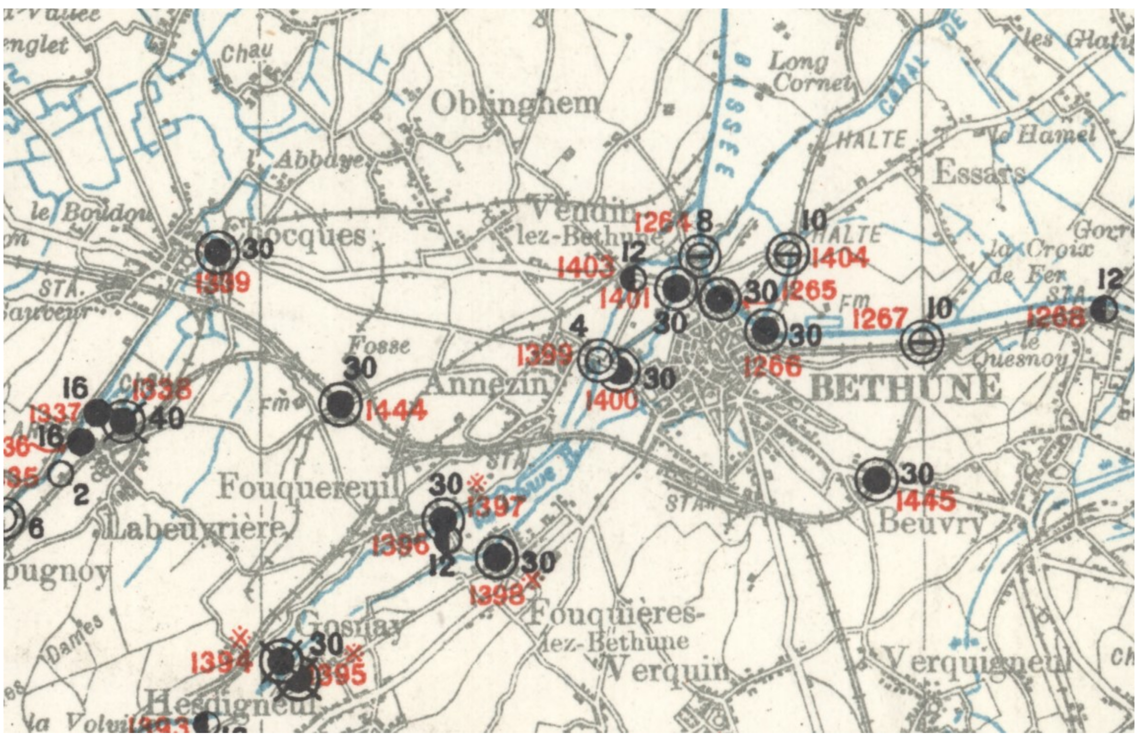

Figure 1: A detail of a "Map shewing strengths of bridges: Hazebrouck", McMaster University Library.

To make these maps the competencies of professional surveyors were unnecessary. For this task, anyone with the understanding of the situation and a minimum of aptitude in map reading could have been the map-maker: indeed a cartographer would not be the best choice to estimate how many tons of weight a bridge could withstand. These maps were not a ‘secondary’ class of maps, because they allowed the troops on the frontline to endure. Nobody should consider the sole projectile as the lone weapon, even if at the end it is only the projectile that destroys the target; in the same way that a gun is necessary to project the destruction, these logistics maps organized and rationalized the efficacy of the armies on the ground.

As in the case of the topographers of the different survey battalions, the officers that traced the logistics maps and sent them to print were very reliable and highly specialized soldiers: for example the engineer testing the bridge most likely would have had either a specialized training in the army or a past with a career in bridge building.

A New Concept of Map Maker.

They were not only surveyors and engineers: thousands of soldiers of all ranks participated in the complex operations behind the printing of the millions of maps during the war. At the end of the conflict the maps represented the information collected by an uncountable number of observers — both in airplanes and on the ground — snipers and soldiers. The information passed through intelligence officers and then was transcribed and printed by an army of proper topographers. I argue that the language of mapping, developed with the intent of sharing information through maps, entered deeply in the structure of the armies. This new instrument strongly influenced the concept that men had of the landscape and pushed the development of important tactics and techniques.

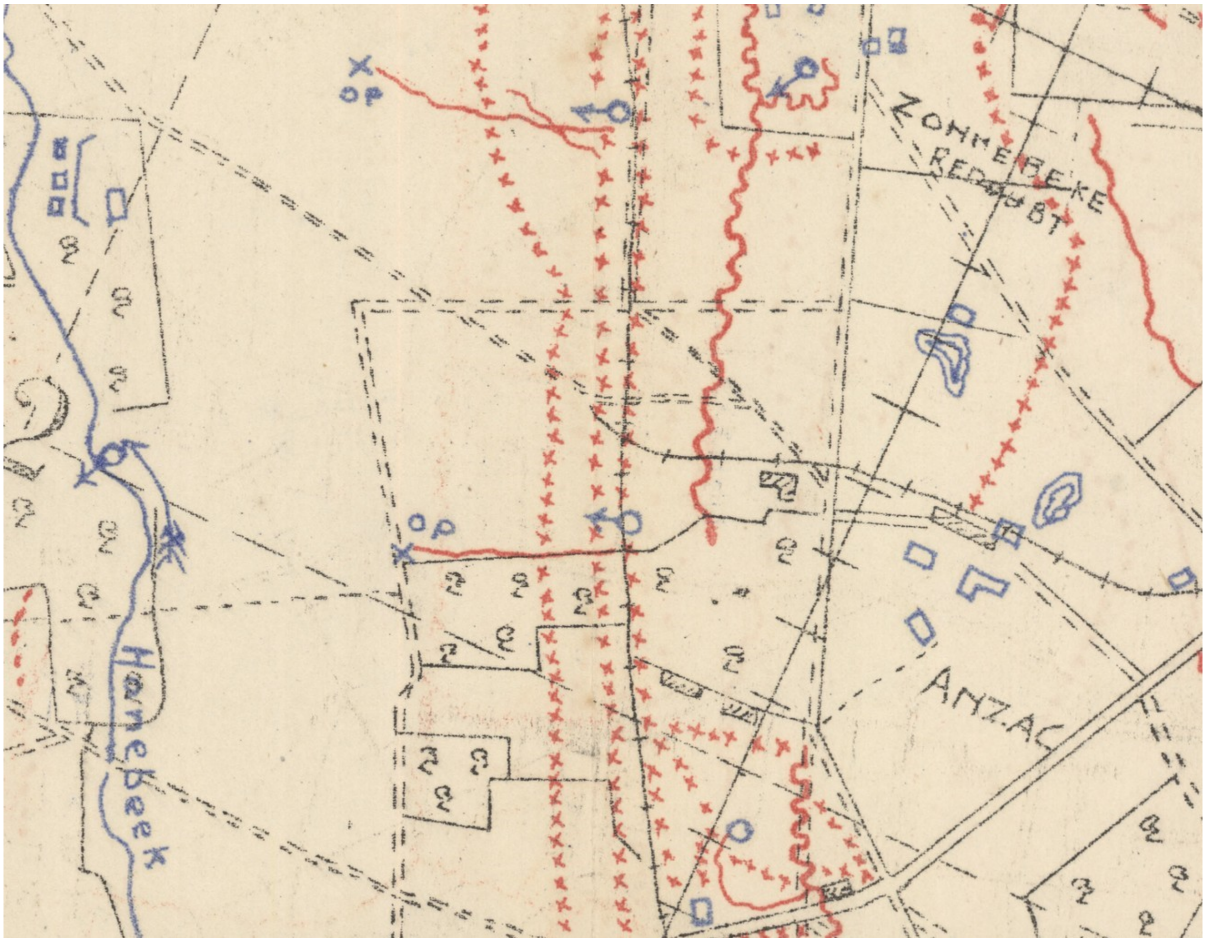

Figure 2: Detail of the 1:5000 scale trench map “28NE1 E-12 Frezenberg - Zonnebeke 11-08-1917”, McMaster University Library.

Let’s take into consideration the case of the trench maps at 1:10000 scale and the tactical maps at 1:5000 scale. (Fig 2) These were highly detailed maps that showed the complex web of trenches that constituted the frontline.[67] The amount of information recorded on these kinds of maps is impressive: the most obvious features were the intricate labyrinth of the enemy's trenches and the geometrically complex pattern of their barbed wire, but in addition to these features the maps showed the position of the dugouts, pillboxes and machine gun emplacements, trench mortar positions, observation and listening posts, undefined earthworks, huts, supply dumps, and the enemy's tracks and communication cables.

All of this information came from two different channels: photographs and observers. Most of the photographs came from the sky, a technological revolution for map-makers that eventually led to the photogrammetric techniques still used in today's mapping. Some pictures however came from the ground in the form of panoramic series usually taken in the first or second line of trenches. [68]

The role of photography in the map making process is well known and studied; instead, scholars gave minor attention to the role of the observers and snipers on the ground, an important contribution from the trenches that was overshadowed by the impact of the new aerial observation. The comparison of the contributions from these two different perspectives is not germane to this article: what is instead compelling to this analysis is their addition to the group of map-makers. Including the observers in the sky

[67] The British trench maps, differently from the French and the German ones, showed only the enemy's trenches. The British side was represented only with the first line trench. This omission of the whole British defense system was due to the fear of giving information to the enemy in the case of capture. In 1918 however this overly prudent attitude stopped in the effort to create a more homogeneous style with the French.

[68] Photogrammetry is the technique that uses photos to measure distances, a method vastly applied to mapping and recently employed to create a tridimensional virtual representation of objects, buildings, and locations.

— with their photograph-interpreting counterparts — and the observers and snipers on the ground — with their Intelligence Officer intermediaries — greatly enlarges the number of people that contributed to the process of making the maps and sharing information throughout the whole army. [69]

There are two important considerations in this regard. First, the increased number of participants in this crucial role revolutionized the concept of the reliability of the information; the position of the machinegun, which would be shared with everyone, was now registered by the private soldier in the observation post. The skeleton maps had previously been made 'from the top', utilizing a small number of highly qualified and specialized personnel, however the vital information that had to populate the maps, now came 'from the bottom'. This new concept of shared responsibility necessitated the ideation and mise en place of a new system of education and control. Second, maps became the language through which to share important information across the army. From the simple private up to the commanders, the ability to read a map and identify a location on it became an essential pre-requisite for any kind of communication.

The huge number of reports, sketch maps, and above all photographs required a new and complex system to manage this vast quantity of information. The organization took the name of the Intelligence Network. The Senior General Staff Officer (GSO1) of Intelligence was attached to the Divisional Headquarters and was responsible for a chain of officers; from Corp (GSO2), Division (GSO3), and then Brigade Intelligence Officers,

[69] Terrence J. Finnegan, *Shooting the Front: Allied Aerial Reconnaissance in the First World War*, paperback ed. (Stroud, Gloucestershire, United Kingdom: Spellmount, 2014).

these officers and their staff were responsible for the general management and filtering of the information, but they were only the tip of the iceberg. Below them a legion of people trained in very different specialties collected and filtered the information as well. Information came from the Royal Air Force (RAF) squadrons, balloon observers, artillery observers, Lovat Scouts, infantry snipers, observation posts, and even from simple soldiers.[70] The structure of the Intelligence Network was complex, but fluid, because the information could flow through different channels: for example, the Lovats who were occupied with looking for enemy's batteries would send their findings to the Corp's Counter Battery Intelligence, who reported to the Reconnaissance Office of the Corp's Artillery, who in turn were connected with the Army Intelligence and with the GSO2. At the same time, the Lovats detailed to an observation post (OP) would have sent their findings to the GSO3's Office of the division through the OP's Intelligence Officer. The key concept was to have a reliable network through which to share the information, select the most important points, and store the others for further reference.[71]

This higher-level intelligence position was not however the only repository of information. Every single soldier dedicated to observation had some reference and archive. In an observation post it could have been as simple as a map with handmade sketches and signs, accompanied by a log that the observers and their officer shared with the other shifts of the day, but in other situations the archive was much more complex.

[70] The Lovat Scouts was a highly specialized unit with expertise in reconnaissance and marksmanship and formed during the Second Boer War.

[71] Terrence J Finnegan, *Shooting the Front: Allied Aerial Reconnaissance in the First World War* (Stroud, UK: The History Press, 2011).

Private Walter G. Ostler helped in managing one of these field archives. Trained as a wireless operator, he was attached to the 17th Kite Balloon Section of the Royal Flying Corps. This section was deployed in the Struma area near Salonika. Ostler did not have much work to do, so the commanding officer moved him to the chart room to help the NCO who was operating it and who had been complaining about the excessive amount of work he had to do. He recounted how "the chart room consisted of the centralization of the intelligence in the camp, [which] consisted of maps, photographs, which we used to stich on a huge sheet of paper and make them on a form of aerial map, all the secret intelligence that used to come through Corps, and everything regarding the operations of the squadron; all confined in that chart room." Each day Ostler collected and archived photographs in petrol boxes, took a log of everything that had happened to the balloon and every conversation they had with the officers in the baskets.

Indeed, one of the main tasks of the chart room was to help the officers in the air. They had only two maps with them and whenever they needed information on an area where they could see something noticeable, they contacted via phone — all the balloons had a phone in the basket —the chart room, which had more detailed and diverse maps. Ostler explained how the conversation usually went: "two miles beyond the minaret of so and so and three degrees to the right, what…might that [be]?" He then had to check "very quickly" on the maps and relay the necessary information.

The officers in the baskets had a "specialized sector of the front," but in the normal rotation of the shifts in the air, Ostler often had to brief them on what they were going to observe and on the general status of the sector they were assigned to that day.

Ostler's expertise apparently became very valuable, to the point that on one occasion one officer, new to the frontline, wanted him to grab a parachute harness and accompany him in the basket, a task that usually was reserved only for the commissioned officers.[72]

Soldiers such as Private Ostler were key figures in the collection of data for map making: he is a good example of the number of people that worked in the shade to grease the cogs of the machine of the Intelligence Network. His training is interesting in that he acquired all the expertise in reading photographs and relating them to the maps in the field as opposed to in his previous career.

Skilled Map Makers.

The soldiers involved in map making had all kinds of specializations and different levels of knowledge on reading maps. Throughout the war, training in map reading intensified, reflecting a different approach to the topic. John M. L. Grover reports how this attitude changed. He trained at Sandhurst in 1914 to become an officer in the Second Battalion of the King's Shropshire Light Infantry: "we spent quite a lot of time in field sketching and reconnaissance and that kind of thing on bicycles and across country, and we actually had to draw sketch maps; nowadays of course you would rely upon maps prepared from photographic reconnaissance and very much more accurate. Indeed, they were very good in France by the end of the war where they were prepared in that way, and by proper survey. But in the early days, sketch maps were of great value… from [a] training point of view… and we did a lot of it." Grover, taught in one of the most

[72] "Ostler, Walter Glenn (Oral History)." Imperial War Museums. Accessed October 27, 2016. http://www.iwm.org.uk/collections/item/object/80000039.

illustrious military schools of England, was trained to approximate a landscape without maps. This had been a very useful expertise in reconnaissance in the kind of warfare that armies expected to fight in August of 1914, but the advent of trench warfare necessitated a much more technical training. [73]

Officers like Grover received an in-depth training on map reading, yet during the war the necessities of having soldiers in the field who were not only able to read a map, but also to make one from scratch — and not as a sketch — became apparent. The experience of William Shipway provides an excellent example: following a year in France as an NCO in the 4th Battalion of the Gloucestershire Regiment, after the battle of Loos he was commissioned as 2nd lieutenant and sent back to England for training. He went to Oxford for a course on map reading and map making; "a very useful course indeed! And a thing that then I put in good use in France...When you went to a strange trench, and I was often acting company commander, you always lose your sense of direction in the excavated trenches because they weren't nice and tidy [they were] all waggling all over the place. You try to make a map of that without losing your sense of direction. With the compass you could take your bearing, but over the short distances you see, it was impossible. My first job when I went to the trenches was usually to make a map of the trench and there was not one there before." It was neither a simple nor safe job however, so he avoided doing it in the middle of the day and usually made the maps at first light: "the very early mornings I would get men at strategic points to hold up rifles

[73] "Grover, John Malcolm Lawrence (Oral history)." Imperial War Museums. Accessed October 27, 2016. http://www.iwm.org.uk/collections/item/object/80000045.

and I pace out at the back of the baseline and then take bearings on those various points … and make a plan of the trenches. And I could leave [the maps] behind; when I left, there was a nice neat plan." These trench maps while surely not of the same quality and precision as the official ones, were however of paramount utility in the continuous shift between companies and regiments on the frontline: the new commanding officer would have had a clear representation of his sector, shortening the time of adaptation and helping him to not get lost in the labyrinth of trenches.[74]

These handmade maps were usually for 'local' use only, and didn't go further than the battalion headquarters. They were often catalogued in the battalions' war diaries, which were the archives that contained all of the important information on the day-to-day operations, the casualties, medal commendations and promotions, and so on. One example of these maps is the one in Figure 3, collected in the August 1915's War Diary of the 1/6th Battalion Argyll and Sutherland Highlanders. It is a schematic but precise representation of the sector occupied by the unit and illustrates the most important features without adding too many details. The fire trenches are in blue and the sap and communication trenches are all in red. All the basic information of a proper map is present: a clear and well-organized legend helps in understanding the symbols and letters indicating the sniping posts, machine gun emplacements, telephone location, and the commanding officer's dugout; an arrow indicates north; and the scale on the bottom left helps in understanding the proportions. It is interesting to note which noticeable features

[74] "Shipway, William George (Oral history)." Imperial War Museums. Accessed October 27, 2016. http://www.iwm.org.uk/collections/item/object/80009899.

of the landscape that the maker considered to be necessary to include on his map. The two roads and the buildings are clear features, but the author showed interest in illustrating the woods in two different ways: on the German side the woods are roughly drawn, but on the English one the author precisely traced the limits of the woods using little pine-tree shapes. On the lower right the author broke the rules of modern mapping and illustrated on one side of the second line trench, the side-view of two trees, instead the perspective from the top. These two trees evidently dominated the landscape, making them an important feature to understand the map. Of practical importance are the dotted lines of the old out-of-use trenches — an important detail to know in order to not get lost when navigating the trenches in the dark — and the limits of the company's sections, where the responsibilities of the commanding officer ended.

The National Archives' reference WO 95/2865/1

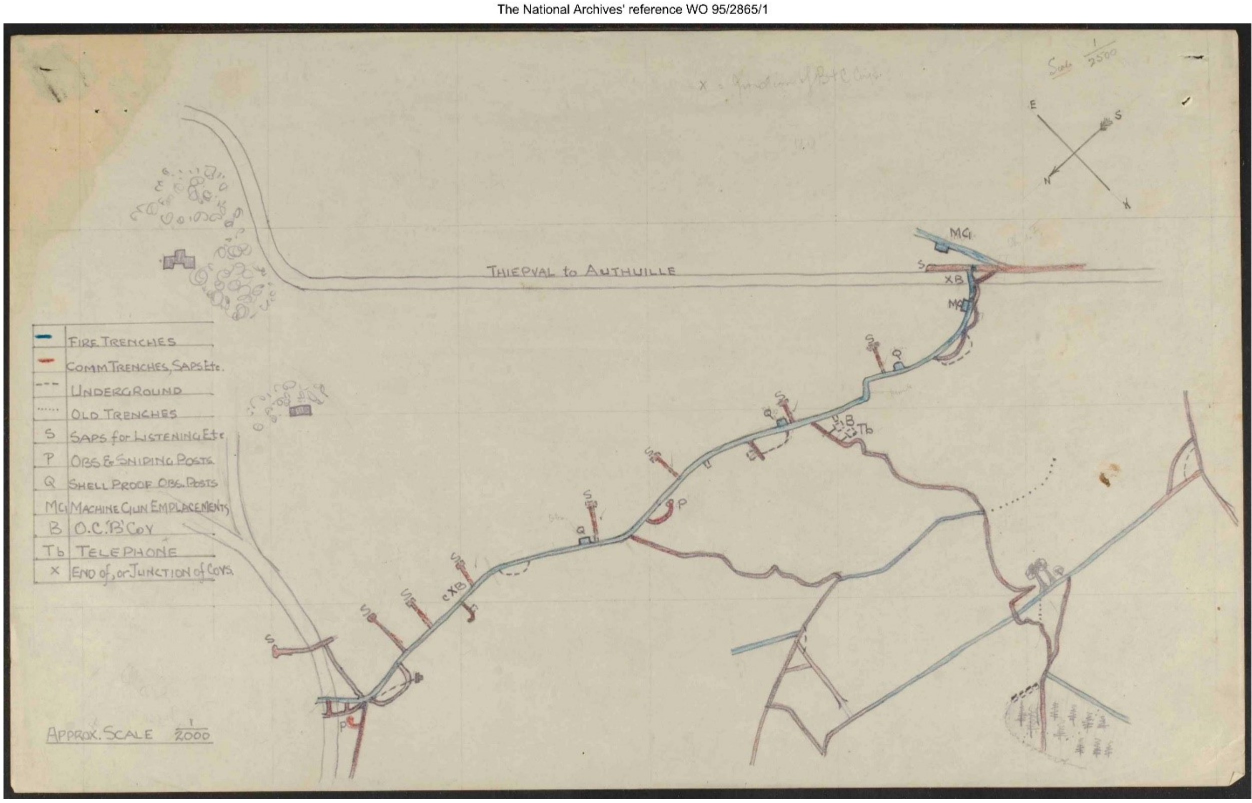

Figure 3. Handmade trench map. From the War Diaru of the 1/6th Battalion Argyll & Sutherland Highlanders Vol. 5 (July 1915).

Not all of the handmade maps involved the trenches: one example is the map of Fig. 4. This beautiful object, painted with ink on linen, shows a camp for the stationing of soldiers in the rear lines. Half map, half birds-eye view, it was created by the hands of a talented illustrator. The artist not only made an object of practical utility, leaving the most important features clear and schematic, but also took pride in decorating the empty areas with three-dimensional features such as trees and hedges. The map shows the direction of flow of the rain on the ground, and the ditches and the bridges required for what looks like a reorganization of the camp to make it more hospitable for the troops. Indeed, the camp was not far from Ypres, in an area that was problematic for water drainage. The need to use the map in wet or humid conditions was probably the reason behind the use of linen, a more water-resistant material.

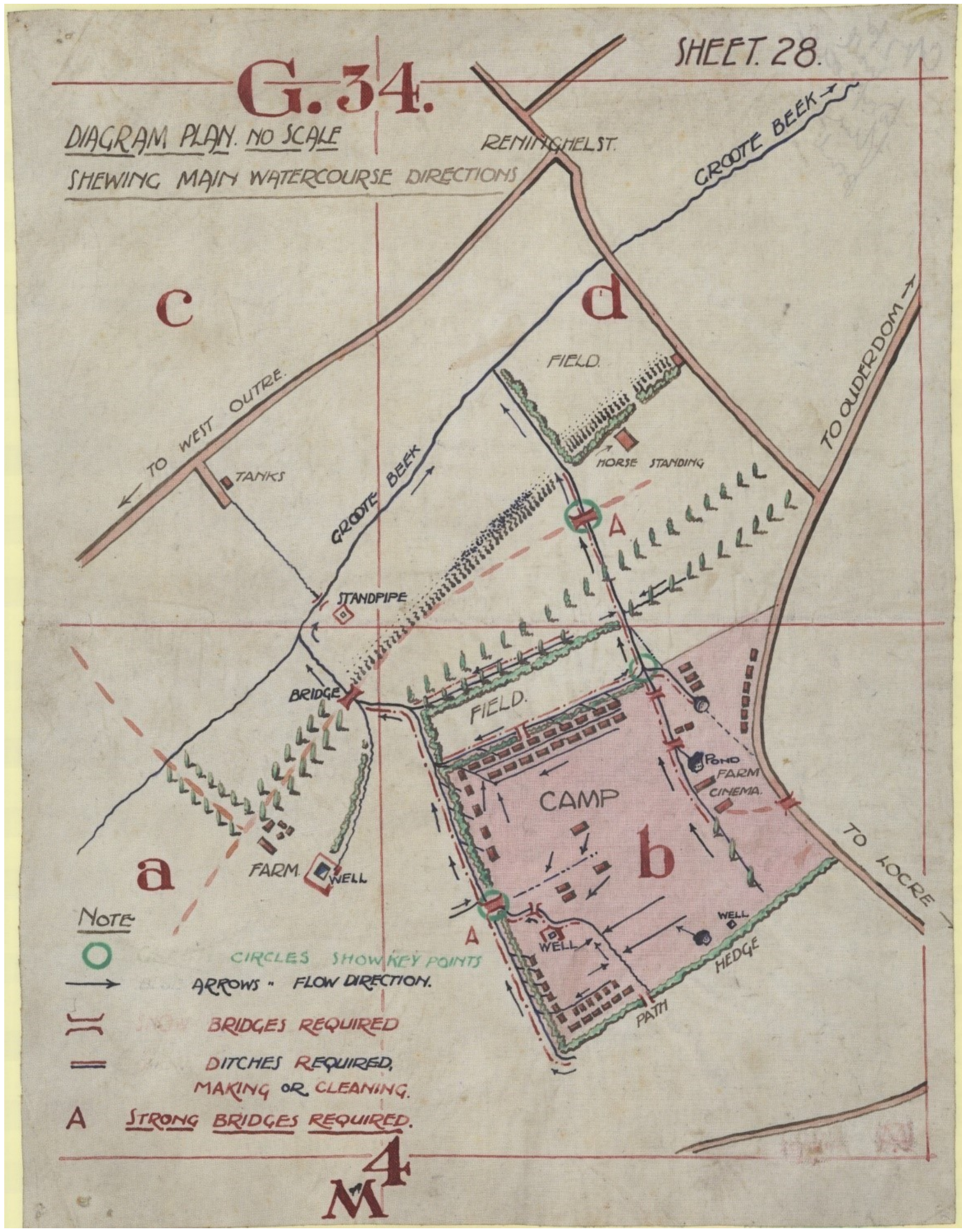

Figure 4: 28 diagram scale of a camp 1916 or 1917, McMaster University Library.

The officers in the RAF received, for obvious reasons, a precise training on maps. During the war the connection between aerial photography and maps arose automatically. Because maps were the means through which to share information, and photographs were a revolutionary way of recording the status of enemy's lines, it became vital to teach to as many soldiers as possible how to read a photo, analyze and decrypt it, and relate the information via the corresponding map. This task was not easy: not only was the quality of the photos not up to our standards, but the absence of color, the variability of the direction of the light at different hours of the day, and the changing seasons could fool the eyes of the reader; even the differences of humidity of the soil for example could show a false positive of a walking trail and confuse the general analysis of the area. The wide diffusion and the refined skills necessary for their interpretation created almost a paradox: on one side the information hidden in the photographs was fundamental for almost any kind of operation and the abundance of them provided an impressive amount of intelligence, on the other they were not always in the hands of the relatively few and highly skilled interpreters. Walter G. Ostler for example explained how he did not receive any training in photograph reading before his appointment to the chart room and that he had to learn by himself how to "work with light and shade."[75]

The necessity of a widespread training, sometimes on the fly like for Ostler, resulted in the printing of a textbook Notes on the Interpretation of Aeroplane Photographs, published in 1916, edited multiple times, and eventually even copied by the

[75] "Ostler, Walter Glenn (Oral History)." Imperial War Museums. Accessed October 27, 2016. http://www.iwm.org.uk/collections/item/object/80000039.

Americans. This book was easy to read and it consisted of two volumes, one for the actual text and the other for the example photographs. In twenty pages, it gave the basic knowledge of how to read a plate: organized in small sections dedicated to teaching how to recognize the common features of the battlefield (such as machine guns, batteries, train tracks, buried cables, and dugouts) it introduced the good practices for commenting on photographs, on the advantages and traps produced by different kinds of light, and the importance of creating a reference to a map. The volumes had an enormous diffusion, all the way down to the machine gun companies and trench mortar batteries.

One clear example of how the book exemplified the way to handle, read, and interpret a photo is the pair of images of Fig. 5. The chaotic nature of an air-photo, cramped with field patterns, trails, and shapes created by different color shades of the grass, all complicated by the shell holes and the destruction of warfare, make these photos very interesting from the scholar's perspective. They were even more interesting for the armies, but these features made them difficult to read for the untrained eye. A schematic drawing (on the left) explained the photo to help the learning process. The first thing to do was to indicate the direction of light: it was the most important reference for any subsequent reading of the plate, because the objects on the ground appeared in very different ways at various times of the day. The trenches were the easiest thing to recognize and did not require any explanation, but the drawing is explicit in indicating buried cables, batteries, tramways, and a dump. These were features that needed a more sophisticated reading: for example, the buried cables looked very similar to a communication trench, but could be recognized by their straight and geometrical directions. The example of Fig. 5 was designed to highlight the importance of the direction of light, for this reason a couple of arrows point to the shadows to explain how they revealed banks. These geographical features were difficult to recognize because like the maps the photographs flattened the volumes of the terrain: to be able to find them through deduction would have helped the interpreter to georeference — the process that precisely situates the photograph to a specific space — the photo correctly and to suggest revisions of the maps.

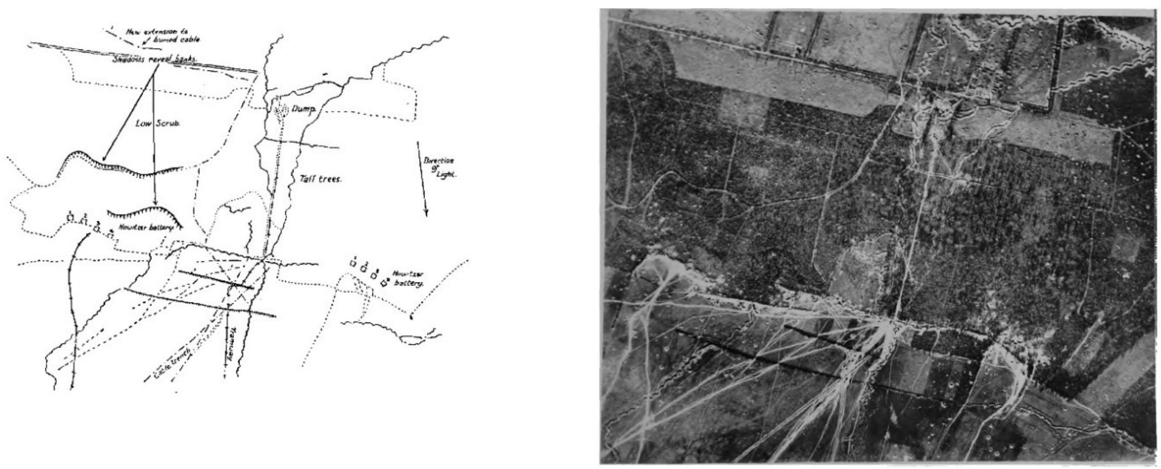

Figure 5: Illustrations to accompany Notes on the Interpretation of Aeroplane Photographs, 1917. Plate 4.

While the illustrations offered good examples, the text suggested the best practices; a series of steps and some rules to diligently follow could help the task of the analyzer in a work that required concentration and patience. A precise knowledge of the terrain was fundamental: the continual study of the maps would familiarize the analyzer with the configuration of the ground and it was a best practice to have the map close-by for a constant comparison with the photo. The textbook then continues suggesting the importance of ascertaining the direction of the light and instructs the reader to follow every detail with a pointer. It was important to maintain one's focus, avoid scattering around one's attention and being attracted by more conspicuous features. Some methods of deduction were particularly fruitful: a comparison with old photos, particularly if shot in a different season, could reveal changes and important details. After a preliminary analysis, which allowed the "[examination of] the photograph as an item of independent evidence," it was then time to compare the findings with visual observations, intelligence summaries, and evidence of "reliable prisoners," putting particular care in avoiding "to read in the photograph what you want to see."

In such an investigative task, the knowledge of the situation on the ground was paramount: the textbook stressed the importance of a continual work and refinement of the techniques, verifying on newly conquered terrain that the past analyses were correct and moreover to check for the features that offered problematic interpretation; the importance of this process did not lie in the education and improvement of the sole interpreter, but in the general shared knowledge of these crucial techniques; for this reason the textbook suggested that "it is not enough for a few people to view these points. A more practical and quite a simple way is to make a model of them before the machine guns or trench mortars have been removed and the emplacements dismantled." Models, inspections, and a constant development of the knowledge of the landscape suggest that the photo interpreter required constant self-training to improve his proficiency. There were no schools to teach these techniques: manuals helped and practical experience on the field like Ostler had filled the gap. Photography was such a new instrument for reconnaissance that the only experts were the ones who were using it in the field.[76]

The wide distribution of this textbook, the precise techniques used to highlight the findings of the photographs, and the models of what was difficult to read all contribute to explain the necessity for a common language to understand, describe, and share information in a more descriptive way than mere words allowed for. Maps were a fundamental cog in this mechanism. Without detailed maps the interpreter had serious difficulties in understanding a terrain that in most cases was on the other side of no man's land. More importantly, the photo could not be geo-referenced. The pilot received orders to reconnoiter an area with map coordinates. He then gave the photographs to the interpreter who could place them in an area only if he knew their coordinates too, and could collect the additional information needed to investigate them only as a reference to the map sheet number.

The importance of aerial photographs started a virtuous cycle. The necessity for better photos and faster development of the negatives pushed new technological improvements both outside and inside the army in regards to cameras, chemistry, and optics. These important advancements increased the quality and details captured, which made aerial reconnaissance even more important. Not everything was easily accepted however. In an article in the Publications of the Astronomical Society of the Pacific of February 1920, Paul W. Merrill, explained how "the new officers, doing the best they

[76]*Notes on The Interpretation of Aeroplane Photographs*, (Washington, Government Printing Office, 1917).
Finnegan, *Shooting the Front*., 129.

could under trying conditions, were hampered by the organization and methods of the war department, which are not at all adapted to the rapid development of innovations… [they were] unable to grasp the essential requirements of the situation; who gave no heed to the query 'what can be done?' but were only concerned with 'what has been done?'" Innovation came from below. At the end of the war however not only did the photographs provide an irreplaceable source of intelligence, but also the new chemicals and filters used to enhance the images opened a new era of photography: new dyes introduced color into photography, and they also allowed an extended vision outside of the range of visible light, such as infrared.[77]

The link between photographs and maps may seem clear today, but was neither obvious nor easy at the time. The first problem occurred in the air; the pilot needed to fly not only over a precise spot, but also parallel to the ground: any tilt would have distorted the photo in relation to the map. It might have been easy to do in normal conditions, but between the shelling of the anti-aircraft artillery and the unwanted attention of enemy's fighters, the precision of the pilots suffered. Geoffry McCall, a pilot of the 1st Squadron, trying to explain to the interviewer why they had to fly high, remembered "the bullets [fired from the ground] turning over at the top of their trajectory, and they catch a glint from the sun, and they looked like fish." At the start of the war it was the pilot who took the photographs while the gunner took care of enemy aircraft. This configuration created some problems, as McCall recollected clearly: "if you are looking down there [to find the

[77] Paul Merril W., "Progress in Photography Resulting from the War," *Publications of the Astronomical Society of the Pacific* 32, no. 185 (February 1920): 16–26.

place to photograph] you get the machine on a slight bank without knowing about it, and then you get your photograph possibly off the target altogether but anyway distorting." Later it was the observer who took the photographs, making the whole process a lot easier for the pilot, but introducing new problems because the observer and the pilot could not communicate easily between the noise from the engine and the one from the wind; only with the introduction of the laryngophone — a microphone that wraps around the throat to record from the vocal cords — did the situation get better.[78]

Once the photographs were on the ground, a team attached to the squadron would develop the plates, analyze them, and then send them to the intelligence unit. If the information was new and interesting then they sent these annotated plates to the topographical section, which then had to deal with a set of problems caused by the distortion of the photo. The first method used was a manual plotting of the points using as a reference the clear and recognizable features of the photos such as buildings, roads, and rivers. This technique was sufficiently reliable, but very tedious and time-consuming, because for every feature that had to be transcribed on the map there was the need of at least two, better three, measurements of angles and distances. The second method adopted the 'camera lucida,' an instrument used by artists before the war. After careful placement of the photo, the draftsmen could look through a prism at both the photo and the map at the same time, and copy on the latter all the information from the photograph. This technique was fast and precise, but as Lt. Col. MacLeod recalled in a conference at

[78] "McCall, Geoffrey (Oral history)." Imperial War Museums. Accessed October 28, 2016. http://www.iwm.org.uk/collections/item/object/80032409.

the end of the war, when he was Director of the Survey Office, “the strain on the eyes is so great that the draftsmen is often tempted to trace in only a few features and sketch the rest by eye.” The last method was to use a “cumbrous affair called a ‘projectograph’” that cast the photograph onto a map pinned to a plate that could be tilted in all directions. Each field survey battalion had one of these awkward machines. MacLeod confessed, “I eventually made good use of mine, but only after disintegrating it into its component parts.” In the continuous competition against time and the difficulties of war, it was this kind of tinkering that fixed problems, found new solutions, and developed new techniques that allowed for the numerous technological innovations and refinements that changed how war was waged.[79]

Proficient Map-Makers.

As the war went on and maps became ubiquitous, more people required training. Not everyone however could be a professional topographer such as MacLeod or could become an expert studying the topic at Oxford like Lieutenant William Shipway. The members of the intelligence section of the battalion for example needed a specific education. Their teacher was the intelligence officer of the battalion. He was appointed by the commander of the battalion but the manuals suggested that he should choose his own staff. These men should have been the best: “bright, active young fellows, who have followed an outdoor life, have the best of health and a good education; they must have these qualifications to start in on, as their work often places them in situations alone and

[79] M. N. MacLeod, “Mapping from Air Photographs,” *The Geographical Journal* 53, no. 6 (June 1919): 382–96.

entirely dependent on their own resources, at which time their early training will stand them in good stead." A good education and a bright mind did not mean that they already had the basics to read and understand maps. The manual reveals some apprehension on the recruits' basic understanding of a map. In the section that explains how to efficiently teach what are the contour lines, it suggests to use an umbrella, a table, books, and some chalk: with the umbrella opened on the table with its handle resting on the edge, a man would turn the handle, while another held the chalk firmly on the books, drawing a series of parallel circles on the umbrella. Once finished, the teacher could show the top of the umbrella to the class and compare the circles of chalk to the elevation curves on the map. The men then received training on the use of compasses, scopes, range finders, field glasses, and on how to write reports and the general information on aerial reconnaissance and trench warfare.[80]

Snipers required a special training, and the divisions organized schools that selected the most proficient volunteers and educated them in the subtle and dangerous work they had to endure on the battlefield. Alfred C. Razzell was one of these men; he served in the 8th Royal Fusiliers from the start of the war until his capture in 1917 and remembered how his knowledge of map reading was basically non-existent before being trained as sniper: "we always did map reading… because one of our useful duties was that if someone was being worried by trench mortar continuously firing, they were sending through a sniper and we sent the map reference back through the signals to the

[80] Captain C.D.A. Barber, *Map Reading and Intelligence Training* (Ottawa, Canada: E.C. McKay, 1917).

artillery and they would concentrate on it; or the mortar people [would take care of it].” Being the eyes of the infantry in the trenches, snipers and observers had to know the language to precisely and unambiguously report their observations on the map. For this reason more than one and a half days out of the sixteen of training in the sniping schools was on map reading and interpretation of photographs.[81]

While the snipers were the eyes, the trench mortar teams often were the punch, and they relied heavily on maps for their job: “you were getting a map reference, you never saw your target, because you’ve got to remember we lived as I always say below ground, we never saw above ground; you were getting a map reference, it might [have] been part of a farm building, it might [have] been what the brigade commander or the higher authorities thought was an observation post and you were told to strike that … you very rarely knew whether you’d hit the object because we hadn’t got what they called preps, observation posts like the artillery had… we had a firing [range] of three-four hundred yards: it was too dangerous to try and poke your head up to see if you had [hit].” In the blind world of the entrenched infantry, during the day maps became the way to interact with the battlefield.[82]

The Poorly Trained Ones.

The private soldier received only a barebones instruction in map reading during training: “so it was field, feet training. We had the instruction on a little map reading;

[81] “Razzell, Alfred Charles (Oral history).” Imperial War Museums. Accessed October 28, 2016. http://www.iwm.org.uk/collections/item/object/80011692.

Major H. Hesketh Prichard, *Sniping in France* (New York: E. P. Dutton and Co., 1920).

[82] “Burke, Ulick Bernard (Oral history).” Imperial War Museums. Accessed October 27, 2016. http://www.iwm.org.uk/collections/item/object/80000565.

well, the NCO would have a map, I think we knew about as much about it probably as he did but [he] had been told to give us some instruction; and then have a colored map and there would be outlines of hills and all that and tried to describe what to look for a hill or a wood or whatever there was, and try and think in your own mind where you were in comparison to a bigger one. It wasn't as good a map reading as they get today, nowhere near, but they wanted the skilled people to give it to us." Surely they did not receive the training that 'the skilled people' had, but it was important to understand the symbols and language of maps, if the necessity required, they could at least try.[83]

The need sometimes arrived. Private Herbert Cooper was one of them: enlisted in the 1st Battalion of the King's Own Royal Lancaster Regiment, he landed in France in April of 1918. One night he was in the support line when the corporal woke him and sent him to the company HQ; he went back wondering if some tragedy happened to his family, and eventually found the cozy headquarters. "[the officer asked] 'Are you Cooper?' I said 'yes sir'. – 'Oh you are not Cooper ... no they want an intelligent man for the battalion's observers' [it seems that the officer made a joke to break the ice]; 'Well can you map-read?' 'Yes, I can because I was in the map-reading course once.' 'Ok I think you'll do.' He asked various questions and then I had a nice cup of tea. 'You might have a bit of sniping to do'," a thing that alarmed him "because the sniper is in such a dangerous position." He did not quite understand what the observer's duties were, but he was hired for the job and they took him to meet the other four observers. When he met

[83] "Calvert, Horace (Oral history)." Imperial War Museums. Accessed October 28, 2016. http://www.iwm.org.uk/collections/item/object/80009738. "

them they were all shaken; the cottage was full of pieces of bricks and there was blood on the walls and on the floor. They had been hit by artillery and two observers had lost their lives.

The next morning his new mates introduced him to the routines and accompanied him to the observation post, which was in the attic of a small one-story house. Charlie, the soldier that accompanied him, showed where they were on the map. Cooper then looked through the powerful telescope that was in the room while Charlie indicated to him the distances of what he was seeing through the lens. "As close as I am looking at you now [the interviewer], I saw a German! … It took my breath away; there I was just looking at the enemy!" The surprise is understandable, because it was rare for an infantryman in the trenches to see the enemy. "We had to report every movement that we saw to the intelligence officer." All their reports were logged with a "map reference."[84]

Cooper considered himself lucky: he thought that the job was "very cushy," because their shifts were only two or three hours long. The reason for such comfort was that after this amount of time the concentration of the observers wore down. It was not a safe job however, because any minute "an artillery shot could hit you," and for this reason they took every precaution not to show any movement to the enemy so as not to reveal their presence.

[84] "Cooper, Herbert Howard (Oral history)." Imperial War Museums. Accessed October 28, 2016. http://www.iwm.org.uk/collections/item/object/80009212.

Conclusions.

While his experience of being transferred without training to the observers most likely was an exception to the rule, Cooper's memories are useful to understand how at the end of the war most soldiers understood the basic rules of map-reading. At the start of the war even the officers were still trained more in sketching maps than in reading them, but in 1918 an intelligence officer in need could find a simple private that had a basic training with maps. Cooper had to train 'on the frontline' to become a proficient collector of information, but when he entered the observation post he did not have any trouble in understanding where they were on the map. He was much more surprised by seeing the enemy than in dealing with coordinates.

Giving a precise estimate of the number of soldiers that dealt commonly with maps is a very difficult, if impossible, task. Proficiency varied greatly and different Corps would have varying statistics. Some considerations however might be useful in understanding the level of permeation that map-reading reached at the end of the war. Given the higher numbers of soldiers and the low specialization of the branch, which would indicate a smaller percentage of map literacy, for a ballpark statistic on the use of maps at the end of the war a useful starting point is the Infantry. By 1917 the officer, the NCOs, and all of the Lewis gun section of a platoon were specifically trained on reading and using maps. This means that out of an average number of 36 men, 14 were proficient with maps. To these we need to add the two snipers/observers of the platoon, who received extensive and detailed training on the topic.[85] However Cooper's experience shows that even simple privates eventually received some level of map-related training. Hard proof would probably be difficult to obtain, but it is easy to imagine that in an environment where at least half of the soldiers were able to use maps, some of the language of maps became shared knowledge.

Indeed in 1918, the language of maps had become the baseline for almost any kind of communication. The incredible amount of information collected from the sky and from the ground could be organized, refined, and shared. One piece of data clearly shows the importance of map making at the end of the war: the British printers produced approximately 34 million maps during the war, an average of more than 266 thousand maps for each kilometer of the front.[86] The Ordnance Survey Office and the little army of topographers that it employed surely were the ones that measured the ground, traced, printed and updated these maps. It is also true that the majority of their work was for the most powerful weapon of the world, the artillery.

These skilled technicians however were only the tip of the iceberg. The pilots that risked their lives on fragile airplanes, the officers that spent hours in the baskets of their balloons ready to jump and deploy what was a dangerously unreliable parachute, the snipers and observers that silently controlled the frontline, and in general any man that

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[85] Instruction for the Training of Platoons for Offensive Action 1917 (Washington Government Printing Office, 1917). From British original text.

[86] Chasseaud, *Artillery's Astrologers*, 499. Chasseaud takes into consideration the sole British sector.

collected intelligence and traced its position on a map deserves the consideration and attention of the historian.

To manage these many contributions, the army organized the Intelligence Network, a complex structure that connected separated corps in the attempt to create some order in the continuous chaos of the modern battlefield. Like a modern network, it was flexible and adapted to the diverse situations, sharing data with different people accordingly to the nature of the information.

The map, a humble piece of printed-paper, hardly a novelty of modern technology, acquired a central role during a war dominated by advanced technology. The symbols traced on the sheets allowed anyone to understand the situation around them, even if they never dared to raise their head above ground.

CHAPTER 3. HUBS OF KNOWLEDGE: THE OFFICIAL CHANNELS OF INNOVATION

In the British Army the natural centers of innovation were schools and the Royal Engineers' (RE) research units. However, these institutions were not only laboratories to produce research or mere centers of training. Above all, these hubs were collectors of the experience gained in the trenches by the fighting units, acting like filters to select the best practices and tactics. In this chapter, I will use the example of the 2nd Army Trench Mortar School; the Special Works Park (a unit of the RE dedicated to camouflage); the case of a RE officer, Nissen, who designed an innovative hut; and the case of the development of sound ranging. These examples help us to understand the institutional ingenuity of the British Army. Despite being officially instituted facilities, most of the innovation came from below, collecting the experience of the army on the battlefield.

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When we analyze innovation in the British Army during the war, we cannot limit the scope to soldiers and inventors alone. The system of change was a complex and dynamic web in which numerous actors interacted continuously. Where and how they interacted changed throughout the war, and one of the most important steps in this process was the creation of channels to ease the exchange of knowledge. While people without power or freedom of decision had to lobby for change, and generals had difficulty grasping technical details, there was a middle ground that bridged these worlds: institutions made specifically to innovate and spread new ideas.

One kind of institution was the technical schools. One of their official goals was to study new solutions using resources and men allocated for this specific task. A second actor was the Royal Engineers Corps (RE), which historically was the army's hub of ideas and recruited minds educated to solve practical problems. Trench warfare, with its trail of new problems to tackle, both in the trenches and behind the lines, was in a way a war tailored for the RE: they were the ones specialized in siege warfare and logistics, the two aspects of war that in the Autumn of 1914 had become overwhelmingly important on the western front.

This chapter explores this connective ground. I will examine how these institutions navigated the complex sea of a military bureaucracy tangled with a problematic war and pushed for important innovations in warfare. In the discussion on schools, a topic that we will explore again in chapter 5, I will use the example of the 2nd Army Trench Mortar School.[87] The infantry's support artillery was a fundamental aspect of trench warfare and a task that the British Army was unprepared for at the start of the war, since it had no mortars and therefore no doctrine for their use. As a result, the army had to scramble and build from scratch a system of research, testing, and training for this new weapon. The novelty of the school makes it a good case to see how an institution free from established regulation would react to innovation and how it would interact with the army.

[87] The available documents dictated the choice of the 2nd Army Trench Mortar School. Indeed, to my knowledge the only war diaries of a trench mortar school are held at the National Archives and are the ones of this unit.

For the Royal Engineers, I look at three cases: the Special Works Park, which developed materials and techniques for camouflage throughout the war; the invention of the Nissen hut, which efficiently solved the issue of inadequate shelter for troops in over-crowded areas; and the sound ranging section, which greatly improved the efficacy of British artillery. In the impossibility of covering the multitude of developments in technology, these examples offer a range of experiences. Additionally, camouflage, sheltering, and sound ranging had a tangible and major effect on the war.

The success of these three endeavors was due to two factors: the quality of soldiers employed in these units and the pressure of necessity. Trench warfare continually put weapons and doctrines under stress, creating an environment of enduring urgency. This condition was reinforced by the nature of the conflict. For years, the armies found themselves in the impossibility of breaking the balance and obtaining a clear success on the battlefield. This constant need to solve problems empowered these institutions as sources of expertise for the army. Consequently, these experts were granted resources to tackle the problems, starting a virtuous cycle of innovation.

Eventually schools and workshops influenced the general doctrine of the armies. They needed to inform non-specialists of their findings, both with training and official manuals. The trust on their expertise of both the War Office and the GHQ made the distribution of their knowledge much easier. The more trust GHQ had in these institutions, the faster the adoption of their findings. As for the sniping schools, we will see that it was not an easy path. Part of the problem was their expertise overlapped with other, well-established institutions like the musketry schools. The trench mortar schools had a different experience as well because they had to solve a problem that was much better defined and quantifiable— they could produce tables out of their tests, providing hard evidence of what did or did not function, while snipers' efficacy was much more difficult to define. Unlike snipers, trench mortars had a better-defined doctrine, plus they did not have to fight for a niche outside of the theorical limits of trench warfare.

Schools.

The new weapons of trench warfare required a system of learning. Disorganized testing could not work. At the beginning the troops were testing the weapons directly on the battlefield and in many cases they were building them in workshops just behind the lines. This makeshift solution happened because the armies were unprepared for this new style of warfare. With industrial production overstretched, they could not react quickly as demonstrated by the shell crisis of 1915. This "homemade" production on the frontline was the case with hand grenades, which were produced by filling tin cans with explosives and nails. These tins then were provided with old-fashioned fuses. This was not the best situation, but better than not having hand grenades at all.

The British Army had to improvise mortars too; I will describe the development of this weapon in a more detailed fashion in chapter 4. In 1915, when the new models produced in England arrived on the western front, the units were not trained to use them. The creation of schools was an obvious solution. The 2nd Army for example organized one of these education centers in Berthen, a little town southwest of Ypres just behind

Mount Kemmel, the hill that dominated the area, and a little more than ten kilometers away from the Messines Ridge.[88]

On March 11, 1915, Berthen received one of only two experimental models of 2-inch mortars sent to France along with fifty bombs by the Ministry of Munition. As soon as the school was instituted in early April of the same year, its testing ground became an attraction for the officers of the area who visited the school to see these new inventions.[89]

The very first activity of the instructors and their aides was public relations. They wore fatigues, placed some barbed wire, and dug some trenches to blow them up in front of some senior officers. To add some realism to the show, the men added mannequins with German uniforms to the defenses. On the day of the demonstration, one officer shot a few dummies a couple of hours before the arrival of the general and his entourage, to ensure that the range was accurate. It was better to avoid any embarrassment at the inauguration.[90]

At this point the instructors were experts on the weapons only in principle: there were no statistics, doctrine, or mention of manuals in the school's diaries. They required data to understand the possibilities offered by the new weapon. Therefore, they started trials immediately, using the bombs fired during the inaugural show for the generals. Resources were scarce and every shell counted. The number of shots, range, and efficacy were duly recorded, showing an unsurprising number of duds, given the experimental

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[88] The source for the 2nd Army Trench Mortar School is at the National Archives, WO-95-398-2.

[89] *History of the Ministry of Munitions.*, vol. 11 (London: Her Majesty Stationery Office, 1922), 37.

[90] "WO-95-398/2 Second Army Trench Mortar School," April 1915, The National Archives, London, April 1915.

nature of the weapon. While on the battlefield duds were more of a nuisance than anything else, on the school's range the problem was much worse because it meant that someone had to locate the unexploded shells and set them off.

The new instructors also experimented with gun emplacement. The first design had all its key features retained thereafter, such as a separated bay for ammo and personnel. A recessed position protected the servicemen who fired the mortar in the unfortunately common event that the piece exploded due to misfire. The design, however, only reflected the actual emplacement and did not demonstrate how to connect it with the trench system, an important factor in the schematics published one year later in the official pamphlet, *SS 98/6*. Nevertheless, to have only experience testing the weapon on the training ground, despite its undoubtable usefulness, left them unable to understand how to deal with the enemy's response to the weapon.[91]

Indeed, the school itself had no experience in the trenches. Nothing about it appears in the diaries in the first month. Meanwhile, some officers went to trench rocket school and the Commanding Officer, Captain Keane, took two days off in Boulogne to buy an apparently fundamental "experimental pigeon trap." Surprisingly, while the school prepared, mortars were already in use on the frontline and there is a report of a mortar returned to the institution from the trenches because it was missing some parts. The school had a hybrid nature: it made demonstrations and trials (no classes yet at this

[91] The schematic of the first mortar emplacement is at page 07 of the WO-95-398-2; "S.S. 98/6 Artillery Notes: No. 6. - Trench Mortars," March 1917, Imperial War Museum.

time), but was also a logistical hub, connecting the batteries on the frontline to workshops for repair and ammo dumps for refilling.[92]

When the school's unit, the 20th Trench Battery, was finally ready, it took a long trip to the frontline. On April 27 and 28 1915, they were near Hill 60 to deal with a German *minenwerfer*. They were in a tough spot; they were constantly gassed and forced to retire each time they fired. Afterwards, they changed positions and tested a night bombardment. Then they moved again to fire on the redoubt near Spanbroekmolen.[93] They moved twice again to different positions on the line until they returned to the school, ending a two-week tour. During this time, the mortars were often separated and sent in different trenches, attending to specific problems. These could be a particularly pestering German mortar or the location where the enemy seemingly hid the "loopholes for the use of gas." For every attack, the units precisely recorded statistics, with particular attention to the number of unexploded projectiles.

The fact that the unit gathered the most basic knowledge at the front demonstrates the improvisational nature of the whole process of weapon development. Indeed, this series of tests on the frontline supplied vital new data that one would expect to have been already tested on some proving ground in England. For example, they discovered basic information like the "fuze for 1 ½ in is ineffective except between 250 and 320 i.e. for light bombs."[94]

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[92] "WO-95-398/2 Second Army Trench Mortar School", April-May 1915.
[93] The diary reports the name of the location as *Spanbruik mulin.* WO-95-398/2.
[94] "WO-95-398/2 Second Army Trench Mortar School", 7 May 1915.

In this first month the school fired a limited amount of shells, but by May they finally were in the hundreds. Home production had accelerated and the school established a good logistical connection with the dump at Strazeele, a few kilometers west of the school. At this point tests were organized multiple times a week and it became evident how questionable was the quality of the weapons. The men were not completely disheartened however because although the mortars were unprecise and unreliable, when they hit, they were devastating.

As the school's reputation grew, the connections to the top strengthened. On June 21, the Brigadier General William Thomas Furse, commander of the 9th Scottish division, arranged a test to see the effectiveness of daylight fireworks, used for signaling: "in order to judge their general effect in view of field experiments at later date." Furse, an artillery officer by training, kept an interest in such technicalities throughout his career. His knowledge on the matter of artillery ammunition and guns was a decisive factor in his promotion to Master-General of the Ordnance a few months after this test with the mortar school, at the end of 1915. His visit to the school was not a mere show of the firing of light signals. After the shootings, he went with the commander of the school to the workshop of the Second Army to talk with the officer in charge. The topic was the beds of the 2-inch mortars, which were "not strong and satisfactory." General Furse was famous for being "alive to the necessity of testing all new tactical appliances, and in his numerous conferences the principal motive was 'not fault-finding but fact-finding.'" Furse therefore seems to be one of the enablers that allowed communication between the bottom and the top of the army, an intermediary that connected practice on the frontline and tests in the schools to doctrine and standards.[95]

Staff officers continued to be one of the major customers of the school. They visited Berthen possibly to enjoy the fireworks, indeed shooting tests became a social entertainment of the brass. However, they went mainly for more serious business, such as reviewing important testing of fuses or new mortars. For example, in October the school organized an event for some officers to test a direct-action fuse —a percussion fuse, possibly in the hope of solving the issue of rounds bursting in the air before hitting the target. This was an issue that pestered mortar teams in the previous months. The test was a failure.[96]

On occasion they made grander plans. On November 22, the school received a French mortar, the De Breviare model. Two days later they shot several dummy rounds in front of the 6th Corps commander and some officers. At the beginning of December, they had a great trial in front of an experimental committee with a large number of staff officers. After testing the French gun, the committee examined how a direct-action fuse (it is unclear if it was the same model tested in October) behaved against wire entanglement. For this purpose, they used both the 1.5 and the 2-inch mortars. The test was a partial success because although the projectiles were erratically out of the line of fire, they demonstrated a good lateral burst. The direction of the blast was one of the most

[95] John Ewing, *The History of the 9th (Scottish) Division 1914-1919* (London: John Murray, 1921), 170-1.

[96] "WO-95-398/2 Second Army Trench Mortar School", 5 October 1915.

important factors in the effectiveness of a mortar shot, and therefore seemed like a good trade off.[97]

As it happened at the start of production of trench mortars, the school received new material well before the frontline troops. For example, on January 6, 1916 they tested the 1.5 silencer (Temple silencer) in front of the Major General of the Royal Artillery and Corps representatives. This appears to be very early in the development of this add-on for the 2-inch mortar, considering that the official history of the Ministry of Munition placed its development and distribution later in the spring.[98] This silencer was a muzzle flame reducer that tried to solve the worst problem of the 2-inch mortar: firing it made both a great sound and a long flame, a detail that was a major drawback at night. Despite the problems of heating and the complication of reducing the diameter of the barrel, this silencer was later produced, but only in a limited number.[99]

In the Fall of 1915, the school started to resemble more of a training ground than a testing facility. Tests were still carried out, even with more intensity if we consider the number of shells fired, but the school also started to organize four-day-long classes. The school taught groups of officers on the theory and use of the trench mortar. Additionally, the school's renown grew outside of the British Army and they even hosted events for French officers.

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[97] "WO-95-398/2 Second Army Trench Mortar School", December 3, 1915.
[98] *History of the Ministry of Munitions.*, 11:65.
[99] Saunders, *Reinventing Warfare 1914-18*, 2011, 138.

Keane, the commander, lectured in the Artillery School of the 2nd Army from the early days of the mortar school. As the social connections grew and the use of trench mortars became much more impactful on the frontline, he started to also teach at the Officer School, the NCO School, and the 1st Canadian Division Training School. His experience on the matter was recognized at the highest level. In February 1916, he participated in the meeting of the Trench Mortar committee of the Canadian Corps, then the school welcomed the visit of Kitchener and the Army Commander, General Herbert Charles Onslow Plumer. In March, Keane went to England to lecture on the Stokes mortar (the main interest of the school in the previous months) and organized public demonstrations with hundreds of shots fired each day.

The importance of the social connections and the horizontal movement of ideas inside the British Army cannot be overstated, with the Trench Mortar School as a good example. From the start, the institution lacked momentum and materiel, but with more tests, visits, and lectures given at the school, the more it is clear that, not differently from a London socialite, the school was building up a web of connections. On the one hand these links gave authority to the school itself -- it gained visibility. In addition, these connections kept its instructors well informed of what occurred outside their immediate horizon.

It was not solely that Keane was a commander engaged with the duties of his job, but also that the British Army favored these exchanges with meetings and conferences. In the final months of 1915 and early days of 1916, these exchanges multiplied and Keane traveled weekly to consult with staff officers, attend lectures on the lessons learned on the battlefields (like Loos in the Autumn of 1915), and participate in the conferences of school commanders at GHQ.

At the same time, schools promoted visits to other schools: for example the Royal Engineers School of Instruction, which trained officers for the command of field squadrons, required its students to visit the Heavy Bridging School, the Trench Mortar School, the Camouflage Factory and the Cement Factory. This tour was instructive and it also occupied the students during the break session when the reorganization of the school testing fields occurred.[100]

Socialization and tinkering coexisted as well. With almost the same weekly cadence, Keane visited the army workshop. The school not only tested new weapons and inventions coming from the other side of the channel, but also actively took part in the innovation process. One example is when the school attempted to find a way to increase the range of the 2-inch mortar. The 'toffee apple' was indeed a relatively successful design with high explosive power, but its range was limited. This was a serious problem that required the batteries to set up too close to the German lines and made it easier for the enemy to discover their positions. To find a solution, they tested how to fire the ammo for the 1.5-inch mortar with his bigger 2-inch brother. This was possible because of the projectile's design, which was a sphere of 9 inches of diameter screwed on top of a stick —hence the nickname 'toffee apple'. This tube was then slid into the bore and the whole projectile fired with a charge. It was possible to use the head of the smaller

[100] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:427–28.

projectile with the 2-inch tube. The smaller head made the whole projectile lighter and therefore increased the range. It seems however that this attempt was a failure because there is no mention of this solution in manuals and reports thereafter. However, it was this kind of tinkering and testing that created new ideas.

In 1916, just a few months after the start of the school, we can already see a well-integrated organization and its influence on its discipline. The school acquired ideas from the trenches while providing a venue for a more scientific approach. It became a repository of knowledge that hosted 'social' gatherings and test trials that provided expertise on the demand for other schools and the Ministry in London. The school's officers had three main tasks: to tinker with mortars and designs, to help building up good practices and doctrines, and to be travelling salesmen, spreading new ideas in throughout the army.

Each army had its own Trench Mortar School and many other schools organized and trained soldiers in the new disciplines of trench warfare, so we should imagine the events of the 2nd Army as a piece of a much bigger puzzle. The *SS 152 Instruction for the training of the British Armies in France*, printed in January 1918, demonstrates the complex situation at the end of the war. In England, the training schools instructed the higher ranks, but the bulk of the training schools were in France. There, the training institutions were divided into two main categories: GHQ schools, that grouped technical schools such as machine gun, anti-aircraft, Royal Engineers, and so forth; the second group was army schools and camps, which grouped the schools for general training. The Infantry and the Artillery schools had a prominent position and controlled specialized training programs: the Infantry had the Commanding Officers, the Scouting, Observation, and Sniping schools, while the Artillery had the Trench Mortar School. Independent from these two main schools were the Signal School, Anti-Gas School, and Musketry Camps. Corps had their own schools and camps for the training of NCOs and instruction and refresh courses for the officers. The light mortars batteries were trained in the Bombing and Light Mortar schools, at the level of the corps.

This complex structure for the instruction of the troops highlights how armies had to change and adapt to modern warfare. The 2nd Army Trench Mortar School was one of the first two to be formed. By May 1916, three more armies were created and three more schools. The school in Berthen therefore was only a cog in this great engine of change. By reading the official pamphlets on trench mortars of 1916 and 1918, we can see how the knowledge accumulated in France. The numerous designs of emplacement for example are in stark contrast with the first design appearing in the first pages of the school's war diary: they were deeper and safer, but most importantly integrated into the trench system, lessons learned on the battlefield. The diagrams of the mortar beds are not the result of theorical abstraction, but of a collaboration between different know-hows, a dialog that refined designs and found alternative options to practical problems.

Special Works Park.

As I described in Chapter 1, in the autumn of 1914 the French private Guirand de Scevola initiated his personal experimentation with camouflage and was eventually assigned to command a small department in Amiens to further develop his ideas. The results were so good that before the end of 1915, the French Army had three of these workshops.

At the end of December 1915, Scevola went with another French officer to the British GHQ in France to spread the gospel of camouflage. They described the matter in detail to General George Henry Fowke and General James Edward Edmond. Fowke spoke to Douglas Haig, recently appointed Commander-in-Chief. Haig was convinced of the value of the project and asked to begin testing camouflage in the British Army. The established artist Solomon J. Solomon was called from England to look into the question.[101] In early November, he organized a team to erect a fake tree observation post north of Ypres near the location called Burnt Farm. As a test, the plan was scheduled to be easy: the object was relatively small and the place was near a road, so there was no problem to move it to location. The tree was quite literally a piece of London because the entire metal structure had been welded and shipped from there. Moreover, in an excess of attention to details —or national pride— the exterior was made with real bark from a tree in King's Park at Windsor, a generous botanical contribution to the war effort from a truly British tree.[102] In the long run, the position of the tree was too conservatively

[101] Sir James E. Edmonds, "The Conception and Birth of Some of the R.R War Babies, 1914-18," *The Royal Engineers Journal* 58, no. 2 (December 1944): 227–28.
[102] Hartcup, *Camouflage*, 18.

chosen: it was too far away from the lines to be a useful spot for observation. Solomon, however, with the successful results of the test in hands, went back to London and suggested GHQ to look for volunteers in the army with particular attention to those trained in theatrical works and carpentry.

In February 1916, the army bought a small building in Wimereux to base this new operation in France and the unit was put under the command of Captain Wyatt of the Royal Engineers. It consisted of 6 officers and 100 men. The second in command, Captain Pages, went with 45 men to Amiens to learn from the French.[103] The unit diary starts rather pedantically: “Scope is construction of concealed observation posts designed to be indistinguishable at close range from surroundings and at same time allow complete protection to observe except from direct hit by HE shell or to cover trench guns, etc. that are to be concealed from observation by enemy by materials painted and treated in such a way to make them merge into natural surroundings.” The description sounds rather obvious to us, but the commander felt obligated to clarify the goals of his unit in detail. This introduction reminds us that camouflage was at the time a completely new and experimental affair.[104]

As in the case of the 2nd Army Trench Mortar School, from the start the workshop was occupied making connections. Solomon and Lt Russell, who were only attached to the unit and not official members, were free from the duties of learning in Amiens or organizing the workshop. They went on “reconnaissance” missions to army or

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[103] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:107–8; WO-95-120-3.

[104] WO-95-120-3, 17/3/1916.

division HQs. These trips were an exercise in public relations and self-promotion. Sometimes one of the seven French “camoufleurs” accompanied them in their errands. These French officers were the ones the ally’s school in Amiens offered as help in starting the British counterpart. They were artists like the cubist painter André Mare, and one can understand how helpful it would have been to have fellow artists such as Solomon to welcome them.

At the beginning the pace was rather slow and several days were spent waiting for machining tools and materials. Particularly problematic was the steel work, which was fundamental in making the frames of all the structures they needed to build. These fake trees had to be rigid enough to withstand the harsh conditions of the front line for a long time. Steel frames insured the necessary sturdiness, while wooden frames would have required frequent repair, a task that would have been difficult.

As soon as the workshops were organized, the officers began their industrious work, which was mostly to substitute trees with replicas. These mock-ups were hollow and contained ladders inside to allow a soldier to observe from a vantage point safe from enemy recognition. Making these camouflaged observation posts was not an easy task: after the request from the frontline, the Special Works Park (SWP) sent someone to recon the place to ensure that the project was feasible. If this was the case, he then had to take precise measurements and sketches of the tree. This was a dangerous job that often required the officer to crawl out of the trenches, sometimes even into no-man’s land, and make a colored sketch of the plant. This was the reason the SWP was looking for artists. Photographs were not very useful because they were in black and white. Additionally, cameras were not good enough to take pictures at dawn, which was the best time for these kinds of jobs; the early hours were the safest against the threat of enemy snipers.

It was impossible to make completely different models for every tree, because the workload of the workshops would have been unmanageable. A standardized metal structure, with a design laid out in March 1916, was therefore imported from England. The French had a similar idea: their design was heavier and sturdier, but these perks increased the difficulties of putting it in place on the frontline, the most delicate part of the whole project. Until the first English models arrived in France in July, the SWP had to use the French metal frames.[105]

Specialized men from the unit then formed parties and went to the frontline to erect these observation points in secrecy. On May 3, a team formed by two officers (one French), 2 NCOs, and ten men were dispatched to erect three trees near La Belle Alliance, a farm north of Ypres at the center of an important salient. They could not work during the day because they would have been perfect targets for the enemy, but also because they needed to keep the whole project secret, transforming trees in observation posts without the enemy noticing any difference. The first tree took only one night but they broke one saw because the plant was green and strong. They also had problems getting rid of the fallen tree, but they finished the work at 1:30 am, well before sunrise. The second and third trees took two nights of work each because of enemy gunfire. Trees were particularly effective because they allowed a higher point of observation, but were

[105] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:122–23.

also the most difficult to make. It seems, however, that the procedures were already streamlined, and a few days after a team set up a periscope tree and a trench observation post in a single night.

Fake-tree observation posts appear in many historical narratives. They also made headlines on the pages of illustrated magazines during the war. This is understandable, considering they are fascinating and somewhat extravagant.[106] Even more peculiar were periscopes, objects that would fit perfectly in a Bond movie.[107] They were telescopic like the ones in submarines, but hidden either in a fake tree or interred underground, allowing the observer to reconnoiter an area safely in a dugout well below the ground level. However, despite their interesting features, these observation posts were not a significant change on the frontline. Usually another position, one that did not require such effort, could be found instead. This is probably the reason that most of the British trees were placed north of Ypres, where the flatness of the land did not offer many advantageous points and the troops had to be inventive.

An additional problem for the workshops was that, on top of all the design and building complications, the projects were often handicapped by the ignorance of the unit that ordered them. These highly specialized structures required knowledge that was often oblivious to the common soldier. This was a catch-22 situation, in which the unit knew the ground but not the limitation of these structures, while the camoufleurs knew the

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[106] Andrea Siotto, "Image at War," *Vulcan* 4, no. 1 (August 1, 2016): 76–111, https://doi.org/10.1163/22134603-00401004.

[107] Indeed, in a famous movie scene, James Bond used a similar contraption to spy on a meeting in a Russian consulate. Terence Young, *From Russia with Love* (Eon Productions, 1963).

designs, but not the terrain and the necessities of the troops. These trees were sometimes placed observing non-essential strips of land or were made too thin, therefore not allowing for lengthy sessions of observation with maps to reference the notes taken in their surveillance.

More useful and surely more widespread were observation points hidden in the parapets: the SWP designed two kinds of models that could fit in the trenches. These types had all the features to make them successful, and moreover were armored, increasing the safety of the observers. The Oliver model was bulletproof in the front thanks to a sniper plate, which could be provided with or without shutter on the loophole; it was deep enough to allow an observer to use field glasses and was shrapnel-proof for its cover and sides. The Roland model was designed only for sentry duties: it was similar, but portable to allow it to move it into the trenches. A final model, the Beehive, was a portable chicken wire cover that was only large enough to host the head of the observer and was designed to be carried in the recently conquered trenches. Its limited use allowed for some camouflage without much preparation.[108] By the end of the war, the SWP produced 45 fake trees and 92 periscopes. The total production of parapet O.P. was 581 Roland models, 920 Oliver, and 1706 Beehive. The numbers are partially connected with the ease of production of the different models, but they also speak clearly about their success.[109]

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[108] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:122–26.
[109] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:149.

Throughout the war, the workshop had two main issues: the output that they could produce, which could never outgrow the increase in demand, and logistics, because there were 60 miles that separated the workshop from the frontline. One order of material to hide 24 guns in June 1916 required an entire day to complete, even though it only constituted painted canvas. The poor man on the job had to work fourteen hours straight to stitch the pieces together because he was the only one who knew how to use a sewing machine.[110] The distance from the action exceedingly complicated the helping and directing of the unit on the frontline in placing the observation points, because without considering the costs of transport, it impaired the work of the officers and men. For every commission, the officer in charge of the project had to make a long trip in the traffic-filled roads behind the lines to make reconnaissances and talk with the requesting unit. Additionally, any problem that could not be solved in situ required another 120-mile round-trip.

For these reasons, at the end of 1916 the whole establishment increased with the addition of two advanced workshops, one in Amiens (Southern Special Works Park) and one in Aire-sur-la-Lys (Northern). These workshops increased production and made trips to the frontline shorter, but did not solve all the problems. In May 1917, following the stress test of the battle of Arras, the commander of the Southern section explained the lesson learned. They realized that they needed to streamline the process of distribution of their products, in particular that they should have their own dumps at the rail stations, because it was impossible for the units at the frontline to fetch the material in Amiens.

[110] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:109.

Indeed, it was not feasible that the SWP would deliver them. In addition they needed more officers to manage the increasing orders and they had to maintain their car park in pristine conditions, which was difficult with the continual lack of parts and the month-long wait for the ordered pieces. Finally, the whole operation could not go on without the use of civilian labor.[111]

This was a trend that already started in Wimereux with the hiring of a hundred local French women in November 1916. In January, the new advanced workshop started to gear up and by the start of February, the Northern SWP consisted of 50 men and 280 women, while the Southern had 50 men and 190 women. The role of these French women was crucial: without them it would have been difficult to undertake any important job. Although they were unskilled labor working under the direction of the Royal Engineers officers, their contribution made possible the success of these workshops.[112]

One example clarifies the importance of women's participation in the work. At the beginning of April 1918, Amiens appeared in danger, considering the successes of the German Army. The British Army was retreating on most of the southern part of its sector and it seemed that Amiens was the goal of the German advance. The Southern SWP received orders to leave the town and Captain Houghton was exploring Abbeville to find a new place for the factory. This was a little town on the Somme river 20 miles northwest of Amiens. The problem was that Abbeville was already full of British troops retiring from the frontline and of French refugees fleeing from the Germans. Houghton was lucky

[111] WO-95-120-1. 30/4/17.
[112] WO-95-120-3. 1/2/17.

enough that the Commander of the Royal Engineers could offer him a hangar. Houghton initially discarded Abbeville and went up the river to St. Valerie sur Somme, an even smaller town on the Channel. However, the SWP commander, Lt. Col Wyatt, sent him back to Abbeville because although there was a nice place for a factory in St. Valerie sur Somme, it lacked the two fundamental characteristics to make it successful: "[the] difficulty is to find a situation on a railway and within reach of female labor," commented the commander. If there were no women, then there would be no camouflages.[113]

The experience of the rush withdrawal during the German offensive was nonetheless a positive learning opportunity. The SWP had been too centralized and inflexible, and the organization needed to change. For this reason, the commanding officer in May of 1918 sent a letter to the Engineer-in-Chief suggesting some substantial changes to their structure. The GHQ, each army, and each corps should have dedicated camouflage officers attached. Additionally, each army should have its own camouflage factory. These modifications would have allowed more resilience in the entire schema, giving as much autonomy as possible to each sector of the frontline. In 1918, camouflage was no longer an obscure and over-specialistic aspect of trench warfare, but a necessity of all the troops on the ground.[114]

The ability to interiorize the lesson of spring 1918 came from the previous two years of learning. The first change was the addition of education to the number of tasks of the SWP. Despite their nature as a workshop, the three departments built a strong bond

[113] "WO-95-120/3," March 1916, The National Archives, London April 6, 1918.
[114] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:111.

with the machine gun, Royal Engineers, and Artillery Schools. This was not a prerogative of the HQ at Wimereux, but a constant of all three workshops: for example, Chesney, the CO of the Southern SWP, was often invited to lecture at the 5th Army Artillery School.

With the multiplication of the workshops in 1916, Wimereux, which was partly freed from workload, also became the British Army's education center on camouflage in France. From August 1916 until the end of the war, more than 300 officers participated in a two-day workshop. The details of their education are fortunately available because a textbook was published by the Stationery Service.[115] This short booklet condensed concisely and clearly the main point of camouflage in 1916. It was divided into five parts. The first two were descriptive: an overview was followed by details on how to make observation posts. The last three parts described how to deal with the transport of the orders requested from the SWP, which details to include in the demand, and a section on suggestions. The last section's subtitle, "a few examples are given here to suggest possibilities and to promote new ideas," demonstrates once again how these institutions were crowdsourcing innovation, condensing the cumulative knowledge of the army, and at the same time stimulating change through the distribution of the knowledge. They understood that they needed to allow as many officers and men as possible to develop their own ideas on the field.

The first descriptive part of the booklet, titled "Concealment", offers an overview of the current knowledge on camouflaging, explaining what one can hide and what

[115] "S.S. 528 Notes on Camouflage: For Use of Officers Who Attend the Course," 1916, Imperial War Museum.

materials to use, along with some general theory and details on how to efficiently use colors to break the shape of the object to hide. This introduction is an important development in comparison with how camouflage was theorized the year before, because camouflage is no more a selected number of very special works, but a tool applied in general to any aspect that could be revealed to the enemy. Here we can see laid out the foundations of strategic camouflage. Indeed, while the observation posts and intricately-built periscope trees were made to confuse the eyes of an enemy close by, even when aided by optical magnification, in 1916 the techniques were used mostly to fool the airplane cameras that continually surveilled the frontline. The historical importance of this shift is clear when considering that fake trees and elaborate artistic renditions of observation points did not survive the war, while netting and color patterns are still in every emplacement of today's armies.

The trend is even more evident in the *SS 206 The Principles and Practice of Camouflage* of March 1918. The overview of the discipline grew both in pages and quality, adding sections on aerial photography, both as a means to reconnoiter the enemy position and as "protective photography," that is to constantly take pictures of your own lines to assess the visibility of your own defenses. The section not only described the materials and use of colors, but also the new attention to details that commanders on the field need to have well in mind if they wanted to hide the presence of their troops. Against the natural tendency for order in the army, commanders had to avoid tidy, geometrical lines for tents and batteries. Easily overlooked details became incredibly important: for example, commanders had to check the blast marks made by the artillery pieces on the ground in front of the guns (and cover them if present) and keep in mind the importance of breaking straight lines to blend in with the environment. They had to constantly keep in mind the unfamiliar perspective from the sky, by eliminating the shadows of the emplacements using gentle slopes instead of vertical surfaces. Even the section on the practice of camouflage, which still in 1916 focused mainly on the topic of the observation posts, in this manual shows techniques that are generally applicable to the entire depth of an army. The concealment of artillery is still the main focus, but bivouacs and camping, false works, spoils from dug-outs and mining, and the attention to covering the tracks on the ground to hide the presence of troops all enrich a much more nuanced and modern approach to camouflaging.

The expansion of knowledge in camouflaging and photographic interpretation were clear and linked at the end of the war. These two disciplines converged for the obvious reason that camoufleurs needed to understand the final effect of their work and interpreters needed to understand precisely how the enemy was trying to deceive them. In 1920, Solomon wrote an incredibly interesting treatise entitled *Strategic Camouflage*, in which he detailed with the help of numerous photographs what could be done to conceal troops, facilities, movements on road, batteries, and all the activities that the enemy wanted to know.[116]

The details in observation and the acumen reached at this point is impressive, particularly considering the very low resolution —by today's standards— of the

[116] J. Solomon Solomon, *Strategic Camouflage* (New York: E. P. Dutton and Co., 1920).

photographs they were using. The treasure of knowledge developed during the war by the British would be the foundation for the excellence of the Royal Air Force's photographic intelligence in the Second World War. Although Solomon's analysis is controversial at points and his conclusions on the extent of future utilization of strategic camouflage are somewhat overstated,[117] Solomon's work highlights the level and quality of analysis that photographic intelligence developed during the conflict in its continual game of cat and mouse with the enemy.

This move to a strategic use of camouflage is clear in the change of production of the Special Works Park. Until 1916, they were mainly making observation posts, but thereafter the concealment of batteries gradually took most of the effort.[118] Supplying fish nets and painted canvas, which were considerably simpler objects than the tree mock-ups, was however not a simplification of the production, but instead represented a surprisingly complex problem to solve. Not only was the vast production of the material hindered by the small scale of their factories, compounded by the constant logistic troubles that the workshop experienced throughout the war, but also the material that they used presented some inherent challenges.

One issue was about paint, which had to endure constant exposure to the elements and retain as much of its original color and texture as possible. Far from working with ideal materials and facilities, the main concern for the workshops was to reach a fast and economical production. New solutions were constantly tried and the unit's chemists did

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117 Hartcup, *Camouflage*, 30.
118 *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:121.

not abstain from any imaginative solution. For a while they even used animal blood as a medium for paint because a nearby factory could produce it in high quantity which surprisingly was a complete success. Hand painting was the simplest method but laborious. Dyeing was an appealing alternative, but the idea never stuck because the unit had no men with knowledge of this trade. Therefore, they never satisfactorily solved the problem that they had of printing green colors, which, needless to say, along with brown were the most important colors for camouflaging.[119]

The most problematic aspect of the workshops' production was the drying, not only because it required precious time for the oil in the paints to exsiccate, but also because the oil medium produced heat when drying, which was a danger for stacks of freshly painted canvasses. The British did not have any serious episode of auto combustion, but only because they learned of this danger from the French, who lost a train and an entire workshop in accidents related to these processes.[120]

Another issue the workshop had was how to fireproof the nets and canvases. Indeed, one of the most important tasks of these camouflages was the concealment of guns, which, when they shot, became a fire hazard. Considering the prolonged activities of the batteries on the frontline, their exposure to enemy counterfire, and the presence of explosives nearby, it was problematic to use canvas strips, oil paints, and flammable fibers to hide them. Therefore, a chemist transferred to the SWP from the Special Brigade —the one that took care of gas warfare — to study this and other chemical matters. He

[119] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:118.
[120] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:117.

found out that the use of water-glass (Sodium Silicate) would fireproof the surfaces, but it would also rot wood over time.[121]

Research and experience from the frontline were strongly intertwined: with the German retreat to the Hindenburg line of early 1917, the limitations of immoveable camouflages became suddenly evident. The need to move forward following the enemy to his new positions made it very difficult to transfer overly elaborated observation points. Even when this was possible, these structures were tailor-made for a specific location and therefore became obsolete. “All energies have been devoted to increasing the light and portable forms of camouflage,” reported Captain Chesney. These were nets, light frames to hide artillery and the portable O.P. models. This new experience of mobility made him reflect on the future of the discipline. He concluded that “undoubtedly this is the only practical and useful form in the end,” a new philosophy that would soon have important results.[122]

The SWP continued its mission to spread the gospel of camouflage in the British Army. In July 1917, Chesney wrote that “lately much greater efforts have been made to missionarise [sic] amongst the infantry.” They connected, for example, with the Canadian Corp Headquarters in Duisans on the outskirts of Arras, where they assembled a showground of their products. The idea was so profitable that the new Royal Engineers Training School in Rouen, which began in October, copied it, making a permanent

[121] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:116–20.

[122] “WO-95-45058/1 Northern and Southern Special Works Park,” n.d., The National Archives, London, March 17, 1917.

gallery of the products obtainable from the Special Works Parks, a showroom of the items of the unit.[123]

Their ideas became more influential as the new philosophy on mobile camouflage separated them ideologically from trench warfare. At the same time, the constant increase in the use of aircraft for air reconnaissance made camouflage more important behind the lines. In Autumn 1917, the camouflage officers were no longer the extravagant group of artists making fake trees, but strategic thinkers whose ideas had become fundamental to the final success on the battlefield. This was understood in the workshops: a new self-confidence emerges from the records of the Southern SWP when they describe their contribution to the battle of Cambrai. Chesney noted with pride that the work with the III Corps area had gone so well that the enemy's air reconnaissance could only have seen the tracks of the tanks, a problem that seriously worried him because "all other trouble and labour will be nullified if preparations are rendered obvious by these tank tracks."[124] The infantry had been mostly hidden in towns and woods, which had been filled with camouflaged tents placed in irregular order. In the towns, the presence of men was concealed using local material and brushwood. There were three battalions however that could not be billeted if not in the fields. To solve this problem, Chesney and his workshop designed a system to completely cover the area. Wires were put in tensions by A-frames above ground, holding wire rolls and camouflage firmly above the tents. Wood,

[123] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:367.
[124] "WO-95-4058/1 Northern and Southern Special Works Park," November 23, 1917.

presumably colored, was used to pave all the paths to hide traces of movement of the soldiers. Finally, they paid particular attention to conceal latrines and kitchens.

The experience obtained in preparing in grand secret the offensive of Cambrai surfaces very clearly at the end of the war in the British Army's final doctrine on camouflage. The pamphlet *SS 206* follows almost verbatim Captain Chesney's report on the matter of tents and bivouacs. This could be evidence that the author of this pamphlet was possibly from the workshops (if not Chesney himself). This appears even more probable if we consider that experts of the units had already been contacted to write about camouflage: Solomon remembered in his diary that when he was in France, he was asked to write a pamphlet on the topic.[125] Therefore, it seems reasonable that the SWP had been the main reference of GHQ and War Office on doctrinal matter on camouflage.

Chesney was very pleased with the work of the two officers attached to the III Corps, which supervised all the mis-en-place of the camouflages before the battle of Cambrai. One managed the logistical aspect, communicating with the SWP and distributing the material to the unit, while the other was attached to the Headquarters in quality of expert and toured the area with the car, checking the actual works and reporting the faulty ones. From the experience, Chesney calculated that in the future the SWP could only work with a maximum of two Corps with their current roster.[126] Fulfilling the enormous task had been possible only because the SWP had a three-week warning on the order. This consisted of 450,000 sq. yards of fish nets and wire from Amiens, plus 40,000

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[125] Olga Somech Phillips, *Solomon J. Solomon, A Memoir of Peace and War* (London: Herbert Joseph, 1933), 157.

[126] WO-95-120-3. 23/11/17.

special nets for tanks made at Wimereux. The operation went smoothly because the remainder of the frontline was calm and therefore the units not at Cambrai made fewer orders. Reconnaissance airplanes provided the camouflage officers with fresh photographs of the areas, which was probably one of the most important reasons for their success. However, they had problems entering the queue to obtain new photos. This was a problem because they needed to check the quality of the camouflage in specific areas. This experience suggested that in future operations a plane should be assigned exclusively for the use of the camouflage officers.[127]

From the early experiments of Scevola until the end of the war, camouflage steadily gained more and more importance. At the beginning, it was the result of the imagination of few artistic minds, then the craft of a selected group of engineers, and eventually a scientifically designed, mass produced and ubiquitous tool of modern warfare. The evolution of techniques highlights the key role of the Special Works Parks in transforming the discipline from a theatrical expedient to play hide and seek in the trenches to a powerful tool that allowed strategic surprise. We should not, however, fall into the temptation of giving to these British engineers complete paternity over this innovation, even if we put aside the fact that camouflage was an idea copied from the French and we focus only on its development by the British Army. The reality is that camouflage was the result of a system in which a constellation of factors and actors contributed together. The Special Works Parks responded to necessity, which is crucial in innovation, but these men were not the only actors. The ever-growing importance of air

[127] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:130.

reconnaissance and air photography influenced probably even more the kind of camouflages necessary in modern warfare, hence the scramble for the workshop to modify their products. At the same time, the education of the entire army that the camoufleurs were actively pursuing on one hand made their work and importance more visible, thereby opening the minds of the troops and of the generals to the possibilities of camouflage. Even the most basic knowledge among the troops inspired ideas that eventually changed the methods to obtain strategic surprise with important consequences for later warfare.

As soon as the troops on the ground were allowed to utilize the tools of modern warfare, the seeds were planted. The Special Work Parks planted these seeds, but it was the experience and the ideas of the soldiers on the battlefield that grew them. To support them the nation needed to provide the necessary funds and raw material. The education systems and the scientific —and artistic in this case— communities empowered the soldiers on the frontline to imagine the solutions. When this environment was present, it was only a matter of time before these factors allowed the birth and evolution of camouflage. The British and French took the opportunities offered to them by their ranks and institutions, and the Royal Engineers were fundamental in providing the British Army with these important and often overlooked centers of innovations.

The Battle over Billets: Nissen Huts

The stationary nature of the First World War obliged armies to cramp troops and logistical units in small areas of Northern France and Belgium. Millions of men lived for years in areas that even if not destroyed by the artillery, were not fully equipped for this occupation. The mobile warfare of the summer of 1914 did not require thinking about accommodations and the subsequent winter was occupied in learning trench warfare. However, with the preparations for the battle of the Somme in the winter of 1915-16, the question of where to accommodate Kitchener's army became more important. The discomforts of trench life hindered the morale of the troops when better accommodations for the soldiers in the rear line would have helped. The problem was that the type of accommodations owned by the Royal Engineers had the unpleasant characteristic of being cold.

Along came the Royal Engineer Peter Nissen to the rescue. He invented a sturdy structure that granted comfort to the troops both in winter and summer and thereafter named the Nissen hut. The characteristic semi-cylindrical shape of corrugated iron was so successful that it became a symbol of military installations even after the war and outside of the British Army.

The myth of the inventor who solves singlehandedly the problem of an army is strangely not commonly linked with this invention, perhaps because the hut did not have the appeal of a weapon or an innate elegance. However, the presence of Nissen huts was so widespread on the frontline at the end of the war, that its impact on the life of the soldiers can hardly be understated. The importance of the Nissen hut was not overlooked by experts either, and in 1917, while the war raged on the frontline, the RE officers that had been more or less involved in the project were fervently discussing the paternity of the idea. The Deputy Engineer-in-Chief William Andrew Liddell put an end to the discussion in May 1918, stating diplomatically that "the greatest share of credit ... is due to Major Nissen”. He made his point by not naming the other contributors and listing the core designs that made the hut so successful under Nissen’s name alone.[128]

The Royal Engineer’s habit to append the name of the designer to a standard model was a common practice as we can notice from the names of the standard Observation posts produced by the RE. The previous models of huts followed this naming pattern, which allows us to track the chain of inventors before 1914. The army did not arrive totally unprepared in France: knowing that the canvas bell tents would not suffice the needs of a modern army, Captain Bertie Harold Olivier Armstrong, a Royal Engineer at the War Office, was commissioned to produce a sturdier alternative.[129]

Armstrong devised a “demountable” hut, which was designed to be partially constructed in England and sent to France in pieces, ready to be assembled in place. They were not the easiest to manage, because the wooden substructures were ten feet long and not easy to erect, while the floor panels were too large and heavy. In the early months, they were often used as hospitals, but they were too small for this role.[130]

Another model, the Aylwin, had a triangular section and was covered with canvas. They were de-facto tents, but with a sturdier frame inside. In the summer and autumn of 1915, they did their job well, but they were not good enough for the winter. While the Armstrong model was sturdy enough to resist the harshness of the cold

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[128] Letter quoted in: F. W. J McCosh, *Nissen of the Huts: A Biography of Lt. Col. Peter Nissen DSO* (Bourne End: B D Publishing, 1997), 82.

[129] Karey Draper, “Armstrong Huts in the Great War (1914-1918),” in *Studies in the History of Services and Construction* (Cambridge: Construction History Society, 2018), 345–56.

[130] *Work of the Royal Engineers in the European War, 1914-19. Work under the Director of Works (France)*, vol. 8 (Chatham, Kent, 1924), 178–79.

weather, it did not provide enough insulation for comfort. These two models were not good enough for the western front and the problem of sheltering the soldiers remained unsolved. Two more models were released: the Tarrant from a private contractor and the Liddell from the same major who settled the discussion about who was the official designer of the Nissen Hut.

Seeing the number of models and the decent solutions they offered, the intervention of Nissen seems a minor improvement. Surely it was not the revolutionary idea that changed the world, as his biographer McCosh described. However, there are some factors that made this innovation important and recognized by experts and soldiers. Nissen was the Mr. Ikea of the First World War. He did not invent the hut as Kamprad did not invent the bookshelf, but Nissen invented a hut that had all the qualities necessary for the job, which was sorely needed with the enormous armies of modern warfare. The curved shape made it light and sturdy while also allowing for more space inside than the other huts. The other models were limited in width by the weight of the wooden frames for their roofs. To insulate the inside from the heat in the summer and the cold in the winter, the Nissen hut was made of two shells of corrugated iron, which also improved the impermeability of the roof. The corrugated iron was not screwed on the metal frame, but had some special (but inexpensive) joints: the builders needed only to slide the sheets into these joints without any special tool. In addition, like an Ikea bookshelf, the Nissen hut's parts were all interchangeable and required only a spanner to be mounted. A group of 6 unskilled men could build a Nissen hut in 4 hours. Watching the mounting of one of these huts in a video of 1917, it is easy to understand the quality and modernity of the design.[131] Finally, the hut used much less timber than its predecessors, saving the material for use in the trenches.

In theory, the Nissen huts had retractable beds on the sides of the room. The soldiers would then collapse these beds during the day to leave more space for other activities. However, as often happens in war, this was not always the case and frequently beds were only an optional luxury. Percy Webb was an NCO who served as a machine gunner with the 6th Battalion Dorsetshire Regiment on the western front. In 1917, his unit was sent to a rest area in Carnoy, south of Arras. “It was a very desolate place;” the area did not differ too much from the frontline, because shell craters and tree stumps were everywhere around it. His accommodation was “one of these Nissen huts” and in one of them 40 or 50 men would lie on the rough floor.[132] It was not a problem of the Nissen hut and the men knew that the alternative was not better. Indeed, the soldiers happily received them. As Rev. Grice noted cheerfully in his diary, “The men [are] in the usual miserable little shelters they have put up. There is, however, a Nissen hut coming to each battery.”[133]

Specially designed Nissen Hospital huts were larger to allow a better care for the patients. They often formed small hospital camps with multiple huts, such as the one in Etaples where Sergeant Stanley Lane landed for a couple of weeks after being hospitalized in Le Havre. It was a large area surrounded by barbed wire, where a

[131] “BUILDING A NISSEN HUT [Main Title],” Imperial War Museums, accessed July 19, 2019, http://www.iwm.org.uk/collections/item/object/1060022642.
[132] Webb, Percy (Oral history), IWM.
[133] *Artillery & Trench Mortar Memories: 32nd Division* (Uckfield, East Sussex; Woolwich: The Naval & Military Press Ltd.; Firepower, The Royal Artillery Museum, 2012), 284.

population of approximately a thousand soldiers from the entire Commonwealth tried to kill boredom with gambling. Nissen huts were a blessing for these field hospitals, considering the alternatives.[134]

There is another factor that we need to take into consideration when we analyze the importance of a comfortable accommodation: some jobs required solid places, which were a rarity on the frontline. When the Germans retired to the Hindenburg line, for example, the 4th Army moved forward to an area that did not have a place suitable for the H.Q. However, they had the opportunity to move shortly after the men because they could set up Nissen huts quickly and easily. I understand that the comfort of the brass does not inspire much pity, but staff officers were not the only ones to move in. Among them was the 4th Field Survey Battalion, a unit highly specialized for the creation and update of maps. They brought lithographers, photographers, and different models of printing machines. These delicate tools required an enclosed space to function properly.[135] Nissen huts thus also provided a place for highly technical support units.

The hut became a symbol of the rear line, a resource of war. In a picture painted by Adrian Hill in 1918, the artist illustrated the destruction of Nissen huts during the retreat in the spring. The image is quite powerful because it depicts the use of tanks to demolish the structures, metal monsters crushing the more pacific creatures of corrugated iron. This animal metaphor was an image that came naturally to mind. In an article published in the *Daily Mail* in February 1917, the journalist called them “immense

[134] Private Papers of S A A Lane, IWM.

[135] Lt. Col Macleod MC RE, “4th Field Survey Battalion,” accessed July 19, 2019, http://www.defencesurveyors.org.uk/Historical/WWI/WWI.htm.

creatures of the tortoise species," animals that appeared overnight on top of their beds. "And when such a pioneer found that the situation was good and the land habitable, it would pass the word, for by twos and threes, by tens and hundreds, its fellow monsters would appear, so that in a week or two you would find a valley covered with them that had been nothing but pulverized earth before."[136] A new colonization of land transformed the areas behind the trenches with new villages and cities in which you could get lost: "Olive and I walked round our old assembly positions of July 31st, now clustered with round-roofed Nissen huts, and traversed with elaborately drained roads. We could not recapture ourselves at all!" remembered Edmund Blunden in *Undertones of War*.[137] The scene of the tanks crushing one of these army villages illustrated well how, with the retreat, war reached areas that until that time were a buffer zone between peace and the horror of the trenches. The Nissen hut after 1916 had become the symbol of these areas, where soldiers could take respite and reintroduce themselves gradually to a more civilized way of living.

The example of Nissen shows how the Royal Engineers, as the technical Corps of the British Army, represented a resource of innovation. Many of the problems of the First World War required a practical solution. The culture of invention among the engineers, who expressed a pride that the officers could barely hide, as we have seen with the polemics about the paternity of the Nissen hut, enabled the British Army to promote innovation in its ranks. Social status was an important factor among officers, and

[136] Article quoted in: McCosh, *Nissen of the Huts*, 100–101.
[137] Edmund Blunden, *Undertones of War* (New York: Doubleday, Doran & Co., 1929), 266.

according to his biographer, Nissen, who was not a career officer, suffered because of it. His career and the official record, however, tell a different story. The fact that he was Canadian, not a career officer, and even that he was somewhat old at the start of the war never overshadowed the fact that his design was a success in the eyes of the army. On the contrary, even those of highest ranks showed admiration for his "most ingenious mind," as Sir James Edmonds, the editor of the official History of the Great War, described Nissen in a 1944 article.[138]

Although the stiff characters of the military men apparently annoyed the civilian inventor, we must acknowledge the entrepreneurial spirit of the Engineers Corps, which actively pursued fertile minds and ideas even outside the ranks of career officers. Examples of this mindset can be easily found beyond the billeting problem, such as in the evolution of mine warfare, where civilian mining engineers like Captain Stanley Hunter contributed significantly to the development of new techniques and tools.[139]

Sound Ranging

Another famous, although not famous enough, example of how the Royal Engineers impacted innovation during the war is sound ranging. This is the technique used to find the position of an enemy battery by analyzing the time difference of sound recorded in different places. As often happened during the Great War, the French Army was the first to introduce the new technique. The Germans, whose reputation for scientific prowess one expects would have put them on the forefront in the matter, did not

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[138] Edmonds, "The Conception and Birth of Some of the R.R War Babies, 1914-18," 228.
[139] Fox-Godden, *Learning to Fight*, 81.

notably develop their system.[140] Indeed, for years they did not need it because their observers had the higher ground and could easily spot the firing batteries. At the end of the war, the Germans did not have enough time to catch up when the refinement of the British and French sound ranging allowed them to fire completely blind and mute the German batteries without any warning. [141]

While the technique of indirect shooting, which is to fire without direct line of sight with the target, was not a novelty, this type of firing became dominant during the First World War. In the French Army for example, before the war it was common to find a specific bravado on direct fire in the batteries. Artillerymen prided themselves on remaining near the fight, and in the annual maneuvers they wanted to demonstrate their courage by looking for artillery duels in a spirit that was more apt for Napoleonic warfare than a modern one. The accuracy, rate of fire, and range of modern cannons brought by new metal alloys, precision metalworking, recoil mechanisms, and new explosives completely changed the possibilities offered by artillery. Some in the army understood this change, and realized that the role of the artillery in battle would be to assist the infantry from a distance and not to inflate their egos on the frontline, but it was a tough

[140] The German Army at the end of the war was still using only tools that enhanced the earing of observers and was very crude. Bragg thought that "they were committed too early to a simpler but ineffective system, and it was too late to change it when ranges increased and greater accuracy was essential." Sir Lawrence Bragg, A. H. Dowson, and H. H. Hemming, *Artillery Survey in the First World War* (London: Field Survey Association, 1971).

[141] Martina Schiavon, "Phonotelemetry: Sound-Ranging Techniques in World War I," *Lettera Matematica*, April 14, 2015, 1–15, https://doi.org/10.1007/s40329-015-0077-1; John Jenkin, "The Braggs, X-Ray Crystallography, and Lawrence Bragg's Sound-Ranging in World War I," *Interdisciplinary Science Reviews* 40, no. 3 (September 1, 2015): 222–43, https://doi.org/10.1179/0308018815Z.000000000115; Daniel J. Kevles, "Flash and Sound in the AEF: The History of a Technical Service," *Military Affairs* 33, no. 3 (1969): 374–84, https://doi.org/10.2307/1985116; E. Lancaster Jones, "Sound-Ranging," *Proceedings of the Musical Association* 48 (1921): 77–89; W. Hope-Jones, "Sound-Ranging," *The Mathematical Gazette* 14, no. 195 (1928): 173–86, https://doi.org/10.2307/3603791.

medicine to swallow for a Corps that already suffered from an inferiority complex.[142] However, with the development of trench warfare during the Great War, artillery became increasingly important, enlarging its ranks and dominating the battleground to the point that it was crowned queen of the battlefield.

The lesson artillerymen had to learn was to be at a safe distance from the frontline and fire under the direction of observers. With the increase in the importance of the artillery came the realization that one of the most crucial roles during battle was to silence the enemy's batteries. In a way this closed the circle, allowing the artillerymen to finally engage in artillery duels. However, these were no more the gallant brawls between batteries in each other's sight, but a less glamorous but technical game of hide and seek. The batteries had to hide from the enemy, while observers from airplanes, balloons, or on the frontline would find the enemy guns for them. The artillery then registered the position of their targets with few, non-consecutive shots as to not reveal their intentions to the enemy. This left the KO punch for the right moment. Eventually the artillerymen got rid even of the registration shots, utilizing only mathematics to determine their angle of firing and the amount of charges to use.

We therefore need to look at sound ranging as a technique that evolved throughout the war, developing in the process a much more theorical approach to firing. Sound ranging offered two appealing qualities: it did not need dangerous observations from airplanes or balloons and there was no camouflage for sound. Therefore, the

[142] Goya, *La chair et l'acier*, 82–92.

enemy's batteries, which had become incredibly sophisticated in hiding themselves from the observer's glasses, could not hide from sound ranging while they were shooting.

The idea of sound ranging came, as one might expect, from a scientific mind. A French astronomer of the Paris Observatory, Charles Nordmann, was serving as an NCO artilleryman on the frontline. He explained to his CO that he considered it possible to understand the enemy's batteries location by giving three men three carefully synchronized stopwatches, placing them in three different positions, and comparing the differences in time when the sound of the shooting reached them. His officer found the idea interesting and allowed for a test. The results of this unrefined test were good enough to warrant more research, so his CO authorized him to go to Paris to investigate the matter. When he arrived in the capital in the middle of October 1914, Nordmann leveraged his academic connections to find someone with experience in microphones. He found a good possibility in the person of Lucien Bull, a British scholar who taught at the Marey Institute and researched methods of recording heartbeats with an Einthoven string galvanometer. This instrument was the first electrocardiograph and could record the faintest change in electric current. Therefore, it could register the change in voltage from far away microphones. An instrument made to save lives became a weapon.[143]

However, the tool was set up with a single string and was able to connect only to a single microphone. Bull enlisted his "clever mechanic," G. Kelsen, "without whose remarkable skill I don't know if we could have ever completed so well, and certainly

[143] *Report on the Survey of the Western Front 1914-1918* (London, 1920), 109; Sir Lawrence Bragg, A. H. Dowson, and H. H. Hemming, *Artillery Survey in the First World War*, 33–34.

never so rapidly, our instrumentation." Kelsen added two more strings to the machine, enabling the recording of the sound coming from three locations a kilometer apart from the base. Equipped with the new tools, Nordmann and Bull organized a trial in front of three French generals. They fired a gun on the other side of the river Seine, in the park of St. Cloud, four kilometers away from the institute. After some computing they could pinpoint the position of the gun with an error of only twenty meters for the direction and forty for the range. After the success, the French Army authorized more research. Nordmann tested a semi-manual system, training men to tap a key when they heard a gun shooting. The signal was then recorded on a smoked cylinder. In the meantime, his assistant Bouquet, an electrician, tested a system that used microphones instead but connected to the same recording mechanism. Bull spent the next couple of months making a portable set capable of recording five (later six) microphones on a single 35mm film. After some testing, the instrument reached the frontline on January 6, 1915, in Tracy le Mont, a small village northeast of Compiègne managed by the 8th Section du Génie under the command of Lt. Taris de Ferre.[144]

At the same time, another French officer, Captain Bougier of the French Engineers, set up a section near Arras working on the same concept with men trained with stop-watches. It is unclear if Nordmann and Bougier had any contact while working in parallel on the same idea, but it appears that the two were working independently. This is another clear example of a community of thinkers developing similar techniques at the

[144] Sir Lawrence Bragg, A. H. Dowson, and H. H. Hemming, *Artillery Survey in the First World War*, 33–34; *Report on the Survey of the Western Front 1914-1918*, 110.

same time.[145] Bougier was clearly intellectually interested in the opportunities offered by recording sound on the battlefield. He later developed a fascinating contraption that allowed the operator to precisely detect the direction from which the sound of an aircraft was coming.[146]

After some tests it appeared clear that the microphones used were not suited to the task. Indeed, the French units were using carbon granule microphones, which were good for recording voices and in general high pitch sounds, but lacked the sensitivity necessary to register the low frequency vibrations coming from far away artillery. Therefore, the recordings showed clearly the French guns and the explosions of the enemy shells on the French frontlines, but not the real goal, the German batteries. In addition, the unit that tested the Bull apparatus discovered the Achilles' heel of the whole concept of sound ranging: with adverse wind the recordings became extremely difficult.

In the autumn of 1915, Colonel Ewan Maclean Jack of the Maps Section of GHQ recalled Lawrence Bragg from his unit. Jack ordered him to find a fellow officer with scientific competence and go to Paris, acquire a Bull system, and start testing the new technique. A Nobel laureate for the development of crystallography, during the war Bragg was in the Royal Horse Artillery and then moved to the Royal Engineers. Having both technical competence and training in artillery, Bragg was the perfect candidate for

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145 *Report on the Survey of the Western Front 1914-1918*, 110.

146 Captain Aaron Bradshaw, "Recent Development in Antiaircraft Materel," *The Coast Artillery Journal* 58, no. 5 (May 1923): 454.

the job. As his aide, Bragg chose H. Robinson, a fellow scientist enlisted in the artillery who afterwards became a Professor of Physics at the London University.[147]

Bragg then went to the frontline with Robinson to train with a French officer. The choice of the training location was not lucky: they went to Vosges, where the frontline was so calm, that the nearby French battery used its guns as hangers to dry laundry. However, when they had a decent understanding of the system, Bragg went to Paris to obtain the apparatus, while Robinson went back to organize an experimental unit in the village of La Clytte, south of Ypres. Once the equipment arrived, the two officers and their eight soldiers started the first sound-ranging operations of the British Army. In the spring of 1916, the British Army formed seven new sections and had some successes, especially in locating the enemy's howitzer. The projectiles shot from this kind of artillery were sub-sonic and did not produce the explosion that comes from surpassing the speed of sound, allowing for an easier recording of the noises from the batteries.

The rudimentary techniques developed by the French in 1915 and tested afterwards by the British Sound Ranging Sections were interesting and somewhat useful, but they required refinement to filter out the consistent noise of the battlefield. Allied guns and a continual drumming of shell explosions crowded the recordings and made it extremely difficult to detect the correct noises and filter out the rest. Lawrence Bragg and his team were the ones to find the solution. The answer to the problem appeared as they commonly do to thinkers: when they are not thinking about it. It did not happen in the

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147 Sir Lawrence Bragg, A. H. Dowson, and H. H. Hemming, *Artillery Survey in the First World War*, 34.

shower, cold and infrequent on the battlefield, but it happened in the loo. Bragg noticed how the small shed filtered out the noise of the explosions, but when an artillery gun fired, even from a distance, the whole structure vibrated. Later, during winter, the second inspiration came from their shabby shelter. Every time a battery fired they could not hear the distant explosion because the other noises covered it; however, they could feel the unpleasant cold streams of air flowing from the numerous holes in the tarred paper that made the walls of their hut. The idea for an instrument that measured the flow of air through a hole came to Corporal Tucker, a new acquisition of the unit. Tucker came from the Physics Department of the Imperial College and his previous studies on the electrical properties of platinum wires came in use. He decided to record the flow of air by measuring the cooling of one wire placed across a hole drilled in a wooden munitions box. The cooling of the wire changed its electrical resistance, and this variation could be easily measured.

> I remember vividly the night we rigged it up. A German field battery obligingly fired towards us, and when the film was developed there was a small sharp 'break' for the shell wave, followed by a quite characteristic and definite large break made by the gun report…it was a wonderful moment, the answer to prayer. It converted sound-ranging from a very doubtful proposition to a powerful practical method.[148]

With this new 'microphone' the sound ranging units not only could easily discard all the background noises such as machine gun and rifle fire, traffic, and the sound waves coming from the projectiles flying at high speed in the sky above them, but they could precisely understand the caliber of the shooting artillery pieces, the number of guns in the

[148] Sir Lawrence Bragg, A. H. Dowson, and H. H. Hemming, 36.

battery, and the target they were registering with their fire. The results were impressive. In a pamphlet distributed in 1917 to all the batteries, the British Army advertised the power of sound ranging: it could “fix the position of an hostile gun within 50 yards,”[149] reveal its caliber and its target, indicate which hostile batteries were firing, and help the British batteries to precisely find where their shells were landing and therefore help considerably their accuracy.[150]

The development of such a complex technique involved several different areas of expertise. In addition to physicists such as Bragg, Robinson, and Tucker, sound ranging also required the knowledge of the atmospheric data of the sky over the battlefield. At the beginning, it seemed like a relatively easy problem to tackle and the units carried basic instruments to measure the atmospheric pressure and wind velocity. The importance of this data on how a sound ranging unit could precisely locate an enemy battery suggested the need for a more scientific approach on testing. At the end of 1916, an experimental section was created in Salisbury Plain. From the collected data it was clear that the army had to establish Wind Sections on the frontline, one for each army. These operated in quite a clever way, because they did not simply take local meteorological measurements, but calculated directly from a practical experiment. Three semi-circles of microphones were placed at five, seven, and nine thousand yards from an explosive charge, which was ignited to measure the speed of sound at ground level. The results were then compared with the data collected by the Meteorological Field Service (commonly known as Meteor

[149] SS 552 Sound Ranging, March 1917.

[150] “S.S. 199 Co-Operation of Sound Ranging Sections and Observation Groups with Artillery (Provisional),” November 1917, Imperial War Museum; “S.S. 199/1 Ranging with Observation by the Field Survey Company,” May 1918, Imperial War Museum.

RE) unit of the local army. The problem of these Wind Sections was that they each occupied an area of 35 square miles and needed 48 thousand yards of air lines, the lines in which the cable hangs on poles. Therefore, they required a long time to set up and were practically immoveable. However, by 1918, when this characteristic became a problem, the army had already collected enough scientific data that the sound ranging units could reliably estimate the corrections based on a set of rules.[151]

Another problem that required a different expertise was the storing of the sound recordings. The data was useful only if the signals from the microphones could be traced on a plot, allowing a detailed analysis. The best solution would have been to have a pen plot similar to the ones used to register earthquakes, but it was difficult to switch from an optical recording to a mechanical one. Indeed, throughout the war these recordings were stored on film. However, developing the film slowed down the entire process and in a busy day could seriously impede the work of the units. The solution was to have an automatic developing apparatus and the first design was French, from M Dufour. It was far from perfect and the British workshops attached to the units made modifications but could never obtain a great result. The units then switched to bromide paper, which made the process faster and cheaper. The suggestion came from Captain Field, commander of the Printing Company, a unit at GHQ.[152]

Part of the success of the sound-ranging endeavor was the creation of a community of tinkerers. Each section had a mechanic with a small workshop that

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[151] *Report on the Survey of the Western Front 1914-1918*, 114.

[152] *Report on the Survey of the Western Front 1914-1918*, 118; Sir Lawrence Bragg, A. H. Dowson, and H. H. Hemming, *Artillery Survey in the First World War*, 38.

included a lathe, precision tools, and building materials. This arrangement allowed the individual units to test new ideas and fix problems. Every other month, each section sent an expert to a central conference, where all these men could discuss their ideas and share their achievements. At the end of the conference a high dosage of alcohol reinforced the camaraderie and *esprit de corps*. Bragg remember how important these meetings were:

> If the experiments had been done in England with (a) the inevitable lessening of a sense of urgency, (b) less touch with the actual problems, and (c) delay in communicating and testing ideas, sound-ranging would have taken two or three times as long to develop.[153]

We can see how the whole development was successful thanks to the specific knowledge of a number of experts coming from diverse units and different trades. One factor however was fundamental: they solved specific problems either with contact and knowledge of the daily experiences on the frontline or with direct experience from the field. When this connection was missing, the results were often negative. For example, the army hired the Cambridge Scientific Instrument Company to produce and improve the necessary instruments for sound ranging. Bull visited from Paris and brought with him the drawings. The instrument maker company then decided to reinforce the sensors' containers making them in metal instead of wood. This was a fundamental mistake, because the metal box resonated and flattened the specific character of the recorded sound, making it exceedingly difficult to deduce the caliber and kind of gun in the enemy batteries.

[153] Sir Lawrence Bragg, A. H. Dowson, and H. H. Hemming, *Artillery Survey in the First World War*, 38.

The problem of mobility for sound ranging units became clear with the experience on the battlefield and was solved in a practical way on the frontline. In 1917, the battles of Arras and Messines were stress tests for the sound ranging units and highlighted a number of technical and organizational problems that made operations slow and cumbersome. It was clear that air lines took too much time to be placed, that the units should rely on themselves for the *mise en place* of their material, not expecting the Signal Corps to arrange everything, and that the units needed a serious training not only for the acquisition of the data, but also for an organized and fast deployment of the sound-ranging instruments.

Addressing these problems required a significant effort. They had to test new and more resilient ground cables that the units could simply lay on the fields and solve the problem of the increase of electric resistance due to this kind of cables. The organization of the unit had to be overhauled, putting a greater emphasis on expert builders and the logistical side of the operations. They also had to change the instruction of the units, using field exercises to train the men on fast deployments. All these improvements, done with the intent of adapting better to trench warfare, became fundamental in the successes of the units in the more mobile warfare of 1918.

Sound ranging —and the importance of artillery in general— added a purely mathematical dimension to the battlefield that was almost unknown before. Surely the knowledge of math had already been foundational in the education of technical corps such as artillery and engineers, but previously, in the heat of battle, everything had been much more empirical. Instead, sound ranging allowed for the elimination of the visual component of observation by analyzing the battlefield merely on scientific measurements and mathematical interpretation of data.

This scientific approach to the problem of counter-battery was incredibly successful and the men of the sound ranging sections were rightly proud of their contribution to the war. In the summer of 1917, Maps GHQ distributed a message to all the Field Survey companies that summarized well how effective this new weapon system was. The message was an extract from a German Order captured by the army:

> In consequence of the excellent sound-ranging of the English, I forbid any battery to fire alone when the whole section is quiet, especially in east wind. Should there be occasion to fire, the adjoining battery must always be called on, either directly or through the Group, to fire a few rounds.[154]

Bragg and his men were very pleased to read the message, not only because it represented a badge of honor, a welcome certification of their successes, but also because the Germans were so behind with their sound ranging technology that they were not able to grasp the level of accuracy of the British sound ranging apparatus. “We could record almost any number of guns firing at once, the more the merrier,” proudly remembered Bragg.

Conclusions

The examples of the 2nd Trench Mortar School, of the Royal Engineers’ Special Works Park, the development of the Nissen hut, and sound ranging show a dynamic community of change in the British Army. The solicitous endorsement of the top officers

[154] Sir Lawrence Bragg, A. H. Dowson, and H. H. Hemming, 38.

such as Haig and his desire for a British camouflage section should warn us against a shallow analysis of the static nature of the First World War. The immobility of the frontline was not the result of a disconnection between the strategists and the experience of the soldiers in the trenches. The War Office and the GHQ in France in particular did not hinder innovation, but allowed the creation of research institutions and cooperation that continually produced new weapons, doctrines, and tools. These institutions remained well connected to the reality of trench warfare because their main task was to provide services for the troops on the frontline. While the soldiers in the trenches experienced to their misfortune the worst side of a continual trial and error, behind them the experts were constantly and frantically attempting to find solutions to problems and imagining new plans for the future.

Institutions like the schools and the Royal Engineers persistently explored new ideas. Although they faced serious limits in logistics and funds, most of the time they were free to conduct their own investigatory mission. Their nature as experts, the constant horizontal conversation they had with the frontline, sister schools, headquarters, the War Office, and GHQ France made them the connector links of worlds that often spoke in different languages regarding technological innovation.

While oftentimes the practicality of their projects made their creations only of limited influence on the general course of the war, the cases that I discussed demonstrate that their contribution was substantial. The mortar schools continually tested a weapon that had a strong influence on the creation of a more independent infantry by providing a support weapon that was light and effective. The schools developed a doctrine collecting and refining the experience on the battlefield, while also supporting it with a scientific investigation of the possibilities and limits of the weapon. The Nissen hut allowed a cheap, fast, and light design for giving respite from the harsh and uncivilized environment of the trenches, allowing the soldiers to recover faster and promoting morale. Sound ranging became one of the most powerful weapons to silence enemy artillery and a strong contributor to the final victory on the western front. Finally, the Special Works Park developed the concept of camouflage for the British Army. While the French invented it, a successful understanding of camouflage in the British Army without an internal research and production facility would have been difficult. The Special Works Park provided a place where the army could develop the concept of strategic camouflage, which had an important impact not only in the second half of the war, but in the remainder of the century.

All four examples alone can hardly be defined as revolutionary, but this is a statement that generally fits the evolution of warfare during the Great War, particularly on the western front. To accept that there were no single inventions or innovations that changed the course of the war —as illustrated by the prolonged stalemate— is the first step in understanding that the incredible revolution in warfare from 1914 and 1918 was the result of numerous changes that together transformed the armies. The most successful armies possessed a widespread, open-minded culture of innovation. Institutions such as the schools and the Royal Engineers laid the foundations for such a mentality.

CHAPTER 4. A WIDER WORLD OF INFLUENCERS: UNOFFICIAL LOBBYING FOR CHANGE

Official army institutions were not responsible for all the innovation that took place during the war. Soldiers and civilians with no official role also had an interest in ameliorating the situation in which they were living. Technology is made with the intent of solving problems; soldiers and civilians tinkering with tools and weapons was a natural consequence of the challenges they encountered. In this chapter I will analyze the mindset of inventors and the problems they confronted. I will then give some examples, ranging from the most idiotic to the most effective solutions. Surely this is not an exhaustive collection, considering the mass of innovations throughout the war, but I chose examples on a wide variety of topics with the intent of showing a glimpse of the complex world of interaction between inventors and the war. In this chapter, I use a variety of examples from different nations. While this more comparative approach veers from the focus on the British Army that I adopted in the rest of this study, it offers some advantages. Looking at other nations puts the experience of the British soldier in perspective, because Tommies were not exceptional, nor did they have a completely unique experience of war. Moreover, enlarging the pool of examples helps to highlight the key factors in the success or failure of ideas. As we will see, comparing different approaches to the same designs is sometimes the only way to find how details easy to overlook helped or hindered the development of technology.

The Great War monopolized the energies of many, both in the trenches and at home. Workers put countless hours into producing goods for the war effort; the government rationed food; and newspapers and journals eagerly reported the events on the frontline and described trench warfare in detail for readers keen to learn not only what happened, but also how it happened. Of course, the most involved were the many soldiers who put their lives at stake on the frontline—willingly or not. The problem of the stalemate was clear to most of them: one only needed to see on a map the appalling results of the costly offensives; many lives were sacrificed to conquer small amounts of terrain. This problem, along with the many issues that the troops were having in the trenches, inspired many to tinker on solutions. Many of these solutions were ridiculous, often detached from reality. This happened in particular with the ideas of the armchair generals at home, who sometimes decided that their odd designs were worthy of a letter to a journal, a magazine, or even to the government. These entrepreneurial civilians did not have the monopoly on bad ideas and generals and soldiers had their share. At the same time, some individuals were highly influential in pushing forward innovation.

The fact that civilians and businesses continually used their suggestions and patents to sometimes successfully poke through the barrier that divided the military from the rest of the society indicates that, despite its autonomy, the military did not exist in a completely sealed bubble. Instead, the army maintained a conversation with the rest of the society. Sometimes this meant enlisting scientists, engineers, and other skilled experts, giving them positions in schools and research facilities, like the case of the artists and engineers that formed the Special Works Parks or the miners and experts that developed the schools of mining and tunneling. Other times it meant relaxing the standards in ordnance, as in the case of the rich market for personalized military items, an example that we will see later in this chapter.

Why does this interaction between the military and independent inventors matter? The answer is two-fold. First, we need to observe the process of innovation in its entirety, avoiding the mistake of considering only the ideas coming from the military as worthy of investigation. If we accept the highly problematic yet very useful concept of total war in the analysis of the First World War, then we should also have a more holistic approach for the development of technology. Second, the examples that I will discuss describe well the concept of innovation from the bottom, because the inventors, lacking an institutional connection with the decision-makers, often had to go against the grain of the bureaucracy of the armies. Despite their lack of connections, some of the inventions that originated outside of the military world were highly influential. The mechanism that allowed for shooting through the propeller of an airplane, steel helmets, trench mortars, and wristwatches all had strong impacts on the Great War and on the following conflicts of the twentieth century, while trench knives became part of the standard equipment of modern armies.[155]

[155] Despite the general interest of the military historian, specific research on the development of weapons is sparse. Some scholars investigated the complex dynamics between technology and institutions: Elizabeth Greenhalgh, "Technology Development in Coalition: The Case of the First World War Tank," *The International History Review* 22, no. 4 (2000): 806–836; Mark Pattison, "Scientists, Inventors and the Military in Britain, 1915–1919: The Munitions Inventions Department," *Social Studies of Science* 12, no. 4 (1983): 521–568; D.M. Leeson, "The British Army's Percussion Hand Grenades, 1914–16," *First World War Studies* 1, no. 2 (October 2010): 81–102, https://doi.org/10.1080/19475020.2010.517411. For a general introduction to the scientific development of technology during the WWI: Guy Hartcup, *The War of Invention: Scientific Developments, 1914-18*, 1st ed (London; Washington: Brassey's Defence Publishers, 1988); The only historian who focused on the technology in the trenches is Saunders: Saunders, *Weapons of*

Before starting to see these examples, we should take some time to analyze the social and even psychological aspects of this topic. This collective participation with ideas for the war effort offers a good opportunity to understand how societies deal with technology and innovation. The ancient Greeks understood that complex societies developed around new technological abilities and knowledge. To explain this, they used the myth of Prometheus, the titan who stole the secret of fire and gave it to humanity, allowing them to master matter and energy and giving them the power to create civilization. For the Greeks, fire was the perfect symbol of the invention that changes everything, the one that appears on earth and transforms men from animals into dominators of nature. Unlike the ancient Greeks, we now understand that inventions are never an instant success. Even the light bulb needed a system around it before it could shine the era of electricity across the globe. To have light we needed power grids, a consumer market, and power plants. But the myth of Prometheus, like the old titan himself, is hard to kill.

The legend of the game-changing technology is even harder to dismantle in military matters, where the continual research on weapons is a natural expression of the desire to obtain the item that will win the war. This is still a problem: some people think that the answer to the failures of today's asymmetrical warfare is a new bomb or the most modern, stealth, and expensive aircraft. War is carried out with tools, and therefore the obsession with new weapons is natural — and not completely wrong. However, to think

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the Trench War, 1914-1918; Saunders, *Dominating the Enemy*; Saunders, *Reinventing Warfare 1914-18*, 2011.

that a new weapon would immediately change the course of the war is to make the same mistake that was repeated again and again during the First World War. Chemical weapons, airplanes, and tanks all captured the attention of generals and the public, but despite their clear importance and influence over the battlefield, they never singlehandedly broke the balance of the war, demonstrating the inaccuracy of the myth of a single super-solution.

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The myth of Prometheus has also trapped many historians, even of great fame and competence. The dyad cutting-edge technology/modernization is too much of a temptation. Tim Travers, for example, used his analysis on the importance of the tank to win the war to highlight the incompetence of Haig.[156] Not only is it an unfair evaluation, condemning the general from the easy pedestal of hindsight, but it is also a distorted perspective that leaves many questions unanswered. If a modern doctrine and the use of tanks meant certain victory, how did the German Army in the spring of 1918 almost obtain the long-coveted breakthrough without the use of tanks? Conversely, how did the British offensive in Cambrai stop short despite the impressive number of tanks deployed? We cannot underestimate the importance of technology and its impact on warfare. Weapons are indeed a crucial part of the system and innovating often means a change not only in how they are used (doctrine), but also in the weapon itself. The description of the contest between barbed wire, metal posts, and the 106 fuse that we discussed in Chapter 1

[156] Travers, *How the War Was Won*.

provides a good example of this concept. An analysis on innovation must embrace complexity and avoid easy shortcuts. In more recent years, scholars have started to incorporate a more complex view of the system of change in their research.[157]

Soldiers were the first to experience the impact that a new tool could have on their lives and were the ones with the most practical approach to problems. Private Clarke reported in his memoirs how one day in early 1915 his officer handed him a sniperscope, which is a device that enabled soldiers to shoot a rifle while using a periscope to aim and therefore keep well below the dangerous parapet. The officer who gave Clarke this ridiculously looking contraption was trying to find someone to test it. Clarke went off to the trenches to try it out, catching the attention of his fellow soldiers: "the lads looked at me as if I had a secret weapon," he remembers. "Sir, I said, the war will soon be over if we have about fifty of these," Clarke reported to his officers after trying the weapon on a tin can on the German parapet. "There's only one fault," he continued sarcastically with a theatrical pause, "it should fire shells, not bullets." The contraption did not impress Clarke, who tried it only a couple more times in the following days. It was not a total waste of his time, however, because the soldiers in the trenches, fearing some shelling as a retaliation for the use of the weapon, offered him cigarettes and tea to move to another position to try the contraption.[158]

The sniperscope's limitations did not render it completely useless. This tool made aiming more difficult and it was no substitute for a sniper with his skills and telescopic

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[157] Fox-Godden, *Learning to Fight*.
[158] "Private Papers of E. A. Clarke, Imperial War Museum."

sight, but it was extremely cheap to produce and helped to maintain control over no-man's land. No soldier liked to be shot at, even by an inaccurate enemy. The nuisance that it caused to the enemy was enough of a result. Indeed, these sniperscopes were produced in the thousands with different patterns and even sold at home to soldiers willing to buy them privately. All armies used them, and they became a common sight in every trench, especially where the enemy's positions were close enough that their inaccuracy mattered less.[159]

The challenges of trench warfare attracted an unquantifiable but surely large number of inventors, and their contributions varied in quality. Anthony Saunders focused his research on these tinkerers, and his knowledge of the world of patenting made his study an invaluable source for understanding this hidden technological background of the war. We also need to consider the financial component, because many of these inventors were eager to either sell their patents to the government, or to start companies for the production and sale of their products in the very lucrative market of war.

It is important to recognize that ideas and implementation are often very distinct processes and their differences could lead to the success or failure of inventions. To give some depth to this concept and in the hope to inspire a more sophisticated approach to the question, I will use the example of body armor. At the start of the war, armor was rarely used by any of the armies and seemed an old remnant of the past, relegated solely to museums or parades. Indeed, with the increasing dominance of firearms over the

[159] Saunders, *Dominating the Enemy*, chap. 6.

battlefield, from the late sixteenth century armor gradually disappeared from uniforms. Headgear suffered the same fate, except perhaps for the German Pickelhaube, which was made with leather and offered almost no protection.

The French Army was the first one to issue a steel helmet for its troops. General Adrian is credited for its invention. The story goes that he got the idea from a soldier who recounted how he survived a shrapnel wound only because the hit had been partially absorbed by a metal mess bowl that he was wearing on his head. Adrian polished the concept and came out with a hemispherical skull cap made of steel, trying out the idea in December of 1914. A few months later a better version, the Adrian helmet, substituted the simple skull cap and was distributed to the troops. Despite the complicated process for the production of this piece of armor, its success was extraordinary, and the other armies followed the practice.[160] The Belgian and Italian armies copied the French design, while the British and German ones came out with their own.[161] The reason for its success is twofold: head wounds were often the most dangerous type of traumas and in the trenches the upper part of the body was the most exposed.

Army doctors certified the effectiveness of the new tool with statistical studies on the wounded. Soldiers got used to wearing them, especially after the helmets' shape was refined. Two articles from *The British Medical Journal*, one published in 1915 and the

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[160] Very recently a comparison of modern gear with this helmet in its strength of protecting the soldier from a pressure wave of a near-by explosion went viral because the century-old French model outperformed the modern counterpart. "How a WWI War Helmet Outperformed Modern Gear in a New Study," PBS NewsHour, February 27, 2020, https://www.pbs.org/newshour/science/are-todays-military-helmets-better-at-preventing-brain-injury-not-always-study-says.

[161] Saunders, *Dominating the Enemy*, 64.

other in 1916, are both very clear on the usefulness of wearing head protection. However, they differ significantly in describing how French troops responded to wearing it. In 1915, talking about the skull cap, the author reports how a French study explained that "it [was] not popular with the men, owing, probably, chiefly to defects in its construction; it is too hemispherical to fit the cranium well, and it keeps in the perspiration, and for this reason and on account of its weight is apt to produce headache." The second article instead, just a year after, reports enthusiastically that the new helmet "presents an outline which suits the majority of French faces" and that "the men do not hasten to take off their helmets when sitting about off duty in cafés and elsewhere." A comment that continues the French cliché even for its army: not only were protection and comfort important, but so was fashion. Both authors (or perhaps the author, the articles unfortunately are unsigned) conclude with a similar remark: if the helmet is so useful on the modern battlefield, perhaps chest protection would be as well.[162]

They were not the only ones to have this idea, and indeed all the major armies produced some kind of personal armor for the soldiers. Civilians and companies participated in the process, often giving their names to the armor. Not all the attempts were successful, because while the helmet could offer advantages without encumbering the soldier with too much weight, to do so with chest armor was not an easy task. For this reason, and to maintain the flexibility of the torso, a number of lighter protection vests

[162] "Modern Armour," *The British Medical Journal* 2, no. 2847 (1915): 147–147; "Armour," *The British Medical Journal* 1, no. 2886 (1916): 603–603.

with metal plates inside were tested. Some found their way to the front, but they were never a success.

Even when the armies were not officially issuing such armors, men sometimes acquired them and wore them under their uniforms. Such a case is described in Emilio Lussu's memoirs, *Un anno sull'Altipiano*. Lussu dedicated two whole chapters to the relationship of the major who commanded his unit with his personal body armor, which he wore secretly under his shirt in battle. It was made of scales and had become almost an obsession of the officer. One day the battalion was going to the first line and everyone foresaw that an Austrian attack was coming soon. The major was very irritable because his armor remained behind in his personal box. When the mule that was bringing the box eventually arrived, his whole mood changed for the better. It was a vain effort. When the attack finally arrived, the major died, his armor pierced multiple times by an Austrian machine gun.[163]

These body armors were not completely useless, however, or at least not all of them. A light scale armor such as the one worn by the Italian major or the many models of vests with plates sewn inside were basically useless against anything more powerful than a weak shrapnel hit. However, a solid metal plate could help more, at least against bullets fired from a distance. That was the case of perhaps the most successful model of the war, the German *Infanterie Panzer*. It was comprised of a solid chest plate, linked to a series of mobile and smaller plates that covered the abdomen. It was heavy enough to

[163] Emilio Lussu, *Un anno sull'altipiano* (Torino: Einaudi, 2012), chap. 4-5.

offer some protection, but also too heavy to be used in an attack. Indeed, the armor was used most successfully by soldiers on sentry duty or in the listening post, jobs that exposed them to sniper shots and shrapnel and for which mobility was not an issue. Machine gunners liked this armor, because running around was not an option for them. The fact that, being sensitive targets, they attracted fire made the additional protection welcome, even if not perfect. Wearing it was a choice of the men, not a standard issue. However, it is common to find photographs of British machine gunners wearing *Infanterie Panzer*, which they captured from the Germans.

A comparison between helmets and body armor shows how success balances on a very thin line between a good — sometimes even odd — idea like going back to medieval technology, and its practicality. This line is obvious with the hindsight of decades of natural selection, where bad ideas disappeared and good ones, such as the helmet, became so common that their initial oddity completely vanished. In the past decades the helmet even abandoned the old medieval steel and embraced cutting edge composite materials, becoming a high-tech apparel for modern armies.

Bad ideas however were not so obvious at the time, at least not for everybody. The case study of the armors gives us the opportunity to see how the search for the perfect tool to solve a problem could blind soldiers and tinkerers alike. Miscalculations led to deaths, and there is no more blatant irony than an object that should save lives instead puts them in danger. In his memoirs Lussu recounts another episode that is very symbolic of the folly of pursuing ideas without thinking seriously about the consequences. His book is densely populated with critiques of the top brass, partly because his novelized diary fell in the post-war literary trope of the wasteful war, but mainly because the Italian Army had a problematic social rigidity and tended to be too stiff and ideological on rules and discipline.[164] The episode that I am describing revolves around the foolish use of the Farina armor, a heavy design worn together with its own especially thick helmet.

The commander of the division visited the frontline just before an attack to personally lead its preparation. After some failed attempts to cut the barbed wire in front of the enemy's trenches, he decided to bring out the Farina armor allotted to the division. "We have the special privilege to have them [the armors]. The enemy can have rifles, machineguns, guns: with the Farina armors you [can] go anywhere," the general explained. He then ordered a number of sappers to put the armor on, leave the trenches, and create passages in the enemy's entanglement with wire-cutters. While these poor men were stepping over the trenches, the general solemnly put himself at attention and stated with distasteful grandeur, "The romans won because of their good armor." None of the poor fellows even reached the barbed wire: they all fell shot by the Austrian machineguns.[165]

The episode is so appallingly ludicrous that it is almost certain that Lussu tailored it to follow his general artistic agenda. However, literary details aside, the Farina armor itself was not a figment of his imagination and was indeed produced precisely for the

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[164] To understand the reasons for the problems of leadership of the Italian Officer Corps: Gooch, *The Italian Army and the First World War*; Wilcox, *Morale and the Italian Army during the First World War*.

[165] Lussu, *Un anno sull'altipiano*, chap. XIV.

purpose described by Lussu. The armor was heavy and cumbersome, to the point that the lower part of the chest plate severely limited the mobility of the hip and upper legs, impeding any kind of crawling or ducking. It did not provide the 'roman invincibility' to bullets pointed out by the general and prevented the agility necessary for doing dangerous actions at night. Instead of saving lives, this armor endangered soldiers by giving a false sense of protection.[166]

In Italy, Lussu's memoirs had a strong impact on the memorialization of the Great War. After 1945, Lussu's anti-fascist past helped to make his book the Italian version of *All Quiet on the Western Front*. In addition, his denunciation of the idiocy of the Italian leading class resounded well in a nation that had just been led once again into a tragic war and this second time even losing it. The powerful story of the cruel general and the useless armor made it onto the silver screen when Francesco Rosi directed the translation of Lussu's book into a movie. It became one of the most important Italian movies on the First World War together with Monicelli's La Grande Guerra.[167]

These body armors returned recently in our memorialization of the war, as they appeared as part of the optional gear of a soldier in the widely played videogame Battlefield I. The myth of the invincible armor that shields soldiers from bullets continues to be perpetuated, as I saw first-hand while teaching classes on the First World War.

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[166] Saunders, *Dominating the Enemy*, 45–47.

[167] Francesco Rosi, *Uomini Contro* (Prima Cinematografica, Dubrava Film, 1970),; Mario Monicelli, *La Grande Guerra* (Dino De Laurentiis, 1959).

Some enthusiastic video gamer students were appalled to learn that these armors were never used during assaults and offered little protection to the soldiers.

The general problem of armor is that a new model rarely survives for long before it is surpassed by a new kind of projectile. While designing a new bullet does not change its portability unless the caliber also changes, the armor's efficacy increases with its thickness, but the portability decreases exponentially. New materials can counteract this limitation, but at the start of the war steel production had already reached a high level of sophistication and new alloys were not greatly increasing its strength.

Therefore, the more effective the armor, the less portable it was. This was also true of tanks, that initially were very slow and had to balance speed with defense. Armor was generally effective in cases that didn't involve movement. Indeed, millions of armor plates were produced throughout the war and protected sentries and observation posts. Yet even these had serious limitations: to begin with they needed a hole in order to see through them and therefore offered a target for snipers, but they also became targets for a new kind of bullet, specialized in armor piercing.

Snipers did not wait for direction from the top to find a solution against armor. Frederick Crum, a sniper officer whose story we'll encounter in chapter 5, recounted that in September of 1915, during his first leave in England, he visited the War Office and gunmakers to talk, among other things, about armor-piercing bullets which were "at this stage in their infancy and left to the private enterprise and financing of pioneer enthusiasts."[168] Another one of these enthusiastic tinkerers was officer Andrew Ramsay Bain. One time he was on leave and came across a friend that worked at the Kynoch cartridge company, a major productor of ammunitions in Scotland. He explained to his friend that the Germans had started to use armor plates. His friend told him that the company was testing armor piercing bullets. In great secrecy Bain asked his friend to procure him some and he managed to obtain 20. He brought them back to the frontline, using them with great satisfaction.[169]

After the war, with the long list of failures in trying to stop the destructive power of modern bullets, it was time to reassess the use of armor. Captain Edward C. Crossman, an expert gun connoisseur, did just that in the pages of the *Scientific American* with a poignant article titled *Why Armored Suits Fail*. "Every once in a while or even more frequently there bobs up a hopeful gentleman who has discovered that certain forms of alloyed and heat-treated steel will stop most bullets," began Crossman, setting the tone for the rest of the text. He explained that the United States' Ordnance Department even had "a special officer detailed just to 'shoo away' the inventors of armor suits or armor shields for our soldiers during the war." The article then goes into the details of the physics of bullet impact, the design of armor piercing bullets, and the tests made during the war. The conclusions are unsparing: "you can imagine, therefore, what use an armored suit or armored car would be, if armor steel more than half an inch in thickness

[168] F. M. Crum, *With Riflemen, Scouts and Snipers from 1914 to 1919* (Oxford, 1921), 46.

[169] Judging from the fact that the armor piercing bullets started to be produced at the end of 1914, this could have happened in the first half of 1915. Bain, Andrew Ramsey (Oral history),IWM. Ar".303 Inch Armour Piercing - British Military Small Arms Ammo," accessed July 6, 2019, https://sites.google.com/site/britmilammo/-303-inch/-303-inch-armour-piercing.

can be easily punctured by a little bullet any soldier may be carrying in his belt, remembering that steel plate a half-inch thick weighs about 20 pounds to the square foot." The conclusion was clear: personal armors were foolish against modern weapons. And yet, helmets became a standard of every uniform after the war, while armors throughout the war had discrete successes even though only in specific cases. Crossman's assessment is precisely the kind of strong opinion that comes with hindsight, after numerous tests, attempts, and failures. Surely he was right in pointing out that many inventors, naïve and unknowledgeable, produced solutions that should not have even reached the testing stage of development. However, in the heat of war the value of each invention was not always clear-cut. Indeed, even some medieval oddities came back into fashion, like the helmet.

In viewing the contribution of tinkers, we must also consider another factor: the differences between this war and previous ones in regard to social context. The Great War lasted much longer than the previous major European war, the Franco-Prussian War, and therefore people had more time to tinker. But the most important factor that we must consider is the level of education and interest in mechanics that developed during the forty years before the war. Germany, France, Italy, and the United Kingdom in the second half of the nineteenth century invested a consistent percentage of their treasuries on the education of their citizens. Literacy rates rose, not only because of the schools, but also because of the new kinds of professions, which required new and complex skills.[170]

[170] A. G. Howson, *A History of Mathematics Education in England* (Cambridge [England] ; New York: Cambridge University Press, 1982); J. J Findlay, *The Children of England: A Contribution to Social History and to Education* (Abingdon, Oxon: Routledge, 2012), http://site.ebrary.com/id/10589071.

Mechanics and engineering were solidly respectable disciplines: great engineers had become a matter of national pride as much as military commanders. Architectural feats such as the Eiffel Tower or the Tower Bridge in London were the new symbols of an era in which man dominated the landscape with his metallurgical knowledge.

This power over metals and their cheap production allowed small barns to become workshops to produce cars and bicycles. Aggressive entrepreneurs such as Edison or Isambard Brunel had crystallized in people's mind the heroic figure of the inventor. It is no surprise therefore that many were passionately interested in this universe. Looking at the magazine production in England during the Victorian era, in addition to the expected newspapers and entertainment press such as those dedicated to sports or comical relief, there is an impressive number of professional magazines, many of which, such as *The Engineer*, advertised the latest mechanical inventions of every kind, ranging from agricultural tools to sewing machines.[171]

These magazines also became a kind of public corkboard where readers could share information about new events and machines. The readers that were not brave enough to face the risk of being 'shooed off' from the Ordnance Department, as Crossman remembered, could still see their suggestions and comments printed on paper. Not all ideas were naïve, some were quite on point: George Hall of Katonah, N.Y., in the correspondence section of the *Scientific American* of March 1916 commented on a previous article regarding the use of bayonets in the trenches, suggesting two viable

[171] J. Don Vann and Rosemary T. VanArsdel, eds., *Victorian Periodicals and Victorian Society*, Reprinted in paperback (Toronto: Univ. of Toronto Press, 1995).

alternatives. The first seems a little too “cinematic”: armies could include with each platoon a man armed with two automatic pistols — “a two-handed gun fighter.” The second suggestion was to use shotguns, to which “spare magazine cylinders could be devised.” Hall at the beginning of 1916 already understood how powerful this weapon could be in the cramped space of a trench. Two and a half years later American soldiers armed with such weapons brought havoc to the trenches, to the point that the German government tried to ban the weapons at The Hague, rather ridiculously, considering the horrors of gas warfare.[172]

Case Studies

In this second half of the chapter, I will explore a variety of ideas from the bottom that found their way to success. The range of themes should hopefully highlight the importance of the participation of inventors to warfare. I will start with a small selection of examples to offer a glimpse of this complex universe, covering cases with different technological and social issues. I will then address more closely the case of the trench knife to better analyze the interaction between institutions — in this case the War Office — and soldiers during the development of a weapon.

The machine gun synchronization mechanism

Military aviation was in its infancy at the start of the war. Some camaraderie was exchanged at the very beginning between pilots of opposing nations meeting mid-air during their reconnaissance, but soon they too started to shoot each other. Initially pistols

[172] George Hall, “Pistol vs. Bayonet,” *Scientific American* 114, no. 12 (1916): 301–301.

and rifles were used either by the pilot or by the observer, but it was clear that an airplane with a machine gun would have had a great advantage. The only problem was how to aim it: the observer could have managed it, but in the best models of fighter aircrafts, the engine propeller stayed rather fastidiously in between the target and the machine gun of the plane in pursuit. Machine guns became an obvious choice in defending a plane, because in the two-seater airplanes, commonly used in reconnaissance, the observer could handle a machine gun to shoot at pursuing aircrafts. However, if the role of the airplane was to hunt the enemy's planes, this configuration was ineffective, because commonly the fighter was behind its prey, not in front of it. The pilots, their mechanics, and airplane engineers tried different solutions, but they were not very effective: the best way was to have the machine gun fixed right in front of the pilot, where he could aim with the plane itself, avoiding the need to juggle between the weapon and the control stick.[173]

Unfortunately, this position was precisely behind the blades of the propeller. The common story is that a genius Dutch engineer who produced airplanes for the Germans, Anthony Fokker, invented a mechanism that synchronized the machinegun with the movement of the propeller: the bullets were always shot between the blades. Problem solved. Another version, a little less common, recounts that a French pilot was the first to place a machinegun behind the propeller. To avoid the unpleasant result of destroying the propeller with his own bullets, he fitted the wooden blades with metal wedges, which

[173] Leon Bennett, *Gunning for the Red Baron*, 1st ed, C.A. Brannen Series, no. 7 (College Station: Texas A&M University Press, 2006), chap. 1.

deflected the shots. While effective, this was an inelegant solution that reduced the speed of the airplane. Additionally, this idea required a pilot brave or reckless enough to forget that he was shooting his own propeller every time that he pulled the trigger. The reckless Frenchmen from this story was Roland Garros, the famous aviator who in 1913 was the first person to cross the Mediterranean Sea by plane. His name is now more famous for the prestigious tennis tournament, which is played in the stadium that carries his name.

Recklessness was a common trait of the earliest aviators, an attribute that helped to make them stars. With the start of the war their abilities and courage were employed by the armies, where they kept shining, offering to their fellow citizens heroes to admire and cheer like they had done with famous sport personalities before the war.[174] Roland Garros took advantage of his new weapon, shooting down two enemy aircrafts before being captured on April 18, 1915, when ground fire obliged him to land on the wrong side of the trenches. Fokker then took the idea, improved it, and produced the synchronizing mechanism; apparently, all in 48 hours, as he claimed in a book published in the 1930s.[175]

The reality is much more complex. Digging under the surface of these thrilling stories, appears a world of interactions between different actors that mutually inspired one another. To begin with, Garros did not have the original idea, nor did he single-handedly build the modified propeller and fit it to his plane. In November of 1914 he

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[174] Luc Robène, "Les Sports Aériens : De La Compétition Sportive à La Violence de Guerre," *Guerres Mondiales et Conflits Contemporains*, no. 251 (2013): 25–43.

[175] H. Woodman, *Early Aircraft Armament: The Aeroplane and the Gun up to 1918* (Washington, D.C: Smithsonian Institution Press, 1989), 181.

heard that Raymond Saulnier, the engineer behind the production of the highly successful airplane Morane-Saulnier, was testing some armored propellers and visited him in Paris. After talking with Saulnier, back at the front he developed his own version with his mechanic Jules Hue, who, one imagines, did all the legwork.[176]

Even Fokker's story is clearly oversimplified: it would have been very difficult, if not impossible, to design the mechanism, make the prototype, and test it all within 48 hours. In addition, we need to consider two more factors. Firstly, there were two international patents for similar synchronization mechanisms, one filed in 1914 by Saulnier and another filed in Germany in 1913 by the Swiss engineer Schneider. Secondly, experts consider Fokker's engineers to be the real inventors, most likely H.F.A. Lübbe. If we add to these important factors that French and British engineers were working on the same problem, we can see how there was a movement of ideas around Europe that led to change. The British in 1915 developed a partial solution, a smaller metal propeller synchronized to the main one but not attached to the propellers, therefore protecting it without the limitation of Garros' deflectors.[177]

If the idea of synchronization was already around in 1913, why did it take four more years before this important innovation transformed airplanes into effective weapons? The answer lies in the understanding that the presence of a tool does not automatically imply that people recognize its importance, even in the exceptional time of

[176] Woodman, 172.
[177] Woodman, 181.

war. Until the pilots had the necessity of stopping enemy aircraft, simply the interest was not enough.

The French, British, and German institutions had three different attitudes in the development of such a mechanism. At the beginning the French official channels were out of the picture: it appears that Saulnier was testing new things like the armored blades on his own initiative. Even when he patented things that should have caught the attention of the army, such as his version of the synchronizing mechanism, no one stepped in asking for further development. In the case of the British, we can give some blame to Churchill, keeping up a sport appreciated by many historians. In April of 1915, understanding the importance of having airplanes with guns mounted behind the propeller, he detailed in a memo to the Director of the Air Department that they should proceed with the development of the new models. They had to be small single seaters with fast climbing abilities and have a "Lewis gun firing through a deflector propeller."[178]

With the best intentions and following his nose on the new developments in aerial warfare, Churchill went a step too far. The Lewis gun, a weapon loved by men on the ground and that more importantly was light —a crucial detail for what were essentially kites with engines that pilots were flying at the time— was unsuited for being synchronized because of the design of its firing mechanism.[179] Pushing the model of the

[178] Woodman, 175.

[179] The Lewis gun was gas operated, meaning that the expanding propellant moved a piston to release the spent cartridge case. The Maxim gun instead used the recoil.

gun instead of giving a general direction and trusting the designers, Churchill put the British design at the back of the line.

The German institutions adopted what was perhaps the best attitude. When Garros' propeller ended up in their hands, it was packed and sent to Berlin, where inspectors invited different designers to take and develop the idea. They gave Fokker a new Parabellum MG 14 machinegun to study a solution. The result was the 'Fokker scourge of 1916,' when German pilots dominated the skies and aces such as Immelmann and Boelke developed doctrines destined to influence air warfare for decades.

In all these cases it appears that none of the three actors —institutions, inventors/engineers, and pilots— could solve the problem by themselves. Pilots knew what they wanted but did not have the means or the knowledge to design it; engineers needed the input of pilots and the money from the institutions, while institutions had the money but plenty of red tape to clog the gears of innovation. Two years of war eventually pushed innovation: the necessity of the pilots, not ideas from the top, solved the gordian knot from the bottom.

Trench mortars

Mortars had been a siege weapon for a long time before the First World War. The shape of these pieces of artillery resembles almost identically the kitchen tool used to mix and pound ingredients, hence the name. Soldiers had long thrown projectiles, often explosive ones, over fortifications, to directly hit the occupants. It is therefore not a surprise that in the prolonged siege on the western and other fronts, these pieces of artillery played an especially important role. Their small dimension, the ability to fire under cover, and the high explosive charge they carried made them the go-to tool for demolishing the enemy's lines. Trench mortars did not replace the artillery, since they were less effective for barrages and had to be fired close to the trenches because of their short range. They were localized weapons strongly linked with the infantry, while the artillery had more a strategic role.

This kind of weapon required dedicated men: to be part of a trench mortar battery was not considered the safest job. In addition to the risk of misfire and the subsequent unpleasantness of needing to pull an unexploded and live shell out of the bore, trench mortars were prime targets on both sides. Officer Ulik Burke remembered that his group was called the "Suicide Club."[180] Lieutenant Scott recalled that when he landed in France in 1916 "we were all posted to a unit which we had heard little of at home, and what little [we] had heard was bad —the Trench Mortars. On hearing our fate our spirit fell considerably as on the way up the line we had been advised to stay clear of a trench mortar battery."[181]

The methods of employment of these batteries changed during the war. During the first year and a half of their use, these men were sent to solve problems. For example, they could have been called to demolish an observation post, retaliate against sniper fire, or destroy barbed wire. The team went to the location, placed itself in or near the support line, rained some destruction across no-man's land, and then moved back. Unless being called to retaliate, trench mortar batteries were rarely welcome, as they were magnets for

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[180] Burke, Ulik Bernard (Oral history), IWM.

[181] *Artillery & Trench Mortar Memories: 32nd Division* (Uckfield, East Sussex; Woolwich: The Naval & Miliatry Press Ltd. ; Firepower, The Royal Artilery Museum, 2012), 19.

enemy artillery, which usually fell upon the infantrymen occupying that sector of the line. Even when nobody got hurt, the havoc caused by German shells would have required a night of repairs, an activity that no infantrymen enjoyed.[182]

In 1916, the use of trench mortars was consolidated into a coherent doctrine. Production was reduced to three models, light, medium, and heavy, with three different uses. The heavy ones were difficult to move but were highly destructive and were used for the bombardment of strong tactical points. The medium models still needed a good firing platform and therefore required some time to be put in place. They were the choice for the destruction of barbed wire and defenses, but they could not follow the infantry during the attack. The light ones could advance with the infantry during an assault, providing support against counter-attacks: “their [light mortars] effect against material is inconsiderable, but they are useful for engaging targets in the open, for minor retaliation, and for over-whelming the defence by rapid fire just previous to an assault.”[183] The Stokes mortar was adopted in January of 1916, just two months before the printing of the manual: it was a light mortar that had a great influence over the years to come and became the foundation for the whole concept of modern mortars. It was light and mobile yet maintained a punch. The Stokes mortar, in conjunction with the Lewis gun, added much needed firepower to the infantry, laying down the basis for the platoon tactics that changed warfare in the last year and a half of the war.

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[182] Shelford Bidwell and Dominick Graham, *Fire-Power: British Army Weapons and Theories of War, 1904-1945*, Pen & Sword Military Classics, series no. 44 (Barnsley: Pen & Sword Military Classics, 2004), 124.

[183] S.S. 98/6 “Artillery Notes No. 6: Mortars,” 1916.

While the lighter models could cooperate directly with the infantry, the other two categories operated more like artillery. The *SS 98/6* manual indeed indicates that they should operate in close contact with artillery observers, who could provide vital information for the registration of the targets. Their static nature, in conjunction with the high danger of counter-battery fire against them, inspired a kind of emplacement that was a hybrid between a trench and a dugout, a deep pit sloped accordingly to the angles of fire of the mortar. It was often covered with concrete in the attempt to make the emplacement position bomb proof. The 1916 manual provides a general doctrine and is accompanied by diagrams and maps.

The concluding notes print out the common refrain that we saw with other such pamphlets: "These notes are based on the best experience so far available and must be carefully studied. There is however, no intention of cramping the initiative of trench mortar officers...[who] must be prepared to make such modifications in the procedure here described as circumstances may render advisable from time to time." The army expected change. Indeed, change arrived: trench mortars became even more strongly connected with artillery, and in 1917 their use was integrated under artillery officers, who controlled all the fire-power of a sector and started to insert trench mortars into complex barrages.[184]

To understand the tactical changes of the use of these weapons however, we need to see who developed them and how. At the start of the war, the German Army, which

[184] Sanders Marble, "'The Infantry Cannot Do with a Gun Less': The Place of the Artillery in the British Expeditionary Force, 1914-1918," 2003, chap. 7, http://www.gutenberg-e.org/mas01/.

was already interested in siege warfare due to their intention to pass through the Belgian system of fortifications, already had trench mortars. These guns could send heavy projectiles a short range and therefore became one of the best tools to demolish fortified positions and sensitive targets such as observation posts. Their destructiveness and precision instilled fear in the British ranks, while the German gunners could fire safely from the trenches thanks to the high trajectory of the gun.

It was not long before the British soldiers started to desire their own version.[185] John William Collins in 1914 was a stretcher bearer with the Royal Army Medical Corps attached to the 7th Bde Royal Horse Artillery. He remembered vividly the lengths the men would go to for retaliation against the use of the *minenwerfer*. The unit he was attached to was occupying a sector at Sanctuary Wood, near Ypres. The location was an important part of the sector's defense system during the whole war, and it had been from the beginning one of the favorite targets for enemy artillery and mortars. The artillerymen lacked a weapon to respond with, but they did not lack inventiveness. To their ideas they added a certain dose of recklessness because they decided to make their own artillery pieces. They welded a bottom plate to a metal pipe and made a hole in the barrel near the base. In this way they re-created an old-fashioned smooth bore mortar. The managing of the weapon was straightforward: put a fuse in the hole, insert several black powder-cartridges in the bore, then add the projectile. The cartridges were hand-made and their number in the bore was decided depending on the distance of the target. "It was a very

[185] By the twentieth of October of 1914 the Command in Chief had already requested new models of artillery for short range support. *History of the Ministry of Munitions.*, vol. 11 (London: Her Majesty Stationery Office, 1922), 34.

primitive affair," remembers Collins, "the fuse was lit, and they all crammed in the next bay of the trench because it was even money where the bomb went over to the Germans or the gun exploded."[186]

This use of improvised mortars was not an isolated case. Philip Neame, an officer of the RE, remembered the make-it yourself attitude of his corps at the start of the war. The sappers had the technical knowledge for this kind of work, but not the machinery necessary. The divisional commanders therefore scrambled to buy metalworking tools in France to set up workshops behind the lines. Neame recalled that the workshop of his division, the 8th Infantry, was set up in a Brewery and produced some dozens of these mortars, using drainpipes for the bore. Asked by the interviewer, he confirmed that the "RE components attached to each division took this responsibility upon themselves for the use of their own division." There was a need at the frontline, and they answered to that need knowing that the army would be too slow in developing an official solution. This was a common attitude and Neame was certain of that: "other divisions did the same, they might have invented them too." However, he had a very different perspective from the men using them, because he proudly remembered that these contraptions were "quite efficient, locally made trench mortars." Clearly, he had not encountered the quite thrilling experience of firing these finnicky weapons.[187]

While soldiers on the field improvised their answer to Germany's mortars, the British Army institutions grappled with how to manage and channel innovation.

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[186] Collins, William John (Oral history), IWM.
[187] Neame, Philip (Oral history), IWM.

Frederick W. Stokes had direct experience of how red tape could kill good ideas. During 1915 he proposed his project to the Army three times, in February, April, and June. He was rejected each time. His design introduced the very good idea of a projectile that, dropped in the bore from the top, would hit a pin on the bottom and therefore start the ignition without any external mechanisms. It is still the preferred design for mortars today, and it allows for a very high rate of fire. The idea was good and the mortar itself has such a simple design that, except for the steel barrel, any small workshop with basic metalworking tools could build one. The problem was that the projectile was detonated with the Bickford fuse, which had been proved to be extremely dangerous.[188]

Changes in the cabinet and in the Ministry of Munition led to Stokes' idea being given a second look. Kitchener needed help to manage the problematic situation that unfolded with the shell crisis that was enflaming the front pages of the newspapers. The revised cabinet called in to fix the situation reviewed all the proposals for new trench mortars and issued new tests in June 1915. During these trials, Stokes' design captured the attention of Lieutenant Sutton of the RE, who had been sent to look for a better trench mortar by General Hunter-Weston, commander of the 29th Division in Gallipoli. Sutton connected Stokes directly with the new cabinet and the two organized a fifth demonstration in September, this time not for some bureaucrat, but for Lloyd George and Churchill, who finally ordered the production of the weapon.

[188] *History of the Ministry of Munitions.*, 11:39.

When the design of the Stokes mortar finally became public, the urgency of its production became immediately apparent. The GHQ in France telegraphed on August 22 to ask for several pieces with the intent of using them with smoke ammunitions during the upcoming planned operations at Loos. Neither the mortar nor the ammo existed yet, but the command needed them in ten days. Extraordinarily, the demand was fulfilled "by the improvisation of a pattern, the issue of unproved stores, and by the completion of manufacturing processes in the army workshops."[189] With the official request from the top, the Trench Warfare Supply department finally gave some necessary attention to the problem of the fuse with the Stokes mortar and found a solution. The trench mortar after a year-long ordeal reached the soldiers on the frontline in 1916.[190] It is interesting to note that another previous attempt, passing through the soldiers at the front, failed. Stokes attempted to find a parallel avenue by sending one of his mortars to General M.F. Rimington, who tried unsuccessfully to convince GHQ to accept it. The general's authority was clearly not enough to change the decision on the matter.[191]

This whole Stokes saga shows that a design rarely starts without faults and that even successful designs often take tortuous paths inside the corridors of bureaucracy. It is noticeable that such a good design, so good in fact that it would influence all future mortars around the globe, received so many rejections. However, we must consider the flood of ideas that were overloading the offices of the Ministry of Munition. During the war, tens of thousands of ideas were submitted, of which only a fraction were found

[189] *History of the Ministry of Munitions.*, vol. 11 (London: Her Majesty Stationery Office, 1922), 3.
[190] Griffith, *Battle Tactics of the Western Front*, 105; Hartcup, *The War of Invention*, 25.
[191] Griffith, *Battle Tactics of the Western Front*, 106.

useful. Probably a number of the rejected ones were good, but until a strong-willed scholar decides to dive through all of these failed patents, we can only make conjectures.[192]

The story of the trench mortar shows us two main things: first, we can see how soldiers on the ground adapted to the new warfare despite the slow reaction time of bureaucracy. Responding to a necessity, soldiers and officers in the trenches both in the French Army and in the British had enough entrepreneurship and leeway to pursue new tools and new ways of doing things when necessary. Second, we can appreciate the importance of an efficient system for the adoption of new ideas. The Stokes mortar, an important weapon that considerably improved the firepower of infantry brigades, is a good example of how the route to the adoption of new weapons was full of traps, which were partially defused only when the Army changed the whole system of testing new designs.

A comparison of the role of Churchill in the development of the synchronization mechanism and the adoption of the Stokes mortar helps us to understand what makes a good system of adoption. The final decision is often political because that is where the money is; the interaction between who decides and who analyses is very important, because the decision from the top should generally come after research from the bottom and not vice-versa. With the synchronization mechanism, Churchill suggested to the developers what they had to do, not the result to obtain, therefore negatively influencing

[192] Hartcup, *The War of Invention*, 189.

the outcome. With the trench mortar, the cabinet were lobbied by experts such as the Royal Engineers officer and gave funds to an idea that had been totally developed from the bottom.

Lastly, while chance is somewhat important, especially if we focus on the single story of the Stokes mortar, how the system (in this case the army) responds to necessity is much more important. Up until May of 1916, seven different patterns of mortars had been produced and distributed to the troops. What superficially seems to be a waste of energy and complicated interactions with multiple ammunitions and different trainings, in reality was a response to an emergency that arose from the trenches. This prompt answer from England, even if somewhat muddled, also had the fortuitous consequence of letting practice, not theory, lead the way in the subsequent simplification of the number of models adopted. Indeed, the army in 1916 could use the trove of experience matured in the previous years by the men on the frontline to analyze the pros and cons of all the models and choose the three best ones when they were sure about their qualities.[193]

Fashion in the trenches

In the rigid class structure of British society, the officers came in large part from affluent families. These officers' status as gentleman implied that they had to dress accordingly. In the British Army and Navy, it was very common for an officer to wear tailored uniforms and accessories that were not part of the standard equipment. In the pre-war army this market was dominated by small tailor shops, some of which made a name

[193] *History of the Ministry of Munitions.*, 11:4.

for themselves as uniform specialists. With the expansion of Kitchener's army these shops could not cover the increase in demand. Medium-size companies seized the opportunity by providing products that had a high enough quality not to be confused with the high-quantity but low-quality clothes for the lower classes.[194]

It is not unfair to say that these companies profited from the war, but we should not be too harsh: they provided a service which officers were long used to, and surely they felt that their industriousness was a productive way to help their nation in the effort for victory. One of the most successful items was the trench coat. It is unclear who actually invented the garment and there is evidence that it was already produced before the war. During the war, companies such as Aquascutum or Burberry, famous for their high quality outerwear for sports, hunting, and fishing, provided their know-how to help men in the harsh conditions of the trenches, tailoring a war garment that became and remained a staple of the fashion industry. As often happens with the origin of commonly used terms, despite the clear link, the name slowly lost its connection with the First World War, and the trench coat continued to help keep gentlemen dry even outside of rainy Flanders.[195]

The coat had to be waterproof and warm, yet light and tailored enough not to impair movement. Burberry combined elegance with practical design. In an advertisement on the pages of the *Royal Engineers Journal,* they described their model of Trench-Warm [coat] as "SMART BRITISH WARM…a lightweight, yet luxuriously

[194] Jane Tynan, "Military Dress and Men's Outdoor Leisurewear: Burberry's Trench Coat in First World War Britain," *Journal of Design History* 24, no. 2 (May 1, 2011): 139–56.

[195] Peter Doyle, *The First World War in 100 Objects* (The History Press, 2014). Obj. 26.

warm and snug, wrap-coat for wear in dug-outs or when off duty." Copy-cats and different versions soon occupied the showcases of shops in London and the advertisements in the press.

The advertising for such products populated the pages of most military journals and gentleman's magazines such as *Country Life*. Additionally, it appeared in unofficial publications on military topics: these highly technical booklets were the perfect host for such advertising, because the audience was the entrepreneur officer who wanted to remain up-to-date on the recent advancement of military techniques. One example is the *Machine Gun Manual* by Captain H. Douglas, a 150-page encyclopedia of all the models, tactics, and doctrines in the use of automatic weapons on the frontline. At the start and end of the book there are several ads for different kinds of coats, boots, and wristwatches.[196]

Wristwatches are another interesting example of this connection between the fashion industry and war. Before the war, the public considered wristwatches a piece of jewelry appropriate only for the arm of a lady, while men preferred the pocket watch. Before 1914, various companies tried to break this convention but failed to make the wristwatch a commodity for the masses. The war changed everything, and wristwatches became objects for men as well as women. Soldiers came back home used to this novelty and kept using it.

[196] H. Douglas, *Machine Gun Manual a Complete Manual to Machine Gunnery...* (London: Harrison and Sons, unknown). IWM.

The wristwatch greatly influenced the complex and time-sensitive operations of modern warfare. One has only to think about the precisely timed artillery barrage to understand how vital it was to provide such mechanisms to the officers. Another small innovation of the pre-war years contributed to its success: the glow-in-the-dark paint on the hands and face of the watch, which allowed for its use in complete darkness and without the need to use a light source. The result was obtained in a way that would terrify any buyer today: the paint contained a radioactive substance. However, the tiny amount of material was harmless. The fact that it could be used at night became the focus in the marketing of these watches: the Benson company for example sold a model called the Luminous "Active Service" Watch.

While war influenced fashion by introducing wristwatches to the masses, the trench coat influenced uniforms. In 1923, in an article in the *RUSI* journal titled *The Equipment of the Infantry Soldier in the Light of War Experience*, Captain Tebbutt explained the changes needed to the British uniform. Reduction of weight was of the utmost importance, as the army learned when the Entente broke the German trench system in the last months of the war. The overcoat was one of the heaviest items and it also needed to be shortened to save weight and not hinder movement. Indeed, men in the trenches often folded up the bottom of the coat and fastened it with buttons. In addition, Tebbutt suggested using lighter fabric and taking inspiration from the trench coat. After the war, the United Kingdom had bigger problems to face other than updating the uniforms, but in the late 1930s denim resurfaced as a military tailoring material.[197]

Trench Knives: Violence, Necessity and Establishment

The relationship between the bayonet and the soldier was a contradictory one: it was not very effective in the trenches, sometimes even dangerous if it got stuck or broken, yet no soldier with a rifle would leave the trenches without it. The power of the bayonet was to reassure the attacker that if he safely crossed no man's land and reached the enemy's defenses, he would have a chance in a fight. The soldier would have something to cling to in the cramped space of the trenches where the rifle was useless. While the practical utility of the bayonet on the battlefield is debatable, the armies clearly understood its value in increasing morale and its importance as a training tool in initiating soldiers into an aggressive military attitude.[198]

Continuing to train the men in the use of the bayonet was not a bad idea if we consider that it was physical exercise, it did not require any expenses or waste of ammo, and it trained soldiers for the not so common yet still plausible possibility of close combat. Yet all medical statistics said that bayonet wounds were a small percentage of the total recorded in the hospitals. However, we should consider that once in a close fight,

[197] C.L. Tebbutt, "The Equipment of the Infantry Soldier in the Light of War Experience," *Journal of the Royal United Service Institution*, February 1, 1923, 115–20.

[198] John Stone, "The Point of the Bayonet," *Technology and Culture* 53, no. 4 (2012): 885–908; Rob Engen, "Steel Against Fire: The Bayonet in the First World War," *Journal of Military and Strategic Studies* 8, no. 3 (2006); Paul Hodges, "They Don't like It up'em!: Bayonet Fetishization in the British Army during the First World War," *Journal of War & Culture Studies* 1, no. 2 (March 14, 2008): 123–38, https://doi.org/10.1386/jwcs.1.2.123_1.

someone who was wounded by a blade was not likely to survive, for the simple fact that few were left alive after they succumbed.

In the audio tapes of the Imperial War Museum the fascination for the topic emerges in the questions of many interviewers, and indeed the soldiers had a magnetic attraction to the enemy's bayonet as a souvenir.[199] However, in these interviews the ambivalent value of the actual use of bayonets in battle is clear. The idea of having to brawl for your life was terrifying for many soldiers, and not only for the ones who had experienced it. Private Morris Parry remembered how "it was a bit frightening" [with sarcastic voice], he was glad that he never actually had to do it. To some it was a breaking point: Harold Holttum, who grew up as a pacifist, recalled how at the Officer Training Corps (university clubs operated by the British Army) he did not have any trouble with most of the activities, including shooting at targets. This ease did not last however: "what really put me off and reminded me of the Quaker's ideas was when I started bayonet practice ... Go on and hit him in the guts! [the NCO said], well that really put me off: this is wrong, I know it's wrong."[200]

For the men who had the unpleasant experience of being in a bayonet fight, the ordeal left a strong impression in their memories; the voices of the interviewed veterans in these cases changed to emotional tones. Aled Parry recalled the sudden terror of being attacked in the middle of the night by a German. Parry got bayoneted in an arm but managed to react violently: "I kicked him, one or two [times] at most, down he went, and

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[199] Hampson, Granville (Oral History). IWM.
[200] Parry, Morris; Holttum, Harold (Oral History). IWM.

I got hold of his rifle." The old man still showed the emotional baggage of the traumatic experience when his voice started to break: "I struck him like a pig. It was him or me wasn't it?" George Singleton also remembered this kind of experience with great sadness: "seeing Germans screaming for life and put a bayonet in the man, that was the worst. I never wanted to do that anymore... your heart twisted." A fight with the bayonet was much more personal; while he did not have any trouble shooting enemies down "it is a different story altogether when it comes to the hand to hand stuff."[201]

Many simply did not use it. They had an alternative because they had two weapons in one, the first ancient, the second modern: the bayonet "was of use in [hand to hand combat], but I shot them…you can kill them from two or three yards with a bullet." "Use the rifle!" commented another veteran; "I shot a pair of men, it was easier," remembered another.[202] The men in some cases were forbidden from keeping a bullet in the breach, because in the heat of action it was easy to pull the trigger by mistake and wound a friend by accident, but it was not a popular measure. "I never took mine out," recalled Marmaduke Walkington, "if I came up against a bloody Prussian guardsman, I would rather have a round in my rifle, thank you very much."[203]

Brawls however were a constant in trench warfare and the rifle was not always the best choice. Early in the war, soldiers of every army searched for new and more efficient tools for the gruesome job of trench cleaning, the process of eliminating any presence of

[201] Parry, Aled; Singleton, George (Oral History). IWM.

[202] Rayne, Frank; Grover, Walter Ernest; Payne, James Albert (Oral History). IWM.

[203] "Walkinton, Marmaduke Leslie (Oral History)," Imperial War Museums, accessed June 20, 2020, https://www.iwm.org.uk/collections/item/object/80008923.

the enemy in the recently-conquered trenches: transmission cogs became heads for medieval-inspired maces and field blacksmiths recreated morning stars with big nails. These weapons were heavy though and added weight to an already overburdened soldier.[204] With an impressive description Erich Maria Remarque explained how a spade with a razor-sharp edge became a weapon of incredible efficiency, able to kill an enemy with a single blow; moreover, it did not break as easily as the bayonet. The use of a rifle and spade at the same time however was problematic.[205] The sharpened spade developed as a bottom-up solution from soldiers caught in a situation that manuals, training, and officers had not previously considered. The rigid but inadequate army rules nonetheless left space for innovation not theorized by professionals. In the use of this improper weapon there was a certain brutal practicality that conflicted with army standards, but it was so simple to transform a spade, the everyday companion of the trench men, into a weapon, that the solution was almost natural.

It was not, however, the only solution readily available. In most armies knives started to appear on the soldiers' belts. Shortened bayonets and hunting knives were the first to be used, then field blacksmiths started to produce so-called trench knives, handmade weapons requested by soldiers with experience on the frontline. These rugged weapons were tailored for close combat: double edged blade and strong hand guards. Another common way to obtain such blades was to buy them at home during leave, a

[204] Todd, "The Knife and the Club in Trench Warfare, 1914-1918."

[205] "The sharpened spade is a more handy and many-sided weapon; not only can it be used for jabbing a man under the chin, but it is much better for striking with because of its greater weight; and if one hits between the neck and shoulder it easily cleaves as far down as the chest. The bayonet frequently jams on the thrust and then a man has to kick hard on the other fellow's belly to pull it out again; and in the interval he may easily get one himself." Remarque, 48.

detail that again highlights the existence of a market for soldiers even far from the frontline.[206] To consider the knife an innovation in the warfare of the First World War could seem unreasonable. Yet soldiers invested precious time and money in obtaining such an ancient weapon, resources that they could have spent relaxing and recovering from the constant fatigue of surviving.

The German Army in late 1916 issued a standard knife in the officers' equipment, substituting the sword as the symbol of command and courage. Carrying the knife had become evidence of being able to plan and execute tasks that required not only valor, but also entrepreneurship and skill, because it was the weapon of the night raid and trench fight, dreaded activities of war that required strong minds and cool blood. [207]

In Italy the knife, together with the hand-grenade, similarly became the primary symbol of courage. As such it was adopted by the newly formed shock troops, the *Arditi* (the brave men). The institution of the *Arditi* marked a change in structure of the Italian Army, the same change that Germany had with the Stormtroops, although with much less impact on the general conduct of war. The Arditi collected in their ranks people who demonstrated nerve and audacity. These elite, almost fanatical soldiers took great pride in showing off their reliance on their hand grenades and their blades. The knife fit perfectly in the mysticism of violence of these soldiers, a mysticism that was carried on after the war by Fascism. D'Annunzio chiseled its rhetoric with his poetic talent — thankfully his taste for violence does not appeal to most people today. In a letter to a company of *Arditi*

[206] Todd, "The Knife and the Club in Trench Warfare, 1914-1918: 147.
[207] Ibidem, 148.

that invited him to a party, D'Annunzio excused himself for not being able to attend, recounting how "he was very proud to have been consecrated 'Ardito'…by a young captain that gifted me his knife not yet totally clean from Austrian blood…I believe that the Arditi's knife is very thirsty. And I am happy about it. Viva the war!"[208] Exuberance, desire for action, and even joy for going to battle were common among these 'hot heads,' and before an assault they would often take an oath of to win by vowing on the tip of their blades.[209]

The official adoption of knives did not happen only in Italy: the German officer's knife has been discussed already, but all the major armies addressed this issue. Arriving last to the party and with plenty of resources, the American Army could dedicate ample research to the subject. With its first knife, the model 1917, the army adopted the design of a Philadelphia producer: it had a guard to protect the hand and a peculiar blade with a triangular section. It closely resembled an icepick and offered the best possibility to pierce multiple layers of cloth or leather. In the mind of the designer, stabbing was the only task for such weapon; however, the experience of combat proved that this was not the case. For the second knife, unimaginatively named model 1918, the design process changed: the army chose four different knives used on the battlefield by different armies and tested them scientifically with a practical approach. The resulting design appeared to

[208] Quote in: Ferdinando Cordova, *Arditi e Legionari D'Annunziani* (Padova: Marsilio Editore, 1969), 10.

[209] Giorgio Rochat, *Gli Arditi Della Grande Guerra* (Feltrinelli Economica, 1981), 36.

be the best combination of all the tested models; the blade shape was changed and a sturdy brass knuckles substituted the guard.[210]

The army tailored this knife for a veteran, well-trained, and aggressive soldier who used the weapon in dangerous operations, adapting its design to the needs of the soldiers at the front. The perfect knife was a weapon for expert soldiers who were able to fight in a brawl and use the blade in a quick and deadly way; they would have used the knife together with other weapons on the same hand, such as grenades or a gun, because the knife would have been an emergency weapon. Between the first and the second models almost 250,000 pieces were produced before the end of the war, but the government originally ordered 1.2 million of them.[211] The number of pieces ordered is indicative of the importance that the knife had in trench warfare considering also its low cost.

The case of knives in the British Army is much less self-evident. As with all the rest of the armies, the British acknowledged the usefulness of this weapon. In the cramped battleground of a trench, brawls were not so uncommon: to have a knife against an enemy armed only with a rifle and bayonet often meant surviving the day; in a night raid it allowed for silent takedowns. Knives were an obvious solution: they were available on the market, relatively light, compact, and useful as a utility tool for the every-day necessities. Yet the British Army did not issue any. When the institution failed,

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[210] *America's Munitions 1917-1918: Report of Benedict Crowell, the Assistant Secretary of War, Director of Munitions* (U.S. Government Printing Office, 1919), 227–29.

[211] *America's Munitions 1917-1918: Report of Benedict Crowell, Assistant Secretary of War, Director of Munitions* (Washington: Government Printing Office, 1919), 228-29.

soldiers took the initiative buying or making their own knives. In some cases, officers even bought knives and distributed them to the troops.

In 1917 Colonel Sir John Macdonald, in his article *The Knife in Trench Warfare* in the *RUSI Journal*, a magazine distributed widely in the British Army, pleaded:

> It is to be hoped that it may be possible to induce authority not to refuse a real consideration to the question of the trench-knife, which, it is believed, may save many a life and give many a success in the trenches[212]

Macdonald listed a number of reasons why the British army still did not arm their men with knives as the French did: on one hand there is the false idea that the knife would substitute the bayonet, on the other "it involves a style of fighting which is distasteful to the British character." However, he soon after asserted that "stabbing in war is a duty, and not a private wrong." The rest of the article is an interesting but somewhat disturbing list of good reasons to issue an official knife to the soldier. Methodical in his reasoning, Macdonald maintained a scientific and detached tone even when he described the most gruesome scenes, a hint perhaps of how the brutality of the trench brawls had become normal on the frontline.

So how did the army respond to the plea of Macdonald and to the requests of the units? The answer was complete silence. A comparison with the multiple public calls for bids issued by the American Army to find the perfect trench knife makes the silence of the British Army even more deafening. However, even if official blades were not forged, the knife sneaked into manuals and training: manuals of close combat and training in

[212] Col. John Macdonald G.C.B., "The Knife in Trench Warfare," *Royal United Services Institution* LXII, no. 445 (February 1917): 64–69.

1918 showed not only how to properly stab a straw man with a bayonet, but also where to wear and how to use the knife in a one-on-one fight. The British Army did not consider the production of an official knife necessary, probably because the soldiers demonstrated the independence to obtain them by themselves. Energy could be focused elsewhere.

Conclusions

Trench warfare found the armies unprepared. With hindsight, we can see that the signs of change started to appear at least a decade before the war. The new system of combat demolished doctrines and certainties obliging the armies to find a new path but also leaving space for imagining the future of warfare. The process of innovation was not unidirectional and surely did not come solely from the top: institutions, the private sector, civilians at home, and soldiers on the battlefield all influenced the process and were influenced by it at the same time. This complex interaction of different actors, together with the sharp necessities of a war that monopolized the energies of entire nations, created an environment of innovation in which many factors contributed to the survival or extinction of new weapons.

In the United Kingdom the social connections of officers and the self-advertising abilities of company men in many cases influenced the final result of an idea, but the experience built up by the soldiers on the battlefield was one factor in the success, if not the main one. Not all the armies were so open to change in the practice of war. The Italian Army —at least until Caporetto and perhaps with the exception of the *Arditi*, who were not even the best example of successful innovation— offers a good example of a country that did not provide a culture of innovation to help its army keep up with the ever-changing need of modern warfare.

The literacy of a nation was an important factor, not only in terms of its impact on the ability of soldiers to be trained well and kept up-to-date with the latest doctrines, but also in a more practical, industrial way: a nation with engineers, metalworkers, and problem solvers would have responded better to the challenge of modern warfare than a nation of farmers.

Surely the British officer corps contained the people with more knowledge and means to influence the direction of change, but the common soldiers did not passively accept the situation. They devised or improvised new solutions, sometimes despite the apparent unresponsiveness of the institutions. Behind an apparent silence there was often an industrious activity to solve the problem, with an army that was scrambling against a lack of resources, challenges of production, and design defects that required time to be solved. For the combatants in the trenches there was no time to waste; instead of waiting for new tools or techniques from above, they often pushed for change and found new solutions to their everyday challenges.

CHAPTER 5. DOCTRINE FROM THE BATTLEFIELD: THE NEW DISCIPLINE OF SNIPING

It is often difficult to make a direct connection between the knowledge developed on the frontline and the final result of a doctrine for the whole army. Fortunately, in the case of sniping we can follow the process along all its path. Being an invention of trench warfare, modern sniping serves as a useful test to understand the interaction between the British soldiers and the institutions of the army. In this case, the clear importance emerges of the mid-level officer expert, who was able to understand the details of the discipline and recognize the potential of new techniques invented in the frontline, while at the same time could talk to the decision-makers and convince them to adopt them in the general doctrine of the army.

The experience of sniping

At the start of the war, 'sniper' was not an official military term. It seems that the word originated in India, where a small bird called Snipe was the unfortunate target for shooting show-offs of the British troops. The term had become of common use during the Second Boer War, when the Boers demonstrated the devastating effectiveness of the new rifles when used by skilled shooters. Before the diffusion of the term and concept of a sniper, marksmen and sharpshooter were the commonly used words, but referred to no more than soldiers with particular skills with rifles, sometimes equipped with scopes. Often their skills were used in battle against "sensitive targets" such as officers.[213] By the

[213] Glenn Wahlert and Russell Linwood, *One Shot Kills: A History Of Australia Army Sniping*, Australian Army Combat Support Series 2 (Newport, N.S.W: Big Sky Publishing, 2014), 1.

end of the war, every soldier knew what a sniper was, and his role acquired more competencies than simple marksmanship: they were expert in reconnaissance, camouflage, and tactical intelligence. Even the people at home were used to this new term from reading about it and seeing photos of snipers in magazines and newspapers.[214]

In four years of war, snipers became one of the most dreaded terrors of the soldiers in the front line. While artillery rained destruction with a great and terrible show, snipers offered a sudden, almost silent and surgical violence that threatened anyone that made the mistake of showing a part of his body to the enemy. In early 1915, a single battalion lost eighteen men in a single day to enemy snipers.[215] They also became the eyes of the infantry on no man's land: while every soldier sought to remain unseen deep down in the trenches, snipers were usually the ones taking watch. Their job was a dangerous one, and throughout the war snipers developed new techniques, contraptions, and ideas to survive their deadly lifestyle.

Technology allowed for the development of this new role: modern rifles offered range and precision, while optics magnified the targets to the point that one could aim at objects that were only a few inches wide. Optical magnification also meant that snipers could control the battlefield from their hidden observation posts, adding an important

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214 Despite the impact that snipers had on trench warfare and their continual presence in the armies from then on, the historiography is short and often covered. For a general history of sniping: Glenn Wahlert and Russell Linwood, *One Shot Kills: A History Of Australia Army Sniping*, Australian Army Combat Support Series 2 (Newport, N.S.W: Big Sky Publishing, 2014); Martin Pegler, *Out of Nowhere: A History of the Military Sniper* (Oxford: Osprey, 2004). Some historians investigated the psychological impact of sniping: Edgar Jones, "The Psychology of Killing: The Combat Experience of British Soldiers during the First World War," *Journal of Contemporary History* 41, no. 2 (April 1, 2006): 229–46; Joanna Bourke, *An Intimate History of Killing: Face-to-Face Killing in Twentieth-Century Warfare* (London: Granta Publications, 1999).

215 Major H. Hesketh Prichard, *Sniping in France* (New York: E. P. Dutton and Co., 1920),2.

perspective to the collective effort of gathering information on the enemy movements and systems of defense. The new possibilities were self-evident to the point that every army that fought in the war had, in one form or another, soldiers dedicated to this task. As was the case with maps however, opportunity to change does not automatically equate with actual innovation. To be effective on a large scale, sniping had to be a system, and the shape of this system depended on the continuous dialogue between the different actors on the scene. Indeed their role at the end of the war was more than to harass the enemy and contribute to the war of attrition; snipers carved out their niche both as fighting specialists, either in the assault or in the defense, and as reconnaissance teams working both solo and in pairs with techniques that are still in use in the modern armies.

The General Headquarters (GHQ), the soldiers on the front line, private citizens at home —trying to contribute with their ingenuity to the war effort by patenting a myriad of new inventions — and instructors in the army's sniping schools all participated to shaping this new system of practices around the new technology. There is, however, an important detail to take into account: sniping started as a practice of the soldiers and permeated the impervious bureaucratic paths of the army under a pressure from below exercised by the troops on the front line. Only after two full years of this pressure did the discipline become official and obtain a standard.

At the start of the war, armies did not train snipers; units relied on the initiative of the soldiers. In Germany, the Duke of Ratibor collected all the Mauser hunting rifles equipped with telescopic sights that could be found on the market and distributed them to the troops, especially gamekeepers.[216] On the British side, no big name provided equipment: innovation came directly from the troops. As on the German side, hunters were for obvious reasons the ones who started the trend: they simply applied to the enemy the patience and skills refined in years of stalking their prey. The Canadians and Highland regiments had more soldiers with the necessary background and therefore led the way.

In an article on snipers in the *English Review*, Major E. Pemberthy recollected two colorful episodes that could well describe this pioneering time. In the first, a major, frustrated by the efficacy of a German sniper, went to a cook, "a man noted for his marksmanship and a winner of the D.C.M. [Distinguished Conduct Medal] in South Africa" and asked him to get rid of the problem, which he solved in twenty minutes. In the second example, Pemberthy recalls "one of the finest snipers I ever met, …a full-blooded Red Indian — John Ballantyne…he had been known to wait patiently for seven days in a wonderfully prepared and concealed sniper's post for a valuable target — a Hun officer, whom he finally killed." In both cases the distinctive character of the two soldiers, one a simple cook, the other a skilled hunter of the Canadian forests, were obviously of literary value for the entertainment of the *English Review*'s reader. The author illustrated a grass-roots movement that adapted tactics to the new environment of trench warfare through the personal experience and initiative of individual soldiers. This change was not limited to tactics, however, because "many privately owned weapons

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[216] "The Hun's hunting," *Arms and the Man: The Official Organ of the National Rifle Association of America* LXIV, no. 8 (May 18, 1918). The fact is confirmed by Hesketh-Prichard, *Sniping in France*, 165.

began to appear in the trenches — sporting rifles of various patterns and caliber." The soldiers on the ground were expressing the need for a different approach and new tools.[217] Despite this, there was not yet a connection between the experience on the ground and the world of doctrine and bureaucracy of the army. This connection was made by important bridge figures, usually captains and majors, soldiers connected with the every-day experience of the trenches who were also able to navigate the labyrinthine and class-oriented organization of the British Army; men able to reach keen ears.

Hunting or outdoor experience was a common trait of two of these middlemen: Hesketh-Prichard had the hobby of big game hunting while F.M. Crum was a Boy Scouts enthusiast. Prichard was a staff captain and he used his connections in the division to push the idea of setting up a training system for snipers. He went against the conservative environment of the army, even accepting a reduced pay, to be able to leave the headquarters and go around in the trenches to fix unaligned scopes, assess the problems, and teach shooting techniques. He then started a school to teach officers and snipers of the Third Army, but remained in a "regulatory limbo" for more than a year, often dealing with the constant problems deriving from his not-officially authorized position, a situation that ended with the official opening of the school at the end of November of 1916.[218]

Major Crum at the start of the war was a 42-year old veteran of the Boer War, experienced but vexed by old war wounds. For this reason, in 1910 he resigned from the

[217] E. Penberthy, "British Snipers," *The English Review*, September 1920, 234–39.
[218] Hesketh-Prichard, *Sniping in France*, 76.

army and entered the Boy Scouts. He was in Scotland organizing summer camps for this organization when the war broke out. He then re-joined the army as a volunteer. For one year, from May 1915 to May 1916, he honed his knowledge of trench warfare as a second in command of the 8th King's Royal Rifles Battalion. In July 1915, he met Sergeant Forbes of the 4th Gordons, who, in one of what he recollected as his "best days I spent during the war", introduced him to sniping. "From that time onward I was sniping mad," he wrote in his memoirs. He thereafter spent most of his time managing the snipers of the battalion and sniping himself. In May 1916, he started a Brigade School of Sniping in Acq, where he taught for one year. In April 1917, the GHQ in France invited him as a "Scouting and Sniping Expert" to help organize a uniform system of regulations for sniping throughout the five armies.[219]

There are some noteworthy commonalities between these two important figures: they both had ranks that allowed them a certain degree of freedom but that kept them in constant contact with the reality of the front line. They both had their troubles with the organization of the army: the first for not having a definite position, and Crum for his constant harassing GHQ in asking for a systemic organization of the training of snipers and observers. Lastly but perhaps most importantly, they were both great enthusiasts that respected the experience of their subordinates and took great personal risks, therefore increasing their experience on the matter in a practical —if dangerous — way.

[219] Crum, *With Riflemen, Scouts and Snipers from 1914 to 1919*.

However great is the importance of these two figures and their influence over the development of sniping in the British Army, it would be inaccurate to think that they were its "inventors." The idea that an individual or even a small group of people developed the techniques and the tools of such a complex 'art' evaporates as soon as we consider that such techniques matured at the same time in a similar fashion in different armies, with comparable results but different paths. In the French Army sniping was not a special department. Crum once remembered how difficult it had been in a conversation with a French officer—with his clumsy knowledge of the language— to even translate what his work entailed. However, he and the French soldier eventually found a common ground around the word "*guetteur*" [observer, spotter]. The French *guetteur* was not only observing the enemy however, which became clear from their brief encounter. In the exchange of courtesies and boasts common when members of allied armies meet, Crum was introduced to a private who had become famous for killing two Germans with a single shot. To satisfy the curiosity of the British major, the French marksmen led him to the spot where he made the shot, the roof of a tall ruined house 50 meters from the enemy lines. This therefore was not the occasional kill of a simple soldier in the trenches, but the deliberate act of a skilled hunter who chose his spot carefully with the intent of killing enemies: indeed, a sniper.[220]

Sniping was a crowd-sourced project. The precision of the modern rifle and the magnification of the optics were enablers, while figures such as Crum and Prichard were the ones that aggregated the collective experience and shared it with the armies. The only

[220] Crum, 77.

path to innovation in sniping was practice. Men with experience, such as gamekeepers and big game hunters, led the way, such as many of the *Jäger* battalions on the German side, which were infamous among the British troops. “Sniping in a dangerous sector — and there were many of these — was really neither more nor less than a very high-class form of big game shooting, in which the quarry shot back,” which was no secondary detail. [221]

This constant duel between snipers and their targets —often other snipers— was extremely dangerous but necessary. There was not much of a choice: not participating to the sniping duels meant not only to lose a dear amount of men, but also surrender to the enemy the surveillance and information-gathering on the ground. Snipers had a fundamental role in trench warfare. Outside of trench raids and conventional attacks, which were relatively rare occurrences in the units’ time on the first line, there were two main causes of death: artillery and snipers. Of the two, artillery was the major threat, able to reach well beyond the first lines and capable of causing havoc among soldiers in the trenches or, in the case of heavy artillery, killing or burying alive even the ones well-hidden down in dug-outs. Snipers, however, were the real reason everyone stayed constantly hidden in the trenches: while artillery very politely announced in advance that destruction was coming, to the point that experienced ears could understand from the pitch of the whistle that the shell made in the air if they were in danger or not, the death from a sniper was sudden and unexpected, almost unsportsmanlike. They controlled

[221] H. Hesketh-Prichard, *Sniping in France: with the British Army During the First World War* (New York: E. P. Dutton and Company, 1920), 37.

every inch of the front line and a careless exposure of any part of the body was an invitation for a bullet.

In the novelized memoirs of Frederick Sleath, *Sniper Jackson*, a book that Crum suggested to his readers if they wanted to get an idea of what actual sniping was, the author described an amazing shot made by one of the most experienced members of the sniper team. The day was hot and clear, an ideal day for sniping, and therefore the worse for it, because the enemy would have been paying exceptional attention to his movements, preferring the safe and cooler bottom of the trenches. In the silence of the line, a single noise disturbed the quiet: the rhythmic hammering of a mallet: the Germans were fixing the trenches. They were working in a section that was shallower than the rest and the hammer was popping out of the line of sandbags. The more they were going on, the more the hammer was showing. Eventually the big hand of what seemed to be a very large soldier started to show against the sky. The sniper officer was wondering what a good target his head would have been, "he'd made a rare target"— a comment that shows how sniping was naturally connected to hunting and its desire for trophies. While the officer indulged in such thoughts, the old and experienced NCO on duty with him disappeared. The soldier came back with the best shot of the sniper team. The new arrival quietly gauged the distance, took his time to enter in the rhythm of the moving hand, and hit the hand on the move. We don't know if the episode was a real memory, but even if it is a tale, like the old mythologies it teaches us a lesson, a dogma vital in the life of the trenches: don't show yourself to the enemy, not even for a fraction of a second.[222]

It remained common for snipers to be relatively free to roam in a sector, creating troubles for the enemy or solving them for their mates. In his vivid memories, Private P. R. Hall recollected his first action as a sniper. His unit suffered 17 kills in a week or two, all in one section of a communication trench. His Intelligence Officer, Captain Blainey, said to Hall, "You are my best shot – what are you going to do about it?" Hall had already thought about the problem, and after "taking bearings" along the problematic area of their sector reached the conclusion that the hidden loophole had to be from a specific direction. He then carefully inspected this imaginary line with binoculars and found a slight rise on the ground. He determined that it was the only location to place and hide a sniping plate: this was a thick shield of steel with a loophole, used to protect sentries and snipers from the enemy's bullets, which could pass through sandbags and hit the men behind.

He had in mind a very specific plan to take the shot without risking too much. He organized a couple of fixed rifles in the British trenches near the area where he thought the enemy sniper's lair might be. He then instructed a couple of soldiers to fire them ten minutes after he left for no man's land, taking care to wait a few minutes between each shot. These shots were the hunter's bait to lure out the enemy's sniper to his shooting spot. He had dug a shallow ditch to pass unobserved from an old German communication

[222] Frederick Sleath, *Sniper Jackson* (Boston: Houghton Mifflin Co., 1919), 122–24.

trench to a large shell hole right in front of the German parapet, a place that offered a clean sideview of where the enemy sniper was shooting from. At dawn he went out, and when the sniper was lured out by the firing, he shot him.[223]

Many memoirs of snipers, especially the novelized ones such as *Sniper Jackson,* focused heavily on the duels between snipers. The fair competition, the preparation of ruses, and the dangers of such episodes made them memorable for snipers. The many kills of regular soldiers, easy targets for these skilled marksmen, remained often unrecounted. On the other side of the trajectory of their bullets, the victims and their comrades had much stronger experiences. Private Harold Bashford, interviewed on his memories of war, could not hide the emotions in recollecting what it meant to be the target. It was a bleak morning and they were in a desolate area, where the destruction of recent bombardments made it very difficult to recognize your own positions from enemy ones. He was behind his officer, who was observing the enemy's line with binoculars. Suddenly, without hearing the shot, the officer's helmet flew above his head. He noticed that right in the center of the helmet there was a hole; the officer collapsed in front of him. "It was a mystery where the shot came from, and this was reflected on the young officer's face as he died. That puzzled look will stay with me until the end of my days…it was terrible." The old emotions surfaced again in the interview: the old man paused a while, and with a broken voice excused himself with a dignity that many veterans show when dealing with such suffering memories. He then explained that "it's a well-known fact that snipers, if they had the choice, would take an officer in place of other ranks. The

[223] "Private Papers of P. R. Hall, Imperial War Museum."

fact that he was using binoculars notched him down in preference to me. Such is fate." The distinct feeling of the terror of a silent and sudden death was still alive in him after many years, probably compounded with the guilt of being the one still alive.[224]

Shooting was forbidden in well-placed and carefully camouflaged observation positions from advantageous points, because the information that they could provide was more important than any single kill. Details and observation were paramount in trench warfare. Hesketh-Prichard dedicated an entire chapter to describing an episode that illustrated how a trained sniper could be useful even without a rifle. Soldiers on guard in an observation post spotted a cat that was sunbathing on the parapet of the enemy's trenches. When the officer responsible of the observation post came in to check the situation and asked if everything was OK, the two observers reported that for fun they noted on the log the position of the "Hun cat". Reading the log, the officer noticed that in the past days the cat had been reported multiple times. In the British trenches there was an infestation of rats at the time, perhaps the Germans had the same problem. A cat would have been a luxury for any dug-out in that situation and therefore the spot probably deserved more consideration.

The officer thought that, even if it was a very long shot, it was worth the try; he contacted the Intelligence, asking for a new aerial photograph of the cat's home; since he knew that a cat probably would have not been considered a worthy subject of such a great risk he asked for it to be done on his personal responsibility. The Intelligence officer

[224] "Bashford, Harold (Oral History)." Imperial War Museums. Accessed July 11, 2018. http://www.iwm.org.uk/collections/item/object/80009770.

trusted him and ordered a recon with detailed photographs. A few days later a precision bombardment of heavy artillery erased the area. The cat fortunately survived, undoubtedly spending one of his many lives, but many Germans were not that lucky, dying in the explosions that destroyed a newly built headquarters. The episode, reported quoting names and official reports of the event, describes a high complexity of inter-army cooperation: the Intelligence officer's trust in the observer team permitted the planning of a dangerous operation of aerial recon; after the recon, highly specialized Intelligence officers would have interpreted the photographs checking every detail to understand what was behind the cat's favorite spot; eventually the artillery officers would have calculated the trajectory and destroyed the objective with precision. Between the observation through the lenses of the stalking scope and the explosions of the projectiles on the enemy HQ lay a chain of highly skilled and autonomous field officers and NCOs who interpreted and analyzed the situation. The observer officer put his reputation at stake asking for blind trust and the intelligence officer did the same in ordering the recon. Both officers did not follow regulations choosing to take personal disciplinary risk to achieve an objective. All this complex inter-army ballet started from the apparently mundane observation of a cat on the parapet.

Snipers observed most of the time, but when the occasion arose, they were supposed to be cold killers. They had to be deliberate and reasoned: if everything was done by the book there was no heat of the action blurring their emotions. To obtain this state of mind, propaganda was a useful tool. "There were also those who preached the doctrine of 'Hate,' but wiser men preferred to leave the 'Hymn of Hate' to the Hun," described Crum in his memoirs, conforming to the propagandistic idea that only the enemy was petty and immoral. "And yet, though it may seem strange reading and ill to reconcile with Christian teaching, there was a time when it became an urgent necessity to preach the duty of killing." Crum uses the word duty to contrast with a more immoral 'Hun' doctrine, a difference that hides the horrible reality of murder behind an artificial moral high ground. This distinction followed the basic rules of propaganda so common in every war, and Crum wrote them down transparently and with emphasis in the following paragraph, in which he dutifully described the average British soldier as a "good-natured civilian dressed in khaki," that didn't realize that "the Hun, so seldom seen, [was] a foe filled up to the brim with hate, and trained to kill by masters in the art of war." Here it is, the evil German.[225]

Private Hall, writing his memoirs after the Second World War, had similar thoughts, but came to different conclusions: "I have often speculated about the differences between the Germans of the First World War, the Nazis, and ourselves; and what relation this had to the Germans being the mercenaries of Europe for a long time in the Middle Ages. The Jerries of our war were perhaps more like our-selves with a slight if somewhat grim sense of humour." He described how an enemy machine gun one night "opened up tapping out with his gun the rhythm of "Take me back to dear old Blighty…[provoking] rousing cheer from our side."[226] They were Germans, but they

[225] Crum, *With Riflemen, Scouts and Snipers from 1914 to 1919*, 41.
[226] "Private Papers of P R Hall," 10.

were not Nazis: apparently more recent horrors mitigated the judgment over the old enemies.

However bad the Germans were, in both these memories there is a background of respect or even camaraderie for the "masters in the art of war" that continued the long tradition of being the professional soldiers of Europe. Sniping was always putting the soldiers on this unstable balance between hate and admiration for the enemy, especially if on the other side there was an enemy sniper who demonstrated courage and skill. Hesketh-Prichard described these emotions in one of his most catching chapters titled "Wilibald the Hun," assuring that the story was true and not an imaginary example. Wilibald was the name that the British soldiers of a certain sector gave to a very effective enemy sniper. He showed exceptional skills, hitting constantly the small hole of an observation point and killing more than 20 men in the sector. Prichard explained that to give a nickname was a common occurrence. It laureled the ones that demonstrated "personality," renaming them from a generic 'Fritz,' to more specific monikers such as 'Old Seven-threes,' 'Bluebeard,' or indeed Wilibald. One British sniper, 'Red,' became obsessed with him and eventually with a ruse and a good deal of deduction was able to find his position. What gave away the well-hidden spot of the German was the chilly air of the early morning. Red knew that the gas from a rifle shot hang on a little longer in cold air. One day he lured Wilibald to shoot just after dawn and from a vantage point spotted the faint trace of smoke left by his rifle. To the general surprise and admiration of the British, Wilibald crawled every early morning to a little ditch he made between some turnips that grew near the remnants of a house less than 70 yards from the British trenches. To hide himself better he even tied turnip tops to his cap. The sniper and his commanding officer decided to organize a patrol that crawled out in no man's land during the night and waited to capture the "pretty gallant fellow" on his commute to his hunting spot. The excuse was for "purposes of identification," a very generous alternative to being simply killed. Surely the respect inspired by his actions played a decisive role in saving Wilibald's life.[227]

Sometimes hatred between the two sides of no-man's land was enhanced by misunderstandings, which created a series of myths about the enemy, tales shared by the soldiers, which were often groundless or inflated by the natural rules of the word-of-mouth and storytelling. Paul Fussell and J.M. Winter collected these stories, such as crucified soldiers and bayonets blades modified with a saw profile to add gratuitous pain to the victims; snipers had their own tales.[228]

One of these myths is directly connected with the most horrible side of their job. Snipers suffered a great number of casualties, and in most of the cases the victim was shot in his own trench. In case of non-lethal wounds the fact that the victim was on friendly terrain made the trip to the dressing station easier and safer, but whenever the wound was deadly it often forced the comrades of the victim to see a very grim show: "a bullet sang between officer and sergeant. Their companion slid down into the bottom of the trench with a hole in his head into which a man could have put his fist. His brains were on the parados; yet he lived for three hours. 'Tampered bullet,' said the sergeant

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[227] Major H. Hesketh Prichard, *Sniping in France*, 164–75.
[228] Fussell and Winter, *The Great War and Modern Memory*, 123–27.

curtly." From their perspective such a devastating wound was the effect of bullets that the enemy modified to create untreatable wounds. Fussell explained well how there was no need to modify a bullet, this kind of wounds are unfortunately common when a high velocity bullet such as the one used in the war hits a human body. In the harsh reality of war, the fact that this was a lie was unimportant, because it helped the soldiers to frame the enemy as cruel and vile. The spectator of the devastating headshot "had learnt his lesson. The casualty had revealed to him the unscrupulous brutality of the men who were his foes." The myth had served its purpose of spreading the "doctrine of Hate."[229]

Such a lesson, even when drawn from false pretenses, was almost necessary for such a job. The narrative of the above episode follows all the common paradigms of the rite of passage: the young officer doesn't yet believe in the evil schemes of the enemy and hesitates in aggressively pursuing the kill, while the old and experienced fellow sniper ruthlessly takes the shot and adds another notch on his list of kills; after the horrible spectacle of death, remorse is left behind as an old ghost of an once civilized, past life, enabling him to do his job efficiently.

Such difficulty to kill is human — one hopes — especially with the practice of sniping where the stalking, the active search for victims, and the magnification of the sniper scope made the killing personal. Not everyone chose to kill, and soldiers that did not receive specific training and were not accustomed to this kind of killing could be caught in the ethical dilemma. Emilio Lussu vividly recounted this experience. He was

[229] Sleath, *Sniper Jackson*, 59.

not a sniper, and he hesitated to kill in such an almost cold-blooded fashion. Hidden behind a bush in the shallow, swiftly-dug ditch in no man's land that offered a clear enfilade view of a section of the enemy trenches, Lussu watched an enemy officer through his sight. It was a rare opportunity for an infantry soldier to see the enemy, they spent their days hidden in the trenches as their enemy were doing and to be in a position from which you could see the enemy often meant that he could see you and shoot; after days spent organizing the feat and a cold night of waiting, he observed the morning corvée and soldiers awakening in the cold dawn. The officer was a perfect target: sixty feet away and visible from head to boots, he was unaware of the danger. Lussu almost squeezed the trigger when the young Austrian officer took a packet of cigarettes from his pocket and lit one. It was the morning cigarette, a ritual that Lussu shared with his target: this simple link transformed the enemy into a man. Lussu did not shoot. In front of him he could not recognize an enemy, but only a man. In the confused brawl between two parts of his conscience, he felt that to kill a man like that, like an animal, was not war but murder. He was not a pacifist, for throughout the war he killed multiple times. He was a man of action, who after the war carried a gun for self-defense against the fascist squadristi and used it, killing one of them when attacked. But he did not kill that time.[230]

All these examples show us that in the trenches the life of the snipers was slightly different from the one of their fellow soldiers. The sole fact that they were for the most part the only people to dare to watch the enemy lines daily —not to speak of their habits

[230] Emilio Lussu, *Un Anno Sull'altipiano*, 19. ed., Einaudi Tascabili (Torino: Einaudi, 2014), 128-31.

of sneaking out of the trenches to occupy positions in the middle of no man's land—implied that to be a sniper a soldier needed a specific kind of character: aggressive to do the job, yet steady and reasoned to survive it. Most of the snipers were volunteers, rarely appointed against their will, because it was such an important role that it would have been counterproductive to have un-enthusiastic soldiers doing it.

Being a sniper also had some positive sides, like some degree of freedom: "I was free to pick my own position and shoot any Germans I saw," remembered Private Barlow "in this way I visited all parts of the line and back areas and I was able to supplement my rations with visits to the Cook Houses." Most of the time it also meant that you were free from the common building of corvées that bothered so much the life of the soldiers in the trenches.[231] The 'privilege' of snipers, however, was a myth. Herbert W. McBride, a U.S. citizen that volunteered in the Canadian Army at the start of the war, was a machine gunner that despite his troubled character arose from private to the rank of captain. He was also an enthusiast self-taught sniper, he loved guns and defined sniping as his "fun." However, he did not sugar-coat it: "it's just a lot of extra work and misery for the sniper, that's what. So, if you are looking for a soft job in the dugouts, take up something besides sniping."[232] To not consider the danger, which mavericks such as McBride perhaps did not ponder much, but most soldiers did.

[231] "Private Papers of K T Barlow, Imperial War Museum."
[232] Herbert W. McBride, *A Rifleman Went to War* (Mt. Ida, Ark: Lancer Militaria, 1987), 301–2.

The Development of Sniping Throughout the War

At the start of the war there were no rules to select, equip, organize, and lead the snipers of the battalions, but the needs of trench warfare, to which no army was still even remotely adapted, soon compelled the armies to select men for this task. The quality as a marksman was a necessary requirement, but enthusiasm was often enough. Private Clarke, who enlisted a few months before the start of the hostility in January 1914 and fortuitously survived the early slaughters, volunteered to train as a bomber in the first months of 1915 when the army acknowledged the necessity to have soldiers specialized in using hand-grenades in battle. He remembered the horrible experience of the early trenches, often too shallow and precariously positioned against better German ones, chosen carefully on higher ground. He thought that the Germans had a definite advantage and had the opinion that "when they dug in at the end of 1914, that was the kind of war they wanted. We had never trained for trench warfare … [and they had] snipers with telescopic sights – we had none". The Germans did not want trench warfare as Clarke thought, but it is a vastly shared opinion that they adapted to it faster than the British. However, they did not passively accept this disadvantage, nor did Clarke. One day, after moving to Neuve Chappelle, he had been sent to HQ when he met Sgt. Major Lee, an older soldier that at sixty years old was considered "the Father of the Regiment." He wanted him to try "a new gadget" —what seems like an early version of a sniperscope. This was a frame that held the rifle well above the line of sight of the shooter, who aimed through a periscope and could therefore fire the weapon remaining well below the parapet. He tried it, liked it even if with some reserve, and became de-facto the first sniper of the 2nd Northants Regiment.

Not much later the HQ of the Regiment gave him four sniper rifles with scopes, promoted him to lance corporal (L/Cpl), and ordered him and a fellow L/Cpl to organize a team of ten snipers. Each company had to provide two marksmen or first-class shots, eight men total. The new rifles surprised Clarke, who finally could understand what kind of advantage the Germans had: "no wonder they always picked our officers off. You could see if a soldier wanted a shave at 400 yards."[233]

The first half of 1915 was the formative moment for sniping in the British Army. After months of losses between the ranks thanks to the early adoption of scopes in the German Army, scoped rifles started to arrive in the hands of the British soldiers on the front line. As it often happens with technology, the new tools by themselves, even if prodigious as Clarke remembered, could not change the war. Even an airplane without a pilot is only a big piece of metal. Optical magnification for sniper rifles is a very delicate matter. To shoot accurately one does not only need the qualities of a marksmen, but also the technical knowledge necessary to correct misalignment of the scope, a problem that could make the rifle worse than without a scope, because the shooter then fired always aiming at the wrong target even at short distance. This apparently small technicality represented a great problem, and one that could easily pass unrecognized.

[233] "Private Papers of E. A. Clarke, Imperial War Museum."

GHQ understood the necessity to distribute scoped rifles but had yet to realize that there was still a problem, which required the right men to fix. Hesketh-Prichard was one of them. He was in a good position to recognize the mistake, but not in the best to solve it. When he reached the front line in May 1915, he was attached to the Intelligence Department as an officer in charge of war-correspondents, a job that allowed him to visit freely all parts of the front line. As a big game hunter, whenever he went to the trenches he carried with him one of his own scoped rifles that he brought from England. Such weapons always intrigued "brigades and battalions [which] were soon applying to me to lend these rifles." In one visit to the trenches, he found a soldier shooting from the parapet near a "smart notice board on which was painted the word 'sniper'". Obviously interested in the matter, he started to talk to the soldier, but when he showed Prichard his abilities, the officer noticed that the soldier was consistently shooting six feet to the left of the iron plate that he was aiming for six hundred yards away. And yet, the soldier thought that he was consistently hitting the loophole of the plate![234]

From this recollection we can understand two important things: first, Hesketh-Prichard and the officers were not 'inventors' in the common meaning of the term — sniping was already a practice when Prichard started with the discipline; second, many British snipers in 1915 had the technology, but not the technique. Both observations are important for us in understanding who had the agency in developing sniping during the war. With a superficial analysis, making a direct parallel between doctrine and development, the answer would be that the directives came from the top. In a way this is

[234] Major H. Hesketh Prichard, *Sniping in France*, 3.

true, even more so in a rigid organization such as an army. An additional proof of this theory is that at the start of the war, when there were no directives from the top, sniping was not 'homogeneous' and confusion and mistakes such as the one described by Prichard were basically the norm.

However, to follow this logic, we could only say that the true start of sniping in the British Army was in late 1917, when the official *SS 195* pamphlet for snipers and observers came off the press, creating a uniform 'tactical doctrine.' Even if we relax our parameters and we decide that sniping was born with the start of the special training schools in the winter of 1915-16 —more on this later— we would stumble on the fact that these school were all teaching with different mindsets and syllabi, because they were not a reflection of the will of GHQ, but experiments of single armies or divisions. The problem here is a matter of perspective: often doctrine means a set of rules imposed after study and testing from the top to help standardize tactics and guide officers and men in the accomplishment of their objectives. Sniping offers a perfect example of how this perspective is at least very partial, and in this case, I would argue, simply wrong: sniping on the western front started in 1914, was a consolidated reality in 1915, was taught in schools in 1916, and was somewhat codified in 1917. The evolution of this practice was not imposed from the top but lobbied for from the bottom.

Personalities such as Major Crum and Captain (later Major) Hesketh-Prichard were the heralds of this pressure from below, but we would commit a great injustice if we considered that only these officers and middle men were the 'inventors.' Firstly, it would be a misleading British-centric perspective: first and foremost the Germans fully developed this discipline and the French created dedicated sniping schools and used snipers to devastating effects during the battle of Verdun and in the forests of the Argonne in 1918.[235] Second, even considering only the British Army, these two men were synthesizers, not inventors. Crum and Prichard surely made a difference, but they did so by collecting the ideas developed on the ground by individual, inventive soldiers that constantly tried to win the daily battles against enemy snipers. The price of failure for these 'original inventors' was often death, and their 'inventions' were often mere refinements of old techniques or cautious steps forward in the art of sniping. All these steps eventually were codified in the *SS 195* and redistributed to the rest of the army. The point here is that sniping was a system of technology that developed organically, influenced by different sides from various actors: the soldier on the front line, the instructors in the schools, private citizens inventors, and eventually the GHQ with the adoption of the techniques that survived the enemy and their transformation into practice, training, and organization of the army.

One example of how soldiers participated from the bottom to the development of sniping is camouflage. In comparison with the development of rifling and optics, which required precision tools and technical knowledge usually out of the reach of the common soldier, the creation of new camouflage techniques needed only basic materials, keen observation, and imagination. Sometimes it was something as simple as a big piece of canvas: "he had a rifle and a bayonet with him, and a large square of sacking big enough to cover him and his equipment completely. The outside of the sacking had been

[235] Pegler, Martin. "French Sniping." In *Sniping in the Great War*. Pen and Sword, 2008.

carefully caked with mud, so that a man could lie under it as securely hidden as though earth indeed had been used to cover him," something like the elfish cloak used by Frodo in Lord of the Rings. "It was the sergeant's idea, tested on several occasions with complete success."[236]

Even when the invention and creation of the camouflage was not 'from scratch' it often required some craftiness and imagination from the sniper. Private Hall once found a smashed house with a coal cellar in no man's land, on the Broodesinde ridge. The 45-degree chute used to refill the cellar offered a perfect view on the town of Roulers eight miles away, which was a major road junction. The location would have been perfect for an observation post to control and report the German movements in the town to the artillery. "I managed to conceal the opening with a six-foot length of 2-inch chicken wire which had been dragged through the mud to give it the appearance of the surrounding ground. Then I installed a four-foot telescope focussed on the square in the centre."[237] This episode happened in the winter of 1917 during the battle of Passchendaele. Hall did not have to invent anything new, he was even provided with the necessary material by the army; however, improvisation and a keen attention to details was key in camouflaging locations near the trenches or in no-man's land, for the obvious reason that every location was different and the contraption had to adapt to the surroundings without raising any suspicion. A mere standard-issue mimetic cloth would have not served well in this situation.

[236] Sleath, *Sniper Jackson*, 120.
[237] "Private Papers of P. R. Hall, Imperial War Museum."

As we saw in chapters 1 and 3, in 1917 camouflaging had become a common tool for the army, and almost second nature in the daily routine for a sniper/observer such as Hall. It was an essential trait of trench warfare, and the Royal Engineers already provided ‘advanced materials’ for this task such as chicken wire and pre-fabricated mobile hidden observation stations. The RE had a specific section dedicated to the construction of complicated camouflages and the provision of material to the troops. During the war the army provided more than six million square yards of chicken wire, in addition to 7.4 million square yards of fish netting and almost one million square yards of painted canvas sheets.[238]

Even if the question might sound trivial, why carry a bulky chicken wire instead of a much more comfortable canvas or camouflage net? These kinds of details however were not trivial for snipers, as their lives relied on the correct choice of material for their work. In this case chicken wire could be sculpted to adapt to the surroundings and more importantly did not flap around with the wind. Simple choices such as this were almost automatic in 1917, and this natural response came from lessons learned on the ground in the previous years, often at high price.

Private Clarke remembered one occasion in which his battalion moved to a section of trenches in which they had never been. It was almost the end of 1916 and the state of the sniping posts in these trenches was abysmal. There were no plated loopholes and instead “all it had to cover the sniping hole was some bully beef tins. I kept my head

[238] *Miscellaneous*, vol. 3, 9 vols., Work of the Royal Engineers in the European War, 1914-19. (Chatham, Kent, 1921), 149.

down and moved two of the tins so as to show a light through, then I put them back and waited. I was doing the same again when a shot came through the hole. We found two more just the same. They would have meant three snipers less." Clarke described the episode as one of "what you'd call premonitions […] many a time I've heard our men telling one another if they'd have done this or that they were certain they would have been killed." What Clarke called premonitions, I would call experience, the kind of experience that you gain through a dreadful process of natural selection.

This selection was not unique for snipers, and not even unique of this war; it is part of the natural progression from 'green recruit' to 'hardened veteran.' However, soldiers could not be let alone to learn from their mistakes; the price in lives would have been a terrible waste even for the incredibly low consideration of human life imposed by such grueling war. Soldiers needed education and training.

Sniping Schools

Sniping schools were the first official answer —at army and division level— to the pressure from below. Crum and Prichard started to lead structures for which formation they lobbied before. These schools remained adaptable and well connected to the reality of trench warfare. Private publications describing the techniques of sniping were printed and sold.[239] Only later, after continual lobbying from below, did GHQ acknowledge the need of standardization, and authorize the production of official

[239] Martin Pegler, *Out of Nowhere: A History of the Military Sniper* (Oxford: Osprey, 2004), 153.

pamphlets and manuals to be printed by the Stationary Service in France and distributed in great numbers to the troops.

Chapter 3 is devoted to the creation and management of schools and to the circulation of knowledge through official and unofficial publications, but it is important to focus here on how the sniping schools channeled the development of technology. The raw material, the proactive soldiers that volunteered to be snipers, often without the basic knowledge necessary for their tasks, could not simply be tested in the trenches to see if they were fit for the job. The numbers of kills they reported could not be verified, and some boasting soldiers even caused irritation in the higher ranks: a Brigadier, annoyed by a vocal sniper that with sometimes pompous eloquence reported incredible numbers of new "little wooden crosses required in the Hun trenches," responded to the sniper's C.O. that from then on "the left ears of all Huns killed by Pte. ------ will be attached to his report, please."[240]

Schools were the natural response to such confusion and unreliability and the best place for testing novel inventions in a safe environment. The concept of specialized schools was nothing new, considering the hundreds of years of military academy history; even the concept of schools near the front line was not novel: grenadier — later bomber— schools had already been instituted in France in May 1915.[241] The 2nd Army

[240] E. Penberthy, "British Snipers," *The English Review*, September 1920, 237.
[241] Saunders, *Reinventing Warfare 1914-18*, 2011, 166.

pioneered this new discipline, instituting a school for snipers and Intelligence Officers near Ypres in December 1915.[242]

Why did it take so long to start a school for a task that was so obviously important? The army already recognized the necessity of sniping in the front line and scrambled to distribute scoped rifles to the battalions, but it took almost a full year to establish the schools. Historians of technology would condense the answer to a single term: 'momentum.' Technological systems follow the rules of an avalanche: the start is slow because the new technology needs general understanding and a network of agents to function properly. In the case of sniping, we saw how basic the knowledge among the soldiers was, and these men were the ones whose lives were dependent on a correct use of the new rifles. For the top brass to understand the new necessity in a more nuanced manner than a simple 'give them scoped rifles,' the troops on the ground had to comprehend, digest, and synthetize the details of the actual use of the technology in a coherent and convincing way; only at this point could the message travel up the ranks.

The concept of 'momentum' might also help us to understand that new technology starts with pre-existent 'forces.' Old technologies have high momentum: complex systems are more difficult to displace or modify because they are well established. New technologies have low momentum because they carry less 'baggage' and therefore are less influential, they express less force onto society (in this case on warfare). However, old technologies are less flexible because a lot of energy would be

[242] Major E. Pemberthy, "British Snipers," *The English Re*, n.d.

necessary to modify them; on the contrary, new technologies are more adaptable on the one hand, but on the other more susceptible to modification or perturbation.

The problem was well understood at the time even if not codified by a theoretical framework: Hesketh-Prichard described the phenomenon with the term “Establishment.” This was the first problem that he encountered, and perhaps the most difficult to surmount. “There was no Establishment for a sniping officer, and if the matter were put through the War Office it would probably take some months, I knew, to obtain an establishment.” Prichard however could count on the help of his C.O., Colonel Stuart, who went to the M.G.G.S., 3rd Army, Major-General Sir A. L. Lynden-Bell, “who was in full sympathy with the idea. It was thus that the matter was mentioned to Sir Charles Monro, commanding the 3rd Army, and Colonel Stuart arranged with Brigadier-General MacDonogh … who was then in command of the Intelligence Corps, to allow me to serve with the 3rd Army as sniping expert. John Buchan, who was at that time the *Times* correspondent on the western front, also gave the idea great encouragement. He had seen for himself the awful casualties that we were suffering and considered the scheme which I laid out to be a sound one.” Prichard’s idea jumped from desk to desk four times before he was authorized to start the experiment. This Kafkian property of the army in its bureaucratic nature should not be unexpected, it was — and still is— in the essence of such complex organizations.

However, this was not always the case: sometimes the urgency of innovation compelled the top brass to change the situation. This was the case for Major Crum, who on October 23, 1915 was called by General Jeudwine to train his brigade’s snipers. In less than a week, despite his need to wrap up his duties substituting his commander and participating to court martial trials, Crum selected the snipers and organized a trip with these men to see the "model school of the 49th Division." There the group was testing a "simple invention of one of my corporals," when they received the visit of Gen. Plumer. Crum promptly showed and explained this new device to the general— unfortunately we don't know what it was— who "made a note and said he would push the idea." The sergeant's idea just jumped a bunch of bureaucratic steps, for the joy of Maj. Crum, who ended his letter to wife with "it saves so much time and energy if you can get direct to the fountain head."[243]

If the natural customer of a school are its students, and in this case the soldiers selected to be snipers, the byproduct of these new and unstandardized institutions was to provide an equally important service: assess the ideas coming from the bottom ranks, provide new ones to test in the trenches, and to become an authoritative showcase of innovation for the top of the army. The schools in France were carrying out in a much nimble, focused in scope, and quick way, even if often with much improvisation, the research that before was prerogative of arsenals, proving grounds, and bureaus at home.

If their being new created some problems for these institutions — Prichard did not receive any pay for several months while he was waiting to be officially recognized as a sniping-officer[244]— it also provided flexibility and adaptability while still granting

[243] Crum, *With Riflemen, Scouts and Snipers from 1914 to 1919*, 56–57. To learn more on the importance of the personal connection in the innovation of warfare during the Great War in the British Army, Aimeé Fox – *Learning to Fight*.

[244] Major H. Hesketh Prichard, *Sniping in France*, 68.

authority on the subject. The schools were directly connected to the top ranks of their division and in continual dialogue with the soldiers on the ground because they were constantly training their students in their courses and helping to solve delicate situations in the trenches. They became therefore the place of a ‘conversation’ between institutions and simple soldiers on techniques, materials, weapons, and tactics.

The definition of these words was often blurred in the case of sniping, and what we consider as ‘object’ or ‘technology’ often encompassed all the above terms. We cannot use as an example what Crum’s corporal invented because we do not know what it was, but Prichard described the case of one of his school’s instructor’s inventions. It served to solve the problem of the efficient and more importantly undisclosed creation of a new sniping post. The problem was not trivial, as Private Clarke reminded us with his example of deadly ‘bully beef tin’ posts. Good and hidden observation posts (OP) saved lives while still providing the necessary function to check the moves of the Germans.

A simple solution was necessary, because in the trenches anything complicated would not have survived. Snipers did not have neither the know-how or the resources of the Royal Engineers and therefore cumbersome, expensive, or too complicated tools would have been not helpful. Hesketh-Prichard’s assistant teacher invented a method that was quite laborious, but it could be implemented with simple materials, in a single night of work, and without special training. A section of the parapet was glued to a frame with a canvas, detached from the wall of the trench, recreated in the same fashion on another frame with an armor plate covered by fake sandbags and put back in place. With this stratagem, the shape of the wall in the subsequent morning would not have changed appearance and the enemy would have missed the alteration. The builders then closed these sniping positions with a small cabinet with a cloth on the back to prevent sunlight shining through and revealing the loophole. Every detail was important and experience was fundamental in determining both more evident factors such as position and camouflage, as well as less obvious ones such as deciding the hours or even the season when to use them and when not, because the sun's position or snow could reveal or hide details to trained eyes.[245]

Sniping schools did not represent the only source of innovation in the British Army; however, they were natural magnets for new inventions and techniques. A case in point is the 'dummy heads' tool. The invention is unanimously attributed to the French both in the official histories and in personal memoirs like Prichard's.[246] These contraptions were nothing more than *papier-mâché* representation of heads, painted and provided of fake helmets or berets; they were mounted on a frame that allowed the operator to move them freely on the vertical axis. They were used in a variety of different ways: as distractions to attract the enemy fire or as ruses to confuse enemy's intelligence on the nature of the troops in the trenches, exposing for example dummies in the uniforms of Sikhs or Gurkhas. Snipers also used these heads in a very clever way to reveal easily and safely the position of the enemy's snipers. The sniper would raise the head slowly to a specific height, trying to imitate a natural movement; once the enemy

[245] Hesketh-Prichard, *Sniping in France*, 20. *Notes of Training for Rifle Fire in Trench Warfare,* 10-13. *Summary of Recent Information regarding the German Army and its Methods* (General Staff (Intelligence), General Headquarters, January 1917), 15.

[246] Major H. Hesketh Prichard, *Sniping in France*, 10; *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:128.

shot the head, they would drop it as though it were a real victim. The truly ingenious part was when, using a special periscope mounted on a frame with a probe, they could use the hole in the head of the dummy to place the periscope perfectly aligned with the trajectory of the shot, therefore aiming at the precise location of the sniper. These dummy heads were so important that Hesketh-Prichard used the school's money to order them in London at Clarkson's, a theatrical wigmaker. It was a smart but temporary adaptation, as one day when he visited the French Camouflage Works at Amiens, he discovered that the French made a great number of these heads with British uniforms. He bought a big load of them and did not have to rely on his amateurish —at least for war— London provider. As we discussed in chapter 3, in January 1916 the Royal Engineer Corp organized their own section, the Special Works Park where they produced all kinds of camouflages and tools for the troops, and several items for the snipers, such as silhouette practice targets and sniping suites, of which they produced almost five thousand. They also produced almost three thousand dummy heads.[247]

Another fundamental source of inspiration was the enemy himself. British snipers, for the nature of their work, were ironically more in 'contact' with the enemy than with the French. Not that they spoke or shared ideas with one another, but the observing nature of a sniper, together with the constant competition over concealment and kills, made it very important to recognize the enemy's techniques and whenever effective, to adopt them. Hesketh-Prichard gave multiple examples of this 'conversation.' The Germans, for example, had the habit of placing two armored plates one near the other; the more visible

[247] *Miscellaneous*, 9: 128,149, Plate XV.

one was a decoy, while the other was well concealed behind the parapet with the loophole disguised as an element of the wall such as an open tin can. The sniping schools studied these techniques and reconstructed them in the reproduction of the German trenches that they displayed in their shooting ranges, using them to lecture the students on the fine art of disguise. The students then went back to the trenches and put into practice their newly acquired expertise in making their own sniper posts.

It was a never-ending battle of knowledge, and trained snipers and their officers needed refresher courses. Private papers and diaries rarely dedicate time to these routine events, and the unofficial nature of the sniping schools meant that there are no official documents reporting these refresher courses. We can however thank diligent diary-reporters such as Private Smith for filling the gap. He volunteered as a sniper in December 1915, then he went to train in a school in April 1916, again on May 31, and June 26. The first was a week-long course, the others were each two-days. The last time he went to a sniping school was in October 1917, a big gap explained by his having been wounded the first day of the battle of Arras on April 9, 1917 and was recovering in England until August 17. After so many months of action, in December 1917 his commanding officer started to notice signs of nerve strain and moved him to HQ as the brigade draughtsman, where he still could help the war effort by making maps in a less stressful environment.[248]

[248] "Private Papers of M. Smith," Imperial War Museum.

The schools were the place of absorption for the accumulated knowledge on sniping of the army, a knowledge gleaned from different sources that had in common the practical experience of the battlefield; this knowledge then was redistributed to the men. However, these schools also directed their attention upward. The directors knew how important it was to obtain the attention of their superiors. Prichard remembered that “the chief reason, I think, for the success of the school was the great personal interest taken in it by the Corps Commander, Sir R. Haking, who would come out from his headquarters at Hinges and inspect the school at frequent intervals, as did also Brigadier-General W. Hastings Anderson, then B.G.G.S. (chief of staff officer) of the Corps. We were inspected in July by the Army Commander.” Schools had indeed the double interest of teaching to the troops and being recognized officially from Armies, while the War Office and generals considered these semi-official schools their natural hunting ground for expertise.

Hosting a constant stream of visitors was not a prerogative only of Prichard’s school. Not only generals and staff officers, but also experts from other divisions and French liaison officers show up frequently in the memoirs of Crum. The school proving ground, with the re-creation of the battlefield and imitations of German trenches, proved to be the perfect and safe scenery for showing practical examples of the new techniques. This was a very different method of spreading knowledge from the old-fashioned lectures and drills, but it was much more effective and memorable for the audience.

The Formalization Process

Innovations climbed up in the 'instructional social ladder" of the army together with the instructors. In December 1917, in one of the most exciting but also terrifying moments of his career, Major Crum was invited to lecture three hundred colonels, selected to be battalion commanders, on sniping. The training took place at the military base of Aldershot in England. We can understand his anxiety when he realized that he would be teaching classes formed entirely of his superiors.

Crum's experience at Aldershot was surely different from his time at his sniping school in Acq. Far from the front line the training facilities were impressive and even had a grandstand overlooking the trenches which could accommodate 250 men. With small groups of students, the target audience was focused on privates, NCOs, and commissioned officers. The stand could accommodate a whole company however, and when the audience was a bigger unit not only there would have been the commanding captain, but also members of the staff. They were usually not invited but were naturally attracted to these 'big' events. In addition, this school organized events specifically tailored for groups of officers of the War Office.[249]

Even if at this point the sniping schools were not officially recognized, they were an integral part of the training of the army and produced an expertise that was highly valued. The situation evolved to the point that the only trusted reports came from officially trained snipers/observers: Herbert W. McBride, the enthusiastic American

[249] Crum, *With Riflemen, Scouts and Snipers from 1914 to 1919*, 111.

volunteer in the Canadian Army who could be defined as the North American counterpart of Ernst Jünger, remembered the frustration that non-specialized soldiers like him had in reporting intelligence to the HQ: “that was one of the advantages which the “graduates” of the later sniping schools had over us forerunners; they had a recognized organization in back of them with considerable official standing and “weight” and when they turned in a report covering their observations for the day, that report was given real consideration by the powers who were running things from the rear.” His pride was wounded when his reports were “pooh-poohed as being merely “some soldier’s imagination.”[250] It is interesting to see how ‘the powers who were running things from the rear’ according to McBride accepted only reports from trained observers, yet previously, Crum and Prichard had such difficulty convincing the top brass to officialize the discipline. It is important to consider how authority develops in new technological systems during the process of innovation, moreover when we observe it in stiff organizations such as the military. The concept of authority is, in this situation, tightly linked to the one of institutionalization. The creation of a school was not an automatic decision from the very top however, because they started as regional solutions made by the single armies. The general adoption of the findings of the schools as a doctrine was a subsequent, separate step. The more people who passed through the schools, however, the more these institutions acquired authority on the subject. They acquired visibility in the fighting units and refined their teachings, but they also attracted VIPs and generals, steps necessary in their

[250] McBride, *A Rifleman Went to War*, 317.

reaching the War Office and GHQ, the institutions that could allow their findings to become doctrine.

To accommodate the needs of a diverse audience and improve the effectiveness of their fast and dense training sessions, the instructors abandoned the old-fashioned training approach and refined their techniques using new methods and recent technologies. In his school in Aldershot, Crum and his instructors used cinema and lantern slides —the grandfather of PowerPoint— but most importantly they used acting. Instructors of the school acted out theatrical sketches in front of the audience, illustrating common scenes of life in the trenches, with their dangers and solutions: "men frying bacon over a brazier, making too much smoke, cleaning their rifles and making mistakes in doing so, which have too often proved fatal, or incautiously exposing themselves and so being hit and carried away on a stretcher." Acting was immediate and emphatic and could educate a large group of students in an entertaining way, while the message was refined by a commentator.

Training with theatre was a technique that Crum picked up in France, where he sharpened his tools even if sometimes at the cost of some embarrassment. For example, one time at Acq he and his men were giving a special demonstration to the divisional school; Crum rightfully thought that some pathos would better carry the message, so he asked his 'cast' to put some action and drama or some comic relief into their sketch. They were showing the dangers of revealing the loopholes to the enemy; a soldier impersonating a German showed himself in the 'enemy trenches,' and another one impersonating a British observer showed precisely what not to do: scrambling all excited to the loophole, shooting ten rounds in rapid sequence and then leaving the loophole open while announcing his kills to his friends. The German however was not only unscathed, but also discovered the position of the sniping post. In the meantime, Crum served as the narrator and provided comments on the scene to enhance and clarify the message. From the background another actor entered the scene impersonating a sniper coming to relieve his comrades. He entered in the post, a shot was fired in the German trenches, followed by screams of pain and anger coming from the sniper. The impersonation apparently was very realistically rude and colorful, but too much for Crum's gentleman ears. Crum remembered that "the flow of abuse completely unmanned me. For a second I lost my head, and then I blew my whistle and sounded the 'cease fire'." Right after this embarrassing episode he lectured his guests on the art of training, and he grabbed the opportunity to emphasize that "strong language was not a part of [his] curriculum."[251]

We can imagine that the privates in the public enjoyed the scene, but not everyone in the audience was entertained, and some officers considered the episode distasteful. While teaching senior officers helped bring this discipline closer to a definitive official recognition, it also increased the natural attrition that novelty had with the establishment: not everyone thought that theatre was appropriate for the army's environment. "There are always some who disapprove of anything new" commented Crum. However, in England "the show became popular" and the school received visits from a number of VIPs such as

[251] Crum, *With Riflemen, Scouts and Snipers from 1914 to 1919*, 90.

admirals, generals, and even high nobility such as the Duke of Connaught and Prince Albert of Belgium.

At this point Crum's authority as a sniping expert was solid: he became the go-to man for the War Office for all things sniping related. In May 1917, after lobbying for years to create standards for sniping, eventually the GHQ in France asked Crum to implement this "co-ordination." The result was condensed in the *SS 195*, one of the hundreds of publications printed in France and in England by this newly created service dedicated only to the diffusion of knowledge in the army. Why was Crum chosen to create the sniping standards and not others, for example Prichard?

In the spring of 1916, while he was the director of his school at Acq, Crum wrote a book on scouting and sniping; it was a completely personal, self-published effort that received no official sponsorship from the army. It was not completely off the record, however, because Crum asked and received special permission from the general headquarters of the BEF. To this specific purpose, Crum personally brought the proofs of his book to Montreuil. His long-time friend Baden-Powell, founder of the Boy Scouts movement, wrote the introduction.[252]

This new book was an instant success and by November the one thousand copies that had been printed were all given away. The success in the ranks raised the eyebrows of the War Office. Despite the official authorization in France, the WO said "no more to be issued." Even if the publication was eventually considered problematic because they

[252] Crum, 95.

had not given the official sign-off, his name as an expert was established. When in December he received the communication to stop the distribution, Crum was in England. On the 19th, he gave a one-hour lecture on scouting to 150 senior officers. With the help of lantern slides, he advertised the importance of sniping and scouting, highlighting how dangerous and delicate it was. The conference was tailored for an audience completely ignorant on the topic, giving historical context and basic examples of what a sniper should act on the trenches of the western front.[253]

Considering his authority and that he had received some form of authorization, the behavior of the WO could seem myopic, but we also need to consider that Crum was de facto going against his own desire of standardization, spreading his own ideas instead of a standard created by all the schools. In May 1917, GHQ France tasked Crum to organize a uniform system among the different sniping schools in the army. There were five of them at the time, one for each army, counting the Canadian one. Crum handed over the school at Acq and started a tour de force of activities. First, he visited all the other schools, then he organized a conference of experts in Boulogne to discuss their views on the question. After this convention, he tested for three weeks the results on twelve 'young soldiers' and distilled a "suitable system of intensive training." Most notably this system was afterward demonstrated not to the War Office or to GHQ France — the patrons of his work— but to representatives of the five armies and of the sniping schools.[254]

[253] The text of the conference is in the Appendix 1 of Crum, *With Riflemen, Scouts and Snipers from 1914 to 1919*.
[254] Crum, 122.

It would be interesting to understand if this was an expression of Crum's will or of the lack of interest in the details on the part of GHQ France. We don't have evidence that would lead us to one conclusion over the other, however the de facto situation was clear: the schools were the authors and they decided autonomously how to train snipers in the British Army. This did not mean however that the War Office and the GHQ France had no voice in the matter. The definition of a sniper was under scrutiny from the top, even if slightly less attention was paid to the training details. This desire surfaced when at the end of the process the War Office asked Crum to write the official pamphlet on scouting and sniping, which eventually came out in print in December 1917 as the document *SS 195 Scouting and Patrolling*:

> The wish of the Training Authorities was to introduce more night patrol work and open warfare scouting and sniping," Crum commented. "The days of trench warfare seemed numbered and it was not considered advisable to keep a special staff merely for training in scientific marksmanship. The tendency at that time was to do away with the specialist and make men all-round handy men.[255]

This last remark is very important for us because it shows an evolution of the concept of soldier that had an incredible influence on warfare. What is important to understand here is the development of the official definition of sniping; crystallized by Crum in the *SS 195* —with the collaboration of other experts— this definition was the result of two different forces: the knowledge on the matter with the passion for innovation from the bottom, and a strategic vision from the top. They were the ones that

[255] Crum, 121.

envisioned the end of the trench warfare paradigm against the very practical, but hyper-focused approach of the experts on the ground.

Crum and his team of experts were essential in ensuring the future of sniping and the nature of the pamphlet reflects it. The title does not even mention sniping, while the book dedicates ample space to it. Not only are there sections on the use of snipers in trench warfare, but in almost all cases, whenever you read about scouts, the practices and knowledge are precisely the ones of the sniper. Reading the pamphlet, one really wonders if Crum delivered what he and the schools wanted under false pretenses. Crum and the experts wanted to preserve sniping in future doctrine even though the WO was not so sure of their utility when mobile warfare would come back as they predicted. To do so they used the experience matured during the preceding years, which showed that snipers were not only useful to kill enemies but also to observe, collect, and report intelligence on enemy activity. The value of these specialized soldiers was fundamental for integrating the new possibility offered by aerial reconnaissance and for substituting the role that in the past had been played by light cavalry and was not yet completely filled by armored vehicles.

The signals that armies were finally moving out from the frustration of trench warfare were read, with some degree of hope, by GHQ and not by the armies' schools, which, as Crum remembers, "often thought they knew better than GHQ." Crum was caught in the middle in this discussion: while he was part of the system of schools that tried to innovate from the ground, he was also however part of the newly created training staff of GHQ This made him almost as a referee of the competition. Even in his memoirs he remained almost neutral: did the schools know better? "Possibly they did, sometimes, anyway," he thought.[256]

If the War Office understood that trench warfare was destined eventually to obsolesce, the experts were not blind. They knew that snipers still had much to learn, and they understood that in the past, in the rare "glimpses of open warfare," snipers did not transform seamlessly into scouts. It is therefore probable that GHQ's request to focus on scouting and patrolling had been somewhat internalized by the group that wrote *SS 195*, adapting the current competencies of snipers to a more flexible concept of scout. The relative novelty of the concept of sniping allowed them to play around it. They did not have to fight any pre-existent doctrine or disrupt solidified traditions between the soldiers: the momentum of their ideas was small enough that they could nudge it easily to a different direction.

In many cases this was not too difficult a task: for example, snipers were trained on sketching the position of the enemy and on a very competent use of maps, which were fundamental skills in any reconnaissance; keen observation, a proficient use of optics, and a skillful use of terrain were also basic pre-requisites to survive the ruthless life of a sniper. Therefore, it was easy to translate the ability to gain a position unseen and to kill without showing yourself to an easier task of simply moving closer to the enemy and watching him without being discovered.

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[256] Crum, 121.

The experiences accumulated in the past years surface often in the *SS 195*. Many of the innovations on the ground, techniques that demonstrated their efficacy and simplicity, are illustrated in the pamphlet: when not related directly to safety they were never imposed as dogma, but always suggested as useful methods, a reminder of the snipers' creed of adaptability. The observer for example was invited to facilitate focusing their telescope by indicating the best positions with a scratch on the focusing ring, to lubricate it and open it with a circular motion, to keep the sunshade on to avoid detection, or to cut the map of the area into quadrants and glue them on a notebook's pages to aid in the collection and reference of intelligence observations. These small details demonstrate how snipers were working out solutions not yet implemented in their equipment.

A sniper's —or scout's— war was won on details, and therefore the pamphlet gave examples of things to look out for, such as how "the assault kit [of Germans] can be easily identified by the fact that the men wear their greatcoats … rolled and slung over the left shoulder in such a way that the ends meet at the right hip." To recognize such a detail meant that the sniper could warn the commanders of an imminent assault. This attention to detail was a treasured trait of snipers/observers, and the pamphlet shows the pride of their authors in this knowledge: "all that observers learn in trench warfare is of use to him in open warfare" —it almost sounds like a warning to GHQ not to waste the great amount of expertise gained painfully over the years. This reminder of 'the roots' of a scout is the beginning of the manual, in the short list titled 'what to look for' in the section on open warfare. The remark that "the importance of noticing small things should be impressed on the observer" concludes the list, followed by a short but colorful selection of practical examples, such as a gas attack "forestalled [prevented] owing to the rats being seen escaping across 'No Man's Land,' and a retirement detected through a hawk being observed perched on a trench." If the utility of such details is perhaps questionable in 'open warfare,' the message behind them was clear that soldiers trained as scout/snipers were still useful outside of the trenches, implying the long-term importance of scout/snipers even outside of trench warfare.[257]

The fear of 'being forgotten' outside of trench warfare was a common sentiment in the schools. In his article for the *English Review*, Major Penberthy described how snipers "seemed to be regarded as only essential to trench warfare, and no special duties were assigned to them in the attack. This point had not been overlooked in the schools, where very definite plans were laid down for the employment of snipers in the attack." Pemberthy fought to diffuse this idea, giving "scores of lectures" at conferences for the staff officers of battalions and brigades. He had some success, but the final acceptance of the concept came from the enemy: nothing could better teach commanding officers than seeing a proper use of snipers from the enemy, and Germans used snipers very well in the retreat. Pemberthy gave the example of Mametz Wood, where snipers, after carefully selecting of their positions, covered alone the escape of the main body of the enemy.[258]

What is evident is that from the inter-sniping schools' conference organized by Crum to design a doctrine grew a concerted effort to find a definitive niche in the army, and not only a temporary recognition of the role of the snipers in trench warfare. The key

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[257] "S.S. 195: Scouting and Patrolling," 1917, Imperial War Museum.
[258] E. Penberthy, "British Snipers," *The English Review*, October 1920, 327–32.

they used to reach their goal pivoted on the nomenclature of the concept of sniper. *Nomen est omen* said the Romans, but the sniper schools cared more for the practice of sniping than its name. In the *SS 195*, the word 'sniper' is used when talking about trenches, but in open warfare the word used is 'scout', the same term found in the title, most likely selected to satisfy GHQ

The strategy was deliberate, but somewhat natural: the distinction between an observer/scout and a sniper was only found in the last moment, when the soldier decided to pull the trigger or not. This simple fact was probably not obvious to staff officers. Complicated and immoveable contraptions such as fake trees, dummy heads, state-of-the-art disguise for observation posts had become so embedded in the concept of sniping that it would have been difficult to imagine a sniper's utility outside of the static world of the trenches. The reality was much more complex, and snipers were trained to move silently in no-man's land, to observe and report any detail, and to distinguish from afar officers from privates. Their survival skills revolved around a good understanding of camouflage and blending with the surroundings; their keen eyes had been trained in the proper use of a vast array of optics in a time when most officers used only binoculars. In addition to their marksmanship, this set of skills acquired in the environment of trench warfare added new opportunities to their use on any kind battlefield.

The schools obtained what they wanted: after more than three years of war, snipers gained their stripes. Quite literally so, because on their left sleeve appeared a green band. What showed on the uniforms was the official recognition of a new specialization desired and lobbied from the bottom and eventually distilled and accepted from the top: “from beginning as a freelance, the British sniper developed into a valuable controlled weapon in the hands of the commander of the fighting unit, the platoon,” recounted Pemberthy.[259] *SS 195* officialized the requirement for every battalion: every platoon had to have two men that received further training in scouting, observing, and sniping; every company should maintain four specially trained scouts grouped with company headquarters; every battalion should have a scout officer responsible for “scouting, sniping, and intelligence duties”. These specifications were already a practice in most of the units, but now they were official. Snipers had finally secured their “establishment.”

Conclusions

Sniping offers the best example of how soldiers interacted with the new technology, imagined novel uses of their tools, and lobbied for a general acceptance of these techniques as a doctrine in the British Army. To have a doctrine meant not only that they could share their experience with the rest of the army, but also that their status was finally solidified as a standard in the army. Therefore, snipers fought for a social acceptance of their role in the war. For most of the war, their position was uncertain, accepted because it was indispensable in trench warfare, but always at risk of being discarded as soon as mobile warfare returned the normal condition on the battlefield. Snipers however knew that their contributions to the war, the experience and techniques they collected and developed with their dangerous job, were extremely valuable. For this reason, snipers lobbied for recognition: they fought to obtain a role, then to receive

[259] Penberthy, “British Snipers,” September 1920, 329.

authorization to create schools, and eventually they promoted an official doctrine to definitively establish their position in the future of the army. Sniping was a pure creation of the soldiers on the frontline, one of the best examples of how knowledge climbed from the bottom to the top of the army.

CHAPTER 6. THE ARTERY OF KNOWLEDGE: THE STATIONERY SERVICE AS A CHANNEL FOR THE ABSORPTION AND DISTRIBUTION OF INNOVATION

The distribution of knowledge was a fundamental aspect in the Great War. With the continual changes in warfare, to have a well-oiled bureaucratic machine to take care of the collection and printing of any kind of information and manuals was an essential ingredient for the success of the army. The British Army was ill-prepared for this task at the start of the war, but throughout the conflict a small unit, the Stationery Service, grew steadily in number and competence and was eventually able to manage the most daunting printing tasks. In this chapter I will tell the story of this unit, the kind of material that they produced, and their centralizing and streamlining process.[260]

The Stationery Service

One of the elements of industrial warfare was bureaucracy. While the production of weapons, heavy machinery, and mountains of shells for the artillery are self-evident in their impact on the final result of the conflict, we often forget that behind the lines the First World War produced other mountains, made of paper. While not a novelty in the army, this was a novelty in war. Trench warfare loaded the armies with an unprecedented amount of paperwork: static warfare allowed bureaucrats to produce copious amount of

[260] Other historians studied this unit, however a complete study is still missing. For a general but technical overview of the publications produced by the Stationery Service: Peter T. Scott, "The Army Printing & Stationery Services, 1914-1918," *Antiquarian Book Monthly Review* VI, no. 3:59 (March 1979): 90–97. A short description of the development of this unit is in Paddy Griffith, *Battle Tactics of the Western Front: The British Army's Art of Attack, 1916 - 1918* (New Haven: Yale University Press, 1996), 179–86. For an analysis of the dissemination of doctrine through the publications of pamphlets: Aimée Fox-Godden, *Learning to Fight: Military Innovation and Change in the British Army, 1914-1918*, Cambridge Military Histories (Cambridge, United Kingdom ; New York, NY: Cambridge University Press, 2018), 78–85.

records, freed from the nightmare of having to move around their documents while following their troops. In addition, industrial warfare and the increase in size of the armies required bureaucracy to streamline the management of the troops and avoid wastage. As with the other innovations in the war, the British Army was unprepared even for this dull work behind the scenes. The Stationery Service (SS) at the start of the conflict was not a priority and until December of 1914 it remained a trivial side note in the organization of the British Army.

In the Summer of 1914, Captain S. G. Partridge, an obscure clerk of the War Office, was in France managing the small stationary service, which at that time distributed rubber stamps, stationery, and booklets. All the material was made or printed in England and shipped to the Depot in Le Havre. The unit's place was nothing more than a distribution spot, where it finally settled in after a summer of retreating. At this time Partridge directed a grand total of seven men with the help of two other officers. This humble beginning makes the situation at the end of the war even more impressive: in 1918 Partridge was a Colonel, managed 62 officers and 860 other ranks in 30 centers. His officers were directing branches on all the fronts, from Italy to Mesopotamia, while Partridge was now working at GHQ France, consulting and dealing with vital problems of strategic scope.[261]

This incredible growth highlights the increasing importance of the role of this unit. The British Army had to adapt to modern warfare and therefore to absorb and

[261] *Statistics of the Military Effort of the British Empire during the Great War 1914-1920* (London: H.M. Stationery Office, 1922), 200–204.

redistribute information to ease change. The development of the Stationery Service is a story in which bureaucracy innovated the army instead of burying it under red tape and pointless regulation; this story represents well both the problems and the strengths that the British Army had in its troubled but eventually successful path to mastering modern warfare.

At the start of the war there was no real understanding of how important the circulation of information and the standardization of communications would be in the following years. The British Army undervalued the importance of printed material during war. They had not needed it much in the past, therefore they did not anticipate its importance in future conflicts. The British Army, as well as the other armies, mistook the scale and the amount of bureaucratic work necessary, but it was not completely unprepared. Understanding that even in war an army needs stationery, at the beginning of 1912 the War Office asked Her Majesty's Stationery Service (HMSO) to organize a supply ready for mobilization. It took almost one year, but eventually a substantial amount of material was collected in Portsmouth and ready to be loaded and shipped with an Expeditionary Force. Paper, stamps, pencils, and all the common tools of office life were carefully boxed and stored in a dry location. To avoid deterioration, expensive tools such as typewriters and copying machines were not stored with the other materials; instead at the start of the conflict they would have been provided by the Ordnance Services who would collect specifically registered machines in use in the army's offices. This system also assured that the armies would use the latest models during the war and not some old and inefficient pieces. Similarly, the manuals for the troops were not stored in the warehouse to allow up-to-date copies to be distributed to the men.[262]

This arrangement was a good start; however, it fell well short in delivering the amounts and kinds of material that a big campaign would need. While paper and normal stationery material were amply provided, only 90 typewriters and a same number of duplicators were "earmarked" for mobilization. While the reticence to bring to the field such expensive and somewhat delicate machinery is understandable, the chronic lack of typewriters would haunt the Stationery Service for years. Indeed, the units, in desperate need of these tools, throughout the war kept pestering the SS to obtain these coveted typewriters. Anyone that has had to decrypt the handwriting in the units' war diaries can understand the reason for these incessant requests.

In 1914, before settling down definitively in Le Havre, mobilization did not go smoothly for the Stationery Depot. Partridge and his men were mobilized two weeks later than scheduled. They had some trouble finding a place for their stocks in Le Havre, which was full to the brim with all the paraphernalia of the British Army. When they finally found a location, after just one month from their disembarking, they received the order to repack everything and get ready to bring the material back to England because the German advance seemed unstoppable. In the following confusing days, instead of embarking to go back to England, they moved to the west coast of France and lost their cargo in their transfer to St. Nazaire. While there they could not find a suitable place to

[262] WO/95/4189 – Jan.-Oct. 1912.

store their material. Thereafter they moved to Nantes, lost some material again, and discovered that their boxes were all scattered around on different ships. To add insult to injury, the army was still sending all their new material to their former address in Le Havre. All this happened while Partridge had to deal with the ordinary business of distributing Army Orders, Field Service Post Cards, and general office provisions to the units. To his humiliation, no unit seemed to know what the Stationery Service was or that they had to deal with them for their orders.

Given this chaos it is understandable the SS spent its first months in a mostly futile attempt to provide the basic necessities to an army already under logistical stress. Things started to straighten out when an entrenched frontline began to form on the western front, and the British Army was finally able to catch a breath after the frantic operations of the summer. At this point Partridge was finally able to go back to Le Havre to re-open a depot in the city and enable the Stationary Service to begin to operate as it should have been from the start.

While Partridge was not enjoying his tour around northern France, GHQ France's requests were mostly on the shoulders of the Royal Engineer's Printing Section. This unit however was not prepared for anything but small works and clerical work for the staff.[263] There was not a central printing organization for the army in France: most of the material was produced in London by the same office that printed all governmental documents. This system had been devised before the war to provide the necessary safeties in dealing

[263] WO/95/81 – Jan. 1, 1915.

with sometimes sensitive matters, but it was not up to the new requirements of the army. Indeed, it burdened the communication between GHQ and the troops with delays. Any printing that numbered more than a few hundred copies —the amount that the RE could handle— needed to be sent back and forth across the channel for proofreading and editing. When it was finally printed, it was shipped to France, but it was slowed down by the already congested logistical routes through the channel.

The need for a more expedited production of printed material required a structural re-thinking. Now that everything seemed calmer on the frontline, the time had come for a revision. The SS was moved to the office of the Inspector General of Communication (IGC) on December 3, 1914; here Partridge could participate in the decision-making process regarding all stationery and printing matters. In the previous months, many decisions had been made without knowing the problems that the SS was dealing with or sometimes even without the basic knowledge of the trade of their work. The decision of the director of IGC, Gen. Capper, to move the SS was important because the new location of the unit's offices in the main HQ of the branch sanctioned the importance of the Base Stationery Depots and made it existence more visible to the rest of the army.

After the SS unit had settled into its new home in the IGC and in Le Havre, the end of 1914 and the firsts months of 1915 were dedicated to transforming the Stationery Depots from warehouses for collection and distribution of material made in England to places of production of printing material. After almost a year, Partridge could finally fulfill the order received during mobilization to scout the local printing shops. The original order allowed him "the placing of local contracts for the supply of articles of stationery and the provision of local printing, where facilities exist … as may be necessary from time to time."[264] The situation however was now completely different, and the SS was trying to contain an overflowing and relentless number of requests; what the original order defined as "time to time" had become a daily routine in a constant race against the clock.

The French printers used by the unit were scattered all over the region. They were in Boulogne, St. Omer, Rouen, Abbeville, and Dieppe. This was a logistical problem, but they needed the help of these shops, so they had to adapt. This situation also presented a problem of security, because using these civilian enterprises could reveal sensitive material to unreliable sources. Therefore, any secret document or document that had any information useful to the enemy had to be printed in England, with the consequent delays and issues.

This was one of the main problems that the SS had, and they could not solve it until well into 1916. In the summer of that year for example, when the demands of the army overflowed again and at the same time the new tactical complexity of the attacks required new methods to prepare the troops, the SS started to receive a new kind of job, "rush printing with diagrams or plates attached." They were schemes for the planning of assaults, with names of locations and the positions of the enemy defenses. The department was not however ready for printing jobs with images, and they had to bring the plans to a private printer to prepare a lithographic stone for their power press so they

[264] "WO-95-4189/5," August 1914, The National Archives, London. Appendix III, August 19, 1914.

could reproduce copies in time. "The danger of entrusting a secret plan like this, with the name of the town actually written on it, to a private printer in a town infested with enemy agents, needs no emphasizing," commented Partridge. The only solution was to acquire autonomy of production.[265]

The transformation from distributor to producer of printing material however required a series of steps. The move to IGC was only the first one, because it sanctioned the importance of the SS, but it did not yet recognize the importance of its autonomy in the actual organization and circulation of the information. Partridge understood that to keep up with the requirements of the army he needed to work without the supervision of institutions that did not grasp the complexity of the work of his unit. He therefore took the initiative, starting perhaps the most important step of the building of his small bureaucratic empire:[266] he contacted GHQ in France to discuss the option of moving from IGC to the GHQ, since most of his work was with them.[267] The SS could ask this 'promotion' confidently, because GHQ was totally reliant on Partridge on the matter of printing great batches of work at a fast pace.

The occasion to ask arose when on October 13, 1915 Gen. George Macdonough, chief of intelligence at the GHQ, telephoned the SS to understand how they handled "important, secret, and urgent printing." He wanted a power press managed by the nearby

[265] WO/95/81 – Jul. 3, 1916.

[266] Griffith rightfully defined Partridge "a brilliantly successful empire-builder," an insight in the importance of his managerial prowess that I am happy to borrow here. Paddy Griffith, *Battle Tactics of the Western Front: The British Army's Art of Attack, 1916 - 1918* (New Haven: Yale University Press, 1996), 180.

[267] WO/95/81 – Sept. 20, 1915.

British GHQ. The SS had already installed a power press in the main depot in Le Havre, but this was too far. At the same time, the Field Printing Company RE, the printing unit of GHQ, was not able to satisfy the growing demand. In a lengthy memorandum, Partridge explained what the SS could provide, giving the example of the pamphlet 1607- "Asphyxiating Gases and Method of Combating," of which they produced 700,000 copies in 24 hours. No example could have been clearer: it highlighted the capacity of their printers and the urgency of the army in redistributing knowledge as fast as possible. The pamphlet indeed had been hastily produced and circulated to inform the soldiers on the latest terrible invention of the Germans. In trench warfare knowledge could save lives and the troops needed to be updated constantly, because the changes in tactics and weapons were continuous.[268]

The SS was therefore answering a demand, but in doing so was also following its own agenda. The definitive move to GHQ of October 20 was a crucial moment for the success of the unit. However, Partridge was not following some personal career goal: while from time to time on the unit's war diary appear complaints about the necessity of promotion for him (but mostly for his officers), these promotions were to pair the newly acquired responsibilities to the more appropriate rank for the job. Instead, the agenda of Partridge is the one of a talented clerk trying to solve a complicated problem inside the army: there was a need, there were the means to fulfill it, but there was not yet a

[268] WO/95/81 – Oct. 13, 1915.

bureaucratic structure to allow the solution. This situation impeded a smooth running of the operations and produced considerable waste, both in time and material.

Troops in the field were showing their needs with continual printing requests. The units sometimes even took their own initiative to fill their own requests. For example, at the end of December of 1915 the Second Army forwarded a large bill for refunding: they printed at their own expense "Notes on Trench Mortars." They were on the forefront of the British Army on the matter as we saw in chapter 3 and were probably eager to distribute the results of their findings to the rest of the troops. The lack of a central printing organization however created chaos. To leave to the unit on the field, even at the level of armies, the freedom to produce their own manuals led to mistakes, leaking of sensitive information, and diminished uniformity in the army and the control that GHQ and the War Office had on the general direction of change.

When he finally established the SS as a central node in the bureaucracy of knowledge in the British Army, Partridge started to work on the streamlining of its operations. This was not an easy task, because the unit still officially depended on the War Office in England while operating with the GHQ in France. The Channel was between Partridge and his supervisor and the situation delayed every correspondence, while the SS dealt with a customer/commander (GHQ) that needed a fast response.

On top of this stressful accommodation, the demand for printed material seemed insatiable. The more printers and depots were added, the more the requests came. Kitchener's recruits landed in France throughout 1915, followed by the conscripts of 1916. These new troops not only increased the number of units, but they also needed training in the specialized schools, required updates printings of new regulations, and overflowed the depots with requests of the ordinary stationery and postage material. The shops were often running all night long with long shifts for the operators. The depots dealt with the requests by re-organizing themselves: on June 21, 1916, Partridge proudly described the new system organized by his men at Le Havre. The men split themselves into shifts, each managed by an NCO: the day shift dealt with the local orders and therefore a front desk had to be open during the working hours; a night shift packed orders for expeditions, free from any disturbance both in the shop and in the streets.

While these men were working, the presses were producing the new material. The new system of shifts allowed them to run for 16 hours instead of the previous 8, doubling the output. The men liked the new system, which probably gave some respite to what before had been a frantic day of work followed often by overtime; they even had volunteers for the night shifts, because most of the men working for the SS were working in the printing business at home and were used to producing newspapers during the night. Indeed, throughout the war the SS was often calling for volunteers from the troops in the trenches, requiring people with experience with the trade.

Important changes in the types of requests added to the SS's struggle to supply the army. The innovations on the battlefield required more maps and more printed photographs. The importance of the technical competence of the SS in the production of photographs can hardly be overstated: it would be even more important later in the war, when the Royal Air Force formed in 1918. In September of 1916, when the Royal Flying Corps (RFC) asked Partridge to undertake the reproduction of their aerial photographs, not only did he steer them away from the use of halftone and collotype printing, but he even formed a photographic section in Amiens, finding the machines, the locations and providing the men.

The suggestion to avoid halftone and collotype could be easily overlooked in its importance. The halftone method reproduces the grayscale by varying the size of small dots of ink on paper. It offers a bad quality of image in the details but is very fast to produce. The collotype produces higher quality images, but it is slow, requiring time to cure the layers of sensitive gelatin for the printing. With good insight into the key elements for the success of aerial photography, Partridge judged both unsatisfactory. This happened during a very delicate moment for aerial photography: in January of 1916 the French printed *Étude and Exploitation des Photographies Aérienne*, which would be their basic text on the matter for the rest of the war, while in November of that same year the SS printed the *SS 445 Notes on the Interpretation of Aeroplane Photographs* for the RFC.[269] While the importance of aerial photography was so clear to anyone with a minimum of insight and therefore the production of low quality photographs would have not stopped the development of aerial reconnaissance in the British Army, we can imagine that the bad results in such a seminal moment could have slowed the momentum.

The more important air warfare became, the stronger the SS' collaboration grew with the air force. The new significance of air warfare did not go unnoticed by Partridge: in June of 1918, as a side note on the report of the work of the 6th section in providing

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[269] Finnegan, *Shooting the Front*, 129.

photographs with enhanced details of an enemy salient, he described the new importance of the aircraft in modern warfare "especially with regard to photography." The photographs were of "Cologne and Mainheim [sic]" and Partridge immediately contacted the 3rd Army to consider the extreme secrecy necessary to deal with such photos. This report is perhaps some of the first evidence of British strategic photographic reconnaissance.[270]

Up to this time, maps had been provided by the Field Survey sections. However, Partridge lamented the fact that many of the lithographic works they produced and labeled as urgent were instead given to French presses in Amiens, which constituted a problem on multiple levels. The price was "extravagant" and the danger of leaking important information to the enemy was unacceptable. He therefore suggested that the SS should have Advanced Printing Sections nearby the line.[271]

Indeed, the creation of advanced sections became the next step for the SS. This new logistical feat cut down the time for providing services to the troops on the line, which was an important factor, also considering the traffic on the clogged roads in the rear lines. On top of this the recent French experience of the Somme highlighted the new crucial role of having freshly updated aerial photographs, which the sections could provide to the interested parties safely and promptly.[272]

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[270] WO/95/81 – Jun. 21-22, 1918.
[271] WO/95/81 – Oct. 10, 1916.
[272] WO/95/81 – Nov. 7, 1916.

In July 1917, in addition to the depots in Le Havre and Boulogne, on the western front the SS had a dedicated shop for photographs in Amiens and six advanced depots well distributed along the British sector of the front: one in Dunkirk; two nearby Ypres, in Hazenbrouk and Waton; two in the Arras area in Saint Pol and Divion; and the last one covering the Cambrai sector from Albert.[273] The 1918 Spring Offensive of the German Army considerably disrupted this nice and tidy organization. The whole network was designed for a static frontline and no serious plan had been laid down for an emergency withdrawal. All considered it is surprising that only one depot was completely lost, while the others had the time to load all the heavy machinery and move, which of course however brought to a complete halt the whole production of printed material. The unfortunate section No. 5 lost all its presses and stores because Col. Piggotts, GSO1 (General Staff Officer) of the 5th Army remained undecided for too long on the necessity to pack everything up. He continued to reassure the section that there was no need to leave. When eventually the CO of the depot decided to move despite the completely unrealistic reassurances of the colonel, the roads were completely jammed by the retiring forces, the connecting bridge was blown up, and all the material had to be abandoned to allow the men to escape.

This was a hard way to learn the lesson but pushed Partridge and his men to improve. The section No. 2, the one near the lost No. 5, moved to Bayenghem, but this time the commanding officer Lt. Norton did not look for a building and chose instead to reorganize the shops in Armstrong huts and in a temporary wooden shed "with particular

[273] WO/95/81 – Jul. 13, 1917.

regard to mobility." Partridge visited the section and embraced the change, ordering all the commanders of the other sections to visit Bayenghem, learn the new system, and imitate it in their own advanced depots. Yet again we can see the opportunities provided by prefabricated huts, empowering the army with flexibility. The new depots could be dismantled and moved in a matter of days, without complicated reconnaissances to find a suitable warehouse, freeing the SS to decide what was the best place to support the troops.[274]

In June of 1918, the Stationery Service in France reached its final shape. Considering the number of orders and the complexity of its organization, they published a pamphlet to describe how to contact them, the services they provided, and their organizational chart. This pamphlet —*SS 716*— was published in one thousand copies, which appears were not enough, because they had to re-issue an identical edition in the October of the same year.

Looking at the organization of the unit we can understand the complex logistical feat of managing the printing of a modern army. The SS had to deal with multiple fronts, with overseas branches in Italy, Egypt, and Salonika. They had to create from scratch contacts and procedures with a new and independent Royal Air Force. They had to manage a very diversified portfolio of activities that included all the photographic material, publication of manuals, material for training such as targets, general

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[274] WO/95/81 – Apr.-May, 1918.

publications of stationery for the soldiers, and dealing with the distribution and repair of typewriters.

The SS now had officers in every army headquarters to control the advanced sections, manage the requests and decide where to send them for printing, and help corps and schools in providing training literature. These officers streamlined the dialogue between the SS and the rest of the army, solving the problem of the bottleneck of sending all requests directly to the SS. The unit finally had an efficient division of the work, with people responsible for the design, standardization, and reduction of paper use, and a department dedicated solely to the publication and editing. From the small and unrecognized unit of 1914, in four years the Stationery Service had become a publishing juggernaut.

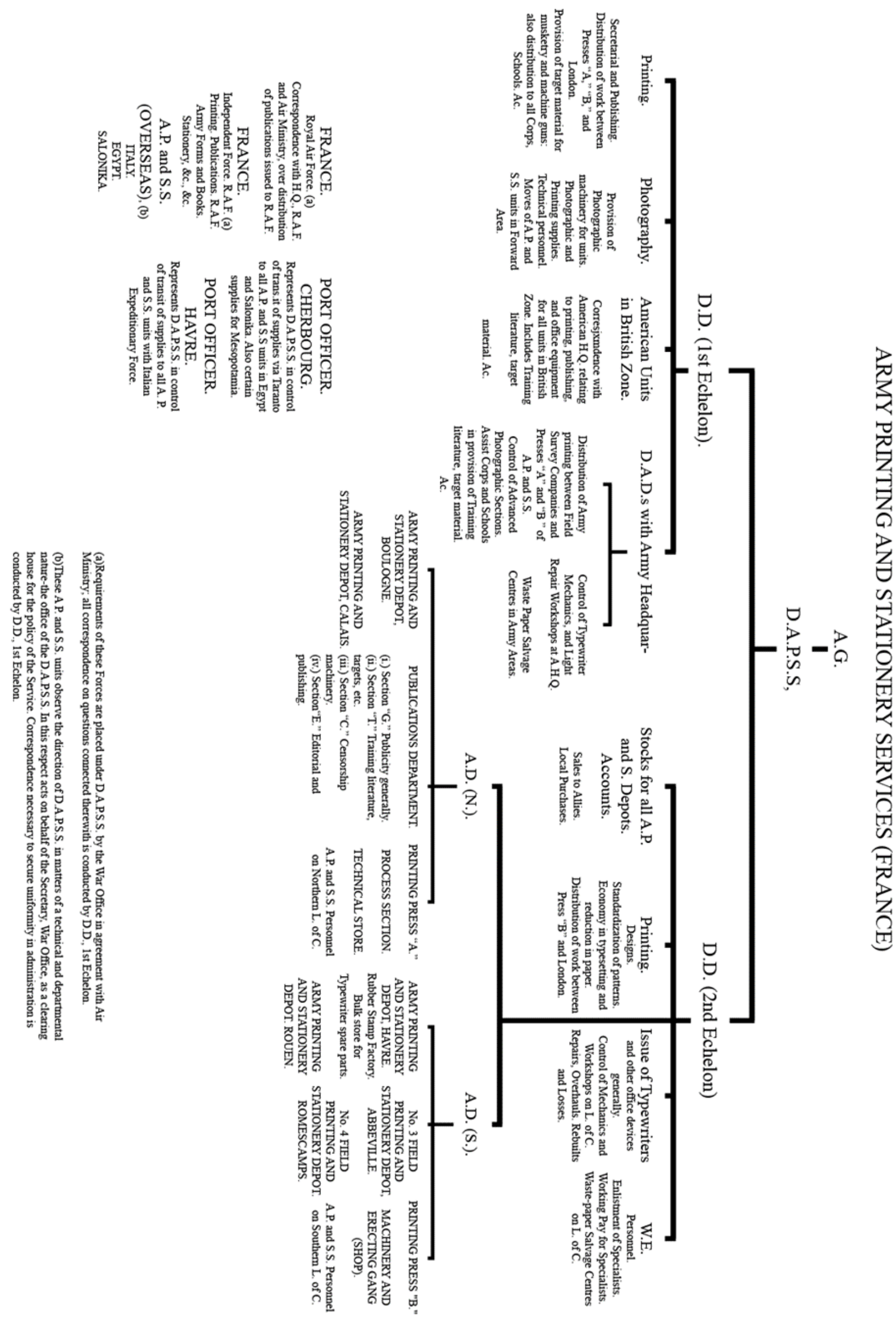

Figure 6. The organization of the Stationery Service in France, from the pamphlet *SS 716*

The Production of Manuals and Pamphlets

The events of the retreat during the Spring of 1918 can help to explain how at the end of the war the manuals printed by the SS were fundamental in the British Army. Pamphlets distributed the latest knowledge to the troops in a never-ending transformation of tactics, weapons, and doctrines. The limits of these changes in the attack were self-evident in the inability of the armies to break through the enemy's defense systems. It was not only a British problem; all armies tried and mostly failed to find the key to solve the puzzle. However, the cumulation of these changes radically modified both warfare and the structure of the armies. The results of this evolution were visible in the last year of war with the return to a more mobile warfare. The German offensive broke the French and British lines and between the end of March and July 1918 pushed them back by almost 60 kilometers. The shock for the British Army was great, increased by the fact that the last time they had a general retreat was four years earlier, years spent with a series of offensives that had a meagre result in terrain conquered, land that now the Germans were re-conquering in weeks.

Despite being a second line service, the SS also felt the shock. On April 2, Gen. Welsh came to discuss the plan of evacuation, commenting that "the Huns will quite probably get through to Dieppe." In which case, Partridge would have to move south of the Somme after the evacuation of Abbeville and Amiens. This eventuality did not happen, because the German offensive fell short at the last mile.[275] At the beginning of the retreat, however, when the safety of the trench system had to be abandoned and a

[275] WO/95/81 – Apr. 2, 1918.

more open-warfare system of defense was becoming a norm, GHQ France understood that the current defense tactics were not successful anymore. The German Army had found new ways to break the stalemate, as was confirmed by a number of important German documents that fell into British hands: they illustrated a new tactical system, with a novel use of infantry guns and light machine guns to increase the firepower of the attacking infantry. This was the latest evolution of the art of the assault, a new doctrine of in-depth attack with shock troops. In addition, the German Army strategically concentrated the attack against specific points, with the intent of forcing the enemy to retreat from the remaining pockets of defense.[276] These documents were translated and printed in a rush in two pamphlets: *Notes on Recent Fighting No.1* was "read 11 a.m., taken to Boulogne 3 p.m. proof in hands of G.S. [General Staff] 6 p.m.;" the Printing Company RE at GHQ tried to print the document No. 2 but the quality of their job was so poor that the SS had to undertake the printing the same day. These pamphlets were then distributed to the divisions with the order to not sub-issue them to the formations "whose H.Q. are likely to be over-run."[277]

The second step was to analyze the enemy's tactics and the British mistakes and develop a new doctrine on the defense. A few days after issuing the notes to the army, GHQ ordered the SS to print with maximum urgency the manual *The Division in Defence*,[278] which listed all the urgent and necessary changes that the units had to adopt to counteract the new German tactics. While the notes sent before were a description of

[276] *Notes on Recent Fighting, March - April 1918* (London, 1918) This pamphlet was printed in England by Harrison and Sons afterwards and contains both the document printed on the field by the SS.

[277] WO/95/81 – Apr. 6-8, 1918.

[278] "S.S. 210, The Division in Defence," 1918, Imperial War Museum.

what the enemy was doing, this manual illustrated how to react, refreshing the commanders on a war of movement that many of them had never experienced before.

The importance of the SS in the British army is evident in this situation. Surprise was a fundamental factor of the success of the German offensive in the Spring, regarding not only the date and location of the attacks, but also the tactics used to crumble the system of defense that had been so successful in the past years. On the British side the information, both as captured documents and as experience of the British units in battle, was of the utmost importance not only for GHQ to understand the general situation, but to be shared down to the single divisions, transforming the local experience and the partial successes into a general understanding along the whole frontline.

Without the Stationery Service's printing system developed in the preceding years this knowledge would have been difficult to distribute efficiently and rapidly. Instead, Haig could issue clear and detailed general tactics on top of the orders to the units, providing them with a better understanding of how to fight effectively. The manual for example stressed strongly the importance of wearing down the enemy with a good choice of the defensive terrain and with a new, in-depth distribution of the divisions on the ground that obliged the Germans to arrive in front of the main line of defense already tired. Haig was right, and the battle was won wearing the enemy down and adopting this new organization of the defenses.[279]

[279] David T. Zabecki, *The German 1918 Offensives: A Case Study in the Operational Level of War*, Cass Series: Strategy and History 16 (London; New York: Routledge, 2006), 130–31; D. Stevenson, *With Our Backs to the Wall: Victory and Defeat in 1918* (Cambridge, Mass: Belknap Press of Harvard University Press, 2011), 110–11.

These manuals often did end up, in a way or another, in the hands of the enemy. The final evidence of this intelligence conundrum is the number of German documents that ended in the hands of the British Army, translated, and distributed to the units by the SS. Probably in most of the cases they were captured in the trenches or in the hands of some unfortunate and mindless officer that brought them around in their pouches, but these were not the only opportunities. The level of care necessary in dealing with delicate information was not always shared among the multitude of hands that held sensitive documents. Partridge was constantly worried about printing material in private presses. Even if it is difficult to imagine how a Frenchmen would share them with the enemy, Partridge considered the towns with the printers as the best targets for enemy agents, which is not unreasonable. But even when there were no spies actively pursuing this information, lack of care and attention were a constant danger.

On October 9,1916 for example, Partridge wrote an infuriated letter to the War Office pointing out that extracts from the *SS 478*, a translation from a German document labeled “confidential,” had appeared all over English newspapers: apparently someone in the government handed the document to the press. The irritation of Partridge was two-fold: the superficiality of this behavior offended the hard work that officers were doing in keeping these papers safe. Additionally, the War Office’s lack of understanding of the risk of this behavior enraged the members of the SS who had to deal almost daily with the complications of handling confidential material.

The sheer number of publications in circulation was also a security problem: at the end of March of 1918 for example, while the chaos caused by the German offensive was engulfing the SS and an entire section lost all its material, Partridge had to suspend all the shipments to England because someone had put secret documents in a batch of paper for recycling. The strategic importance of this continual leakage of information should not be underestimated and contributed strongly to equalizing the armies on the battlefield, as we analyzed in chapter 1.

The authorship of manuals and the acquisition of knowledge

The importance of these manuals is not new to historians, and Partridge's contribution to their production has already been acknowledged by authoritative scholars; it is essential however to understand who was behind these texts and who was responsible for their creation. [280] Before the war the organization responsible for the production of these booklets and manuals was Her Majesty's Stationery Office, who commissioned the printing to a group of commercial printers and in particular to Harrison and Sons, who printed most of the military material for the crown.[281] At the start of the war, the SS in France produced part of this material, but whenever possible the order went to London, simply because Partridge's men were most of the time at their maximum limit of production, clogged by the important but tedious projects that allowed a normal functioning of the army's bureaucracy. Partridge's consolidation of the responsibility over anything related to printing made the SS the sole distributor of the manuals, even the ones printed in London.

[280] Griffith, *Battle Tactics of the Western Front*, 179–91.
[281]Peter T. Scott, "The Army Printing & Stationery Services, 1914-1918," 93.

Partridge was not the author of these manuals, and neither were any one of his officers. The War Office was technically the author, but the actual material came from GHQ France. It seems reasonable that the General Staff produced the technical, training, and doctrine material for the British Army, but this was not always the case. Until 1918, when Haig appointed Lt. Gen. Maxse as the lead of the Inspectorate on Training there is no official schematic to understand who did what. Even the organization of this new unit of the army did not put a definitive order to the unruly nature of printed military material, and it seems that the situation did not change much.[282]

Despite the apparent lack of organization, the quality of the pamphlets was high, and the innovation constant and effective. Indeed, the production of the material followed very practical paths that were not influenced much by the absence of a codified rule. Sometimes they were developed and printed completely outside the control of GHQ, as we saw already with the case of the *Notes on Trench Mortars*. In other cases, the War Office asked experts to produce material to print, like in the case of the *SS 195 Sniping and Patrolling* as we saw in chapter 5.

The pamphlets on field work, mining, wiring and in general all material relevant to the Royal Engineers came from the office of the Engineer-in-Chief, with the sole exclusion of the first pamphlet published on the topic —*Notes for Infantry Officers on Trench Warfare* of March 1916— which had been prepared without consulting the corps. Until 1918, when a single officer was appointed to supervise any publication, three

[282] Griffith, *Battle Tactics of the Western Front*, 184.

different sections, Defences, Mining, and Stores, each dealt with their own area of competence. The material was collected from the troops on the ground, French liaison officers, special tests ordered both by RE and GHQ France, and the training schools. Internally producing the material was inefficient, because the RE officers were not trained for the layout and printing, a problem that caused delays and increased the amount of back and forward corrections. Eventually the RE gave up its autonomy and sent the material to the SS, which organized it and sent a manuscript to revise. Captured German documents on field defense topics were sent to the Engineer-in-Chief's office to be scrutinized; if it was deemed important to spread the knowledge to the rest of the army it was then sent to the SS that translated and printed it.[283]

The different channels through the army that knowledge could take on the path to publication show what seems to be a labyrinthic and bureaucratic quagmire, one that fits perfectly with any joke on the red tape in the armies. We can therefore understand why Partridge tried to concentrate all the responsibilities of printing in his own department. The army lacked a central body to collect, vet, and distribute knowledge, something that seemed necessary but that the British Army did not organize officially until the very end of the war. This uniformity was not really a priority because the GHQ France was already doing a good job. Moreover, the information was coming from the bottom, sometimes autonomously, and the rigidity of a central directorate could have hindered the absorption of the constant changes coming from the frontline. Under this light the somewhat chaotic

[283] *Work of the Royal Engineers in the European War, 1914-19. Miscellaneous*, 9:77–84.

collection of knowledge created more than a headache for Partridge, but also allowed for a more natural integration of the bottom ranks of the army in the learning process.

The SS however contributed largely with a practical knowledge that had a strong impact on how the army dealt with information. One example is the format of the pamphlets. There are surely technical reasons behind the different dimensions of the booklets, likely linked with the number of copies required and the consequent cost of production; however, handling the different formats suggests also more subtle and cunning reasons: the pamphlets printed and distributed to the troops are compact booklets with a cover, cheap but solid; the more secret material, such as translations of captured German documents and intelligence reports however use long pages similar to our legal format, delicate in structure and uncomfortable to bring around in a pocket. The first kind of document would fit perfectly on the small desk of an officer in the support trenches, while the other calls automatically for a proper office. Details such this do not win a war but help in protecting sensitive information or distributing more comfortably the knowledge that needed to reach the troops.

Another expertise had a much more important impact on the training of the soldiers: illustrations and diagrams. Throughout the war the amount and quality of images that accompanied the text in the manuals increased steadily. This was not only a British trend, as French documents were amply illustrated,[284] but it was not an easy feat to obtain in the much more precarious conditions in which Partridge operated. While the

[284] A good example of the high quality of the French manuals could be: *Instruction Sur l'organisation Du Terrain à l'usage Des Troupes de Toutes Armes. Première Partie*, 1917, https://gallica.bnf.fr/ark:/12148/bpt6k6564551b.

French had all the governmental tools available in Paris, the big British printer shops were all on the other side of the Channel.

Illustrations in the manuals allowed for a much more intuitive and less codified understanding of the new tactics. Diagrams of trenches were much better than simple descriptions. Plans and schematics allowed good designs to be implemented all along the frontline, but images were even more important with completely novel techniques such as camouflage and photographic interpretation. The manuals for these highly visual innovations were accompanied by appendixes made out of photographic examples and drawings. The sole use of text would have been completely useless in teaching the reader about the importance of camouflaging a tent from the enemy's airplanes or on how to conceal the traffic on a road with screens. Moreover, breaking from a dogmatic description with words, the use of illustrations as examples encouraged the imagination of the men on the ground, starting a virtuous cycle of innovation through interactions between the experts and the frontline, something that, as we saw, the Special Works Park particularly desired, as they stated clearly in their teachings.

Schools were the ones that probably appreciated the most the use of images and their ability to simplify the transmission of knowledge. In November of 1917, Partridge noted with pride how "In connection with the printing of S.S.192 The Employment of Machine Guns G.S. wrote 'The G.H.Q. Small Arms School have commented on the excellence of the production of the many diagrams'."[285] This was indeed a very technical

[285] WO/95/81 – Nov. 18, 1918.

manual with multiple images on almost all the pages, which helped with the comprehension of trigonometry, map reading, ballistics, entrenchments, and machine gun positioning. Browsing the manual, it is clear that teaching such complicated and yet fundamental techniques would have been impossible without the help of illustrations and we can understand Partridge's pride in hearing how all his and his men's efforts had made a difference.

Looking at the production of new pamphlets throughout the war (Figure 2), we can notice a general pattern. Until the end of 1914 the unit did not publish much while it was trying to solve the problems created by the frenetic initial months of the conflict. After the establishment of the unit first in the offices of IGQ and then the final move to GHQ, the SS in 1915 increased their portfolio of publications, mainly with the printing of reports and technical documents. Settled into a new, technical warfare, the army was trying to understand their new context: the development of weapons and the sharing of new knowledge acquired through the experience of trench warfare was a priority. The big hiatus of 1916 highlights the difficulties that the British Army in general, and the Stationery Service in particular, had in dealing with the incredible growth in the ranks brought by the conscription. The SS had serious problems in managing the new volume of common material necessary for such a giant army and had to focus on the improvement of their logistics and production capacity.

When the dust of the Somme battle settled down at the end of 1916, the army understood that learning from errors and a continual research for innovation were key ingredients for success in modern warfare. The amount of new publications increased considerably: while a consistent amount of technical publications was accompanying the innovations that the army was bringing to battle, the number of new manuals increased steadily, showing a new attitude to change in the army. The data add another fundamental consideration on the importance of knowledge on the battlefield. There are three big spikes in the publications of German documents in May, August, and October. These are the times when the British Army fought at the Second battle of Arras and the two parts of the Second Ypres battle. One of the beneficial aspects of being the attacker was the collection of the instructional material of the enemy in the captured trenches, an advantage that should not be undervalued.

Finally, in 1918 we can see the maturity of the Stationery Service. Despite the great problems of the spring and summer with the loss of materials and advanced units, the publication of new material never slowed down. After four years of war, the British Army reached maturity and the new system of acquisition and redistribution of knowledge shows its strength. While the battle raged on the frontline the SS kept producing new manuals and pamphlets for the army, demonstrating a good organization and integration into the general structure of the army. With a clear subdivision of the work and moreover of the responsibilities, the acquisition of ideas from the frontline and its publication and distribution had become a natural practice. In the early summer of 1918, when our data stops,[286] the British Army held the line against the last pushes of the German Army. When the time for counter attacking came in August, the army had

[286] Data from: "S.S. 390 - List of Official Publications: Available for Issue to the British Expeditionary Force. Part II: Non-Confidential," 1916, Imperial War Museum; "S.S. 390 - Special Publications: Army Printing and Stationery Services. Part II For Official Use Only.," 1918, Imperial War Museum.

already absorbed the experiences from the battlefield, created a doctrine, and updated the units.

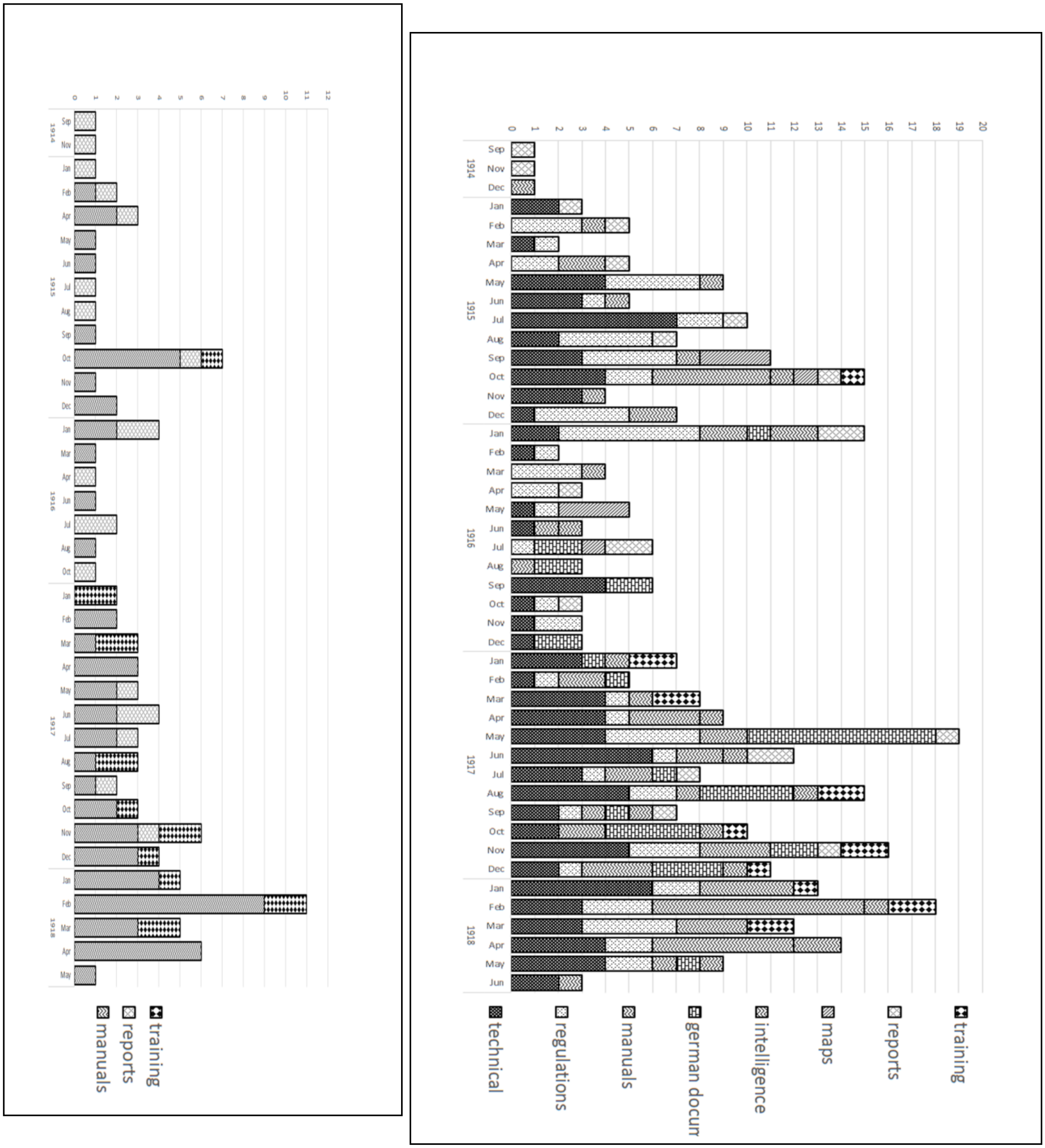

Figure 7. Stationery Services' new publications/month. Left: educational material; Right: all publications.

The Battle for Streamlining

There is, of course, also the matter of the participation of the SS in the war logistical effort. Modern warfare necessitated an increasing amount of resources behind the lines to support the men, which required never-ending work to streamline procedures and economize on expenses. In this job, clerks such as Partridge excelled. He had neither the total understanding of the needs for his orders, nor the power to stop them, but he provided a check for unreasonable requests (especially when they came from the units and not from GHQ).

For example, in February of 1917 GHQ asked for 7,500 copies of a translation of a German document on a new "stick bomb launcher;" Partridge answered that the request was unreasonable, it would have slowed much more important material that was in production, and to contact the WO in England for such orders if they really needed it. He ended the note in his diary cautiously sounding victory: "apparently nothing was done further, at the moment." However, he was wrong. We know who won on the matter in the end. Indeed, the copy of the manual held at the Imperial War Museum indicates that the SS printed it before the end of the month in Boulogne, and in 8,000 copies. However, his complaints allowed his men to finish their work before.[287]

Partridge was not a lone hero of bureaucracy; he had a system around him. He contributed to the creation of this system, but the system also contributed to streamlining the service he was directing. The War Office for example started the paper-recycling

[287] "S.S. 541 German Instructions for the Employment of 'Granatenwerfer' or Stick Bomb Throwers," 1917 The press run line shows "ARMY PRINTING AND STATIONERY SERVICE A-2/17 S724 -8,000." A is the Boulogne shop, 2/17 the date, and 8000 the number of copies made.

effort, even though as we saw it could be a security problem. Another good example is the optimization of the printing standards. This was Partridge's specialty, and yet it was the War Office in London that took the initiative. At the end of the war, the war machine required such a great number of resources that even paper became expensive. Partridge received a letter that explained how the printers in London cut down the number of pages used for the pamphlet *SS 197 The Tactical Employment of the Lewis Gun* from 40 pages to 28, simply avoiding the use of blank ones. It is somewhat surprising that the printers in London, with much more means of production than the sections in France, were the ones to come out with the idea. "Admittedly is done at the expence of appearance," commented Partridge showing how this would hit his pride in the quality of his own work, but it "cannot be allowed to weigh at the present time." It was efficiency after all that he had chased in the previous years.[288]

From the perspective of our time these details appear obvious. We can write, edit, format, edit again and finally print a document from the comfort of our home. Yet, at the time everything was much more complicated, moreover in the problematic arrangements in France. The British Army needed an industrial output of printed material, but the infrastructure that it could use was the very limited one that a rural area could spare, considering also all the other needs of the army. Every time that the SS created a new depot, they had to do a reconnaissance. Often the unit had to contact again the local quartermaster because their specific needs were commonly mistaken. They were offered

[288] "WO-95-81/5.1," n.d., The National Archives, London, March 1, 1918.

small houses that could not host the printers or buildings with staircase entrances that impeded the movement of the heavy boxes full of paper.

One of the most important technical improvements of the unit was the use of electric printing machines. With more advanced equipment came the problem of finding a suitable location, because it was not uncommon in rural France that small villages and farms lacked electrical setups. Even when the building had been deliberately chosen for its connection to the power grid, the standards were not always what the industrial machinery of the SS required. In July of 1916, right in the middle of the expansion of the shops because of the impressive increase of demand from the army, Partridge sent a newly acquired Ferguson electrical motor to power up the presses in Boulogne. With great disappointment, they could not use it because "the new building to which the press is going to move in [is] on a different current from the old."[289] They had to call the Engineers and ask them to install other engines, while the Ferguson, which was also not suitable for Le Havre, had to be sent back to England.

The adoption of electricity was essential to fulfilling the requests, so the SS adopted every measure necessary to solve the nuisances. New technology however was not always the solution for the problems, and Partridge had the right practical attitude of being open to change and yet not blind or too enthusiastic in its adoption. In the Fall of 1917, the Ministry of Munition sent a report from Sir H. Norman, a famous and influential journalist, who enthusiastically contacted the Ministry, convincing them that a

289 WO/95/81 – Jul. 26, 1916.

new French photographic printing machine would have "rendered obsolete" the hand printing used in the army. After some consideration, Partridge responded in a very measured way. After testing one of these machines for some time they concluded that it was able to "absorb 20 or 30 machines," but only after a series of modifications necessary to fix some serious limitations. This positive attitude to tinkering appears to be one of the reasons behind the successes of innovators and enablers during the war.[290]

Printing presses and duplicators were not the only tools of bureaucracy. The army's clerks were used to typewriting machines from their previous civilian jobs. The cost of a typewriter however was substantial, about a third of a motorcycle.[291] For this reason, as we already saw, the mobilization plans in 1912 decided to allocate only 90 of them to the units through the Stationery Depot. As soon as the armies settled down in the trenches, the demand for typewriters arose like a tsunami wave. The units asked the Ordnance, GHQ, and the divisional HQs to send them, but the only one that had the responsibility to distribute them, Partridge, was very jealous of the few that they had. They even received requests from the units to be given authorization to buy privately owned typewriters (probably from home) but the SS always declined them. This unofficial path in obtaining typewriters remained a constant nuisance throughout the war, as units kept asking for help in repairing privately owned machines that they were using. It was, however, an illegal use of public funds and therefore the answer was always a severe no. Bureaucracy was not always flexible enough to be an enabler.

290 "WO-95-81/4," December 1917, The National Archives, London, Sept. 27, 1917.
291 Griffith, *Battle Tactics of the Western Front*, 180.

The reason behind this continual request for typewriters puzzled some of the brass. For example, Bdr. Gen. Dawkings, the Assistant Quartermaster-General, was irritated by the demands to the point that when in January of 1915 Partridge contacted him to see if the army could issue them to the troops, Dawkings replied testily “people write too much already.”[292] The brigadier general clearly never suffered the frustrations of secretarial jobs. Indeed, typewriters eliminated the fastidious problem of handwriting: legibility. It is a problem that most people have encountered in their lives, either trying to decipher a grocery list or the war diary of a British unit during the Great War. However, this was not the main reason: from the lack of good calligraphy common in such documents we can infer that few cared (they were much more used to dealing with handwriting than we are). The real luxury of a typewriter came with its use with carbon-copy paper or even a duplicator. Carbon copy simplified the red tape jobs, allowing someone to write copies of reports in a single session. A duplicator could produce hundreds of copies of an order in a small amount of time and without any particular knowledge of printing. Indeed, duplicators were common in offices and would remain so until the arrival of photocopying machines.

The complicated planning for modern warfare required an industrial production of documents. Lt. Col. Nail Fraser Tyler observed this new evolution of army bureaucracy directly in the June of 1917: “On my way back I called at Brigade HeadQuarters for tea and found them up to their necks in paper connected with the most ambitious and complicated Artillery Barrage that has ever been evolved by the British Army. On being

[292] WO/95/81 – Jan. 9, 1915.

bribed by the Colonel with a well-polished Dunhill pipe, I weakly promised to lend them for a few days my private Corona Typewriter to enable them to cope with this flood-tide of paperwork." Considering the cost of such machines his reticence in lending his to the Brigade HQ is understandable.[293]

For these reasons, the number of typewriters employed in the army arose steadily throughout the war. From the original 90 at the start of the conflict they became 300 in January of 1915, 5,000[294] at the beginning of 1918 and 7,200 at the end of the war (Figure 3).[295] Not all the designs were fitting for the rough life in the army, and Partridge consulted for the War Office on the matter, letting them know for example that the Empire models were not strong enough for use on the field. To provide a thorough report he sent a circular to all the officers who were using them asking not only how sturdy and portable they were, but also if they worked well with carbon copy and with wax stencils for the duplicators, an indication of the importance of these tools.[296]

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[293] The quote is in Marble, "'The Infantry Cannot Do with a Gun Less': The Place of the Artillery in the British Expeditionary Force, 1914-1918," chap. 4, note 26.

[294] WO/95/81 – Jan. 9, 1915, Feb. 11, 1918.

[295] James E. Edmunds, *Military Operations France And Belgium 1916* (London: Macmillan And Co Ltd., 1932), 131.

[296] WO/95/81 – May. 6, 1915.

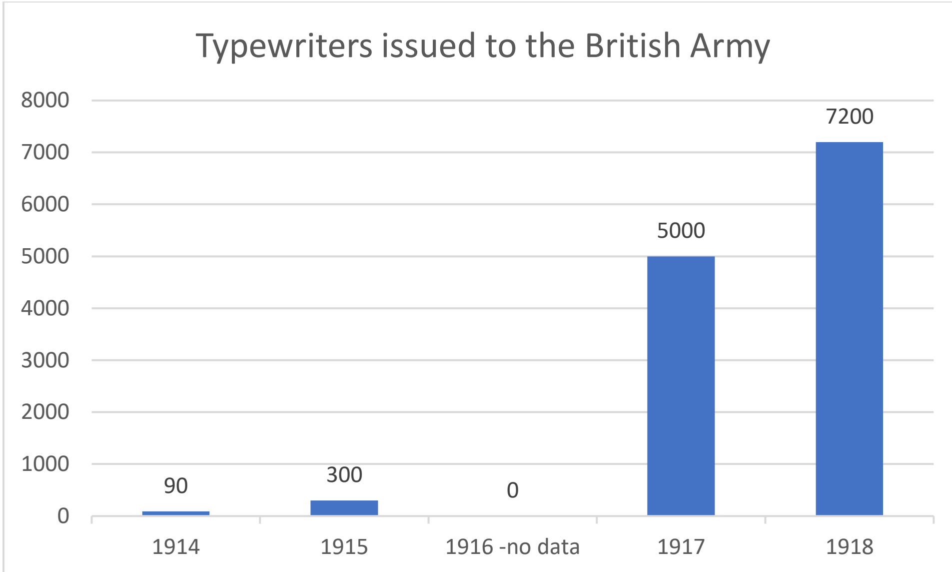

Figure 8: Typewriters issued to the British Army.

In the harsh conditions of the Western front soon arose the necessity to fix the machines. Partridge asked the War Office to do a special enlistment of a typewriter mechanic. It was a matter on which there was some confusion as to who had the responsibility on the matter so before the official request he asked the Ordnance, which responded that it was "an excellent idea" —probably also because it freed them from dealing with the problem. A few weeks later H. Smith, the first typewriter specialist of the British Army, joined the team in Le Havre, where he set up a small shop in a shed on a schoolyard.[297] Soon the number of these mechanics increased, the supply of typewriters was falling thanks to the diminished shipping across the Atlantic, so the army had to deal with more repairs. Every depot of the SS started hosting one of these specialists, and at the end of the war they were 21, including 12 without a fixed shop that were attached to

[297] WO/95/81 – Jan. 12 - Feb. 2, 1915.

the armies, general headquarters, and the Royal Air Force. Many of these one-man-traveling-shops had a motorcycle and drove around continually fixing typewriters for the units. By the end of the war, these men had done 40,000 inspections and repairs and contributed greatly to the effort of keeping the cogs of bureaucracy well-oiled and running.[298]

Conclusions.

The production of printed material for the army filled the need for educating the troops on the evolving nature of trench warfare. Green troops had to learn the ropes, while veterans required updating on the new techniques. The frontline units' constant request for manuals and pamphlets indicates that these booklets were used extensively. The Stationery Service was a fundamental tool in opening a channel for the distribution of knowledge in the army, an important connection between GHQ and the units on the ground. Looking at the manuals, the distribution of doctrines and general information to the troops seems a clear example of a top-down flow of knowledge with an active actor, the army, and a passive audience, the learning soldiers. This is certainly true, but this perspective cuts off the origin of the knowledge, which was generated from the collective experience of the troops and experts fighting in the trenches.

Acknowledging this provenance transforms our understanding of the role of GHQ, because the top of the army appears as a filter that collected the experience before redistributing it, not as a creator of knowledge. The genesis of doctrines during the war

[298] *Statistics of the Military Effort of the British Empire during the Great War 1914-1920*, 202.

was therefore not the result of the theoretical effort of a staff officer behind the desk, but of dialogue between the different layers of the army. To not recognize this dynamic skews our understanding of the war: the trials and errors that slowly changed tactics and doctrines were the result of a collective effort to understand the opportunities and shortcomings of the new technology.

The story of the Stationery Service is also a cautionary tale on the role of GHQ in the evolution of the British Army. Of course, the SS became a powerful tool of control of the knowledge in the army as soon as it became an integral part of the commanding unit, but this was not the result of a deliberate plan from the top. Indeed, the SS slowly climbed up the chain of command, lobbying at every step for a better placement to allow the unit to do a better job. Necessity gave Partridge the persuasive arguments to obtain an increased size and influence, but it was his vision and his ideas that created the unit, not the idea of a staff officer from GHQ.

CONCLUSIONS

Technology has an important social component, even on the battlefield. It is too easy to oversimplify the complicated interaction between weapons and soldiers and focus only on one component of war, weapons. This approach is often a dead end but has still an enormous appeal. Military aficionados could discuss endlessly technological details such as 'what was the best tank of the Second World War.' To my irritation, Google included me in this category of people, constantly suggesting to me articles on Hitler's secret weapon that could have changed the war or on the mother of all bombs that will eradicate terrorist groups. This impoverishes our understanding of war, transforming an extremely complex dynamic into a mindless arm-wrestling match between objects. The emergence of drones and unmanned vehicles on the battlefields will most likely intensify the problem.

In 1916, after a week of preliminary bombardment on the Somme, the British soldiers discovered that technology alone would not solve their situation. The bombardment was based on the theory that the destructive power of artillery would make the enemy disappear, yet this dream was never reached in the war by artillery or anything else. The constant research for the new revolutionary technology to win the war was of course necessary. With continual innovation the armies could remain updated on the latest changes in warfare, yet no technology noticeably altered the balance of the conflict. New models of aircraft sometimes had a temporary impact, as the Fokker Scourge in the fall of 1915 reminds us. Similarly, the addition of the tank on the battlefield had substantial successes, but the impact that this new weapon had on the final victory is highly disputable; indeed, the German Army almost managed to win the war without using it. Arguably other technologies had a bigger impact: the use of barbed wire and corkscrew poles seriously influenced the ability of entire armies to attack successfully, buying time for the artillery to hinder any advance; the introduction of the 106 fuse in 1917 gave back to the artillery its ability to open gaps in the entanglements efficiently, but considering the two additional years of costly struggle we can hardly define this tool as transformative.

The reason for this equilibrium is the weapon system of the trenches. This highly effective defense evolved faster than new technologies and doctrines for the attack and therefore became the main problem to solve to win the war. However, trenches were also the main reason for change, obliging the armies to adapt continually to their evolving nature in the pursuit of victory. Before the war, theorists did not change doctrines despite the introduction of new technologies. During the war, having no time to develop new precepts but plenty of examples of failing theories, the General Headquarters of the British Army allowed for suggestions from the battlefield to flow upward. Eventually they set up a system to filter these ideas, consolidate them into doctrines, and redistribute them to the army. Success on the battlefield resided in this ability to accept ideas from the frontline and therefore in the ability of the frontline to provide them.

If we take this perspective, the soldiers on the battlefield acquire an influence over the evolution and resolution of the war that has often been overlooked. This is not a novelty for historians that deal with technology who have long been used to analyzing its social construction (SCOT). As a society, we commonly accept that customers have an influence over the production and utilization of gadgets. Historians explained the importance of looking at complex systems of technology such as electric networks as the results of the interaction of society, inventors, economic interests, and the technology itself. Instead, military historians tend to discard this complex relationship between soldiers and technology. Therefore, they diminish the agency of the soldiers on the battlefield. However, the success of a technology on the battlefield is dependent on the men and women that use it. For example, when men on the frontline started to receive scoped rifles, their usefulness was very limited. With time and trial and error it became clear that the real weapon was behind the rifle: the sniper.

The example of snipers is very clear in showing the pressure of ideas from below. Indeed, in the British Army the first to utilize scoped rifles were seasoned big-game hunters. On the battlefield they easily made the connection between their experience in killing animals with their current job of killing enemies. When the British Army eventually started to issue scoped rifles, gentlemen like Partridge and Crum could use their social connections to start a more rational organization. They could distribute basic knowledge such as how to properly set up the scope and start some unofficial training. Local sniping schools were the next step, and eventually the ideas surfaced as official doctrines.

This example highlights the shortcomings of the narrow approach that only considers objects in the investigation of technology. Sniper scopes were pieces of high-end optical technology and therefore could not be produced in the trenches by the men. Highly specialized factories had to produce them with great precision. Therefore, these objects were distributed to the soldiers as an effort of the British Army in what clearly seems a top-down movement. Yet two factors show that the actual pressure was from below. First, early users bought them privately because the army initially failed to understand the need of scopes on the battlefield. Second, when the army finally started to issue sniper rifles, untrained men misused the scopes until outside the official trainings fellow soldiers with more experience taught them how to set them up. Indeed, the highly specialized rifles came without instructions and it was the entrepreneurial attitude of the soldiers in the trenches that made the tools effective, not the army's distribution of scopes to the troops.

The entrepreneurship of the soldiers in the trenches is evident when they lacked the weapons they considered necessary for the new trench warfare. Despite the inherent danger of makeshift mortars, we have multiple records of units that went to the corps workshop and requested these weapons be made. For these improvised artillerymen the sole alternative was to leave complete freedom to the enemy's trench mortar units, a prospect that was even less appealing than risking misfire while lighting the fuse of their makeshift mortars.

Among the soldiers' requests that workshops accommodated were trench knives. These weapons were simple and cheap to make, yet very effective in trench brawls. To use a knife in battle was an extremely personal matter with a severe psychological impact. Such intimate violence was rare in an industrial war that usually left soldiers with a feeling of powerlessness in front of the enormous scale of the events. The deliberate choice to carry a knife was the decision of expert soldiers. However, despite its cheapness and effectiveness, the British Army did not issue any official version of a knife during the Great War, showing how the debate over weapons and technology between the soldiers on the frontline and the institutions managing the resources did not always lead to a solution of the problem.

Both the case of the early trench mortar and the trench knife highlight one of the most important factors that allowed regular soldiers to participate to innovation: the unpreparedness of the army as an institution. The British Army was not the only one to have problems keeping up with wartime production. Throughout the war all the belligerent nations were constantly chasing solutions to unfamiliar problems and they were often behind schedule in providing their troops with the necessities of modern warfare. These institutional shortcomings created a void of power that the troops on the frontline filled with their imagination and adaptation.

Even when the army supplied the necessary tools, the participation of the soldiers was constant and fruitful. When the entrenchment of the armies made evident the urgency for detailed maps of France and Belgium, the British Army scrambled to fulfill the need. Squads of expert surveyors acquired the data and a number of military agencies in England printed them. In 1915, part of the map production moved to France, but it remained a process under the direct control of GHQ and the Ordnance Survey Office for reasons of consistency and secrecy. However, the data to populate these maps came from the bottom, from the frontline and air reconnaissance.

Collecting the intelligence on the enemy positions became a very sophisticated process of deduction that required highly trained men and officers. Being a novel discipline, the development of the techniques fell to the men themselves: in the trenches snipers took upon themselves the role of observers, perfected the crafting of hidden observation posts, and refined the deductive methods to collect more information from observing the battlefield. Airmen and photographic experts developed from scratch the new techniques for air photography, analysis of the plates, and translation of the acquired data onto maps. Therefore, while the maps as a medium were produced from the top, it was the bottom of the army that collected the important information that populated them.

We could consider the Special Works Park as another institution that distributed knowledge top-down. Indeed, it was a highly specialized unit instituted by GHQ to develop the new concept of camouflage and provide services for the soldiers in the trenches. However, a deeper analysis of the evolution of the operations of this unit shows a different reality. The unit was not producing new ideas in an isolated laboratory, but in constant contact with the frontline, not only taking inspiration from the experiences of the fighting troops, but also directly inviting suggestions and new ideas in the manuals for their classes.

In all these cases, soldiers of any rank participated to the process of innovation. Both officers with decision making power and men who lobbied for their ideas up the chain of command had agency over technological innovation and change. Their ingenuity and engagement contributed substantially to the transformation of the British Army from the small, albeit well-trained, professional army, to the modern and innovative citizen army at the end of the war.

There might be a temptation to overextend this understanding stating that armies with the best soldiers won the war. Following this idea, having prevailed in the technological race of the war, the British soldier and consequently the English society should have been more intelligent, more mentally flexible, or more adaptable to change. It is a dangerous path to take, a route that would explain more about the historian who uses it than the historical reality, as Michael Adas amply demonstrated.[299] Was the Italian, Russian, or Ottoman soldier less modern and therefore lacking the ability to create new ideas? I refuse to think with these parameters in mind. Yet education probably had an important role in the transmission of knowledge for the simple reason that the more people could read the more they could assimilate new information. This is, however, almost a moot point, because it is very difficult to prove how much reading was important in training soldiers.

However, the British Army offered an environment that accepted and even encouraged the flow of ideas from the bottom, despite the social division and the stiffness natural in most armies. It was not an inherent characteristic of the war to create this environment, even if it probably was a component in the equation. Circumstances were the key factor: the great change in character of the British Army, transformed from the small professional army to the gigantic machine of conscripts, made space for the evolution. The new necessities of the inflated army, together with the stress of the

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[299] Michael Adas, *Machines as the Measure of Men: Science, Technology and Ideologies of Western Dominance*, 5. paperback print, Cornell Studies in Comparative History (Ithaca, N.Y.: Cornell Univ. Press, 1995).

industrial production and the continual stream of the strategic frustration of trench warfare, set the terms that allowed success.

Bureaucracy was a positive force to channel innovation. Red tape is rarely accepted as a positive force of change, but the Kafkian experience of soldiers following the official channels with their requests was only the annoying byproduct of the search for efficiency. The example of the Stationery Service highlights how the creation of proper channels empowered the British Army, organizing a dialogue between its bottom and its top. Of course, a big part of Partridge's men's work was still the provision of stamps, paper material, and typewriters, but the masterpiece in management of this bureaucrat was the merging of the processes of collection and redistribution of knowledge as the work of a single unit. Printing was not an easy task on the field and the necessities of modern warfare required a constant stream of booklets, pamphlets, maps, and photographs. This productive endeavor sustained the process of distribution of responsibilities to the commissioned officers and NCOs. If soldiers down the chain of command needed to make decisions, they also needed instructions, information, and constant updates on the new techniques.

Bureaucracy created a venue for this constant flow of information and knowledge. There were two factors that allowed the success of the Stationery Service: the direct connection between the unit and GHQ and the ability to collect expertise and knowledge from the frontline. Being within the center of decision-making on the western front provided the unit with the fundamental authority to effectively deal with the continual requests from the front. Additionally, the Stationery Service could provide the staff officers with their skills, avoiding technical mistakes, while the proximity to the GHQ facilitated the whole process of editing. For the collection of knowledge from the trenches, centralizing the production of training material made the unit the sole venue for the publication of the expertise gathered by other institutions inside the army. Concentration of production provided uniform standards and more importantly, a single place where units could search for manuals to train their troops and stay informed on the latest lessons learned in battle.

The Stationery Service did not provide the content of the manuals. However, the first deputy director of the SS chose the authors, picking an expert on the discipline. The evidence suggests that these authors were chosen from the official centers of expertise in their field and therefore the content of the manual directly reflected the experience matured on the battlefield. When Salomon was contacted to write a manual on camouflaging, he was a well-connected member of the Special Works Park, the unit that developed camouflage for the army; the author of the manual on sniping, Major Crum, was the most prominent sniping school director.

The frequent training and updating of the troops were fundamental in a war that continually changed methods and weapons. This necessity made schools and workshops the natural place where new knowledge consolidated. The granularity of these schools probably made the whole process easier. Instead of having a single, central school in England, each army formed and managed its own center of education and training. From memoirs of members of these schools like Hesketh-Prichard and Crum, we observe that the practical attitude of small schools counteracted the risk of rigid regulation. Far from the austere nature of the historical military schools in England, local army schools had to adapt to the problems of being nearby the frontline and maintained an environment of camaraderie. Being close to the battlefield also allowed instructors to inspect the frontline and answer to the calls of assistance from the units in the trenches. Whenever there was a special case, the soldiers could call in the experts for help.

Through their direct experience in battle and the continual interaction with the many soldiers rotating in and out of schools, instructors had the pulse on the current developments. They also had the important role of teaching green recruits how to survive and be effective in the dangerous world of trench warfare. Teaching required clarification and simplification, putting them in the best position for writing the official pamphlets and manuals on their discipline. However, the ideas that they distilled in their teachings were not all theirs. Building up the knowledge base was a collective effort, not the work of single, talented experts. In a war of such magnitude and balanced competition, new ideas came from the practitioners in the trenches. The schools participated to the creation of new ideas, but their most important job was the accumulation of the collective experience of the troops on the frontline.

Considering the soldiers as an integral part of the process of innovation bears with it the question of whether or not this has always been the case. I cannot imagine it was not although likely to varying degrees depending on the circumstances. War is an overwhelming experience and, in such situations, people tend to think of ways to increase their chances of survival and success on the battlefield. Looking at the incredible variety and constant evolution of medieval weapons and armors, it is easy to imagine that a great number of them came from the ideas of veterans of the battlefield. Later, a soldier in the army of Frederick the Great probably did not have enough independence and resources to innovate in the extremely rigid and hierarchical organization of the Prussian Army. Uniform training to maintain cohesion of the regiments on the battlefield took away from the lower ranks a great amount of their agency.

The First World War gave to soldiers the ability to influence big changes in warfare. The shock of modern technology shattered doctrines, requiring new adaptation in war time without much time for debate, but giving ample space for requests and ideas from the trenches. However, one factor is paramount: it was a long and balanced war. The fact that no army seemed able to gain a decisive advantage over the enemy highlighted the necessity to change, to find a way to win the war, but time was the essential ingredient that allowed soldiers to participate to the process. A short and violent conflict would have occupied men solely with action and survival. On the contrary, four years of war meant that the soldiers had ample time to adapt to their new life in the trenches and express their creative side to improve their chances of getting through the war alive and succeeding on the battlefield.

If we want to understand the Great War and have in general a better grasp on the dynamics of innovation during a conflict, we need to keep the soldiers in the picture and understand the degree of participation that they had in the process of change. Doctrines and documents tend to hide the contribution of the men on the battlefield. It is often difficult even to give a name to the author of the official manuals that the British Army published during the war. However, the ideas of officers and privates are there, between the lines.

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