Wilhelm Albert 2.0
Ore Mining in The Harz Mountains

by Don Sayenga and Roland Verreet

As of the summer of 2018, several websites have been posted which are purported to be lists of the greatest inventions of the 19th century. So far none of the lists has included wire rope, despite the fact this may have been one of the most significant innovations of all time. One of the websites quotes a 1913 Scientific American study where the commercial success of any innovation was one of the key criteria for ranking the importance of the invention. Wilhelm Albert, who invented wire rope in 1834, was not aimed toward creation of profit. He was a government official trying to solve a very specific problem.

The Upper Harz mining region, located in central Germany midway between Frankfurt and Berlin, has been a source of metallic ores since the medieval era or perhaps even earlier. Originally the ore bodies were found on the surface. The importance of silver metal for coinage caused the local reigning authorities to establish and maintain governmental controls over the mines. Wilhelm A.J. Albert, whose job title *Ober-Bergrath* can be translated "superior mining supervisor" was the person in charge during the 1830s. He was higher in rank than the other supervisors at each of the mines.

Albert's title apparently was devised specially for him when he was placed in total control. The mines were owned and operated by the royal government of the Kingdom of Hanover. Previously, a member of the royalty would have been in charge. The map of Europe has been redrawn several times since 1820, but the Kingdom of Hanover was one of the 39 sovereign states which formed the German confederation in 1815. Hanover had been allocated to the Royal family of Great Britain at the Congress of Vienna. As a direct result, official actions such as Albert's wire rope experiments were published in both German and English official technical summaries. In turn, the English version was transmitted to the USA. These became the three nations where most of the earliest wire rope improvements took place.

Albert's office was located at Clausthal-Zellerfeld in the Upper Harz where the vertical shafts for transporting metallic ore from the underground digging sites to the surface employed a device known as a *"Göpel"* or horizontal horsewhim equipped with hemp ropes. The hemp used in the ropes didn't last very long because all of the shafts were open at the top and therefore damp. The hemp was imported. Thus, his initial concerns were aroused by *"Den grossen Kostenaufwand"* as he called it. In short, it was cost-control which first motivated him to begin thinking about finding a way to replace those hemp horsewhim ropes.

Wilhelm August Julius Albert, (1787-1846) the inventor of steel wire rope.

Before he began contemplating the subject, he had already spent seven years studying wrought iron chains. As described by Jens Weis and Isabel M.L. Ridge: *"Albert was driven in his work by an apparently hopeless situation: increasing shaft depths and the continually rising numbers of failures of the conveyor/lifting link chains. At almost five times the payload, the weight of the chains was more and more a risk, especially as the shafts reached depths of 400 meters. It was even leading to a situation where hemp ropes were becoming a first choice again – even if they were much more expensive and had to be imported from abroad."*

IRON CHAINS AND THE HORSEWHIM REEVING

The horsewhim Albert used for experiments had a vertical central axle with a large horizontal drum mounted on top of it. At ground level, the shaft was rotated in either direction by a harnessed horse walking around it. The drum on top was reeved with an endless chain. During his first experiments, an ore bucket connected to the central part of the chain was lowered and raised in the mineshaft by the rotation of the axle. When a progressive changeover to waterwheel power began, the basic principle was still the same. Horizontal rotation and motion were converted to vertical motion by sheaves mounted over the mineshafts.

In 1827, Albert believed at first he could devise an improved style of chain. Because the links of the chains were hammer-forged one at a time, he designed and tested different shapes for the links, various ways to forge and connect, and he tried to analyze the nature of the wrought-iron which was the strongest metal available.

In the end, everything he tried to

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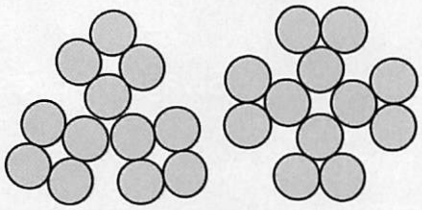
do to manufacture better chains was stymied by the same roadblock: if one link failed in service, all was lost. He became even more frustrated when he learned other people had worked on the problem for many years without getting anywhere. Having reached a conclusion his studies with conventional iron link chains were a waste of time and money, he chose to drop all of it.

Very suddenly he turned in an entirely new direction. He wrote: *"However, It occurred to me subsequently, at the commencement of last year (1834) that iron wire might be plaited or twisted together to form a whim rope..."* Albert was not the first person to experiment with mechanical combinations of wire, but as of 1834 no applications in the world required long lengths of iron wire. He was confronting hoisting problems in his mineshafts which were hundreds of meters deep, but the longest rings of cold drawn iron wire available to him were only 35 meters or less.

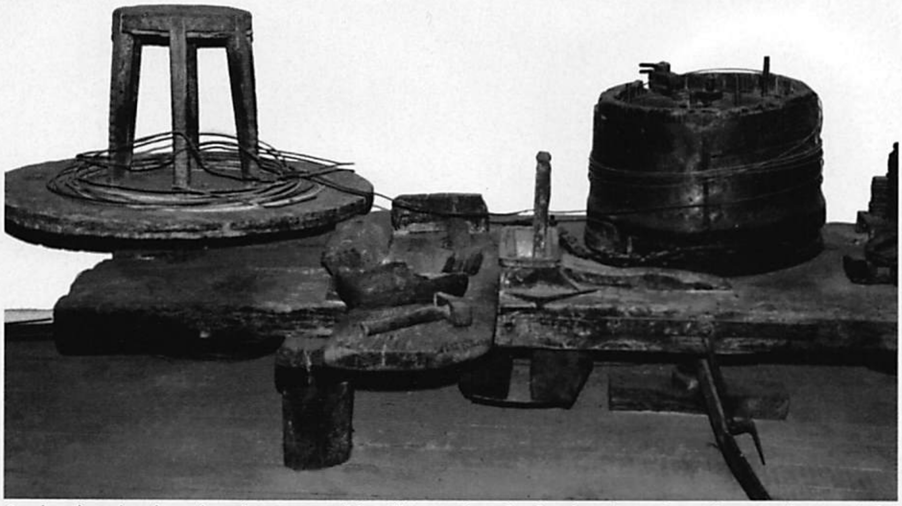
One of the first questions he had to answer was how to go about splicing short pieces of iron wire end-to-end to achieve longer lengths of strand. He faced a similar question with the splicing of strands. It was obvious the manufacture of wire whim ropes would be more difficult than the existing technique for making an iron chain longer by forging connections of additional links one at a time.



The 3-strand and 4-strand Albert ropes, both made of 12 wires with no core and no center wires.

THE FIRST WIRE ROPES

To fabricate his successful wire ropes, Albert decided to use cold drawn iron wires with a diameter he called *"Königshütte am Harz mit No. 12 bezeichnet wird"* which could be purchased locally in the Upper Harz. This size of iron wire was approximately 3 mm in diameter. For some reason the 1837 American translation of his report has stated the wire diameter he used was *".144 inches"* (which corresponds to 3,667mm). In retrospect, this seems slightly larger than what we'd expect for that gauge number. Perhaps this is an indication of the general confusion surrounding the numerous and varied wrought iron wire gauge systems being employed in European and American wire mill commerce during the 1800s.



A wire drawing bench as it was used in Albert's time had a drawing plate die standing upright between the payoff and the pulling capstan

Albert's meticulous notes contain the key questions he posed to himself and the answers he recorded about the manufacture of wire ropes to replace iron chains and hemp ropes. In Germany, Q&A in this format for responses is called "telegram style":

Question 1 – Is this feasible?
Answer – Yes
Question 2 – What are the costs?
Answer – ¼ the costs of hemp rope
Question 3 – What is the comparable weight?
Answer - 1/5 the weight of chain
Question 4 – What is the comparable strength?
Answer – Far more than we need
Question 5 – Is it flexible?
Answer – Yes
Question 6 – Can I make attachments?
Answer – Yes

When posing Question 3 to himself, he used as his basing points the hemp rope and the 1900 kg chain that had been used in one of the mineshafts known as *Hzg. Georg Wilhelm* which was 361 meters deep. The more expensive hemp rope weighed only 842 kg but his careful calculations showed he could have made a wire rope for this shaft with more than enough strength but weighing only about 80 kg.

Concentrating his reasoning on the answers to Questions 5 and 6, he ordered two rings of 10 gauge wire on January 18, 1834 from which he made two short pieces of wire rope using 12 wires for each of them. One of the experimental ropes he made was 4 by 3 and one was 3 by 4. Because only short lengths of wire could be obtained, the splicing of strands and wires and the flexibility needed for the existing hoisting equipment emphasized the answers to Questions 5 and 6 were of paramount importance.

Albert made two crucial decisions regarding Question 6. To join the short lengths of wire he wrote: *"After many trials I found it best to unite them by friction..."* which turned out to work quite well. The wires were twisted around each other, and whenever one wire end approached they added one more wire which first served as a center wire of the strand around which the other wires were twisted for several turns. Then the new wire was brought

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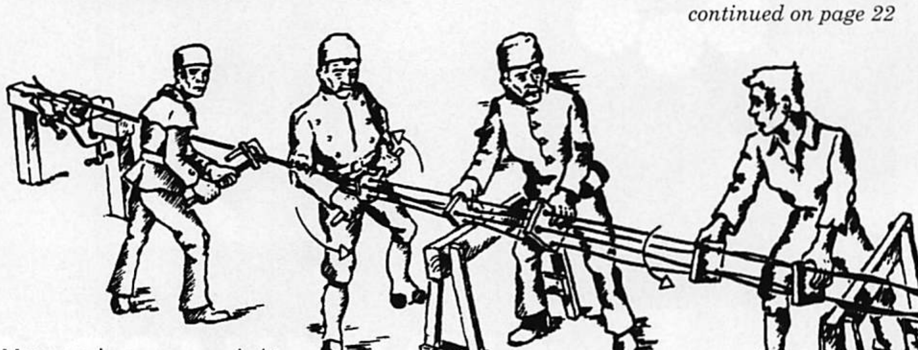

Many workers were needed to produce a strand or a rope. The man on the left moved the closing point while the ropemaker on the right twisted the rope or strand. Between them other helpers got the twist out of the remaining rope or strand length.

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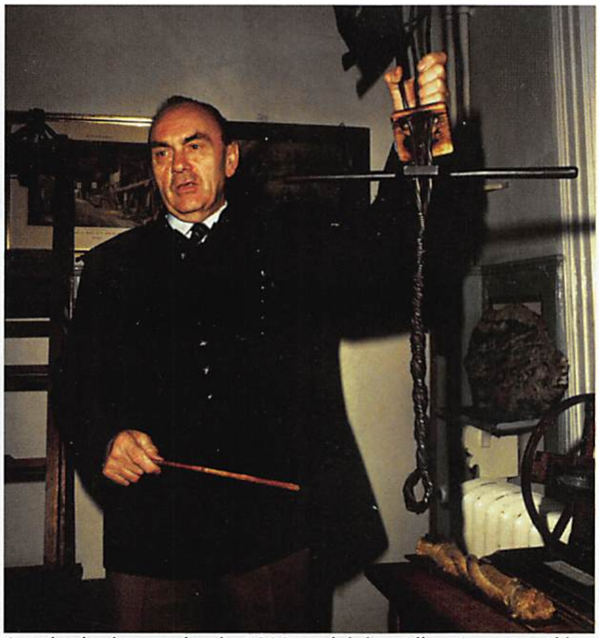
to the outside of the strand and the ending wire to the inside. After a few turns around the ending wire this end was also secured. Thus in the connection area the number of wires increased either from 3 to 4, or from 4 to 5, for a short length of the strand.

The second decision was to connect different sections of rope using the same or a similar technique. For testing this he only had his short trial lengths of 3 and 4 strand rope at hand, but that did not stop him. He spliced the two different rope designs together and then connected them to the hemp rope which was installed in the "Caroline" shaft. The two short rope lengths with the splice had already run over the capstan a few hundred times when the bucket got stuck in the shaft and the hemp rope broke. The short 3 and 4 strand ropes and the splice connecting them had proven to be stronger than the hemp rope!

Albert had to make a decision whether he should use a 3 strand or a 4 strand rope for the first field trial. Both rope designs were made of the same number of wires, they had the same breaking strengths and were similarly flexible. But production of greater lengths was going to be difficult and would require greater floor areas and employ more workers. In order to reduce time and costs, on May 18 he decided to do the field tests with 3 strand ropes.

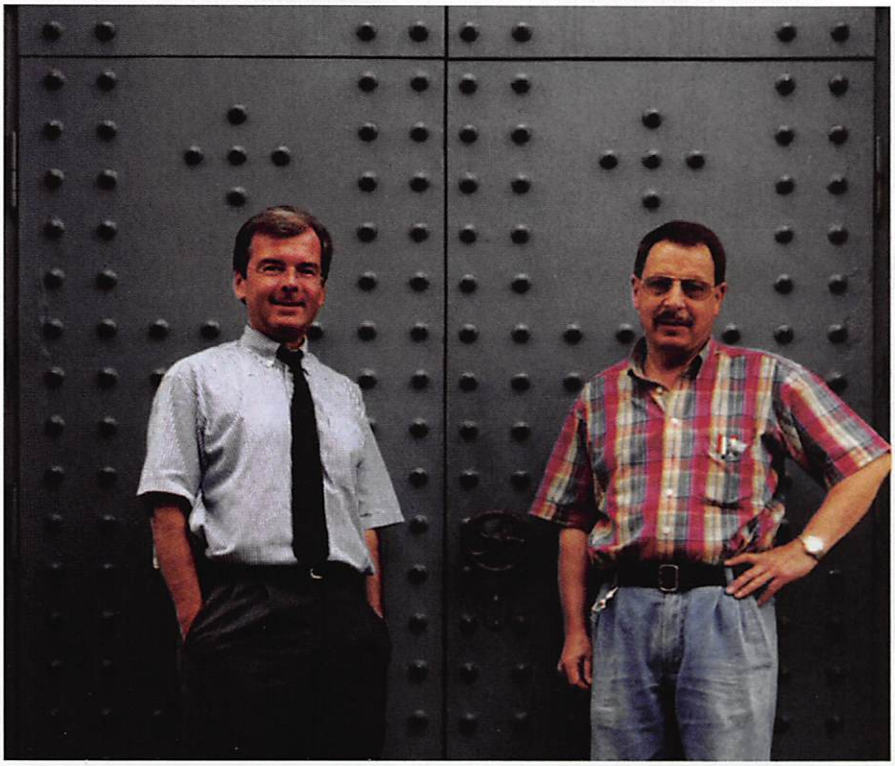
The length of rope to be made was the same as with a 4 strand rope, but the lengths of strands to be made was 25% less. He made a time trial to show it would take about 2 minutes to combine 4 wires into 1 *"lachter"* of *"jedes Stranges"*. The Lachter was the common measurement used for length in mining and excavating. One Lachter was the distance between a man's hands when his arms were held straight outward from his body.



A retired mine worker in 1980 explaining Albert's ropemaking at the Clausthal Mining Museum.

In order to further reduce production time Albert experimented with doing both the stranding and the closing at the same time. Three teams made one strand each, while at the same time another team closed the rope. So on one side of the floor you had finished rope, on the other side you had the strands and, further on, the wires. He even tried to start the rope production in the middle of the length, putting the first meters of rope in a hair-pin type of winding directly onto the drum of the horsewhim, and then fabricating on two sides of the reel working outward toward the rope ends! A follow-up time study on June 3 confirmed all of his earlier estimates.

In 1990, Roland Verreet (l.) had a meeting with Mr. Olaf Schubert (r.) at the main gate of the Technische Universität Clausthal. Mr. Schubert is the person who discovered a surviving 4-strand Albert rope being used as a fence around an abandoned mineshaft in the nearby forest.



"DER ERFOLG" = SUCCESS

Although the shaft known as "Caroline" was the one chosen for the initial attempt to employ a long wire rope for hoisting ore, Albert reasoned that it would make more sense if rope-making could be performed at a single location near to all the mines, instead of making each rope individually adjacent to the mineshaft itself. The best place seemed to be at the mineshaft known as "Dorothy". On June 8 he noted he had completed a 20 Lachter (approximately 120-ft.) wire rope at "Dorothy" in the same time frame as he hoped for.

On July 22, 1834, one full page of his notes proclaimed a wire rope twice that long at the "Dorothy" shaft was a complete success!

In his public summary, as published by Dr. C. J. B. Karsten at Berlin, Albert reported as of April 1835 his wire ropes were already being used *"...in four of the principal shafts of the Upper Harz. In a few weeks they will be employed in two shafts more, and they will be gradually adopted, in a manner compatible with a due regard to the interest of those who have heretofore supplied the hempen ropes and iron chains. The adoption of the wire rope is a matter of essential importance for the mines of the Upper Harz, where more than 84,000 feet of rope (partly hemp and partly iron) are in constant work, and where every year upwards of 38,500 feet of new rope are required."*

By emphasizing the crucial need for the innovative product but at the same

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time recognizing the effect it would have on chain and hemp rope companies as part of that emphasis marks Wilhelm Albert's wire rope attainment as a nearly unique event in the history of technology. Any private individual who had invented something as significant as wire rope (e.g. Samuel F.B. Morse who was active with his telegraph) would have applied for patent protection immediately in hope of gaining market domination and attractive profits.

Albert went even further in his announcement of success. He proceeded to supply detailed instructions regarding the tools and techniques he had devised: *"The manufacture of them from iron wire is, in fact, a very simple and not an expensive operation, and yet there are a great many apparently insignificant circumstances which materially delay the work…I have, therefore, resolved to describe the process and its peculiarities, and hope thus to render some service to practical science…"*

It seems virtually inconceivable that Wilhelm Albert's great wire rope success in 1834 has been largely ignored on the internet. As wire rope professionals we need to do everything we can to make historians more aware of his work, and its global impact on our society. Hundreds of applications for his innovative product have been devised by other people and put into use all over the world on a daily basis. He has fully achieved his intent to *"render some service to practical science"*. One of his most fascinating ideas about how to double production speed still makes sense today – to hairpin wind strands and begin in the middle of the rope using two closers simultaneously – that would also double the maximum length produced!

A few contrasts and comparisons provide emphasis for a need to giver higher ranking of this attainment. The legal procedures pursued by the Wright brothers, for example, demonstrate how the Patent Office regulations of the United States actually delayed the advent of moveable control surfaces on fixed wing aircraft, one of the great steps forward in the technical history of transportation and warfare. At a history-teaching website, the advent of steam and electricity are cited by John Buescher as the two most important inventions of the 1800s, but wire rope, which extends the utility of both, is not included in his depiction. A 5-page article about the History of Technology published in the on-line Encyclopaedia Britannica does not include any mention of Herr Albert and his wire rope, and nothing about the subsequent UK and USA improvements and inventions which caused wire ropes to be adopted by other industries.

Roland Verreet giving a presentation of Albert's methods at the Clausthal Mining Museum.

CONCLUSION

The internet now provides the much-needed tool for establishing recognition of how rapidly wire rope applications were expanded from a simple fix for a single problem in a wet mineshaft, into hundreds of other uses, many of which did not exist until wire rope enabled a test of someone's bright idea for solving another problem. It is a product that is manufactured and used daily all over the world, yet it goes unnoticed in many cases simply because it is so ubiquitous.

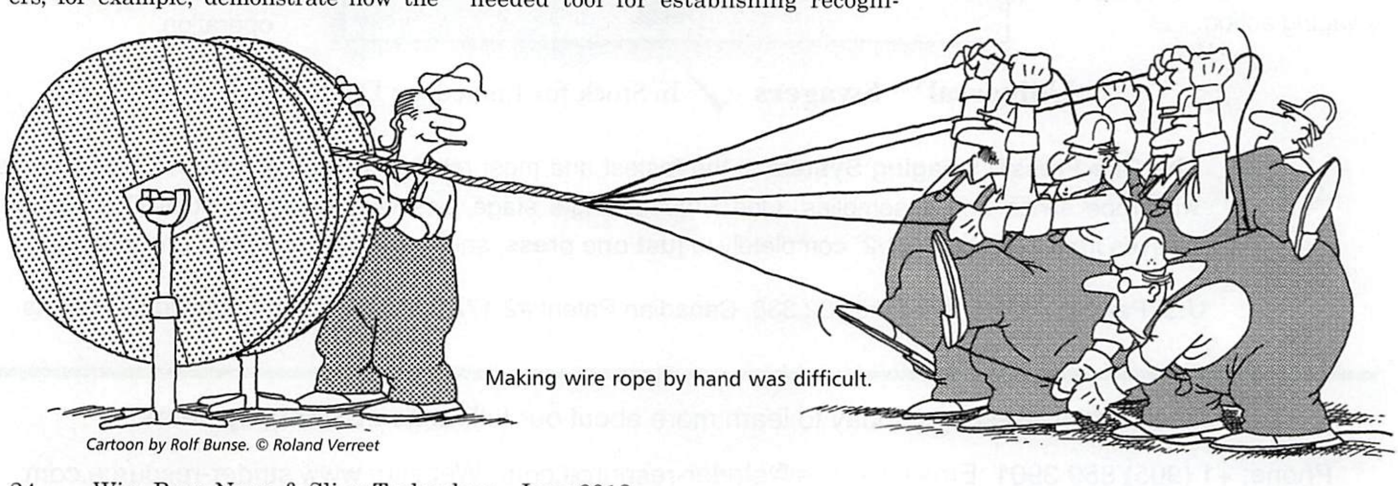
In Leadville, Colorado, USA there is an active organization called the National Mining Hall Of Fame. It was established in 1987 aiming to construct a museum building on the campus of the Colorado School of Mines. The initial plans for creating a hall proved to be too ambitious; a vacant high school school building in Leadville was chosen instead.

As of this summer, 240 men and women already are enshrined in the NMHF. This includes people like Simon Ingersoll (1818-1894) who was one of Albert's contemporaries. His only successful invention (the rock drill) was immediately patented by him. He next quickly sold it off to investors who were actually the ones that developed it.

The announced purpose of the NMHF is: *"To ignite a torch from the blazing chapters of mining and prospecting history, with which to illuminate the lives and heroic deeds of men and women who pioneered the development of this vastly rich empire, and thus encourage and inspire future generations of young Americans."*

The worldwide wire rope industry has been remiss in not nominating Wilhelm Albert for recognition by the NMHF and other organizations. We all ought to become more active, bringing attention to what he achieved and how he gave it freely to everyone.

Sources:
The primary details of this essay come from Wolfgang Lampe's lecture *"Alberts Aufzeichnungen in der heissen Phase seiner Erfindung"* (2009) and from the OIPEEC essay *"W. A. J Albert and his wire rope"* ODN834 by Jens Weis and Isabel Ridge (2009).
The illustrations are from Roland Verreet's collection.



Making wire rope by hand was difficult.

Cartoon by Rolf Bunse. © Roland Verreet