

# Alexis Køhl: A Danish Inventor of Cryptosystems

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**Abstract** A Danish engineer, Alexis Køhl (1846–1920), invented a number of cryptographic systems between 1876 and 1919. Some of these systems were simple, others were more complicated machine systems. Few of Køhls systems were ever used. One system was used to some extent in the Nordic countries, but generally Køhl felt that his “genius” was not properly recognized. There were no sensational cryptographic innovations in his systems, but some of them were quite smartly implemented. His first machine systems made use of some of the earliest mechanical typewriters. All his life Køhl claimed that his systems were unbreakable. He never made the fortune that he thought he deserved. This paper discusses Alexis Køhl’s life, his systems, and describes the known surviving devices. Additional information would be highly appreciated by the author.

**Keywords** Alexis Køhl (1846–1920), Danish inventor of cryptographic systems, crypto machines, manual cipher devices, Danish, Swedish, Norwegian and Finnish Ministry of Foreign Affairs, Great Northern Telegraph Company

## Introduction

Reinhold Alexis Køhl was born on 3 May 1846 in Copenhagen. He called himself a civil engineer, but no proof of his graduation from the Technical University has been found. He was an able technician, however and he made a number of inventions, many of them related to cryptography, one of his major interests throughout his life. This article describes his cryptographic inventions.

Alexis Køhl moved many times. In the early 1870’s he lived in Vienna, Austria, where he was in charge of a factory. From 1875 to 1888, he lived in Copenhagen, and during that period he produced a number of his inventions. In the non-cryptographic field, he invented a type of compound armor intended for use in naval vessels. He tried to make various countries interested, but without success. He later claimed that Great Britain had made use of his invention without giving him credit. During the same period, he constructed a steam streetcar locomotive that was tested in Copenhagen. In the years from 1888 Køhl also worked on an underwater signaling/security system for ships to prevent collisions between ships and facilitate navigation in fog. Køhl’s first cryptographic inventions were produced in 1876–1888. He lived in Paris for some time around 1888, but from 1890 onward he was back in Copenhagen where he founded a patent office which he owned until 1898, when he sold it. During the period 1902–1904 he lived in Berlin where he was busy writing a book about patent law. He spent the remainder of his life in Denmark. His second period of cryptographic inventions was from 1914 until his death in 1920. He spent his last years in the small Danish town of Sorø, more and more eager to get his

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cryptographic inventions accepted and sold. He had some success, but not enough to satisfy his own ambitions to be recognized as a genius in the field of cryptography. He died alone in the local hospital on 13 April 1920, leaving all his belongings to a foundation to fund the education of talented and poor boys at the local boarding school. The foundation still exists, but the vast sums Køhl thought he possessed, turned out to be rather modest.

Alexis Køhl probably never felt that his works were properly recognized. However, he received two high decorations from the Danish authorities and at least one Finnish decoration.

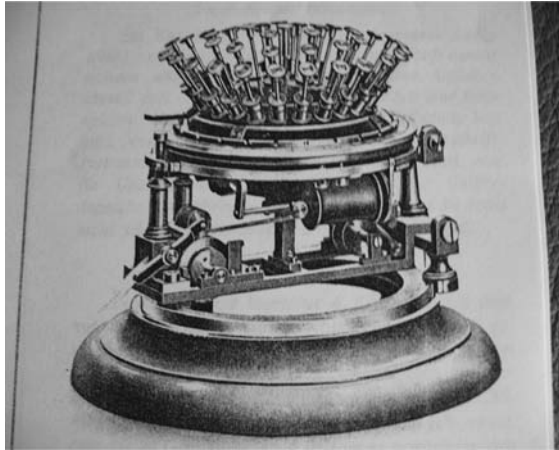
### **Alexis Køhl's Cryptographic Systems and Machines**

Thanks to Alexis Køhl's own publications, supplemented by studies in archives and museums in Denmark, Sweden, Finland, Norway, and France, it has been possible to follow many of his inventions rather closely, but new information may still be found. Fortunately a number of his products have survived and can be studied hands-on. His first devices were developed in 1876, two rather similar systems, one released in January and another in March. Throughout his life, it seems typical of Køhl to present one cryptographic system, and then release an updated version with "improvements." This likely did not encourage confidence with potential customers who had already read his bombastic statements about the unbreakable first version.

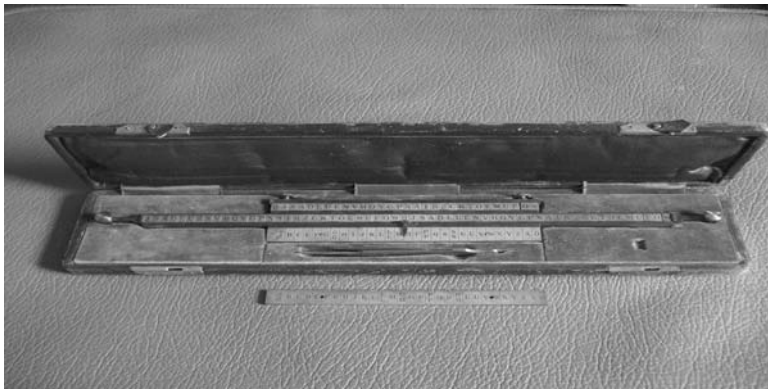
The two 1876 systems, presented in pamphlets, both replace each plain text letter with a two-digit group, perform a transposition according to a given key, and split the two-digit groups up before transmission. Køhl offered the systems to several governments, e.g., the Swedish, the German, and the Danish, but the systems were not accepted. According to the German Ministry of Foreign Affairs (MFA) Køhl's system was "absolutely secure, but too slow."

According to Køhl's own words, his reaction to these criticisms was to construct an "automatic cryptograph", which was apparently presented in 1883. It was a rather advanced device, based on what was probably the world's first mass-produced mechanical typewriter, the so-called "writing ball", constructed by the Danish inventor Rasmus Malling-Hansen. Køhl called this cryptograph "version I" (Figure 1). It was also produced in a "non-writing" pocket version (Figure 2), a slide with exchangeable metal letters.

The original instructions for use of the automatic cryptograph still exist. A "non-writing" pocket cryptograph is in Copenhagen, possibly a test specimen delivered to the Danish MFA; it still carries the secret alphabet mentioned in the instructions for use of the automatic cryptograph. The system was shown to the Danish, the German, and the Swedish MFA and to the Danish and the Norwegian General Staff. In 1883–84 the Swedish MFA ordered two automatic cryptographs and two "non-writing" cryptographs, but received only the latter. The automatic cryptographs were not delivered due to technical problems. No sales were apparently made, except to the Swedish MFA. The "Version I" automatic cryptograph probably does not exist today. A very similar cryptograph was presented by Alexis Køhl to the French government in 1888, and it can still be seen at the Technical Museum in Paris (*Conservatoire National des Arts et Métiers*) (Figure 3). It is not exactly identical with Version I, but it is based on the same "writing ball". It is a 24 letter-version, whereas "Version I" is a 30 letter-version. The cryptograph in Paris may be an early prototype, which could be "Version 0". Both cryptographs work on the same principle,



**Figure 1.** Automatic cryptograph (I) (1883).



**Figure 2.** “Non-writing” pocket cryptograph (I) (1883).



**Figure 3.** Automatic cryptograph (prototype, version 0?).

with a secret alphabet arranged by a keyword, and with encipherment with a partly autokeyed message key. The cryptograph in Paris might be one that should have been delivered to Sweden or used for demonstration there, since the secret alphabet on it is still arranged according to the Swedish keyword, mentioned by Køhl in a letter to the Swedish MFA.

In 1883, Køhl published a rather simple manual cipher system, similar to the ones from 1876, but without transposition. In 1888, Køhl presented a manual system to the Swedish MFA; it was based on transposition of the codegroups of a codebook, and it had certain similarities to the 1876 systems. Both systems were presented in pamphlets.

After this time a period followed with no known cryptographic activity from Køhl. In 1916 (with a supplement from 1917), he published a paper describing his technical inventions. In that paper he described his new cryptograph, “Version IV”. “Versions II and III” are not mentioned, but they must have existed, at least in a planning stage. In the Danish Technical Museum in Helsingør (Elsinore) is a fine and complete “Version IV” (Figure 4), called EPISTOLA; it probably was constructed around 1914–15. The instructions for use still exist. The cryptographic principle is more or less the same as for the old Version I from 1883, but it is technically quite different. EPISTOLA is designed both for encipherment of codes (digits) and written texts (letters). In the Danish Technical Museum there is also an unknown and incomplete cryptograph, based on a Hammond typewriter from the late 1880’s that might be a prototype of the missing “Version II (or III?)” (Figure 5), but that can only be speculated. In the 1917 supplement to Køhl’s publication, a cryptograph, “Version V”, is shown in a photo (Figure 6). No further information about this cryptograph is currently available. It may have been a typewriter that Køhl planned to modify, but never finished.

Køhl constructed a number of manual cipher devices during the period 1914–1919. So far we know of three different types of manual cipher devices from Køhl’s hand from that period:

- a) A cipher disk with ivory letters. See Figure 7.
- b) A cipher disk with ivory figures (no complete specimen is known to exist). See Figure 8.
- c) A cipher slide with ivory figures. See Figure 9.

The two latter types (with figures) are both designed to superencipher codegroups in the conventional 4- and 5-digit MFA codebooks of that era. We know from the archives that Køhl delivered type (b) to the Danish MFA in 1917, while type (c) was delivered to the Swedish, the Finnish, and the Norwegian MFA during 1918–20. Type (b) was replaced by type (c) in the Danish MFA in 1918, because the diplomats found type (b) too difficult to operate. Køhl insisted that he would not “sell” the systems to the Nordic MFA’s; he only asked for donations to his above mentioned foundation. He got money from Sweden, Norway, and Finland, but apparently not from the Danish MFA.

The purpose of type (a) is a little more uncertain. It may have been a pocket version of EPISTOLA (Version IV), which according to the documentation should include such a feature. It may also have been a separate cipher device for manual encipherment of texts, and it was used as such.

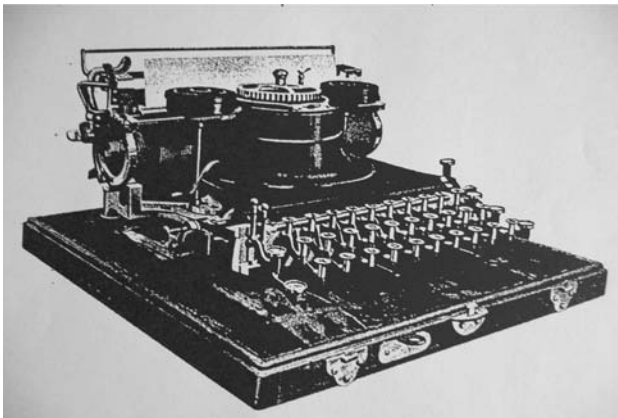
All three manual devices were produced at the workshops of the Great Northern Telegraph Company (GNT) in Copenhagen. They produced at least 13 of type (a),



**Figure 4.** Cryptograph "EPISTOLA" (version IV) (1914–15).



**Figure 5.** Unidentified prototype (II?).



**Figure 6.** Cryptograph version V (unfinished prototype 1917?).



**Figure 7.** Cipher disk with ivory letters.

at least 25 of type (b), and more than 100 of type (c). Many of these devices may still exist, but only 13 of type (a), 1 (incomplete) of type (b), and 5 of type (c) are known at present.

After Køhl's death, his executor tried to sell the devices that Køhl had left behind which, according to Køhl's will, were worth a fortune. It is likely that the crown jewel of the estate was supposed to be Version IV, the specimen today at the Technical Museum in Denmark. The money was to go to the foundation that would inherit all of Køhl's fortune, but the efforts of the executor were mostly in vain. He tried to sell the machine to the British Admiralty and to various Danish and foreign authorities, but was unsuccessful. GNT finally bought back some of the manual devices (type (a)) that they had produced themselves and delivered to



**Figure 8.** Cipher disk with ivory figures (no complete specimen known).



**Figure 9.** Cipher slide with ivory figures.

Køhl, Version IV and a number of other devices, including the possible Version II, were taken over by another Danish inventor of cipher systems, Mr. Beyer. He presented a new cipher system in 1933, partly inspired by Køhl's ideas. Beyer was even less successful than Køhl—with no sales at all as far as we can determine, in spite of fine press coverage and patents in many countries. Køhl's Version IV, Version II(?), along with two manual systems and one of Beyer's own devices were given to the Danish Technical Museum in 1968, where they are in storage for the time being.

### About the Author

Niels Faurholt, born 1934, is a major (retired) in the Danish Army Signal Corps, with a keen interest in old Danish cipher devices, both military and civilian.

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