Nobel's long-distance correspondence led to gunpowder startup in Karlskoga

– It would be great to see old Sweden rivalling arms producers like Germany and England

by Cecilia Beckmann

Resumé

I den här artikeln beskrivs det innovativa samarbetet mellan uppfinnaren Alfred Nobel och hans assistent, kemiingenjören Ragnar Sohlman. Det var ett unikt samarbete då deras kontakter mestadels sköttes brevledes eftersom Nobel oftast var i Paris eller San Remo medan Sohlman var stationerad på Bofors i Karlskoga. Här analyseras resultatet av deras samarbete med ett konstruktivistiskt förhållningssätt där innebörden av händelser och individers ageranden tolkas i relation till begreppet diversifiering. Nobels och Sohlmans gemensamma experiment ledde till att Bofors, som ursprungligen var ett järnbruk och som nyligen börjat tillverka kanoner, år 1898 också började utveckla och tillverka krut samt senare ammunition. Brevväxlingen visar att för Nobel var Bofors den experimentverkstad han saknat. Här kunde han testa såväl raketer, krut, granater och tändrör som nya metoder för att dorna upp kanonrör. Men medan Nobel var nöjd med att bara experimentera på Bofors hade Sohlman entreprenöriella ambitioner. Och när svenska flottan föreslog en flytt av Nobels ballistittillverkning från Stockholm till Karlskoga gick Nobels och Sohlmans meningar isär.

THE STORY ABOUT the friendship and innovative collaboration between Alfred Nobel and his assistant Ragnar Sohlman, and how this partnership eventually led to the introduction of gunpowder and ammunitions manufacturing at Bofors in Karlskoga, takes place during times of crisis among many Swedish ironworks during the late 19th century. Although Bofors, originally an ironworks, had diversified in the 1880s and started manufacturing guns, the future was very uncertain. Nobel's purchase of Bofors in 1894 meant that the company entered a financially stable and dynamic phase. The opportunity to start production of gunpowder emerged quite soon, but there were conflicting interests among the actors involved. When Nobel passed away in late 1896, nothing was settled regarding the gunpowder issue. And without his financial backup, Bofors' situation once again became uncertain. The willpower and determination of Sohlman would be crucial for the gunpowder startup.

In this article, based on the correspondence between Nobel and his assistant Sohlman, we follow the sometimes-hazardous experiments performed at Bofors during an intense period of development work. Sohlman was in charge at the Bofors shooting range and the chemical laboratory while Nobel super-

vised from Paris or San Remo. The article is based on my dissertation about Bofors' struggle through periods of crisis and uncertainty from the late 19th century to the early 2000s.[1] It reveals that the driving force of a distant Nobel and his locally embedded assistant, Sohlman, at Bofors, constituted a unique, innovative and even modern partnership. Because, to find explanations for the survival and success of knowledge-intensive industrial cities in non-metropolitan areas, researchers Bathelt, Malmberg and Maskell have emphasised the meaning of place-based knowledge networks, "local buzz", *and* partnerships with distant economic actors, "global pipelines".[2] Nooteboom found that being locally embedded can thus be an advantage, yet "an escape from local embeddedness may also be needed for innovation".[3] Working with a local partner may imply that a company can gain deeper knowledge within a particular area while a distant collaborator may bring new knowledge of crucial importance for a company's long-term development.[4] In addition, local social networks are important prerequisites for entrepreneurship, especially in rural areas. But social bonds must not be too tight or there is a risk of lock-in effects, such as stagnation. On the other hand, if social ties are loosened due to changing economic conditions, the network might disintegrate.[5] It is a balancing act.

In the following, I present the theoretical concepts that I have applied when interpreting the actions of economic agents in this article. I understand economic agents as being individuals as well as companies or state actors. Then follows the empirical part covering three years of the collaborators' correspondence where I also present my understandings of the events and experiences of the actors. Lastly, there is a concluding discussion.

Theoretical concepts

Innovation – a definition

The aim of the many experiments performed at Bofors under the supervision of Alfred Nobel was to create innovations. "Orders we take to get by, but the idea is to create and not to walk in our great, great, great grandfather's shoes,"[6] he stated in a letter to his assistant Ragnar Sohlman. The term 'innovative' in this article follows Joseph Schumpeter's[7] definition of innovation which implies: 1. A new good, or new quality of a previously known good; 2. A new method of production within a certain branch; 3. To venture into a new market (diversification); 4. Gaining access to a new source of supply; 5. Reorganisation of an industry by creating or breaking up a monopoly-position within a branch.

Diversification

Diversification is the core concept in this article. Whether related to existing industrial activities at a location or not, it requires agency. Researchers agree that, in order to create new industrial paths, such as diversification, in a region, economic agents from different spheres are needed.[8] Local knowledge resources may not be enough. The necessary knowledge for diversification may be acquired from actors, such as universities or foreign partners. Creating a new industrial path or engaging in diversification is thus not an isolated act, but rather the result of interaction between actors, in partnerships, who share a worldview related to the economic activities they are pursuing, locally or globally. This worldview can be conceptualised as the institutional environment. It includes the rules, norms, practices and traditions that shape people's everyday lives.[9]

For a company having to cut down its production within a certain branch, yet hoping to retain as many jobs as possible, one solution is to venture into some area related to what the company already does. In Evolutionary Economic Geography (EEG) this is sometimes called related variety or related diversification. Previous research has revealed that companies venturing into a business area related to their own branch indeed increased job opportunities in their region. Meanwhile, diversifying into an unrelated business or knowledge field (unrelated variety) can mitigate the effects of a drastic decrease in job opportunities within a regional labour market.[10] This means that the effects of the closing down of a local industry can be mitigated if a new business in an unrelated branch is established in the region. I employ a broad definition of related variety, which includes theoretical relatedness as well as related hands-on skills. Yet, there is also a commercial aspect, which I think is important. Two products can be unrelated in terms of their theoretical knowledge base, yet go well together commercially, like guns and gunpowder. Several quantitative studies have been conducted in which the effects of companies' diversification in different regions were investigated. Neffke, Henning & Boschma showed that new companies starting activities in an area were usually in the same branch as the companies already operating there. Meanwhile, companies leaving an area for some reason were generally not related to the existing branches from a technological perspective. In their case study of Linköping, these researchers found that this tendency, operating over 30 years, led to an increasingly homogeneous industrial environment in the investigated area.[11]

In another study, Neffke and Henning found that skill-relatedness was decisive for companies diversifying. Having staff with the right skills, skills that could be used for similar work tasks, guided decisions as to which branch a company would diversify, rather than value chain-linkages.[12] Further research by Neffke, Hartog, Boschma & Henning showed that companies venturing into an unrelated branch in a city were more successful if they were already established in that city than economic actors who were new to that place.[13] Regarding unrelated variety, and following their literature review on this topic, Content and Frenken called for research investigating why some regions manage to diversify into unrelated branches and how they can make radical innovations, break with path dependence and combine their existing knowledge with new ideas.[14] Researchers then found that unrelated diversification is often associated with actors who have gained experience and capacity elsewhere.[15]

Companies in regions producing many innovations are more likely to venture into branches unrelated to their core business than companies in less innovative regions where companies tend to diversify into branches related to their existing business. The latter is therefore more path dependent.[16] The interest in related and unrelated variety and increasing employment was also displayed in the study by Content, Frenken and Jordaan, in which the authors distinguished between opportunity-driven and necessity-driven development. Opportunity-driven development means that the actor grasps a spontaneously emerging business opportunity, while necessity-driven means that it is initiated out of a need for new jobs in a place. The authors found that related variety led to greater employment growth when development was opportunity driven.[17] Applying a local or regional perspective, it is clear that diversification will support knowledge transfer between companies in related branches sit-

uated nearby geographically. A structure of this type can provide fertile soil for innovations. This type of culture should then be more resilient when economic or political conditions, that is the institutional environment, suddenly change.[18]

Method

This article is to a large extent based on a letter conversation between Alfred Nobel and his assistant Ragnar Sohlman. While some researchers have read these letters before me and used a couple of quotes from them, no one has, to my knowledge, presented such a detailed description and analysis of how their partnership led to the founding of AB Nobelkrut in Karlskoga. The correspondence is held at the National Archive in Stockholm, where it was copied in the summer of 2019. The constructivist approach means that I have interpreted the events taking place and the meaning of actions and experiences of the actors in relation to the theoretical concepts presented earlier. For example, this means that I apply the concept of diversification to understand the actions of Nobel and Sohlman to see who did what during the diversification process and how they felt about it.

There are things to consider when choosing to search for data in the archives. The data found should be relevant to the research questions. And the researcher has to be careful about making interpretations from a conversation that took place a long time ago. Marshall and Rossman caution that "…the meaning of the documents is never transparent", which I understand to imply that the meaning is context dependent, and the researcher needs to consider that events and ideas in the data can have different implications in different times.[19] The world of Nobel and Sohlman was very different from the one I perceive currently, regarding both norms and traditions. Careful reflection was needed when gathering knowledge about their relationship. All in all, I read and transcribed 145 letters and 20 telegrams from Ragnar Sohlman to Alfred Nobel, and 77 letters and 38 telegrams from Alfred Nobel to Ragnar Sohlman. In order to learn how Sohlman felt about Nobel I also copied letters he sent to his mother and his wife while he was employed by Nobel. These letters are kept at the Royal Library in Stockholm. I read and transcribed 47 letters that Ragnar Sohlman wrote to Ragnhild, his wife, and 39 that he wrote to his mother, Hulda Sohlman.

While the technological development taking place at Bofors in Karlskoga during the Nobel ownership have been depicted in literature produced by the company, the correspondence used as data in this investigation sheds new light on events and human relations behind the introduction of gunpowder manufacturing at Bofors. I argue that there are events that could stand re-examination, and where these letters will provide a more thorough, richer understanding of the development. However, I have also used secondary data relevant for this investigation. These are two corporate biographies about Bofors and Ragnar Sohlman's two biographies on Nobel as well as his printed accounts in a corporate Bofors magazine.

Translation

The correspondence used as data in this investigation was written in Swedish, but I had decided to write the dissertation, upon which this article is based, in English. This decision had implications. A researcher must be cautious when sentences are translated into a new language, perhaps changing the nuances from the original language.[20] There are many quotes in this investigation. However, I argue

that both Nobel and Sohlman were very precise in their language, and most of the time I found the translation process manageable. Guns, shells and projectiles are not difficult words to translate. Yet, there were occasions when I had to think carefully about how to translate a particular word or sentence. This is especially true of Sohlman's letters, where he was expressing his emotions. The translation process gave me yet another opportunity to engage intimately with the data, as Marshall and Rossman insist that researchers should do.[21] The correspondence originates in the 1890s. The Swedish is therefore quite different from the Swedish we are familiar with today. The old Swedish sounds more formal most of the time, although Nobel is sometimes rather informal. I could not possibly translate this kind of 1890s Swedish into 1890s English. At times I have therefore constructed sentences in English that are not as formal as they were originally in Swedish. In this way, I think I have also made the story more accessible. Regarding secondary Swedish sources, in some cases I have found an English edition of the source. Unless an English edition was available, I have translated such Swedish quotes to English.

Results

Escaping the crisis

The place where I have conducted this investigation is Karlskoga. Today, there are slightly more than 30 000 people in the municipality.[22] However, at the beginning of the period investigated here, in the 1880s, it was just a village with a small population. Bofors and Björkborn were then neighbouring estates in Karlskoga, originally typical Swedish iron works, founded in the 17th century, with manors for the masters and little cottages for the workers. During the 20th century, Bofors and Björkborn were transformed into large industrial sites. Steel and gun manufacturing were located at Bofors, while chemical operations were introduced by Alfred Nobel at Björkborn.[23] The diversification into gun manufacturing took place against the backdrop of the hard times experienced by Swedish ironworks in general in the latter part of the 19th century. In the province of Värmland, where Karlskoga is situated, only five ironworks made it through the crisis, Bofors being one of them. Most of the ironworks that closed down were small and could not adapt to the demands of industrialisation regarding rationality and productivity.[24] However, Bofors was also in financial crisis.[25]

What started the diversification process at Bofors was the decision in 1878 to try and make cast steel in a new way, using the French method, the Terre Noire. This attempt was successful. They managed to create a cast steel which showed such strength that the Navy in Sweden, when informed about it, was eager to use it for their guns. The diversification was therefore opportunity driven. The initiator was an external actor that provided Bofors with an opportunity to diversify. While the engineers at Bofors had no knowledge of gun manufacturing, Swedish artillery officers were able to support them with such skills. At the time, artillery officers were really the only professionals possessing the expertise needed for the construction of guns. What is more, these officers also persuaded the government to finance the development work at Bofors.[26] At a time when many of the old Swedish ironworks were closing down due to lack of profit,[27] Bofors thus diversified into a new branch, unrelated to its core business at the time, from a knowledge perspective. Starting its gun-building mechanical workshop in 1883, Bofors entered an institutional environment

that consisted of international rearmament, where technological development was rapid due to recent major European conflicts. There were rising demands for precision, as well as rate and range of fire. Competition was fierce from companies in Germany, France and the UK.[28]

Major investments were needed to keep up with foreign gun manufacturers and Bofors' owners, the Gothenburg–based trading company Kjellberg & Sons, was heavily in debt and could not provide any more financial resources. This company had provided a substantial amount of money to keep Bofors from going bankrupt. In the beginning of 1894, at a point in time when the economic prospects for Bofors thus seemed bleak, the inventor of dynamite and multi-millionaire, Alfred Nobel, bought the company.[29] Nobel had a keen interest in guns and explosives. Ragnar Sohlman, who would become Nobel's assistant, stated that: "His [Nobel's] aim was to acquire a factory in Sweden for the manufacture of guns and other war materials…".[30] Until he bought Bofors, Nobel had performed trial shooting outside Paris as part of his experimental activities. However, the French authorities had been harassing him, a circumstance which forced him to move elsewhere, and that place was Italy. Yet the shooting conditions in San Remo, by the Mediterranean Sea, were unsatisfactory, and Nobel therefore decided to search for a place in rural Sweden. An offer to buy the estate of Finspång, where they made guns, was turned down by Nobel, because the workshop seemed outdated. Then Nobel learnt of Bofors and its new gun workshop, and that there was a shooting range large enough for the activities he wanted to perform. Following the acquisition, he made major investments in development work on gun mechanics at Bofors. He also made a private investment in a chemical laboratory at Björkborn, the neighbouring property that also belonged to Bofors.[31]

Chemistry, beyond that needed to work with iron, was a new technology at Bofors. The investment in a chemical laboratory therefore represents yet another diversification unrelated to the company's core activities, the second one in ten years, considering the gun manufacturing in 1883. Since Nobel resided in San Remo and Paris most of the time, he hired Ragnar Sohlman, a 23-year-old Swedish chemical engineer who was employed to initiate and run the daily work at the laboratory. Sohlman, a former classmate of one of Nobel's nephews, had recently returned to Europe from a period of training in the USA. Following his return, he and Nobel had worked together for nine months, from November 1893 to August 1894, in the laboratory in San Remo. Then Sohlman was relocated to Bofors.[32]

Alfred Nobel and Ragnar Sohlman – a long-distance collaboration

After the introductory period in San Remo, Ragnar Sohlman arrived at Bofors on 12 August 1894, where he was met by Nobel. It was not decided whether Sohlman should stay permanently at Bofors. There was the alternative of returning to San Remo after a while and continue laboratory work there. However, at Bofors Sohlman was instructed to lead the experiments related to military equipment and artificial materials in accordance with guidelines set up by Nobel. Meanwhile, Nobel himself left within days. It was not known when he would return. "In general, nothing is more uncertain than Mr Nobel's trips, his residences and plans",[33] Sohlman had told his mother earlier. As well as performing new experiments that autumn, Sohlman was also expected to lead his new colleagues at Bofors in activities where the

outcome was sometimes hard to foresee, as explosives were involved.

How their working relationship had evolved

While in San Remo, Sohlman and Nobel had become quite close professionally when experimenting in the laboratory. Sohlman certainly met the intellectual requirements set up by Nobel. Among the experiments Nobel asked Sohlman to perform while working in San Remo (and while Nobel himself went to Paris) were the mixing of substances in order to create artificial caoutchouc (rubber), leather and gutta-percha.[34] These substances were then supposed to be applied to fabrics, making them waterproof. Sohlman not only performed these experiments and sent the enveloped results (small samples) to Nobel in Paris, but he also analysed and evaluated the results, and suggested how they may be improved.[35] Yet, rising to the intellectual level of his employer was quite stressful at times, as Sohlman confided to his fiancée, Ms. Ragnhild Ström, in a letter.

> But you would not believe, how it feels, when I want to make something out of myself and then sometimes, I feel as if it is no use trying. Luckily, I am usually able to restore my self-confidence after such periods. For these past few days I have done some new work, or rather, entered a completely new field which has occupied me for some time now, and I have had very promising results. Mr Nobel was very pleased and said among other things: "Yes, you know Mr Sohlman, it was far better that you came here, to me, and got to work with new things, than to be over there in America, in a factory." Yet this means I have an almost endless amount of work in front of me.[36]

Nobel appreciated the judgements and viewpoints that Sohlman shared with him. This was clearly evident even when they did not agree on all issues. In a letter to Ms. Ström, sent from San Remo, Sohlman explained that he must respect Nobel's wishes, since Nobel could easily find a replacement for him, while he could hardly find a position like this elsewhere. "But you should not think that I have given up my independence towards Mr N. On the contrary, I often argue with him. This sometimes annoys him, but he still appreciates it".[37] Nobel apparently believed so strongly in Sohlman's ability that he was prepared to let him run the experiments at Bofors while Nobel was supervising the activities from his residences in Paris or San Remo. In a letter to his mother, written while he was still in San Remo, Sohlman told her that Mr Nobel often spoke appreciatively of him. Beckett, his colleague at the lab, was apparently a much better analysist, but Nobel claimed that Sohlman was more creative and worked more independently.[38]

Rather early in their partnership in San Remo, they had developed a sympathy for each other. The emerging friendship strengthened their professional bond. They also spent time together when not in the laboratory, taking walks or swimming in the Mediterranean Sea. Sohlman felt that Nobel was very kind and generous towards him, much more so than he had expected. As time went by in San Remo, Sohlman began to feel gratitude, admiration and affection towards his employer, and these feelings would grow stronger with the years.[39] He was attentive to Nobel's changing moods as he noticed that Nobel seemed to suffer from a "nervous depression".[40] In a letter to Ms. Ström, Sohlman worried that Nobel was overworking. It seemed to him, as though work was the only pleasure Nobel knew, that he knew not of love, other than French love, paid for monthly. "Sometimes I feel such compassion towards him, who in the midst

of this wealth, and abundance of ingenuity, still is so poor in some ways".[41] Nobel, on the other hand, who was "explicitly pessimistic in his view of people",[42] after he had known Sohlman for some time, wrote to a friend that his assistant was "one of the few people I am really devoted to".[43]

Plans for gunpowder manufacturing. Or just experiments?

When the Nobel takeover of Bofors was completed, in February 1894, Nobel and Sohlman got on the train to Sweden, to pay a visit. Nobel was considering a diversification of the Bofors activities. When conducting his first meeting as chairman of the Bofors board of directors, he stated that it was not unlikely that the company would start manufacturing gunpowder and argue for its use together with the Bofors guns, just as the German gun manufacturer Krupp did. "That's very rational".[44] Later that spring, when they were back in San Remo, this idea about a gunpowder factory at Bofors was published in a Swedish daily newspaper.[45] However, two weeks later, the newspaper published a disclaimer stating that Nitroglycerinbolaget, a Nobel-company in Stockholm, had been given the exclusive rights, by Nobel, to manufacture not just Nobel's smokeless gunpowder, ballistite, but all future military gunpowder invented by Nobel.[46] The published idea about a gunpowder factory at Bofors most likely led to the management at Nitroglycerinbolaget confronting Nobel who then backtracked on his former statement. Because Sohlman told Ms Ström in a letter: "Mr Nobel was rather annoyed by this rumour".[47] The plans for a new laboratory at Björkborn enabled the possibility of producing the ballistite needed for trial shooting with guns at the shooting range which belonged to the estate, but that was all, he told her.[48] Gunpowder is a commodity closely related to guns from a commercial perspective, and it is an advantage to develop these commodities as a pair, to make them fit with each other. But the basic theoretical knowledge and manufacturing skills behind gunpowder are unrelated to those required to make guns. To plan and draw up a draft for the new chemical laboratory at Björkborn, Nobel therefore hired his long-time business partner and friend, the chemist Alarik Liedbeck, who had worked as a consultant for Nobel all over Europe.[49]

Autumn 1894 – Nobel leaves Sohlman with a pile of instructions

When Sohlman arrived at Bofors in August 1894, he was uneasy. He felt that he was perceived as Nobel's right-hand man, a position he thought would require his utmost diplomacy in this new environment. He learnt that he would be performing a lot of gun experiments. The head of the gun workshop at Bofors, Arent Silfversparre, was apparently somewhat discontented with this situation, in which a young newcomer was to be in charge. This troubled Sohlman because he found Silfversparre to be a friendly person and feared that he would face an adverse attitude from the employees at Bofors. On top of this, there was a "silly rumour" that Nobel was going to make Sohlman managing director at Bofors. "I have a feeling that my presence here is not appreciated",[50] Sohlman told Ms Ström, in a letter. However, a couple of days later Sohlman had gained a new sense of the atmosphere at Bofors. Now, it seemed less threatening.[51]

While Nobel was away during the autumn and early winter of 1894 and the chemical laboratory was not yet ready to use, Sohlman was expected to perform some expensive experiments with explosives and armoured

plate and "it is of greatest importance for me not to fail, and to present some results before the return of Mr N".[52] Sohlman also became involved in the construction of projectiles for 12-centimetre guns. His co-worker was the head of the mechanical workshop, Silfversparre. They also made preparations for trial shooting.[53] While in Paris or San Remo most of the time, Nobel still took part in the Bofors activities from afar. In the evenings, after experiments on forging, hardening of plate and trial shooting with guns and projectiles, Sohlman systematically wrote down the results, along with his reflections on the experiments. Then, the letter was taken to the evening train departing from Bofors Railway Station, to be read by Nobel a few days later, in San Remo or Paris.

Sohlman was particularly interested in the hardening of armoured plate. He tried hardening steel plates in calcium chloride and then in sodium bisulphate. The results were "beautiful",[54] according to Sohlman. During October and November of 1894, Sohlman wrote to Nobel approximately once a week. Nobel usually answered more than one of these letters at a time. After spending time in Paris in September, Nobel went to San Remo for the winter. Sohlman continued to work on the procedure for the hardening of armoured plate with sodium bisulphate and calcium chloride and sent Nobel a table of the results, in which he suggested ways to avoid the problems he had encountered. Nobel was happy with the results, which he said "look splendid"[55] to him. Silfversparre joined Sohlman and they reflected upon the hardening results together,[56] based on their complementary expertise.

Forging with ballistite – Nobel is needed

The norms and traditions of the Bofors workplace, as they were perceived by Sohlman, obviously signalled a one hundred percent dedication to one's work tasks. This is evident when Sohlman told Nobel in a letter about his upcoming marriage to Ms Ström. He explained that some of his work at Bofors would have to wait for a few days, because of some apparatus that needed to be prepared. Meanwhile (from Sunday to Wednesday), he planned to go and see Ms Ström, her parents and "get the wedding over with". He then explained to Nobel that his future wife would spend the autumn at his mother's place in Stockholm. "I hope Mr Nobel does not mind my marriage and I can assure you that it will in no way interfere with my work." He finished the letter by stating that he would find the alternative, of living abroad alone, difficult.[57]

In late September, Sohlman started new experiments to forge out gun barrels using explosives. He had already tried to forge a steel bar from the outside. Now he wanted to work a plugged steel barrel from the inside using ballistite.[58] When he received the news about these experiments, Nobel concluded that they would need to double the internal pressure to achieve any results, but that they must be careful. The barrel might explode from the pressure and Nobel wanted no harm done. "Maybe you should start with rifles".[59] Sohlman felt that the experiments in which they used explosives for the forging of larger guns should wait until Nobel returned to Bofors. "For many different reasons, Mr Nobel's presence here is long awaited",[60] Sohlman told him. Nobel's answer included detailed written instructions on how to perform the external as well as internal forging of gun barrels, using explosives. Also, he reflected upon Sohlman's decision to go for the bisulphate-hardening method and then came up with a proposal, hoping that it would further improve that method. Nobel's reasoning indicates that he

was involved from afar, while also honouring Sohlman's judgement.

> I wonder if sulphuric acid would work. If you pour while stirring, I do not think there would be any fragmentation or evaporation. If it does, certainly it would be harmful. If not, sulphuric acid would work very well since it is viscous.[61]

Lastly, he asked Sohlman how he was doing at Bofors, and if his wife had arrived. "The place is big enough for the two of you".[62] Nobel apparently did not share Sohlman's need for working face-to-face. The Bofors manager had told Sohlman that Nobel was not expected in Karlskoga that autumn, most likely due to poor health.[63] Yet, Nobel clearly recognised the insecurity and needs expressed by Sohlman since he was so encouraging in the letter, proposing various solutions to the issues Sohlman had told him about. Yet, in spite of Nobel not being there, he expected all his new ideas to be carried out at Bofors, to the extent that Sohlman occasionally considered quitting the job that autumn.

> I will probably never find this position altogether satisfactory, I do not expect to do so, but consider this work as a good, but difficult, school, leading to something better. (…) You would have to know Mr Nobel and our work to be able to understand that I often find my position intolerable and wish to change it for the humblest little job.[64]

This was how Sohlman expressed his feelings to his mother while in the midst of the continuous flow of Nobel's ideas arriving in letters. Years later, his reflections upon Nobel, the employer, were milder:

> Nobel was primarily a brilliant inventor, untiringly working on new principal ideas. Unlike many other inventors, he was also an outstanding organiser and businessman. However, he was not very interested in technical queries, especially not those related to construction, so he left those problems for his assistants to solve.[65]

The long-distance research relationship was thus based on Nobel's presumption that his assistant could work independently. From Nobel's perspective, they did not need to work face-to-face very often. However, in November 1894, Nobel sent Sohlman a letter in which he told him that if he was not busy in San Remo entertaining some visiting woman, he would come to Bofors. He also told Sohlman to report his expenses so that he could compensate him.[66] Sohlman sent him this report but insisted on not receiving any increase in pay. "Until a full result has been achieved, I feel that I am not worthy of any increase in pay".[67] Nobel answered him that he would not listen to any such nonsense, "even though it is a real delight to work with people so sensitive and humble".[68] He also decided that he and Sohlman should both sign the patent application for the bisulphate hardening procedure. Bisulphate was the substance Sohlman had introduced while experimenting, a circumstance that Nobel recognised:

> Even though I introduced this new type of hardening and pointed out the direction to go when searching for the right substances, it is doubtful whether I would have come to think of using bisulphate. That was a very clever thought, and I am not inclined to steal someone else's record.[69]

In mid-December, Sohlman asked Nobel in a letter if he should settle in Karlskoga for the winter, rather than returning to San Remo.[70] Then, Sohlman and his wife spent Christmas in Stockholm. They received Christmas greetings from Nobel, who was in Berlin.[71] On Boxing Day, Sohlman wrote to tell Nobel

that carpenters were putting in the floor of the new chemical laboratory at Björkborn. Meanwhile, he and Liedbeck, the Stockholm-based Nobel consultant, would go shopping for apparatus for the laboratory. Sohlman also told Nobel that he wished he would soon pay a visit to Bofors and "point out the direction" for the experimental work. Sohlman felt that Nobel should be physically present and take the lead. "But of course, I cannot expect any attention to be paid to this view of mine".[72] He received an answer from Nobel in which he stated that he might come to Bofors on 20 January.[73]

1895

At this stage, there were three actors taking part in the preparations for diversification into experimental chemistry at Bofors/Björkborn. Nobel had the original plan for the chemical activities, he provided the financial resources and the ideas that were intended to be realised in the laboratory. Liedbeck was a human resource sent by Nobel, as he saw to that they purchased the right equipment from the shop and that the laboratory was organised in a practical manner. Indeed, he was an important knowledge resource, provided by Nobel, and without whom things would not have run so smoothly. Sohlman, then, saw to it that the ideas were materialised and that this new discipline, chemistry, was integrated into the everyday work at the company.

Sohlman expected the arrival of Nobel at Bofors in January and, having done some shopping for the laboratory at Björkborn during Christmas,[74] he told Nobel in a letter that the furniture and equipment were due the following week, while the plumbing and the powerhouse would take a little longer to complete.[75] But Nobel did not come to Bofors at that time. He feared the cold climate. Instead, they met in Berlin in early January at the Hotel Continental, where Nobel provided Sohlman "with enough projects to nearly make me burst".[76] Some of the experiments to be performed seemed pleasant, but some were less appealing to Sohlman. Also, Nobel asked Sohlman whether he and Mrs Sohlman wanted to stay in Sweden, or return to San Remo. Sohlman said that it was "parti égale" to him whereby Nobel decided that they would remain in Sweden until the autumn when they would discuss the matter again.[77]

Nobel apparently wanted to know how Sohlman felt about staying in Karlskoga, and being guided from a distance, since he had written twice during the previous months asking for Nobel's physical presence. The circumstance in which Nobel actually asked Sohlman how he felt about the residential alternatives indicates a certain degree of care and consideration. What would have happened if Sohlman had decided to return to San Remo at that stage? The chemical laboratory was just about to open, but there was no one at Bofors who could possibly run the experimental work Nobel had planned for it, except Sohlman. When Sohlman left the decision for Nobel to make, Nobel quite naturally saw that the need for Sohlman's skills and knowledge was greater at Björkborn than in San Remo. This also implied that Sohlman's skills could be combined with those of Silfversparre, the mechanical engineer, because Nobel had a new idea about where the two of them should collaborate. To be sure, there were several ideas waiting to be materialised at Bofors, and where Nobel wanted Sohlman to be in charge.

Forging barrels, making shells

When Sohlman returned to Bofors, he and his colleagues took on another of Nobel's ideas, that of forging a barrel using hydraulic pressure. They were successful in doing this and decided to try to forge it further by shooting a mandrel through the barrel. Sohlman also told Nobel about the weather conditions in Karlskoga (deep snow but not very cold), and said that within days they would start trial shooting on armoured plate.[78] However, it soon became so cold that no experiments whatsoever could be performed outside. Sohlman spent his days in the laboratory, unpacking newly arrived equipment. A small rolling mill, intended for the production of gunpowder or artificial caoutchouc, had been sent to them by Liedbeck, Nobel's consultant/friend from Stockholm.[79] As Sohlman stated many years later, Nobel often left the technical problems to be sorted out by his assistants.[80] This was also the case when Sohlman and Silfversparre discussed a proposal by Nobel for how to design a shell.

Colonel Centervall had told them that these products needed to be armour-piercing, to go through 20-millimeter plate, but the explosion must be retarded until the shell was well inside the ship. Also, it should be as safe as possible for the user. Sohlman and Silfversparre had received an idea from Nobel on a safety fuse with which to delay the explosion when the shell hit the hull of the ship. They made a draft of how to create this delayed explosion within the shell and sent it to Nobel.[81] A day later, there was a telegram from Nobel. He was eager to know how they were doing: "Is all well? If the laboratory is ready to use, send a telegram to 'Nobel, Paris'".[82] In early February 1895 it was freezing cold in Karlskoga and there were no outside experimental activities at Bofors. In the laboratory, most of the equipment was in place and Sohlman began his work there by producing some hydro nitrocellulose and some nitro-mannite, intended for use in gunpowder. Liedbeck was there too and kept him company.[83] But the idea was still to produce gunpowder for experimental use only.

Nobel wants to compete with arms producers in Germany and England

Meanwhile, in San Remo, Nobel was busy thinking about the shells and their construction, which he considered to be possibly innovative. Referring to the sketch sent to him by Sohlman and Silfversparre, he thought it had advantages compared to his own original proposal.

> The main thing is to achieve the goal whereby a non-detonating gun powder safely produces a nudge to a small piston or projectile, which will then produce the detonation of a very unsusceptible explosive. This is the new thing which, if it works out as planned, will be of utmost importance. Having a shell which will not detonate in the barrel is a considerable advantage. There will be high spirits at Bofors when we have results from these new experiments. It would be great to see old Sweden rivalling arms producers like Germany and England.[84]

Actually, this first attempt to create an anti-armour shell incorporating a safety fuse at Bofors, where the chemist Sohlman collaborated with the mechanical engineer Silfversparre, is a good example of the advantage of having these two disciplines combined in the same place. In 1910, Bofors would diversify once again and start selling ammunition, such as shells, where the mechanical engineers built the shell of the shell, so to speak, and the mechanical components.

Meanwhile, the chemists made the explosives, TNT, for the shell and the propellant charge to send the shell off towards its target.[85]

The chemical laboratory at Björkborn is ready

Freezing cold weather and snowstorms in Karlskoga during February kept Sohlman and his colleagues from outside experiments on most days, but the laboratory was now fit to use, "looking perfectly proper and nice".[86] Sohlman performed experiments on gunpowder and artificial caoutchouc, experiments he and Nobel had discussed when they met in Berlin.[87] The meeting in Berlin probably strengthened Nobel in his conviction that Sohlman was one of the few persons he was really devoted to, judging by his next letter. Nobel mentioned an issue regarding an innovator who was working on an idea similar to one of his own. This reasoning ended with an affectionate request, a longing for closer friendship.

> There are two things which I never borrow – money and projects. But if anyone as sound as Mr. Sohlman is willing to lend me a little friendship, I shall accept it with gratitude. We have many great things ahead of us.[88]

By now, the temperature in Karlskoga had risen somewhat, and at Bofors they were able to perform outside experimental activities, like the attempt to forge out a barrel using a projectile as a mandrel. This was an experiment of which Nobel said he had limited experience, so he expected Sohlman and his colleagues to make the necessary modifications.[89] The experiment implied using a 57 mm gun from which they shot a projectile into a barrel with a diameter of 56.1 mm, positioned and firmly attached at the open end of the gun. The projectile had a diameter of 56.9 mm and went straight through the barrel, forging it and also smoothing the inner surface of the barrel. Sohlman was keen to proceed with these experiments, he told Nobel.[90]

Nobel was very pleased when he learnt about the success of his original idea for forging out barrels. He considered this the right time to apply "everywhere"[91] for a patent for this particular method. At Bofors, they prepared for further experiments where they would use this method of Nobel's. Sohlman presented a detailed programme involving three shots with projectiles into a 57 mm barrel intended to be a gun for later use. He concluded that the programme was very close to the idea presented by Nobel when they met in Berlin.[92] The physical meeting in Berlin probably facilitated their common understanding regarding this method. How would Sohlman have felt if the idea had just been presented in a letter, without him having any opportunity to discuss the method beforehand face-to-face with Nobel? Ten days later they received a telegram from Nobel stating that he found the programme most suitable.[93]

Sohlman is in high spirits and enjoys his work

The circumstances surrounding Nobel's gunpowder, ballistite, an innovation from the 1880s, were such that: 1) Nobel had given the exclusive right to manufacture ballistite in Sweden for commercial purposes to Nitroglycerinbolaget in Stockholm,[94] a company founded by Nobel in 1864;[95] 2) The first generation of ballistite had the advantage of being smokeless, in contrast to brown gunpowder, which caused large clouds of smoke, revealing the whereabouts of the gun;[96] 3) Yet this ballistite caused erosion in the gun because the gunpowder gas was so hot. The experiments initiated at Björkborn

in the spring of 1895 therefore represented an endeavour to reduce the temperature of this gunpowder gas by adding something to the combination of nitroglycerine and nitrocellulose – the basic ingredients of ballistite. This would imply yet another innovation, i.e., a new product.[97]

In late February, Sohlman wanted to know if they should start trial shooting with their new low-temperature gunpowder, "or should we wait until your arrival?" He added: "I am very happy working for Mr Nobel, on all these interesting things".[98] As he expected the cold weather in Karlskoga to end soon, Nobel thought that his journey to Sweden was drawing near.[99] When Sohlman received the news that Nobel planned a visit to Bofors, he told Nobel that the days were indeed warmer, but at night it was still minus 15 or 20 degrees Celsius,[100] an expression of his caring attitude towards his employer and friend.

Telegram for a "much needed" Nobel

In the gun factory at Bofors, work continued for several weeks during March in order to prepare the barrel for the next experiment using Nobel's method for forging, consisting of shooting a projectile right through the barrel. When Sohlman was not at the gun factory overlooking the preparations, he was busy in the laboratory at Björkborn, where he mixed ammonium perchlorate destined for explosives in shells. So far, this latter work had not been satisfactory.[101] A week later, Liedbeck, the Stockholm-based knowledge resource upon whom Sohlman relied, paid a visit and decided where to put the rolling mill they had acquired for the small- scale manufacturing of gunpowder.[102] On 24 March, Sohlman sent a telegram to Nobel: "Your presence here is much needed...".[103]

That very same day, Sohlman also sent a letter to Nobel in which he explained that the preparations for several experiments were in the making. But, to go through with them, they would need the guidance of Mr Nobel himself, as soon as possible.[104] Sohlman managed the everyday work perfectly well, but for new experiments involving explosives, he apparently needed Nobel, his intellectual leadership, as they entered into unknown and perhaps dangerous terrain. The answer from Nobel was wired two days later, and stated that he expected to arrive at Bofors on approximately 10 April.[105] Meanwhile, Sohlman continued to pursue his work in the laboratory, where he was preparing new sorts of gunpowder made from hydro-nitrocellulose. They planned to assess the qualities of this gunpowder by means of trial shooting as soon as Nobel arrived.[106] The advantage of having ready access to guns is evident. From a practical and commercial point of view, guns and gunpowder are related, as Nobel stated at his first board meeting.[107] However, as they rest on different theories and demand different manufacturing skills, from a knowledge perspective, they are unrelated. Yet development work on gunpowder and guns is easier if you consider their respective function and effect simultaneously during trial shooting.[108]

Nobel leaves San Remo for Sweden

In early April, Nobel began his northbound journey as he left San Remo for Paris. At his home in Paris, he received a letter from Sohlman. Nobel was told that they had been able to make quarter of a kilogram of gunpowder from a recipe of his consisting of 70% hydro-nitrocellulose, 10% nitro-glycerine, 10% nitro-mannite and some solvents. However, this kind of gunpowder became "rather brittle". Before ending the

letter, Sohlman told Nobel that "your arrival here is long-awaited."[109] A couple of weeks later, Nobel was still in Paris and received a letter from Sohlman in which he was told that the barrel they had been preparing for some time in the gun factory was ready for forging the forthcoming week. Sohlman had made another half kilo of gunpowder, this time containing mostly nitro-mannite, and the result was a less brittle product.[110] Liedbeck had told Sohlman to make some ballistite in which they added amyl succinate[111] in order to reduce the temperature of the gunpowder gas. They had performed some preparatory trial shooting using this new gunpowder, Nobel was told.[112] It was a gunpowder that would become an innovation.

On 20 April, Nobel sent them a telegram with his address for a few days: Palace Hotel, Berlin.[113] Following that telegram, they expected Nobel's arrival within a week. Apparently, he was not going to stay for long, but would continue his journey to Stockholm, only to return later to Bofors. "It is quite ok that he is coming, but it will feel even better when he has been here",[114] Sohlman told Mrs Sohlman in a letter. On 28 April, they learnt that Nobel would arrive later that very same day, and Sohlman felt quite tense about this.[115] Probably Sohlman knew that Nobel would bring his globetrotting-intensity when he arrived, demanding all the attention Sohlman could provide. Meanwhile, after eight months in the church village of Karlskoga, Sohlman was used to a rather comfortable lifestyle, taking his bike to the lab, to the shooting range and then back home. He was socially integrated and had adjusted to the ways and habits of his colleagues and friends.

That morning, he had breakfast at Silfversparre's place, and together with Pehrsson, the manager of the metallurgical workshop, they planned to make a bicycle excursion. When Nobel arrived, Sohlman was supposed to greet him and accompany him to Björkborn Manor. Then it was dinner at the manager's place, the Bofors Manor. The manager had been eager to know whether Mrs Sohlman would possibly return from a trip while Nobel was at Bofors. The manager feared that Nobel would find the company of himself, Silfversparre and Sohlman too boring.[116] At the dinner, Sohlman found that Nobel appeared to be well and, thus, he was also in a splendid mood. After the dinner, at 11.30 pm, he gave Sohlman a ride home.[117] While Nobel was at Bofors, Sohlman and Mrs Sohlman, who had returned from Norway, were twice invited to him for dinner. Sohlman learnt that Nobel planned to hire another chemist or two for the laboratory, since there were so many things to do.[118]

Nobel goes to Stockholm

On 7 May, Nobel left for Stockholm.[119] Meanwhile, further experiments were performed at Bofors. The barrel they had been forging out repeatedly for the past few months, was once again treated with the projectile, shot from a gun. But this time the projectile got stuck within the barrel. Apparently, this was as much as they could do to forge out the barrel, Sohlman concluded. He also began experiments on gunpowder containing nitro-starch and hydro-nitrocellulose, trying different proportions in order to make a product that was not too brittle. Three fuses for shells were prepared and would be fired within days, Nobel was told. And a shooting range for small guns and rifles was soon ready to use in the yard outside the laboratory.[120] Nine days later, Nobel was still in Stockholm and learnt that the fuses worked very well and that Sohlman and his workmates would

begin experiments on blasting charges for the shells.[121] The chemical laboratory was about to go through a final inspection, and for that purpose Liedbeck would arrive soon. "When Mr Nobel returns, I do not know. I rather fear he will just pop up and then leave again",[122] Sohlman told his mother in a letter, indicating the unpredictable side of Nobel's personality.

The King wants to pay a visit to Bofors

There were no letters sent between Nobel and Sohlman from late May to late June. It is not unlikely that Nobel spent these weeks in Karlskoga as he was in Stockholm just before that period. Sohlman and his colleagues were told that the King of Sweden, Oscar II, would pay a visit to Bofors 19 September. They expected Nobel to have returned to Bofors by then. Nobel was temporarily in London, but three Russian horses that he had acquired had arrived and been stabled at Björkborn.[123] Nobel's leadership was mostly exercised from afar that summer. Sohlman had apparently become accustomed to the role of carrying out the many experiments. There were no requests for Nobel's physical presence anymore. They performed several chemical experiments at the laboratory during the summer of 1895. Among these were new types of gunpowder. Sohlman sent samples to Nobel, who was then in Stockholm. The gunpowder had been tested in rifles with manometers in the shooting range right outside the laboratory. The results were presented to Nobel in letters, along with results from all the other experiments.[124] One of Nobel's nephews, Ludvig, was at Björkborn with his wife for a couple of days. Dining together with Sohlman and his wife one evening, they shared a toast to their mutual benefactor, Nobel. "We are grateful to you for making us so happy",[125] Sohlman told Nobel in a letter. Nobel's response included an affectionate "Brother Sohlman". He then elaborated extensively upon topics such as the solvent methyl dinitro-tartrate, the strength of nitrated threads and possible directions for future research on gunpowder and artificial rubber, resulting in sustainable patents which would keep the "parasites" off.[126]

Nobel travels, Sohlman tries out rockets

For the rest of July, Nobel sent telegrams to Sohlman from various places including Brussels, Paris, Oostende and London. These telegrams mostly concerned patents, but one just stated: "Wire me if anything seems interesting".[127] Nobel was no control freak but was apparently happy to pursue his mobile lifestyle while Sohlman and his colleagues continued with the sometimes-hazardous experiments back home in Karlskoga. At Bofors they built three rocket projectiles designed to receive rotation and direction from gunpowder gas streaming out at an oblique angle. This was an idea that Nobel had presented to Sohlman when they met in Berlin in January.[128] The objective was to create a projectile with no flutes and no recoil. Two of these rocket projectiles disappeared into the sandbank when fired, while the third was found and appeared to have experienced a slight rotation. They then decided to blast the test gun. When told about this in a letter,[129] Nobel sent a telegram: "Wire me the bursting pressure".[130] Meanwhile, they also carried out trial shooting at one big piece of armoured plate, hardened in bisulphate. "It endured 13 shots and there are no flaws whatsoever. Tomorrow we will continue the shooting with your safety fuses",[131] Sohlman told Nobel, who was in London.

Nobel's forged-out barrel is burst

On 2 August, Sohlman sent a graphic protocol of the estimated pressures when they tried to burst the barrel of the test gun. The barrel had been forged out several times over the previous few months using Nobel's method in which a projectile was shot through it. Now, they were aiming to determine the bursting pressure. Sohlman told Nobel that the pressures had been so high that the manometer broke down, but they would continue after some practical adjustments.[132] Nobel received telegrams over the following few days containing details of the estimated pressures and subsequent enlargement inside the barrel, but it was still in one piece.[133] A couple of days later, when it was fired, there was an enlargement of more than 8 mm in the chamber of the gun. At the next shot, the gun carriage broke and the gun plunged far along the shooting range. It was bent and swollen, but solid.[134] In the end, Sohlman managed to burst the barrel using one kilo of ballistite and two projectiles, giving a pressure inside the barrel of 11 160 atmospheres. He admitted to Nobel that in the end he felt there were so many practical difficulties associated with this particular experiment that he wanted to burst the barrel "as quickly as possible".[135] Many years later, there would be recollections at Bofors suggesting that some of these Nobel experiments were considered of no practical use.[136] Sohlman stated in 1929:

> As is not infrequently the case with inventors of genius, Alfred Nobel was not always able to draw the line between epoch-making ideas and grotesque impracticalities. This was apt to be when he was dealing with a subject in which his knowledge was superficial or amateurish, as for instance in certain questions affecting the construction of artillery…[137]

I understand these experiments as Nobel's "skunk work",[138] experiments pursued mainly to satisfy his insatiable curiosity. Bofors became the place where Nobel allocated the resources for such experiments. Yet, his leadership was sometimes at odds with the local norms and traditions at Bofors, which had been moulded from years of practical solutions based on a smaller budget.[139] Nobel's passing in 1896 brought the experimental activities at Bofors and Björkborn back to a harsher reality, where Sohlman had to determine which experiments to close down, and which might possibly end up producing innovations and therefore ought to be pursued.[140]

The "local buzz" and the "global pipelines"

What happened during the summer and autumn of 1895 was a slow changing of the scene. As Nobel's health deteriorated, Sohlman became used to running the experiments independently. There was a change in their involvement in the experimental activities which probably followed from Sohlman being present all the time at Bofors, while Nobel was elsewhere. While Nobel still provided the financial resources and ideas, Sohlman was the organiser, and was also responsible for the safety of all those taking part in the experiments.

In early August, Nobel told Sohlman from his Paris home that he was not feeling well. But his letter was extensive and covered the nitration of different sorts of fibre, ideas on how to create a substance for isolating electric circuits, artificial caoutchouc intended for bicycle tires, safety fuses, the method for hardening armoured plate and whether the hardening could be improved using electrical treatments. Referring to the results of the experiments on rocket pro-

jectiles, where two out of three were lost in the sandbank, Nobel stated that he did not expect very much from these trials but that he would return to the topic after speaking to an Italian friend "who is very intelligent and has long standing experience on this matter".[141] The supervision provided by Nobel from afar was therefore not just based on his own experiences. He was constantly travelling around Europe meeting with experts to learn more. He would also visit factories where they had progressed further with development work on artificial materials. During such visits, he would try to grasp the methods used with the aim of providing Sohlman with input for the experimental work at Björkborn.[142] Together they actually represented what Bathelt, Malmberg and Maskell have found to be crucial for innovative companies in non-metropolitan places: Sohlman and his colleagues at Bofors were the "local buzz" while Nobel had all the international connections, the "global pipelines".[143]

"Is all well? When do you need me?"

Nobel was thrilled by the results of the experiment with the forged-out barrel, which in the end was burst. He wanted Sohlman to do this over again with a piece of red-hot steel ingot weighing 1150 kilos. The original centred hole should be 5 cm and each projectile shot through this hole should forge it out by a further 2 cm, until it had a 24 cm calibre. Then it should be plugged and filled with ballistite, fired, and the pressure estimated for each shot until it burst. With the results of such an experiment, indicating very high durability of the material, Nobel thought that Bofors could sell guns with a warranty. He also presented an idea for a hardening method for armoured plate and provided Sohlman with a description of how to go about such an experiment. Nobel was still not feeling well, but hoped to return to Bofors "somewhat repaired" in early September.[144] A week later, while Nobel was in Carlsbad, a Czech health resort, Sohlman sent him the results of experiments on the hardening of armoured plate using electricity. He thought they were quite successful, but they needed higher currents.[145] Perhaps Nobel was feeling better following his stay at the health resort, because a week later a telegram came for Sohlman asking: "Is all well? When do you need me?"[146]

A turning point

There now follows a turning point in the story, from a diversification perspective. In the autumn of 1895, the Swedish Navy received ballistite made at Björkborn and tested at the Bofors shooting range for the first time. Nitroglycerinbolaget in Stockholm was the Navy's regular supplier of this type of gunpowder. But Nitroglycerinbolaget had no proper shooting range where the ballistite could be tested in the kind of 57 mm gun, for which it was intended. Hence, this opportunity emerged for Bofors, where such a gun stood fit and ready to fire at the shooting range, to show that they could manufacture ballistite that met the requirements set by the Navy. The Swedish Navy was a crucial actor regarding the future manufacturing of ballistite in Sweden.

In late August 1895, Nobel's friend and consultant, Liedbeck, came to Bofors to support them in their attempts to press a limited amount of ballistite (including succinic acid to reduce the temperature of the gunpowder gas) intended for the Swedish Navy. The Navy placed certain demands on the performance of the ballistite regarding its speed and pressure within a 57 mm gun. Yet Liedbeck, who worked as a consultant

for both Nitroglycerinbolaget and Bofors, hoped the results from the trial shooting at Bofors would lead to Nitroglycerinbolaget receiving an order from the Navy.[147] Although Liedbeck was not aware of it at the time, he had just started the diversification process leading to the founding of AB Nobelkrut. However, it would take another six months before this became apparent.

Sohlman wants to stay at Bofors

Meanwhile, Sohlman had apparently found his feet as manager at the chemical laboratory at Björkborn and was not prepared to return to a humbler position in San Remo. This was quite a change from his standpoint when he met Nobel in Berlin earlier that year. And, rather than asking for Nobel's physical presence when faced with his hazardous ideas, Sohlman curtailed the experiment that Nobel had asked him to perform. When Nobel wanted him to forge out a red-hot piece of steel ingot with a 5 cm centred hole as projectiles were shot through it, until it had a calibre of 24 cm, Sohlman told him that the largest gun at Bofors had a calibre of 15 cm. He thought it would be enough to forge out the barrel from 5 cm to 12, perhaps 15 cm.[148] A week later, he received a telegram from Nobel in which he accepted Sohlman's proposal.[149] To his mother, Sohlman confided that Mrs Sohlman's father wanted them to return to San Remo, as it would be better for Mrs Sohlman, who had some health issues. However, Sohlman considered that alternative to be out of the question since it would mean that he would have to resign from his position at the Björkborn laboratory, and that he would be replaced. "Certainly, my work carries a lot of responsibility and is quite difficult, but for our future it is far better than a position as an assistant in San Remo".[150] This statement is not just a clarification regarding the higher status of the managerial position at Björkborn, but it also indicates Sohlman's growing confidence. He was now ready to take on more complex and demanding work tasks.

In September, Nobel arrived at Bofors, and so did the King of Sweden, Oscar II. This time, Nobel stayed a little longer. He appeared to be well and was, as always, very kind towards Sohlman and his wife. The visit paid by the King was not the kind of social event appreciated by Nobel, but it was soon over. While Nobel was at Bofors, Sohlman was eager to talk to him about the experimental work they were supposed to perform during the upcoming winter. Recently, things had been going very well and "I am perhaps even more happy about this than Mr N is",[151] Sohlman told his mother.

Trial shooting with gunpowder to meet the Navy's demands

In early October, Nobel left for Stockholm, where he remained for a few days before travelling on to Berlin, and then Paris, where he arrived in mid-October.[152] At Bofors they prepared a stamping machine for gunpowder.[153] When this machine was ready, they made perforated gunpowder.[154] The next day there was a telegram from Nobel: "If perforated powder tried, please wire velocity and pressure obtained".[155] The answer was wired the following day.[156] Three days later, a full report on the results of the trial shooting, including a comparison between the results from flat and tubular gunpowder, was on its way to Nobel.[157] The trials at the shooting range continued while they adjusted the stamping machine until the gunpowder grains were completely consumed.[158]

Nobel had an idea for how to achieve a more even result when making gunpowder, that of having three layers: slow ballistite

+ quick ballistite + slow ballistite, and they should not make it perforated, he told Sohlman.[159] Then Nobel's health deteriorated once again. As his dynamite managers from all over the world gathered in Paris, he could not work as he wanted.[160] Meanwhile, in early December at Bofors, they focused on the requirements set by the Swedish Navy regarding ballistite. At this stage, it was still hoped that the gunpowder trials would result in an order for Nitroglycerinbolaget in Stockholm. The ballistite was intended to go with the new 12 cm guns ordered by the Swedish Navy that were being made at the Bofors gun workshop.[161] Sohlman and his colleagues followed Nobel's proposal of three-layered gunpowder, with quick ballistite in between two layers of slow ballistite. The quick form of ballistite contained more nitroglycerine than the slow one.[162]

Then a letter arrived in which Nobel, who was feeling somewhat better, said that this kind of gunpowder would reduce the problem of erosion within guns, usually caused by hot gunpowder gas.[163] A few days later, Sohlman wired Nobel that he had prepared an application for a patent for the three-layered gun powder, called progressive ballistite.[164] Despite Nobel's poor health and physical absence, the arrangement whereby trials were performed via instructions in letters and telegrams proved successful, and Nobel's new gunpowder was patented. Eventually, they managed to make gunpowder that produced the speed and pressure demanded by the Navy. "Some technical difficulties remain before the gunpowder is completely even, but as the process continues, we will solve them"[165], Sohlman told Nobel on the day before New Year's Eve. It is evident that the Swedish Navy had emerged as the actor that was setting the requirements regarding the quality of gunpowder. Yet soon the Navy would also take on a leading role in the industrialisation of the new gunpowder.

1896–1898

After the New Year, Sohlman and his workmates were busy trying to achieve better shooting results with the new three-layered gunpowder.[166] For the past few weeks they had received telegrams or short letters only from Nobel, who had been bedridden at his home in San Remo. Then eventually, a longer letter arrived, in which Nobel expressed his eagerness to hear news of the double-barrelled gun he had introduced at Bofors, for studying and comparing erosion in the barrels caused by the gunpowder gas.[167] Sohlman explained to Nobel that they were so eager to complete the trials with the progressive gunpowder (three-layered) that everything else had been put aside for the time being, "and I hope you do not mind." The results of these trials were of utmost importance to Bofors, he stated.[168]

Two days later, they took photographs of the bores of the double-barrelled gun, indicating that ballistite did not produce as much erosion as black gunpowder.[169] Ever since the laboratory had become ready to use in early spring of the previous year, Sohlman had conducted repeated experiments to create ballistite producing a lower temperature, thereby not causing as much erosion.[170] The solvent they used for this purpose was amyl succinate, which they also used when making artificial caoutchouc.[171] As he felt quite confident regarding the results of the trial shooting, Sohlman told Nobel that what remained to be determined was the effect that storage would have on this new gunpowder, if time would cause the different layers in the gunpowder to mix, which they were not supposed to.[172]

Silfversparre as well as the control officer Aquilon thought the comparison of the bores in the double-barrelled gun clearly demonstrated the difference between the progressive ballistite and the black gunpowder in terms of erosion.[173] A couple of days later Nobel learnt that they had made 40 kilos of progressive gunpowder for trial shooting on the upcoming Saturday, if the weather was good enough.[174] The report from the trial shooting showed that the progressive gunpowder gave results in accordance with the Navy's requirements.[175]

Trial shooting with the Navy

At this point in the innovative process, the three-layered progressive ballistite, if approved by the Navy, was still supposed to be manufactured at Nitroglycerinbolaget in Stockholm. The reason for the trials at Bofors was simply that they had no proper shooting range for guns at Nitroglycerinbolaget. This circumstance had been observed by the Navy and was why they were prepared to become involved in the industrialisation part of the innovative process, and to propose the transfer of ballistite production to Karlskoga. This would prove a rather complex issue to deal with, especially for Nobel, who felt that he must be loyal to Nitroglycerinbolaget in Stockholm, while he could not ignore the entrepreneurial spirit in Sohlman at Bofors.

By the end of January, they had made 50 kilos of progressive ballistite powder at Björkborn. Some of it was for trial shooting, while the rest was to be stored to check its long-lasting qualities.[176] The next day, a commission from the Swedish Navy was at the Bofors shooting range. These officials were there to oversee the final trial shooting of the new 12 cm gun they had ordered from Bofors, and shots were to be fired using the progressive gunpowder. This included ballistite but was produced in layers (slow-quick-slow ballistite) to reduce the temperature of the gunpowder gas. Five shots were fired altogether, and the commission was very pleased and accepted the new gun. The commander now told Sohlman that the Navy would like to see the manufacturing of ballistite transferred from Nitroglycerinbolaget in Stockholm to Bofors, or at least that gunpowder from Nitroglycerinbolaget should be tested at Bofors.[177]

This was the moment when the diversification into a new branch, gunpowder and explosives, was brought up by the customer for the first time. Nobel had mentioned the possibility briefly when he held his first meeting with the board at Bofors in early 1894[178] but since then the idea had been that gunpowder production at Björkborn was just for trial shooting, nothing else.[179] Yet the Navy was displeased because the management at Nitroglycerinbolaget did not want to give any quality warranty regarding its ballistite, and this attitude left the Navy prepared to buy gunpowder from elsewhere, like France or Belgium.[180] This was indeed a sign of a malfunction in the Swedish gunpowder market. The upcoming industrialisation of gunpowder at Björkborn can therefore be understood as an opportunity-driven diversification.

Sohlman proposes transfer of ballistite production

As soon as the trial shooting with the Navy was over, Sohlman sat down and wrote a long letter to Nobel in which he proposed that they should start large scale production of ballistite at Bofors. He also told Nobel that an upcoming armaments bill included new guns to be ordered for the Navy. And, finally, the Navy also wanted to buy gunpowder for rifles, since the gunpowder

from Åker was of such poor quality that the Navy ended up importing 70 tonnes from Troisdorf, and was reprimanded by the public accountant for doing so.[181] There was indeed a new actor, the Navy, that wanted to have a say on the future of gunpowder production, and Sohlman was all ears when the Navy turned to him. The diversification process that started here therefore had several actors working to change the existing conditions, traditions and agreements regarding gunpowder production.

When the next letter from Nobel arrived at Bofors, he was still in bed in San Remo, trying to recover from illness. His letter was quite short. He had an idea for how Sohlman should combine the quick and slow layers of ballistite in a charge, which ought to keep the solvents in each layer from eventually mixing. Relying on Sohlman's ability, Nobel thought it would be easily prepared: "Surely you will come up with a solution for this device".[182] However, Nobel did not mention the request from the Navy to start full-scale gunpowder production at Bofors. It is possible that he had not yet received that letter from Sohlman.

Nobel is hesitant regarding the Navy's proposal

In his answer to Nobel, Sohlman expressed his sympathies: "I am so sorry to hear that your health has been, and still is poor, and I can only express my sincere hope that you will soon feel better." Then Sohlman presented the latest results from the trial shootings with the double-barrelled gun, and from experiments in the laboratory.[183] In San Remo, Nobel, although rather weak, was eager to receive some more photographs of the erosions in the double-barrelled gun and said so in a telegram that arrived at Bofors.[184] Then, a few days later, he went to Nice and there, Nobel managed to write a letter in which, for the first time, he commented on the request from the Navy to start full-scale gunpowder manufacturing at Bofors:

> We do not have the right to manufacture ballistite since the patent belongs to Nitroglycerinbolaget. But they are considering an increase in production. Perhaps we could manufacture some other kind of gunpowder, but then you have the difficulty of gaining approval for the composition.[185]

Nobel also expressed some impatience regarding the slow speed with which the experimental forging of barrels was being performed at Bofors. He imagined that the delay was due to that "damned order for armoured plate". Nobel wanted to hire yet another engineer for the laboratory at Björkborn, to lighten the burden on Sohlman, he said. This new engineer should be a specialist in mechanics. He was considering one of the Ljungström brothers, famous for a bicycle-innovation. The Ljungström fellow was not very familiar with guns and weapons, but Nobel considered him a quick learner. There were so many ideas that Nobel wanted to probe into, but he was lagging behind because of his illness and still needed to rest, he told Sohlman.[186]

Sohlman tries to persuade Nobel to stop expansion in Stockholm

While in Stockholm, Sohlman learnt that Nitroglycerinbolaget planned to increase its manufacturing of ballistite up to 200 kilos a day, and that it had already begun some "preparatory blasting"[187] near the Winterviken factory. It becomes evident now that Sohlman did not accept Nobel's standpoint regarding the proposed transfer of ballistite production to Karlskoga. Sohlman was eager to learn whether Nobel would

not find it wise to stop ballistite manufacturing from being locked-up in Stockholm and rather plan for its transfer to Bofors. He argued that no one at Nitroglycerinbolaget, except for Liedbeck and one of the employees, Mr Caspersson, really cared about the manufacturing of gunpowder:

> If Liedbeck stopped helping them for some reason, they would not be able to come up with any new type of gunpowder working for a previously untested calibre or gun construction. They neither want, nor can, acquire guns for trial shooting. Mr Smitt [chairman at Nitroglycerinbolaget] even thinks that trial shooting with a gun is totally unnecessary, as testing the gunpowder in a rifle will do, if you calculate the results to find the right thickness for guns. And then the military authorities have lost confidence in Nitroglycerinbolaget because of the poor quality of their ballistite. It is fair to say that the manufacturing of gunpowder at Winterviken will never achieve any significant progress. But if the operations were brought here – whether Nitroglycerinbolaget were persuaded and permitted to put their factory here, or if the exclusive rights to the manufacturing of ballistite were returned to you – there would be many advantages: the gunpowder could be tested first-hand, the war administrators could acquire guns and ammunition from the same place, and without doubt things could be operated with much more energy and under better conditions. If you should by any chance consider transferring all of your Swedish gunpowder production to Bofors, I enclose a draft with approximate estimates of the cost of the expansion of the plant here, with the aim of producing as much gunpowder as they plan for at Winterviken. Even if you do not find this ideal, we would gain a lot if the management at Nitroglycerinbolaget were persuaded to transfer their manufacturing of ballistite here and gained the opportunity to perform trial shooting (in exchange for some royalty) using our guns. Mr Liedbeck thinks an arrangement like this is much needed.[188]

Obviously, the proposal from the Navy made Sohlman, and probably some of his colleagues too, very enthusiastic. Liedbeck backed them as well, even though, being a freelancer, he also worked for Nitroglycerinbolaget. This was only two weeks after the day when they had first heard about the Navy's request and there was already, as stated above, "a draft with approximate estimates of the cost of the expansion of the plant here, with the aim of producing as much gunpowder as they plan for at Winterviken". Also, Sohlman completely disqualified the management at Nitroglycerinbolaget, telling Nobel that the company really had no future in the gunpowder business, or that it would not "achieve any significant progress". This is Sohlman showing growing leadership. He was acting in the interests of Bofors, and this would put him in a very different position from that of Nobel, who had a global empire in explosives. The Swedish gunpowder market was just one of many to him.

Nobel is annoyed by the idea on a gunpowder industry at Björkborn

While this letter was on its way down to San Remo, Nobel sent a rather long letter to Sohlman in which he answered all the reports that had arrived from Bofors during January, while he was ill. He commented on the experiments regarding progressive (three-layered) ballistite, trial shooting with gunpowder for rifles, the double-barrelled gun with its differential erosion, the insulated material, artificial caoutchouc, celluloid, alloys and nitrated hemp. Then, regarding the request from Commander von Feilitzen and the Swedish Navy and his view on Nitroglycerinbolaget, Nobel stated that the

board of directors at Nitroglycerinbolaget was more crippled than his nephew Hjalmar was when he broke his leg, and he added: "I will give them a reprimand."[189] He also conveyed his view on the proposal to transfer the manufacturing of ballistite to Bofors: "Apparently, the management at Bofors has not really understood that I bought the place only to develop new things. Orders we take to get by, but the idea is to create and not to walk in our great, great, great grandfather's shoes."[190]

He also commented on the experiments with the forging out of gun barrels: "Things are going too slowly. I fear the management is losing time and I will have to turn to Krupp or Armstrong, which would be pleasant when you have your own workshop."[191] Lastly, he told Sohlman that he felt better now and was able to work again.[192] The sarcasm in Nobel's letter was probably a sign that he was recovering somewhat from his illness. Also, Nobel's and Sohlman's different standpoints become clear now that Nobel was emphasising that he actually wanted to keep the gunpowder activities at Björkborn at an experimental stage. "I bought the place only to develop new things. Orders we take to get by, but the idea is to create", a statement that was in line with what he had said 10 years earlier when he considered withdrawing from big business and focusing on experimental work. "In saying that I intend to live like an old spinster on my bonds, I should add that I do not mean to sit and twiddle my thumbs, but that I intend to devote myself to science to the exclusion of business."[193]

However, Sohlman's persuasiveness apparently had some effect, because a few days later another letter from Nobel arrived at Bofors. Nobel said that he would contact the management at Nitroglycerinbolaget. But he feared that taking up the production of ballistite at Bofors would possibly make his foreign gunpowder companies think that he was competing with them. "I have to stop writing now since I am more than tired. This year I have more quarrels than ever, and I do not have the health to put up with a tenth of it".[194]

The Bofors manager leaves his job

By now the manager at Bofors, Jonas Kjellberg, had announced that he was going to step down from his position and leave the company. Nobel would have to find his successor. Nobel asked Sohlman if he knew anyone suitable for the job.[195] Kjellberg had been at Bofors for many years, and been deeply involved but, since Nobel arrived, Kjellberg had found the job less satisfying because he constantly had to adjust to the ways and whims of his chairman, Nobel.[196] At times Kjellberg had shared the frustration with Sohlman, who had stated earlier that: "You have to know Mr Nobel and our work to understand that I often find my position intolerable…".[197] Indeed, Nobel managed to be involved in spite of the physical distance and his poor health, to push his employees in various directions to fit his many ideas, and to do this mainly via letters and telegrams. Kjellberg and Sohlman were the selected recipients of these communications at Bofors,[198] the ones who were expected to integrate the Nobel vision into the existing traditions of a Swedish ironworks. This was evidently a stimulating task, yet sometimes exhausting and frustrating.

In late February 1896, they prepared for trial shooting with shells against armoured plate at Bofors. They were going to try the new fuses, constructed in accordance with an idea of Nobel's, as well as different compositions for the explosive charges. As fragments were expected to go flying around, they

had built walls from boxes of sand around the armoured plate.[199] They were also very busy in the factory, working on the 12 cm guns for the Navy and finishing the armoured plates. It had been five months since Nobel and Sohlman had met. Nobel's illness also made communication less frequent. Sohlman wrote to him: "I often long for your personal guidance and worry that we might be going in the wrong direction. Therefore, I shall be very happy when you return to Bofors".[200] A week later, a letter from Nobel was on its way to Sohlman:

> You tell me that you long for my personal guidance. So do I, in the sense that I wish I could be of any use. But for six weeks now I have had a heart condition making me totally incapable of work. Meanwhile, there is so much work piling up that I do not see when I could possibly leave. Also, my doctor has warned me that the slightest cold could cause a second, escalated occurrence of the same ailment.[201]

Sohlman was also told that Nobel had been in touch with Nitroglycerinbolaget but had not yet received an answer regarding the transfer of the manufacturing of ballistite to Bofors. Lastly, Nobel added that he would persuade one of the Ljungström brothers to come and help Sohlman with the mechanical work. "He is skilful as well as pleasant to be with".[202] This is a typical Nobel way of showing leadership. During his endless travelling around Europe, he met with very many people, and those he found to be skilled or clever in a way that could be useful to Bofors, he contracted and sent over to Sohlman. This is also another example of Nobel's view of Bofors as an experimental workshop, the place where he could try out his many ideas, and where people with complementary skills could work together to generate innovations.

From San Remo, Nobel offered two alternatives to Sohlman, who longed for guidance: either Nobel would come to Bofors in the near future, or Sohlman and his wife, and one of the Ljungström brothers could come to a meeting in San Remo where they would discuss several issues regarding construction. Nobel had an idea about how to forge out guns in a cheap and efficient way.[203]

Sohlman discusses gunpowder quality with the Navy

In mid-March, Sohlman went to Stockholm to talk to the Swedish Navy and learn what was required of the gunpowder to go with the 12 cm guns they had ordered.[204] Was this the next step in the transfer of the gunpowder order originally meant for Nitroglycerinbolaget? Sohlman obviously wanted to show that he was ready for such a transfer, regardless of his hesitant employer. He was told that the Navy did not want to make a decision regarding the new progressive gunpowder until its storage durability had been proved. Still, they wanted to order samples of progressive gunpowder as well as regular ballistite with amyl succinate to be kept at Bofors and tested in the eleven 12 cm guns being constructed at Bofors. Then they would be able to see which sort was to be preferred in these guns. In his letter to Nobel, Sohlman also told him that they had performed trial shooting with gunpowder from Nitroglycerinbolaget that was intended for delivery to Denmark, but the samples tried at Bofors had so far not reached the standard, set by the customer.[205] This was simply a fact but also part of Sohlman's continuing endeavour to persuade Nobel to let the manufacturing of ballistite be transferred to Karlskoga, since Nitroglycerinbolaget was underperforming. Regarding the invitation from Nobel to meet somewhere with one

of the Ljungström brothers, Sohlman considered Easter a suitable time, since work would be stopped then at Bofors.[206]

Nobel did not have the same attachment to Bofors as Sohlman. To Nobel, Bofors was an opportunity to pursue experiments he could not perform elsewhere. Indeed, Steckzén claimed that Nobel, despite being considered the "richest vagabond in Europe, in his heart he was a true Swede, with deep roots in his native country".[207] Yet, Sohlman was able to adjust to the rural life and traditions at Bofors in a way that Nobel probably could not. The everyday life at Bofors, with colleagues, and a wife at home, helped Sohlman to thrive and motivated his steady focus on a career as a gunpowder entrepreneur. Or, as he wrote to Mrs. Sohlman when she spent time in Stockholm: "…yet you are right: Bofors is A1. When you get tired of Stockholm, welcome back to your Ragnar".[208] Sohlman had been socialising with one of Nobel's nephews, who lived at Björkborn Manor. They had dinner together rather late, and then he returned to the manor the next morning for breakfast. Sohlman was also invited to Silfversparre's house for dinner. And on the day of the trial shooting, in the presence of the control officer Aquilon, they shared all their meals at Björkborn together with Nobel's nephew, and stayed quite late, he told Mrs. Sohlman in a letter.[209]

As the Easter weekend approached, Sohlman and his colleagues were still busy making tubular gunpowder in a new pressing machine constructed by Liedbeck, and some of it was enclosed in the letter to Nobel. By now, Nobel had left San Remo and settled at his home in Paris. He learnt that preparations were being made at Bofors for trial shooting with the 12 cm guns.[210]

Sohlman makes another attempt to persuade Nobel

Sohlman resumed his persuasion campaign to win Nobel over to the plans to transfer the ballistite production to Bofors. He told Nobel that he had heard a letter had been sent to Nobel in which the manager of Nitroglycerinbolaget, Mr Öberg, was reputably negative towards the idea of transferring the manufacturing of gunpowder to Bofors. Sohlman had been told that the rest of the staff strongly disagreed with Öberg, and that they were all eager to hear of the proposals regarding this suggested transfer to Bofors, and they wanted Sohlman to let Nobel know of their position on the matter.[211]

This letter possibly reached Nobel in Paris in three days, since his answer was dated 6 April. He commented, gave feedback on several topics that had been discussed by Sohlman in seven previous letters, including progressive gunpowder (ballistite), shells, artificial caoutchouc, the forging of guns, insulating rubber and artificial silk. He considered the possibility of varnishing the gunpowder in order to slow down the rise of temperature within the barrel as shots were fired. He thought there were some problems with this procedure, "but usually such difficulties are quite easy to overcome in practice", he told Sohlman. Regarding the shells and their charges: "It surprises me that picric acid is so sensitive (…) perhaps picric acid dissolved in nitric acid solution would render a satisfactory result."[212] He was optimistic when it came to the samples of artificial caoutchouc they had sent him; he was going to compare them to that new material called Pegamoid, of which he expected to receive samples soon. He had performed some experiments himself and discussed the results in this letter to Sohlman.[213] Nobel showed

a humble, open and encouraging attitude when he discussed their common interests.

Nobel develops a new gunpowder

On the issue of manufacturing ballistite in Sweden, Nobel also told Sohlman that he was working on a new, "very promising" type of gunpowder with no nitroglycerine, and if it turned out well, they would definitely start production of this gunpowder at Bofors, he said. He had told Mr Öberg, the manager of Nitroglycerinbolaget, about this new gunpowder and he thought this message to Mr Öberg would make him more inclined to reach an agreement on the ballistite issue.[214] The Bofors biographer Stig Fransson commented on the obvious detour that Nobel was prepared to make to try and meet the Navy's request for gunpowder:

> Whether this idea represented the wishful thinking of Alfred Nobel can be discussed. As a matter of fact, the ballistite had been in use for nearly ten years while other sorts of gunpowder were still at the experimental stage. Alfred Nobel probably recognised that the quickest way to reach the Swedish market was to offer ballistite, i.e., double-base powder. The existing agreement [with Nitroglycerinbolaget] and a situation where he felt dual loyalties and a clearly deteriorating health must altogether explain why, a few months before his death, Alfred Nobel did not push this issue to its conclusion.[215]

In the search for a new manager to lead operations at Bofors, Sohlman had suggested Caspersson from Nitroglycerinbolaget, whom he knew well and considered a driven businessman.[216] But Nobel considered him "too weak", and he also feared that employing Caspersson would harm his own relations with Nitroglycerinbolaget.[217] It is evident that Nobel's position was more complex than Sohlman's regarding the transfer of ballistite production from Stockholm to Karlskoga. To Sohlman, and the Navy as well, it was a simple, rational decision based on Björkborn being close to Bofors, which meant that gunpowder and guns would always be close at hand for trial shooting. Meanwhile, Nobel had social relations to consider when contemplating a possible reallocation of resources. And I agree with Fransson, above, regarding Nobel's ailing health which also set a limit on the effort he could put into this emerging conflict between his companies. Nobel told Sohlman that his health was still poor and there was so much work not being done.

> Wire me if you think you could take leave for about two weeks and come to San Remo. Naturally your wife should come with you, expenses paid. In that case, I will ask Oscar Ljungström to come here too. I have important things in the making.[218]

The answer from Sohlman stated that, as soon as Nobel told him to, he could be in San Remo in five days and stay for a couple of weeks. There was no manufacturing of gunpowder going on right now at Björkborn, so the time was right for a trip.[219]

A deepening friendship

The letters from the summer of 1896 reveal how affectionate the relation between Nobel and Sohlman had become and how devoted Sohlman was to his employer in spite of their differing views on the ballistite-issue. But the letters also indicate that by now Sohlman was managing all kinds of experiments independently, even when they were new to him, and Nobel was not physically present. In April 1896, Sohlman and his wife went to San Remo where they stayed with Nobel for a couple of weeks before returning

to Karlskoga. After Sohlman and his wife had returned to Bofors, he expressed their gratitude: "We are so grateful, and I am in greater indebtedness to you than to anyone else – except for my mother – since, if I end up accomplishing anything worthy, I will owe it all to you".[220]

There were no letters sent between Nobel and Sohlman between 23 May and 24 June which might indicate that Nobel was at Bofors during that period. In late June, he was in Paris when a letter from Sohlman arrived. Nobel had presented Sohlman with a method for making gunpowder out of pure nitrocellulose (with no nitroglycerine), by hand. This gunpowder represents Nobel's endeavour to avoid a conflict with Nitroglycerinbolaget, where they had the exclusive rights to manufacture ballistite with nitroglycerine. The result, a sample made at the Björkborn laboratory, was sent to Nobel in Paris. Sohlman had ordered special apparatus from a manufacturer in Stockholm for the production of this gunpowder in order to be more efficient. He had done some trial shooting with the gunpowder, but it was too crude in the 20 mm gun he used, so he was going to try again, using a 37 mm gun.[221] Nobel continued his mobile lifestyle, travelling extensively in his pursuit of new ideas and bright technicians and engineers whom he might be able to send to Bofors. In early July, Nobel arrived in Stockholm, where he stayed at the Grand Hotel.[222]

Meanwhile, Sohlman materialised Nobel's ideas at Bofors and Björkborn. He was making plans for trial shooting with rocket projectiles. Nobel had suggested some new charges but Sohlman, who was responsible for the practical experiment, decided to apply their usual slow charge to begin with, and then try the new ones. He thought that the course of the rocket was impossible to predict because it might bounce off the surface of the water and take a new course. But he had found a new very suitable place at the Skagersholm estate, belonging to Bofors, where they could perform trial shooting by Lake Skagern with at least 10 kilometres of open water. "There, we can continue the trial shooting and estimate the range of fire as we watch the rocket hit the water",[223] he told Nobel.

An environment for the budding entrepreneur

From the letters that Sohlman sent to his wife, Ragnhild, it is evident that he enjoyed the company of possibly his closest workmate, Arent Silfversparre. They shared a lifestyle, far from the big cities that Nobel often frequented. While Mrs Sohlman was away, Sohlman often spent the evenings with Silfversparre's family, at their house.[224] Or they spent their days off together, like one Sunday morning in early August 1896, when Sohlman and Silfversparre went for a walk in the morning, followed by a bicycle ride to Kvarnfallet north of Karlskoga where they swam in the stream. In the evening, they had dinner together with workmates Ljungström and Loquist.[225] It seems to have been a safe, secluded world, where an almost constant togetherness must have bred a certain spirit and loyalty to the place and its people, for the 26-year-old Sohlman in this early phase of his career as an entrepreneur.

In mid-August, Nobel left Paris and arrived at the Grand Hotel in Stockholm where he stayed while attending the funeral of his brother, Robert. He confided in Sohlman, yet another sign of deep friendship: "I, the weakest of the brothers, am still barely keeping it together, while the others rest, embraced by eternity".[226] Sohlman extended his deepest sympathies and hoped that Nobel could find some relief in all the work that kept him so

busy, not least all his new ideas. Hoping to make a contribution to this relief, Sohlman sent Nobel the latest report from their trial shooting at Skagersholm.[227]

Bringing the rockets on the bikes

In a letter to Mrs Sohlman, Sohlman described their trip to Skagersholm. There were five of them: Sohlman, Ljungström and Feilitzen brought the rocket projectiles on their bicycles, while Hellström and Berg brought the rest of the equipment on the train. It was a 50 km bicycle ride carrying the projectiles, but it was a nice journey and, when they arrived in the evening, they were very kindly greeted by their hosts at Skagersholm, where they also spent the night. Next day, preparations were made and then the trial shooting began.[228]

In a letter to Nobel, quite naturally the description was focused on the details of the trials. The gun was placed on a bank by the waterfront, pointing up in the air to avoid ricochets. The weight of the projectiles was between four and five kilos, the charge in the projectile consisted of potassium perchlorate, some glue and glycerine, while the gun was charged with black gunpowder. Two projectiles were fired. The muzzle velocity of the projectiles was 150 m/s approximately, and the distance to the checkpoint was 1100–1150 m. The place, Skagersholm, seemed perfect for these experiments.[229]

Back home at Bofors, Sohlman sent further reflections on the rocket projectiles in a letter to Nobel, who was in Stockholm. Since the projectiles took such a long time before touching the water, about 20 seconds, he thought that ballistite would work fine for charging them. He was going to acquire some more equipment for the rockets, apparatus, tubes and such things. They had been sent to Bofors by Captain Unge and Sohlman thought these items would be suitable for their experiments, making them progress faster. Meanwhile, the experimental work on artificial rubber at Björkborn had been successful, and they had made some new products. There was a raincoat, a pair of shoes, spats, a bicycle bag and some covers for books. The craftsmen who worked with the material liked it a lot, especially the bookbinder.[230] These experiments represent preparedness for a number of related diversifications that it was now possible to make, based on the introduction of chemistry at Bofors. However, as mentioned earlier, the passing of Nobel in late 1896 meant that the experimental work had to return to its focus on gunpowder and explosives.

Further plans for making ballistite at Bofors

In September, Nobel visited Bofors for the last time and stayed for a few weeks. By early October, he was back in Stockholm, where he received reports of experiments on rocket charges performed at Bofors.[231] A couple of days later, Sohlman learnt that Nobel planned to return to Bofors with a Mr Sederholm. They wanted to discuss issues related to electrolysis and electro-smelting. However, Nobel never returned to Bofors. After finishing this letter, he hurried to the station in Stockholm to catch a train for Malmö. He was bound for Berlin, where he would stay at the Palace Hotel.[232]

A day later, Sohlman went to Stockholm, where he met with Sederholm and together they returned to Bofors. Sederholm was yet another example of Nobel's way of creating a knowledge network at Bofors consisting of people with complementary skills. Sohlman and Sederholm began experiments on charges for shells. Nobel had suggested barium perchlorate combined with some glue

and glycerine. This was produced efficiently through an electrolytic treatment of potassium perchlorate.[233] From a meeting with the Swedish Navy in Stockholm, Sohlman had also learnt that, in Karlskrona, the Navy was considering the question of shells and the particular fuses originating from Nobel. They would soon let Bofors know of their requests and requirements. Sohlman had also been told by the Navy that they were eager to acquire ballistite for their old 25 cm guns. At the time, they were using brown gunpowder, which produced clouds of smoke, making it impossible to fire more than one shot every ten minutes. Sohlman told Nobel of the detailed wishes he had received from the Navy and then proposed actions that could be taken at Bofors to meet these wishes.[234]

This was yet another attempt to convince Nobel to let them start making commercial ballistite at Bofors. Sohlman and Silfversparre had a plan ready for this particular order for ballistite intended for 25 cm guns: They wanted to convert an old 27 cm gun into a 25 cm one with a cartridge case similar to that of the 25 cm guns the Navy had previously ordered from Bofors. This gun would then be used for gunpowder experiments at Bofors only. A sketch for such a conversion had been made. The conversion of the old 27 cm gun would cost Bofors approximately 15 000 kronor. Sohlman argued: "If we receive the gunpowder order for the 25 cm guns from the Navy, it should easily cover the cost of the conversion of the old gun".[235] There was no answer to this proposal. Regarding the gunpowder experiments, Nobel thought that most states were turning to nitrocellulose, partly because it created less erosion and produced less visible flame at the muzzle, compared to ballistite.[236]

In mid-October, Nobel was back in Paris and received a report from the first trial shooting with gunpowder containing 80% nitrocellulose and some anisole, where it was also compared to regular ballistite. But the results were not good, mostly due to the shape of the gun powder.[237] Sohlman learnt that the Navy had increased its order for gunpowder for 12 cm guns from Nitroglycerinbolaget from 40 kilos to 60 kilos. Supposedly this was the result of trial shooting with this gunpowder at Bofors. "Will you allow me to send an invoice to Nitroglycerinbolaget covering part of the cost, or the total cost, for these shootings?"[238] Sohlman asked Nobel. That month Sohlman received a deed of gift from Nobel.[239] Having signed the document, Sohlman enclosed it in his letter to Nobel, along with a picture of himself and Mrs Sohlman, "two young persons who are very grateful for everything you have done for them".[240]

"How amusing to kill your own product"

Nobel was not feeling well. His heart condition kept him in Paris, where there were good doctors to consult. He was prescribed a new medicine called Trinitrin, containing nitroglycerine. "It is rather ironic that I am ordered to take ngl internally." He added his thanks for the picture of Sohlman and his wife. "The two of you look very nice".[241] In late October, Nobel received new samples of gunpowder from Bofors. It was made from nitrocellulose and contained no nitroglycerine. He commented: "The little sample in your letter seems excellent and I am almost certain that we will outcompete nitroglycerine. How amusing to kill your own product".[242]

Nobel went on to tell Sohlman about the German field artillery returning to gunpowder made from nitrocellulose with no additives. France and Russia were also acclaiming the nitrocellulose gunpowder, he said.[243] This

was Nobel responding to Sohlman's campaign for the transfer of ballistite production from Stockholm to Karlskoga. Nobel insisted on a different road to take, to make gunpowder with no nitroglycerine, in spite of there being no demand in Sweden for that type of gunpowder. There were no letters from Nobel during the first couple of weeks in November. Then there was a telegram in which he wanted Sohlman to make a sketch and a description of the gunpowder made from nitrocellulose, with no nitroglycerine, the so-called "progressive cellulose".[244] A few days later, there was a letter in which he told Sohlman that he would go to San Remo.[245] Meanwhile, at Bofors, an apparatus for the manufacturing of Nobel's progressive cellulose arrived and was installed. Sohlman sent Nobel the sketch for the patent application for this new gunpowder.[246]

"My health is so poor that rest is much needed"

Nobel found himself somewhat delayed in Paris because he had guests: the new manager of Bofors, Commander Dyrssen, and Nobel's nephew, Emanuel, was there too, "but tomorrow I will leave. My health is so poor that rest is much needed",[247] Nobel told Sohlman. A few days later, Sohlman learnt that the nine-month storage of the gunpowder called progressive ballistite indicated that it would not stand the test. The larger quantity of nitroglycerine in the middle layer of this gunpowder trickled through to the outer layers. Sohlman was sorry when he told Nobel the news. However, the manufacturing of nitrocellulose gunpowder continued, even though Sohlman initially had some difficulties handling the new apparatus. But now the method, originating from Nobel, worked fine. A sample was enclosed in the letter to Nobel.[248] A couple of days later, Sohlman performed trial shooting with nitrocellulose gunpowder in the 37 mm gun. But the shape of it was too crude and the gunpowder was not consumed properly.[249]

A final letter for Sohlman

When he received the letter with the sample of nitrocellulose gunpowder, Nobel thought it looked splendid. "Unfortunately, my health is so poor again that I can barely write these words. But I shall come back, as soon as I can, to the topics which interest us both".[250] Nobel then passed away on 10 December 1896. Three days later, Sohlman arrived in San Remo and wrote this letter to his mother:

> It is late – it is past midnight – and I have gone to bed, but I feel such an urge to talk to mother about the distressing events taking place these past few days, that I have to write to you, while I am in bed. Surely you can imagine how terribly painful these past few days have been for me. When I started my journey, I hoped to see my friend and benefactor – as I think I may call him – still alive, to possibly look after him during his illness, or to at least be able to say farewell. Mother knows how one wishes to be positive under such circumstances. I told myself that hopefully this stroke was passing and at worst would leave a partial paralysis. But when we got off the train in Copenhagen, we were told about his death. I still find it hard to grasp that this is really so. During these past three years, I have spent most of my time pursuing his ideas. To a great extent I have lived among his ideas. It is so strange to think that this is over.[251]

Sohlman then quoted Nobel's last letter to him, which he found on Nobel's desk in San Remo, before he continued to share his thoughts with his mother. He told her the news that Nobel had entrusted him and Rudolf Lilljekvist with the executing of the will, which he considered a "terrible

responsibility". He was touched by this proof of trust that Nobel had shown in him. This implied new future duties, but uncertainty as well. His and Mrs Sohlman's lives would change. All he knew just then was that he would like to "pursue some of Nobel's unfinished ideas".[252]

When reminiscing about these days in December 1896, later in life, Sohlman stated that it was indeed an emotional and bewildering situation. The will stated that everything belonging to Nobel was to be sold and the fortune placed in safe securities. Sohlman felt that if the will was to be understood literally, this would be most unfortunate for all the companies owned by Nobel. He also worried about all the experiments being performed at the laboratory by himself and the engineers. They were all employed by Nobel personally, not by Bofors. Sohlman felt that he could not terminate their employment but decided without further reasoning that they should remain for at least a year, paid by the Nobel estate which he now controlled.[253] Obviously, his future as a gunpowder entrepreneur depended on him being able to pursue the experiments, and to provide the necessary financial resources. They needed new sorts of gunpowder that met the demands set by their customer, the Navy, because the progressive ballistite, which turned out to be Nobel's last patent, had not withstood the storage test. And they had the knowledge required to perform these experiments.

Sohlman wants to dethrone the manager at Nitroglycerinbolaget

The circumstances surrounding Nobel's passing implied that Sohlman, could now turn directly to Nitroglycerinbolaget in his endeavour to go through with the transfer of the manufacturing of ballistite from Stockholm to Karlskoga. Yet, the formal institution consisting of the legal agreement giving Nitroglycerinbolaget exclusive rights to manufacture commercial ballistite was fiercely defended by the manager at the company, Mr Öberg.[254] In early March 1897, Sohlman travelled to Paris to perform some duties related to Nobel's will. Yet he was eager to return to Stockholm because Nitroglycerinbolaget's annual general meeting was taking place and Sohlman was very anxious regarding the outcome of this meeting, as he told his wife in a letter:

> We have to replace the old fogy Öberg with Caspersson, this is an issue of greatest importance for further development regarding the manufacturing of gunpowder as well as our rubber and silk. It is too bad that I cannot be in Stockholm and agitate, as this will certainly be needed, to get this thing through. Now it may fail due to lack of persuasive power.[255]

However, Sohlman remained in Paris. He could not be in two places at once.[256]

Ragnar Sohlman – from humble assistant to bold entrepreneur

It had been decided after the passing of Nobel that Sohlman and his wife could move into Björkborn Manor. When Sohlman, pausing from his many trips related to Nobel's will, briefly visited Bofors in March 1897, he found that their furniture had been moved from their home and was now installed in the rooms on the ground floor at Björkborn Manor.[257] Sohlman also travelled to Stockholm, where he and Mr Lilljekvist, his fellow-executor, discussed issues related to their assignment. They were going to pay a visit to the King, Oscar II, the next day and present him with a nice-looking bound issue of Nobel's will. Sohlman expected that "it will be a pretty dull ceremony".[258] At the

time, the king was not in favour of the idea of letting most of Nobel's fortune be placed in a foundation, and thus not inherited by his relatives. Regarding the peace-prize, the King felt that Nobel had been influenced by "peace-fanatics, especially women".[259] Yet, when the process had been completed and the Nobel Foundation and its prizes were installed, the King apparently appreciated the idea and enjoyed taking part in the festivities, which included him presenting the prizes to the laureates.[260]

After Nobel's passing in December 1896, the only remaining obstacle to the transfer of gunpowder production from Stockholm to Karlskoga was the manager at Nitroglycerinbolaget, Öberg, who had opposed the transfer when Nobel spoke to him about it earlier in 1896. It was not until Sohlman and his supporters had persuaded the chairman of the board at Nitroglycerinbolaget, I.W. Smitt, to back the proposal regarding the transfer, and have Öberg replaced, that they reached an agreement to start up AB Nobelkrut in Karlskoga. That was in April 1898.[261]

AB Nobelkrut initially had three owners: the Nobel estate, represented by Ragnar Sohlman, Bofors and Nitroglycerinbolaget. Sohlman then sold the shares in Nobelkrut belonging to the Nobel estate, and he sold them to Bofors. This meant that the power relations within Nobelkrut clearly gravitated towards Karlskoga.[262]

> The founding of a gunpowder factory at Bofors was of greatest importance for the progress of the gun industry. It implied that Bofors could organise close teamwork on a daily basis between the gun industry and the manufacturing of gunpowder, which are really integrated parts of the same problem. (…) The merit of this arrangement could be ascribed to Alfred Nobel and Ragnar Sohlman.[263]

In later years, Sven Gerdin, technological manager at the Defence Division of Bofors during the 1950s and '60s, stated that guns and the diversification into gunpowder constituted a complete and sufficient technological combination upon which all further arms development work at the company would be based until 1945.[264]

AB Nobelkrut also diversified

Ragnar Sohlman was manager at AB Nobelkrut between 1898 and 1920. In late 1917, a year before the end of WWI, he stated that the company must venture into civil industry because orders for gunpowder and war explosives were expected to decrease. This represented necessity-driven diversification. The company planned to diversify because it had to, in order to survive. They had performed a number of experiments within such areas where manufacturing could be matched with the existing factory equipment at Björkborn. Thus, they considered venturing into branches related to their core activities from a skills perspective. Sohlman mentioned Nobelit which was an explosive that could be used for civil purposes. He also considered starting production on formalin, which could be used as a disinfectant.[265] In 1915, Nobelkrut had started making ether for medical purposes.[266] Until this point, the company had been quite successful on the international market with its nitroglycerine gunpowder NK4, NK5, and gunpowder with reduced flame. From 1910, there was also worldwide demand for Bofors' and Nobelkrut's shells, torpedoes and landmines containing TNT.[267] Foreign governments that began to acquire ammunition from Bofors in the early 20th century would eventually also buy guns from the company. The combination of expertise on materials, mechanics and explosives needed for manufacturing

ammunition thus became a door-opener for Bofors in terms of exports.[268]

Furthermore, Nobelkrut engineers had developed some unique methods for nitroglycerine and explosive charges containing TNT, and had been asked by foreign companies in East Asia and South America to be of practical assistance when these companies sought to start manufacturing ammunition. This service would eventually lead to further diversification into a knowledge and business field that was related to the company's core activities, that of setting up ammunition factories worldwide.[269]

Concluding discussion: The diversification – who did what and when?

In relation to the transfer of the manufacturing of ballistite from Stockholm to Karlskoga, Sohlman later stated that Nobel "liked the proposal but there was not enough time to implement it before Nobel passed away".[270] As indicated in this investigation, this was not quite true. I argue that it is fair to say that, considering the circumstances, Nobel was not prepared to carry through such a transfer. Indeed, he had provided the financial and technological resources to start up chemical activities at Björkborn. Yet, he disregarded the customer's preferences and suggested further experiments with a type of gunpowder for which there was no demand at the time, a circumstance that Bofors biographer Stig Fransson also noted. Nobel's passing provided an opportunity to diversify. This was a major change which implied that guns and gunpowder could now be developed and produced together in Karlskoga.

This change represents one of the definitions of a Schumpeter innovation – a new method of production within a certain branch.[271] So, the actors behind this diversification were several. Nobel initiated the chemical activities and provided the necessary money and the human resource, Sohlman, to start the experimental activities, but there was no plan to do this on an industrial scale. The exclusive right given to Nitroglycerinbolaget meant that there was even strong resistance and impediments to the launching of gunpowder production at Bofors. The consultant Liedbeck, although quite unaware of it, set the wheels in motion when he came to Bofors asking them to manufacture a small amount of ballistite, hoping it could provide Nitroglycerinbolaget with an order from the Swedish Navy.

The Swedish Navy, realising the improved quality of ballistite made at Bofors, then provided the necessary demand for this start-up. Sohlman, representing the Nobel estate, provided the financial resources needed to pursue the final, crucial experiments making it possible to launch a new generation of ballistite. In this endeavour, Sohlman also had firm support from the Bofors management, at least from Silfversparre, the head of the gun workshop. It is highly unlikely that there would have been a gunpowder industry in Karlskoga if the Navy had not come up with this idea, and if Sohlman had not chosen to allocate the resources needed to launch new types of ballistite. To Bofors as a company, this was a unique opportunity to diversify where they had Sohlman and his expertise, and a customer. Furthermore, it is unlikely that there would have been any chemical businesses in Karlskoga today, had there not been a shooting range situated between the Bofors and Björkborn estates in the 1890s. The gun factory and the shooting range were the reason why the Navy turned to Bofors with its request for the transfer of the manufacturing of ballistite. Had there been no transfer of ballistite to Karlskoga,

there would have been no AB Nobelkrut and no manufacturing of ammunition later on.

Looking back to the late 19th and early 20th centuries, it is evident that the diversifications at Bofors presented in this article, contributed to the rich variety of interrelated skills and competencies from which local companies in Karlskoga still reap the benefits. These diversifications represented innovations in several ways based on the Schumpeterian criteria. Firstly, new types of gunpowder were introduced. Secondly, Bofors started producing guns and gunpowder in pairs which can be understood as a new production method. Thirdly, the transfer of ballistite production from Stockholm to Karlskoga meant that the company broke up a monopoly-position previously held by Nitroglycerinbolaget. And finally, Bofors entered a new branch when they started to offer the service of setting up ammunition factories worldwide.[272]

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185. Letter from Alfred Nobel to Ragnar Sohlman February 15, 1896.
186. Ibid.
187. Letter from Ragnar Sohlman to Alfred Nobel February 17, 1896.
188. Ibid.
189. Letter from Alfred Nobel to Ragnar Sohlman February 20, 1896.
190. Ibid.
191. Ibid.
192. Ibid.
193. Op. cit., Sohlman, Ragnar and Schück, Henrik, see note 137, p. 18.
194. Letter from Alfred Nobel to Ragnar Sohlman February 25, 1896.
195. Letter from Alfred Nobel to Ragnar Sohlman February 26, 1896.
196. Op. cit., Steckzén, Birger, see note 26.
197. Letter from Ragnar Sohlman to Hulda Sohlman October 16, 1894.
198. Op. cit., Steckzén, Birger, see note 26.
199. Letter from Ragnar Sohlman to Alfred Nobel February 28, 1896.
200. Letter from Ragnar Sohlman to Alfred Nobel February 29, 1896.
201. Letter from Alfred Nobel to Ragnar Sohlman March 6, 1896.
202. Ibid.
203. Letter from Alfred Nobel to Ragnar Sohlman March 8, 1896.
204. Letter from Ragnar Sohlman to Alfred Nobel March 16, 1896.
205. Ibid.
206. Letter from Ragnar Sohlman to Alfred Nobel March 27, 1896.
207. Op. cit., Steckzén, Birger, see note 26, p. 142.
208. Letter from Ragnar Sohlman to Ragnhild Sohlman March 19, 1896.
209. Letter from Ragnar Sohlman to Ragnhild Sohlman "spring 1896".
210. Letter from Ragnar Sohlman to Alfred Nobel April 1, 1896.
211. Letter from Ragnar Sohlman to Alfred Nobel April 3, 1896.
212. Picric acid was indeed too sensitive to be used in shells. Twelve years later, in 1908, Sohlman would acquire Trinitrotoluene (TNT) from Germany which would replace picric acid as an explosive in shells (Op. cit., Fransson, Stig A., [1998], see note 23).
213. Letter from Alfred Nobel to Ragnar Sohlman April 6, 1896.
214. Ibid.
215. Op. cit., Fransson, Stig A., (1998), see note 23, p. 17.
216. Letter from Ragnar Sohlman to Alfred Nobel March 18, 1896.
217. Letter from Alfred Nobel to Ragnar Sohlman April 6, 1896.
218. Ibid.
219. Letter from Ragnar Sohlman to Alfred Nobel April 14, 1896.
220. Letter from Ragnar Sohlman to Alfred Nobel May 23, 1896.
221. Letter from Ragnar Sohlman to Alfred Nobel June 24, 1896.
222. Letter from Ragnar Sohlman to Alfred Nobel July 8, 1896.
223. Letter from Ragnar Sohlman to Alfred Nobel July 21, 1896.
224. Letters from Ragnar Sohlman to Ragnhild Sohlman August 20 and August 24, 1896.
225. Letter from Ragnar Sohlman to Ragnhild Sohlman August 9, 1896.
226. Letter from Alfred Nobel to Ragnar Sohlman August 11, 1896.
227. Letter from Ragnar Sohlman to Alfred Nobel August 16, 1896.
228. Letter from Ragnar Sohlman to Ragnhild Sohlman August 18, 1896.
229. Letter from Ragnar Sohlman to Alfred Nobel August 16, 1896.
230. Letter from Ragnar Sohlman to Alfred Nobel August 17, 1896.
231. Letter from Ragnar Sohlman to Alfred Nobel October 3, 1896.
232. Letter from Alfred Nobel to Ragnar Sohlman October 5, 1896.
233. Letter from Ragnar Sohlman to Alfred Nobel October 13, 1896.
234. Ibid.

235. Ibid.
236. Letter from Alfred Nobel to Ragnar Sohlman October 12, 1896.
237. Letter from Ragnar Sohlman to Alfred Nobel October 15, 1896.
238. Letter from Ragnar Sohlman to Alfred Nobel October 18, 1896.
239. Letter from Alfred Nobel to Ragnar Sohlman October 9, 1896.
240. Letter from Ragnar Sohlman to Alfred Nobel October 18, 1896.
241. Letter from Alfred Nobel to Ragnar Sohlman October 25, 1896.
242. Letter from Alfred Nobel to Ragnar Sohlman October 28, 1896.
243. Ibid.
244. Telegram from Alfred Nobel to Ragnar Sohlman November 18, 1896.
245. Letter from Alfred Nobel to Ragnar Sohlman November 21, 1896.
246. Letter from Ragnar Sohlman to Alfred Nobel November 20, 1896.
247. Letter from Alfred Nobel to Ragnar Sohlman November 22, 1896.
248. Letter from Ragnar Sohlman to Alfred Nobel December 2, 1896 .
249. Letter from Ragnar Sohlman to Alfred Nobel December 4, 1896.
250. Letter from Alfred Nobel to Ragnar Sohlman December 7, 1896.
251. Letter from Ragnar Sohlman to Hulda Sohlman December 13, 1896.
252. Ibid.
253. Op. cit., Sohlman, Ragnar, see note 30.
254. Sohlman, Ragnar: "Grundandet av AB Bofors Nobelkrut", *Boforspilen*, no. 3, 1948, p. 1-4.
255. Letter from Ragnar Sohlman to Ragnhild Sohlman March 6, 1897.
256. Ibid.
257. Letter from Ragnar Sohlman to Ragnhild Sohlman March 20, 1897.
258. Letter from Ragnar Sohlman to Ragnhild Sohlman March 22, 1897.
259. Op. cit., Sohlman, Ragnar, see note 30, p. 281.
260. Ibid.
261. Ibid.
262. Op. cit., Steckzén, Birger, see note 26.
263. Ibid.
264. Op. cit., Gerdin, Sven, see note 25.
265. Sohlman, Ragnar, Overview of the business activities at AB Nobelkrut written 1917-11-06, Ragnar Sohlman's archive at the Royal Library (Kungliga biblioteket) in Stockholm, "Handlingar rörande AB Bofors Nobelkrut", 1917, *https://arken.kb.se/SE-S-HS-L10a-4*.
266. Op. cit., Fransson, Stig A., (1998), see note 23.
267. Op. cit., Sohlman, Ragnar, see note 265.
268. Op. cit., Gerdin, Sven, see note 25.
269. Op. cit., Sohlman, Ragnar, see note 265. These actvities (setting up ammunitions factories) are today known as Chematur Engineering and are still located in Karlskoga.
270. Op. cit., Sohlman, Ragnar, see note 254, p. 3.
271. Op. cit., Schumpeter, Joseph A., see note 7, pp. 65-66.
272. Ibid.