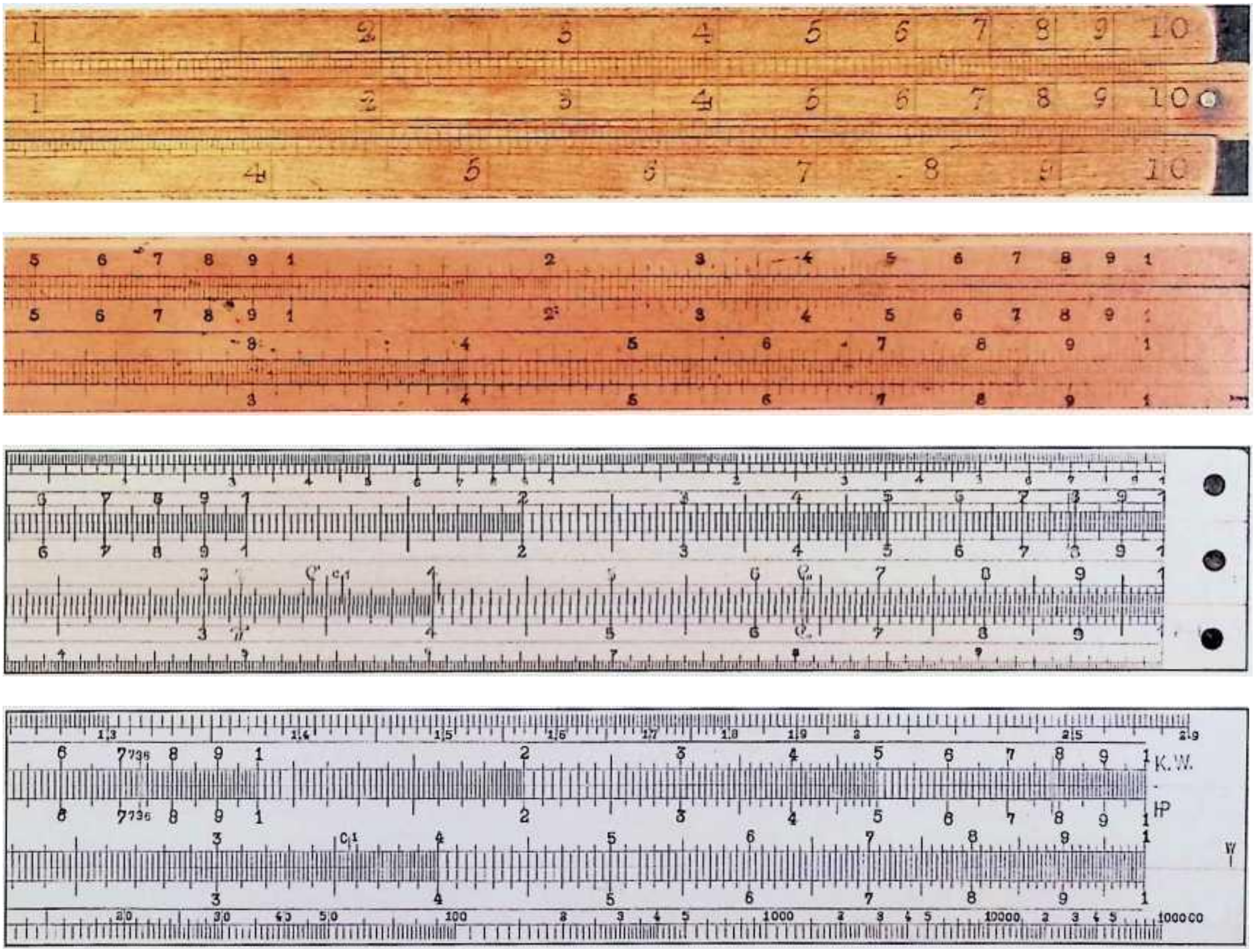
Slide Rules through Time

1787 1905



Guus Craenen

(translation into English by Jose G. Fernández)

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A book is never finished

Heinz Joss

(English translation NOTES:
- references to figure pages are kept to the original book pages, to facilitate finding the original figures there
- text in red correspond to author statements showing inconsistencies. See Annex in the end)

Imprint

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1. Introduction

1.1. Foreword

This book deals with the development history of slide rules with two main themes: the predecessors, variants and successors of the Mannheim system, and the development and cooperation of the companies Dennert & Pape in Hamburg and Albert Nestler in Lahr.

The company Dennert & Pape begins in 1873 with the production of slide rules; Nestler in 1880. Then their cooperation began; in 1905 both companies went their own way.

In 2001 my first book *Albert Nestler, Innovation und Qualität, Die Rechenstäbe von Nestler in ihrem internationalen Umfeld* was published (out of print); in 2004 my second book *Albert Nestler, Innovation und Qualität, Zusammenarbeit mit anderen Herstellern und mit Erfindern*, was published. (almost out of print). In the text of this book, reference is made to these books by means of the abbreviations AN01 and AN04.

Hans Dennert has written a book and three articles, from which I quote in the present text as follows:
Aristo 1862 - 1962: HD62;
100 Jahre Aristo Rechenstäbe 1972: HD72;
Dennert & Pape Aristo 1872 - 1978: HD78;
Zur Geschichte der Rechenschieber 1999: HD99.
The D&P price lists, PV, are given with years: PV98, PV02 and PV05 for the years 1898, 1902 and 1905. Hans Dennert is an authority on the company Dennert and Pape.
From 1995 to 2000 there was an exchange of letters between Hans Dennert and the author. I refer to this in this book.

For French industrial history, I refer to the book by Frank Marcelin: *Dictionnaire des fabricants français d'instruments de mesure du XVe au XIXe siècle,* 2004.

1895 was the beginning of the economic upswing and a turning point in the development and production of the slide rules.

The period from 1880 to 1905, during which Albert Nestler and Dennert & Pape achieved much in common, is referred in the text as the *Common Period.* The period up to 1895 is called the *Early Period;* the period from 1895 to 1905 is the *Late Period.* The combined identification will be used for generic information to the reader. But these periods will be named with one of the *later* words, when pointing differences.

For a better understanding of DRGM and DRP fonts, old words are explained with modern words in brackets. In order to present the scales of old slide rules more clearly, I have saturated the colours a little more.

The book is set up in such a way that it can also be used as a reference work. For this purpose, there are some registers in Chapter 6, *Annex*, and, also, most of the slide rule sections are set up as independent units of information. Before looking up the individual sections 3.1 - 3.9, you should first read section 3. Names of people who are printed in italics are listed and described in more detail in the section 6.2 *Important names*.

If you want to read the main conclusions quickly, we recommend Section *1.3 Summary.* Reference is also made there to other relevant information.

Finally, I would like to thank a whole series of fellow collectors and respondents for their help and suggestions. In the section 1.2 *Acknowledgements*, I have listed them by their names; I hope I have not forgotten anyone.

Above all, I would like to thank Peter Holland for his linguistic revision of the manuscript. This is how the book has become readable.

Soest / NL, Summer 2009 *Guus Craenen*

1.2. Acknowledgements

This book would never have been written without intensive contacts with fellow collectors and experts at home and abroad.

I would like to thank the following collector friends and experts:

- Evelyn Benke, German Patent and Trademark Office, Berlin, Germany, for information on utility models,
- Nanco Bordewijk, Amsterdam, The Netherlands, for information on English and French slide rules,
- Jim Cerny, Madbury, New Hampshire, The USA, for information about Keuffel & Esser,
- Irene Dennert, Hamburg, Germany, for information about Dennert & Pape,
- Harrie van Dooren, Deventer, The Netherlands, for information on slide rules by Tavernier-Lenoir and Barbotheu,
- Rainer Heer, engineer, Hannover, Germany, for information on art in the Zeitschrift für Vermessungswesen,
- Peter Holland, Brühl, Germany, for linguistic support,
- Dieter von Jezierski, Stein bei Nürnberg, Germany, for information on slide rules from Faber-Castell,
- Karl Kleine, professor, Jena, Germany, for information on patents, utility models and Dennert & Pape,
- Hans Kordetzky, engineer (FH), Cham, Switzerland, for information on the Perry system,
- Klaus Kühn, Dr., Alling-Biburg, Germany, for information on slide rules from Dennert & Pape and Peuckert,
- Günter Kugel, Dr. Eng. E.h., Moers, Germany, for information about Dennert & Pape and Nestler,
- Jörn Lütjens, Professor Dr., Ahrensburg, Germany, for information about Nestler,
- Jürgen Nestler, VDI engineer, Hausach, Germany, for information about the dividing machines of Nestler and about Massag,
- Lore Oetling, engineer, Hamburg, Germany, for information about Dennert & Pape,
- Robert K. Otnes, Palo Alto, California, The USA, for information about Lenoir and Gravet-Lenoir,
- Hartmut Petzold, Dr., Deutsches Museum, Munich, for information about Nestler,
- Otto van Poelje, Hilversum, The Netherlands, for information on Leon Walter Rosenthal's slide rule,
- David Rance, Sassenheim, the Netherlands, for information on the Frank and Perry systems,
- Ronald van Riet, Nieuwegein, The Netherlands, for information on slide rules from Gravet-Lenoir and Tavernier-Gravet,
- Werner Rudowski, Bochum, Germany, for information about Dennert & Pape, Faber and English slide rules,
- Hans-Peter Schaub, Allschwil, Switzerland, for information about Nestler,
- IJzebrand Schuitema, Odijk, The Netherlands, for information on French and German slide rules,
- Panagiotis Venetsianos, Brussels, Belgium, for information on French manufacturers and the Mannheim system,
- Jane Wess, Science Museum, London, for information on James Watt's Soho system.

1.3. Summary

This section contains conclusions from the research carried out by the author for this book. It is therefore a kind of summary of the book. To begin with, the order is based on the same classification as the rest of the book. Where appropriate, reference shall be made to the relevant chapters and sections.

1.3.1. The industrial revolution and industrialization

During the 2nd Industrial Revolution, manufacturers of slide rules supported their customers with special slide rules. In the first five years of the 20th century, Nestler launches seven special slide rules for new applications on the market; D&P surprised in 1914 with 28 completely new systems.

- See section:
  2.5 Consequences of industry and trade, p.18

1.3.2. Predecessors, variants and successors of the Mannheim system

In Predecessors, Variants and Successors of the Mannheim System there are some major changes on the fronts of the rules and many small changes on the back of the slides.

- The findings are based on a comparison of several systems.

When dating Sohos, the workshop address is a useful means.

- See Section:
  6.10 Register of Companies, p.97

Sohos do not have rear windows. On the backside of the slide, the body-slide edge is an imaginary hairline.

- See section:
  3.2 System Soho Lenoir, p.25

Very early Sohos are recognizable by the narrow slide of 8.5 mm.

- See section:
  3.1 System Soho by Watt, p.22

Standard slide rules, such as the Soho, Mannheim and Rietz systems, have all been developed approximately 50 years after the predecessor system

- See chapter:
  3 Predecessors, variants and successors, p.21

Sohos by Lenoir without saw cuts (see these in figure 3.3.3.L in page 28) are from the time before 1825 and made by hand.

- See section:
  3.2 System Soho by Lenoir, p.25

In 1825, Paul-Etienne Lenoir was the first to mechanize the synchronous division of several slide rules.

- See section:
  3.2 System Soho by Lenoir, p.25

Despite all the technological improvements, the movement of the slide in the German slide rules (from the *Late Period)* is not better than in the early French Sohos.

- This finding is based on a comparison of several systems.

The rule length of 26 cm is due to the fact that boxwood was only delivered in small, knot-free, pieces.

- See section:
  5.3 Materials, p.79

Slide rules, longer than 26 cm, are mostly made of Zapatero wood.

- See section:
  3.5 System Mannheim by Barbotheu, p.31

James Watt's Soho system also had a predecessor: System Coggeshall.

- See section:
  6.11 Carpenter's Rule, p.98

Scales on slide rules are designated in England from about 1690, with the letters A, B, C and D. It will take until 1905 for D&P to be the first to adopt these designations.

- See section/figure:
  4.3.6 Simplex pocket slide rule, p.62
  6.11.3 Details of the Coggeshall system, p.98

Kurt Woldemar Peuckert is the inventor of the Free-view cursor.

- See section:
  6.12 System Peuckert, p.99

1.3.3. Dennert & Pape and Nestler, capabilities and cooperation

The capabilities of Dennert & Pape and Albert Nestler were largely complementary until 1905.

- See chapter:
  4 Dennert & Pape and Albert Nestler, p.55

1895 was the beginning of the economic upswing and a turning point in the development and production of slide rules.

Slide rules from the *Early Period* (< 1895) can be dated most easily based on features, marks and lengths.

- See sections:
  3.6.2 Dating in the Early Period, p.35
  3.7.2 Dating in the Early Period, p.42

When dating slide rules from the *Late Period* (> 1895), utility models are better suited than patents because there are more related DRGMs than DRPs and protection of a DRGM is only for 3 or 6 years.

- See sections:
  3.6.3 Dating in the Late Period, p.38
  3.7.3 Dating in the Late Period, p.44
  3.8.2 Dating in the Late Period, p.49

All D&P slide rules and D&P blanks from the *Common Period* are recognizable by 2 special marks on the sine scale.

- See section:
  3.6.4 Special marks, p.38

Nestler slide rules from the *Late Period* (>1895) are recognizable by the angled rear window and a longitudinal line over the entire length of the slide; they are very rare.

- See section:
  3.7.3 Dating in the Late Period, p.44

The dating of Nestler slide rules created during the *Common Period* is difficult because the bodies can come from a different year than the scales.

- See section:
  4.5.1 Ahrend slide rules, p.65

In 1873, D&P offered a two-sided knife-edge cursor that could be used to reach the entire range of scales.

- See section:
  4.1.1 Precise cursors, p.55

D&P's progress is based on a patent, a utility model, practical experience with celluloid, and production in economic quantities.

- See Section:
  4.3 The Development of Slide rules by Dennert & Pape, p.60

In 1885, D&P received DRP 34 583 for rulers with celluloid veneer. However, this patent does not apply to slide rules.

- See section:
  4.3.1 DRP 34 583, p.60

D&P began manufacturing celluloid slide rules in 1888. The fact that Nestler purchased these slide rules in 1892 indicates that Nestler did not produce any such slide rule bodies during this period.

- See section:
  3.7 System Mannheim by Nestler, p.39

In 1895, Dennert & Pape received the DRGM 37 191 for slide rules with slotted bodies. D&P supplied these slide rules as early as 1890.

- See section:
  4.3.2 DRGM 37 191, p.60

During the *Common Period*, D&P and Nestler each focus on what they are very good at. For D&P, this is the production of blanks and cursors; for Nestler it is the dividing of scales. Almost all Nestler blanks are sourced by D&P.

- See sections:
  4.1 Dennert & Pape Capabilities, p.55
  4.2 Albert Nestler Capabilities, p.57

A survey of German slide rule collectors for Nestler slide rules from the period 1895 - 1905 has shown that almost all blanks were supplied by D&P.

In 1900 Schweth receives DRGM 148 526 for its exponential slide rule; In 1901, John Perry received the British patent 23 236 for his log-log slide rule. With his DRGM, Schweth prevented Nestler from offering a Perry system before 1906.

- This finding is based on a comparison of several systems.

Until 1905, D&P only produced slide rules with a celluloid plate, and from 1905 only with a metal plate. This delayed change of material is very likely due to DRGM 190 019 from Wilhelm Rees.

- See section:
  4.3.3 DRP 126 499, p.60

Theophil Beck and Albert Nestler founded a small factory for drawing articles in Schaffhausen and Lahr as early as 1876.

- See Section:
  3.7.1 Introduction, p.39

In 1878 Nestler began the automatic dividing of slide rules made of boxwood. In 1880, the manufacture of slide rules was also included in the production program. Nestler produced their own cursors from 1880, but later bought them from D&P and Faber.

- See article by Wilhelm Jordan, 1880, p.87
- See brochure from Albert Nestler, 1904, p.87

The *Maaßstabfabrik Beck und Nestler* was renamed *Albert Nestler* from 1895. Collectors will look in vain for slide rules with the name *Albert Nestler* from the period 1880 - 1895.

- See section:
  4.2 Albert Nestler Capabilities, p.57

In 1952, Nestler bought the Maßstabfabrik Schaffhausen AG, or Massag. Nestler supplied Massag with two dividing machines. This means that blanks were divided and provided with the text *Swiss made.* Thus, the mystery of the *Swiss mades* is solved.

- See section:
  4.2.3. Swiss mades, p.58

All slide rules with the sign have the scales created by Nestler, but not necessarily the bodies.

- This finding is based on a comparison of several systems.

In 1905 Nestler was the first with a scale for small angles on the back of the slide and the intervals of the tangent scale are also extended. Thus, the Rietz system is best suited for accurate trigonometric calculations.

- See section:
  3.9 System Rietz by Nestler, p.50/51

In 1905 Nestler came up with a spectacular innovation in slide rule construction: DRP 173 660, for a flexible rubber plate. Between 1901 and 1905, industrial income tripled. This enables Nestler to finance its own production. Dennert & Pape also obtains DRP 126 499, flexible celluloid plate. This marks the end of the *Common Period*.

- See section:
  4.4.6 In-house production, p.64

1.3.4. Slide rule manufacture and materials, quality and durability

With only one index window, the slide may have to be mostly extracted to access a value in the sinus and tangent scales; with two windows, reading is possible without extracting the slide. By 1890, D&P had one window per slide rule; from 1890, there were two windows.

- See Snippets (Index Window), p.36

Nestler combined different types of wood within a slide rule to achieve an optimal product.

- See section:
  5.4 Lamination, p.80

The desired functionality of slits in the well can be regulated by their number, dimensions, position and pattern.

- See section:
  6.7 Slotted wells, p.94

Chapter 2

The Industrial Revolution and the Industrialization

The profit of the slide rule is far greater than
all my other inventions taken together

Frederick Winslow Taylor (1856 - 1915)

2. The Industrial Revolution and the Industrialization

This chapter contains the following sections:

In order to understand the connections during the *Common Period*, it is useful to look at the developments from the middle of the 18th century onwards. Central to this period is the Industrial Revolution: the founding and development of industries in an original agrarian society. It is the pursuit of rationality and technical renewal.

The process takes place in three time phases. For the *Common Period*, the two most important are:

- 1st Industrial Revolution, 1750 - 1850,

- 2nd Industrial Revolution, 1870 - 1914.

Certain developments, such as the transport revolution, and the comparisons with the development in Lahr, relate to several of these time phases. In order not to lose the context, this is described in a separate section.

2.1. The 1st Industrial Revolution

The 1st Industrial Revolution (1750 - 1850) begins in England in the textile industry with the use of the steam engine. That has a major influence on the textile, mechanical engineering and iron industries, but also on the railways.

During these years, the economy in Germany is growing at an average of 10% per year. Worldwide, the growth rates in this period are a 400% in iron production, a 450% in steam engines, and a 380% in European railways. The causes of this flowering are the availability of capital, the liberalization of society and the abolition of trade barriers. But it is above all the breakthrough of the railway, which from 1840 takes the leading role from the textile industry as the engine of industrialization, and extends beyond the 1st Industrial Revolution.

Around 1800, travelling and transporting was hardly faster than in Roman times. This also applies to information flows. Between 1850 and 1870, the European railway network grew by 364%. The first railway built in Germany runs from Nuremberg to Fürth (6,1 km) in 1835. The first important line goes from Leipzig to Dresden in 1836. Figure 2.1 shows the Bonn-Cologne railway in Brühl, in 1844. The rail network continued to expand, to 6.000 km by 1850 and to 60.000 km by 1910.

Figure 2.1: Bonn-Cologne railway in Brühl

The railway contributed to the emergence of the German Confederation, first a customs union, later the German Reich. Trade and travel will certainly be facilitated.

The transport revolution is also having an impact on sea transport. Steamships replace sailing ships. Intercontinental trade is strongly demanded. World trade grows by 900% during this period. For the first time, a basis is laid for the worldwide sale of European products.

In the middle of the 19th century, the first industrial wave subsided to some extent. New industries are needed to get the engine of industrialization back in track.

2.2. The 2nd Industrial Revolution

The 2nd Industrial Revolution (1870 - 1914) led to many innovations. From the end of the 19th century, industry was decisively influenced by science. Until then, innovations usually came about on the basis of practical experience, often also by very committed laypeople, such as the pastor Cartwright, who invented the machine loom in 1785.

Science and industry enter a symbiotic relationship in this new period. The enormous expansion of scientific knowledge is constantly opening new areas of application. This applies in particular to electricity as an easy-to-transport form of energy with a wide range of applications. Electricity is also at the base of mass industry, first with the light bulb and the telephone, later with the radio and the gramophone, which is well connected to mass communication. But electric motors are also beginning their advance and the use of reinforced concrete is gaining more and more ground. In 1893, the first electric motor was installed at D&P.

Growing market activity also leads to more consumption and more competition. This development stimulates technical, cost-effective innovations. The most important measure to reduce costs is scientific management. The American iron manufacturer Frederick Winslow Taylor (1856-1915) is its founder. Taylor strives to streamline Operations. The old master of factory optimization says about slide rules:

> The profit of the slide rule is far greater than all my inventions taken together.

Figure 2.2: Frederick Winslow Taylor

The 2nd Industrial Revolution makes operations more professional and efficient. Large companies also attract scientists who are able to develop new products on the basis of state-of-the-art technologies. The result is an extraordinary increase in inventions. The innovations of the steel and electricity industries are leading to a new phase in industrialization, with new opportunities for expansion. The years from 1896 to 1914 are marked by feverish economic activity. The transport revolution and "mobile" electrical energy have also made people more mobile.

2.3. Industrialization

Industrialization is the introduction and dissemination of industrial forms of production and distribution of goods and services. The phase of the actual breakthrough of industrial development is called the Industrial Revolution. The term came up in France during the French Revolution (1789 - 1799).

Industrialization begins in England, then reaches France and manifests itself in Hamburg and Lahr, among other places.

In the following sections, reference is made to the production of slide rules whenever possible and relevant.

2.3.1. Industrialization in Birmingham

Since the middle of the 18th century, the number of new inventions has increased, especially in the new use of artificial energy and in the textile industry. The number of patents grows from 100 in 1750 to 6100 in 1850.

At the time of the Industrial Revolution, Birmingham, the second largest city in England, and the surrounding areas flourished. The city is the centre of British mechanical engineering, with James Watt as the most famous inhabitant.

The success of the steam engine, developed by James Watt in 1764 as a single-cycle machine, and in 1782 as a double-cycle one, is convincing. The world will honour the inventor by associating his name with the unit of power.

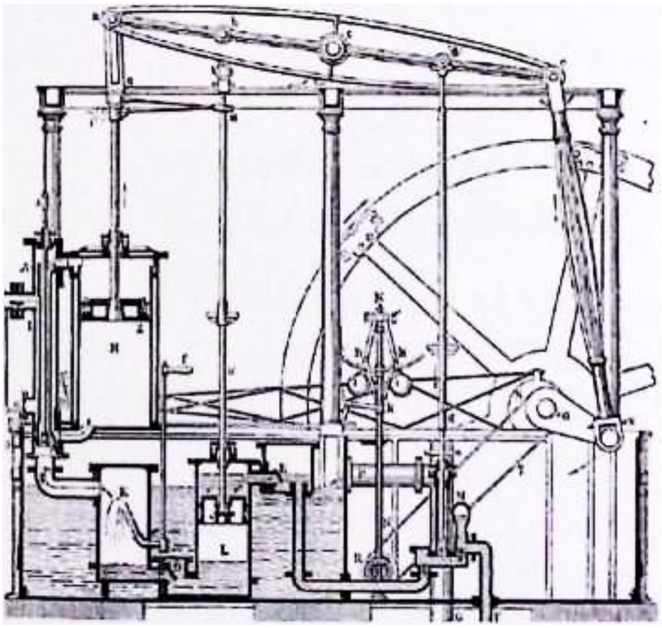


Figure 2.3.1: Steam engine by James Watt

Watt is the inventor of the Soho slide rule. In the period 1779 - 1796 he developed the simple, universally applicable slide rule (see Figure 3.1.3, p.23). It is initially manufactured in Soho, near Birmingham, and from 1804 onwards it is manufactured and offered by William Jones in London.

2.3.2. Industrialization in Paris

At the beginning of the 18th century, Paris was a spiritual centre of scientists such as Ampere, Fourier and Laplace. This gives new impetus to the development of slide rules. Napoleon introduced the metric measurement system and advanced the mapping of Europe. Slide rules are particularly suitable for converting old to new dimensions, for which demand is now increasing.

Etienne Lenoir built the first official metre standard in 1793, which is still kept in the French National Archives today. The mathematician Jerome Lalande wrote in 1801:

> Lenoir has shown that French industry is no longer inferior to English industry.

Lenoir's son Paul-Etienne built his 8-arm dividing machine in 1823, with which very accurate Soho slide rules could be mass-produced. A prime example of industrialization in France (see Section 3.2).

Amédée Mannheim invents a new scale arrangement in 1850 and Tavernier offers the system named after Mannheim. It becomes a breakthrough product.

The 300m high Eiffel Tower is the landmark of Paris and stands worldwide as a symbol of France. The tower was built between 1878 and 1889 by Eiffel's company, *Gustave Eiffel & Cie*, for the World Exhibition on the centenary of the French Revolution. The tower was finished in just two years with 2.5 million rivets connecting 18.000 iron parts. The tower shows the unity between form and function (see figure).

Figure 2.3.2: The Eiffel Tower under construction, 1888

2.3.3. Industrialization in Hamburg

In 1871, Hamburg became a federal state of the German Empire. The city is characterized by great technical progress. The end of the North American Civil War in 1865 brought Hamburg, as a port city, a tremendous economic boom. The city grew in the period 1875 - 1910 from 165.000 to 931.000 inhabitants.

Hans Dennert writes in HD62:

> Railway, road and port constructions increase the need for geodetic instruments. Supply lines and sewerage in the cities are added; In Hamburg, for example, it was not until 1842 that a water supply was built and in 1850 a sewage system was built. With the development of technology in the first half of the 19th century, the slide rule had become an indispensable tool.

In 1873, Dennert & Pape became the first German company to start manufacturing slide rules based on the French model.

The first workshop of Johann Christian Dennert is at Pastorenstraße 5, near the main church of St. Michaelis.

Figure 2.3.3: Surroundings of Hamburg's landmark, the Great Michel

2.3.4. Industrialization in Lahr

In Lahr, industrialization begins early. The first factories owe their foundation to the private initiative of individual Lahr personalities.

In 1774 the merchant Lotzbeck started a tobacco factory, and in 1809 there were already 80 workers working there, which is a lot for that time. In the 19th century, industry and trade flourished: in 1815 there were three factories and 47 trading houses; in 1880 these figures rose to 42 and 113 respectively.

In 1816, the bookbinder Carl Friedrich Dreyspring founded the first German cardboard factory in Lahr. After only ten years, 40 workers are working there. The factory is located at Heiligenstrasse 33. This is also where the production of cases of all kinds - such as those for slide rules - takes place.

These years of the *Common Period* are also an eventful time for the city of Lahr. Mayor Alex Lausch writes in 1991:

> The years 1880 - 1912 were a period of economic prosperity in industry, trade and the expansion of the infrastructure, which in their dynamism also demanded many construction tasks.

In 1878, Theophil Beck and Albert Nestler founded the Maßstabfabrik Beck und Nestler.

In 1880, the manufacture of slide rules was also included in the production program (see section 4.2, p.57).

Figure 2.3.4: Old Nestler factories in Lahr, Black Forest. In the middle stands the founder's villa

2.3.5. Industrialization in Stein

Faber is a pencil factory built in 1761 in Stein near Nuremberg by Kaspar Faber. Lothar Faber decided to diversify their products and founded a slate factory in Geroldsgrün in Upper Franconia in 1861, which also produces wooden rulers. This production experience came in handy when the production of slide rules began in 1892 (see section 3.8, p.46).

Faber is thus the third factory for slide rules in Germany. This encourages them to come out with innovations to differentiate themselves from D&P and Nestler.

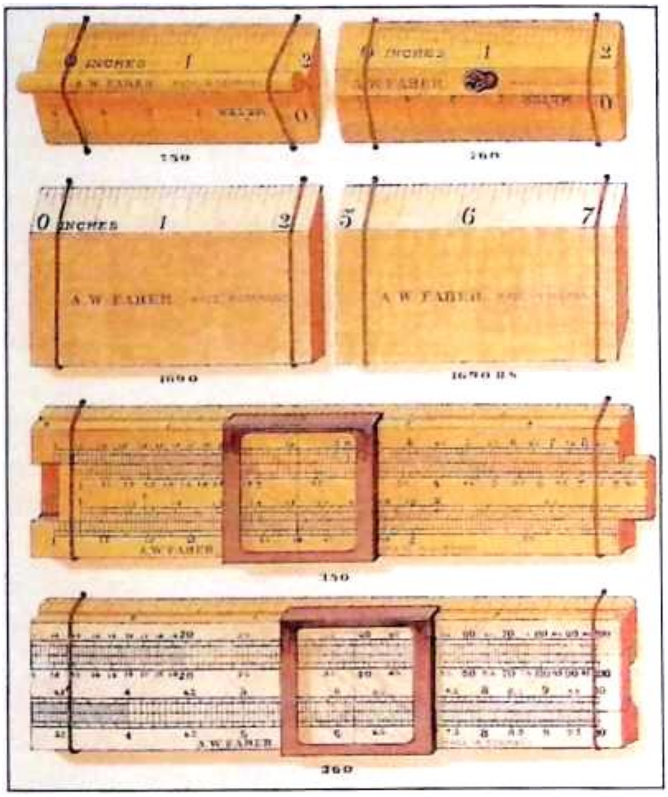


Figure 2.3.5: Wooden rulers and slide rules by Faber

Michael Lösel writes the following about industrialization in Nuremberg in an article about the Nuremberg city scape:

> With the advent of steam power in the factories, the first significant industrialization push began. Parallel to the industrial development, the number of immigrants also rose sharply, and Nuremberg's population doubled from 1834 (44.456) within 40 years.

Faber had produced pencils in large quantities and thus gained experience with mass production. No wonder that Faber came up with a revolutionary idea for the mass production of slide rules in the 1920s: a dividing tool with which all the scales of a slide rule could be cut in one operation.

2.4. Patent Office and Patents

The German Patent Office was founded in 1877 and thus enabled uniform protection of inventions. Karl Kleine writes (see p.96):

> Patents and utility models are so called territorial rights whose history dates back to the Middle Ages. A state [...] grants an applicant of an invention or a special product a temporary monopoly for the manufacture and sale of a certain object in its territory, in return for disclosure and the payment of fees. The motivation for this is to promote innovation by granting this privilege.

Patent specifications are very informative for collectors of slide rules. They help to deepen product knowledge and to compare slide rules in technical terms.

The maximum term for patents is 18 years; the one for utility models (issued from 1891) is 6 years.

In 1878, 2000 patents were filed. Until 1898, registrations increased steadily. The following diagram illustrates the developments and events during the turn of the century (Fig. 2.4). It shows the yearly number of patent applications during the period 1898 - 1902.

Year	**Number**
1898	5300
1899	6700
1900	9000
1901	10200
1902	11150

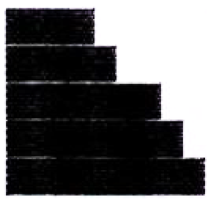


Figure 2.4: 1898 to 1902 number of patent applications

From the figure it can be seen that the years 1898 - 1902 are a time of economic prosperity The first patent that will be decisive for the production of slide rules in Germany, by Dennert & Pape, comes in 1885. It is DRP 34 583 and refers to celluloid covering on rules. Later, celluloid is also used for slide rules.

So much for the industrial revolution. Now into the development, manufacture and sale of slide rules in the German period (1872 - 1972, see AN01, page 10) and into the question of how slide rules can be produced more rationally and how this development is effectively supported by trade and industry.

2.5. The Consequences for Industry and Trade

During the 1st Industrial Revolution, a considerable improvement in transport facilities created a basis for world trade. The 2nd revolution is characterized above all by the symbiosis of science and industry, with the result of a flood of innovations. The focus is on the electricity industry, mass communication and the new possibilities of reinforced concrete construction.

Growing competition is forcing rational production, i.e., more efficient use of materials, machines and labour. Designing and calculating play an increasingly dominant role. Optimal decision-making requires insight into possible alternatives and a lot has to be calculated for this.

Mobility and miniaturization have a strong interaction with each other. What should be mobile must be light and small, but still sufficiently robust. This requires optimal design and critical calculation of the load limits of constructions in order to be able to constantly push the limits of what is possible.

Manufacturers of slide rules continue to develop new products to support innovations at their customers. In the first twelve years of the 20th century, Nestler launches on the market twelve new slide rules for new applications; D&P surprised in 1914 with 28 completely new systems.

Chapter 3

Predecessors, Variants and Successors of the Mannheim System

Knowledge of the development history from
the Watt system to the electrical system led
to a better understanding of the further
evolution of the slide rules

3. Predecessors, Variants and Successors of the Mannheim System

This chapter contains the following sections:

Before the beginning of the 1st Industrial Revolution, around 1740, special slide rules were mainly produced in England. Since these slide rules are designed with special scales and have special marks, they are not of interest to technicians (see Figure 3.1.5). In addition, they are still divided by hand and are therefore inaccurate and expensive.

In England, James Watt invented the Soho system and produced it by hand. Later, Sohos are manufactured in France with an 8-arm divider. The accuracy of the divisions is thus much better (see Figures 3.1.3, p.23 and 3.2.3, p.26).

The Mannheim system was invented in Paris in 1850, and it would be decisive for the coming 50 years.

In 1902, Max Rietz received a DRGM for his cube slide rule, which would be decisive for the next 40 years.

This chapter describes the development history of the Mannheim system. The systems can be divided into:

- Predecessors: System Soho by Watt from England and similar from France,
- Variants: System Mannheim from France and Germany (D&P and Nestler),
- Successors: System Electro (D&P and Faber) and System Rietz (Nestler).

The English and French slide rules are described in sections 3.1 to 3.5. The German slide rules from the period 1874 - 1905 are discussed in sections 3.6 to 3.9.

All systems have four scales as standard, which are designated from top to bottom with the letters A, B, C, and D.

For the Soho systems, the scales A, B and C are the same, namely square (x^2); D is a simple logarithmic scale (x). The slide rule length is almost always only 26 cm. A Soho has no cursor.

In the Mannheim systems, the scales A and B are the same, namely square (x^2); C and D are simple logarithmic scales (x). The length is 26 cm for the earlier slide rules, and 27 or 28 cm for the later ones, so that the hairline of the cursor can reach the whole scale length, of 25 cm. This also applies to the Rietz system. Both systems have a cursor.

For all slide rule systems, the use of trigonometric scales is different. This is due to the scale to be used to read the values, and to other constructive differences. Therefore, the use is described below. The first inscribed line of a scale is referred to as the initial line; the last inscribed line is called the final line. In Sohos, the sine value and the tangent value, are read on the B scale below the final line of the A scale.

Sohos do not have rear hairline windows. On the back, the body-slide edge is an imaginary hairline (see Figure 3.2.7, p.26).

If certain terms are not clearly visible in an image, these indications are printed in italics in the caption.

3.1. The Soho System from Watt, 1787 - 1804

The Scottish engineer James Watt was born in Greenock in 1736 and died in Heathfield, in Handsworth, in 1819. Watt, inventor of the steam engine (see section 2.3.1, p.15), developed a simple, universally applicable, slide rule in the period from 1779 to 1796.

Paul Zoller (p.87) writes:

> It is probably safe to put the development of the simple Soho slide rule between 1779, when Watt

> was clearly not terribly knowledgeable about slide rules, and 1796, when John Southern, by then an important assistant to Watt, was corresponding with William Jones, a London instrument maker, about the design and manufacture of a particular simple type.

The year 1787 is the middle of the period.

Figure 3.1.1: James Watt

Watt probably had his first slide rules made by Edward Nairne (1726 - 1806), royal court mechanic. Watt was working at the Soho Foundry in Birmingham at the time. Hence the name Soho slide rule. The later Sohos are handmade by William Jones (1763 - 1831), which is expensive and time-consuming. Jones is the successor of the famous instrument maker George Adams Jr. (1750 - 1795). William is an optician and in 1794 founded a workshop with his younger brother Samuel, which was given the name W&S JONES. The catalogue of 1804 states:

> A new pocket 10-inch box sliding rule for solving all sorts of problems in trigonometry, mensuration [calculation of surfaces and contents], etc. for 4 Shillings.

When dating, the address, which is often on the slide rule, can be a good means. W&S Jones slide rules in London are manufactured at the following addresses: 135 Holborn (1792 to 1800) and 30 Holborn (1800 to 1860). Sohos made by W&S Jones are extremely rare.

The slide rule shown in Fig. 3.1.3 comes from the Science Museum in London and was used in *Boulton and Watt* at the beginning of the 19th century.

On the back of the slide rule it is written:

- W&S JONES, NO.30 HOLBORN, LONDON

This has been the workshop address since 1800.

The dimensions are 10¼ x $^7/_8$ x $^3/_{16}$ inches, or 260 x 22 x 5 mm. The slide has a width of 8.5 mm. The older the Soho, the narrower the body and the slide.

The scales are almost always indicated by the letters A, B, C, and D. This was first taken over by D&P on the mainland in 1903 (see Simplex system, Fig. 4.3.6.1, p.62).

In the body well there are measurement scales in inches and in mm. To make it easier to move the slide, two operating knobs are often provided. Probably the slides did not run so smoothly at that time.

Rolf Jäger writes in HD62 about James Watt's Soho system:

> However, C is a square scale, because at that time the scales A and B were mainly used to avoid pushing the slide out. The C scale, on the other hand, in conjunction with D, was only needed to calculate squares and square roots. If we consider that the slide rule lacked a cursor, it becomes understandable that a square scale and a basic scale must slide against each other for this purpose.

However, the Soho system also has a precursor: the Coggeshall system (see section 6.11, p.98). The system was already on the market in 1682. Figure 3.1.2 shows a section of a late version. The D-scale is a special scale.

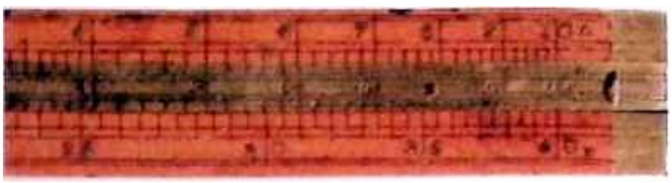


Figure 3.1.2: Section of the Coggeshall system

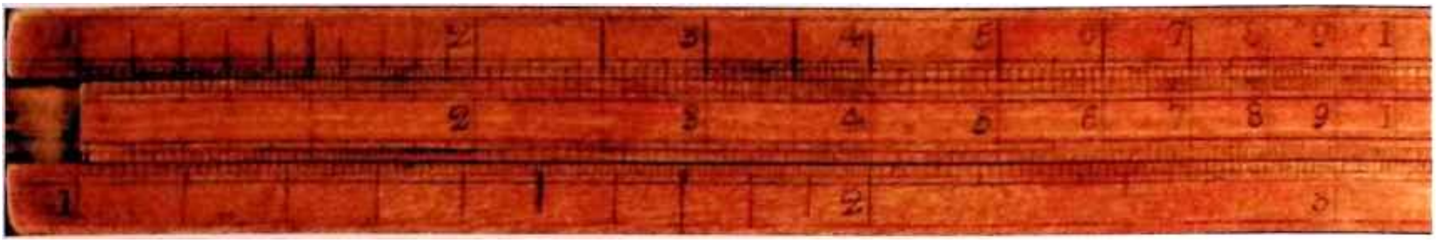


Figure 3.1.3.L: Left part of the front of the Soho system by Watt, manufactured by Jones. Science Museum, London

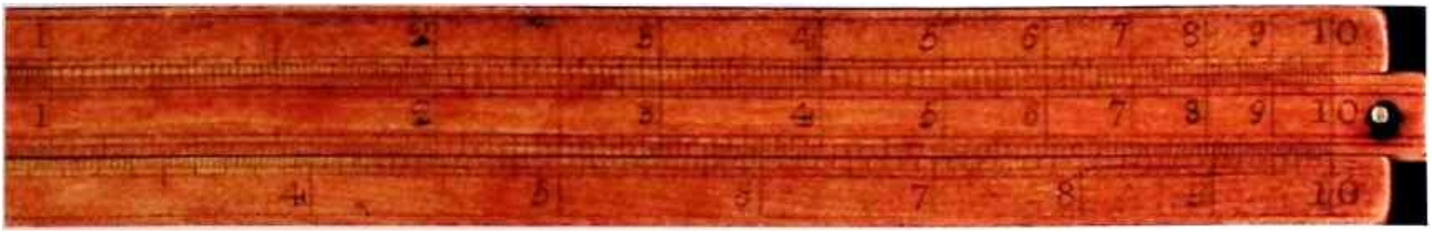


Figure 3.1.3.R: Right part of the front of the Soho system by Watt, manufactured by Jones. Science Museum, London

On the back of the slide there are a sinus, a tangent and an L scale, also called mantissa scale. The sine and tangent scales are related to the square scales. The sine value and the tangent value are read on the B scale below the final line of the A scale. The trigonometric ranges are:

- Sine 35' - 90°
- Tangents 35' - 45°

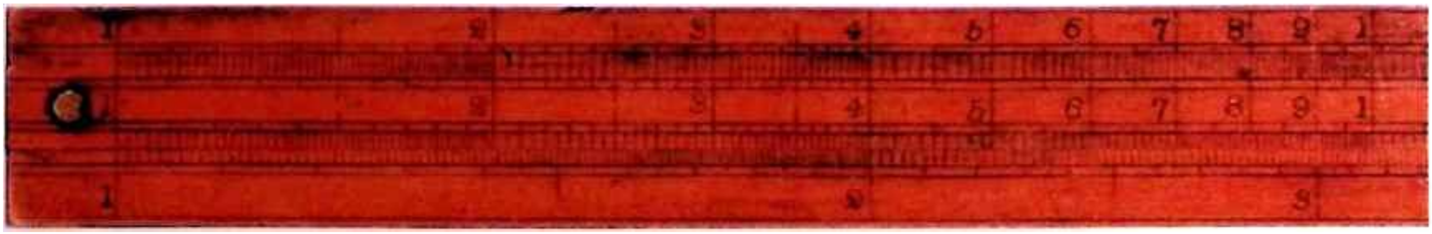



Figure 3.1.4.L: Left part of the front of the Soho system from Underhill, Manchester. IJzebrand Schuitema collection

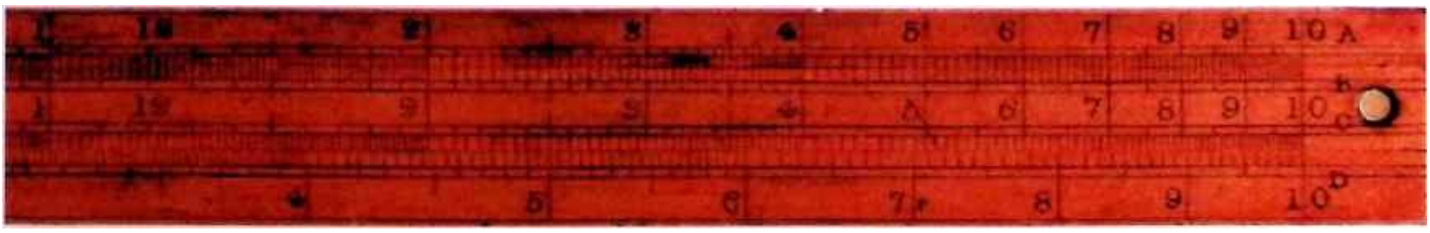


Figure 3.1.4.R: Right part of the front of the Soho system from Underhill, Manchester. IJzebrand Schuitema collection

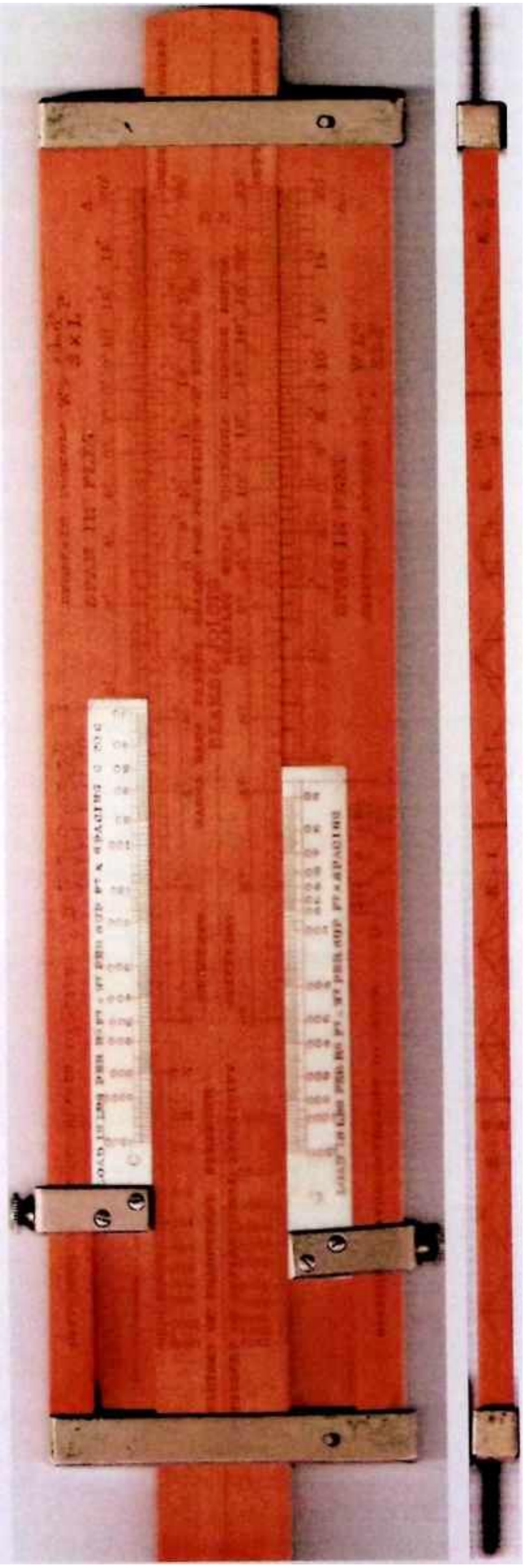
The Soho of Underhill (c. 1814) has some special features (see Figure 3.1.4):

- There are no measurement scales in the well,
- The slide has two operating buttons,
- The slide has the same cross-section as shown in Figure 3.2.2 (p.25),
- The name and place of residence of the manufacturer are on the narrow side.

3.1.1. Special slide rules

Special slide rules are developed for specific areas of application. Figure 3.1.5 shows a slide rule for the calculation of wooden roof structures. The slide rule was developed in 1884 by *Lala Ganga Ram* (1851 - 1927), an Indian civil engineer from Punjab.

In 1885 he received the British patent 2149. The calculator is manufactured by *W.F. Stanley* in London. Another manufacturer is J. Tree & Co. in London. The quality of this slide rule is outstanding.



The front has 10 scales; the reverse (not shown) has 6 scales and a table. Despite the many scales and supporting texts, the staff is very clearly designed.

The front shows formulas for strength (W) and deflection (δ):

$$W = \frac{2 * b * d^2}{S * L} P$$

$$\delta = \frac{5}{8} \frac{W * L^3}{E * b * d^3}$$

The upper half of the slide rule is used to calculate the thickness, and the lower half the deflection.

On the narrow side (see Figure 3.1.5b) 8 roof structures are shown with corresponding K-factors. They are referred to on the back of the body.

The slide has a symmetrical scale image. This eliminates the need for a cursor.

This special slide rule does not have any pairs of scales sliding together of the same subdivision as the A and B scales in the Soho system and is therefore not generally applicable. For a universal application, the slide rule also has too many superfluous elements.

Figure 3.1.5: Special calculating slide rule for roof structures

3.2. The Soho System of Lenoir, 1815 - 1846

Etienne Lenoir was born in Mer near Orleans in 1744 and died in Paris in 1832. According to Antony Turner, Lenoir comes from a humble background and has not received any schooling. In 1793, the famous French instrument maker built the first official metre standard, which is still kept in the French National Archives today.

His son Paul-Etienne was born in 1776. He participates in Napoleon's expedition to Egypt and is elected a member of the Cairo Institute.

In 1825 he invented the 8-arm dividing machine, with which very accurate Soho slide rules can be produced in the factory. It is his last major innovation. According to *Maurice Daumas*, Lenoir says of his dividing machine:

> By building this model, I did not try to imitate the English machine. On the contrary I allow myself to say that my method is entirely French.

In 1817 he took over his father's business. From 1819 Paul-Etienne was completely responsible for the slide rules. In 1823 Paul-Etienne writes in a pamphlet accompanying an exhibition (according to *Anthony Turner*, p.87):

> I have completed the development of my new dividing machines. This means that more than 4000 precise divisions can be made, with which accurate calculations can be made. Women carried out this division work.

When Paul-Etienne died in 1827, his father continued to run the business until his death in 1832. Then Mabire, who has been with Lenoir since 1830, joins. Both are royal court mechanics. Mabire runs the business until 1846. He calls himself *sole successor* of Lenoir.

Sohos of Lenoir are made in 1817 at *Rue Louis le Grand 21*, from 1817 to 1827 at *Rue Saint Honore 340*, and from 1828 at *Rue Cassette 14*, 400 m east of the *Palais du Luxembourg*. An address is rarely given on the slide rules. In Sohos of Lenoir, the name Lenoir is deeply engraved and thus, even in the very old ones, easy to read. The Lenoir specimens do not have saw cuts (like in bottom left of Fig. 3.3.3.L, p.28,) for adjusting the body on the dividing machine, because in the beginning - before 1823 - slide rules are still custom-made. Figure 3.2.3 shows a section of a 35 cm long Soho system made of ivory with two measurement scales, in centimetres and in inches in the well.

The advantage of ivory, a better readability of the scales, is immediately apparent. The material is more pleasing to the eye and largely independent of the temperature. Ivory slide rules are six times more expensive than the corresponding boxwood ones. Other materials are also used. *Cajori* writes:

> In 1821 Lenoir made his first slide rule from brass of 35 cm.

Figures 3.2.5 and 3.2.6 show a Soho system. In the well there is a measurement scale. Thus, the slide rule can be used to measure lengths (from 26 to 52 cm). The slide has an asymmetrical cross-section and is therefore not reversible (see figure).

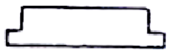


Figure 3.2.2: Cross-section of the slide of the Soho system

On the back of the slide there is a sinus, a tangent and an L scale, also called mantissa scale. The sine and tangent scales are related to the square scales. The sine value and the tangent value are read on the B scale below the final line of the A scale.

The trigonometric ranges are:

- Sine 35' - 90°
- Tangent 35' - 45°

The L scale is linear. This allows to determine the logarithmic value for each number between 0 and 1000. Also, with the L scale, by means of dividers, you can add and subtract, which was very useful at that time.

Sohos do not have rear hairline windows. On the back of the slide rule, the body-slide edge is an imaginary hairline (see Figure 3.2.7).

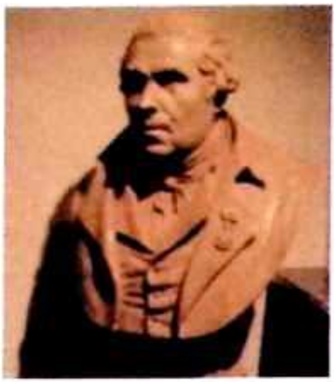


Figure 3.2.1: Etienne Lenoir

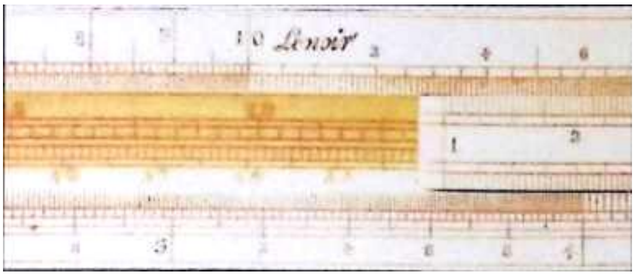


Figure 3.2.3: Section of Lenoir's Soho system

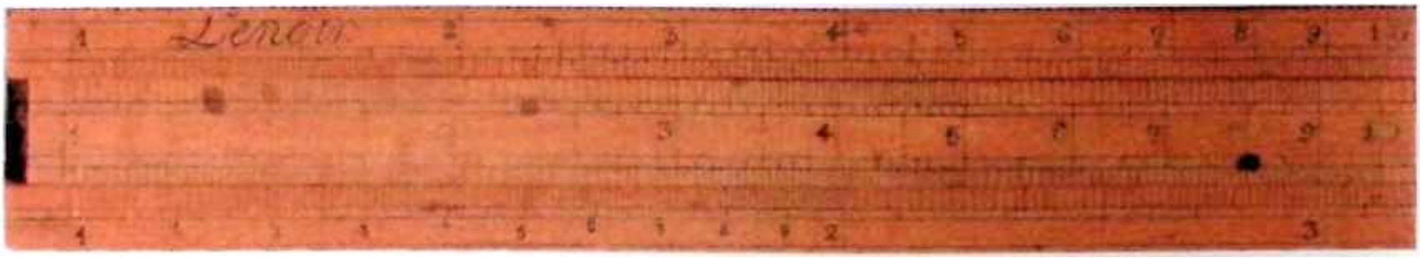


Figure 3.2.5.L: Left part of the Soho system from Lenoir. Robert K. Otnes collection

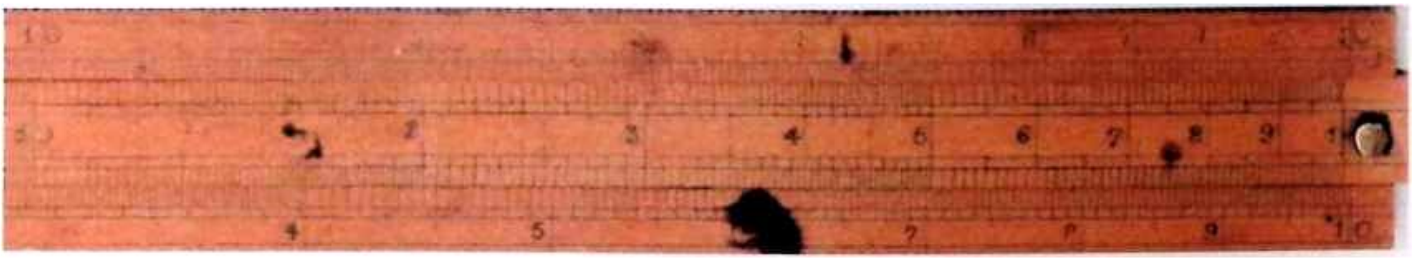


Figure 3.2.5.R: Right part of the Soho system by Lenoir. Robert K. Otnes collection

Figure 3.2.6.L: Left part of the back of the slide of the Soho system by Lenoir. Robert K. Otnes collection

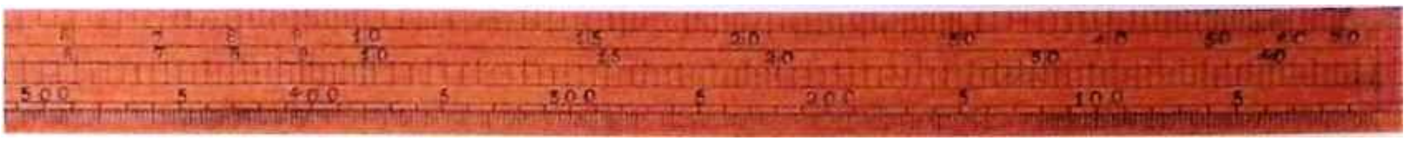


Figure 3.2.6.R: Right part of the back of the slide of the Soho system of Lenoir. Robert K. Otnes collection

V

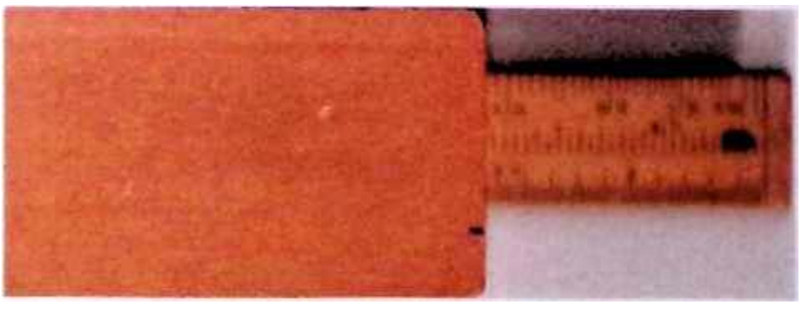


Figure 3.2.7: Back of the Soho with imaginary hairline (V).

3.3. The Soho System by Gravet-Lenoir, 1846 -1874

Little personal data is known about Mr. F.F. Gravet (1812 - 1895). Gravet is an optician (optician engineer). From 1837 he worked in *Rue Dauphine*, and from 1846 in *Rue Cassette*.

Gravet took over the business of Lenoir in 1846 and named himself his successor by giving the shop the name *Gravet-Lenoir*. Gravet marks certain Sohos with the designation *Gravet, successeur de Lenoir*.

When dating, the address, which is often on the slide rule, can be a useful aid. Sohos by Gravet-Lenoir are manufactured from 1846 to 1867 at *14 Rue Cassette*. This is also where the first Mannheims are manufactured (see section 3.4 p.29). From 1867, the business address is *39 Rue de Babylone*, 400 m south of the Rodin Museum.

Figures 3.3.3 and 3.3.4 show a Soho system from Gravet-Lenoir. The name is in the upper left corner. There is a measurement scale in the well. Thus, the slide rule can be used to measure lengths (26 to 52 cm). The Soho has no bevelled ruler scales.

The A, B and C scales are 1-100 square scales; the D scale has a range of 1-10. With the Soho you can multiply, divide and calculate roots. At that time, the scales A and B were mainly used to calculate so that to avoid pushing out the slide. The calculations are made without cursor.

The slide has an asymmetrical cross-section and is therefore not reversible (see figure).

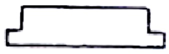


Figure 3.3.2: Cross-section of the slide of the Soho system

On the back of the slide there is a sinus, a tangent and an L scale, also called mantissa scale. The sine and tangent scales, often indicated by S and T, are related to the square scales. The sine value and the tangent value are read on the B scale below the final line of the A scale.

The trigonometric ranges are:

- Sine 35' - 90°
- Tangent 35' - 45°

The L scale is linear. This allows the logarithmic value to be determined for each number between 0 and 1000. You can also add and subtract with the L scale, which was very useful at that time.

Figures 3.3.5.L and 3.3.5.R show an early Mannheim system from Gravet-Lenoir. This name is on the left in the corner of the first figure and can hardly be read. The address, below in the figure, *14.R.Cassette*, indicates that the slide rule was made before 1867.

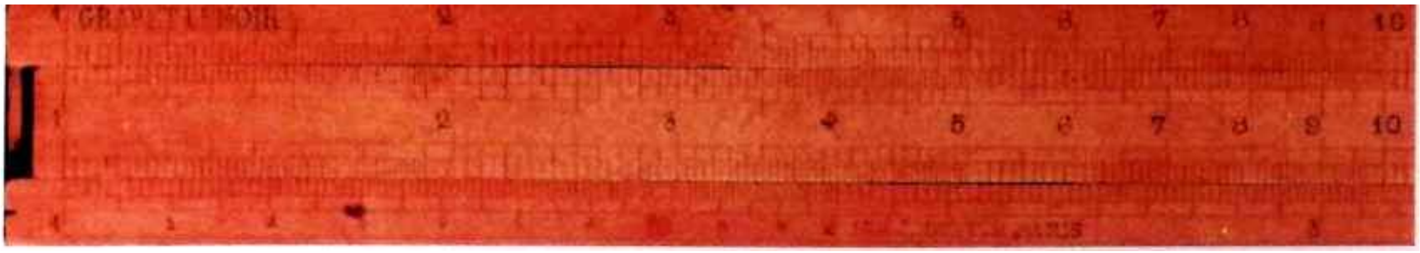


Figure 3.3.3.L: Left part of the Soho system by Gravet-Lenoir (14.R.Cassette Paris). IJzebrand Schuitema collection

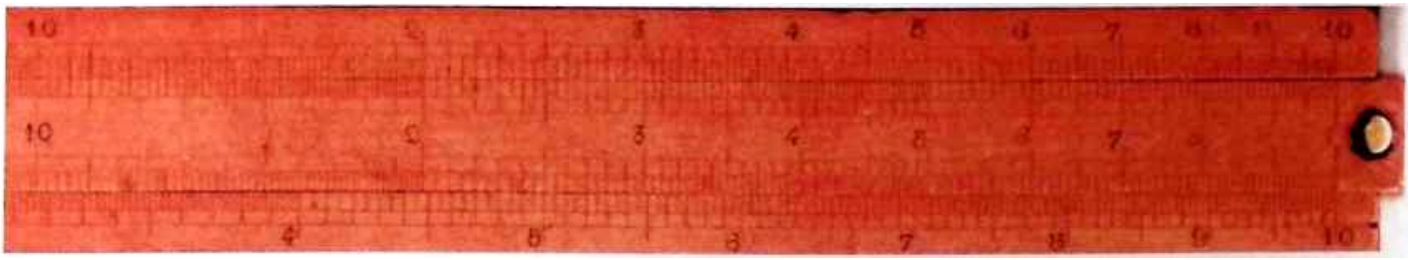


Figure 3.3.3.R: Right part of the Soho system by Gravet-Lenoir. IJzebrand Schuitema collection

Figure 3.3.4.L: Left part of the back of the slide of the Soho system by Gravet-Lenoir. IJzebrand Schuitema collection

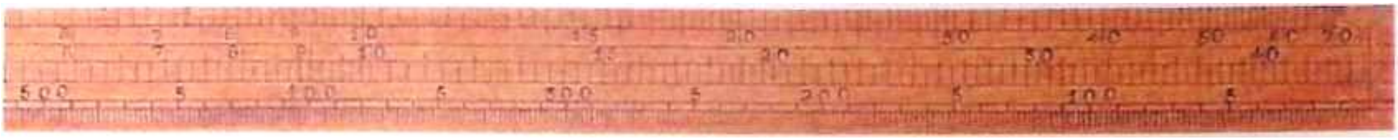


Figure 3.3.4.R: Right part of the back of the slide of the Soho system by Gravet-Lenoir. IJzebrand Schuitema collection

Figure 3.3.5.L: Left part of the Mannheim system by Gravet-Lenoir (14.R.Cassette Paris). Robert K. Otnes collection

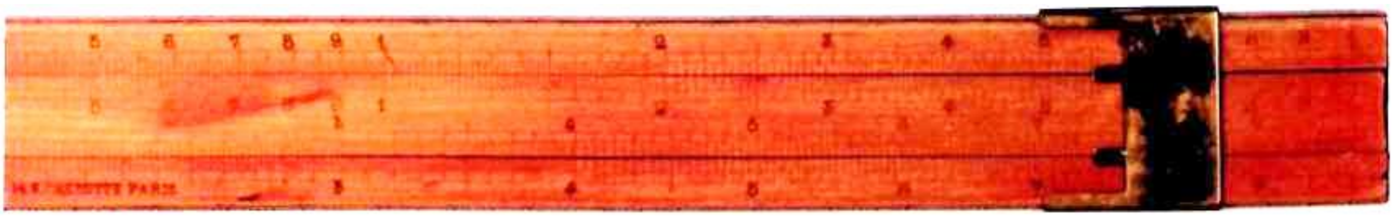


Figure 3.3.5.R: Right part of the Mannheim system by Gravet-Lenoir (14.R.Cassette Paris). Robert K. Otnes collection

3.4. The Mannheim System by Tavernier-Gravet, 1850 - 1906

Little is known about Mr Tavernier. He starts making slide rules at *Rue de Babylone 39*. In 1874 the business was run by Vinay and Tavernier, who had a good relationship with Amédée Mannheim. In 1876, Tavernier took Gravet as a business partner. From 1890 Tavernier-Gravet also produced slide rules for Keuffel & Esser, New York.

Amédée Mannheim was born in Paris in 1831 and died there in 1906. In 1850, at the age of 19, he presented a new order of scales in Metz. After his military career, in 1864 he was appointed professor of descriptive geometry at the Ecole Polytechnique in Paris. In 1872 he received the Poncelet Prize from the Academy of Sciences. Little is known about Amédée Mannheim. Paul and Jouanneau Berché report on his personality:

> He did not want to benefit from his invention - at that time the patent illness was not rife yet - and he gave his rule, without any compensation, to a Parisian precision Instrument maker, Tavernier-Gravet.

Figure 3.4.1: Amédée Mannheim

When dating, the exact address, which is usually on the slide rule, can be a useful tool. The Sohos of Tavernier-Gravet are manufactured from 1867 to 1881 at *39 Rue de Babylone*, and from 1882 to 1939 at *19 Rue Mayet*, 1000 m east of the *Jardin du Luxembourg*. These Sohos usually have a bevelled ruler scale (see Figure 3.4.6, p.30).

Another means of dating are the gold medals that were given in the 19th century at large exhibitions for extraordinary achievements. Tavernier-Gravet received a gold medal in 1878, 1889 and 1900. This is noted on the slide rules of that time with MEDAILLES D'OR and the years. From 1906, the date is given on the backs, top right, in the format month-year (see Figure 3.4.5c). The gold medal of honour is exploited for many years. Thus, the author knows a slide rule with the mentioned three years and with the year of manufacture 1906.

Figures 3.4.3 and 3.4.4 show a Mannheim system. The Mannheims from Tavernier-Gravet have windows at both ends of the back to precisely setting the angles for reading the trigonometric values on the front of the slide rule.

In the well there is a measurement scale. Thus, the slide rule can be used to measure lengths (26 to 52 cm). Name, address and production date (February 1916) are on the back of the body. The hairline windows already exist in 1875.

The new scale system has two pairs of scales with the same divisions: A|B 1 – 100 and C|D 1 - 10.

The slides of Mannheims (Fig. 3.4.3) and Sohos (Fig. 3.4.6) have a symmetrical cross-section and can therefore be reversed (figure).

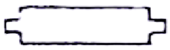


Figure 3.4.2a: Cross-section of the slide, Mannheim system

On the back of the slide, a sinus and a tangent scale are arranged in such a way that these scales slide with the square scale A after reversing. This arrangement is a remnant of the time without cursors. However, the handling button on Sohos (Fig. 3.4.6) prevents the slide from being pushed completely into them after inversion.

Without reversing, it goes as follows: the sine value is on the B scale under the final line of the A scale; the tangent value is on the A scale above the final line of the B scale.

The trigonometric ranges are:

- Sine 35' - 90°
- Tangent 35' - 45°

The " mark (seconds) and the ' mark (minutes) on the A|B scales give constants for the transformation of angles into radians and vice versa. These fixed values are calculated as follows for a circle division of 360°:

- $(180 \times 60 \times 6'') / \pi = 206265''$ (360°)
- $(180 \times 60') / \pi = 3438'$ (360°)

The figure 3.6.2.4 shows a slide rule from 1925 (p.37).

Figure 3.4.2b: Tavernier-Gravet logo

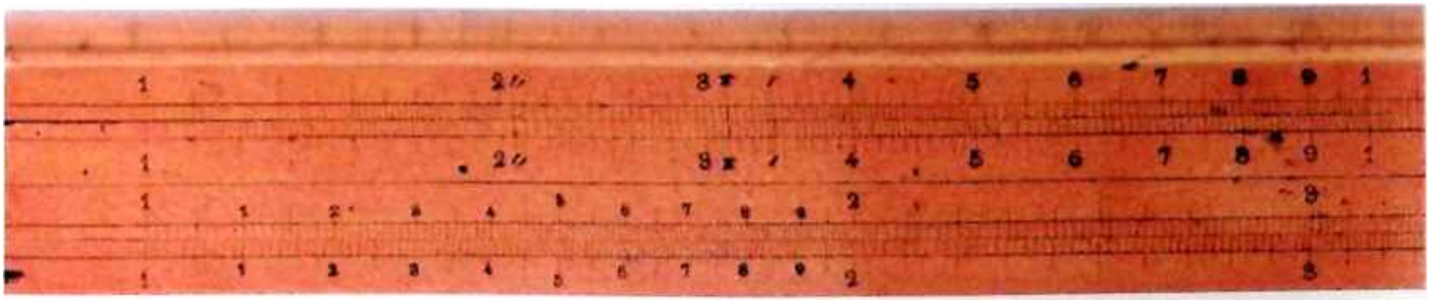


Figure 3.4.3.L: Left part of the front of the Mannheim system by Tavernier-Gravet

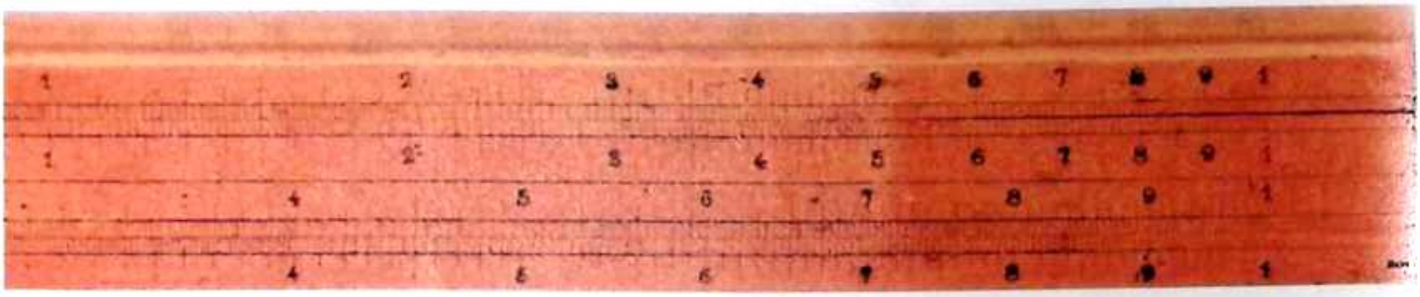


Figure 3.4.3.R: Right part of the front of the Mannheim system by Tavernier-Gravet

Figure 3.4.4.L: Left part of the back of the slide of the Mannheim system by Tavernier-Gravet

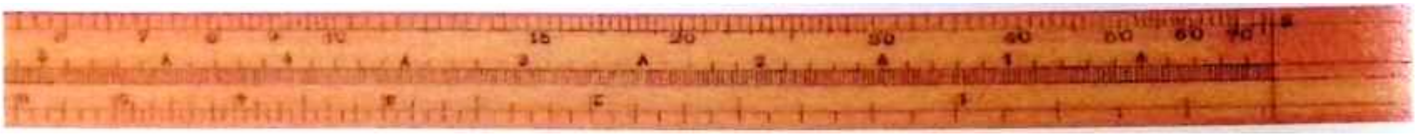


Figure 3.4.4.R: Right part of the back of the slide of the Mannheim system by Tavernier-Gravet

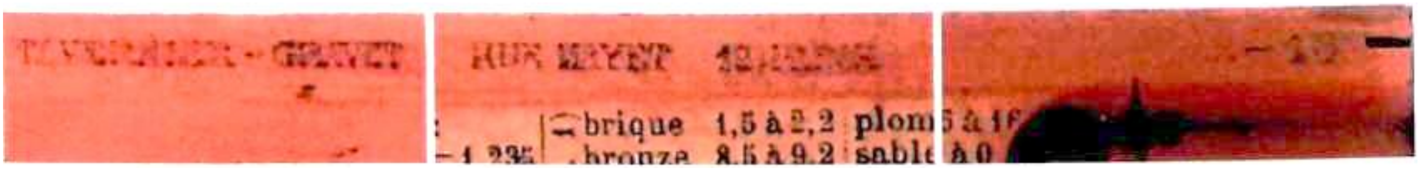


Figure 3.4.5: Name, address and date: *TAVERNIER-GRAVET RUE MAYET 19 PARIS 2-16*

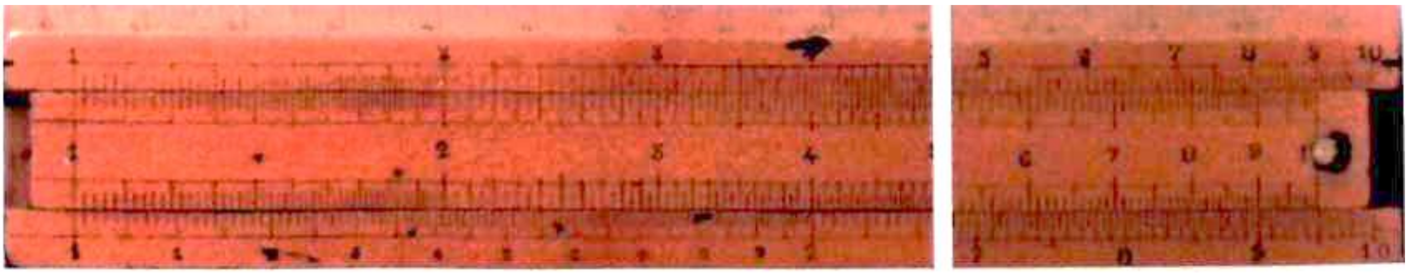


Figure 3.4.6: Front of the Soho system by Tavernier-Gravet with the bevelled ruler scale and handling button

3.5. The Mannheim System by Barbotheu, 1888 - 1913

Barbotheu worked in Paris from 1888 to 1913 as a manufacturer of calculating and drawing instruments.

Barbotheu's Mannheim system is more balanced than that of Tavernier-Gravet. Name and address are clearly positioned on the front face. There, the longitudinal lines are just as long as the scales. These lines are not present on the back of the slide. The principle of the American architect Louis Henry Sullivan (1856 - 1924), *form follows function,* is applied here.

Figures 3.5.2 and 3.5.3 show a Mannheim system. In the well there is a measurement scale. Thus, the slide rule can be used to measure lengths (26 to 52 cm).

Barbotheu's Mannheims have bevelled windows at the ends of the backside, to precisely adjust the angles for reading the trigonometric values on the front of the slide rule.

The scale system has two pairs of scales with the same divisions that slide together: A|B 1 - 100 and C|D 1 - 10.

The slide has a symmetrical cross-section and can therefore be reversed (figure).

Figure 3.5: Cross-section of the slide of the Mannheim system

On the back of the slide, a sinus and a tangent scale are arranged in such a way that these scales slide with the square scale A after reversing. Without reversing, it goes as follows: The sine value is on the B scale under the final line of the A scale; the tangent value is on the A scale above the final line of the B scale.

The trigonometric ranges are:

- Sine 35' - 90°
- Tangent 35' - 45°

The " mark (seconds) and ' mark (minutes) on the A|B scales give constants for the transformation of angles into radians and vice versa. These fixed values are calculated as follows, for a circle division of 360°:

- $(180 \times 60 \times 6'') / \pi = 20626''$ (360°)
- $(180 \times 60') / \pi = 3438'$ (360°)

When dating, the exact address, which is often on the slide rule, can be a useful aid. Barbotheu's slide rules were made in 1888 at *Rue Saint Gilles 16*, from 1889 to 1892 at *Rue Saint Gilles 10,* 250 m north of Place de Vosges, and from 1893 to 1913 at *Rue Bèranger 17*, south of *Place de la Republique*. Name, address and date of manufacture are usually on the back.

Barbotheu also used Zapatero wood. The bright Zapatero is very dense, hard, elastic and durable. It is easy to work and hardly wears. In contrast to boxwood, the wood can be produced in lengths greater than 26 cm.

Figure 3.5.1: Barbotheu logo

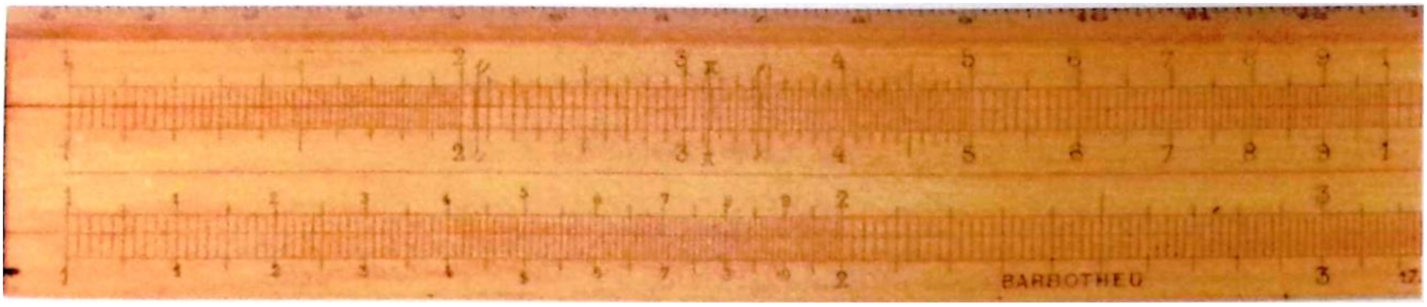


Figure 3.5.2.L: Left part of the front of the Mannheim system by Barbotheu. Ronald van Riet collection

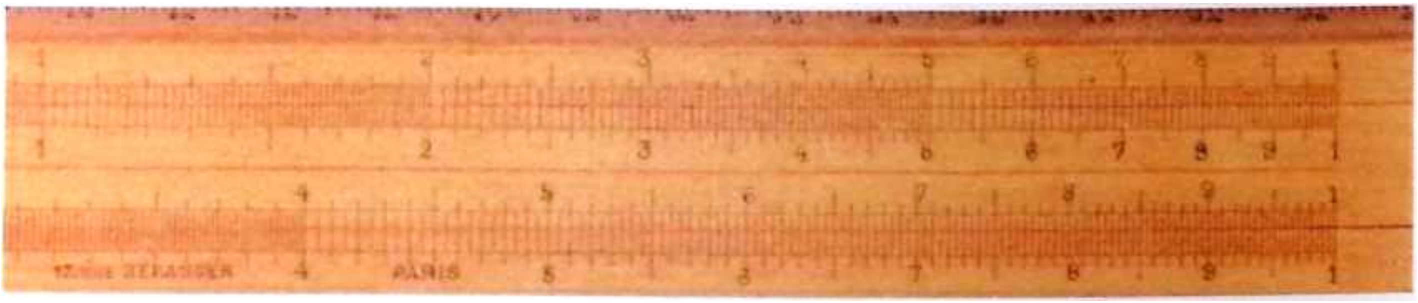


Figure 3.5.2.R: Right part of the front of the Mannheim system by Barbotheu (*Bèranger*). Ronald van Riet collection

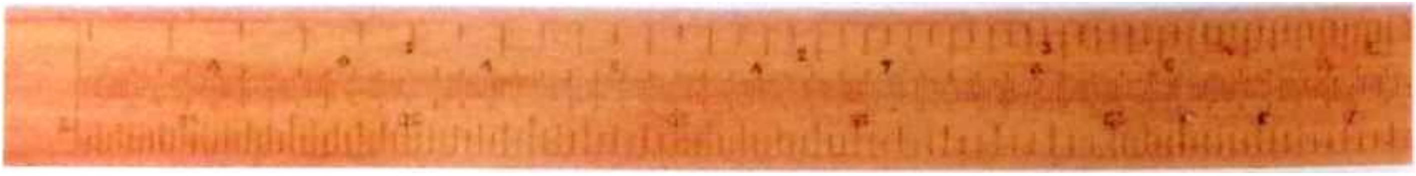


Figure 3.5.3.L: Left part of the back of the slide of the Mannheim system by Barbotheu. Ronald van Riet collection

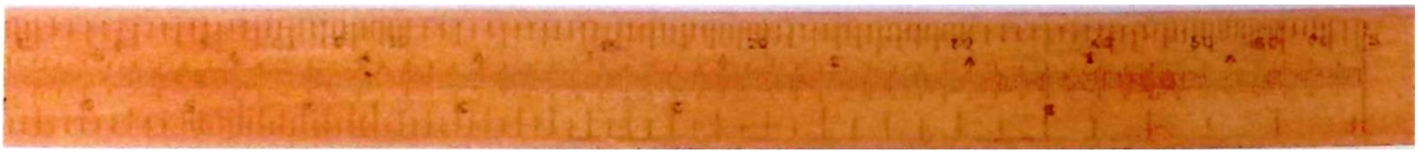


Figure 3.5.3.R: Right part of the back of the slide of the Mannheim system by Barbotheu. Ronald van Riet collection

3.6. The Mannheim System by Dennert & Pape, from 1873

3.6.1. Introduction

In 1862 Johann Christian Dennert (1829 - 1920) takes over the workshop for geodetic instruments from Carl Plath (1825 - 1919). In 1863 the mechanic Martin Pape (1834 - 1884) joins as a partner. The company is now called *Dennert und Pape*, D&P, and is based in Altona (from 1938 Hamburg-Altona).

How D&P came to be the first in Germany to produce slide rules of the Mannheim system can be read in a manual (see Figure 3.6.1.2) by the master builder Adolf Goering (see p.84) from Halberstadt:

> At that time, well-crafted slide rules were obtained directly from Paris (Tavernier-Gravet), while in Germany the production of slide rules was unknown. But in 1872/3, when, after the German-French war, repeated orders to Paris remained without any answer, the author of this manual prompted the well-known company Dennert & Pape, in Altona, to also produce slide rules in Germany, in the manner of the French, but with some changes, such as a tangent scale in double size.

The phrase "tangent scale in double size" requires a discussion: Goering proposes D&P to increase the scale layout by extending the range from 5° 42' - 45° of the tangent scale to the length of 25 cm. This increases the intervals (gaps) and the calculation results more accurate.

The trigonometric ranges are:

- Sine 35' - 90°
- Tangent 5° 42' - 45°

For the Mannheims of D&P, the sine value is read on the B scale, below the final line of the A scale; the tangent value is read on the C scale above the initial line of the D scale.

In 1903, Dennert & Pape invented an improvement of the slide rule by means of adjustment screws and received the DRGM 192 052 for this. The description is:

> Slide rule with movable body guide for the slide and control means to change the lateral guide pressure.

Hans Dennert writes in HD78:

> 1905. The first illustrated Dennert & Pape catalogue shows twelve slide rules corresponding to the mentioned patents as well as the first log-log calculator, D&P No. 15.

It is the exponential calculator invented in 1900 by Wilhelm Schweth, master builder in Cologne. He gets the DRGM 148 526 for this. The description is:

> Exponential slide rule with two scales added to the common layout on the front.

The author owns an Electro slide rule, type 15 (Fig. 3.6.1.5). This Schweth calculator is a successor to the Mannheim system with the following extensions:

- Two scales in the well of the body: a scale for the efficiencies of dynamo machines and electric motors and a scale for the voltage drop,
- Cursor edge at the left end of the slide for reading the above scales,
- two exponential scales, which are at the top and bottom of the front of the slide rule, divided according to DRGM 148 526 from Schweth,
- five adjustment screws according to DRGM 192 052 from Dennert & Pape. Combined slits in the well enabled to adjust the slide guiding pressure (see Figure 3.6.1.5).

In 1906 Faber offered a comparable Electro slide rule, type 368 (see Figure 3.8.1.5, p.48).

Figure 3.6.1.1: Johann Christian Dennert

Figure 3.6.1.2: Instructions for the use of the Mannheim system, A. Goering

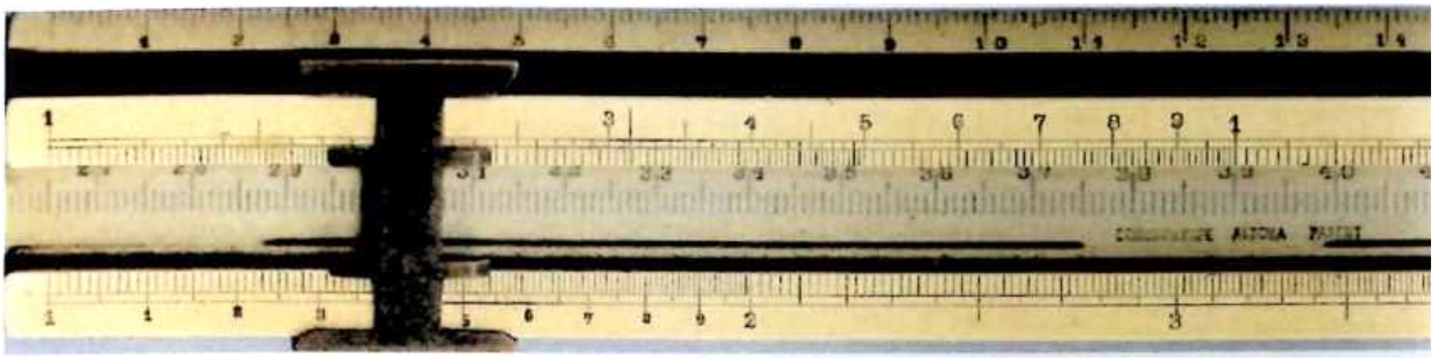


Figure 3.6.1.3.L: Left part of the front of the Mannheim system from *Dennert & Pape Altona*. Period 1888— 1890 Werner Rudowski collection

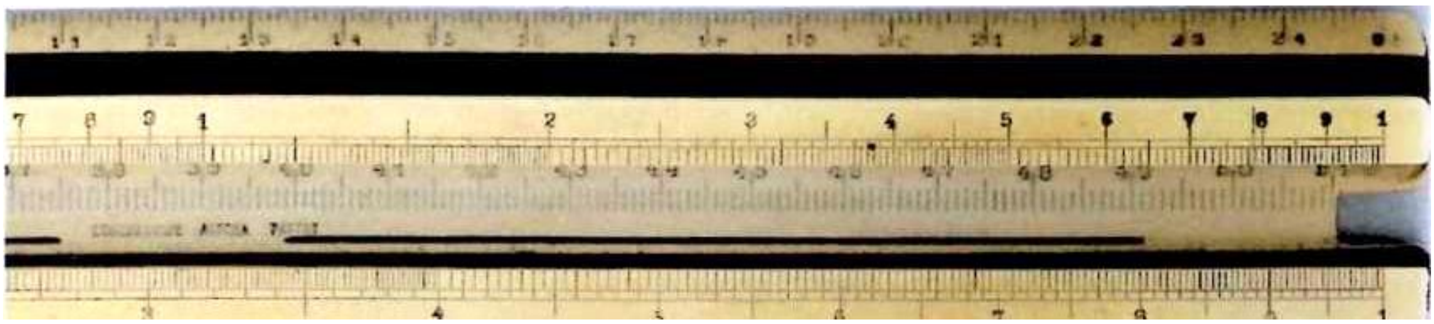


Figure 3.6.1.3.R: Right part of the front of the Mannheim system by *Dennert & Pape Altona*. Period 1888— 1890 Werner Rudowski collection

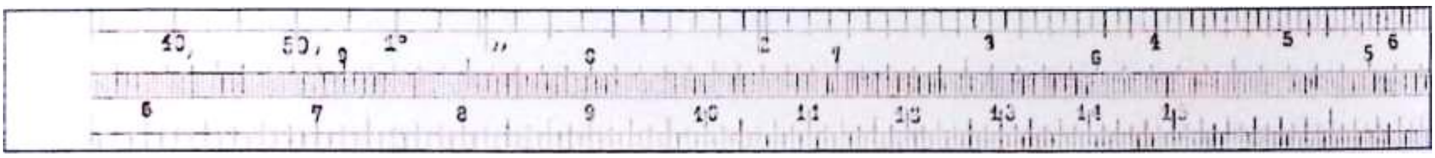


Figure 3.6.1.4.L: Left part of the back of the slide of the Mannheim system by D&P. Werner Rudowski collection

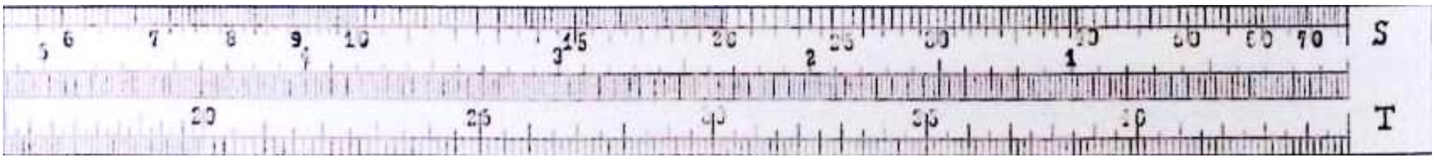


Figure 3.6.1.4.R: Right part of the back of the slide of the Mannheim system by D&P. Werner Rudowski collection

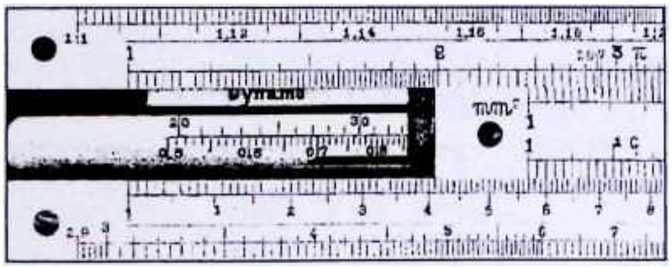


Figure 3.6.1.5.L: Left part of Schweth's Electro slide rule

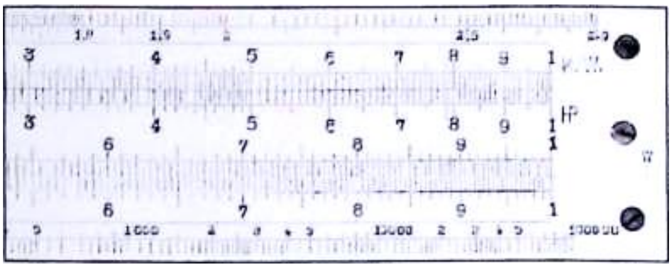


Figure 3.6.I.5.R: Right part of Schweth's Electro slide rule

3.6.2. Dating in the Early Period

Within the *Common Period*, the period 1873 - 1895 is referred to as the *Early Period* and the period 1895 - 1905 is called the *Late Period* (Section 3.6.3, p.38).

Slide rules from the *Early Period* can be dated most easily on the basis of external characteristics. DRGM for slide rules and marks do not exist until after 1895, because the Patent Office did not begin to grant utility models until 1891.

During this period, D&P produced the following slide rules (see Figure 3.6.2.1). The information used is based on an article by Jürgen Bartzik, price lists (1898, 1902, 1905/6), and a production list that Hans Dennert made available to the author in 1999.

Series	Degree	Material	Length	1873	1882	1887/89	1898	1902	1905/6
D&P I	360°	Box/Mahogany	25	76 (26)	94 (26)	109/133 (26)	254 (26)	287 (27)	338 (27)
D&P I	400^g	Box/Mahogany	25	76 (26)	94 (26)	109/133 (26)	254 (26)	287 (27)	338 (27)
D&P II	360°	Box/Mahogany	50		97 (51)	111/137(51)	261 (51)	294 (51)	339 (52)
D&P II	400^g	Box/Mahogany	50		97 (51)	111/137(51)	261 (51)	294 (51)	339 (52)
D&P III	360°	Mahogany & Just.	25						340 (27)
D&P III	400^g	Mahogany & Just.	25						340 (27)
D&P IV	360°	Mahogany & Just.	50						341 (52)
D&P IV	400^g	Mahogany & Just.	50						341 (52)

Figure 3.6.2.1: Type overview of D&P slide rules from the period 1873 — 1905, according to Bartzik

The abbreviation *Just*. stands for adjustment screws; The numbers in parenthesis behind the model numbers indicate the body length. Until 1906, D&P had only two scale lengths: 25 and 50 cm. Not included in the overview is the slide rule without trigonometric scales on the backside of the slide: Type 78 (from 1873 to 1878, see Figure 3.6.2.3, p.37).

With this model overview, a timetable with external features (see Figure 3.6.2.2) can be compiled. On the basis of this timetable, early slide rules can be dated.

Period ➞	1873	1888	1890	1895	1898	1902	1905/6
Rear Windows	1, angled	1, angled	2, angled	2, round	2, round	2, round	2, round
Flexion	none	V-groove	Slits	Slits	Slits	Slits	Plate
Company text	Back	Well	Well	Well	Well	Front	Front
Length	26 cm	26 cm	26 cm	26 cm	26 cm	27 cm	27 cm
Longitudinal lines	yes	no	no	no	no	no	no
Cursor's Track	wide	wide	wide	narrow	narrow	narrow	narrow
Type of cursor	knife edges	knife edges	Glass	Glass	Glass	Glass	Glass
Pi marks	|A	|AB	|AB	|AB	|AB	|AB	A|B
Measuring scale	no	yes	yes	yes	yes	yes	yes
Material	Box	Box/Mah.	Mahogany	Mahogany	Mahogany	Mahogany	Mahogany

Figure 3.6.2.2: Timetable with characteristics of D&P slide rules from the period 1873 – 1905

The characteristics are discussed below.

Rear Windows (Rear Hairlines)

Cut-outs at the ends of the back surface of the body are very helpful to be able to read the trigonometric scales on the back of the slide. These hairline windows are cut straight (angled) at the beginning (see Figure 3.7.2.l.L, p.42, between the letters A and D) and are later milled out in a semi-circle. With one window, the values of the sinus and tangent scales may be only accessible if you pull out the slide; with two windows, reading is possible without pulling out the slide.

Flexion

To improve the spring effect, Dennert & Pape initially created V-shaped grooves on the back of the body (see Figure 4.5.1.3, p.66); In order to additionally relieve the transverse tension, slots are sawn into the well since 1890 (see Figure 4.3.2, p.60). In the beginning their length is 9 cm, later it is 8 cm.

Company text

The company text, *Dennert & Pape Altona*, is written at the beginning on the back, from 1888 in the well, and after 1902 on the front of the body. From 1902, the patent text DRP 126 499 is engraved on the body; from 1905 the letters A, B, C and D are added.

Length

The body length of 26 cm is extended to 27 cm from 1900 onwards in order to be able to better read results in the entire scale range (see section 4.1.1 *Hair-precise cursors*, p.55).

Longitudinal lines

The slide rules from the period 1873 - 1888 (see Figure 3.6.2.3) have nine horizontal lines over the entire length of the body. Functionally, these lines have no use, and they disappear over time. Figure 3.6.2.4 shows that Tavernier-Gravet is more conservative on this issue. The slide rule has two special marks (see section 3.6.4) on the back of the slide.

Cursor track and cursor type

In the beginning, D&P uses knife-edge cursors with a wide upper running space (see Figure 3.6.1.3.L, p.34), because a spring is mounted there. The cursor should be embedded in the overall construction, and this requires a wide cursor track. With the compactly designed glass cursor, the track can be narrower.

Pi Marks

Constants, such as Pi (3,14), are added on the A and B scales. This can be done adding a line (|AB) or with the combination of a line and a π sign (A|B).

Measuring Scale

With the scale in the well of the slide rule, internal dimensions, like of drawers, can be measured. A measurement scale in the well is not available in D&P slide rules until 1886.

Material

In 1888 takes place the material change from box to mahogany with celluloid veneers.

Trigonometric scales

Very useful in the construction of the timetable is the slide rule without angle (trigonometric) scales from the collection of Klaus Kühn (Fig. 3.6.2.3).

D&P began manufacturing boxwood slide rules in 1873 and ended in 1888. This system has no trigonometric scales on the back of the slide. According to production overviews by Hans Dennert, the special slide rule comes from the period 1873 to 1877. Slide rules from the Werner Rudowski collection are equally helpful. Some characteristics for the timetable are taken from these slide rules.

Following to the original design of James Watt, D&P's slide rules have no marks in the *Early Period*, with the exception of two special marks on the sine scale (see Figure 3.6.1.4.L, p.34). A discussion can be found in section 3.6.4 *Special Marks*, p.38.

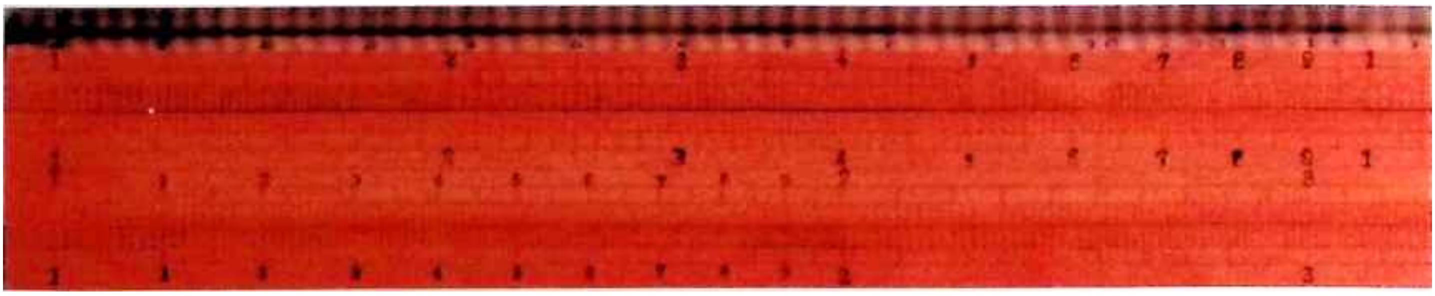


Figure 3.6.2.3.L: Left part of the slide rule without trigonometric scales, Dennert & Pape, 1873 - 1877. Klaus Kühn collection

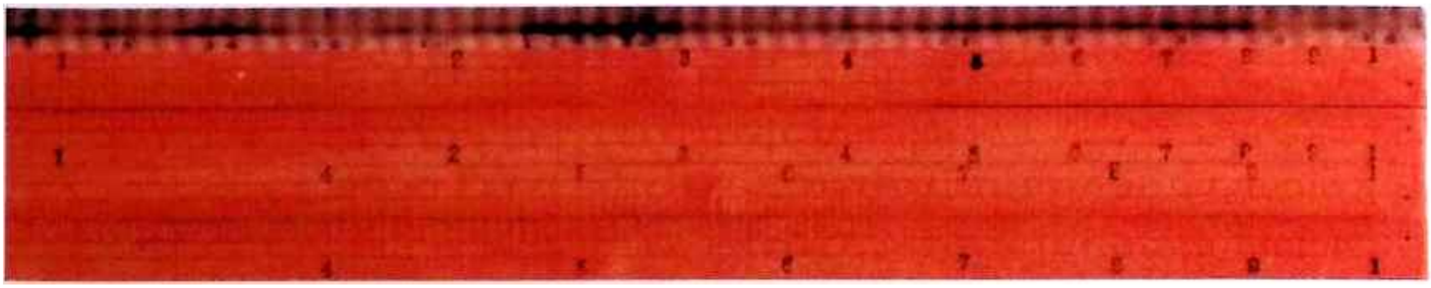


Figure 3.6.2.3.R: Right part of the slide rule without trigonometric scales, Dennert & Pape, 1873 - 1877. Klaus Kühn collection

Figure 3.6.2.4: Tavernier-Gravet's slide rule from 1925 with celluloid veneer and *longitudinal lines* (see p.36).

3.6.3. Dating in the Late Period

For the dating of slide rules from the *Late Period*, 1895 - 1905, utility models are better suited than patents, because there are more DRGM than DRP in the period and the protection of DRGM is only 3 or 6 years.

The company name and the location, *Dennert & Pape Altona*, have been on the well since 1888 and appear on the front of the slide rule from 1902 onwards. In addition to the marks on the front of the slide rule, its length is also revealing. All slide rules from the *Common Period* have two marks on the sine scale (see Figure 3.6.1.4.L, p.34). These marks are discussed at the end of this section under *Special Marks*.

Year	DRGM / DRP	Subject
1895	DRGM 37 191	Slots in the floor
1900	DRGM 148 526	System Schweth
1901	DRP 126 499	Flexible plate
1903	DRGM 192 052	Adjustment screws

Figure 3.6.3.1: Utility models and patent of D&P

Year	π	π /4	c c1	Length
1895	|AB	|AB		26 cm
1902	A|B	|AB		27 cm
1905	A|B	|AB	C C	27 cm

Figure 3.6.3.2: Marks on D&P slide rules

Explanation

|A: π line on scale A
|AB: π line on scales A and B;
A|B: π line and π symbol on the scales.
The constants are: c = √4/π = 1,13 and
c1 = √40/π = 3,57, both on the C scale.

In the case of the Nestler system Mannheim (see section 3.7) and Rietz (see section 3.9), the values 2,06 and 3,43 are marked on the C|D scales with the symbols ζ" and ζ '.

The oldest slide rules are 26 cm long, have no marks and no slots. The newest slide rules are 28 cm long and have four slots.

3.6.4. Special marks

Figure 3.6.4 shows the values of 1,18° and 1,97° above the left part of a Sinus scale. They are special marks because angular and sine values are not the same thing. They are used to convert angles into radians and vice versa (see also Figure 3.6.1.4.L).

If you set 1,18 on the sine scale, you get a value of 206265" (seconds) on the B scale. If you set 1,97 on the sine scale, you get a value of 3438' (minutes) on the B scale.

These fixed values are calculated, for a circle divided in 360°, as follows:

- (180 x 60 x 60") / π = 206265" (360°)
- (180 x 60') / π = 3438' (360°)

In order to continue to calculate with these results, it is easier to reverse the slide. Above the value of 1,18 on the sine scale there is 2,06 on the A scale; above 1,97 stands 3,43.

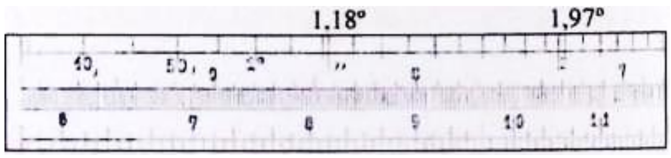


Figure 3.6.4: Back of the slide of the Mannheim system by Dennert & Pape with the special marks

3.7. The Mannheim System by Nestler, from 1878

3.7.1. Introduction

Recently, investigations by Jürgen Nestler have revealed new information about the history of the creation of the Nestler Company. In the following, the description from AN01 is extended by this new knowledge.

The author also owes his knowledge of the creation of Nestler to his collector friends Hans-Peter Schaub and Heinz Joss. In addition, the following books/articles were used:

- Ruh, Max, *Schaffhauser Biographien*, Historical Association of the Canton of Schaffhausen, 1981. (The biography of Beck is in part 4).
- Insler-Hungerbühler, Ursula, *Die Mahler von Schloss Laufen*, Rascher Publisher, Zürich, 1953.
- Briquet, Charles-Moïse, title and date of this article are unknown.

Jakob Siegrist and Theophil Beck are decisive in the creation of the ruler factory.

Jakob Siegrist was born in 1854 in Feuerthalen, near Schaffhausen, and died in 1936. He attended primary and secondary school there and completed a commercial apprenticeship. At a railway engineering office in Zurich, his talent for the art of drawing unfolded and his interest in surveying emerged.

Theophil Beck lived in Schaffhausen in 1814 and died there in 1903. He attends school there and then completes an apprenticeship as a mechanic. In 1833 he continued his education in Nuremberg, a city with a strong tradition of mechanics. There he is certified as having good technical skills in precision mechanics.

Beck first worked as a copper engraver and then, according to Ursula Insler-Hungerbühler, began "with the production of slide rules and rulers". Beck runs an optician's shop in his father's house and “then founds a ruler factory, which later becomes the ruler factory Schaffhausen AG”. (Investigations by Jürgen Nestler show a different course of events. See end of section 4.2.3, p.58).

In 1876, Theophil Beck and Albert Nestler (1851 - 1901) founded a small factory for drawing articles in Schaffhausen and in Lahr (Black Forest) under the name Beck and Nestler. The factory was located in Schaffhausen on Rheinstraße, where Jakob Amsler, the world-famous manufacturer of planimeters, had his workshop. It is very likely that the gentlemen there were able to observe the precise dividing machine.

In 1878 they both decided to move the whole business to Lahr. Briquet says: "During Schaffhausen's existence, the company had a young man among its employees, Jakob Siegrist, who followed his bosses to Lahr in 1878 and worked there for 6 months. During this period, Siegrist made a practical invention of a precision dividing machine". Briquet then continues: "This invention of a dividing machine at Beck and Nestler in Lahr earned Siegrist 300 Thaler, a considerable sum for that period". In the same year, Nestler began automatically dividing rulers made of boxwood.

According to the *Annual Report of the Chamber of Commerce (Lahr)* on the year 1878:

> The Maaßstabfabrik Beck und Nestler, which was founded in the year under review, is operated with a gas engine of 4 horsepower and employs 12 - 15 workers. In addition to a fully equipped carpenter's shop and mechanical workshop, there are 6 self-constructed dividing machines at work, whereupon every measure can be divided into the finest parts. All kinds of drawing and measuring instruments are made. The logarithmic dividing machine recently invented by the owner Beck and built in the factory should be listed as the only existing machine. This very complicated machine produces the slide rule, well known in specialist circles, which until now could only be produced with same precision by Tavernier-Gravet, a manufacturer of Paris.

In 1880 the slide rule manufacture is included in the production program.

In 1881 Beck left and founded the *Mathematical Dividing Workshop* in Strasbourg.

In 1895 the company name becomes *Albert Nestler*. Collectors will therefore search in vain for slide rules with the name *Albert Nestler* from the period before 1895.

D&P began manufacturing celluloid slide rules in 1888. According to *Walther Dyck*, one of the founders of the Deutsches Museum, Nestler supplied boxwood slide rules in 1892 in the scale lengths of 20, 25 and 50 cm and with celluloid veneer only in 25 and 50 cm. These dimensions, 25 and 50 cm, were the standard lengths at D&P until 1903.

The purchase of these slide rules by Nestler in 1892 indicates that Nestler did not produce such slide rules himself during this period. In 1895, D&P received the DRGM for slide rules with a slitted well, after they had already been manufacturing them for several years. Nestler procured these blanks from 1895 to 1905.

From this it can be concluded that Nestler received blanks with celluloid from D&P from the very beginning.

A survey of collectors has shown that almost all Mannheims from the period 1888 - 1905 have a slitted well. These were then either manufactured by D&P or sourced from D&P as a blank.

The author knows of only two Mannheims from this period, which are completely produced by Nestler.

The Mannheims of Nestler have the same scale layout as that of Tavernier-Gravet: two pairs of scales sliding towards each other with the same divisions: A|B 1-100 and C|D 1-10 (see Figures 3.4.3, p.30 and 3.7.1.2, p.41).

On the back of the slide, a sinus and tangent scale are arranged in such a way that these scales slide to the square scale A after reversing. Without reversing, it goes as follows: The sine value is on the B scale under the final line of the A scale; the tangent value is on the A scale above the final line of the B scale. However, if the Tangents scale runs in the opposite direction (divided from right to left, as in Figure 3.7.1.3), then the tangent value is on the C scale above the initial line of the D scale.

The trigonometric ranges are:

- Sine 35' - 90°
- Tangent 5° 42' - 45°

The slide rule in Figure 3.7.1.2 was manufactured around 1909 and has some special features: The π symbol on the C|D scales, which is only offered from 1902; the ζ symbols appear from 1903. In the well there is the text:

- ALBERT NESTLER LAHR I/B

Later, from 1908, Nestler developed a slide rule for light and power plants. The Type 32 is a slide rule for calculating electrical performance. For any current between 0.1 and 1000 amperes, the required cross-section and for any cross-section the permissible current can be read directly. The Type 37 is a slide rule for electric motors and dynamo machines. It has a cursor according to DRGM 400 076 by Heinz-Heinrich Peter, from 1909 (see AN04, p.75)

Figure 3.7.1.1: Albert Nestler

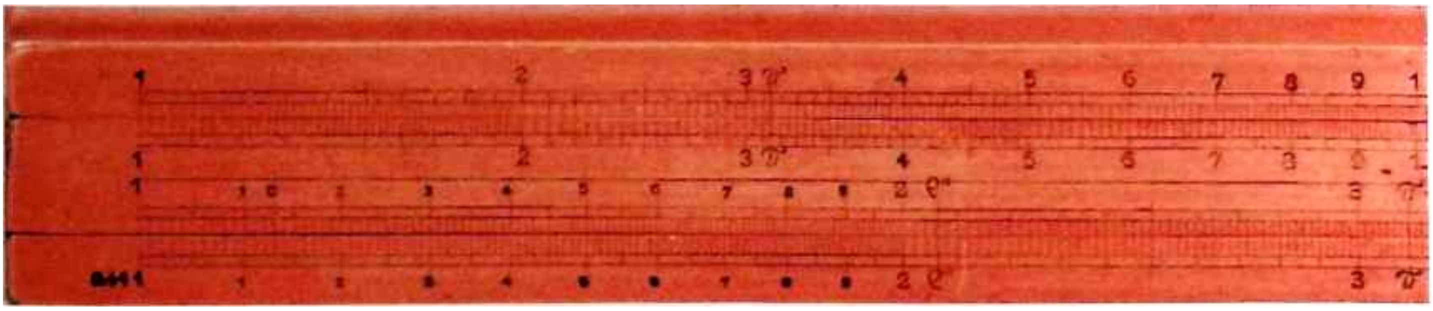


Figure 3.7.1.2.L: Left part of the front of the Mannheim system from Nestler. Formerly Günter Kugel collection.

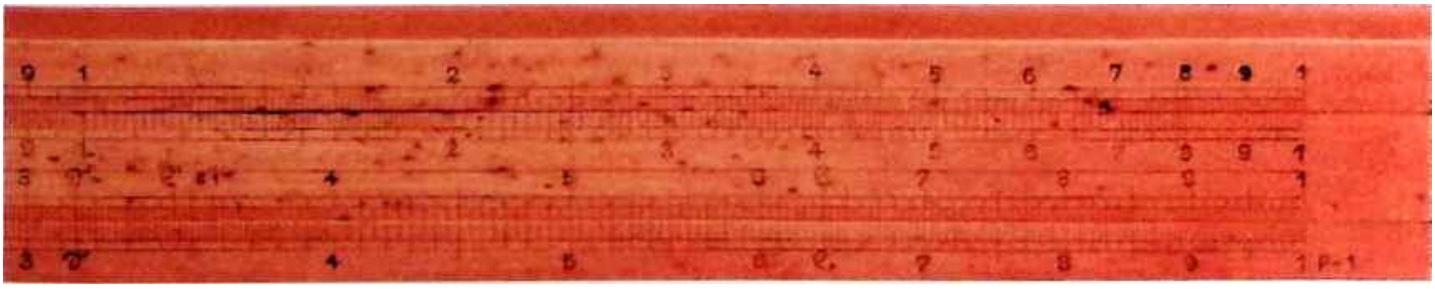


Figure 3.7.1.2.R: Right part of the front of the Mannheim system by Nestler. Formerly Günter Kugel collection.

Figure 3.7.1.3.L: Left part of the back of the slide of the Mannheim system by Nestler. Formerly Günter Kugel collection.

Figure 3.7.1.3.R: Right part of the back of the slide of the Mannheim system by Nestler. Formerly Günter Kugel collection.

3.7.2. Dating in the Early Period

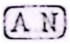
Within the *Common Period*, the period up to 1895 is referred to as the *Early Period* and the period 1895 - 1905 is called the *Late Period*.

Nestler slide rules from the *Early Period* can be dated on the basis of external characteristics. DRGM and marks are only present after 1895. In the literature, only a few very early Nestler slide rules are mentioned; they are not found in collections. This is justified by the following.

It was not until 1895 that the manufacturer from Lahr gave his company the name *Albert Nestler*. Before 1895, the company was called *Maaßstabfahrik Beck und Nestler*. So far, no slide rule with this first company name is known.

This is different with Dennert & Pape: The timetable (Fig. 3.6.2.2, p.36) is constructed on the basis of known slide rules. All old slide rules of D&P from the *Common Period* bear the full name Dennert & Pape. Did Nestler then mainly limit himself to dividing D&P bodies?

Possible name variants may be useful for searching for old Nestler slide rules. Which variants are conceivable for the *Maaßstabfahrik* from Lahr?

- *Beck und Nestler*, or *B u. N*,
- *Beck & Nestler*, or *B & N*,
- Signet with B and N, similar to 

These variants might be found on the front or the back of the slide rule, or on the case.

On the basis of two Nestler slide rules from 1895 (Figures 3.7.2.2 to 3.7.2.5) and a book by *E. Hammer* from 1902 (see Figure 3.7.2.1.L), the following features apply to very old slide rules:

- The material is in the beginning boxwood, and later mahogany,
- The rear window has straight or angled cut-out (see figure, between A and D),
- There is a longitudinal line in the middle of the slide over the entire body length (see figure, between B and C),
- A 25 cm drawing ruler, not 26 cm as at Dennert & Pape,
- The body length is 26 cm up to 1895,
- Finely engraved numbering, not with hand-held punch numbers, as is often the case with D&P.

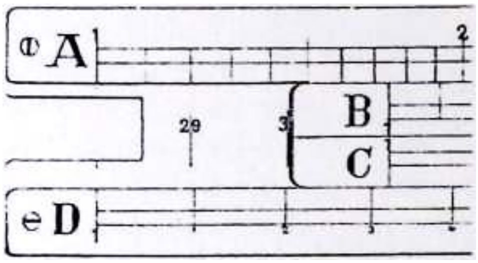


Figure 3.7.2.1.L: Drawing of the left part of a system Mannheim, from E. Hammer book

Although the letters (A, B, C and D) are in manuals and books, they are not present on the slide rules in the *Common Period*. D&P was the first to do so in 1905; Nestler followed only after the 2nd World War.

Hammer writes in 1902 in *The Logarithmic Slide Rule and its Use*:

> The windows at the ends of the back of the slide rule have a slightly different shape on the latest model: they are milled out in a semicircle, not cut off straight.

Straight cut-outs are expensive to manufacture. The fact that the German manufacturers started with this has to do with the fact that the French Sohos - which served as a model in 1873 - did not yet have milled cut-outs.

The above characteristics are processed in the 5th column of the timetable, Fig. 3.7.2.6. The characteristics for the first column are taken from the article *New Slide Rules* (*Surveying Journal*; p.220, 1880) by *Wilhelm Jordan*. The data for the 2nd to 4th columns were obtained by comparing them with characteristics of D&P slide rules from similar periods.

If very old slide rules from Nestler appear later, the timetable can be updated.

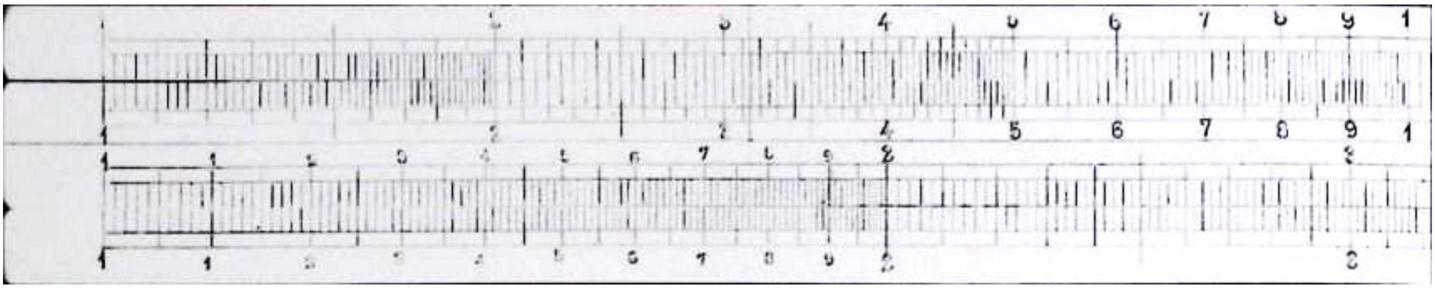


Figure 3.7.2.2.L: Left part of the front of the Mannheim system by Nestler, 1895

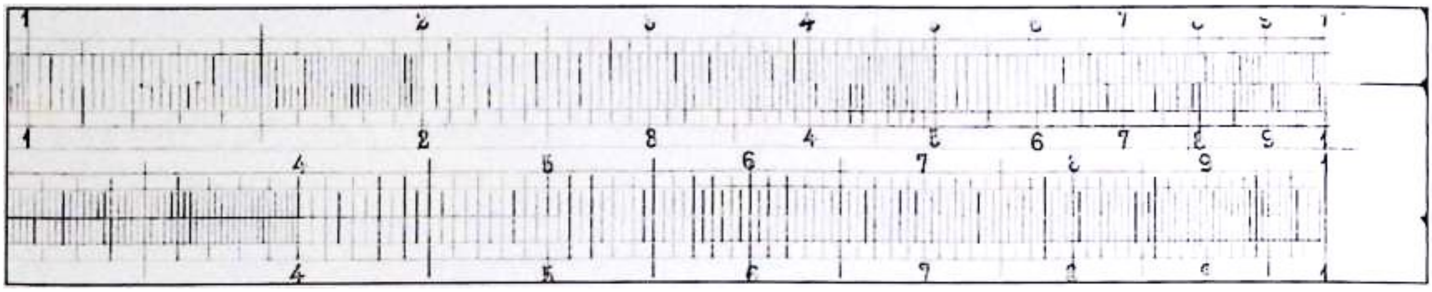


Figure 3.7.2.2.R: Right part of the front of the Mannheim system by Nestler, 1895

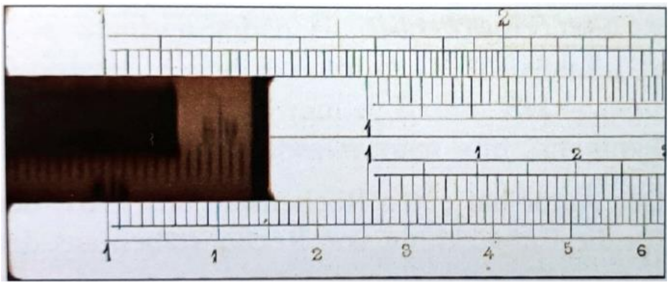


Figure 3.7.2.3: Front with view of the back window

Figure 3.7.2.4: Back with view of the window

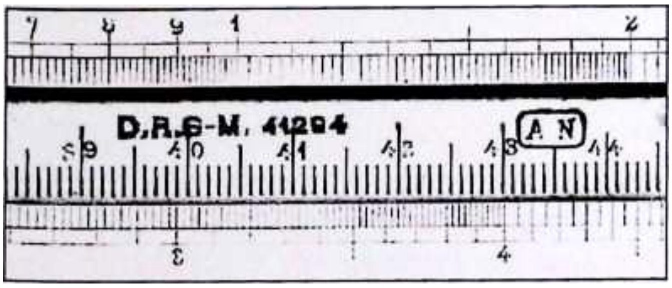


Figure 3.7.2.5: Well of the Mannheim system

Period →	1880	1884	1888	1892	1895
Rear Windows	1, angled	1, angled	1, angled	2, angled	2, angled
Flexion	none	none	V-groove (?)	Slits (?)	Slits
Company text	?	?	?	?	in the well
Length	26 cm	26 cm	26 cm	26 cm	27 cm
Longitudinal lines	1 x	1 x	1 x	1 x	1 x
Cursor’s Track	wide/narrow	wide/narrow	wide/narrow	wide/narrow	wide/narrow
Type of cursor	knife edges	knife edges	knife edges	knife edges/glass	knife edges/glass
Pi marks	|AB	|AB	|AB	|AB	|AB
Measuring scale	no	no	yes	yes	yes
Material	Box	Box	Box	Box	Box/Mahogany

Figure 35.2.6: Timetable with the characteristics of Nestler slide rules from the *Early Period*

3.7.3. Dating in the Late Period

For dating slide rules from the *Late Period*, 1895 – 1905, tility models are more suitable than patents because there are more DRGMs than DRPs in the period and the protection of DRGM is only 3 or 6 years. In addition to the marks on the front of the slide rule, its length is also revealing.

Year	DRGM / DRP	Subject
1895	DRGM 41,294	Two-sided covering
1901	DRGM 164,885	Nickel silver screws
1905	DRP 173 660	Resilient rubber plate

Figure 3.7.3.1: Utility model and patent of Nestler

The author has a slide rule from 1901, which is very informative for the development of slide rules from the *Late Period*. It is probably a prototype because the workmanship is not very expert, and the novelties (marks and screws) are abundantly represented.

The front (see Figures 3.7.2.2) shows marks that match those on the Mannheim system (see Figures 3.7.1.2, p.41). Only the π symbols are still missing.

Thus, the prototype is a precursor of the Mannheim system with 2 x 5 nickel silver screws.

The signet is used until 1902. After that, the name Albert Nestler appears in the well in modest size (see AN01, p.68).

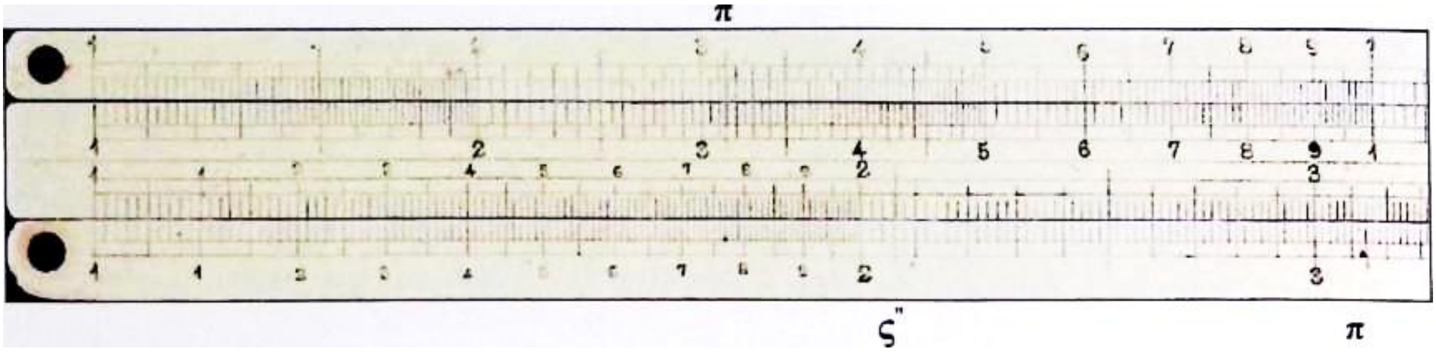


Figure 3.7.3.2.L: Left part of the front of the prototype, 1901.

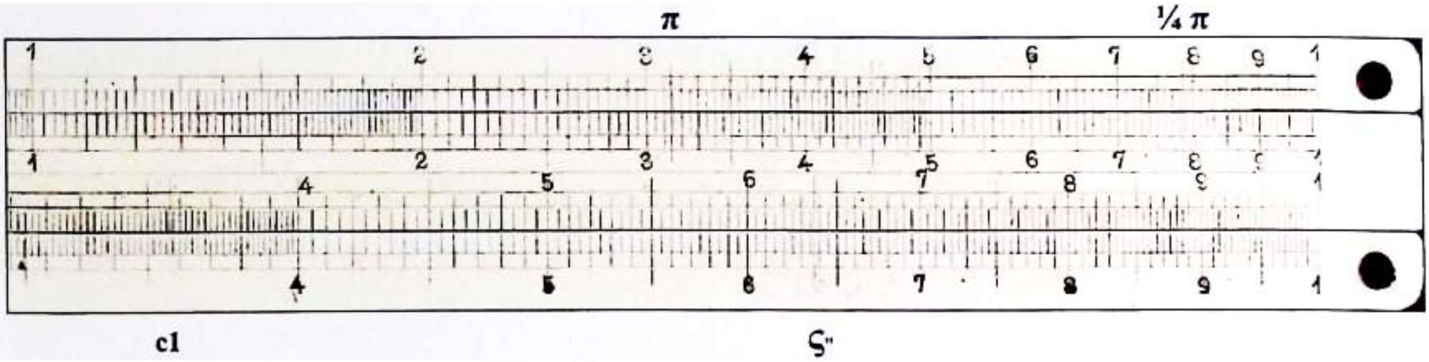


Figure 3.7.3.2.R: Right part of the front of the prototype, 1901.

The steel screws (see Figure 3.7.3.3) on the front are 3.5 mm Ø. The drawing scale in the bevel is fixed with pins, 0.5 mm Ø. In later versions of the slide rule, all screws have the same size, 2.5 mm Ø, and the celluloid coating on the slide is also fixed with screws. The four corners of the front are very clearly rounded to be more shock resistant.

In the well (see Figure 3.7.3.4) there is the text PATENT ANGEM. (registered). What happened to this application is unknown. In 1901 Nestler gets DRGM 164 885 for the nickel silver screws.

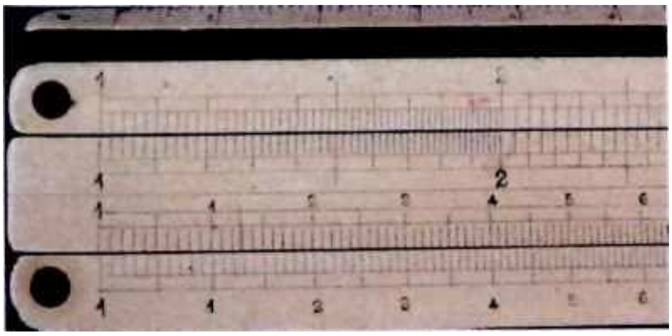


Figure 3.7.3.3: Steel screws of the prototype

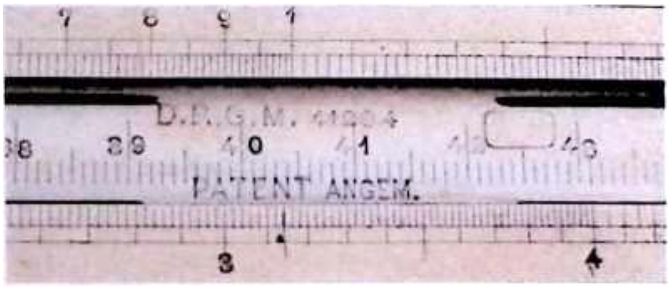


Figure 3.7.3.4: Well of the prototype

Year	π	π /4	c c1	ζ"ζ,,ζ'	Length
1895	|AB	|AB			27 cm
1898	|AB	|AB	C C		27 cm
1901	A|B C|D	|AB	C C	C|D	27 cm

Figure 3.7.3.5: Marks on Nestler slide rules

Explanation

|AB: π line on scales A and B, or C and D; A|B: π line and π symbol on scales A and B, or C and D. The constants are: $c = \sqrt{4/\pi} = 1{,}13$ and $c1 = \sqrt{40/\pi} = 3{,}57$ both on the C scale. The ζ characters (rho) indicate numbers for transforming angles into radians and vice versa:

ζ"= 206265", ζ' = 3438' and ζ,,= 636629,,

3.8. The Mannheim System by Faber, from 1892

3.8.1. Introduction

A.W. Faber is a pencil factory founded in Stein near Nuremberg in 1761.

Lothar Faber (1817-1896) opened a slate factory in Geroldsgrün in 1861, where slide rules were also produced from 1892 onwards.

Faber is thus the third factory for slide rules in Germany. This encourages them to come up with innovations to differentiate themselves from D&P and Nestler. Faber is the first German manufacturer to start with special marks. such as a π symbol on A and B scales, and c and cl marks only on the D scale. On the back of the body there is a bevelled window with hairlines.

The first Mannheim systems are made of Boxwood; soon there will be boxwood slide rules with celluloid on the front. There are two slits in the well. In 1898 Faber receives DRGM 98 350 with a protection for 6 years. The description is:

> Slide rule with elastic strips arranged on the sides or below the slide.

The total length of the slide rule is 260 mm at the beginning, and becomes 280 mm after 1900, so that you can easily reach the whole range of scales with the cursor. Then there are two reading windows on the back. Anyone who takes a critical look at the front and the back immediately recognizes the high quality of this work.

A real innovation is the cursor with counting pointer, with which the number of digits can be permanently marked (Fig. 3.8.1.1). In 1899 Faber receives DRGM 116 832 with a protection for 6 years. The text reads:

> Slide rule with pointer attached to the cursor to be moved along a scale to determine the number of digits of the end result.

To operate the cursor, inscriptions (QUOTIENT +1 and PRODUCT -1) and marks (←±|∓→) are used at the beginning and at the end of the slide rule. The cursor has an extension with a scale and a rotatable pointer on the right side. The scale is divided into 12 intervals, from -6 to +6. The indications in the inscriptions (QUOTIENT +1 and PRODUCT -1) are to be used only for the lower scales, C and D; the mark (←±|∓→) can be used for both the upper and lower scales.

In 1906 Faber offered a very detailed *study on the use of the slide rule*. The use of the slide rule and the pointer is explained with numerous practical examples.

The sine value is on the B scale under the final line of the A scale; the tangent value is, for models with two rear windows, on the C scale above the initial line of the D scale; for models with one window you have to reverse the slide.

The trigonometric ranges are:

- Sine 35' - 90°
- Tangent 5° 42' - 45°

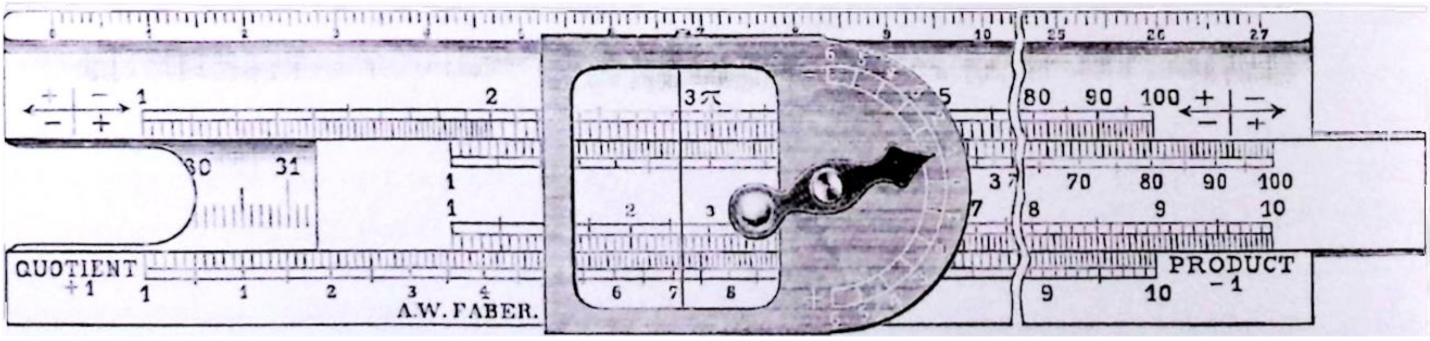


Figure 3.8.1.1: Direct marking of the number of digits by means of inscriptions and marks

Figure 3.8.1.2: Lothar Faber

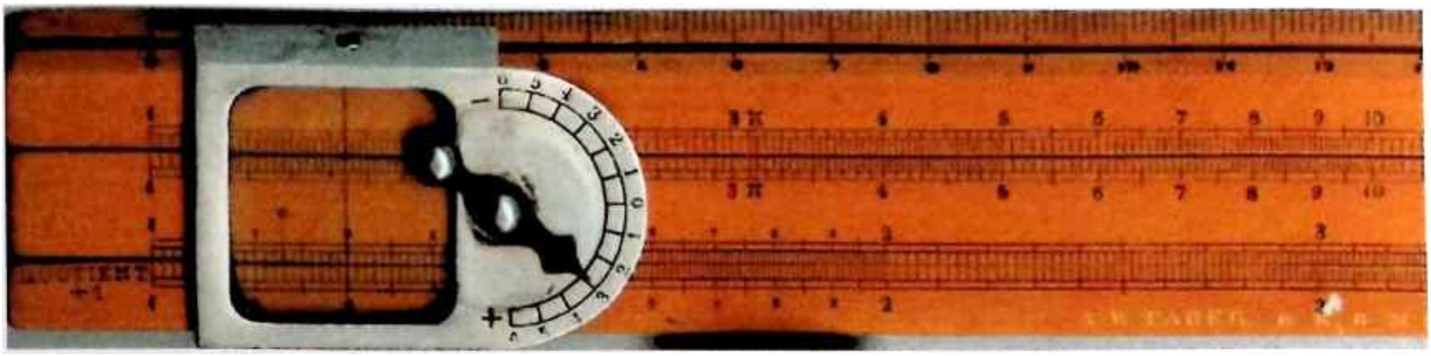


Figure 3.8.1.3.L: Left part of the front of the Mannheim system by A. W. Faber. Werner Rudowski collection

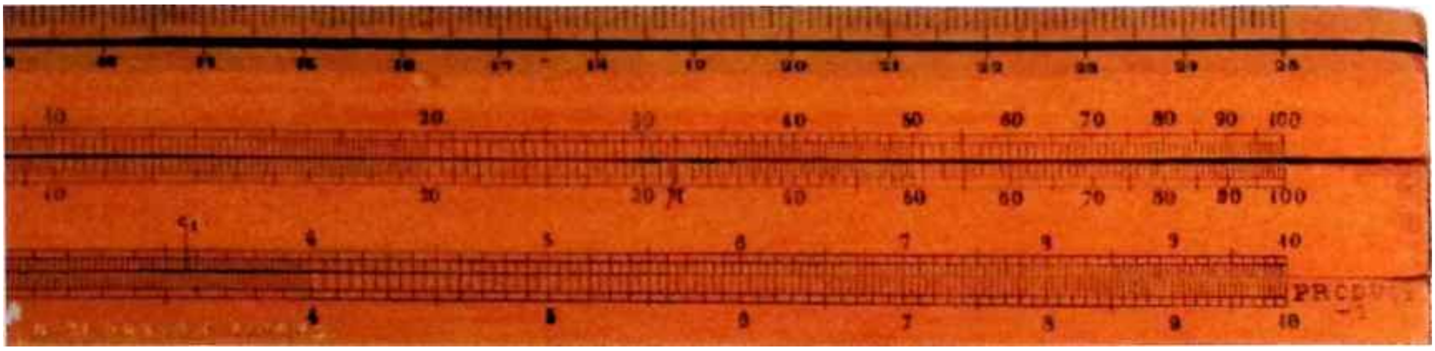


Figure 3.8.1.3.R: Right part of the front of the Mannheim system by A. IV. Faber. Werner Rudowski collection

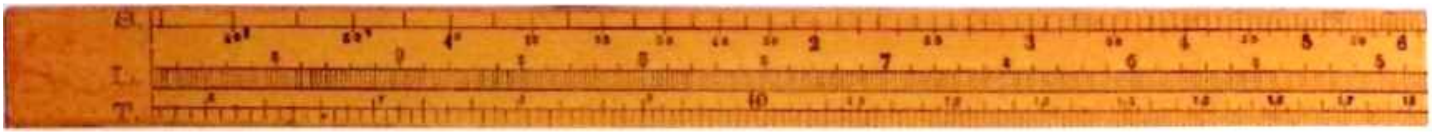


Figure 3.8.1.4.L: Left part of the back of the slide of the Mannheim system by A. W. Faber. Werner Rudowski collection

Figure 3.8.1.4.R: Right part of the back of the slide of the Mannheim system by A. W. Faber. Werner Rudowski collection

A special successor to the Mannheim system is the Electro calculator, type 368 (Fig. 3.8.1.5). There are three additions here:

- Two scales in the well of the body: one scale for the efficiencies of dynamo machines and electric motors; the other scale for the voltage drop,
- Knife-edge at the left end of the slide for reading the above-mentioned scales. In 1905 Faber gets DRGM 247514 with the description:

  Slide rule with knife-edge at the slide end.

- Cursor for a slide rule with an attached knife-edge pointer for the side surface of the body. (See Figure 3.8.1.6: Cursor with side knife-edge pointer). Faber gets DRGM 271 169 in 1906.

The two exponential scales are placed on the bevelled face of the slide rule so that the DRGM from Schweth can be bypassed. Wilhelm Schweth, government architect in Cologne, invented an exponential calculator in 1900 and received DRGM 148526 for it. The description reads:

> Exponential slide rule, which has two scales added to the front with the usual layout.

In 1905, D&P offered a comparable Electro slide rule based on the DRGM from Schweth (Fig. 3.6.1.5, p.35).

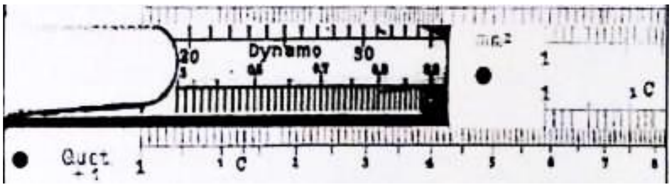


Figure 3.8.1.5.L: Left part of the Faber electro slide rule

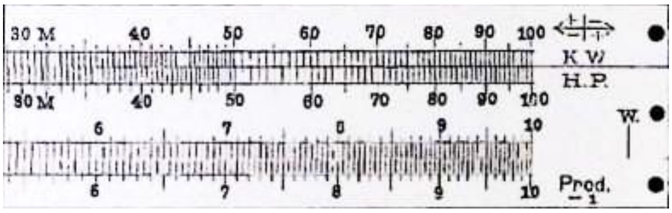


Figure 3.8.1.5.R: Right part of the Faber electro slide rule

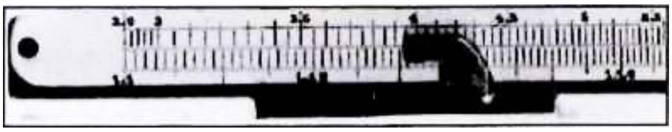


Figure 3.8.1.6: Cursor with side knife-edge pointer

It was only after 1907 that the celluloid veneer was attached with wooden pins. Until then, this is prohibited by the DRGM 164 885 from Nestler. The text of this Nestler DRGM from 1901 reads:

> Rulers, slide rules and the like with celluloid foils mechanically secured against detachment and alteration by screws or pins.

3.8.2. Dating in the Late Period

Because Faber did not start with slide rules until 1892, only the dating of slide rules from the late period, 1895 - 1905, is relevant. Utility models are better suited for this than patents because there are more DRGM than DRP in the period and the protection of DRGM is only 3 or 6 years. In addition to the marks on the front of the slide rule, its length is also revealing.

Year	Utility model	Subject
1898	DRGM 98 350	2 slots in the floor
1899	DRGM 116 832	Cursor with indicator
1905	DRGM 247 514	Slide end with knife-edge
1906	DRGM 271 169	Cursor with side edge

Figure 3.8.2.1: Utility models of Faber

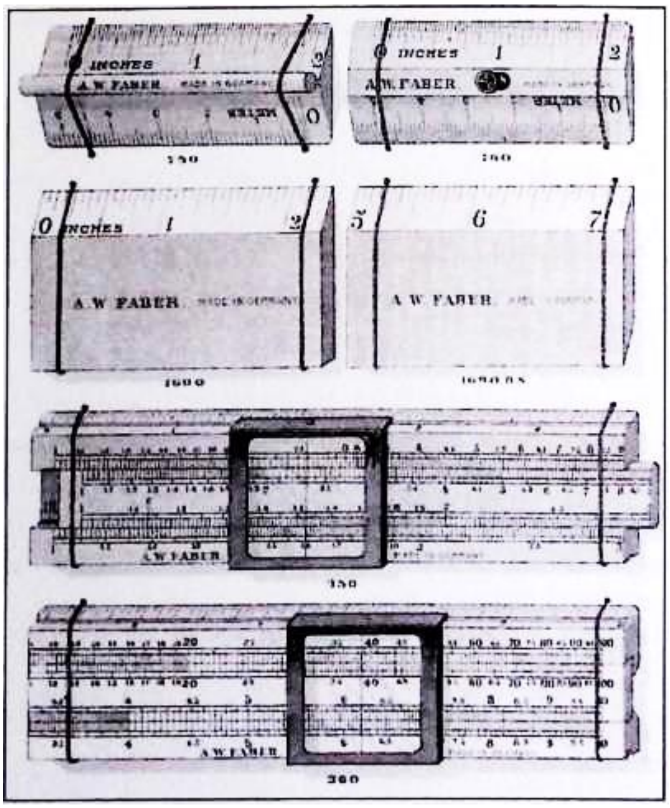


Figure 3.8.2.3: Wooden rulers and slide rules from Faber

Year	π	M	c c1	Length
1895	A| B	...	C	26 cm
1899	A| B	B	C	28 cm
1899	A| B	B	C	28 cm
1906	A| B	A| B	C|D	28 cm
1906	A| B	A| B	C|D	28 cm

Figure 3.8.2.2: Marks on Faber slide rules

Explanation

A|B: π line and π symbol for scales A and B, or C and D. The constants are $M = 1/\pi = 0{,}3183$, $c = \sqrt{4/\pi} = 1{,}13$ and $c1 = \sqrt{40/\pi} = 3{,}57$ on the C scale or on the C and D scales.

The oldest slide rules are 26 cm long, have few marks and few lines and no slit. The newest slide rules are 28 cm long, have more marks and more lines and only one slit.

3.9. The Rietz System by Nestler, from 1903

3.9.1. Introduction

Max Rietz was born in Morrn near Landsberg an der Warthe (today's Poland) in 1872, and died in Erfurt in 1956. Rietz studied at the Technical University of Karlsruhe. In 1901 he came to Erfurt, where he lived at Schamhorststraße 18. He then got a job at the Trenck steam boiler and machine factory. When the factory closed its doors in 1920, he remained an independent engineer in Erfurt.

Figure 3.9.1: Max Rietz

In his field of expertise, Rietz has made several energy-saving inventions in the heating and refrigeration technology. Even at the age of 80, engineer Rietz contributed through his recommendations to the better economic use of steam boilers in breweries, waterworks and weaving mills. He is not only an advisor to these companies, but also a teacher to the workers, who are always in a dense circle around him. Despite great success, Rietz remains of an almost touching modesty.

The most important successor to the Mannheim system was invented by Rietz. The system is basically a Mannheim system extended by a cubic and a mantissa scale (see Figure 3.9.2). Max Rietz is granted DRGM 181 110 in 1902. The literal text reads:

> Slide rules with uniform (numeric), single, double and triple logarithmic scales on the slide rule body, and single and double logarithmic scales on the slide, for direct reading of logarithms, cubic numbers and cubic roots.

The cubic scale is new, like the position of the mantissa scale, which is moved from the back of the slide to the front of the body. This gives space for an extra scale. For the time being, the trigonometric ranges are:

- Sine 35' - 90°
- Tangent 5° 42' - 45°

In 1905 the layout was extended with an ST scale for small angles, 35' - 5° 42'; in this area, the sinus and tangent values are practically the same (see Figure 3.9.7 p.52). At the same time, the sine scale is returned to the original range, 5° 44' - 90°. The new trigonometric ranges are (see Figure 3.9.3):

- Sine 5° 44' - 90°
- Sine/Tangent 35' - 5° 42'
- Tangent 5° 42' - 45°

The sine and ST scales have a length of 25 cm and thus larger intervals. This allows more precisely setting or reading values and to achieve more accurate results. Thanks to the automatic dividing machine, Nestler can develop and engrave new scales in a shorter time.

In the Rietz system, the sine value on the C scale is above the final line of the D scale; the tangent value is on the C scale above the initial line of the D scale because the tangents scale is reversed (divided from right to left) (see Figure 3.9.3).

In the well there is the text:

- ALBERT NESTLER LAHR I/B

Hand-made Prototype

In 1957, Rietz's daughter Marianne donated his father's hand-made prototype (figure 3.9.5) to George Dennert, owner of Aristo-Werke, Dennert & Pape. Hans Dennert gave the author a copy.

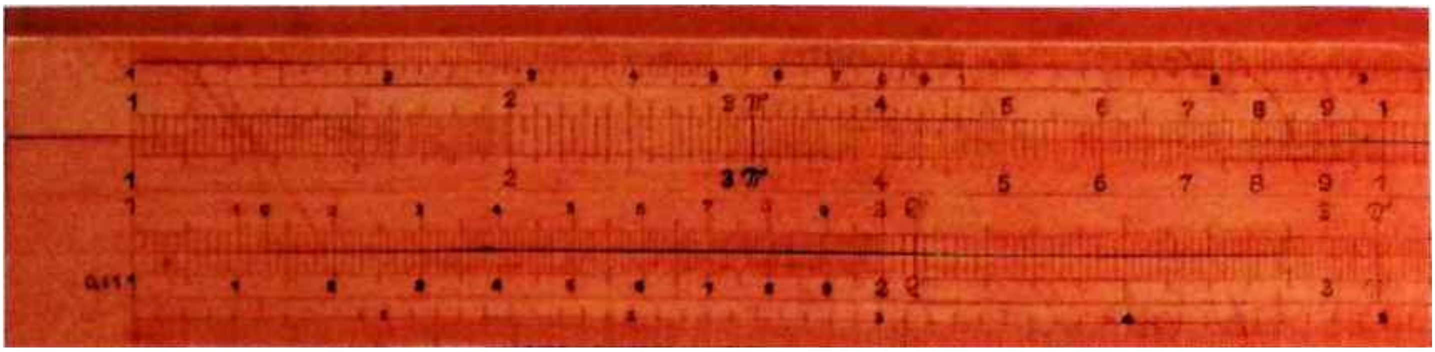


Figure 3.9.2.L: Left part of the front of the Rietz system from Nestler

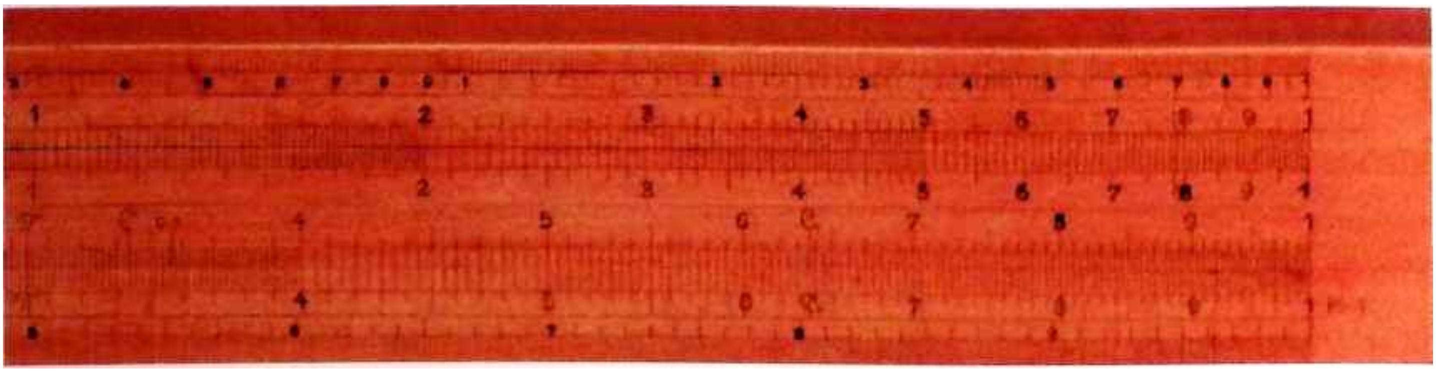


Figure 3.9.2.R: Right part of the front of the Rietz system by Nestler

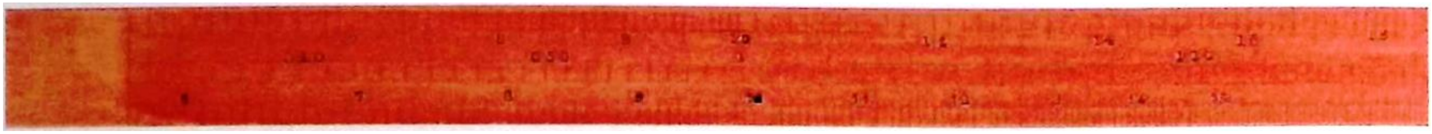


Figure 3.9.3.L: Left part of the back of the slide of the Rietz system by Nestler

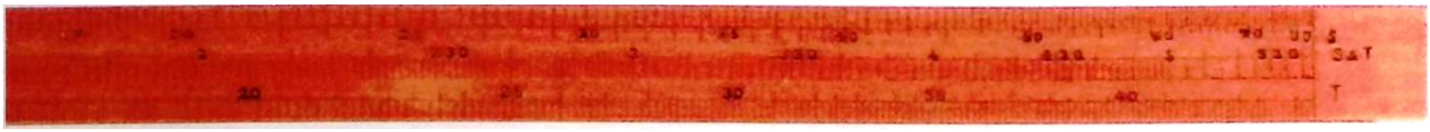


Figure 3.9.3.R: Right part of the back of the slide of the Rietz system by Nestler

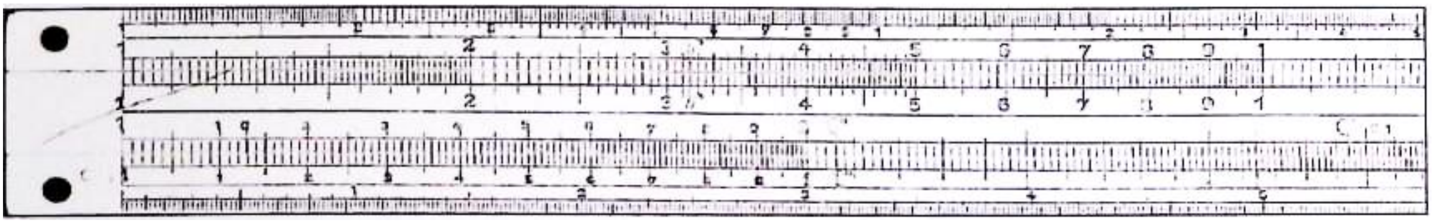


Figure 3.9.4.L: Left part of the front of the narrow version of the Rietz system from Nestler (25 instead of 31mm)

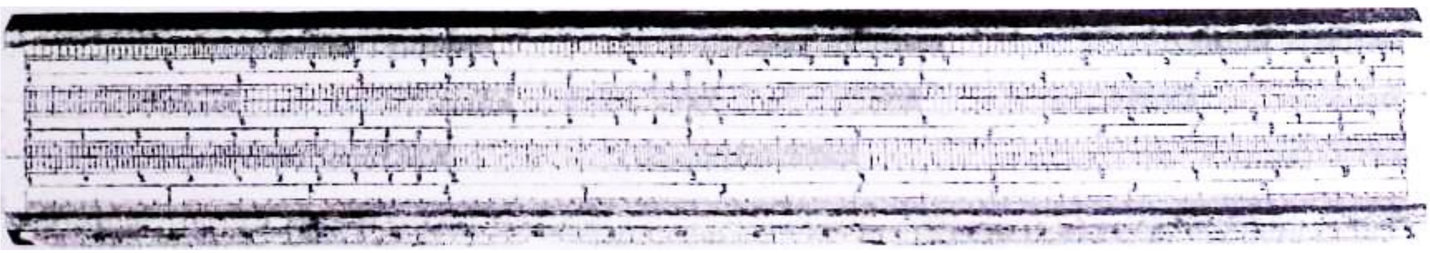


Figure 3.9.5: Rietz's own hand prototype from 1902. Irene Dennert collection

The Rietz system has a front width of 31 mm; the Mannheim system only 25 mm. For certain customers, this was impractical. Nestler therefore produced a narrow version of the Rietz system (see Figure 3.9.4.L). Nestler wrote in 1912:

> This narrow slide rule is a concession from the factory to those computers who, because they have been used to the narrow slide rule for a long time, do not want to use the wider ones at all.

The Rietz system has special marks and constants located on certain scales at certain positions.

Year	π	π/4	c c1	ζ"ζ,,ζ'
1902	A|B C|D	|AB	C C	C|D
1906	A|B C|D	|AB	C C	C|D

Figure 3.9.6: Marks on Rietz slide rules

Explanation

|AB: π line for scales A and B, or C and D; A|B: π line and π symbol for scales A and B, or C and D. The constants are: $c = \sqrt{4/\pi} = 1{,}13$ and $c1 = \sqrt{40/\pi} = 3{,}57$.

Table

The table for small angles (figure) shows that the sine and tangent values are almost the same.

Angle	Sine	Tangent
1°	0,0175	0,0175
2°	0,0349	0,0349
3°	0,0523	0,0524
4°	0,0698	0,0699
5°	0,0872	0,0875
5° 42'	0,0993	0,0998

Figure 3.9.7: Table for small angles

The ζ symbols (rho) give numbers for transforming angles into radians and vice versa: ζ" = 206265, ζ' = 3438' and ζ,, = 636629,,. These fixed values are calculated as follows, depending on the circle divisions (360° or 400g):

- ζ" = (180 x 60 x 60") / π = 206265" (360°)
- ζ ' = (180 x 60') / π = 3438' (360°)
- ζ,, = (200 x 100 x 100,,) / π = 636629,, (400g)

The scales of the Rietz system remain unchanged during the *Common Period*.

Later, two additions followed: in 1913 a reciprocal scale (invented in 1755 by Thomas Everard), and in 1924 divisions at the beginning and end of the scales, Nestler DRGM 889 460.

Until 1934 (the invention of the Darmstadt system), the Rietz system was the basis for further developments in the slide rule industry.

For Nestler, the Rietz system is formative.

Chapter **4**

Dennert & Pape and Albert Nestler, Capabilities and Cooperation

Despite all the technological improvements, the movement of the slide on the German slide rules from the period 1874-1905 is not better than on the French early Sohos

4. Dennert & Pape and Albert Nestler, Capabilities and Cooperation

This chapter contains the following sections:

4.1. The Capabilities of Dennert & Pape

Dennert & Pape has a rich tradition in precision mechanics. In 1862, Johann Christian Dennert (1829 - 1920) took over Carl Plath's workshop for geodetic instruments from Carl Plath (1825 - 1919). In 1863, the mechanic Martin Pape (1834 - 1884) joined as a partner. The company is now called *Dennert und Pape*, D&P, and is based in Altona (later Hamburg-Altona).

D&P built its first length dividing machine in 1862. It is first used for the production of rulers. Because each interval is set up by hand, the same machine can also be used for the dividing of slide rules. According to Hans Dennert in HD99, a slide rule dividing machine with 9 scoring movements follows in 1886 and 3 more later.

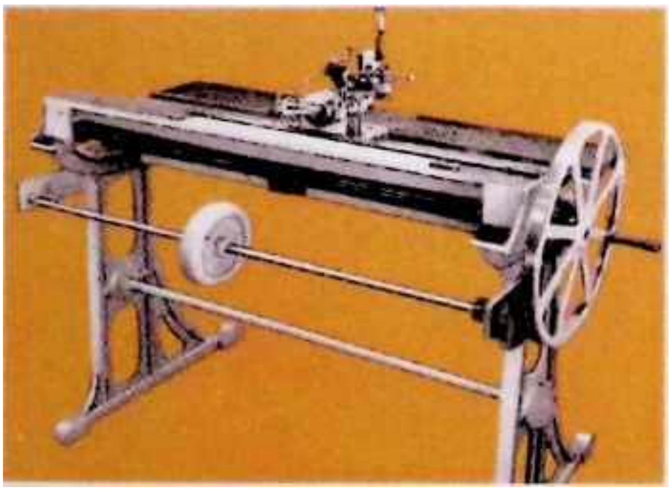


Figure 4.1: First dividing machine from D&P

4.1.1. Hair-accurate cursors

The expertise in precision mechanics is clearly recognizable in the development and construction of cursors. In 1873, D&P began to build a knife-edge cursor based on the French model. This model had the disadvantage that the wide front covers part of the scales, especially at the end.

Later, the two-sided knife-edge cursor, also called wing cursor, is added. This allows slide rules of 26 cm to be adjusted and read over the entire scale.

In 1882 a cursor is offered with a horse hair as the hairline, and in 1890 an aluminium cursor with the hairline etched on glass, the glass cursor.

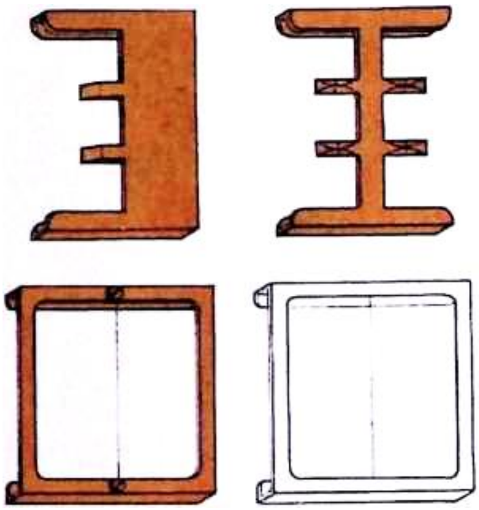


Figure 4.1.1.1: Development of cursors at D&P

In order to meet the demand for more functions, D&P was the first manufacturer to release a cursor with two hairlines shifted by a factor π/4, in 1892. In 1894, D&P received the DRGM 25 025 for:

> Slide rule cursor with a glass window held in the frame between screws and a protrusion.

In 1909 D&P received the DRGM 383 627 for a glass cursor with two metal frames without side strips, the free-view cursor (see figure), so that the scales are not partially covered. (See also *System Peuckert* section, p.99).

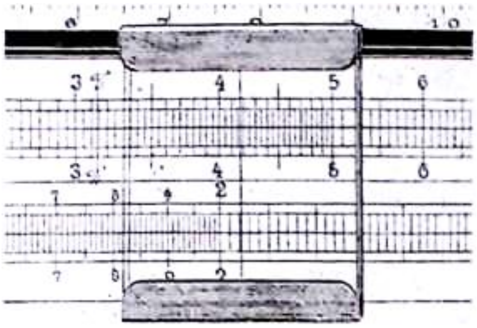


Figure 4.1.1.2: Free-view cursor from D&P

A high-quality example is the cursor of the slide rule by Robert Nelting (1876 - 1947) built by D&P around 1909. This cursor is a masterpiece of fine mechanics, but expensive to manufacture. It is provided with hairlines on all four sides, which can be adjusted independently of each other by means of screws (i).

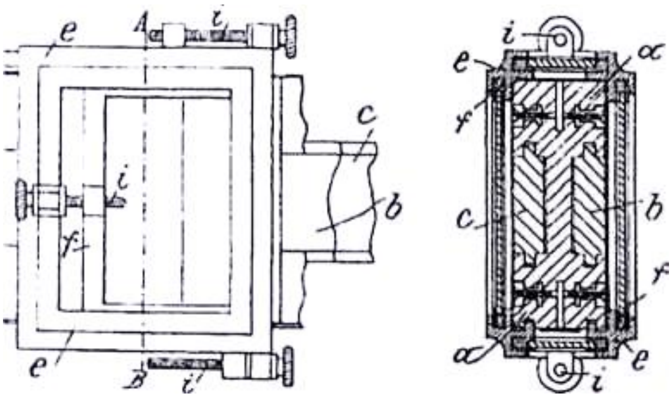


Figure 4.1.1.3: Cursor from Nelting

In 1912, the complete Nelting slide rule cost 140 Mk, two months' wages of a Hamburg dock worker.

Jochen Konrad-Klein reports in his article *Employed at Dennert & Pape* (see Section *6.3 Sources*, p.85):

> Bolte is the only employee who receives a kind of piece bonus. For each cursor he receives 7.5 Pfg. In 1913, Bolte produced 7450 cursors. Thus, his annual earnings are the highest of all employees.

4.1.2. The two-sided slide rule

In 1891, William Cox received a patent for a two-sided slide rule. Cox, an Englishman living in New York, receives US patent 460 930 on October 6, 1891. The slide rule will initially be manufactured by D&P in Germany on behalf of Cox and offered by Keuffel & Esser in America (see Figure 4.1.2).

The order confirms D&P's good reputation as a manufacturer of slide rules and cursors.

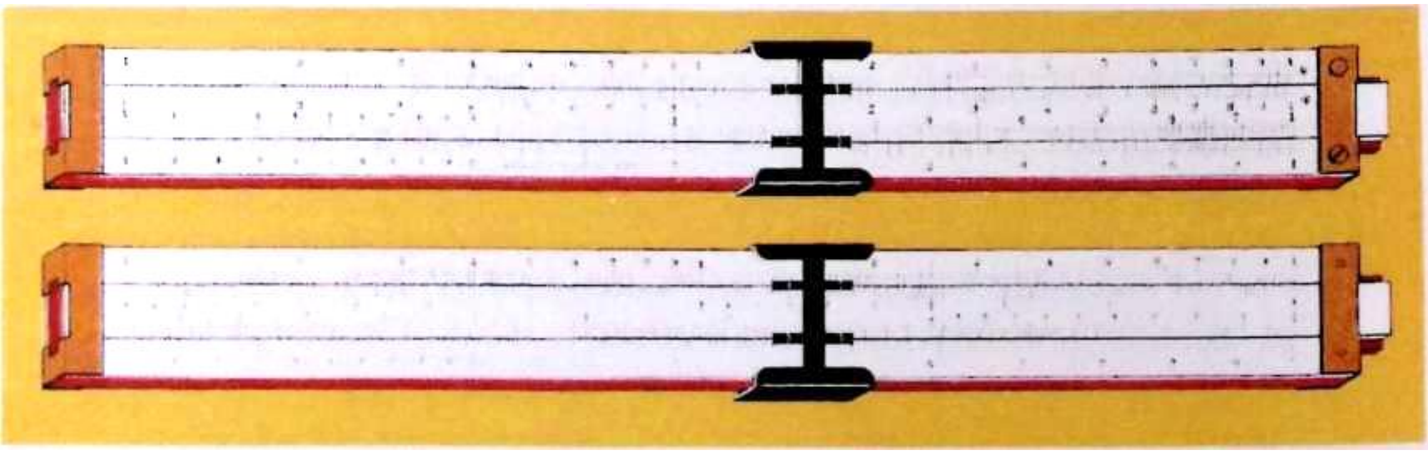


Figure 4.1.2: Two-sided slide rule by Willian Cox, manufactured by D&P

4.2. The Capabilities of Albert Nestler

The company Albert Nestler started under a different name. In 1878, the optician Theophil Beck (1814 - 1903) from Schaffhausen, and the merchant Albert Nestler (1851 - 1901) from Lahr, founded the *Maaßstabfabrik Beck und Nestler*. The gentlemen had met each other in Strasbourg, then the capital of the Imperial Land of Alsace-Lorraine.

In 1880, the manufacture of slide rules was also included in the production program. A year later, Beck leaves the company and founds a dividing workshop in Strasbourg.

In 1895 the company name becomes *Albert Nestler*. Collectors will therefore search in vain for slide rules with the name *Albert Nestler* from the period 1880 - 1895.

Figure 4.2: Albert Nestler

4.2.1. The dividing machine from Beck

Beck develops a fully automatic dividing machine. According to the *Annual Report of the Chamber of Commerce (Lahr)* on the year 1878.

> The *Maaßstabfabrik Beck und Nestler*, which was founded in the year under review, is operated with a gas engine of 4 horsepower and employs 12 - 15 workers. In addition to a fully equipped carpenter's shop and mechanical workshop, there are 6 self-constructed dividing machines at work, whereupon every measure can be divided into the finest parts. All kinds of drawing and measuring instruments are made. The logarithmic dividing machine recently invented by the owner Beck and built in the factory should be listed as the only existing machine. This very complicated machine produces the slide rule, well known in specialist circles, which until now could only be produced with same precision by Tavemier-Gravet, a manufacturer of Paris.

This dividing machine will also prove to be Nestler's great success factor. With this machine, any logarithmic scale can be engraved in any position and length.

The capacity of the dividing machine is considerable. Depending on the scale length, 12½, 25 or 50 cm, the output per setting is 66, 30 or 16 slide rules.

The speed is considerable: in 400 seconds, 66 small slide rules, of 12½ cm, can be divided, or 30 medium-sized ones, of 25 cm, (see AN04, section 3.4 - 3.7, p.13-17).

Hans Dennert has given data that can be used for comparison: In the same period, dividing at D&P takes place exclusively as a one-off production and takes about 3 hours (see AN04, figures 3.7.1 and 3.7.2, p.17). Around 1900, D&P built a 9-arm dividing machine. Later a 20-arm machine.

The effective performance of a dividing machine is partially determined by the number of engravers (arms).

In manual manufacturing, the expert divider is the limiting factor. He has to read every step from a list, set the interval manually and check it visually. In the case of defective scorings, there is reject.

With a fully automatic dividing machine, these problems do not occur.

In the *Common Period*, Nestler focuses mainly on what they can do very well: dividing the scales. Blanks and cursors are sourced from D&P. The blanks are gradually improved by Nestler and finally they came up with their own manufacture. The cursors follow a similar path.

4.2.2. Rollers and wheels

The heart of the automatic dividing machine are the rollers (Figures 4.2.2.1 and 4.2.2.2) and the worm gears (Figures 4.2.2.3 to 4.2.2.8).

The roller for dividing spaces in slide rules has a length of 33 cm and a diameter of 20 cm.

The roller for line lengths of slide rules has a length of 16,5 cm and a diameter of 16 cm.

In order to be able to compare the functions of the rollers and wheels with the respective slide rule, a figure (4.2.2.9) of a contemporary Rietz slide rule is shown.

4.2.3. Swiss made, the Swiss slide rules

In 2000, the first Nestler slide rule appears which the text *Swiss made* in the well. This term use is strictly protected by law in Switzerland. An explanation for this designation, which is perceived as a qualification, was not found despite the efforts of many people.

In recent years, more *Swiss made* specimens have appeared. So far (spring 2009), the author is aware of nine of these Swiss slide rules. It is noticeable that the first *Swiss made* specimens were not offered until 1954:

- Hans Kordetzky collection, Cham, Switzerland: System Landis & Gyr, 25 cm, 1973
- Timo Leipälä collection, Turku, Finland: System Darmstadt, type 11D, 12,5 cm, 1954
- Willy Robbrecht collection, Lebbeke, Belgium: System Darmstadt, type 0210, 25 cm, 1958
- H.P. Schaub collection, Allschwil, Switzerland: System Mannheim, type 14/52, 25 cm, 1954; System Mannheim, type 14/RO, 25 cm, 1954; System Kaufmann, type 40 N, 25 cm, 1955; System Darmstadt, type 21, 25 cm, 1955; System Rietz, type 0232, 25 cm, 1958;
  System Rietz, type 23R/3, 25 cm, 1913
- Pierre Vander Meulen collection, Wezenbeek-Oppem, Belgium:
  System Rietz, type 0232, 25 cm, 1958
- Author's collection, Soest, Netherlands:
  System Mannheim, type 14/52, 25 cm, 1954; System Darmstadt, type 0210, 25 cm, 1958

Recently, Jürgen Nestler has further investigated the origin of the Nestler company and has come across an invention by Jakob Siegrist (see section 3.7.1, p.39). He worked in Lahr for only 6 months. When he returned to Schaffhausen in 1878, he founded the Siegrist rulers factory (Maßstabfabrik).

Due to the constant expansion, the factory had to be relocated near the train station in 1889 and to Stein am Rhein in 1913. In 1923 the factory was bought by the Nestler company and converted to the *Maßstabfabrik Schaffhausen AG*, or *Massag* in short.

Massag's annual report for 1954 states the following:

> In addition, in summer the company started dividing slide rules. In this way, the company has the opportunity to export to countries where there is a demand for slide rules of Swiss origin for commercial reasons.

Thus, the mystery of the *Swiss made* specimens is finally solved and the collectors have slide rules legally manufactured in Switzerland. The author's assumption (see AN01, p.15) has proven to be correct, to a certain extent.

4.2.4. Figures of rollers and wheels

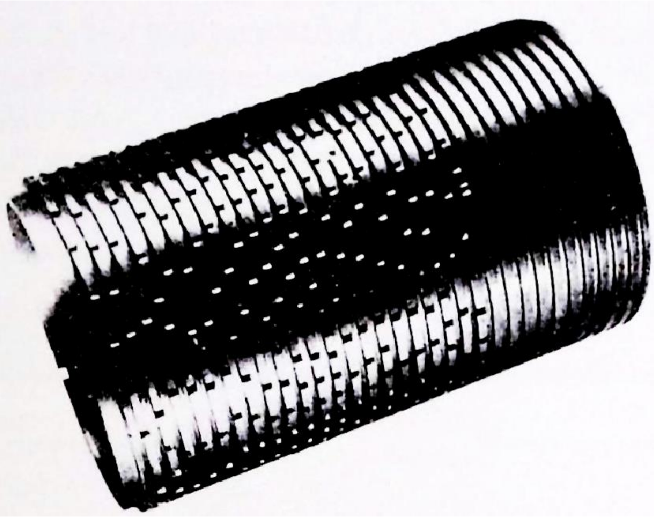


Figure 4.2.4.1: Roller for dividing distances

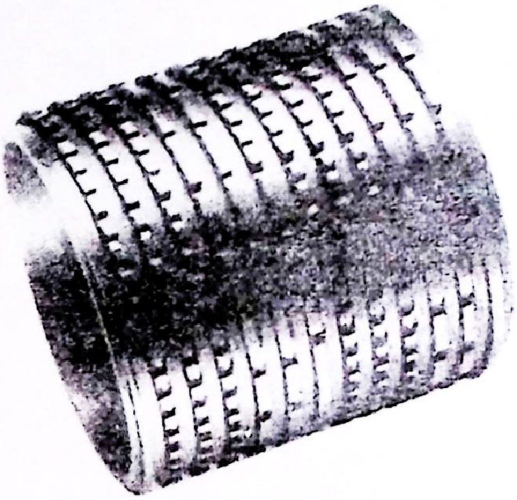


Figure 4.2.4.2: Roller for line length

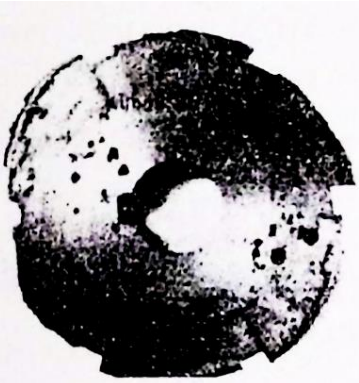


Figure 4.2.4.3: Wheel for K scale

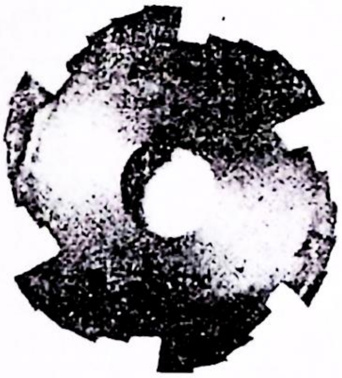


Figure 4.2.4.4: Wheel for A and B scales

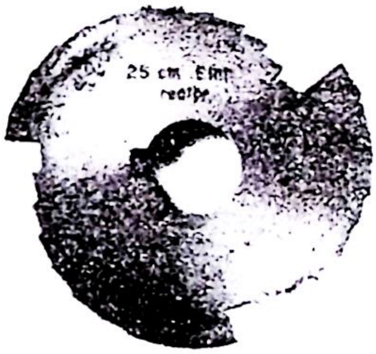


Figure 4.2.4.5: Wheel for CI scale

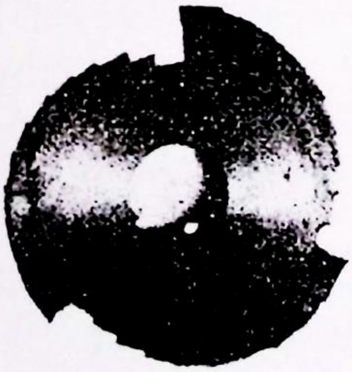


Figure 4.2.4.6: Wheel for C and D scales

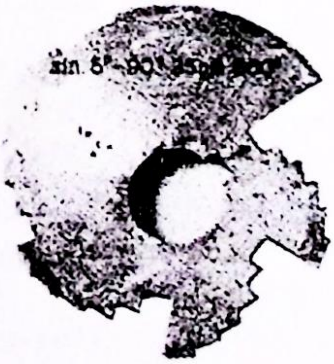


Figure 4.2.4.7: Wheel for sines scale

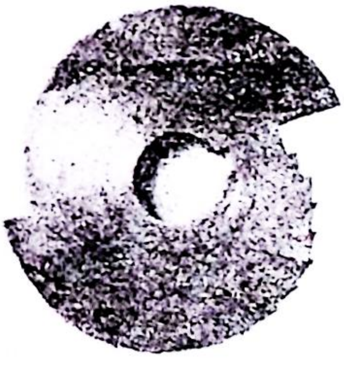


Figure 4.2.4.8: Wheel for tangents scale

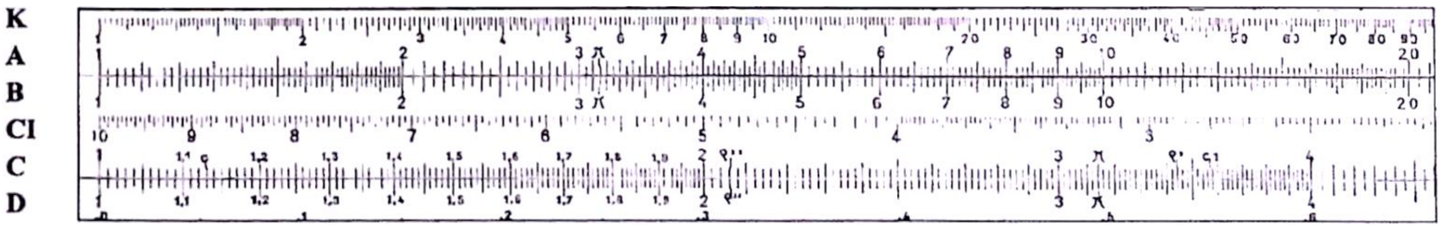


Figure 4.2.4.9: Left part of the front of the Rietz system

4.3. The Development of Slide Rules at Dennert & Pape

Dennert & Pape's progress is based on a patent, a utility model, practical experience with celluloid, production in economic quantities, and an accepted misunderstanding.

4.3.1. The DRP 34 583, immutable ruler

D&P's most lucrative patent is undoubtedly DRP 34 583 from 1885. You could call it the celluloid coating patent, but it's called the *Immutable Ruler*. The claim reads:

> Rulers made of soft wood, which are lined in the direction of the wood fibres with extremely thin layers of celluloid to receive the divisions.

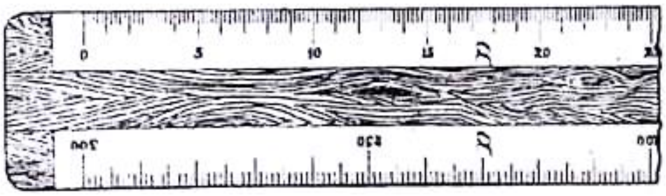


Figure 4.3.1: Immutable ruler, according to patent description

This DRP has often led to misunderstandings because it is assumed that the patent is also valid for slide rules, although this is not clear from the patent description. Hans Dennert wrote the following to the author on April 29th, 1999:

> The above patent (DRP 34 583) related to rulers with celluloid coating. There was no patent for slide rules, which were produced in the same way only after the positive experience with the rulers.

4.3.2. The DRGM 37 191, slit well

A utility model that is very important in the *Common Period* is DRGM 37 191, of February 19th, 1895, with the following description:

> Slide rule with slit in the body well for guiding the slide.

See Figure 4.3.2 with slits on the left and right. D&P wants to eliminate transverse tensions and improve the flexion effect. Because D&P and Nestler use the same bodies, they can be produced economically in large quantities.

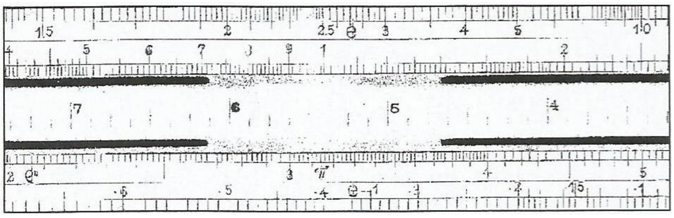


Figure 4.3.2: Slit well

According to Hans Dennert in HD72, D&P produced slide rules with slit wells as early as 1890. This is documented in the 1890 catalogue of Keuffel & Esser, New York.

4.3.3. The DRP 126 499, flexible plate

In the 2nd half of the *Common Period*, there is another patent that gives the bodies a solid base. DRP 126 499 is issued on March 10th, 1901. The claim reads:

> Slide rule with wooden sides and wooden slide, characterized in that the base connecting the sides consists of a plate that is somewhat flexible in the transverse direction.

And the patent description states:

> A celluloid plate can be selected for this.

There is no mention to a metal plate.

Wilhelm Rees receives the DRGM 190 019, on December 3rd, 1902, with the description:

> Slide rule with flexible metal plate in the well.

Until 1905, D&P only produced slide rules with a celluloid plate (see Figure 4.3.3.1) and from 1905 only with a metal plate (see Figure 4.3.3.2) Is this material change due to Wilhelm Rees' DRGM?

Figure 4.3.3.1 shows the drawing of the patent description, a variation without side veneer and the design in a system Frank specimen (see section 4.5.2.1, p.68).

Figure 4.3.3.1 a: Slide rule with celluloid plate

Figure 4.3.3.1b: Slide rule with celluloid plate

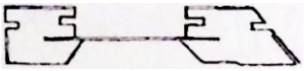


Figure 4.3.3.1 c: Slide rule with celluloid plate

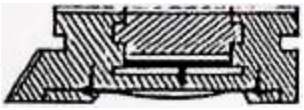


Figure 4.3.3.2: Slide rule with flat spring

The metal plate, also called flat spring, is attached to the body by means of wooden screws.

Johann Christian Dennert received a patent for this slide rule innovation on 25 February 1902 in the USA with the number 694 258.

4.3.4. The DRGM 148 526, exponential slide rule

This utility model, DRGM 148 526, is the exponential slide rule, invented on December 15th, 1900, by Wilhelm Schweth, government architect in Cologne (see Figure 4.3.4). The description is:

> Exponential slide rule, in which two scales are added to the usual layout on the front.

This log-log slide rule design is the basis for the Electro slide rule according to Schweth (see HD78, p.16).

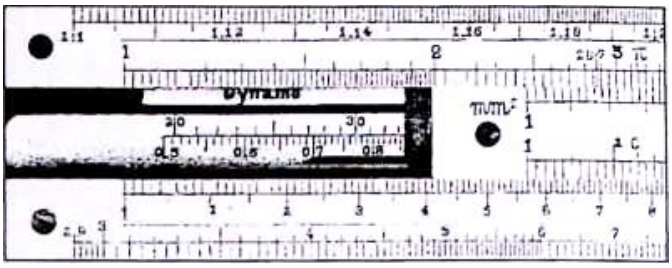


Figure 4.3.4: Electro slide rule according to Schweth

4.3.5. The DRGM 192 052, adjustment screws

The last innovation concerns DRGM 192 052 from 1903. The description states:

> Slide rule with movable body guides for the slide and control means to change the lateral guides pressure.

The regulating means are adjusting screws on the side. For a slide rule of 25 cm, 5 screws are provided. The figure 4.3.5.1 shows their position.

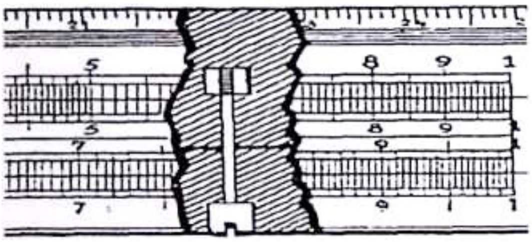


Figure 4.3.5.1: Position of the adjustment screws

In order to adjust the inner width of the body, five overlapping slits are sawn in the well (see Figure 4.3.5.2). By means of the lateral screws, the inner width and thus the mobility of the slide can be precisely adjusted.

One of the best-known applications of this DRGM is the D&P Electro slide rule from 1905, probably the first Electro slide rule from a large manufacturer (see Figure 3.6.1.5, p.35).

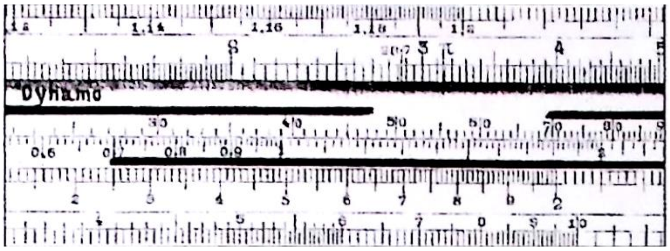


Figure 4.3.5.2: Overlapping slots

This DRGM is particularly important for slide rules with a scale length of 50 cm, because length curvatures are relatively more serious for large slide rules.

4.3.6. The pocket calculator, System Simplex

Until 1903, D&P produced slide rules in two scale lengths, 25 cm and 50 cm. From the very beginning, Nestler also manufactured pocket slide rules, scale length 12.5 cm.

Small slide rules are handier and a somewhat inaccurate calculation result is acceptable for certain applications. That's why D&P offered its pocket calculator system from 1903 onwards.

The design is simpler (see Figure 4.3.3.1b) and therefore cheaper to manufacture. The slide lies between two guides which are glued and mounted with screws on a celluloid plate.

In 1903 in *the Journal for Surveying* appears a figure of a slide rule with the letters A, B, C and D for the scales, and 4 nickel silver screws (see Figure 4.3.6.1).

In 1905, a similar figure (4.3.6.2) without screws appears in the D&P *Price List*.

Later, D&P offers a pocket slide rule with rivets (see Figure 4.3.6.3). D&P has thus respected Nestler's utility model for nickel silver screws.

This body structure is also delivered to Nestler as a 23 cm blank. In 1905, this resulted in the Timber-dealer system (see Figure 5.L, p.77). A final example of the cooperation between the two manufacturers at the end of the *Common Period*.

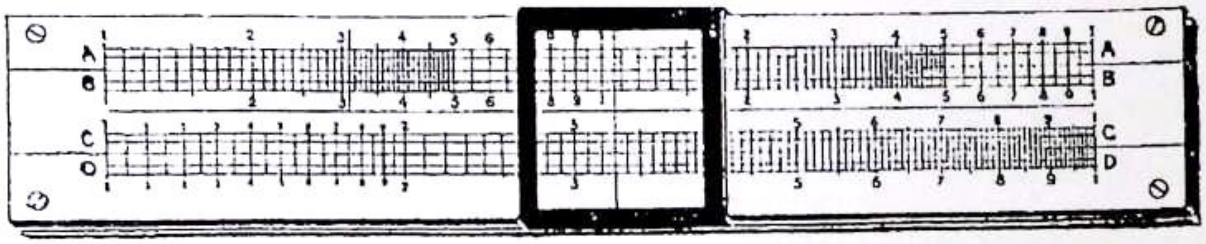


Figure 4.3.6.1: 1903 system Simplex pocket slide rule with screws. Journal of Surveying

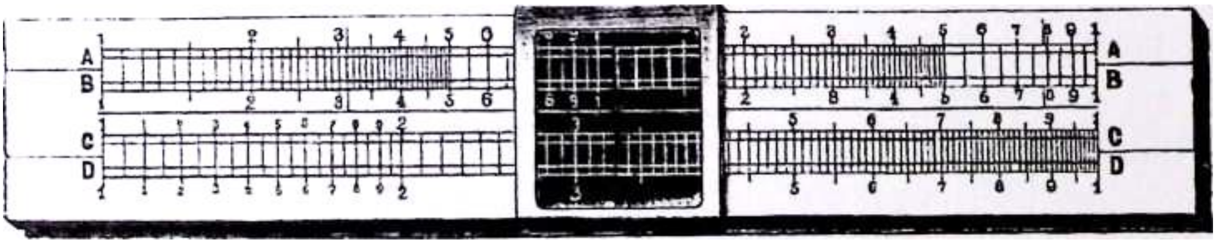


Figure 4.3.6.2: 1905 system Simplex pocket slide rule without screws. Price list of D&P

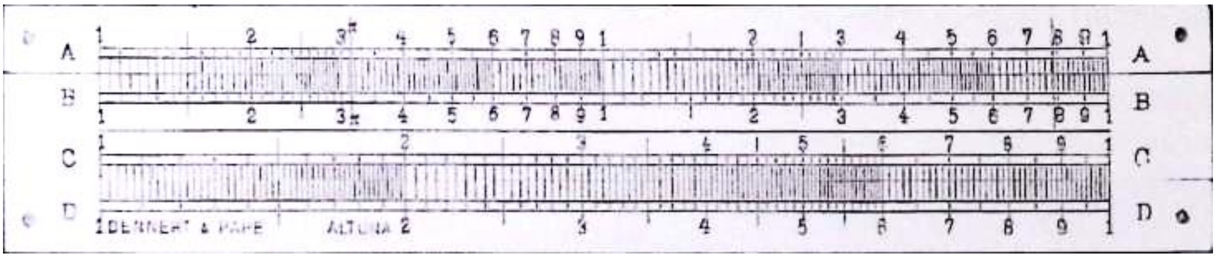


Figure 4.3.6.3: System Simplex pocket slide rule with rivets. IJzebrand Schuitema collection

4.4. The Development of Slide Rules at Nestler

Nestler made Mannheims from boxwood from 1880 to 1925. From 1892, Nestler also offered Mannheims with celluloid veneers, which were purchased as blanks directly from D&P. These blanks are constantly being improved and finally Nestler gets its first patent and thus lays the foundation for its own production. This development is described below step by step.

4.4.1. Blanks with four slits in the well

On February 19th, 1895, Dennert & Pape receives the DRGM 37 191 for:

> Slide rule with slitted body well holding the slide.

As a result, the flexion of the body is improved, and the transverse tensions are reduced.

Over the next 10 years, Nestler will use these blanks with four slits (see Figure 4.4.1) as a basis for further improvements.

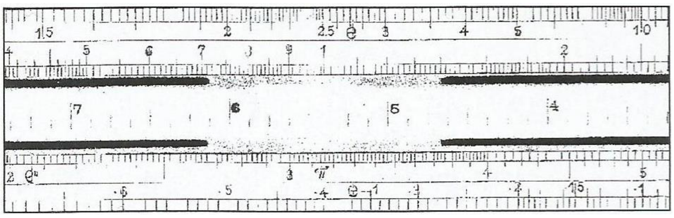


Figure 4.4.1: Slide rule with four slits

4.4.2. The DRGM 41 294, two-sided covering

The blanks purchased from D&P are structurally improved by Nestler. On May 15th, 1895, Wilhelm Rees, from Freiburg, receives the DRGM 41 294 for:

> Slide rule with celluloid covering on both sides of the well.

This makes the flexion of the body more stable. Nestler takes over these rights from Rees.

In the first years of the DRGM, the covering of the well has the same width as the base plate (see Figure 4.4.2a). From 1900, the entire width of the back is occupied (see Figure 4.4.2b). This is a useful feature for dating these slide rules.

Figure 4.4.2a: Double-sided covering

Figure 4.4.2b: Double-sided covering

4.4.3. The DRGM 164 885, nickel silver screws

In 1901, Nestler received the DRGM 164 885 on an improved, double purpose concept, in which the ends of the celluloid plates were fastened with screws. The text reads:

> Rulers, slide rules and the like with celluloid foils mechanically secured against detachment and alteration by screws or pins.

The author owns a Mannheim system with the text *patent pending (Patent angemeldet)* in the well (see Figure 3.7.4 p.45). The author does not know whether this patent registration was ever granted.

This DRGM is known as the nickel silver screws, but the original claim is much broader. At Faber it delayed until 1907 the use of wooden pins to prevent the detachment of the celluloid foils.

The screws will be the hallmark of Nestler slide rules for the next 45 years (see figure).

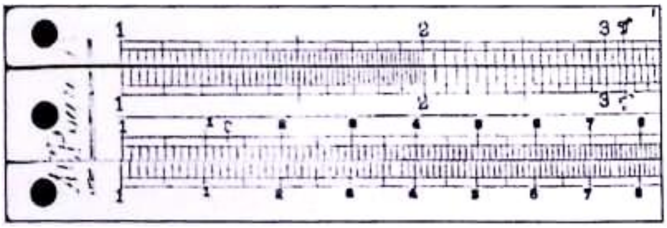


Figure 4.4.3: Slide rule with nickel silver screws

4.4.4. The DRGM 181 110, slide rule system Rietz

The system is basically a Mannheim system extended with a cubic and mantissa scale (see Figure 4.4.4) and is also called cube slide rule. Max Rietz gets DRGM 181 110 in 1902. The original text reads:

> Slide rule with even (numerical), single, double and triple logarithmic scales on the body and single and double logarithmic scales on the slide, for direct reading of logarithms, cubes and cube roots.

Figure 4.4.4: Slide rule System Rietz

4.4.5. The DRP 173 660, the flexible rubber plates

In search of further improvements in the mobility of the slide, Nestler used rubber and in 1905 received the DRP 173 660. The text reads:

> Slide rule, rule or the like with guides pressed resiliently against the slide with the interposition of a rubber plate.

The slide rule is characterized in that the guides are fixed to their base body with the interposition of an elastic plate (c) in order to achieve both a tight fit of the slide on its guide and easy movement (see figure).

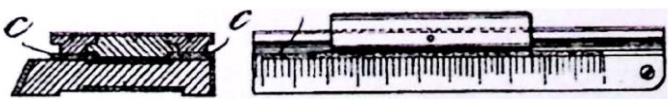


Figure 4.4.5: Slide rule with elastic rubber plates (c)

4.4.6. In-house production

Nestler slide rules with DRP 173 660 are no longer milled from solid wood, but the guides are fixed on the base body, together with the rubber plate. This requires a completely different production method. Nestler is thus going his own way.

Albert Nestler, the founder, died in 1901. The two sons Richard and Albert jr. take the lead. The change of leadership is the beginning of a period of prosperity for Nestler: three quarters of all system innovations are implemented in just twelve years.

Extensive orders from Reich authorities, industry and technical universities are responsible for the rapid development from 1900 onwards. Between 1901 and 1905, the taxed trade income tripled. Nestler is thus able to finance its own production itself. Another three-story production building is built in 1905. At Dennert & Pape, too, management changes take place in 1904: Richard and Jean Dennert, sons of Johann Christian, become partners. 1908 Johann Christian retires from the management.

Dennert & Pape breaks new ground with DRP 126 499 (flexible plate) (see section 4.3.3).

The *Common Period*, thus, comes to an end.

4.5. Cooperation in Europe

The expertise of D&P and Nestler proves to be complementary. Together, they can successfully support other companies, such as Ahrend. In the *Common Period* D&P and Nestler collaborate on the development and production of slide rules.

In addition, the Frank and Perry systems are discussed because there is new information and the Nestler book (AN04) with the detailed descriptions is (almost) out of print.

4.5.1. Ahrend slide rules

The slide rules in this section are the result of a collaboration between Dennert & Pape and Albert Nestler. Because Ahrend is the client, they are hereinafter referred to as Ahrend slide rules. A comparison of these slide rules is very informative.

Ahrend is a Dutch trading company for arithmetic and drawing utensils, founded in 1896 by Jacobus Ahrend. When he reports to the Chamber of Commerce in Amsterdam, he says he comes on behalf of his mother, who is a widow. From the very beginning, the company was called Weduwe (widow) Ahrend.

Two days later, Jacobus says to her:

> *We have set up a trading company; You only need to pay for the stamps.*

The company still exists today.

In the Ahrend biography it is described that the company already offered Nestler rekenstokken (slide rules) in 1897. The author has two specimens from this period. These slide rules were clearly manufactured as blanks by Dennert & Pape. This can be recognized by:

- the cursor with the wide upper beam,
- the wide cursor upper track,
- a bevelled drawing rule of 26 cm,
- the bevelled rear reading window,
- the absence of the celluloid coating on the back of the body, and
- the special marks (see section 3.6.4, p.38) on the back of the slide.

Dennert & Pape delivered these blanks to Nestler, and they:

- carved the scales on the front,
- added the π mark and fastened the screws.

In this way, the slide rules get a more modern look.

Ahrend has removed the logos of the manufacturers and the DRGM number. With this, the customer buys an Ahrend slide rule. At the beginning of 1900, a local trading company was closer to the Dutch customer than a foreign manufacturer. In the well (see figures) it says:

- HOLLANDIA-REKENSTOK
- WED. J.AHREND & ZOON, AMSTERDAM

So much for what both slide rules have in common; however, there are also striking differences.

The older slide rule (see pictures 4.5.1.2 to 4.5.1.4) is signed by the former owner A.C. POUWELS. The back shows a 3 mm deep, V-shaped groove to provide the spring effect. Thus, the blank is very likely produced between 1888 and 1890, a useful indication for the dating of D&P slide rules. The numbering is punched by hand: the digits are unequally deep and not always well centred. There are 2 x 5 nickel silver screws mounted, which cannot rust.

The newer slide rule (see figures 4.5.1.5 to 4.5.1.7) has, barely visible, 2 x 2 slits in the well. On the back there is a strip of paper with Dutch text. The numerals are engraved and positioned centred. The ends of the body front are not rounded, which gives a modern look. The blank is probably fabricated after 1890. There are 2 x 3 steel screws mounted, which can rust.

Anyone who looks at the Ahrend slide rules (including the slide) from the back, immediately thinks of Dennert & Pape; but if you look at the front, you think of Nestler. Ahrend offered these as Nestler slide rules. These slide rules are prime examples of cooperation between the two manufacturers.

Figure 4.5.1.1: Ahrend logo

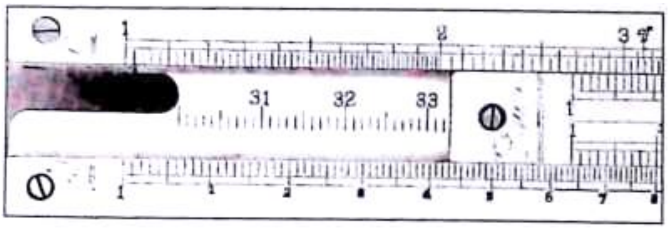


Figure 4.5.1.2: Front of the oldeer Ahrend slide rule

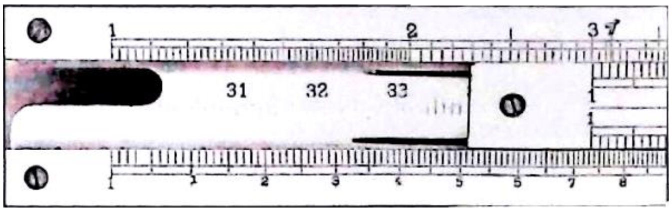


Figure 4.5.1.5: Front of the newer Ahrend slide rule

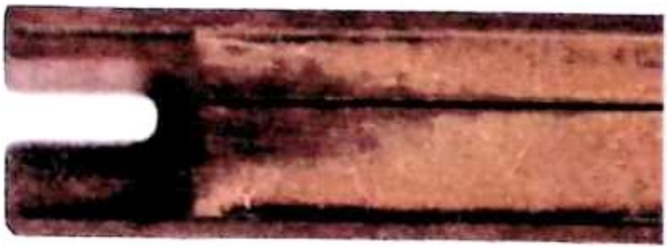


Figure 4.5.1.3: Back of the older Ahrend slide rule

Figure 4.5.1.6: Back of the newer Ahrend slide rule

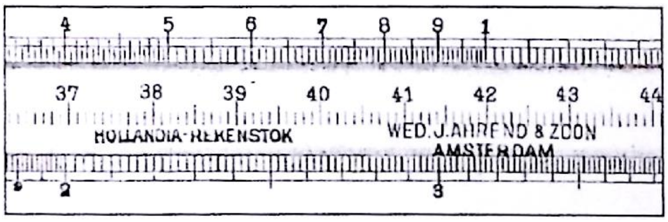


Figure 4.5.1.4: Well of the older Ahrend slide rule

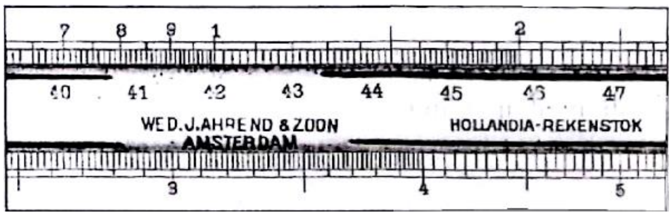


Figure 4.5.1.7: Well of the newer Ahrend slide rule

4.5.2. The Frank system

Wilhelm (Friedrich) Frank was born in Stuttgart in 1876 and died there in 1963. He lived all his life at Neckarstraße 241. Frank studies construction at the Royal Technical University of Stuttgart. There, in 1901, he was the first doctoral candidate at the Technical University of Stuttgart to receive the dignity of a Doctor of Engineering.

In 1902, Frank received Swiss patent 26 145 for his slide rule, which differed in *the way it was divided up logarithmically*. The patent mentions *greater accuracy and direct reading of the reciprocal values as advantages*.

In the same year, Frank receives DRGM 173 095 for *a slide rule with a reversed (reciprocal) scale, in which the logarithmic scales are broken down into individual sections.*

On April 27th, 1907, 40 days before the end of the protection period, this DRGM was transferred to the Albert Martz company (see AN04, p. 25). The reason for this is unknown to the author.

The Frank system is single pair of scales in which a decade length of 500 mm is divided into two halves. The system is therefore referred to as a single-scale slide rule (see Figure 4.5.2.1).

At 25 cm, the accuracy corresponds to that of a slide rule twice as long. Hammer says that he has determined a mean error of around ± 1/3000 for simple multiplications or divisions.

From 1908, the Frank system was manufactured by Dennert & Pape (also called DUPA) and offered as type 11. That this type is rare and somewhat impractical is evident from a letter from Hans Dennert to the author in 1998:

> With DUPA No. 11 you have incorporated into your collection a slide rule which was probably not made in very large numbers. With the so-called long-scale slide rule, the aim was to achieve the same number of digits on a slide rule with the length of 25 cm, as with one of 50 cm, using the scales cut at √10.
>
> From the instructions you can see the somewhat cumbersome way of working. It did not prevail due to the effort involved in relation to the result achieved. As early as 1935 there were no more models of this type in the DUPA program and in 1936 none were included in the ARISTO program.

There are three models of the Frank system, and successor systems, that can be best classified according to the dates of their design origin:

- 1902, first model, according to DRGM 173 095, in the name of Wilhelm Frank,
- 1907, second model, according to DRGM 314 734, in the name of the Albert Martz company,
- 1908, third model, according to DRGM 354 529, in the name of the D&P company.

It is likely that Albert Martz is the manufacturer of first model. Martz had experience from working with D&P before 1900. Second model is called *provided by Dr. Frank*, although Frank is not the holder of the 2nd DRGM. Was that an agreement between the Martz company and Wilhelm Frank?

As the third model was offered after World War I, the protection period for DRGM 314 734 had long since expired. As the owner of the DRGM, the company is of course the publisher. The Model 3 is only offered by D&P from 1909.

All three models of the Frank system show the same scale on the front. The difference lies in the scale at the back of the slide (see AN04, p.27).

- First model has a mantissa scale,
- Second model has two scales: x and x^3,
- Third model has scales for the reciprocals of squares and of cubes.

The slide rule made by Albert Martz show the Martz company logo on the well (see Fig. 4.5.2.4).

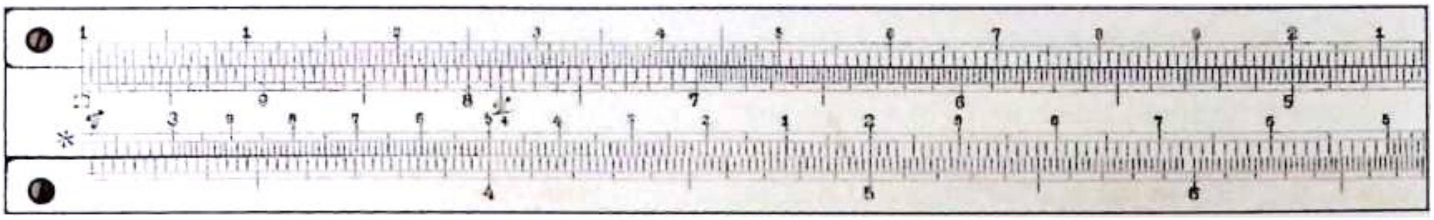


Figure 4.5.2.1.L: Left part of a Frank system, first model

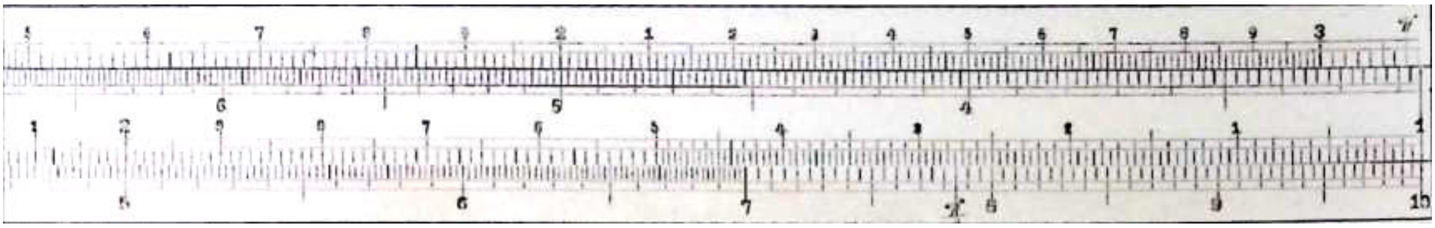
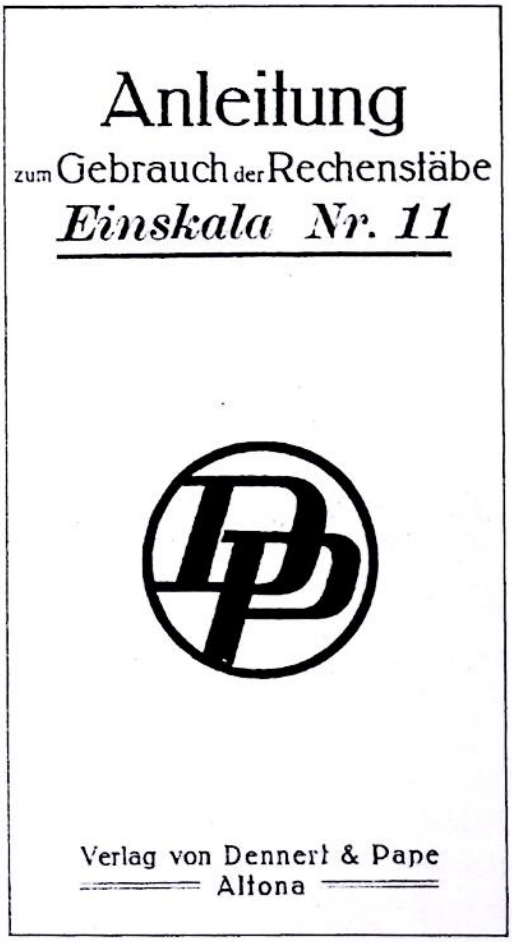


Figure 4.5.2.1. R: Right part of a system Frank, first model



Anleitung
zum Gebrauch der Rechenstäbe
Einskala Nr. 11

Verlag von Dennert & Pape
Altona

Figure 4.5.2.3: Instructions for the Frank system

Figure 4.5.2.4: Albert Martz's logo

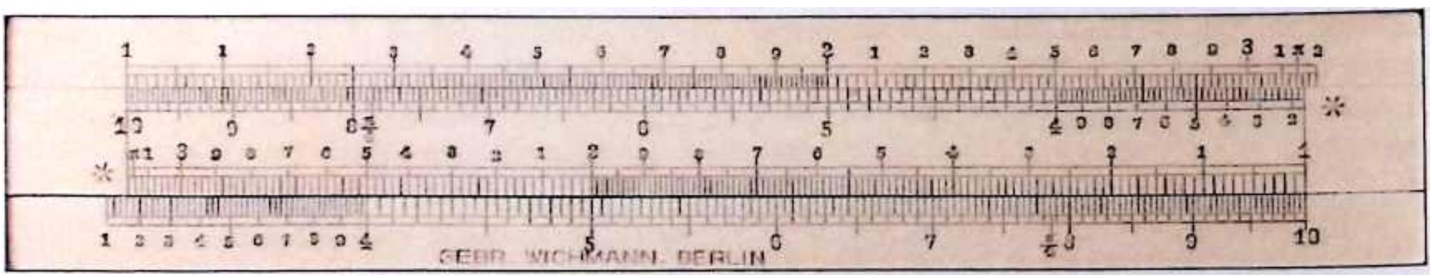


Figure 4.5.2.5: Systems Frank, third model

4.5.3. The Perry system

The English physician Peter Roget (1779 - 1869) invented the double logarithmic or log-log scales in 1814. His invention was forgotten; however, the log-log system was reinvented in 1901 by the English mathematician Perry.

John Perry was born in Garvagh, Northern Ireland, in 1850 and died in 1920. He worked as an assistant to Lord Kelvin at the University of Glasgow and later became Professor of Mechanics and Mathematics at the *Royal College of Science* in London.

Figure 4.5.3.1: John Perry

In 1896, the first edition of Perry's well-known book *The Calculus for Engineers* was published.

In 1901 he received the British Patent 23 236 for this invention. The slide rule is manufactured by Nestler and later offered as the Perry slide rule (see AN04, section 4.5.5 Manufacture and sale, p.31, for a discussion of the position of Thornton, Manchester).

Perry writes in the description of his patent:

> My invention relates to the slide calculating rules of the Gravet type and is designed to increase the utility of such rules. The ordinary slide rule is provided with four scales commonly known as A, B, C and D scales.

The drawing of Perry's prototype (see Figure 4.5.3.2) shows a modified system Mannheim, where the D scale is a log-log scale. Perry himself states in the patent specification that the log-log scale can be divided over two sections.

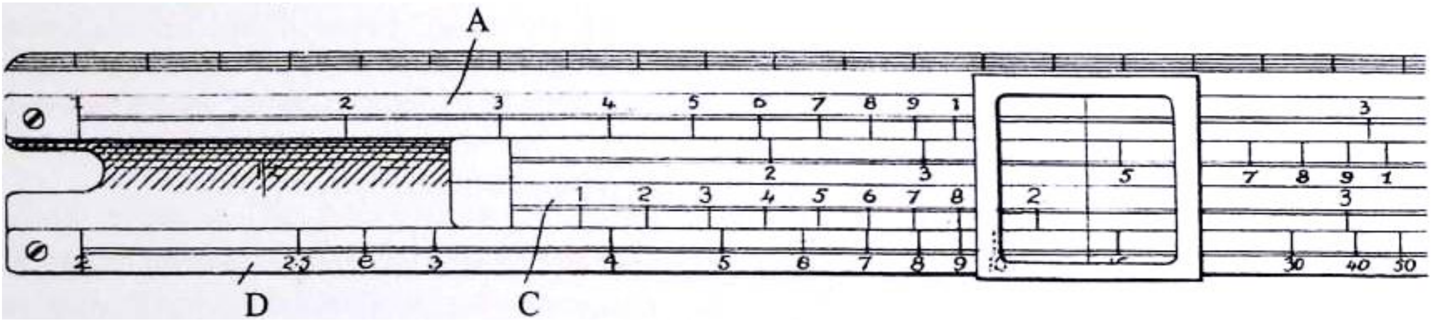



Figure 4.5.3.2.L: Left part of the drawing of Perry's prototype

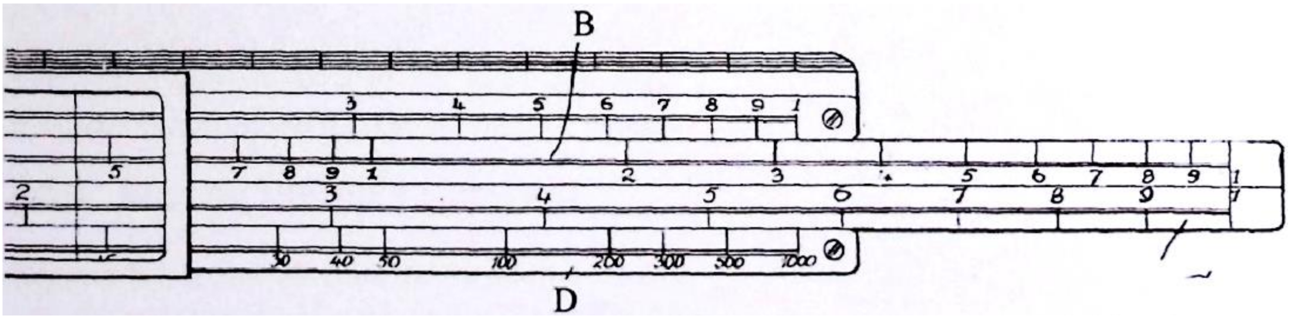


Figure 4.5.3.2.R: Right part of the drawing of Perry's prototype

In the Perry system from Nestler, this layout is implemented in this way, whereby the log-log scale segments have been attached in addition to the four Mannheim scales (see Figure 4.5.3.3.L).

The addition consists of a power scale at the top (1.1 to 0,95) and a power scale at the bottom (0,95 to 10^4).

The system is characterized by the fact that powers and roots with any whole and fractional, positive or negative exponents can be calculated with one adjustment of the slide.

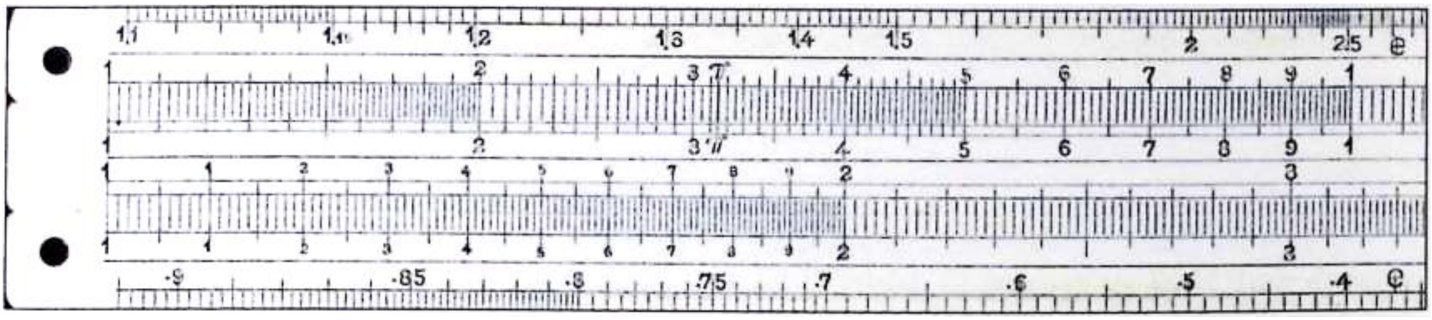


Figure 4.5.33.L: Left part of the Perry system by Nestler. David Rance collection

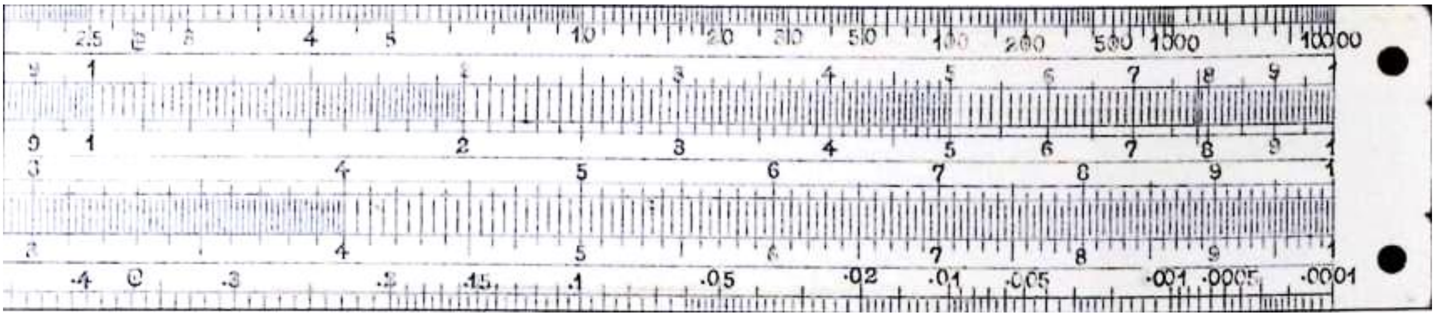


Figure 4.5.33.R: Right part of the Perry von Nestler system. David Rance collection

Figure 4.5.3.4: Perry System with *D.R. Patent 173 660*

Figure 4.5.3.4 shows the well of the system Perry. The four slits prove that the slide rule was made by D&P (see section 4.3.2, p.60). Nestler's patent number (see Section 4.4.5, p.64), the pi sign, and the rho marks prove that Nestler divided the scales.

Perry's slide rules are very rare. Apart from the one in the Science Museum in London, only four other owners are known to the author:

- Ray Hems, Thatcham, England
- Hans Kordetzky, Cham, Switzerland
- David Rance, Sassenheim, Netherlands
- Werner Rudowski, Bochum, Germany
- the author, Soest, Netherlands

In the slide rules of Werner Rudowski and Hans Kordetzky there is the DRP number 173 660 from 1905. Based on this information, it is unlikely that a Perry system was manufactured before 1906. Thus, the DRGM of Schweth from 1900 had been respected by Nestler.

With the exception of the last specimen, all the slide rules have been sold in England. Collectors will have trouble finding a Perry system in Germany. The Nestler log-log system remained functionally unchanged until 1934 when the exponential functions were taken over by the new Darmstadt system.

4.6. Cooperation in the USA

This section is a summary of sections 4.1, 4.2 and 4.4 of the second Nestler book, AN04, which is (almost) out of print. This excerpt is extended by the latest information on cooperation in the USA.

The capabilities of Dennert & Pape and Nestler prove to be both global and complementary. Together, they can successfully support other companies. During the joint period, D&P and Nestler did also work together in the USA on the development and production of slide rules. D&P supplies blanks; Nestler applies special scales.

In the USA, special slide rules are primarily those having special scales, mostly for samples or small series. Manufacturers can use them to further develop their prototypes; traders can thus explore the market. It covers sales areas far away from Germany.

The company histories of Dietzgen and Keuffel & Esser are presented below.

Two systems offered by Dietzgen are briefly explained: Rosenthal and Mack.

In the joint period, Keuffel & Esser offered slide rules from D&P and Nestler. Both made special slide rules for the American market.

4.6.1. Eugene Dietzgen company

Eugene Dietzgen was born in 1862 in Siegburg, at 20 km from Cologne, and died in Chicago in 1929. He immigrated to the United States in 1878. Shortly after arriving in New York, he began working for Keuffel & Esser. This puts him in touch with Otto Lühring. In 1891 Dietzgen bought out his partner Lühring share and founded the Eugene Dietzgen Company. From 1904 the first slide rules are sold. Among them are some very unusual models.

4.6.1.1. The Rosenthal system

Leon Walther Rosenthal, New York, is the inventor of a slide rule with which three numbers can be multiplied by a single setting. In 1904 he received US patent 767 170. The slide rule is a Mannheim system with a special B scale. The left half of the B scale has a reciprocal division, also known as the Br scale (see Figure 4.6.1.1.L).

The text in the well (see Figure 4.6.1.1.1) is difficult to see and reads:

Above: EUGENE DIETZGEN

Middle: D.R.PATENT NO 173 660 PAT. AUG 9, 1904

Below: CHICAGO NEW YORK

The slits prove that the blank is made by D&P. The German patent number 173 660 of 1905 (spring rubber plates) proves that the body is modified by Nestler; the nickel silver screws also support this. At that time, the Br scale with reciprocal division in the left half can only be automatically scratched by Nestler.

There are three reasons to believe that this is a prototype:

- The type number is missing,
- A π sign is missing, although a ¼ π line is present on B scale,
- The numbering of the sine scale (see Figure 4.6.1.1.2) starts in seconds (40, 50) and should then change to one minute. But that mark shows a 10 instead of a 1 (see Figure 3.7.1.3.L, p.41).

Figure 4.6.1.1.5 shows the Rosenthal system as it was offered as Type 1726A. The numbering is very detailed, patent and company specifications are on the front of the slide rule, and the π sign is on the left part of the A scale and on the left and right parts of the B scale.

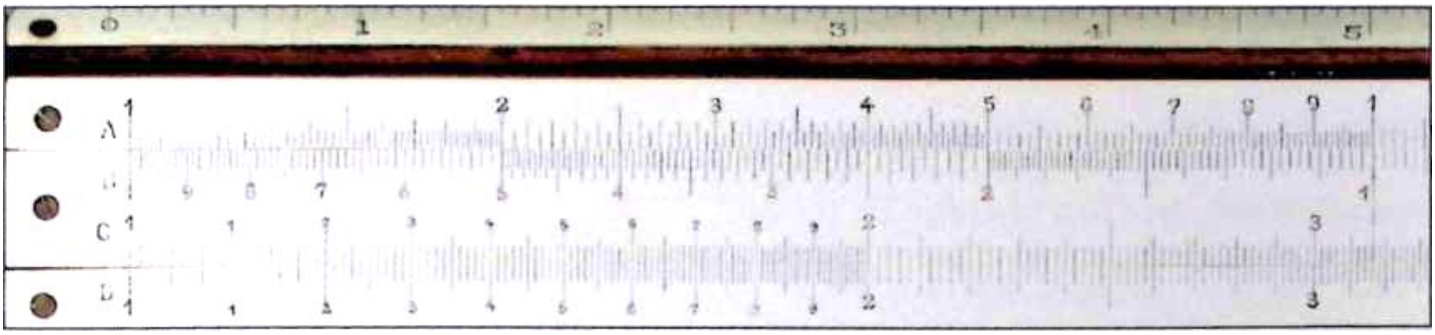


Figure 4.6.1.1.L: Left part of the front of the Rosenthal system from Dietzgen (prototype). Otto van Poelje collection

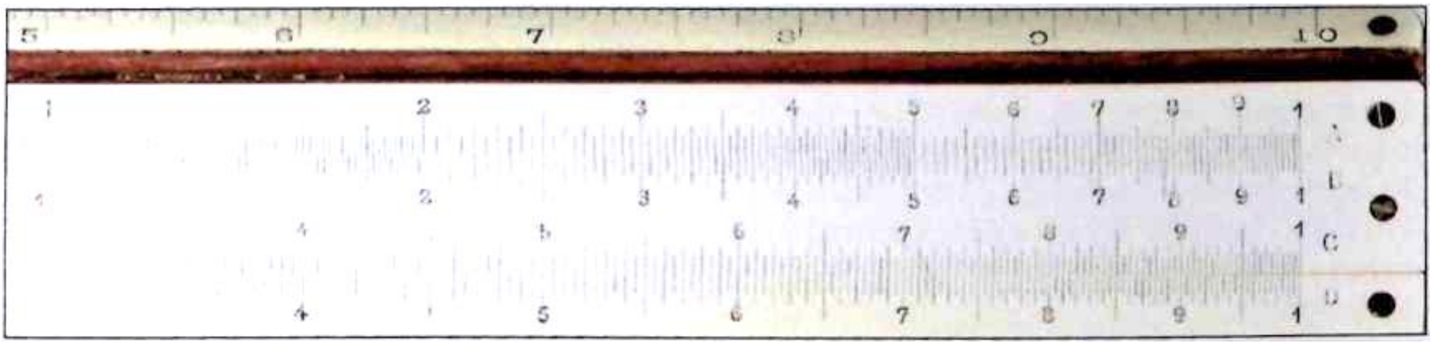


Figure 4.6.1.1.R: Right part of the front of the Rosenthal system by Dietzgen (prototype). Otto van Poelje Collection

Figure 4.6.1.1.1: Well of the Rosenthal system (prototype)

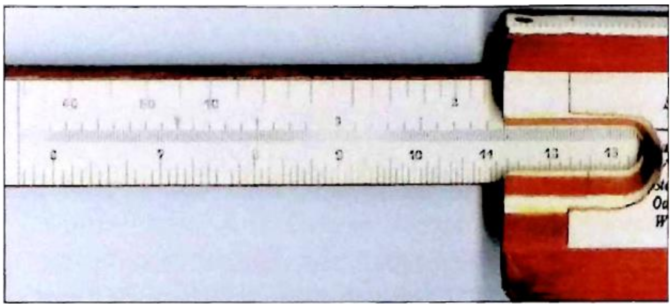


Figure 4.6.1.1.2: Back of the Rosenthal system (prototype)

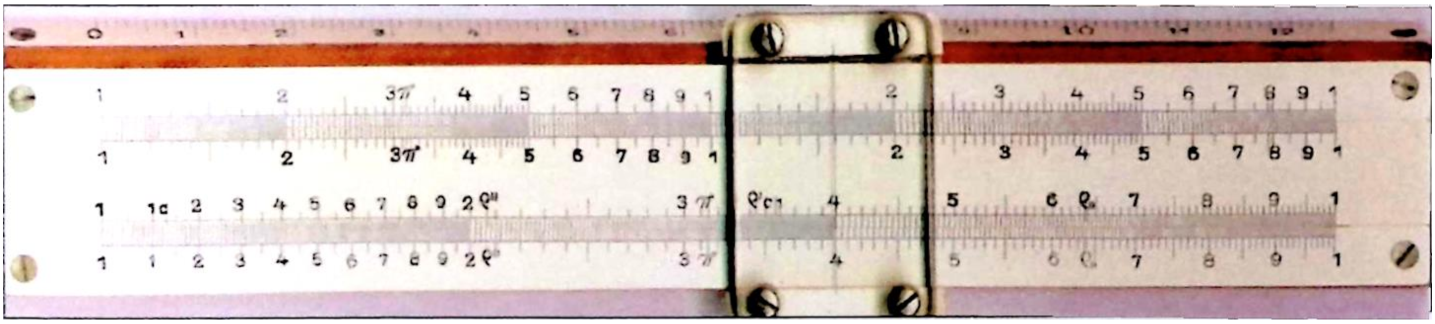


Figure 4.6.1.1.3: Front of the Mannheim system by Keuffel & Esser, type 4031. Jim Cerny collection

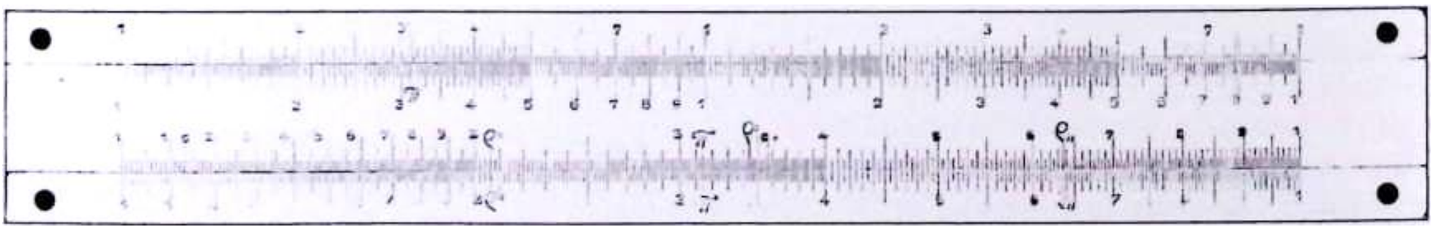


Figure 4.6.1.1.4: Nestler Mannheim system slide rule (with fine divisions), type 12a

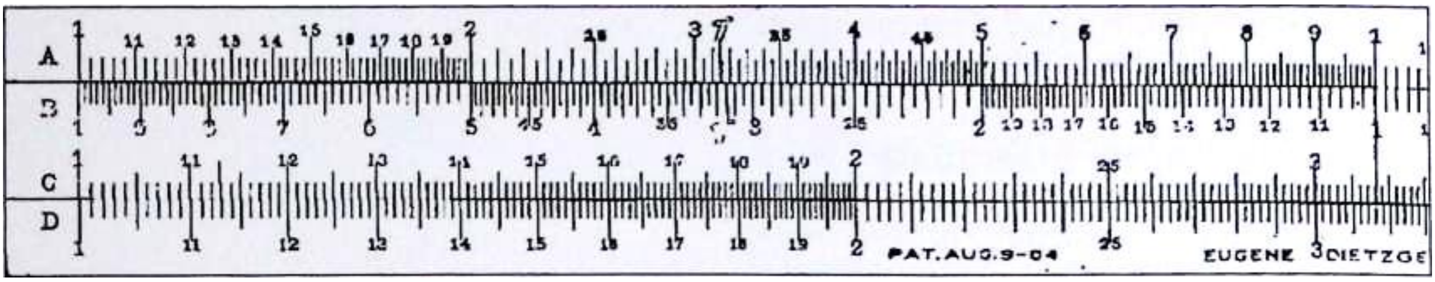


Figure 4.6.1.1.5.L: Left part of the front of the Rosenthal system from Dietzgen. Rodger Shepherd collection

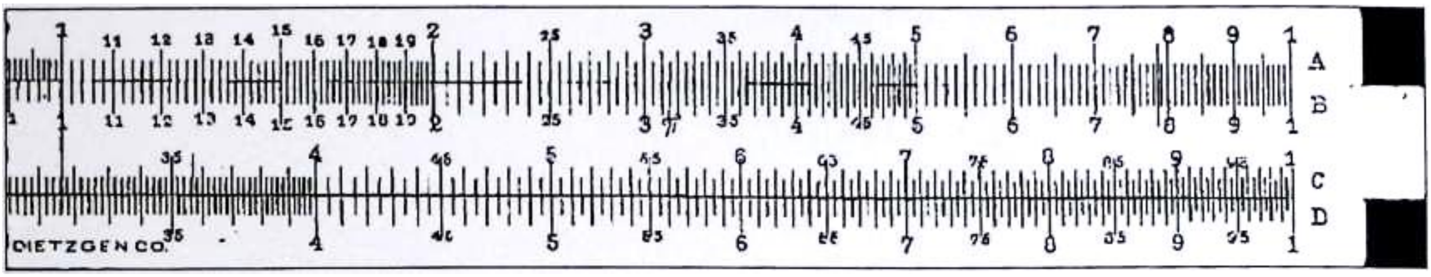


Figure 4.6.1.1.5.R: Right part of the front of the Rosenthal system from Dietzgen. Rodger Shepherd collection

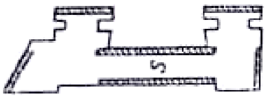


Figure 4.6.1.1.6: Cross-section of the Nestler slide rule, type 12a (S is the well).

4.6.1.2. The Mack system

John Givan Davis Mack, Madison, USA is the inventor of design improvements to slide rules to ensure that the slide fits snugly.

To do this, spiral springs are stretched in the body and fixed with two small nails. There are also three connecting pins to prevent the rule from tilting.

In 1898 he received German patent 102 599 and in the same year US patent 606 388. It refers to a structural improvement of the body, which ensures that the slide fits snugly.

Figure 4.6.1.2.1: Cross-section of the Mack slide rule with spring (G).

The slide rule is composed of two longitudinal parts. The thin dividing line is clearly visible in Figure 4.6.1.2.2. In the well the name Eugene Dietzgen with the letters E.D. abbreviated.

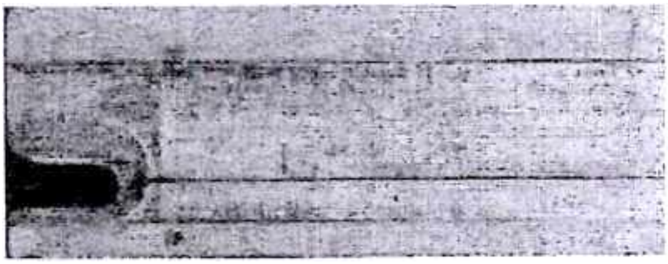


Figure 4.6.1.2.2: Back of the Mack calculator

Mack construction is difficult for collectors to detect unless the slide is noticeably stiff. On the back, however, there are two distinct features: the dividing line and the fixing nails, each about 2 cm from the left and right ends of the body.

4.6.2. Keuffel & Esser, New Jersey

Keuffel & Esser is the largest American manufacturer of slide rules. The founders are Willhelm Keuffel 1838 (Walbeck, Thuringia) - 1908 (Hoboken, New Jersey) and Herman Esser 1845 (Wuppertal) - 1908 (Bad Godesberg am Rhein). K&E begins in 1867 as a mail-order company for artist and drawing supplies. From 1886 slide rules are imported from D&P.

In the period 1895 to 1899 an own production begins, which lasts until 1972.

4.6.2.1. The pocket slide rules

From 1899 onwards, K&E offered small slide rules. D&P did not have pocket slide rules in its own range until 1905. In the period 1899 to 1905, the blanks were initially sourced from Nestler and later manufactured by D&P on behalf of K&E. In both cases, Nestler divides the scales. There are four reasons for the statement (see Figure 4.6.1.1.3):

- The typical π symbol of Nestler can be seen in four places,
- The ζ symbols were common at that time at Mannheims by Nestler,
- The fine scale division was only offered by Nestler and
- As early as 1878, only Nestler was able to supply slide rules of that length

The body of common K&E type 4031 has a special design (see Figure 4.6.2.1). It corresponds to the US patent, 651 142, by W.L.E. Keuffel of June 5th, 1900, for the assembly of the body parts by means of screws from the underside. Thus, the clearance between slide and body, thus the accuracy, can also be adjusted afterwards.

Figure 4.6.2.1: Cross-section of the K&E slide rule

When there are no such adjustment screws and the slide rule does not have the name Keuffel & Esser, the specimen is likely to date from the period before 1900. An American collector, Jim Cerny, has the 4031 pocket calculator from Keuffel & Esser with the said scale image (see Figure 4.6.1.1.3), and a conventional body cross-section.

The slide rule bears the Nestler type number 12a.

Chapter 5

Slide Rule Construction and Materials, Quality and Durability

An optimal slide rule is characterized by
dimensional stability, no bending or twisting
and by a gentle yet taut action of the slide

5. Slide Rule Construction and Materials, Quality and Durability

This chapter contains the following sections:

Until 1885 slide rules were made of boxwood. This year D&P gets the DRP 34 585 for the *invariable ruler* with extremely thin layers of celluloid to engrave the graduations. D&P uses mahogany for these rulers.

The author owes his knowledge of slide rule construction and materials to the authors of the following books:

- Hans Dennert; *Aristo, 1862-1962*; Aristo-Werke KG, Hamburg-Altona, 1962,
- Dieter von Jezierski, *Rechenschieber - eine Dokumentation*, self-published, Stein, Germany. 1997,
- Albert Nestler, *The Logarithmic Slide Rule and its Use*, published by Albert Nestler, Lahr, 1904.

The wood path from the tree to the slide rule is long. Dieter von Jezierski sums it up as follows:

> Delivered in raw logs, it was cut open into planks and, after a lengthy steaming process, it is air-dried for about two years. Then it had to pass another chamber drying with precise humidity control. The wood pre-treated in this way was then cut with wood milling machines in such a way that it received the dimensions and required profiles of the slide rule, namely the slide rule body and the slide. White celluloid veneers were then glued onto the still raw wooden bodies, after they had been roughened.

Slide rule manufacturers are very dependent on their woods. Hans Dennert mentions this:

> A fire in 1913 destroyed some workshops and the entire wood store for the production of slide rules and rulers. The workshops can be rebuilt better and larger, but the mahogany wood that has been cared for over the years is irreplaceable. As a result, the manufacture of slide rules and scales is significantly disrupted.

In order to be independent of suppliers, Nestler integrated a timber trade in 1913 and added a sawmill to the company. As early as 1905, Nestler offered a Timber-dealer slide rule (see Fig. 5.L). The slide rule is a simple and practical aid for calculations throughout the timber industry and is used in appraisals, timber purchases and auctions, and in the calculation of logs and squared timber (see also Section 6.11 Carpenter's Rule, p.98).

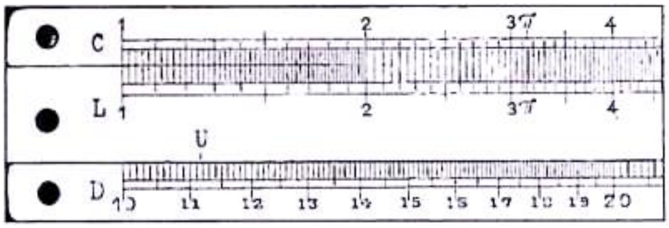


Figure 5.L: Left part of the Timber-dealer system, Nestler

- The L-scale, 1-10, is used to indicate the length of the wood,
- the D-scale, 1-100, is used for the circumference or diameter,
- the C-scale, 1-10, gives the cubic hold and
- the U symbol is applied if the circumference is used, Ø symbol if the diameter is used.

The Timber-dealer system is structurally very simple. The slide lies between two guides which are glued and mounted with screws on a celluloid plate. The scale length of 20 cm is unusual. This construction is the 2nd variant of the DRP 126 499 from D&P (see figure 4.3.3.1b, p.61).

5.1. The Requirements for Slide Rules

Quality of slide rules refers to:

- Stability, no bending or twisting
- Ease of movement, gentle, yet tight sliding
- Accuracy of precise divisions

The French slide rules, such as the Soho and the Mannheim systems, are made of boxwood. This wood has two disadvantages: boxwood is expensive and becomes dark brown when exposed to light, which impairs the legibility of the scales.

D&P has solved this problem by applying celluloid to mahogany bodies. Mahogany is a porous wood that ensures good gluing (see section *5.5 Gluing*).

Nestler studied three woods: boxwood, mahogany and walnut. The coefficient of thermal expansion is small for all. At a temperature difference of 35° C, the changes are very small and are all the less noticeable because the assumed temperature difference is very large and never suddenly occurs to this extent (see Section *5.3 Materials*).

In fact, due to the greater thermal expansion of celluloid, wood with a larger coefficient of thermal expansion may be required for the good condition of the slide rule.

From these considerations it is clear that other properties than the coefficient of thermal expansion are much more important for the selection of a material for the manufacture of slide rules. For example, the readability of celluloid graduations.

Unfortunately, celluloid is subject to fairly severe changes due to changing temperatures. The shrinking and swelling of the celluloid foils is particularly noticeable in the direction transverse to the slide rule. As a result, the width of the opening for the slide varies, not only because of the variability of the individual foils themselves, but also because of the resulting transverse bending of the slide rule.

Because of this, the sliding of the slide will either be far too loose or so tight that it is downright difficult to slide and prevents comfortable use of the slide rule.

5.2. The Well Gluing

A very effective innovation is the two-sided well gluing, for which Wilhelm Rees received the DRGM 41 294 in 1895 (see Figure 5.2). Figure 5.2a shows the two-sided symmetrical gluing of celluloid sheets.

One-sided application shows the problem of transverse bending in Figures 5.2b and 5.2c, because greater forces are effective in the celluloid than in the wooden base. However, if the well is glued on both sides as shown in Figure 5.2a, the forces in the celluloid sheets are cancelled out and the assembly remains level.

At the same time, all improvements are aimed at getting a favourable price-performance ratio and thus expanding the group of customers.

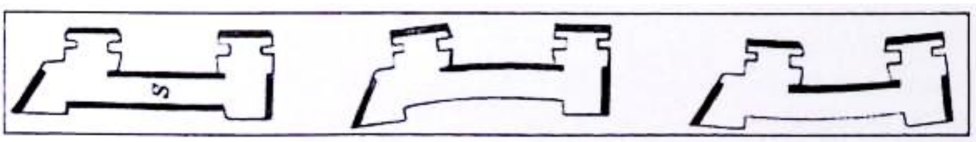


Figure 5.2a: Well gluing   Figure 5.2b: Well gluing   Figure 5.2c: Well gluing

5.3. The Materials

Manufacturers use different materials in the production of slide rules. The most commonly used materials are boxwood, mahogany, walnut and celluloid. Pear tree, very common at Faber, is used less frequently by D&P and Nestler.

5.3.1. Boxwood

The wood grows in the Mediterranean region and reaches a height of 6 to 8 m. It is usually supplied in small trunks, 10-20 cm long. The density is 1000 kg/m^3. The wood is more like a shrub than a tree. This is why boxwood is still rare and expensive today. The colour is yellowish with a brownish or greenish tinge. Exposure to light darkens the wood and makes it difficult to read. Boxwood is very hard, fine, dense, easy to process and hardly splits. It may be polished well and even coloured. In the beginning of the *Common eriod*, boxwood is often used for slide rules. The coefficient of thermal expansion is very low: for a slide rule of 25 cm, the change in length at a temperature difference of 35 °C is only 0,023 mm. See also Zapatero wood, page 31.


Figure 5.3.1: Boxwood

5.3.2. Mahogany

The durable wood comes from America. The trees reach a height of 30 m. The trunk is knot-free up to 15 m. It is cinnamon to reddish in colour and can turn dark brown with exposure to light. The density is 470 kg/m^3. The name mahogany once had a high charisma. It is premium trim wood. D&P prefers Tabasco mahogany, named after a state in Mexico.

The coefficient of thermal expansion is low: for a slide rule 25 cm long, the change in length at a temperature difference of 35 °C is only 0,05 mm. Mahogany was used by Nestler until the beginning of 1972 for all slide rule models in all dimensions.


Figure 5.3.2: Mahogany

5.3.3. Walnut

The wood grows in Germany and France. The trees reach a height of 25 m. It is tawny to liver coloured and may be veined. The colour may darken due to exposure to light. The density is 250 kg/m^3. Walnut is an excellent base for the celluloid paper. The coefficient of thermal expansion is low: for a slide rule 25 cm long, the total change in length at a temperature difference of 35 °C is 0,057 mm. From 1914 walnut is often used because the wood is very supple, can be processed cleanly, is available in war without imports and warps only a little.


Figure 5.3.3: Walnut

5.3.4. Pearwood

The wood grows in Europe. The trunks are knot-free up to 6 m. The light reddish-brown, often flamed, occasionally beautifully veined wood is hard, heavy and dimensionally stable. Pear tree shrinks moderately but tends to warp heavily when drying. The density is 700 kg/m^3. The bond strength is good. Pearwood is widely used by Faber.


Figure 5.3.4: Pearwood

5.3.5. Celluloid

The white material is the earliest thermoplastic. As early as 1860, Alexander Parkes in England was producing "artificial ivory" using wood naphtha and castor oil on guncotton (cellulose nitrate), but without achieving a stable result. It was not until 1868 that John Haytt in Newark, USA, succeeded in producing a stable plastic with the help of camphor. English companies take over the manufacture and supply D&P until 1908; the price of celluloid is 35 marks per kilogram in the first few years of production. According to Dennert & Pape, celluloid production began in Germany in 1905. On the other hand, Hans-Ulrich Kölsch mentions that the first German production of celluloid took place as early as 1878, at the Rhenish rubber and celluloid factories. Celluloid is used as a veneer on various types of wood until the end of slide rule production.

5.3.6. Ivory

This substance is mainly obtained from elephant tusks. The advantage of this material, a better readability of the scales, is immediately apparent. In addition, ivory is more pleasant to the eye and largely independent of temperature. However, slide rules made from ivory are six times more expensive than the corresponding rules made from boxwood.

5.4. Lamination

Nestler has made slide rules from different types of wood in order to achieve the best possible product with a favourable price-performance ratio. An optimal slide rule is characterized by dimensional stability, no bending or twisting and by a gentle yet taut action of the slide.

Nestler was one of the few manufacturers to use different types of wood for certain slide rules. Covering the body with a wood covering with a different grain direction is called lamination. The following examples come from the period 1903 - 1910:

The Rietz system, 1903 - 1907, with the width of a Mannheim system (see Figure 3.9.4.L, p.51). The guides and the slide are made of walnut, which in Nestler's experience is an excellent base for the celluloid foils and does not warp easily. The expensive boxwood is only processed in small quantities and its yellowish colour makes it better suited for measuring or drawing bevelled scales.

The Rietz system, 1908 - 1910 (see figure 3.9.2, p.51). The body and the slide are made of pearwood. The measuring and drawing bevelled scales are also made with boxwood.

5.5. Gluing

Gluing celluloid strips to a wooden body places high demands on materials, adhesives and the gluing process. In the beginning, screws (Nestler and D&P) and wooden pins (Faber) are used to prevent the strips from loosening. Later, the materials and process are greatly improved, eliminating the need for screws and pins.

Bone glue made from cattle bones is a suitable means of gluing the different types of wood together. References to the use of glue already exist in ancient Egypt.

Certain specialist knowledge is required to repair old slide rules. Above all, you should choose the optimal adhesive and experiment with it in the work environment beforehand.

Surfaces should be free of any contamination (dust, grease or release agents). In addition to the condition of the surface layers, the roughness of the surface also has a major impact. A distinction should be made between geometric surface and effective surface. In short, both surfaces should be equally flat. Finally, the adhesive bond should harden sufficiently.

Chapter 6

Appendix

For selective searches

6. Appendix

This appendix contains thirteen overviews that can be particularly helpful to the reader:

6.1. Abbreviations

This list contains abbreviations of a general nature; the abbreviations relating to systems are explained in Chapters 3 and 4.

Sec.	Section
LTD.	Public limited company
Alu	Aluminium
AM	Albert Marz
AN	Albert Nestler
AN01	Book *Albert Nestler*, 2001
AN04	Book *Albert Nestler*, 2004
ANAG	Albert Nestler AG
AWF	A.W. Faber
CR	Carpenter's Rule
D&P	Dennert & Pape
DBGM	German Federal Utility Models
DBP	German Federal Patent
DIN	German Industry Standard
DM	Deutsche Mark
DRGM	German Reich Utility Model
DRP	German Reich Patent
ED	Eugen Dietzgen
F-C	Faber-Castell
F and H	Friedrich and Hippler
G-L	Gravet-Lenoir
GmbH	Ltd.
HD62	Book from Hans Dennert, 1962
HD72	Article from Hans Dennert, 1972
HD78	Article from Hans Dennert, 1978
HD99	Article from Hans Dennert, 1999
i. B.	in Baden
Kap.	Chapter
K&E	Keuffel & Esser
KG	limited partnership
kW	kilowatt
L&G	Landis & Gyr
Mk	Mark in the period before the currency reform, (1924)
Massag	Maßstabfabrik Schaffhausen AG
No	Number
Nr	Number
OHG	Open trading company
o.J.	without year
p.	page
PS	horsepower
PV	price list
RM	currency unit of the German Reich from 1924 to 1948
RS	slide rule

s.	see
S	Sinus
ST	Sinus and Tangents for small angles
T	Tangents
T-G	Tavernier-Gravet

6.2. Important Names

This overview contains the names and biographies of important inventors, manufacturers and trading houses within the *Common Period*.

Beck, Theophil, 1814 (Schaffhausen) - 1903 (Schaffhausen). Co-founder of *Maaßstabfabrik Beck und Nestler*, Lahr. Inventor of the automatic logarithmic dividing machine, 1878

Boulton, Matthew, 1728 (Birmingham) - 1809 (Birmingham). Engineer and entrepreneur. Financed the 1765 steam engine of *James Watt*, and later founded the company Boulton and Watt.

Cajori, Florian, 1859 (St. Aignans, Graubünden, Switzerland) - 1930 (Berkeley, USA). Emigrant to the USA. Professor of Mathematics at three US universities and author of the book *A History of the Logarithmic Slide Rule and Allied Instruments*, New York, 1909

Coggeshall, Henry, 1623 - 1690, described the calculation of wood volume in 1677.

Dennert, Hans, **Dipl.-Ing.**, 1926 (Hamburg) - 2000 (Hamburg). Since 1957 owner and director of Dennert & Pape ARISTO Werke, Hamburg

Dietzgen, Eugene, 1862 - 1929, German emigrant to the USA. Founds a company in 1885 as a supplier of slide rules

Dreyspring, Carl Friedrich, founds the first German cardboard and case factory in 1816. With its export to all of Europe and overseas, Lahr earned the nickname *City of Boxes*

Dyck, Walther, Prof., 1856 (Munich) - 1934 (Munich). One of the founders of the Deutsches Museum in Munich, 1903

Eiffel, Gustave, 1832 (Dijon) - 1923 (Paris), French engineer, built the Eiffel Tower named after him in 1887 on the occasion of the Paris World Exhibition. Involved in the construction of the Panama Canal from 1888

Frank, Wilhelm, Dr., 1876 (Stuttgart) - 1963 (Stuttgart). Inventor of a slide rule with segmented scales for increased accuracy. He gets 1902 DRGM 173 095

Ganga Ram, Lala, Civil Engineer. Building Authority of Punjab, India; in 1884 and 1890 he invented slide rules for roof structures and in 1884 obtained the British patent 2149 for his first slide rule. The slide rule was manufactured by *W.F. Stanley* in London

Goering, Adolf, Prof. Dr., 1841 (Lüchow) - 1906 (Berlin). Lives in Halberstadt in 1873 and encourages the production of slide rules at D&P. 1878 professor at the Technical University in Berlin. Appointed a secret government councilor by the Prussian state.

Hammer, Ernst Herman Heinrich, Dr., 1858 (Ludwigburg) - 1925 (Stuttgart), Professor of Geodesy at the Technical University of Stuttgart. Author of *The Logarithmic Slide Rule and its Use*

Hyatt, John W., 1837 (Starky, N.Y.) - 1920 (Short Hills. N.J.). Invents celluloid in 1870

Jäger, Rolf, 1914 (Berlin-Charlottenburg) - 1979. Studied surveying. Responsible at Dennert & Pape from 1949 for technical documentation, such as operating instructions

Jones, William, 1763 - 1831. London instrument maker (30 Holborn); Manufacturer of the first Soho slide rules

Jordan, Wilhelm, 1842 (Ellwangen - Hannover) 1899. Professor of geodesy and practical geometry at the TH Hannover

Kölsch, Hans-Ulrich, Essen, architect, designer and collector (Bakelite collection)

Lenoir, Etienne, 1744 (Mer, near Orleans) - 1832 (Paris). Manufacturer of the first official standard metre. Etienne is the father of Paul-Etienne

Lenoir, Paul-Etienne, Paris, 1776- 1827. Inventor of the 8-arm dividing machine, 1825

Mack, John Givan Davis, Madison, USA. Inventor of improvements to slide rules. In 1898 he receives DRP 102 599

Mannheim, Victor Mayer Amédée, Prof., 1831 (Paris) - 1906 (Paris). Inventor of a slide rule with four-scale in the front and cursor, named after him, 1851

Martz, Albert jr., 1860 (Stuttgart) - 1905 (Stuttgart), merchant, son of the founder of the Martz company

Nairne, Edward, 1726 (Sandwich) - 1806 (London), Royal Court Mechanic, maker of the earliest Sohos

Nestler, (Christian) Albert, 1851 (Lahr) - 1901 (Lahr). Founder of the company Nestler, Lahr

Newton, Isaac, 1643 (Woolsthorpe) - 1727 (Kensington). First to come up with the idea of the cursor

Perry, John, Prof., London, 1850 - 1920. Inventor of a slide rule with two log-log scales. In 1901 he received British patent 23 236

Peuckert, Kurt Woldemar, Dresden. Inventor of a slide rule with a cursor consisting of a glass plate with a hairline. Peuckert can thus be considered the inventor of the free-view cursor. In 1878 he received the DRP 5 452

Poncelet, Jean-Victor, 1788 (Metz) - 1867 (Paris), mathematician, engineer and physicist. One of the founders of modern projective geometry

Rees, Wilhelm, engineer, Freiburg. Inventor of the double-sided covering of the body well and the flexible metal plate in the well. In 1895 he gets DRGM 41 294 and in 1902 DRGM 190 019

Rietz, Max, engineer, 1872 (Morm bei Landsberg) - 1956 (Erfurt). Inventor of the Cube slide rule. He receives DRGM 181 110 in 1902 for this.

Roget, Peter Mark, physician, 1779 (London) - 1869 (West Malvern). In 1814 he invented the double logarithmic or log-log scales. His invention is forgotten. However, the log-log system was reinvented in 1901 by the English mathematician John Perry.

Rosenthal, Leon Walther, New York. Invents slide rule that can be used to multiply three numbers by a single setting. In 1904 he received the US Patent 767 170

Schweth, Wilhelm, Cologne, inventor of a slide rule with two log-log scales. In 1900 he received DRGM 148 526

Stahl, (Friedrich) Wilhelm, 1887 (Nonnenweiler) - 1974 (Lahr). Chief engineer and designer of the 2nd generation of automatic logarithmical dividing machines, 1936

Stanley, William Ford, 1828 - 1909, founds a workshop at the Great Turnstile, Holborn, in London in 1853. From 1884, *Ganga Ram*'s construction slide rules were manufactured there.

Taylor, Frederick Winslow, 1856 (Germantown, USA) - 1915 (Philadelphia, USA). Founder of the scientific work organization

Thornton, Alexander George, was trained by Harling, set up his own business in Manchester, at 39 Great Cheetham Street, in 1878; sold Nestler's Mannheim system under his own name from 1905

Watt, James, 1736 (Greenock-on-Clyde) - 1819 (Heathfield in Staffordshire). Invents the Soho slide rule in the period 1779 - 1796

6.3. Sources

6.3.1. Books

Bready, Jim, *Mystery Slide Rules*, Proceedings of the 8th International Meeting of Slide Rule Collectors, October 2002

Cajori, Florian, *A history of the Logarithmic slide Rule and Allied Instruments*, Reprint: Mendham, New Jersey, Astragal Press, 1994

Craenen, Guus, *Albert Nestler, Innovation und Qualität, Die Rechenstäbe von Nestler in ihrem internationalen Umfeld*, Soest, The Netherlands, self-published, 2001

Craenen, Guus, *Albert Nestler, Innovation und Qualität, Zusammenarbeit mit anderen Herstellern und mit Erfindern*, Soest, The Netherlands, self-published, 2004

Craenen, Guus, *Rechenschieber im Wandel der Zeit*, Soest, The Netherlands, self-published, 2009

Daumas, Maurice, *Scientific Instruments of the 17th & 18th Centuries and their Makers*, London, Portman Books, 1972

Dennert, Hans, *Aristo, 1862 - 1962*; Dennert & Pape - Aristo-Werke; Hamburg, 1962

Dennert, Hans, *100 Jahre Aristo Rechenstäbe*, Aristo Werke Hamburg, 1972

Dennert, Hans, *Dennert & Pape und Aristo Rechenschieber 1872 - 1978* (see Klaus Kühn und Karl Kleine, 2004)

Dennert, Hans, *Zur Geschichte der Rechenschieber*, lecture, 1999 (see Klaus Kühn and Karl Kleine, 2004)

Dyck, Walther, Prof. Author of the catalog (for the exhibition at the conference of the German Association of Mathematicians) *Mathematisch und mathematisch-physikalischer Modelle, Apparate und Instrumente*, published by Dr.C. Wolf & Sohn, Munich, 1892

Hambly, Maya, *Drawing Instruments*, Sotheby's Publications, London, 1988

Hammer, Ernst Herman Heinrich, Dr., *Der logarithmische Rechenschieber und sein Gebrauch*, published by Albert Nestler company, Lahr, 1902

Jäger, Rolf, *Vom Rechenstah und seiner historischen Entwicklung*, see *Aristo, 1862 - 1962*; Dennert & Pape - Aristo-Werke; Hamburg, 1962

Jezierski, Dieter von, *Rechenschieber - eine Dokumentation*, self-published, Stein, 1997

Jomard, M., *Bulletin de la Société d'Encouragement Pour l'Industrie Nationale*, 1815

Kieswetter, Hubert, *Industrielle Revolution in Deutschland*, published by Suhrkamp, Frankfurt am Main, 1989

Klaus Kühn and **Karl Kleine**; *Dennert & Pape, Aristo; 1872 - 1978*, published by W. Zuckschwerdt, Munich, 2004

Konrad-Klein, Jochen, *Employed at Dennert & Pape*, see *Dennert & Pape, Aristo; 1872 - 1978*, published by W. Zuckschwerdt, Munich, 2004

Lausch, Alex, *Lahr um 1900, Bauten und Baumeister*, Kulturkreis Lahr, Band 2, 1991

Marcelin, Frank, *Dictionnaire des fabricants français d'instruments de mesure du XVe au XIXe siècle*, Franck Marcelin: 7, Rue Jaubert - 13100 Aixen-Provence - France, 2004

Marguin, Jean, *Histoire des Instruments et machines a calculer*, Hermann, Editeurs des Sciences et des arts, Paris, 1994

Nestler, Albert, *Der logarithmische Rechenschieber und sein Gebrauch*, published by Albert Nestler company, Lahr i.B. 1904/5

Nestler, Albert, *Anleitung zum Verwendung des Rechenschiebers*, published by Albert Nestler, Rechenschieberfabrik, Lahr (Baden), 1914

Pugh, Jane, *Calculating Machines and Instruments*, Science Museum, London, 1975

Roth, Käthe, *Die Stadt Lahr*, Bundesanstalt für Landeskunde und Raumforschung, self-published, Bad Godesberg, 1961

Täubrich, Hans-Christian, *Bis in die fernsten Zeiten; Zur Geschichte des Unternehmens Faber-Castell*, see *Das Bleistiftschloss*, published by Hugendubel, Munich, 1986

Thompson, J. E., *A Manual of the Slide Rule*, D. van Norstrand Company, Inc., Toronto, New York, London, 12. Edition 1951

Turner, Anthony, *From Pleasure and Profit to Science and Security*, Whipple Museum, Cambridge, 1969

Wit, Dirk de, *60 + 40 is waarschijnlijk honderd*, Waanders publisher, Zwolle, 1996

6.3.2. Booklets

Albert Nestler, *Anleitung zum Gebrauch des Rechenschiebers*, published by Albert Nestler company, 1904

Dennert & Pape, Price list, published by Dennert & Pape, Altona (Elbe), 1898

Dennert & Pape, Price list, published by Dennert & Pape, Altona (Elbe), 1902

Dennert & Pape, Price list, published by Dennert & Pape, Altona (Elbe), 1905-1906

Dennert & Pape, *Anleitung zum Gebrauch der Rechenstäbe Einskala Nr. 11, Präzision Nr. 19*, published by Dennert & Pape, Altona, o.J.

A.W. Faber, *Anleitung zum Gebrauch des*

Rechenstabes, Stein bei Nürnberg, 1906

A. Goering, *Anleitung zum Gebrauch des Rechenstabes*, third edition, Berlin, 1904

Thornton, A.G., *Improved calculating slide rules*, Manchester, 1902

6.3.3. Essays

Bartzik, Jürgen, *Register der Rechenschieber Dennert & Pape ARISTO*, (see 6.3.1 of Book by Klaus Kühn and Karl Kleine)

Berche, Paul & Jouanneau, Edouard, *Apprenez a vous servir de la règle a calcul*, 6eme édition. Les editions de la Librairie de la Radio, 1950

Hammer, Ernst Herman Heinrich, Dr., *Frank's Einscala-Rechenschieber*, Journal of Instruments, Vol. 23, p.159, 1903

Hammer, Ernst Herman Heinrich, Dr., *Neue Rechenschieber von Nestler*, Journal of Surveying, pages 44-45, 1906

Jezierski, Dieter von, *Two Tavernier-Gravet Slide Rule Systems*, JOS, Vol. 11, No. 1, 2002

Jordan, Wilhelm, *Neue Rechenschieber*, Journal of Surveying; p.220, 1880

Otnes, Bob, *Keuffel & Esser - 1880 to 1899*, JOS, Vol. 10, No 1, 2001

Otnes, Bob and **Schure, Conrad**, *Early French Slide Rules in Various Collections*, JOS, Vol. 11, No. 1, 2002

Schneider, Ivo, Prof. Dr., *Proportionalzirkel*, in 7th International Meeting for Slide Rules and Calculating Machine Collectors, Deutsches Museum, Munich, 2001

Venetsianos, Panagiotis, *Tavernier-Gravet Slide Rules: a Chronology of Cited Examples*, JOS, Vol. 11, No 2, 2002

Wells, Francis and **Wyman, Tom**, *La règle a calcul: Lenoir, Gravet-Lenoir and Tavernier-Gravet Slide Rules*, JOS, Vol. 11, No. 1, 2002

Wyman, Tom, *Description of Two Unmarked Slide Rules of Probable French Origin*, JOS, Vol. 10, No 2, Fall 2001

Zoller, Paul, *The Soho Rule: Genesis and Archaeology*, Bulletin of the Scientific Instrument Society, No. 57, June 1998

6.3.4. Correspondence

Correspondence between the author and Hans Dennert, in the period 1995 – 2000

6.4. Special Characters, Logos and Names

Some characters are enlarged. H is the height of the character.

6.4.1. Albert Nestler

π	Very early Pi sign, from 1902	H = 2,5 mm
π	Early Pi sign, from 1903	H =2 mm
ρ	Rho signs, from 1902	H = 2,1 mm
c, c1	Constants 1,13 and 3,57, from 1901	H = 1 mm
A N	Company logo from 1895 to 1903	H = 4 mm

Name in the ground: ALBERT NESTLER from 1903

6.4.2. Dennert & Pape

π	Very early Pi sign, from 1905	H = 1,5 mm
π	Early Pi sign, from 1908	H = 1 mm
ρ	Rho signs, from 1923	H = 2 mm
c, c1	Constants 1,13 and 3,57, from 1888	H = 1 mm
D&P	Company logo, from 1902	H = 2 mm

Name on the back: DENNERT & PAPE HAMBURG.ALTONA from 1874
Name in the well: DENNERT & PAPE ALTONA from 1888
Name on the front: DENNERT & PAPE ALTONA from 1902

6.4.3. A.W. Faber

π	Very early Pi sign, from 1892	H = 1,4 mm
π	Early Pi sign, from 1900	H = 2,5 mm
M	M-sign, from 1899	H = 2,2 mm
c, c1	Constants 1,13 and 3,57, from 1892	H = 1 mm

Name on the front: A.W. FABER. from 1892

6.5. List of Illustrations

[This chapter has not been translated, as this is an electronic file]

6.6. List of Museums

German, English and French slide rules can be found in the following museums, among others:

Arithmeum
Lennestraße 2
53113 Bonn

Deutsches Museum
Museumsinsel 1
80538 Munich

Musee National des Techniques
292 Rue Saint-Martin
75003 Paris

Museum Boerhave
Steenstraat la
2312 BS Leiden

Museum of the History of Science
Broad Street
Oxford OX1 3AZ

Museo di Storia della Scienza
Piazza dei Giudici 1
50122 Firenze

National Museum of Scotland
Chambers Street
Edinburgh EHI IJF

Science Museum
Exhibition Road
South Kensington
London SW7 2DD

Staatlicher Mathematisch-Physikalischer Salon
at Zwinger
01006 Dresden

Whipple Museum of the History of Science
Free School Lane
Cambridge CB2 3RH

6.7. Slit Wells

Slide rules with slits in the well are offered in the period 1895 - 1905 (see picture). There are three models: first model (Faber) with two slits, second model (D&P) with 4 slits and third model (D&P) with five slits.

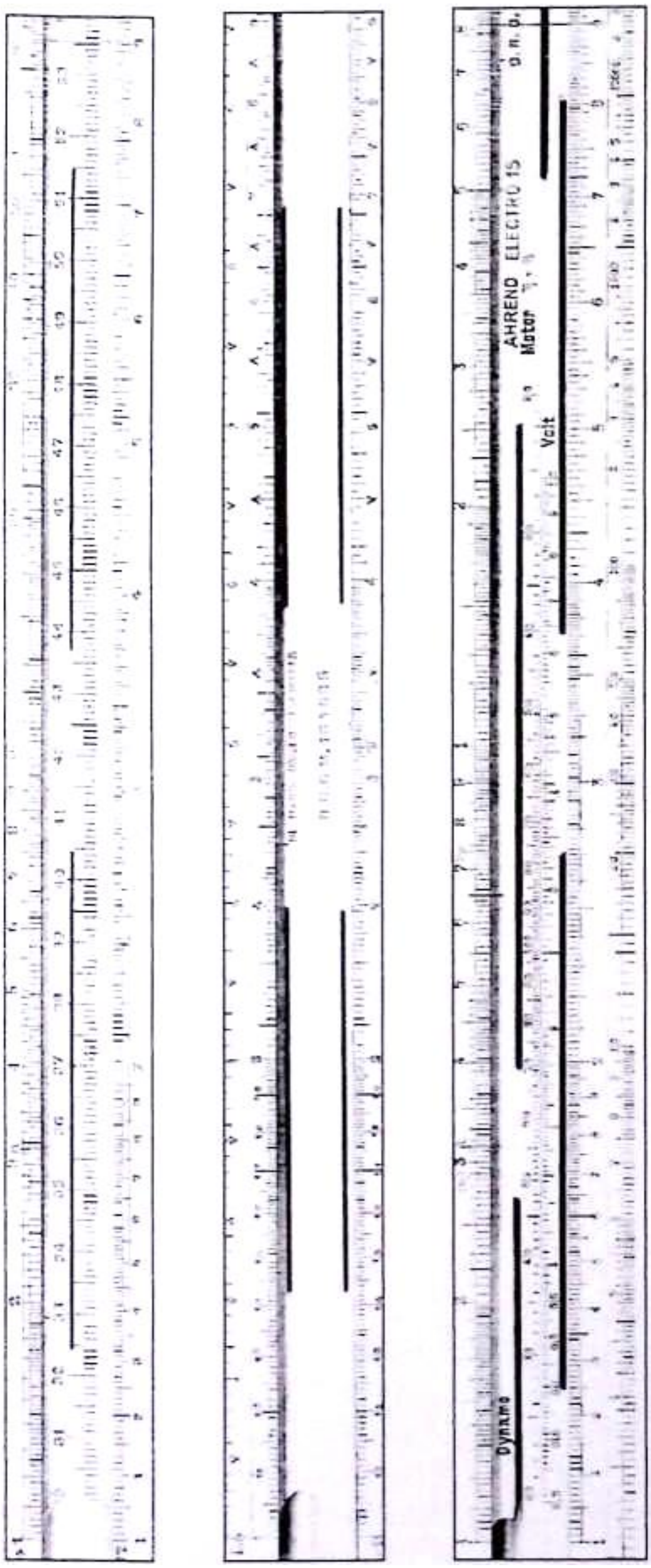


Figure 6.7: Slide rules with 2. 4 and 5 slots

First Model

Faber wants to improve the flexion effect with two slits and gets on June 24th, 1898, DRGM 98 350 with the text:

> Slide rule with flexible strips arranged on the sides and below the slider.

Second Model

D&P aims to fix the transverse stresses with four slits and gets DRGM 37 191, on February 19th, 1895, with the text:

> Slide rule with slit body well guiding the slide.

Third Model

D&P makes it possible to improve the effect of adjustment screws with five overlapping slits. The author is not aware of any DRGM here.

The name Ahrend refers to a Dutch dealer.

All desired effects can be adjusted by the number, dimensions, position and pattern of the slits.

6.8. Screw Pattern

In 1901, Nestler received the DRGM 164 885 for an improved, double-purpose register, in which the ends of the celluloid plates are fastened with screws. The text reads:

> Rulers, slide rules and the like with celluloid veneer mechanically secured against detachment and alteration by screws or pins.

This DRGM is known by the keyword nickel-silver screws, but the original description is much wider. Later, the screws are made of steel.

Although Nestler is clearly the owner of the DRGM, these screws can also be found on D&P slide rules. Can this be considered another form of cooperation?

Originally, all five celluloid strips at both ends are secured against detachment with screws, and also the strip at the back of the slide.

Because the back of the slide is less vulnerable and not immediately visible, these screws are not considered when comparing the patterns. Nestler starts with 2 x 5 screws (see Figure 6.8).

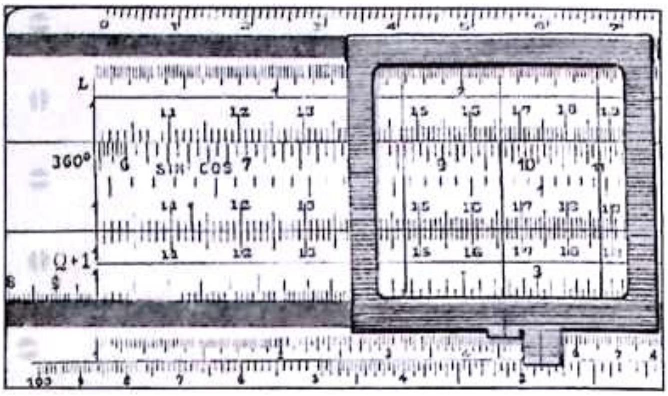


Figure 6.8: Screw pattern with 2x5 screws (left)

Not all strips are equally vulnerable, and the consequences of the damages are not equally severe. From 1902 onwards, D&P therefore only screwed the three scale stripes on the front. Of the three stripes, slide swelling is the least at risk. Thus, from 1905 only 2 x 2 screws remain.

Due to a greatly improved gluing, both manufacturers gradually eliminated the screws. This is what D&P began after the 1st World War, whereby from 1936 only dimensionally stable plastics were used. Nestler no longer uses screws after the 2nd World War.

6.9. Utility Models and Patents

The German Patent Office was founded in 1877 and thus a uniform protection of inventions was made possible. Utility models are issued from 1891 onwards.

[page numbers are omitted from tables as this is an electronic file]

DRGM	Year	Owner	Abstract
25 025	1894	D&P	cursor
37 191	1895	D&P	slit well
41 294	1895	Rees	two-sided covering
98 350	1898	Faber	two slits in the well
116 832	1899	Faber	cursor with counter handle
148 526	1900	Schweth	exponential slide rule
164 885	1901	Nestler	nickel-silver screws
173 095	1902	Frank	system Frank, first model
181 110	1902	Rietz	system Rietz
190 019	1902	Rees	flexible plate
192 052	1903	D&P	adjustment screws
247 514	1905	Faber	reading knife-edge at the end of the slide
271 169	1906	Faber	cursor with side knife-edge
314 734	1907	Martz	system Frank, second model
354 529	1908	D&P	system Frank, third model
383 627	1909	D&P	free-view cursor
400 076	1909	Peter	reading glass cursor
889 460	1924	Nestler	Divisions out of scales beginning and end

DRP	Year	Owner	Abstract
5 452	1878	Peuckert	free-view cursor
34 583	1885	D&P	immutable ruler
102 599	1898	Mack	improved slide rule
126 499	1901	D&P	flexible plate
173 660	1905	Nestler	flexible rubber plate

Foreign countries	Patent	Year	Owner	Short description
England	2 149	1885	Ganga Ram	special slide rule
England	23 236	1901	Perry	log-log slide rule
Switzerland	26 145	1902	Frank	single-scale slide rule
United States	460 930	1891	Cox	two-sided slide rule
United States	606 388	1898	Mack	slide guide
United States	651 142	1900	Keuffel	slide rule
United States	694 258	1902	Dennert	flexible plate
United States	767 170	1904	Rosenthal	special scales

On certain Nestler cursors from the period 1909 - 1912 you will find the text +Patent No. 17 284. This patent number also appears in Nestler operating instructions. The + prefix indicates that it is a Swiss patent. However, the patent corresponding to this number describes a completely different invention, namely a water and wind motor. All of the author's efforts to find the right patent number have so far been unsuccessful.

6.10. Company Register

6.10.1. Germany

Dennert & Pape, Altona near Hamburg

- Friedenstraße 55, from 1869
- Friedenstraße 53, from 1900

A.W. Faber, Stein near Nuremberg

- Geroldsgrün, from 1892

Nestler, Lahr

- Maaßstabfabrik Beck und Nestler, 1878- 1895
- Albert Nestler, from 1895
- both addresses: Alte Bahnhofstraße, Lahr

6.10.2. England

Edward Nairne, London

- Golden Spectacles Royal Exange, 1759 - 1797

W&S Jones, London

- 135 Holborn, 1792- 1800
- 30 Holborn, 1800- 1860

6.10.3. France

Lenoir, Paris

- 21 Rue Louis le Grand, 1817
- 340 Rue Saint Honore, 1817-1827
- 14 Rue de Cassette, 1827 - 1846

Gravet-Lenoir, Paris

- 14 Rue de Cassette, 1846 - 1867
- 39 Rue de Babylone, 1867 - 1874

Tavernier-Gravet, Paris

- 39 Rue de Babylone, 1874 - 1882
- 19 Rue Mayet, 1882 - 1938

Barbotheu, Paris

- 16 Rue Saint Gilles, 1888
- 10 Rue Saint Gilles, 1889 - 1892
- 17 Rue Béranger, 1893 - 1913

6.11. Carpenter’s Rule and System Coggeshall

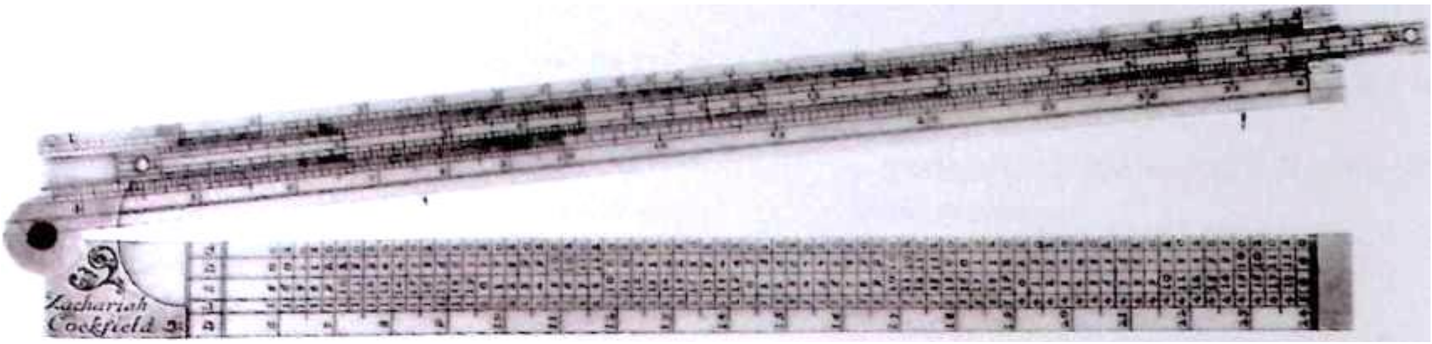


Figure 6.11.1: Coggeshall system with rail-shaped scales, manufactured by Edmund Culpeper at the beginning of the 18th century

The author owes his knowledge of the Coggeshall system to Maya Hambly, Peter Hopp, Werner Rudowski and Prof. Ivo Schneider.

A Carpenter's Rule (CR) consists of 2 rulers, which are rotatable connected by a flat hinge (with angular graduation). The upper ruler has a slide with an inch scale, enabling depth measurements. It is a versatile measuring device used by carpenters. That's why it's called Carpenter's Rule. The English scientist Leonard Digges was the first to describe the Carpenter's Rule in 1556.

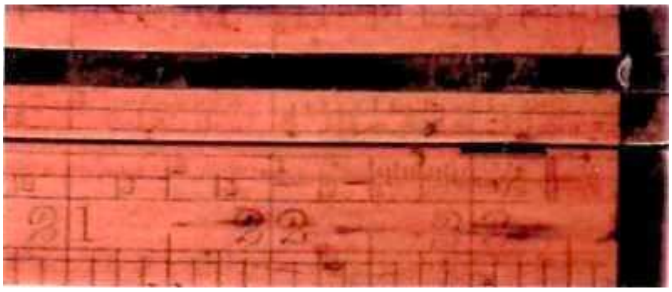


Figure 6.11.2: Section of the Carpenter's Rule

The English mathematician Henry Coggeshall (1623 - 1690) described the calculation of wood volume in 1677 and transferred the principle to the CR in 1682. The extended device is named System Coggeshall (Fig. 6.11.3).

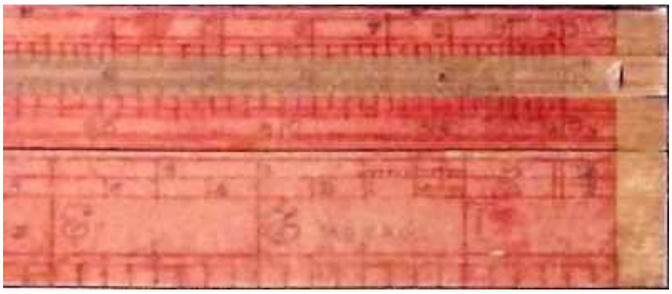


Figure 6.11.3: Section of the Coggeshall system

Figure 6.11.4: Section of the slide rule

In the Coggeshall system, scales A, B, and C are double logarithmic scales (x^2) with a range of 0 to 100. There are no trigonometric scales yet. Due to these characteristics, the Coggeshall system can be regarded as the predecessor of the Soho system (see also Section 3.1).

The logarithmic D scale has a range of 4 to 40.

The following scales are available for calculating the volume of a tree trunk:

- The C scale, 1 - 100, is used to indicate the length of the tree in feet (12 inches),
- the D scale, 4 - 40, is used to indicate the girth (diameter) of the tree in inches.

The calculation goes as follows:

The length of the tree (in feet) is set on the C scale via the value 12 of the D scale. The wood volume can be read on the C scale above the girth value on the D scale. Only a slide adjustment is necessary.

If you do the same calculation with an ordinary slide rule, you get a result that is 20% higher. With the Coggeshall system, the cutting losses are already taken into account.

Figure 6.11.5: Section of the Hawthorn system

Robert Hawthorn (1796 - 1867), Newcastle, civil engineer, developed a system for steam engines in 1832. Tables are available on both sides (see Figure 6.11.5).

6.12. System Peuckert

The author owes his knowledge of the Peuckert system to Klaus Kühn, the patent *Innovation in Slide Rules* and the catalog of *Computing Devices* from the State Mathematics and Physics Salon in Dresden.

Kurt Woldemar Peuckert, Dresden, is the inventor of a slide rule with a cursor consisting of a glass plate with an hairline. Peuckert can thus be described as the inventor of the free-view cursor. In 1878 he received DRP 5 452. The slide rule is a variant of the English system Soho.

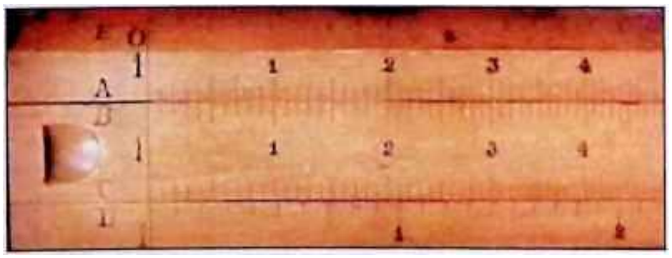


Figure 6.12.1: Left part of the Peuckert system

The slide rule described here was offered on Ebay. A similar specimen - without cursors - is in the possession of the State Mathematics and Physics Salon in Dresden.

Both slide rules have a scale length of 100 cm, which allows more accurate calculations. The scales A, B and C are the same and for squares (x^2); D is a simple logarithmic scale (x). A linear scale, E, is attached to the bevelled side.

Sinus and Tangents scales (0 - 90° and 0 - 45°) are present on the back of the slide.

E is a mantissa scale. Thus, the scale can also be used as a drawing ruler.

In the French Sohos, this L scale stands on the back of the slide and is therefore not to be used as a ruler.

Recesses are made instead of operation knobs, which makes it easier to move the slide.

The mentioned slide rules are made of boxwood. Peuckert has also made brass slide rules.

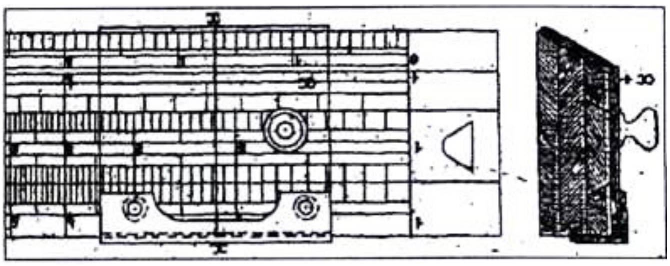


Figure 6.12.2: Free-view cursor of the Peuckert system

The patent specification describes the free-view cursor as follows:

> The precise setting and reading of the values required for calculations is accomplished using a sliding glass plate on the underside of which is a hairline x x (see in figure). With the aid of this hairline, values estimated even between the divisions can be read off with a fair degree of accuracy. The glass plate is bent at an obtuse angle, corresponding to the cross-sectional shape of the slide rule.

Figure 6.12.3: detail of the clear-view cursor

The hairline can be adjusted exactly thanks to the screws. The cursor's text reads:

K. Peuckert, *Patent* *Dresden.*

6.13. Keyword Directory

[This chapter has not been translated, as this is an electronic file]

Annex to English translation

4.2.3. (page 55) 6th paragraph at left:

The author states that “Swiss made specimens were not offered until 1954”. Then the last specimen from H.P.Schaub collection has a manufacturing year of 1913.

4.3.3. (page 58) 2nd paragraph at left:

The author refers to “Johan Christian Dennert” as the inventor in patent US694258. But in this patent the inventor name is Jean Heinrich Carl Dennert.

4.5.2 (page 63) 7th paragraph at right:

The author states “the third model was offered after World War I” and “the protection period for DRGM 314734 had long since expired”. In other paragraphs the author has also stated that this DRGM is dated 1907 and that the duration of a DRGM is 3 or 6 years. Then his statement “The Model 3 is only offered by D&P from 1909 is inconsistent. Was it 1919?