# Oughtred Society Slide Rule Reference Manual

A publication of The Oughtred Society

# Oughtred Society

# Slide Rule

# Reference Manual

**(All About Slide Rules)**

Compiled by Richard Davis and Ted Hume from an original design by Bob Koppany.

THE OUGHTRED SOCIETY

Roseville, California
2012

# PREFACE

The Oughtred Society is pleased to present this new document, *All About Slide Rules*, for all to use. With this document, the Oughtred Society wishes to introduce itself and provide a service to the great numbers of slide rule enthusiasts, collectors, and users with whom the Society is not currently acquainted. In doing this, the Society extends an invitation to all to join us in this fascinating pursuit.

This online document, *All About Slide Rules,* presents what its title suggests, complete information about slide rules. In its seventeen chapters, with 103 pages and 114 photographs, it contains information of all types, from *What Is a Slide Rule and How It Works*, to *History*, to *Common and Less Common Types*, to *How to Use a Slide Rule*, to Major *Makers and Some of Their Common Models*, to *Books and Manuals*, to *Cleaning and Care*, to *Slide Rules on the Internet*, to *Collecting* ... and more.

The Oughtred Society was founded in 1991 by a group of slide rule collectors and is dedicated to the preservation and history of slide rules and mechanical calculators. In the past 21 years, it has evolved to an international organization of some 400 members in 23 countries. It is noted for its highly acclaimed *Journal of The Oughtred Society*, published twice annually, containing articles by its members and others. The Society's activities are carried out by members who volunteer to do various jobs and projects. Membership is open to anyone. Additional membership information is available at the end of this document.

Objectives of the Society include the dissemination and sharing of information about slide rules and mechanical calculators, and encouragement for collectors and researchers. The Society is a non-profit educational organization and is affiliated with similar organizations in Great Britain, Germany, and The Netherlands.

Benefits of membership include:

• Subscription to the Journal of The Oughtred Society, published twice annually. This internationally acclaimed journal is the most authoritative source on slide rules and mechanical calculators, with each issue containing a wealth of information about makes and makers, models, uses, history, and more. Members are encouraged to submit articles.

• Members can acquire back issues of the Journal from its inception in 1991.

• Annual Members Directory, a great resource for locating and communicating with other collectors, enthusiasts, and dealers.

• Annual meetings and auctions for members occur on the West Coast in June, the East Coast in November, and the Southwest in February. At meetings, members exchange information, display items from their collections, and have the opportunity to participate in an auction in which many kinds of slide rules and calculators are sold, from the ordinary and inexpensive to the rare.

*All About Slide Rules* was compiled for internet presentation by Oughtred Society member volunteers Richard Davis and Ted Hume.

The Oughtred Society
2012

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# How to Navigate

# ALL ABOUT SLIDE RULES

The following instructions are for Adobe Reader. If you use a different PDF reader, your procedures should be quite similar.

1. General navigation.
   A. Table of Contents. Click a Chapter title to jump there.
   B. Bookmarks. Jump to Chapters and their subheadings. See 2 below.
   C. Go one page forward or back by two methods:
      i. Press **Page Up** and **Page Down** keys.
      ii. Click **Up and Down arrows** in Adobe Reader toolbar.
   D. Change page number in Adobe Reader toolbar page window and press **Enter** to jump to a specific page.

2. Bookmarks
   A. Click any Bookmark or subheading to jump to its page.
   B. Click center icon at left side of screen (page with blue ribbon) to view Bookmarks, which will appear constantly as you navigate through *All About Slide Rules.*
   C. Click plus **(+)** and minus **(-)** symbols to expand or condense primary Bookmarks, which are Chapter titles. Primary Bookmarks with a + sign will expand to show subheadings within the Chapter.

3. Links
   A. Click any blue link to jump to its destination.
   B. If link destination is another page in *All About Slide Rules* (there are many of these), use keyboard command **Alt + Left Arrow** to return to the page of original link. Left arrow is adjacent to the right **Ctrl** key.
   C. You also can install in your Adobe Reader toolbar a **Return to View** left pointing arrow to return to page of original link. In the Adobe Reader toolbar under **View**, you can find instructions to add this arrow to the toolbar.

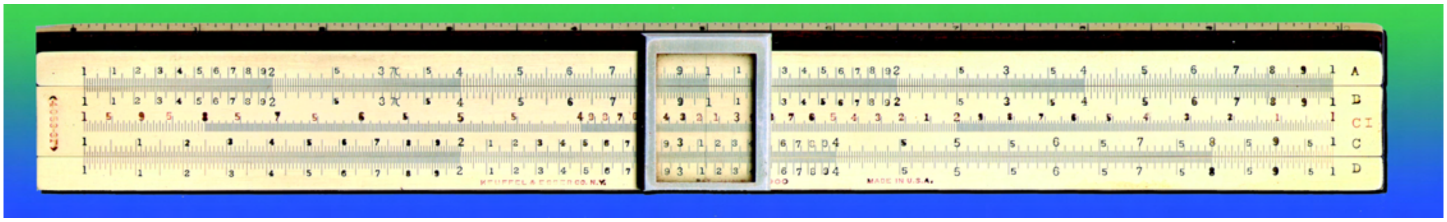
4. Image viewing
   To view slide rules in detail, enlarge the page.

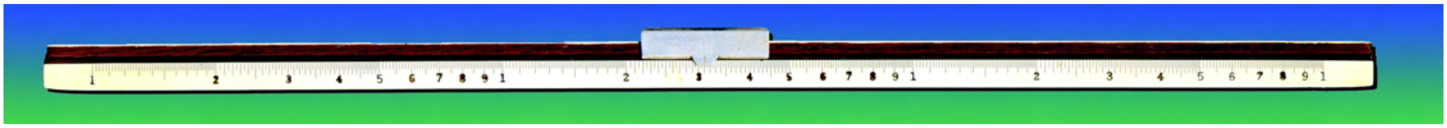
# ALL ABOUT SLIDE RULES

# What is a Slide Rule?

## Definition of a Slide Rule ... and What It Can and Can't Do

A slide rule is a simple looking mechanical device based on logarithms that performs a wide range of mathematical operations. Visually, it just looks like an assembly of sliding and stationary scales, but hidden in the design of the scales is extraordinary mathematical sophistication, able to perform simple operations from multiplication or division to complicated fractional powers and roots, and complex trigonometric functions. The range of its power is quite incredible, and few people can even perform its more complex functions manually. For example, how are your manual cube root skills today?





K&E 4053-3F, 25 cm scales ("10 inch"), celluloid on mahogany core, simplex, USA. Front and edge view.

It can work with numbers of any size but can typically provide only 3 significant figures of resolution. It also does not do regular addition and subtraction (get out your abacus for that), although its fundamental design is based on the addition and subtraction of logarithmically related distances.

Precision of 3 significant figures is enough for most engineering design in the real world, as it provides accuracy to 0.1%, quite adequate for serious work, especially in a world where many measurements and parts are rarely even accurate to 1%. Your calculator may produce 8 significant figures, but when the total uncertainty of your data is considered, often only 3 are used.

The slide rule also has one truly magical property – it is a parallel calculator, rather than a serial one like your desktop electronic calculator. Once a relationship is set up on a slide rule, all variations are also set up at the same time, allowing you to have a visualization of changing results with different values, without any additional real work. On your electronic calculator, you will be pressing buttons for hours to see what a slide rule does just by existing. In the engineering world, this is called a "Monte Carlo" analysis, where the values are varied to see the results, usually with a powerful computer to provide the calculating horsepower. Even the lowliest student slide rule does this automatically.

For a simple example, let's say you are on vacation in India and want to buy an antique statue. Set up the exchange rate of rupees to dollars or your currency of choice on your slide rule, and you can see what it costs, BUT, you also see every other price at that rate at the same time (thus making dickering over the price much easier). This is quite amazing, and impossible for your electronic calculator, but just everyday life for a slide rule.

## Unique Characteristics of the Slide Rule

- The slide rule demonstrates elegant simplicity (few pieces, only two moving parts).
- It embodies classical grace (its dimensions approximate the ratio of length to width of a column in a Greek temple such as the Parthenon).
- It has total "transparency" (every register and scale is readily visible).
- It has very large dynamic range and sufficient precision for most engineering tasks.
- It is easy to learn and simple to operate.
- It provides automatic parallel computations.
- And it has wide computational flexibility.

These features, when coupled with the slide rule's different scales and labels, hint of great complexity and tactile, intimate control of mathematics.

To appreciate the power of this deceptively simple looking tool, pick up a well-made example, and feel its weight, balance, and precision.

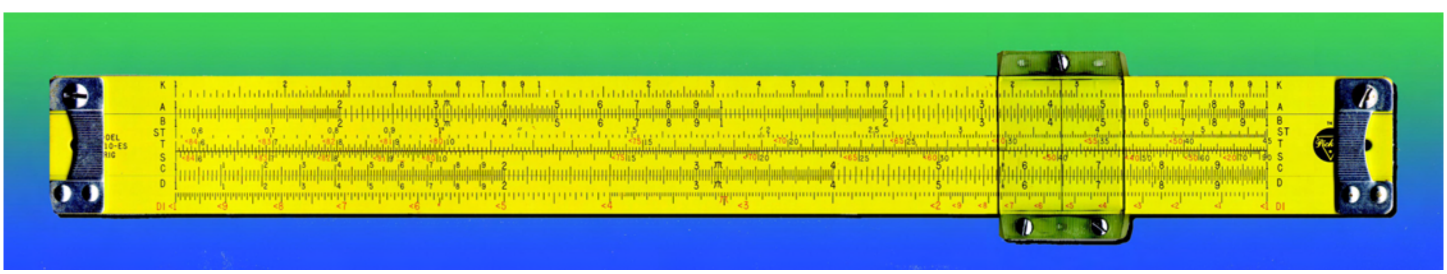
*You hold mathematical magic in your hands!*

The scales and arrangements have been refined through 20 generations of mathematicians and engineers, creating adjacent mathematical relationships that still outperform the calculator and computer generated spreadsheet for certain problems in electronics, surveying, financial risk forecasting, and proportion dependent analysis.

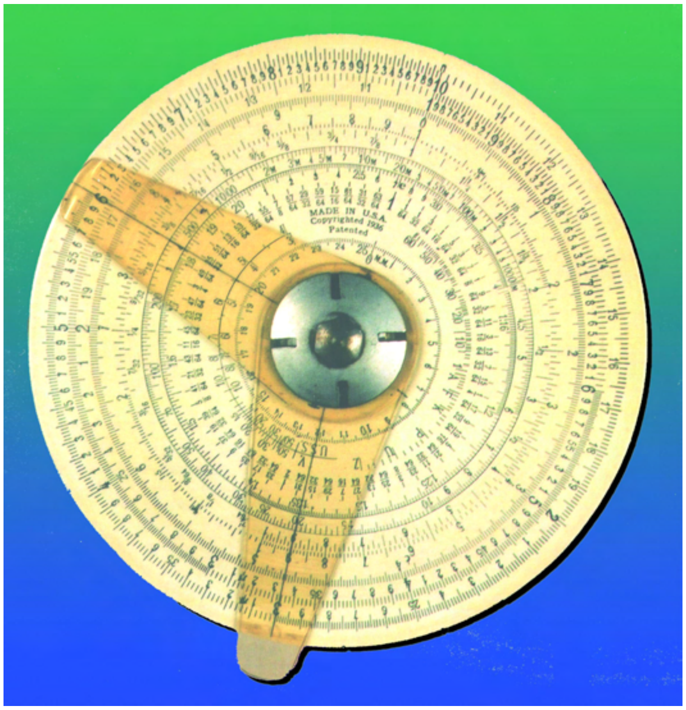
This is simply magic to the uninitiated … and a marvel to watch in action.

## How Slide Rules are Made

The most commonly seen slide rules are made of wood or bamboo covered with celluloid or are made entirely of plastic. One leading American company made them of aluminum. Some were made of plain wood or steel or other metals.



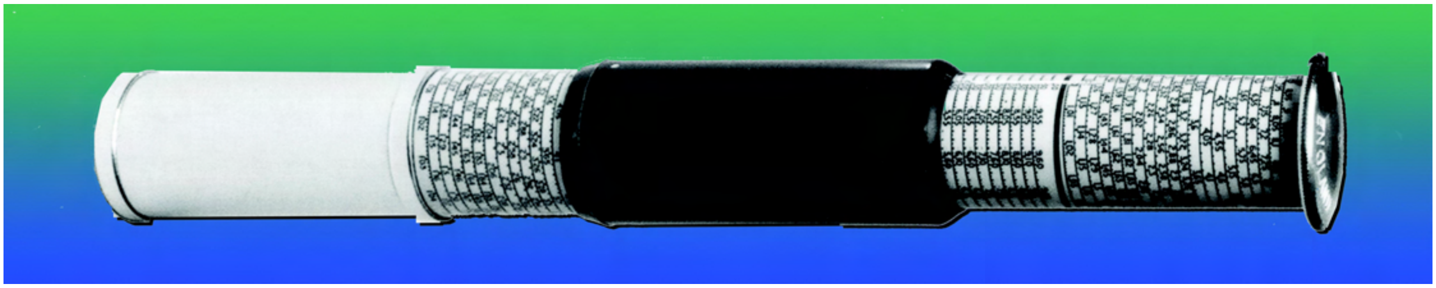
PICKETT N1010ES, 25CM SCALES, ALUMINUM, USA



Gilson Midget, 4" diameter, aluminum, USA

Virtually all 20th Century slide rules have a glass or plastic cursor, or indicator, with a hairline, which slides along its length. The sliding scales allow relationships to be set up, and with a cursor, complex relationships may be used across the entire slide rule body, not just between adjacent scales.

Most slide rules are linear, like a ruler, but some are circular discs.



Otis King, cylindrical, metal with varnished paper scales, England

Some scarce types are cylindrical.

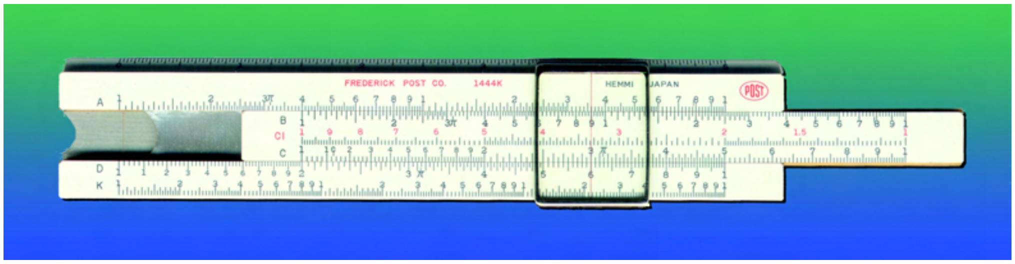
Linear slide rules were made in several scale lengths.

Ten inch scale length is by far the most common. (Actually the length is usually 25 centimeters, but it is normally called a "ten inch" slide rule.)

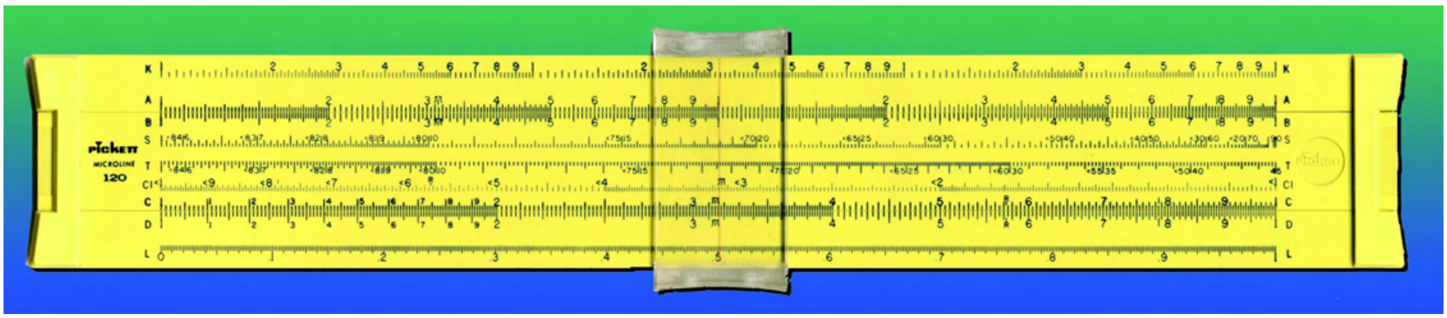
Five inch scale length (actually 12.5 centimeters) pocket slide rules are also quite common.

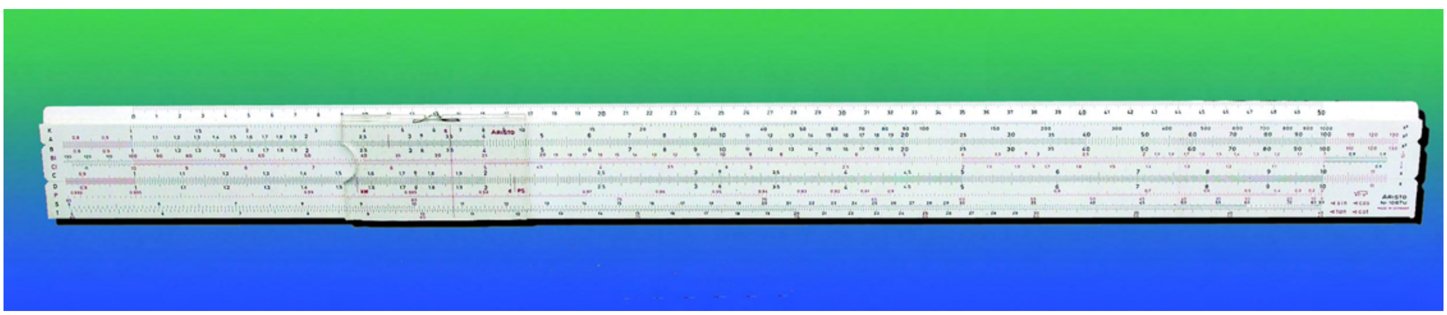
Many major slide rule manufacturers also produced a few examples of their most popular 10 inch rules in a 20 inch (50 cm) size. The additional space between markings on the scales contributes to greater precision and the 20" length certainly creates an imposing desktop presence.

The actual overall length of a slide rule is slightly greater than the scale length, so the cursor does not fall off while working at the scale ends, and to provide space for the end braces on duplex slide rules.




Post 1444K, 12.5 cm scales ("5 inch"), celluloid on bamboo core, simplex. Made by Hemmi of Japan for Post, USA



Pickett 120, 25 cm scales, ("10 inch") plastic, simplex, USA

Aristo 1067U, 50 cm scales ("20 inch"), plastic, Germany

## What Slide Rules Do

Slide rules calculate by adding and subtracting logarithmic distances by positioning the slide and body. As a result, they can multiply, divide, do roots and powers, calculate logarithms and a wide variety of trigonometry functions. The mathematical relationships are locked into the scale distances specific to the calculation.

Scales vary greatly. For example, a scale used to calculate tangents (often called a T scale) has very different arrangements of scale numbers and markings than scales used to calculate squares and square roots (often called A and B scales).

Slide rules cannot add or subtract in the conventional way ... though they work by adding and subtracting logarithms in order to multiply and divide. The designers of most slide rules felt that addition and subtraction could be done adequately by manual computation, but this could have been done (with limited range) simply by putting two linear scales on a slide rule.

Scales have been designed and refined over many years to facilitate chained calculation, thus they are very good for quickly solving complex formulas, especially those with many multiplied or divided terms. Slide rules also visually reveal ranges of answers in a way that calculators cannot do.

## What Slide Rules Have Done

It is interesting to consider that virtually all bridges, buildings and other structures built in the past three hundred years or more were designed with an ordinary ten inch slide rule. This includes the Brooklyn Bridge, Hoover Dam, Empire State Building, roadways and land reclamation projects, and the design of cities and waterways all over the world. Airplane design, basic and advanced electronic design and space ballistics work was also done with a slide rule.


Pickett N600ES Apollo, 12.5cm scales, aluminum, duplex, USA

It was the state of the art technology for calculating until inexpensive electronic calculators became available in the early 1970's. Click Here to see a chapter on the history of slide rules.

In fact, there is some rocket science here, as slide rules were carried (and presumably used) on Apollo Space Missions. We will assume they were not used to swat space flies, and had some real merit, as every payload ounce was very precious. You could calculate exactly how precious with your slide rule.

They were an incredibly weight effective back up computer system to the onboard computers. Pilots all over the world still carry the E6B flight computer and its relatives today, a specialized circular slide rule for doing speed, distance, wind and fuel calculations. Image It is fast, easy, and the batteries never go dead on final approach.

While slide rules blossomed with up to 34 scales, sometimes more, the simpler designs retained their power and popularity. Wernher von Braun's favorite was a 9 scale Nestler 23R slide rule that he used during his career at NASA. Albert Einstein also used a Nester 23R in his work.

# How a Slide Rule Works

**A slide rule multiplies by adding logarithms of numbers.
It divides by subtracting their logarithms.**

Now ... don't go running out the door! Logarithms are simple. Although one does not need to know logarithms to use a slide rule, a basic understanding of them is helpful.

Logarithms are exponents. Exponents are powers to which one may raise a number ... like $4^2 = 16$ (4 to the 2nd power equals 16) and $4^3 = 64$ (4 to the 3rd power = 64). The little $^2$ and $^3$ are exponents.

When you multiply numbers, you add their exponents. When you divide, you subtract exponents.

Thus $2^2 = 4$. $2^3 = 8$. $2^2 \times 2^3 = 2^5 = 32$. And $2^5 \div 2^2 = 2^3$. $32 \div 4 = 8$

A slide rule does this by sliding logarithmic scales of numbers alongside each other and thus adding or subtracting the logarithmic distances.

It is very easy to add numbers with a ruler, as shown in the illustration below.

The ruler on top will add 3 to any number on the bottom ruler. For example, look at 2 on the top ruler and read the answer 5 on the bottom ruler. Look at any number on the top ruler and the number on the bottom ruler will be 3 greater.

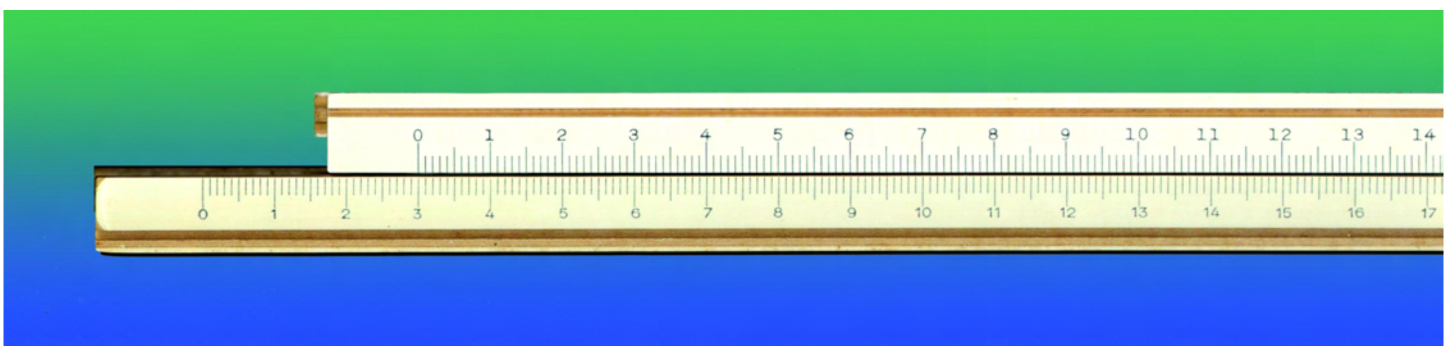


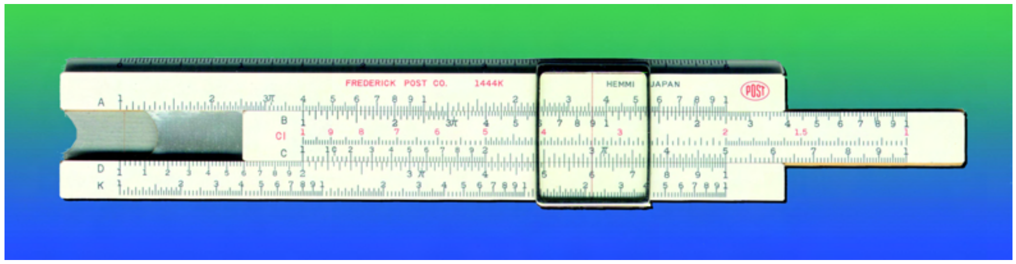

Photo of 2 rulers set to add 3.

Your slide rule adds logarithms in the same way.

At the top of page 8, we see a slide rule adding the logarithm of 2 to the logarithm of 3 to get the logarithm of 6 ... thus multiplying 2 by 3 to get 6. (Remember that when we add exponents, or logarithms, we are multiplying the numbers they represent.)

## Common Logarithms

The common logarithm of a number is the power to which one must raise the number 10 (the base) to obtain the number in question. This power, or




Post 1444K, 12.5 cm scales, celluloid on bamboo core, simplex, USA

exponent, is thus called the base 10 logarithm, or the common logarithm, of the number. Any number can be expressed as ten to some power. (Other bases are sometimes used, but 10 is the most common.)

Using 10 as the base (common logarithms), note the following:

The logarithm of 1 is zero. Log 1 = 0. $10^0 = 1$. 10 to the zero power = 1.

Logarithm of 10 is 1. Log 10 = 1. $10^1 = 10$. 10 to the first power = 10. All numbers between 1 and 10 may be expressed as 10 to some power between 0 and 1, for they are all between $10^0$ and $10^1$. For example, Log 2 = 0.301. 10 to the 0.301 power = 2. $10^{0.301} = 2$.

The logarithm of l00 is 2. Log 100 = 2. $10^2 = 100$. 10 squared = 100. All numbers between 10 and 100 may be expressed as 10 to some power between 1 and 2, for all are between $10^1$ and $10^2$.

The logarithm of 1000 is 3. Log 1000 = 3. $10^3 = 1000$. 10 cubed = 1000.

The logarithm of 0.l is minus 1. Log 0.1 = -1. $10^{-1} = 1/10^1 = 1/10 = 0.1$

Logarithm of 0.01 is minus 2. Log 0.01 = -2. $10^{-2} = 1/10^2 = 1/100 = 0.01$.

Here is an example:

The logarithm of 375 (Log 375) is about 2.574. (Ten to the 2.574 power = 375.) This makes sense, for 10 to the 2nd power is 100, and 10 to the 3rd power is 1000. Thus, the exponent of ten, the logarithm for 375, must be somewhere between 2 and 3. For instructions on how to use your slide rule for logarithms Click Here.

## A Couple of Strange Terms... Characteristic and Mantissa

A logarithm consists of two parts.

In the case of the logarithm of 375, which is 2.574, the 2 is called the characteristic. The characteristic tells us how big the number is... like the words used to describe the characteristic of a person... "He is a *big* fellow"... or "She is a *petite* lady. The number "2", the characteristic, tells us that the number is between 100 and 1000... between 10 to the 2nd power and 10 to the 3rd power.

The .574 is called the mantissa. (You find this on the L scale of your slide rule.) The mantissa .574 tells us where in that range the number actually is.

10 to the 2.574 power ($10^{2.574}$) = 375. Log 375=2.574

It is interesting to note that the mantissa of 375 is the same as the mantissa for 37.5 or 3.75 or 375,000,000! The characteristic tells us which number it is.

Log 3.75 = 0.574
Log 37.5 = 1.574
Log 375 = 2.574
Log 375,000,000 = 8.574

Each successive characteristic represents a number that is 10 times, or one tenth, the number represented by the adjacent characteristic. But … logarithms of numbers less than 1 are slightly different! See end of this chapter.

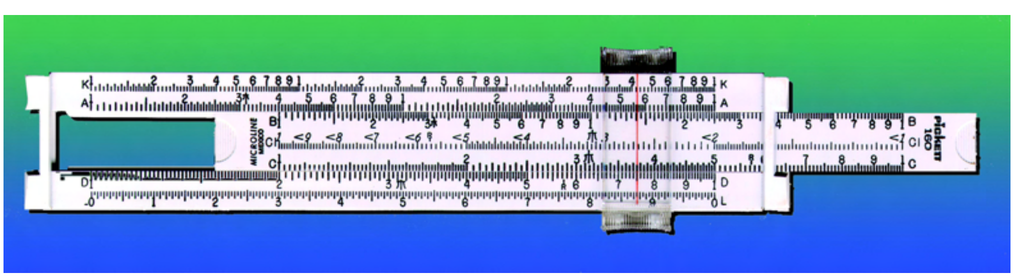
### The Starting Point in Slide Rule Operation – Multiplication

The basic scales, C and D, on a common 10 inch slide rule, are therefore 10 inch rulers whose markings are not in uniform inches, but in the number of inches of the mantissa for each number between zero and 10. The logarithm of 2 is 0.301… and you will find the number 2 on the C and D scales 3.01 inches from the left end. The logarithm of 3 is 0.477, and you will find the number 3 engraved 4.77 inches from the left end. Adding the two distances gives one 7.78 inches, and sure enough, the number 6 is 7.78 inches from the left end.

You don't actually have to add the distances to calculate the numbers. The slide rule has already done this for you.

To multiply 2 times 375, a slide rule adds the logarithms of the two numbers and reaches the logarithm of the answer. But… although the scales are spaced logarithmically, they are labeled with the actual numbers, not the logarithms. So, you read the answers directly.

2 (logarithm is 0.301) times 375 (logarithm is 2.574) = 750 (logarithm is 2.875) The logarithms are added. The numbers are multiplied. Check it out! See photo below.



Pickett 160, 12.5 cm scales, plastic, simplex, USA

They are represented by a logarithm with a negative characteristic.

To determine the logarithm of 0.375, we subtract 1 from the logarithm of 3.75.

Log 0.375 = Log 3.75 - 1.000 = 0.574 - 1.000 = -0.426.

We shifted the decimal point one place to the left of a single digit whole number (3.75), and in doing so we divided by a factor of 10, thus we subtract 1 from the logarithm of 3.75.

Another example:

Log 0.0375 = Log 3.75 - 2.000 = 0.574 - 2.000 = -1 .426

And ... Log 0.00375 = -2.426

This is the same process and reasoning we use for numbers greater than one. For example:

Log 37.5 = Log 3.75 + 1. Log 37.5 = 0.574 + 1 = 1.574.

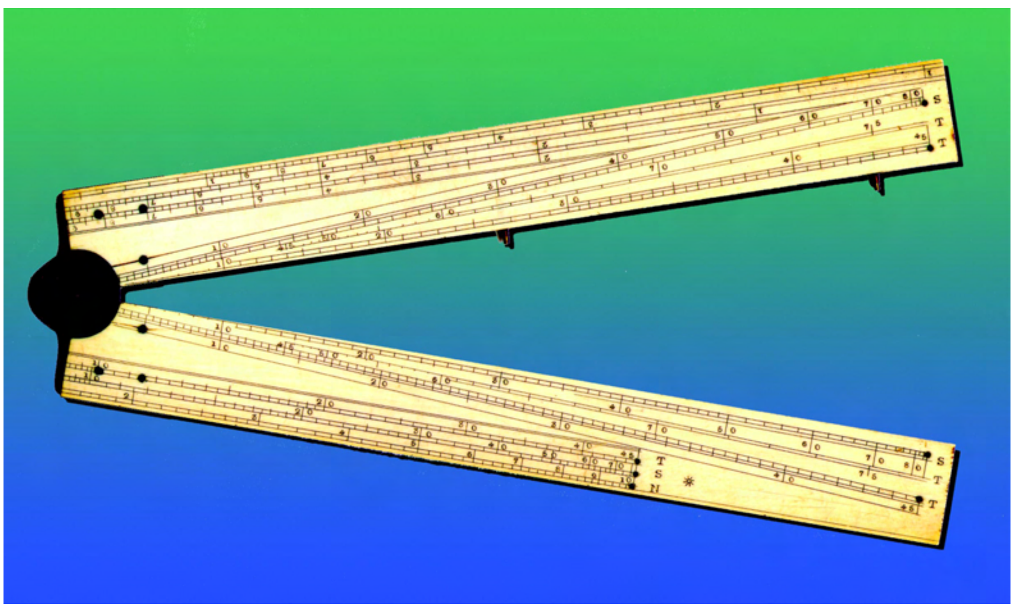
Click HERE for instructions on how to use your slide rule for logarithms.

# History of the Slide Rule

The pre-eminent figures in science both contributed to the creation of the slide rule and made use of it in their work, inciuding Galileo, Napier, Gunter, Oughtred, Newton, Gauss, Watt, Priestley, Fulton, Fuller, Einstein, Fermi, and Von Braun. A quick look at the first five of these men covers the creation and initial evolution of the slide rule.

## Just Before the Slide Rule

Galileo Galilei popularizes the sector at the very end of the 16th Century. The sector is a graduated ruler that uses trigonometric formulae and a caliper to calculate squares, cubes, reciprocals and tangents of numbers. Galileo's design of the sector as a mathematical tool can be seen as the moment when calculation aids cease to be based upon counting and instead exploit the deeper relationships among numbers. His invention is still in use as a navigation aid in the 20th Century ... 300 years later.

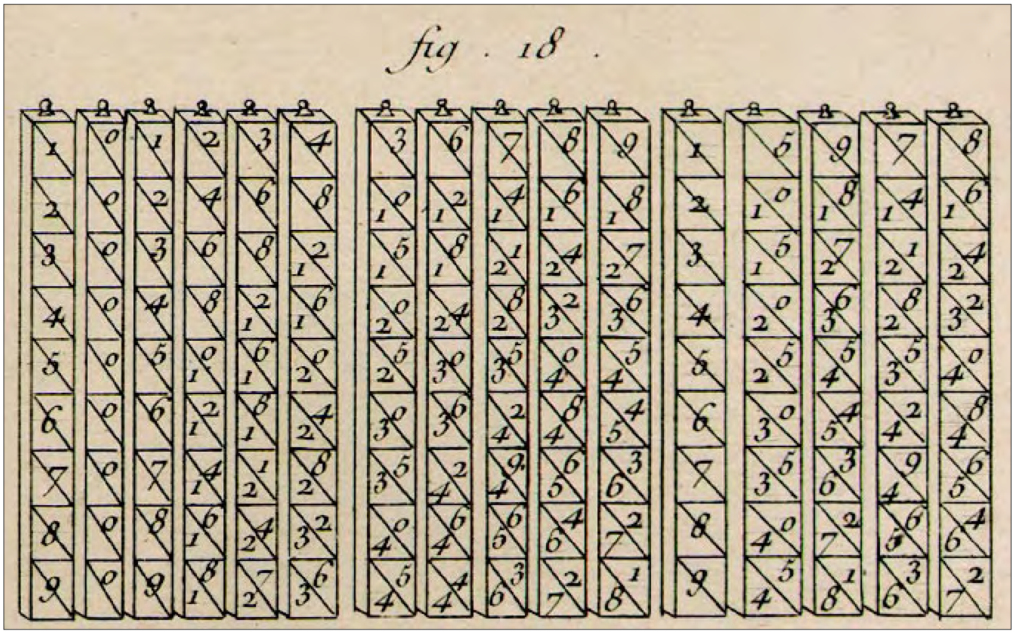


Sector, Ivory, with brass hinge and gauge points

## Chronological History of the Slide Rule

John Napier dramatically advances the understanding of number relationships in 1614 with his invention of logarithms. Since logarithms are the foundation on which the slide rule is built, its history rightly begins with him. His early concept of simplifying mathematical calculations through logarithms makes possible the slide rule as we know it today.

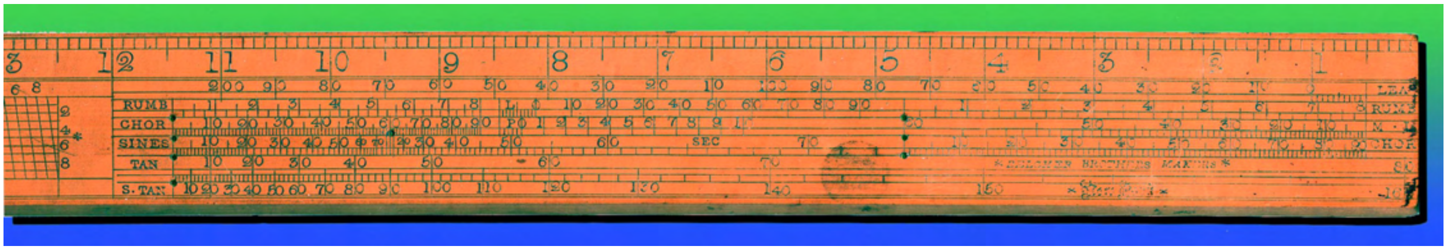
The ability of logarithms to decompose any number into two parts – a base and an exponent – allows the products and dividends of large numbers to be determined by addition and subtraction. Also, using base "*e*" (rather than the common base 10) opens the way for tremendous advances in engineering and science, induding the differential calculus.




Napier's Bones, plate, *Diderot's Encyclopedia*, France, 1762

**Calculating instruments now begin to appear in rapid succession ...**

Napier himself contributes Napier's Bones in 1617, calculating sticks based on the geologia (lattice) multiplication method. In 1620 Edmund Gunter of London makes a straight logarithmic scale and performs multiplication and division on it with the use of a set of dividers, or calipers.

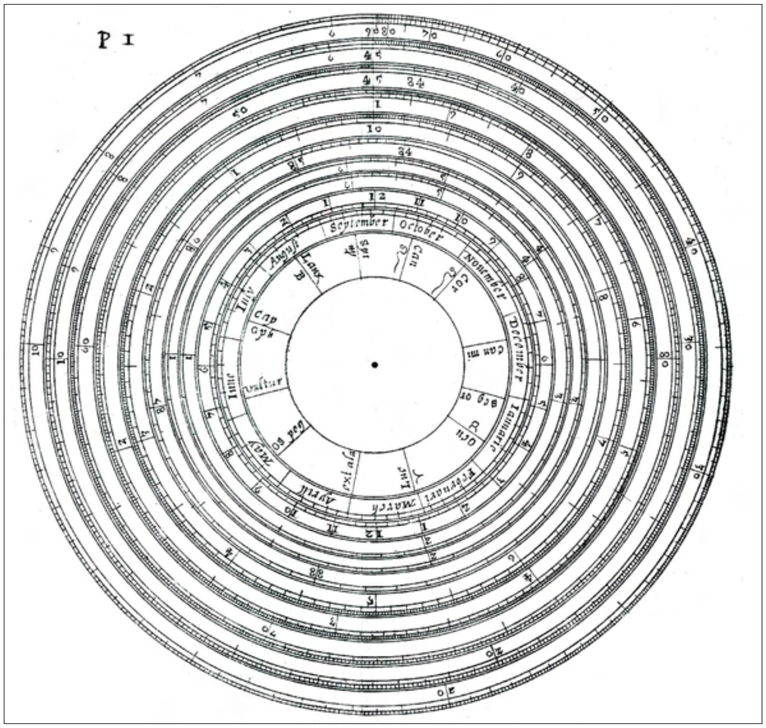



Gunter's scale, wood, England, first devised ca. 1620

In about 1622 William Oughtred, an Anglican minister ... today recognized as the inventor of the slide rule ... places two such scales side by side and slides them to read the distance relationships, thus multiplying and dividing directly. He also develops a circular slide rule.

In 1675 Sir Isaac Newton solves cubic equations using three parallel logarithmic scales and makes the first suggestion toward the use of the cursor.

Early slide rules are carefully incised by hand on boxwood or pearwood, of no uniform length, with each bearing the scale divisions of a unique maker. Expensive handcrafted instruments find use among the scientific elite, but this is hardly a sufficient market to sustain slide rule production. Advances in rule design without practical business application are ignored and then forgotten.



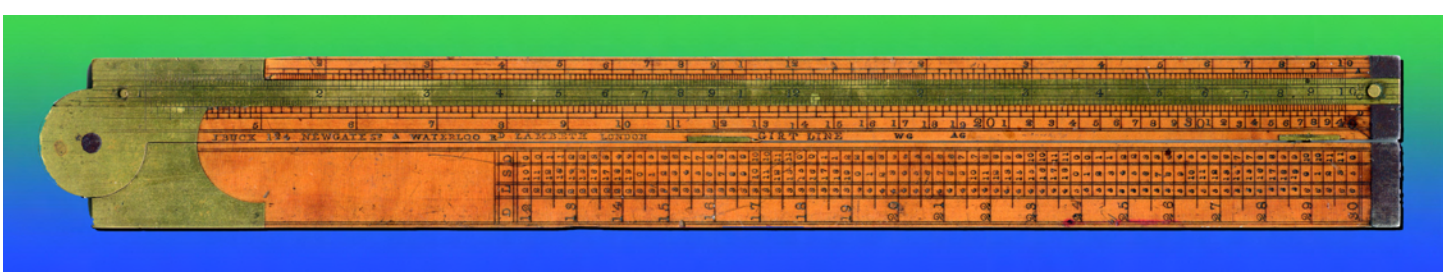
Oughtred's circular slide rule, plate, *The Circles of Proportion and the Horizontal Instrument*, W. Oughtred, Oxford, England, 1660

In 1677, two years after Newton invents the cursor, Henry Coggeshall perfects the timber and carpenter's rule. Newton's cursor fails to catch on at the time. The Coggeshall rule remains in common use 200 years later. His design and its standardization move the slide rule from a tool of mathematical inquiry to specialized applications.

Beginning in 1683, Thomas Everard popularizes the gauging rule, used to determine the content of ale, wine and spirits barrels and to calculate the excise tax thereon. This design, first created by William Oughtred in 1633, sees widespread use well into the 19th Century.

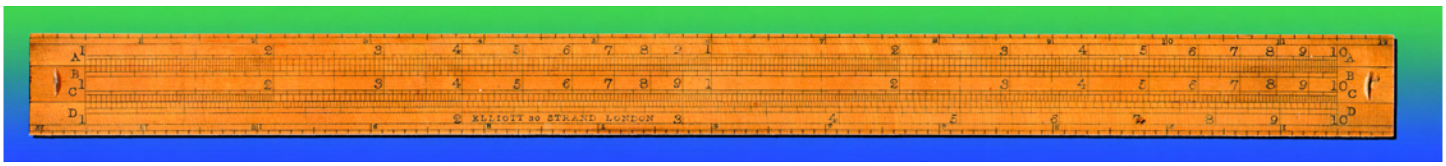
Throughout the 18th Century, slide rule production and use is mostly English, with limited penetration into other capitalist economies, including France and the Netherlands. Interesting to note is the lack of slide rules and makers in Germany, Switzerland, and Italy ... countries which at this time are producing cutting edge mathematics.

The slide rule delivers the mathematical framework for advances in the industrial arts and for ways of thinking about numbers and their applications in engineering. These discoveries are in turn applied to improvements in the



Coggeshall timber and carpenter's rule, boxwood, England, first described in 1677 slide rule's accuracy, precision, and mass production.

In 1722 John Warner, a London instrument dealer, uses square and cube scales. By 1790 James Boulton and James Watt are modifying slide rules to improve their accuracy and usefulness. By 1799 their Soho slide rule helps to usher in the Industrial Revolution. It facilitates the design and manufacture of their seminal machine, the steam engine.



SOHO SLIDE RULE, JAMES WATT AND JAMES BOULTON, BOXWOOD, ENGLAND, CA. 1800

In the 19th Century the engineer learns that precision to the third decimal place suffices to create superb structures. The slide rule allows such calculation, while its portability encourages design verification and standardization on the job.

Modern engineering is invented through the use of the slide rule, itself a design that could only create this impact through modern engineering.

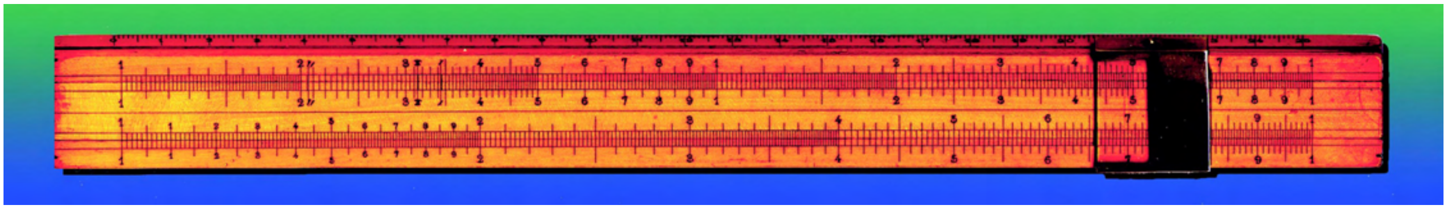
In 1815 Peter Roget, an English physician (and the author of *Roget's Thesaurus*), invents a log log scale, which he uses to calculate roots and powers to any number or fraction thereof. It is regarded at the time as a mathematical curiosity.

Fifty years later, advances in electrical engineering, thermodynamics, dynamics and statics, and industrial chemistry make these scales so necessary they are rediscovered. In the next fifty years they increase from three, to six, to eight scales on the slide rule, as engineering extends its grip on modern computation.

During the first half of the 19th Century slide rule use broadens with the extension of education, democracy and free trade. Britain sees tremendous expansion of slide rule types and manufacturers. France's revolution of 1795 ushers in a period of extreme mathematical rationality. Results include invention of the metric system, advanced knowledge of the movements of the heavens and earth, and the first requirement that all civil servants demonstrate slide rule proficiency as a part of qualifying exams.

In 1851 a French artillery officer named Amedeé Mannheim standardizes a set of four scales for the most common calculation problems. The four scales include two double length, named A & B, for squares and square roots ... and two single length, C & D, for multiplication and division. This scale set becomes the basis of slide rule design for the next 100 years and bears his name today. His design and use of a cursor hastens the eventual widespread acceptance of this feature.

Tavernier & Gravet of Paris quickly develops an international reputation for accuracy in production of the Mannheim design. An inverted C scale (CI) and a K scale (for cubes and cube roots) were added later to the face of the rule by others, along with two trigonometry scales (S & T) and a logarithm scale (L) on the back of the slide. These additions comprise what is often called the "Enhanced Mannheim" scale set.

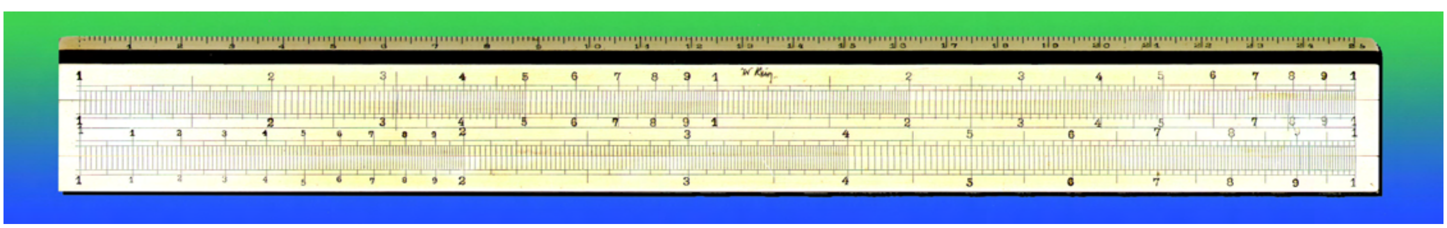


Tavernier & Gravet slide rule, Mannheim design, boxwood, France, ca. 1900

Early in the 19th century the first slide rules come into use in the United States. Ex-president Thomas Jefferson has one, and Joseph Priestley recognizes their advantages in his chemistry work, which includes the discovery of oxygen.

Belcher Brothers, New York (1821-1876), E.A. Stearns & Co., Vermont (1838-1863) and Stanley Rule & Level Co., Connecticut (1857-1920), add versions of English slide rule designs to their product lines. Palmer's Calculator, a circular slide rule, is produced in the United States about 1845. Richardson follows soon after with a steel linear slide rule in 1851.

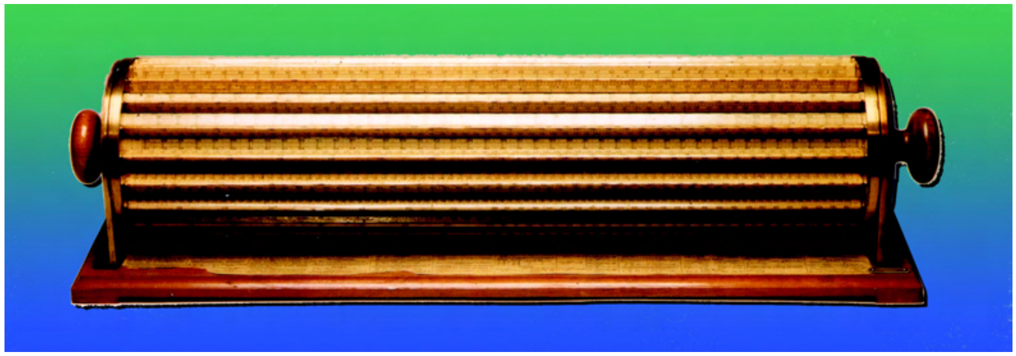
By 1870, Germany produces two giants of the slide rule world, Dennert and Pape (makers of Aristo), and Faber (later Faber-Castell). The Dennert and Pape contributions of "engine divided" (engraved) scales and the stable deposit of celluloid on wood are revolutionary. Slide rules can now be manufactured with any scale sets desired, to a high degree of precision, with highly visible, reproducible colored faces, allowing accurate calculations to three or four decimal places. The tool exactly corresponds to the revolution in engineering occurring at the same time.



Dennert & Pape slide rule, celluloid on wood core, Germany, ca. 1890

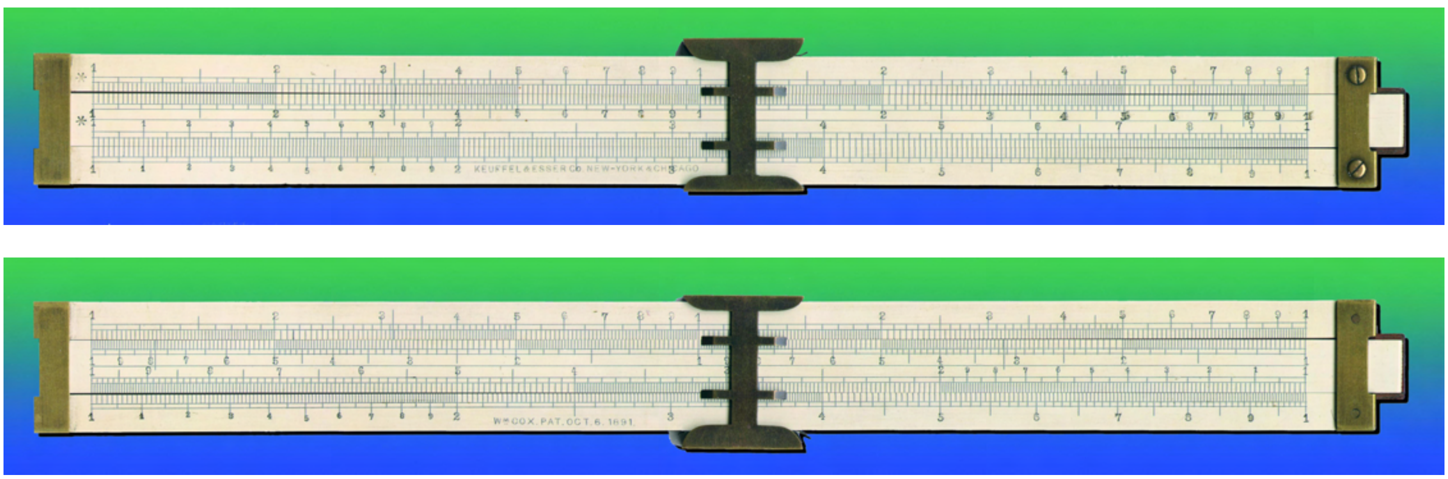
The slide rule's importance to the Industrial Revolution, and the impact of the Industrial Revolution upon the slide rule, are demonstrated by the proliferation of designs. From 1625 to 1800, the first 175 years after its invention, a total of 40 slide rule types, including circular and spiral designs, are recorded. The next 100 years, from 1800 to 1899, sees the creation of 250 slide rule types and manufacturers. Over 90 designs are recorded in the first 10 years of the 20th Century.

Cylindrical calculators with extra long logarithmic scales are invented by George Fuller of Ireland in 1878 and Edwin Thacher of New York in 1881. The plates for printing the paper scales of both the Fuller and Thacher calculators are produced by Stanley of London, who probably makes the first Thachers. Production is soon taken over by a Hoboken, New Jersey instruments company, Keuffel and Esser, that had previously imported slide rules for sale.



Thacher's calculator, Keuffel & Esser Co., Model 1740 (later 4012), ribbed cylindrical, USA, ca. 1890

A revolutionary linear slide rule construction with scales on both front and back and with a cursor referring to all scales simultaneously is patented in 1891 by William Cox ... an invention he calls the "duplex slide rule".



Cox's duplex slide rule, made by Dennert & Pape for K&E, celluloid on mahogany core, ca. 1895. Front and back views

### The Slide Rule's Last Century... the 20th

Folded scales CF, DF and CIF are put on slide rules about 1900 to reduce the amount of movement and resetting of the slide. Log log scales in three sections appear about 1901, enabling very accurate calculation of powers and roots to any number or fraction.

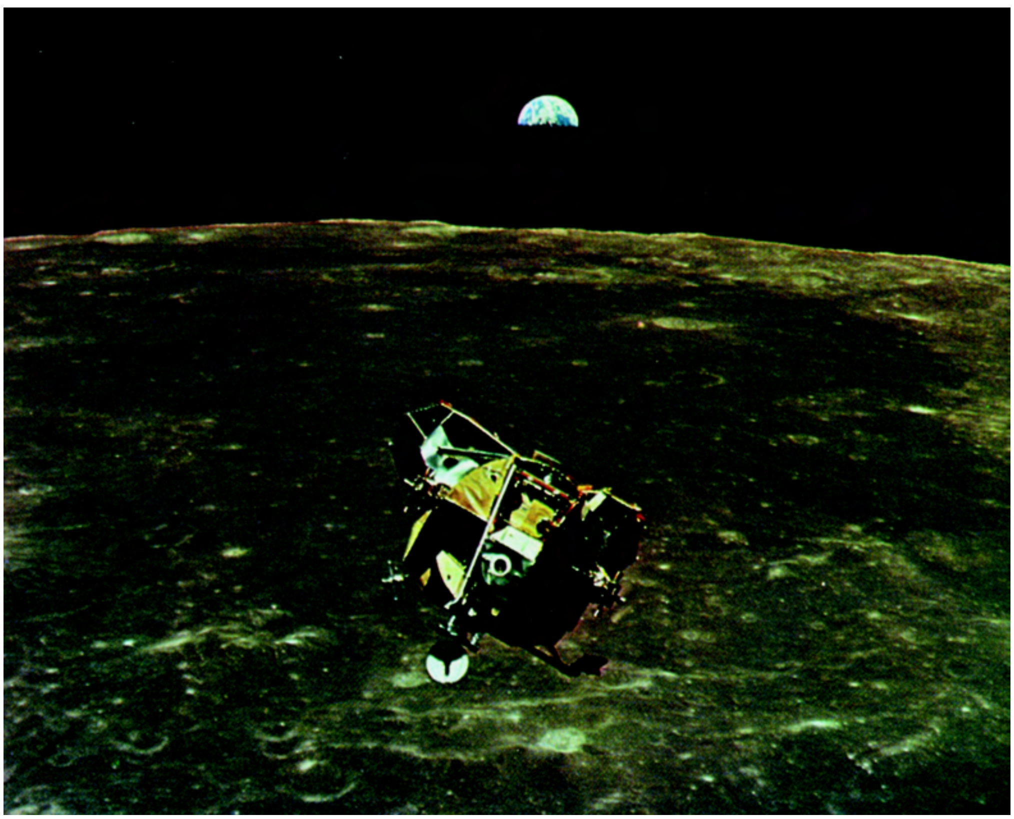
Numerous improvements by several manufacturers follow, contributing to the widespread popularity of the slide rule and its many uses in the mathematics of science and engineering, as well as for calculations of all kinds in business and industry.

The evidence of the slide rule's portable, immediate power stands everywhere around us as the 20$^{th}$ Century's greatest engineering examples, from the Empire State Building to the Apollo lunar landings.

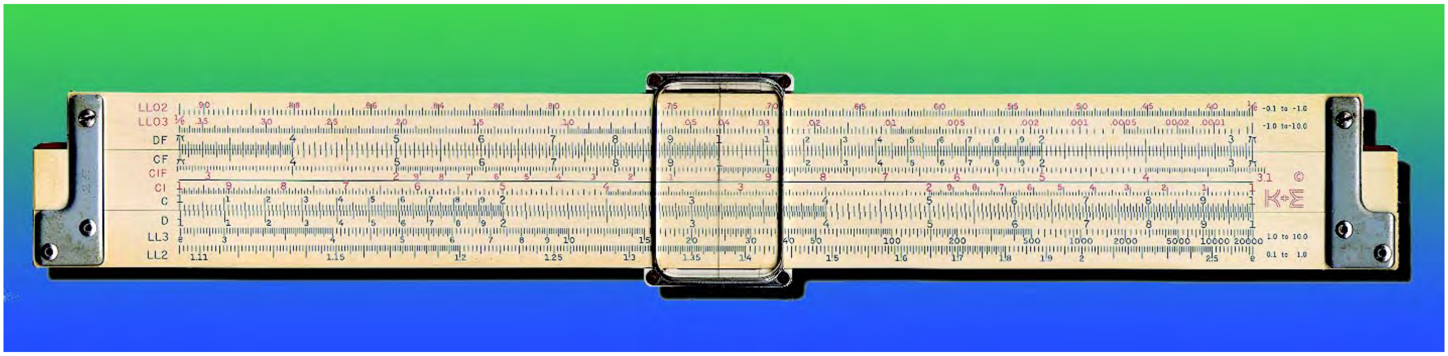
Our last century could not have been built without it, yet its direct evidence is almost totally missing to the uninformed eye.

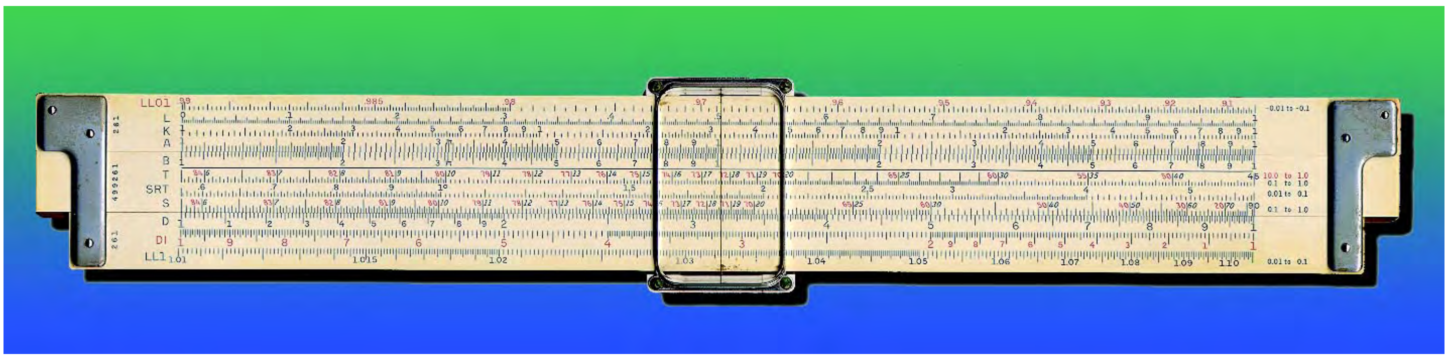
In the United States, this indispensability is seized upon most successfully by Keuffel and Esser. This firm moves from importing rules in the 1870s, to building a complex calculating instrument (the Thacher Calculator) in the 1880s, to manufacturing their own slide rules in the 1890s. Their contributions are legion, including the CI scale, their fanatical devotion to precision, their use of colored scales and slanting italics to aid in reading direction.

Their greatest triumph paradoxically occurs in their tenacious defense of their duplex patent. For 40 years no one but K&E could build a two-sided slide rule in the USA. This grip is broken finally by Dietzgen, founded by an ex-employee of K&E.



Apollo lander "Eagle", earth and moon



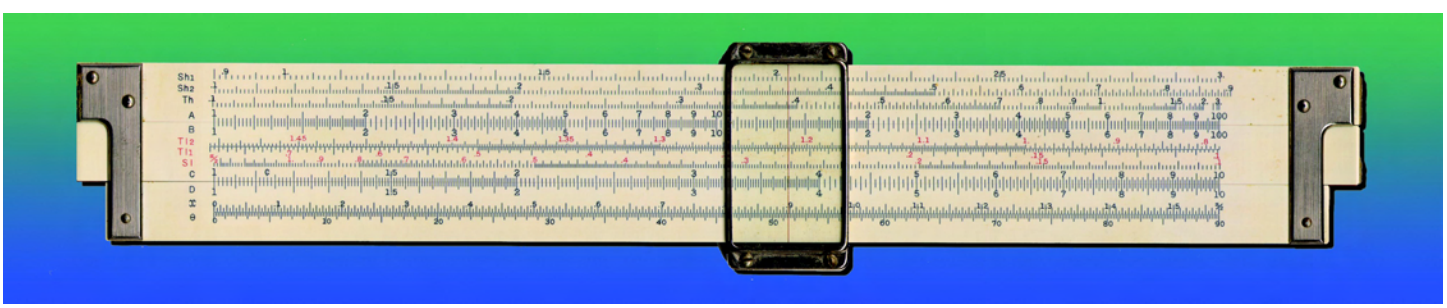



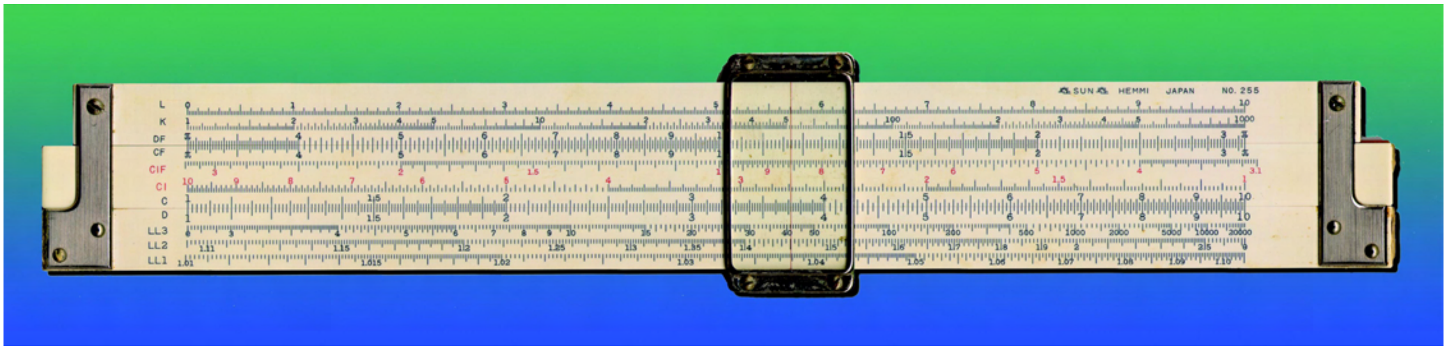

Keuffel & Esser 4081-3 Log Log Duplex Decitrig, 25 cm scales, celluloid on mahogany core, duplex, USA. Front and back views.

A different path to market dominance is adopted in Japan by Jiro Hemmi. Hemmi systematically experiments with both natural base materials and celluloid, settling upon bamboo as the core, and combining this with very modern manufacturing (including celluloid surface lamination), resulting in both high quality and quantity. Hemmi's intense devotion to practical use creates economical, robust and accurate cursors, high standards in legibility of scale numbers, and careful evolution in size, scale arrangement, and other criteria developed from extensive overseas visits and frequent customer questioning.

At the same time, Hemmi persistently pursues Pacific Rim market domination through special labeling for local distributors and for Post in the USA, and extensive marketing and promotional efforts aimed at schools and technical colleges. Their efforts at slide rule magazines, adding slide rule competence to high school and civil service exams, and other channels worked ... in the 1960's Hemmi is producing one million slide rules annually. Under Hemmi, the slide rule joins the automobile in a consumer equation that touts the product as an icon of mass manufacturing quality.

Hemmi 259D, 25 cm scales, celluloid on bamboo core, duplex, Japan. Back view.






Hemmi 259D, 25 cm scales, celluloid on bamboo core, duplex, Japan. Front view.

## Epilogue

The philosophy of engineering moves on. And the triumphs of 20th Century design become limitations for the slide rule. Einstein favors a Nestler slide rule in his work. The approaches to the Golden Gate Bridge and the thrust profile of the Redstone Rocket are designed with simple Rietz based slide rules ... E.H. Lowry's Dietzgen Phillips 1725 and Wernher Von Braun's Nestler 23 respectively. Pickett slide rules provide emergency computational power aboard Apollo missions with their N600-ES model. The Pickett N3 and N4 take their places along with the K&E Decilon and the Post Versalog in designing the F16 fighter airplane.

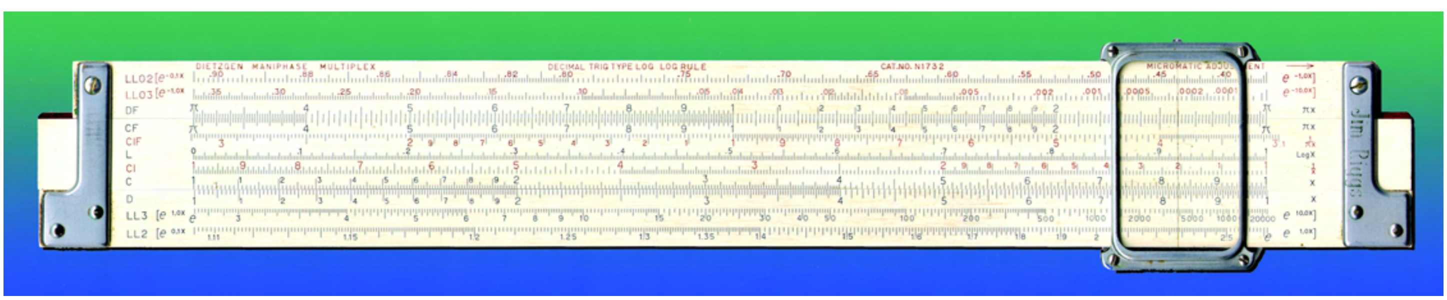
Golden Gate Bridge, San Francisco

But structural design and first principles in physics both seek answers to how structures will react to changing loads and forces. Wind speeds, tidal friction and interstellar collision all require dynamic computational models, rather than the answer to a static structural problem.

Large, slow, obese computing engines designed for these questions give birth to the sleek four-function calculator. K&E's travails with its Analon slide rule model are an excellent example of the change in engineering demands that surpassed the slide rule.

The four function electronic calculator is a symptom as much as a cause of this change.

F-16 FIGHTER AIRPLANE, USA



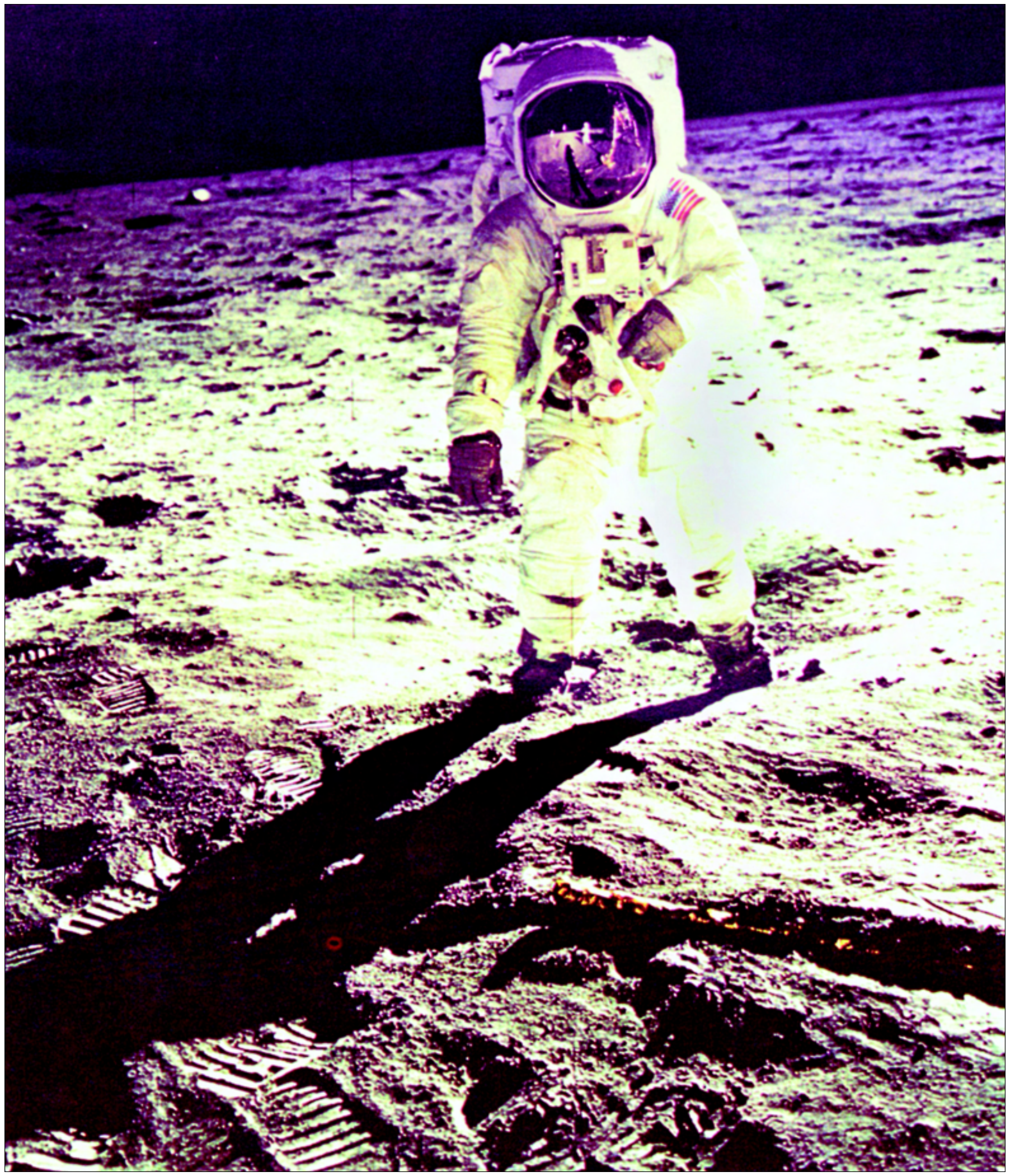

DIETZGEN 1732 MANIPHASE MULTIPLEX, 25 CM SCALES, CELLULOID ON MAHOGONY CORE, DUPLEX, USA

Slide rule researchers have estimated that possibly 40 million slide rules were produced in the world in the 20th Century alone. Among these are many types of specialty slide rules developed and made for specific applications such as chemistry, surveying, electricity and electronics, artillery ranging, hydraulics, steam and internal combustion engines, concrete and steel structures, radio and other special fields.

The slide rule has a long and distinguished ancestry, from William Oughtred in 1622 to the Apollo missions to the moon ... a span of three and a half centuries ... it was used to perform design calculations for virtually all major structures built on this earth during that long period of our history … an amazing legacy for something so mechanically simple.

Additional information about slide rules in general, their use, makers and instruction manuals, mathematics, and related subjects can be found in the extensive list of references (75 listings) in the *Books, Manuals and Articles* chapter, Click Here.

Empire State Building, New York



BUZZ ALDRIN WALKS ON TNE MOON

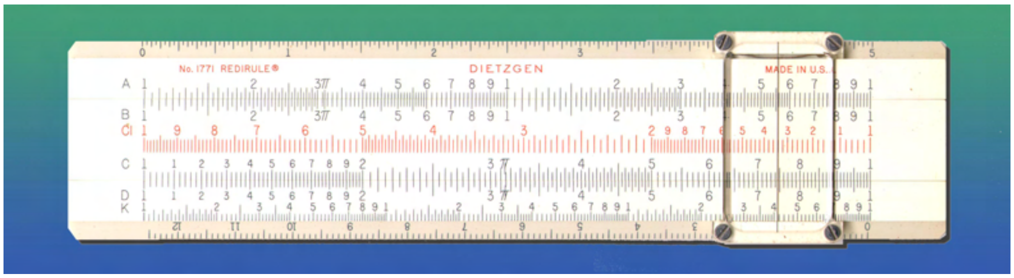
# Common Types of Slide Rules

## Basic Types

### Closed Body Linear

Sometimes called Simplex or Mannheim type.

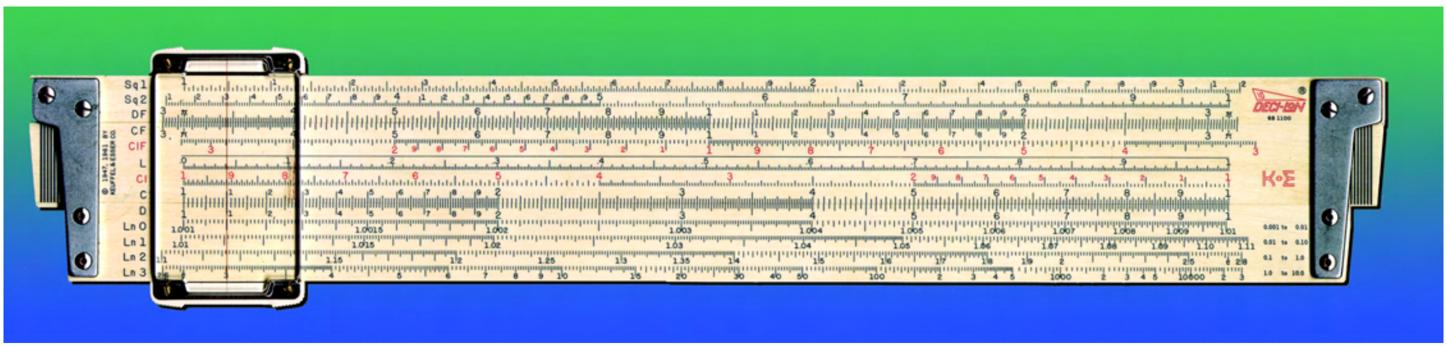
Has a solid back supporting the stators (the top and bottom parts of the body), a center slide, scales on one side of the body only (the slide frequently has scales on both sides), and a cursor (or indicator) on one side only.




Dietzgen 1771, 12.5 cm scales, plastic, simplex, USA

### Open Body (Duplex) Linear

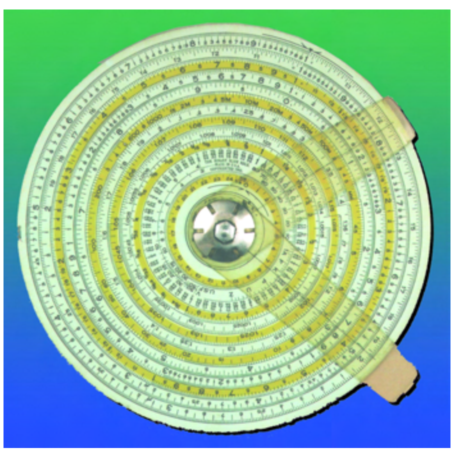
End braces (or brackets) of plastic or metal supporting stators (top and lower parts of the body), center slide, scales on both sides and two sided cursor.




Keuffel & Esser 68 1000 Deci-Lon, 25 cm scales, plastic, duplex, USA

### Circular

Has scales on one or both sides and one or two or more cursors.

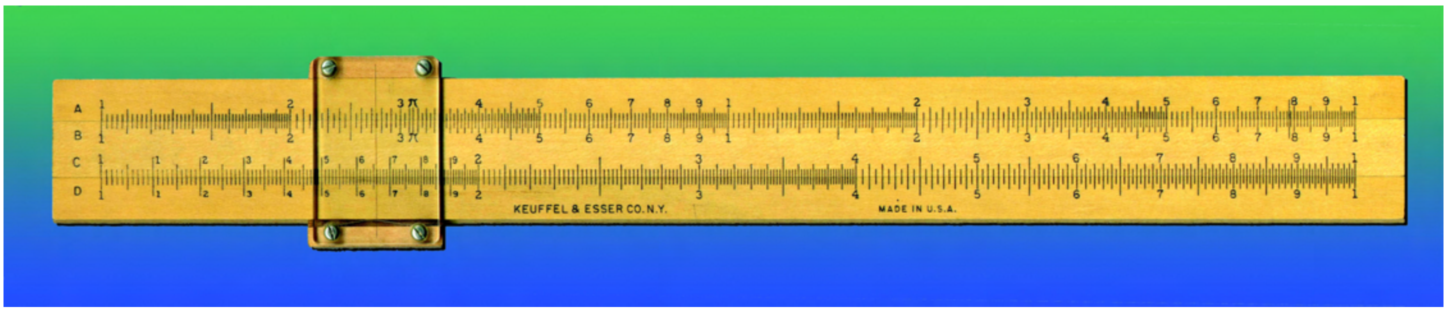


Gilson Binary, 8" diameter, aluminum, USA

## The Materials Used to Make Slide Rules

### Wood

The earliest slide rules were made of wood, with scales incised by hand into the wood faces. Later inexpensive rules had scales stamped into the wood, then filled with black color.

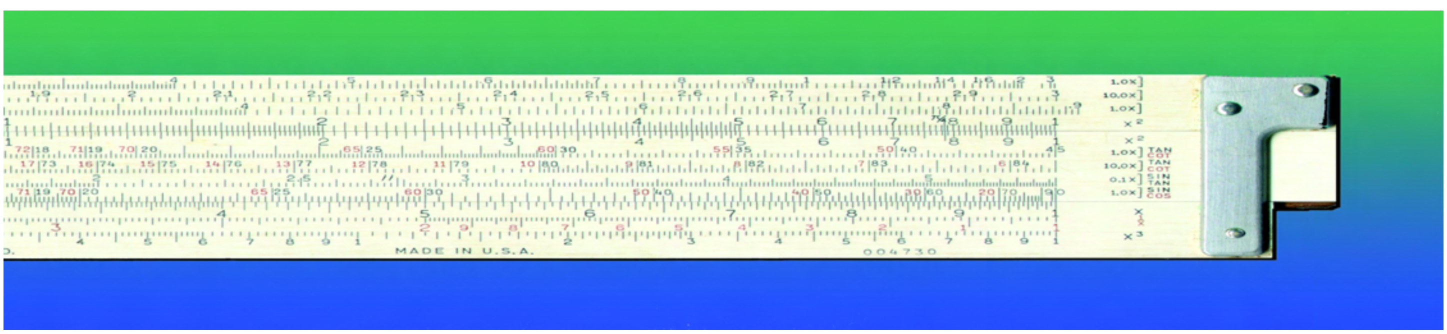



KEUFFEL & ESSER 4058C, 25 CM SCALES, WOOD, SIMPLEX USA

### Celluloid on Wood or Bamboo Core

Celluloid faces laminated onto the core provided the ability to engrave markings for greater precision. These markings were then filled with color of various formulations of inks or paints. After drying, the surface was then sanded or polished to the final finish, removing excess ink from the face and leaving it only in the engravings.

Major manufacturers using these techniques were Keuffel & Esser, Post (made by Hemmi for Post), Dietzgen, Hemmi, Faber-Castell, Nestler, Dennert & Pape (Aristo) and Relay-Ricoh.



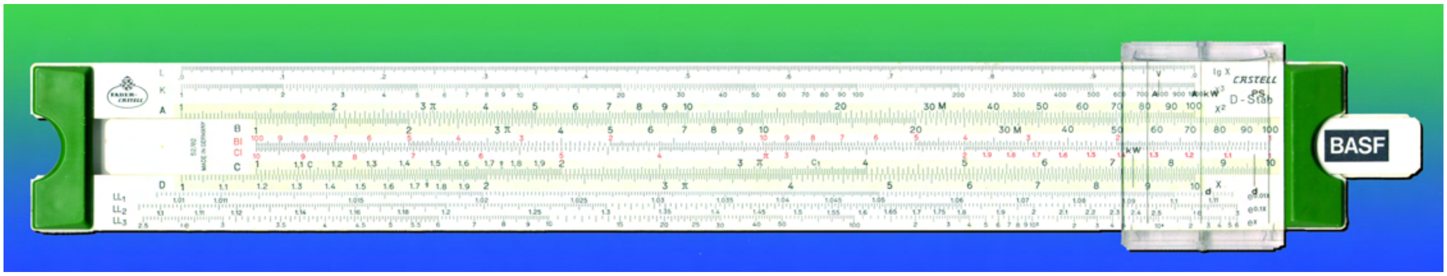

DIETZGEN N1725 MICROGLIDE, 25 CM SCALES, CELLULOID ON MAHOGANY CORE, DUPLEX, USA

### Plastic

Many later slide rules were made of plastic, ranging from very fine rules with engraved (engine divided) scales to cheaper models with stamped scales or scales simply printed on the plastic. Many makers produced at least some plastic rule models in their later years.

Fine plastic rules were made by Keuffel & Esser, Post (made by Hemmi for Post), Dietzgen, Hemmi, Faber-Castell, Aristo, Nestler, Thornton, Diwa and others.

Inexpensive plastic rules were made by Sterling (also Acu-Math), Pickett and others.



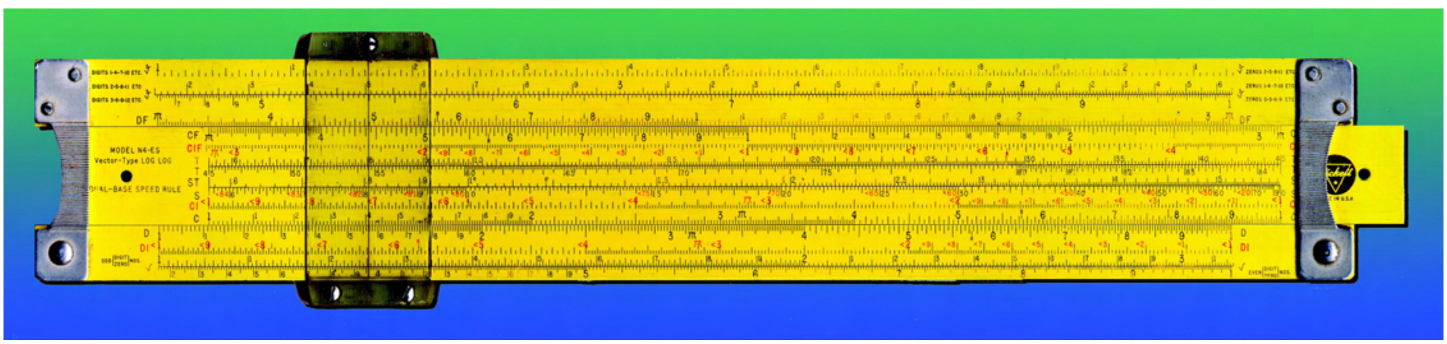

Faber-Castell 52/82, 25 cm scales, plastic, duplex, Germany

## Aluminum

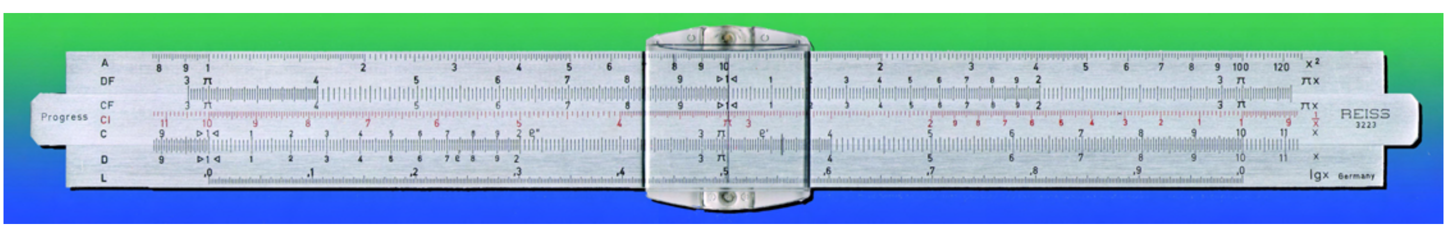
Aluminum slide rules were made by two common methods ...

— scales were lithographed, along with background color of yellow or white, onto the surface (Pickett)

— scales engraved (engine divided) on brushed aluminum surface (Reiss)



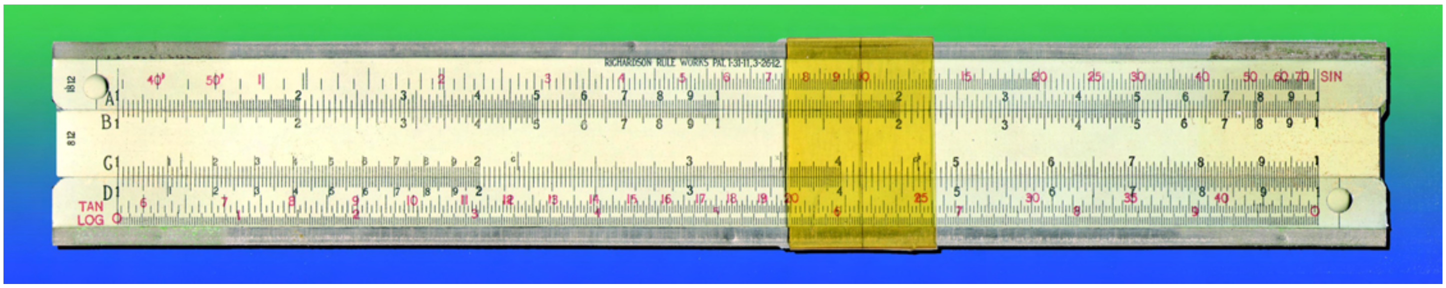

Pickett N4ES, 25 cm scales, aluminum, duplex, USA




Reiss 3223 Progress Duplex, 25 cm scales, aluminum, duplex, Germany

**Steel**

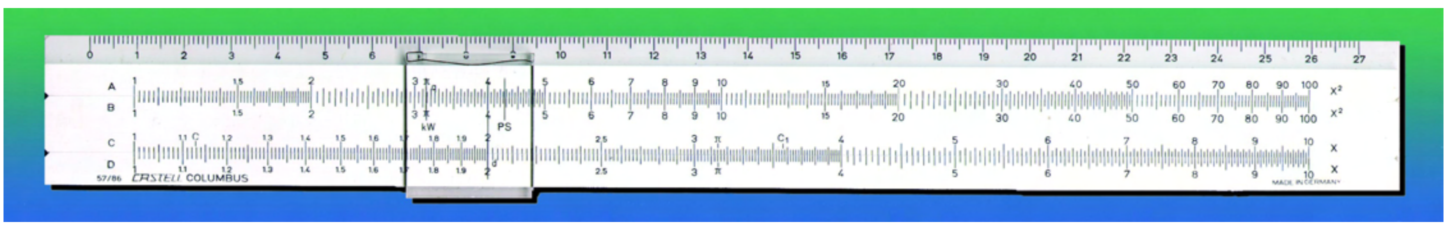
Scales were painted or printed, with white background, onto the surface.




Richardson, 25 cm scales, steel, simplex, USA

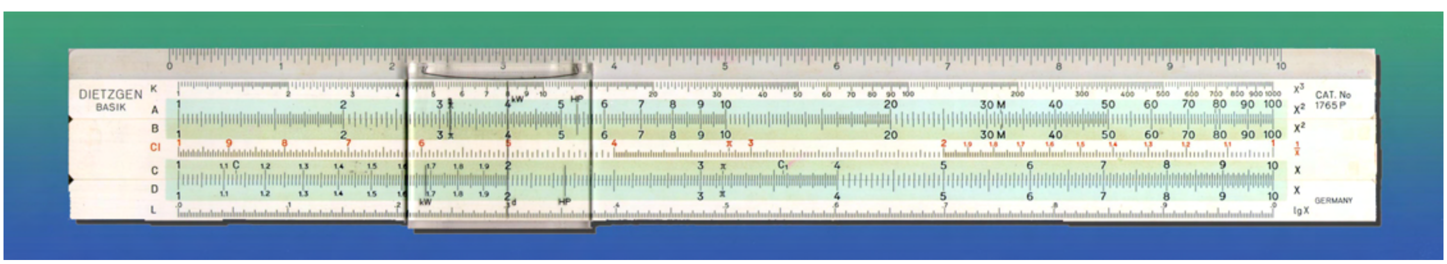
## Scale Arrangements on Common Slide Rules

**Mannheim** – Originally 4 basic scales — A[B,C]D — closed body – simplex type



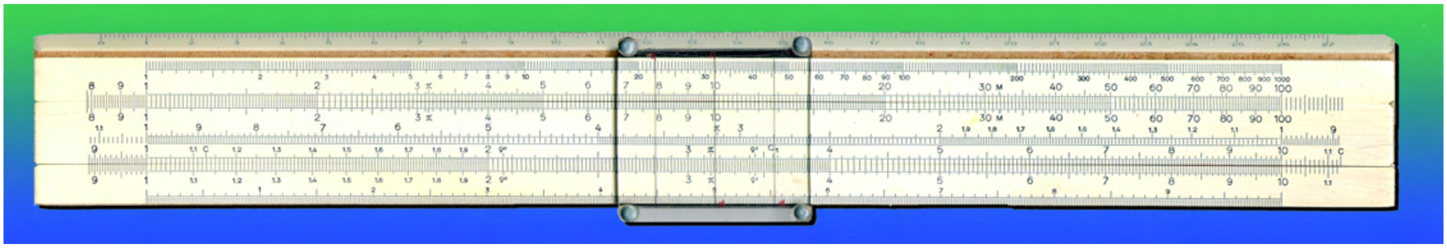

Faber-Castell 57/86 Columbus, 25 cm scales, plastic, simplex, Germany

**Enhanced Mannheim** — 6 to 9 scales — A[B,CI,C],D,K // [S,L,T] — closed body — simplex type



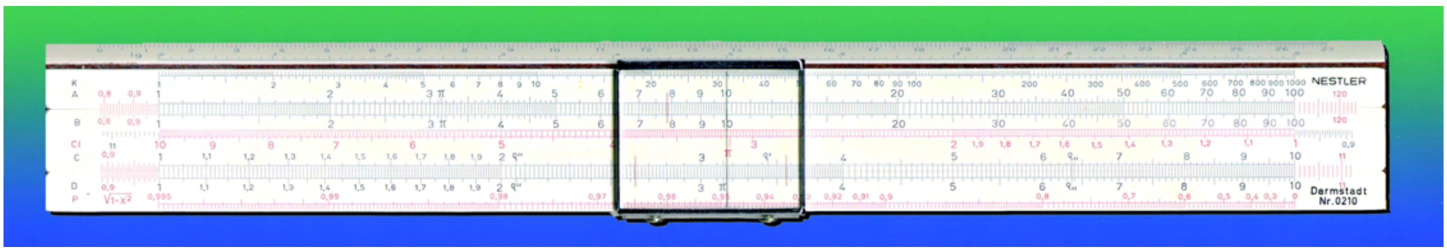

Dietzgen 1765 Basik, 25 cm scales, plastic, USA

**Rietz** — 10 basic scales – K,A[B,CI,C]D,L // [S,ST,T] — closed body – simplex type – popular in Europe



**Darmstadt** – 13 basic scales – L,K,A[B,CI,C],D,P,S,T // [LL1,LL2,LL3] – There are variants in Darmstadt scale arrangement with different makers and models, closed body, simplex type, popular in Europe. Has the interesting P (Pythagorean) scale.

Faber-Castell 1/87, 25cm scales, celluloid on wood core, Germany

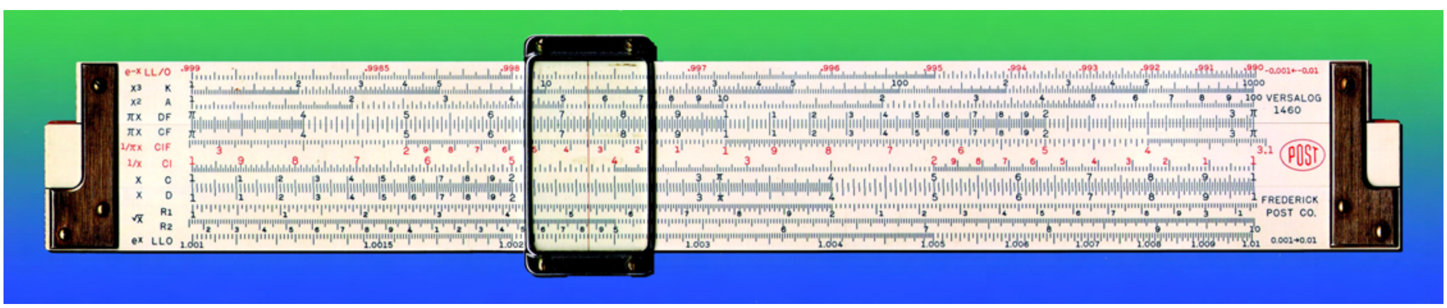


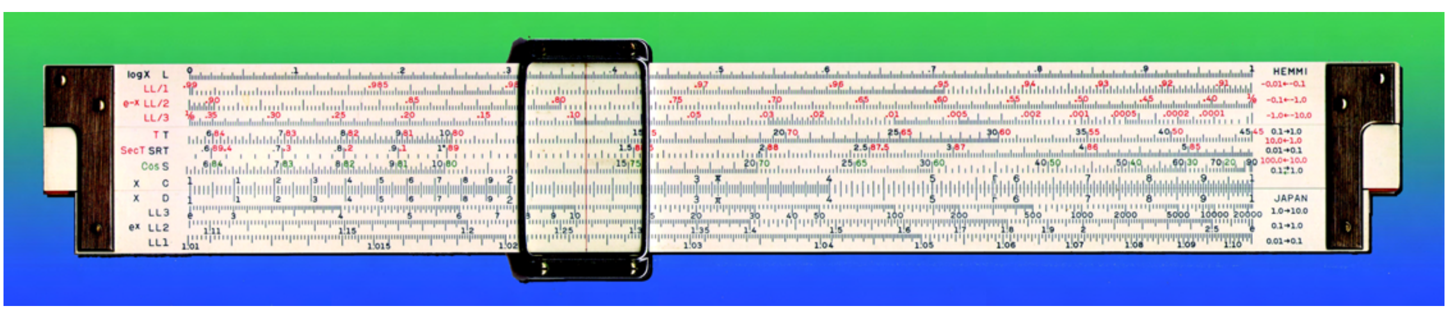

**Log Log Duplex** – Many scale arrangements exist. A basic duplex slide rule design might have from 20 to 30 scales or more, including log log scales, C and D scales on both sides, etc.

Nestler 0210, 25 cm scales, celluloid on wood core, Germany

The Post Versalog II 1460 has these 24 scales: LL/0,K,A,DF [CF,CIF,CI,C]D,R1,R2,LL0 // L,LL/1,LL/2,LL/3[T,SRT,S,C]D,LL3,LL2, LL1
The popular K&E Log Log Duplex Decitrig 4081-3 has these 21 scales: LL02,LL03,DF[CF,CIF,CI,C]D,LL3,LL2 // LL01,L,K,A[B,T,SRT,S]D,DI,LL1
Scale length is 25 cm. Image

Post 1460 "Versalog II", 25 cm scales, celluloid on bamboo core, USA. Front and back views.



Note: Above is a commonly used method for listing the scales on a slide rule. Beginning with the front side of a duplex slide rule (usually the side with the CF and DF scales), the scales are listed from top to bottom, with the scales on the slide being enclosed with brackets [ xxx ]. The double slash marks "//" mean that the scales following are on the other side of the rule. In the case of the Versalog above, on the front side on the top stator are 4 scales ... LL/0,K,A,DF. On the slide are [CF,CIF,CI,C]. On the bottom stator are D,R1,R2,LL0.

## Slide Charts

Not all slide rules are logarithmic calculating devices of wood, plastic or metal. Some of the most useful and commonly used rules are inexpensive cardboard or thin plastic "purpose built" devices. They are not slide rules in the true sense ... most don't have logarithmic scales. One of the original and largest makers of these specialized rules was Perrygraf. The current largest maker is American Slide Chart Corp., who now owns Perrygraf.

Some slide charts were fairly primitive, but many are very sophisticated and are extremely useful for specific problem solving. The electronics industry has been a large user of these devices as product promotions and component specifier guides.

Several companies make slide charts today. They have many stock designs and will make special designs to order. They even have websites.

American Slide Chart Co./Perrygraf
25 W. 550 Geneva Road, Carol Stream. IL  60187
800-323-4433   amslide@americanslidechart.com

Datalizer Slide Charts, Inc.
501 Westgate Dr., Addison IL 60101-5424
630-543-6000  info@datalizer.com

IWA Incorporated
819 Newberry Drive, Batavia, IL 60510
630-879-1900  cg@iwa-slidecharts.com

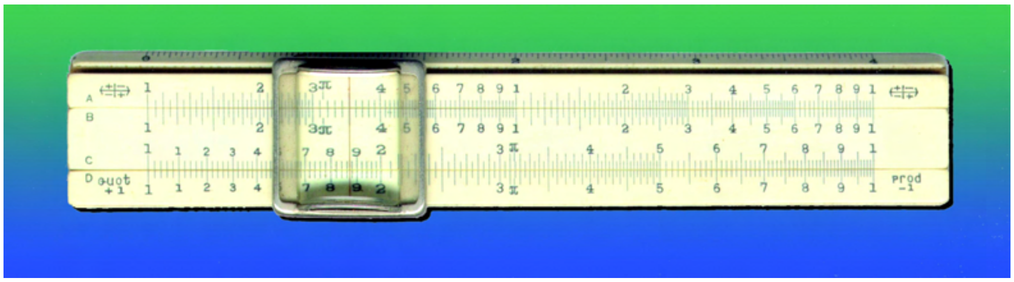
Blundell-Harling
United Kingdom
+44 (0) 1305 206000
sales@blundellharling.co.uk

Visit  http://www.sphere.bc.ca/test/perrygraf.html
for additional information on slide charts.
This is the Slide Rule Universe website, which has
several circular slide charts available for purchase.

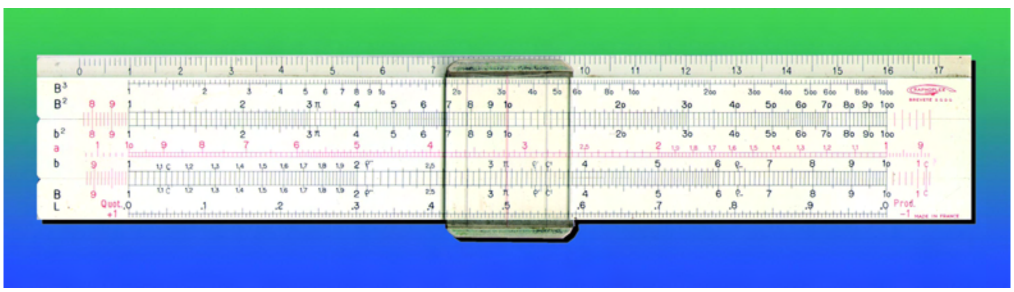
# Less Common Types of Slide Rules

In addition to the most common slide rules with scale lengths of 5” and 10”, slide rules were made with other scale lengths. 4”, 6”, 8”, 16”, 20” and various classroom demonstration models from 4 feet to 8 feet long.

Many specialty linear slide rules also were made ... for chemistry, surveying, finance, electronics, radio, electricity, navigation, etc. Click Here to view Chapter 12, Slide Rules for Special Applications. Special over-sized clear slide rules were also made for use with overhead projectors.

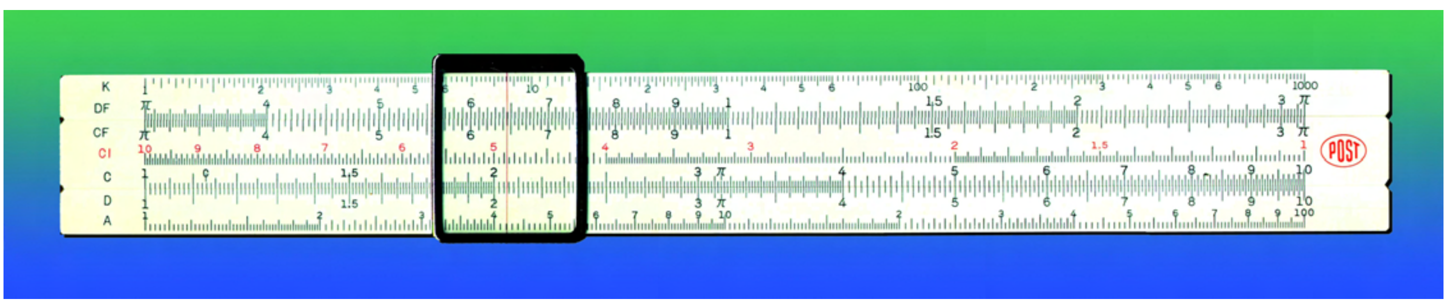


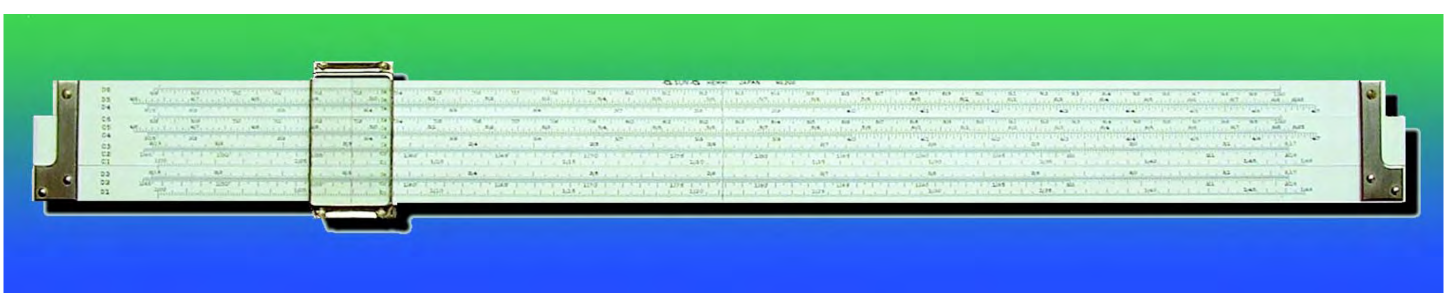
Hemmi 32, 10 cm (4”) scales, celluloid on bamboo core, Japan



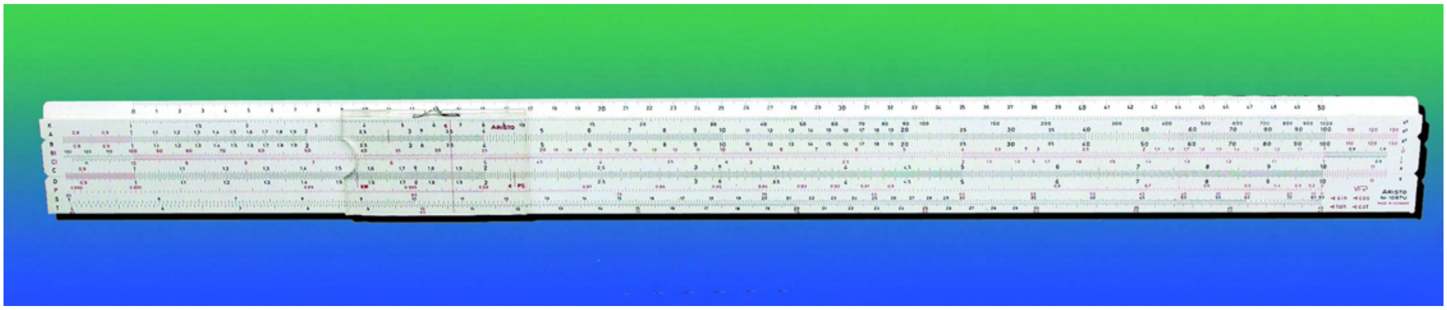
Graphoplex 615, 15 cm (6”) scales, plastic, France

Post 1445, 20cm (8”) scales, celluloid on bamboo core, USA





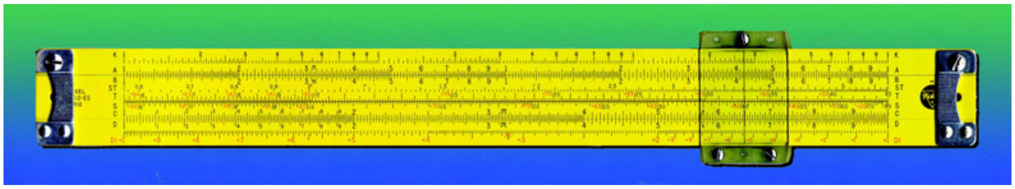
Hemmi No. 200, 40 cm (16”) scales, celluloid on bamboo core, Japan

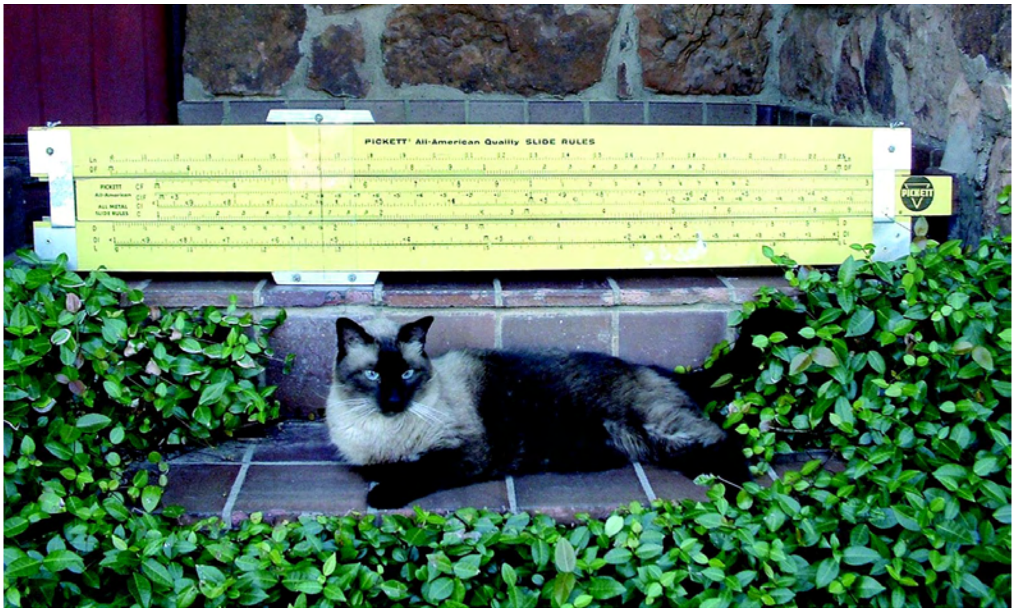


Aristo 1067U, 50 cm (20") scales, plastic, Germany

## Other Less Common Types and the Quest for Greater Precision

Several types of slide rules were developed to obtain greater precision. Most of them are somewhat scarce today. Among these are:






Pickett 1010ES, 25 cm, aluminum, USA, along with Pickett Classroom Demonstration Slide Rule, Model 1010-ES, 100 cm scales, painted wood, USA. [Pet cat used as size comparison was made Reference Manual mascot in lieu of modeling fees.]

• 20" scale length linear slide rules, made in both closed body and duplex types.

• 5" or 10" or 20" slide rules with scales split into double or triple lengths.

• Both 5 and 10 inch rules were sometimes fit with a magnifying cursor to enable precision approaching a 10 or 20 inch rule.

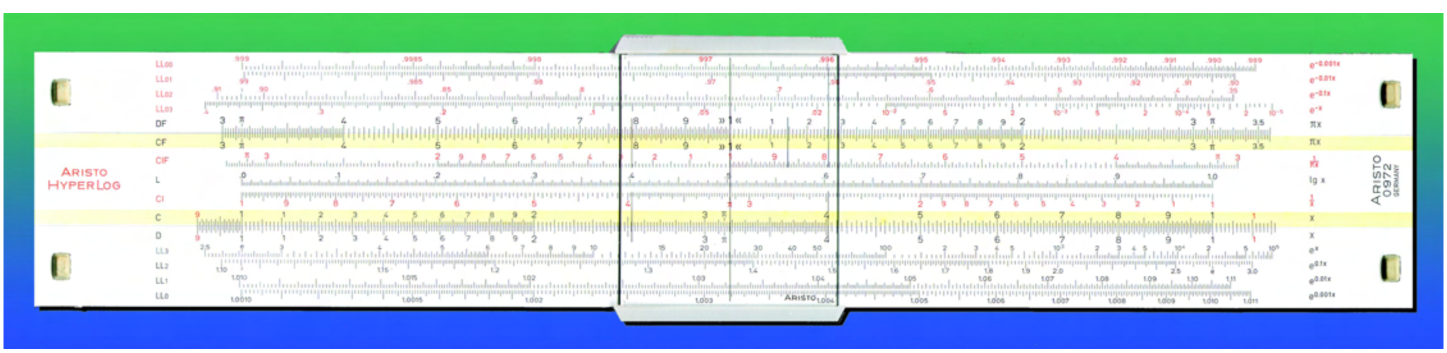
• Circular slide rules with spiral scales... the Gilson Atlas, an 8" diameter rule with scales 25 feet and 50 feet long, and others.

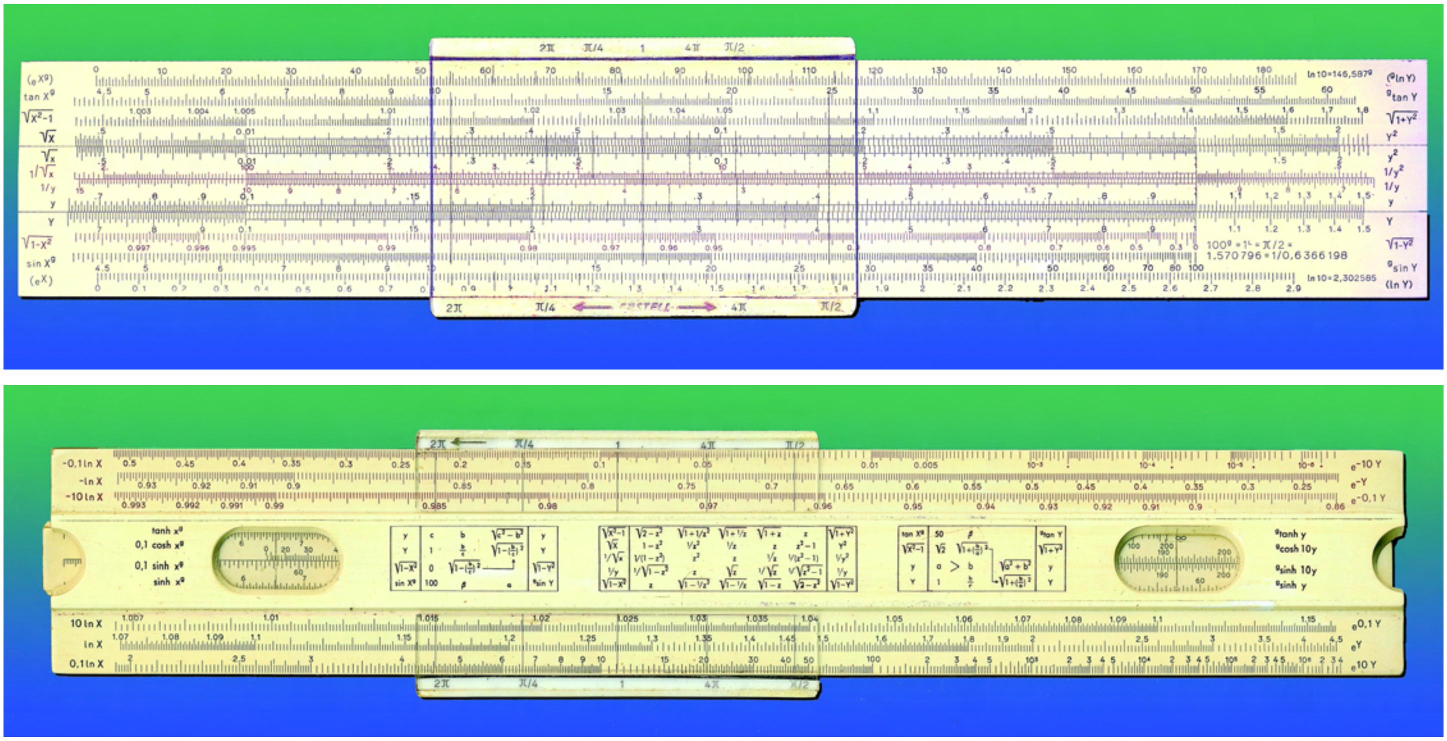
Fuller calculator, cylindrical, wood with varnished paper scales, England, 1926

**Some Scarce Linear Slide Rules which are Popular with Collectors**

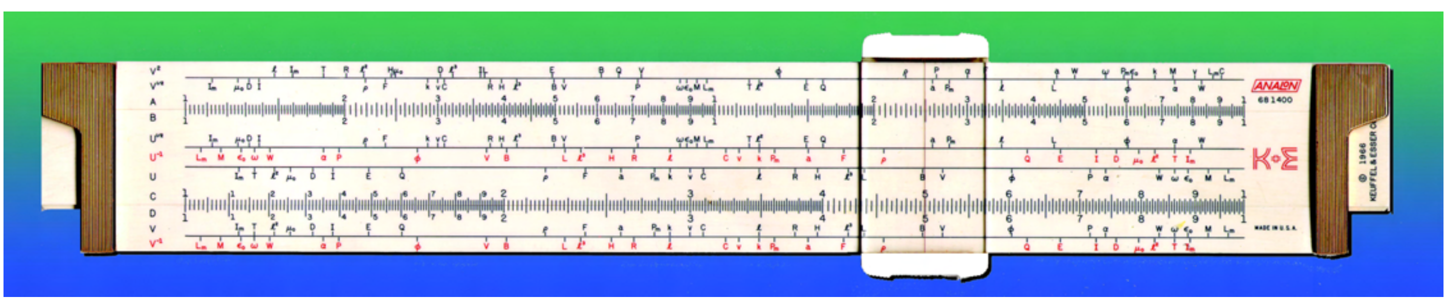
Faber-Castell 2/83N Novo-Duplex Image
Hemmi 257 and 257L Chemistry rule Image
K&E 68-1130 Deci-Lon 5 inch Image
K&E 4160 Chamistry rule Image

Aristo 0972 Hyperlog, 25 cm scales, plastic, Germany





Faber-Castell 2/84 Mathema, 25 cm scales, plastic, Germany. Front and back views.



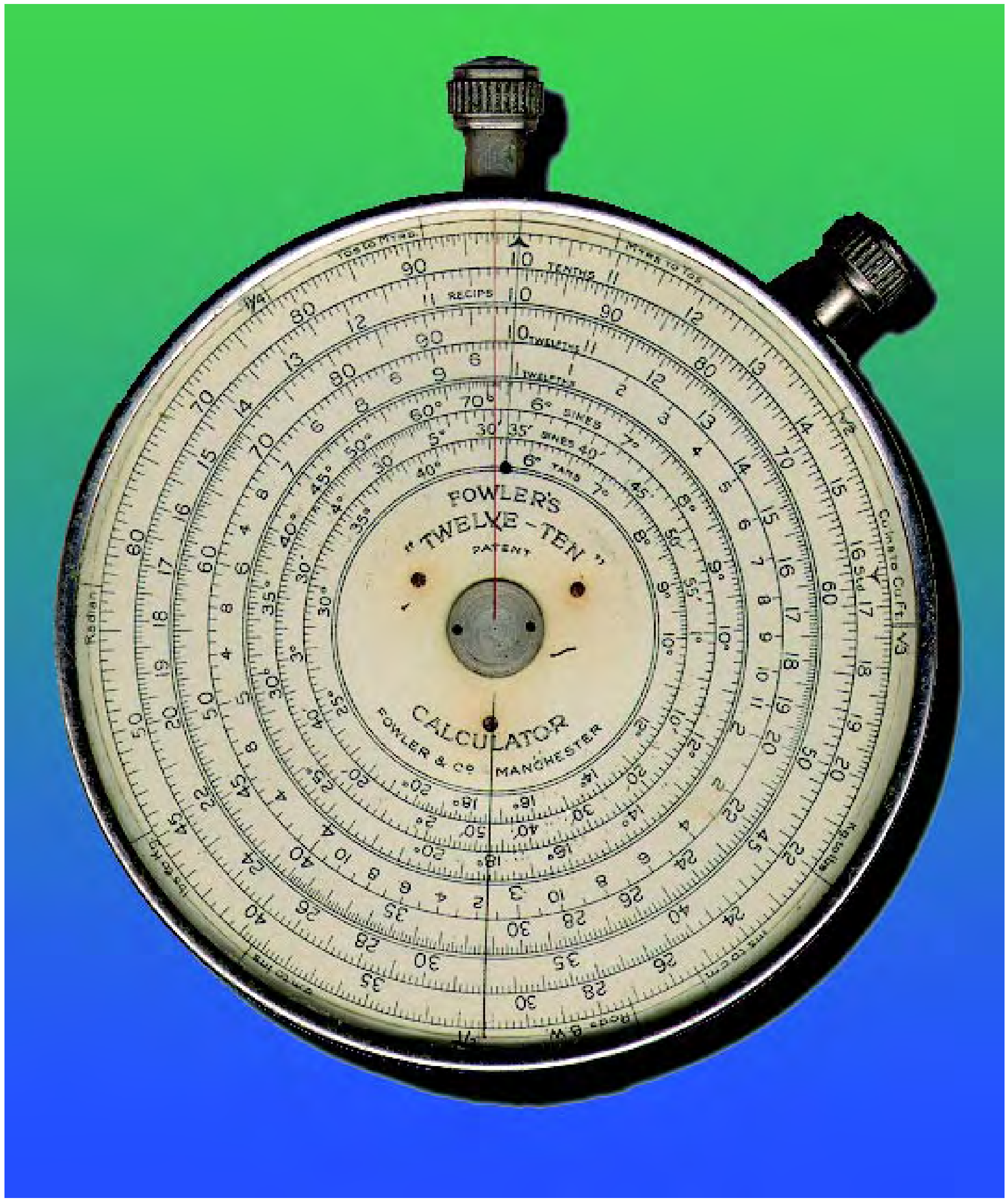

K&E 68 1400 Analon, 25 cm scales, plastic, USA

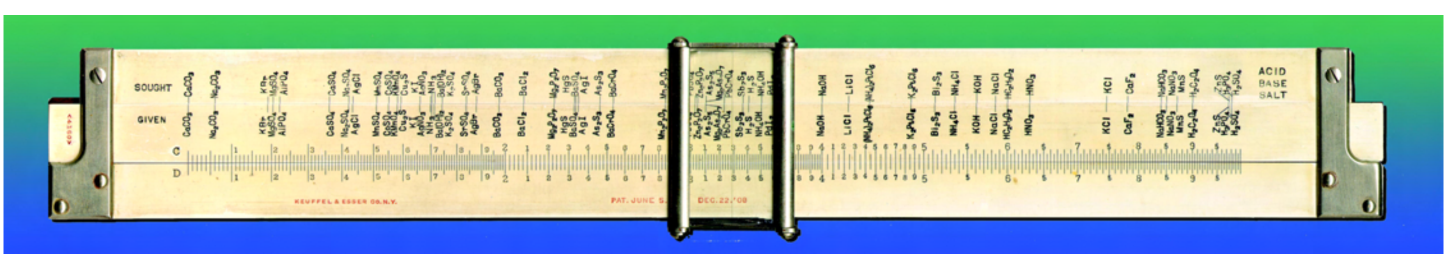

Charpentier Calculimetre,60 mm($2\frac{3}{8}$”) diameter, metal, France, 1882+

### Some Rare Circular Slide Rules which are Popular with Collectors

Charpentier Calculimetre (metal, France)
Dempster Rotarule (plastic, USA)
Boucher Calculigraphe (pocket watch type: France, Germany, England and USA)
Fowler (pocket watch type, England)
Halden Calculex (pocket watch type, England)
Lord’s Calculator (pocket watch type, England)
Sperry (pocket watch type, USA)
Small Calculator (USA)

Fowler's Twelve-Ten Calculator, 3 3/8" diameter, metal and glass, England, 1898+



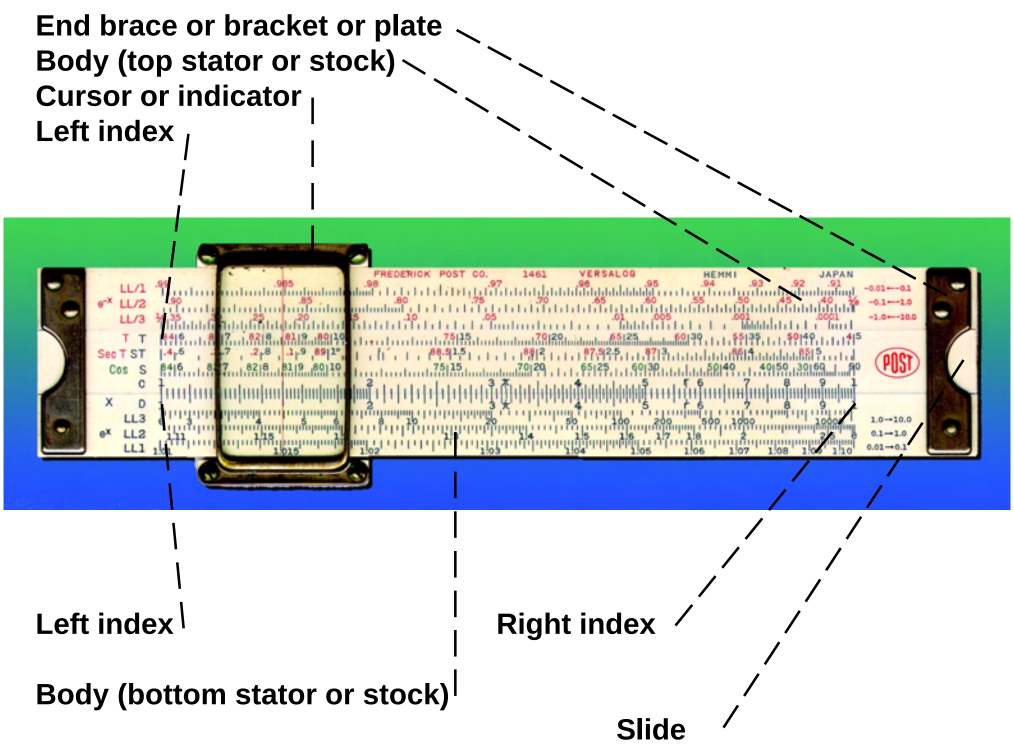




K&E 4160 Chemistry rule, 25 cm scales, celluloid on mahogany, USA

# Learning your way around A Slide Rule

## Basic Terminology

### The Anatomy of a Slide Rule

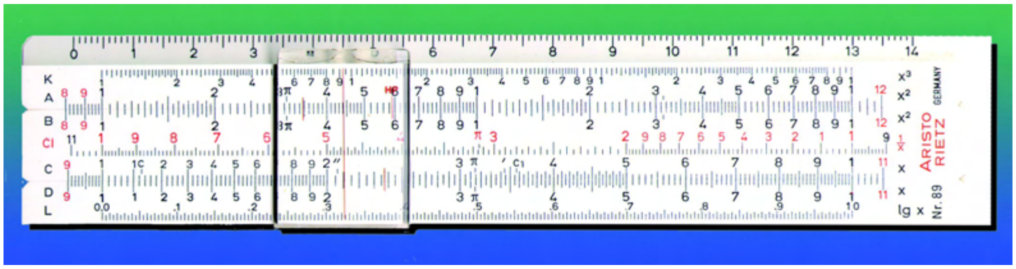



Shown is a Post 1461 Pocket Versalog, 12.5 cm scale length, laminated bamboo core with celluloid overlay, engine divided (engraved) markings, metal framed glass cursor, metal end braces, adjustable. This size is known as a “5 inch” slide rule. Made for Frederick Post Company of Chicago by Hemmi of Tokyo, Japan, from 1957 to 1972. This specimen was made in February, 1962. It is the pocket version of the Post Versalog 1460 “10 inch” rule. It is an open body duplex type slide rule with scales on both sides of the body and slide, and a single hairline on each side of the cursor.

## What the Scale Letters Mean On a Basic Slide Rule

K is for Cubes and Cube Roots
A and B are for Squares and Square Roots
CI is inverted C Scale, for Reciprocals, Chain Multiplication and Division
L is for logarithms. It reads the mantissa of the common logarithm.
C and D are the basic Multiplication and Division scales.
Three Trigonometry scales S, ST, T are on the back of the slide.

Note: Some older slide rules do not have scale labels. Click HERE to view Chapter 10, a list of 24 common slide rule scales and their functions.




The slide rule shown is an Aristo 89 Rietz, 12.5 cm scale length, plastic, 10 scales, simplex, Germany. It is a typical closed body type of slide rule with the Rietz scale set, popular in Europe.

### Naming the Scales

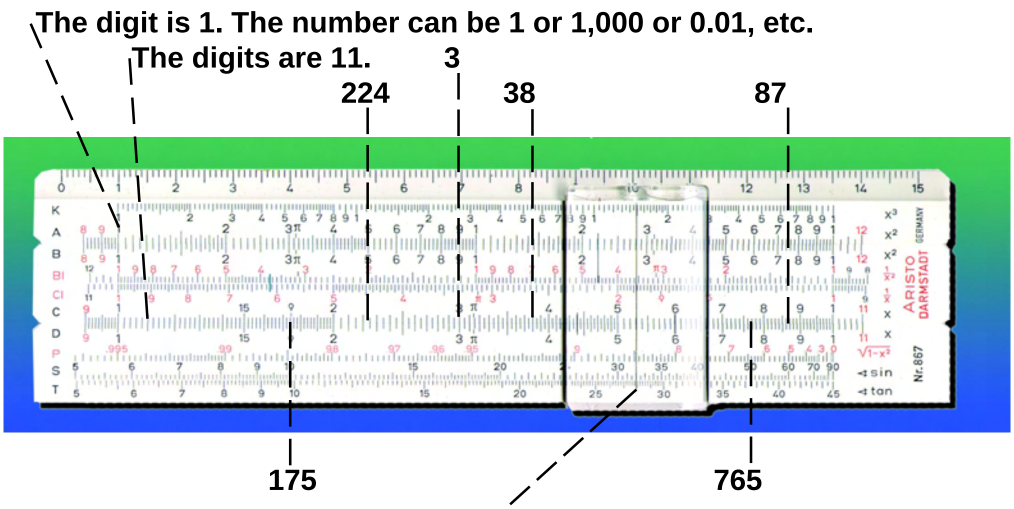
The naming of slide rule scales was possibly the biggest design flaw in an otherwise wonderful work. It would have made far more sense to call the scales x, 1/x, $x^2$, $x^3$, etc., and some rules are made that way, particularly the French Graphoplex rules. For reasons lost to history, the scales ended up with meaningless letter names, especially A, B, C and D. It is likely that they first appeared to make it simpler to produce written instructions, as it can be very difficult to refer to the scales with no names at all, especially for a new user.

Some scales have no real reason to have the names they do; certainly K for cube is a stretch, but L for Log makes sense, as does S for Sine, and T for Tangent, and the added I for inverted or F for folded.

Many European and Japanese rules became “self-documenting” with the function added at the right end of the scale (x, 1/x, etc.), and the scale name letter appearing on the left end. This trend was not adopted in North America due to an attitude best summed up by the Pickett company, who felt that anyone smart enough to use a slide rule didn’t need it. This user-hostile attitude was to carry over into the calculator and computer software disciplines to follow, a perpetual justification for poor user interface design. In Europe, the focus was to create the best possible tool, and their sophisticated but easy to use designs certainly reflect that attitude.

## How to Read the Scales

Read the digits, then determine where your decimal point goes.
All the basic scales start and end with the digit 1.




Cursor reads 53 on C and D scales;
1887 on CI scale;
281 on A and B scales;
356 on BI;
149 on K scale;
0.848 on P;
32° on S;
27.9° on T

Note that the A and B scales are doubled. They have 2 cycles from 1 to 1. They are used for squares and square roots.

The K scale is tripled. It has 3 cycles from 1 to 1. It is used for cubes and cube roots.

The slide rule shown is an Aristo 867 Darmstadt, 12.5 cm scale length, plastic, Germany. It is a closed body type of slide rule. Three log log scales are on the back of the slide.

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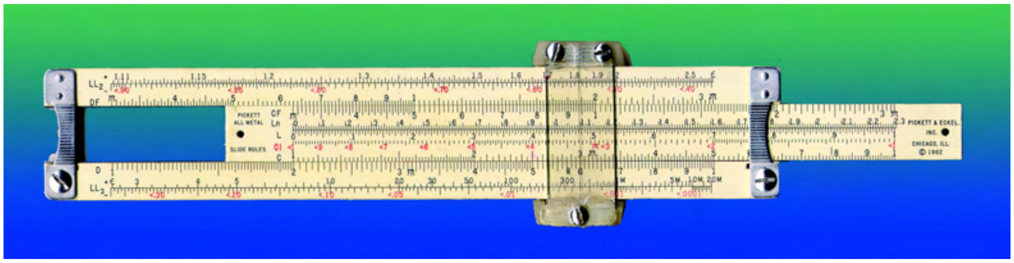
# How to Use a Slide Rule for Basic Calculations

## Multiplication

### The C and D Scales (and the CI Scale) (and CF & DF and A & B scales)

Start with a simple example: 2 X 3 = ?



Pickett N-600T, 12.5 cm scales, aluminum, duplex, USA

Move the slide until the left index of scale C aligns with 2 on scale D.
Move the cursor until the hairline is on 3 of scale C.
Read 6 at the hairline on scale D.

In slide rule language, we would write
Left index of C to 2 on D
Cursor to 3 on C

Answer: 6 on D at cursor

Why does this work? What we really did was to take the distance represented by the logarithm of 2 (log 2), and added the distance represented by the logarithm of 3 (log 3). Log 2+ log 3 = log (2 X 3) = log 6, and log 6 is represented by 6 on the D scale.

Even though the numbered locations on the scales are the locations of the logarithms of our numbers, they are labeled with the actual numbers themselves, enabling us to read our answers directly.

Now try: 6 X 7
If we slide the left index of C to 6 on D, we see that 7 on scale C is off the end or "off scale". So we "switch indexes"...
Right index of C to 6 on D
Cursor to 7 on C

Answer: 42 on D at cursor

The slide rule does not tell us the location of the decimal point, but by estimate we know it must be 42, not 4.2, or 420, etc. We recommend this type of rough estimate procedure for determining the location of the decimal point. See *Tricks and Time Savers* chapter for other methods of locating the decimal point.

Next try: 3.6 X 2.9
Left index of C to 36 on D
Now we try to set the cursor to 29 on C, but it is about a centimeter off the scale.
So, switch indexes.
Right index of C to 36 on D
Cursor to 29 on C

Answer: 10.44 on D at cursor

How can we be confident about the last digit … 4? Look at where the cursor points on D. It is somewhere between 104 and 105. In the original problem, the last digits of the numbers we are multiplying are 6 and 9.
6 times 9 = 54 … and the last digit of 54 is 4.
So, 3.6 times 2.9 must end with a 4.

Therefore, the cursor is at 10.44 on D

Estimate for decimal point: 4 times 3 = 12. So the answer is 10.44

We cannot always use this technique for finding the last digit in our answer. For instance, if we multiply two numbers that have 3 digits each, then the answer would have 5 or 6 significant digits, which is beyond the ability of slide rule reading.

Try: 3.6 X 2.9 using the CI scale
Cursor to 3.6 on D
Slide to 2.9 at cursor on CI

Answer: 10.44 on D at at left index of C

Try: 3.6 X 2.9 using the C and CF and DF scales
Right index of C to 3.6 on D Cursor to 2.9 on CF

Answer: 10.44. on DF at cursor

Try: 3.6 X 2.9 using only CF and DF
Slide CF index under 3.6 on DF
Cursor to 2.9 on CF

Answer: 10.44. on DF at cursor

Try: 3.6 X 2.9 using only the A and B scales
Left index of B to 3.6 on A Cursor to 2.9 on B

Answer: 10.44 on A at cursor

Try: 402 X 0.071

Right index of C to 402 on D

Cursor to 71 on C

Read 285 on D at cursor

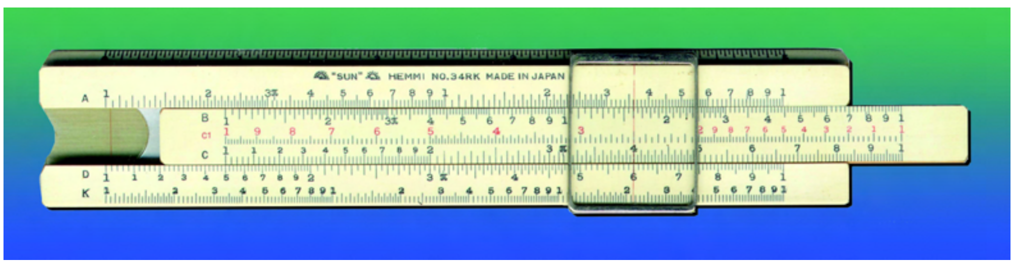
Decimal point estimate #1: 400 X 0.1 = 40.

Decimal point estimate #2: 402 is about 4 X $10^2$. 0.071 is about 7 X $10^{-2}$. Taking the digits first, then the powers of ten second, we see: 4 X 7 = 28. $10^2$ X $10^{-2}$ = $10^0$ =1. 28 X 1 = 28. Answer is about 28.

Answer: 28.5 on D at cursor

## Division

### The C and D Scales (and the CI scale, CF & DF, and A & B)



Hemmi 34RK. 12.5 cm scales, celluloid on bamboo core, simplex, Japan

Solve: 6 divided by 4 (6/4) using the basic C and D scales:

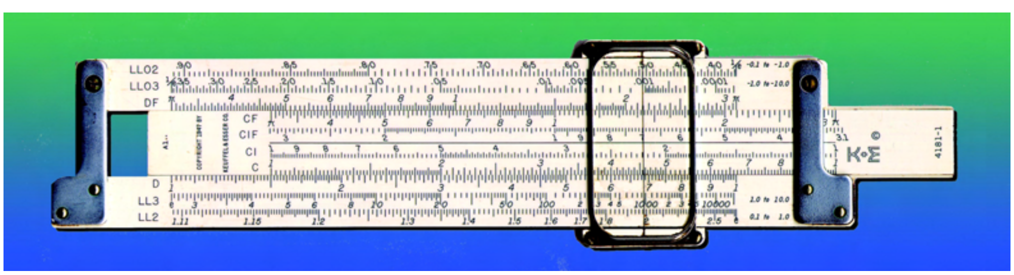
Cursor to 6 on D

Slide to 4 on C at cursor

Answer: 1.5 on D at left index of C

You may note that when the problem is set up on your rule this way, the 4 appears on your rule above the 6 ... upside down ... the inverse of how we would write the problem as a fraction ... 6/4. Strange! But this is a traditional way to divide with your slide rule.

There are other ways. If your rule has CF and DF scales, you can use them to divide ... and the fraction will appear on the 2 scales in the normal manner ... the 6 will be over the 4. The answer 1.5 can be found either on DF or D. See example below:



Keuffel & Esser 4181-1. 12.5 cm scales, plastic, duplex, USA

You can also use the A and B scales to divide ... and the numbers will appear the same on your rule as they do in the fraction ... 6/4. *Any paired set of scales can be used to divide*. Some rules have paired K (cube) scales.

Another method is to set up the fraction in the normal fashion ... 6/4 ... on the C and D scales.

Cursor to 4 on D

Slide to 6 on C at cursor

Answer: 1.5 on C at right index of D

You can also divide using the CI and D scales:

Right index of C to 6 on D

Cursor to 4 on CI

Answer: 1.5 on D at cursor

In this case, you are multiplying 6 by the reciprocal or inverse of 4, which is $^{1}/_{4}$. 6 X $^{1}/_{4}$ = 1.5

Now try: 6 divided by 4 ... using a different method

Move slide until 4 on C is over the left index of D

Cursor to 6 on C

Answer: 1.5 on D at cursor

We divided 1 by 4, then multiplied the quotient by 6

Try: 99 divided by 11 (99/11)

Here are 5 methods for solving this problem:

1. Similar procedure as the first example above, but note that using the C & D scales requires moving the slide a very long distance.

2. You might prefer to use your CF and DF scales, which have 99 and 11 very near the center of the rule. This minimizes slide movement. Your answer can be read on D at the right index of C ... or on DF at the index of CF.

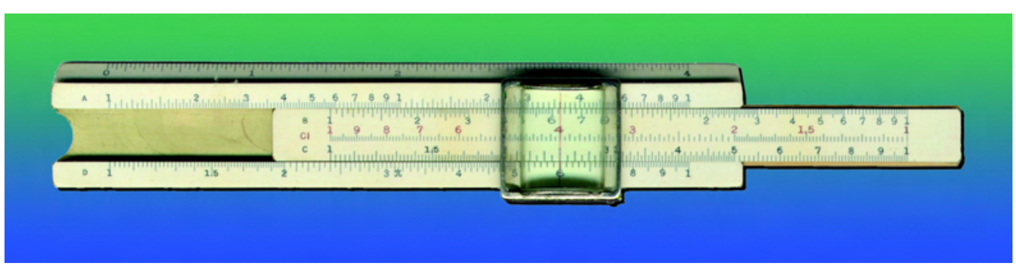
3. Using the CI scale method would also minimize slide movement for this problem.

4. Dividing 1 by 11, then multiplying by 99 is yet another method that works well for this problem.

5. Using the A and B scales can also solve this problem. Note that both 99 and 11 appear on the second section, or "decade", of these scales.

## Chain Calculations And Reciprocals

### The CI (and DI) Scales



Post 1441, 10 cm scale length, celluloid on bamboo core, Simplex, USA (Made for Post by Hemmi of Japan)

Solve: 2 X 3 X 4

Left index of C to 2 on D
Cursor to 3 on C
Product is 6 on D
Right index to 6 on D at cursor
Cursor to 4 on C

Answer: 24 on D at cursor

But there is a better way (see photo above)

Left index of C to 2 on D
Cursor to 3 on C
Product is 6 on D
Slide to 4 on CI at cursor (see prior page photo for this step)

Answer: 24 on D at left index of C

This method is a "shortcut", which saves a step from the first method.

You can continue alternating the use of C, D and CI (and DI if your rule has it) to easily perform chain calculations of any length, whether all multiplication, all division or both in the same problem.

Try: 12 X 6
3 X 4

There are different sequences which may be used to solve this problem ... do all the multiplying first, then the division ... or vice-versa ... or alternate them.

Lets try all the multiplication first, followed by the division:

Left index of C to 12 on D
Multiply by 6
Cursor to 6 on C (product is 72 on D)
Divide by 3
Slide to 3 on C under cursor (quotient is 24 on D at left index)
Cursor to 4 on CI

Answer: 6 on D at cursor

Now try alternating:

Cursor to 12 on D
Divide by 3
Slide to 3 on C at cursor (quotient is 4 on D at right index)
Multiply by 6
Cursor to 6 on C (product is 24 on D)
Divide by 4
Slide to 4 on C at cursor

Answer: 6 on D at right index of C

Any combination of multiplying and dividing the numbers will solve the problem. Any combination of using the C, D and CI scales will also do the trick! If it appears that you are stuck and need to reset the slide, using the CI scale will often save you. You can also use the CF and DF scales in chain calculations.

### Reciprocals

Find the reciprocal of 4.
The hard way:
Cursor to left index of D
Slide to 4 on C at cursor

Answer: .025 on D at right index of C

The easy way:
Cursor to 4 on C

Answer: 0.25 on CI at cursor

The CI scale is the inverse, or reciprocal, of the C scale.
The DI scale is the inverse of the D scale.
CIF is the inverse of CF.

Note that C and CI, D and DI, and CF and CIF run in opposite directions, so that every number on each is the inverse of the corresponding number on the other.

Another easy method for finding reciprocals:
Find: reciprocal of 4
Slide right index of C to 4 on D

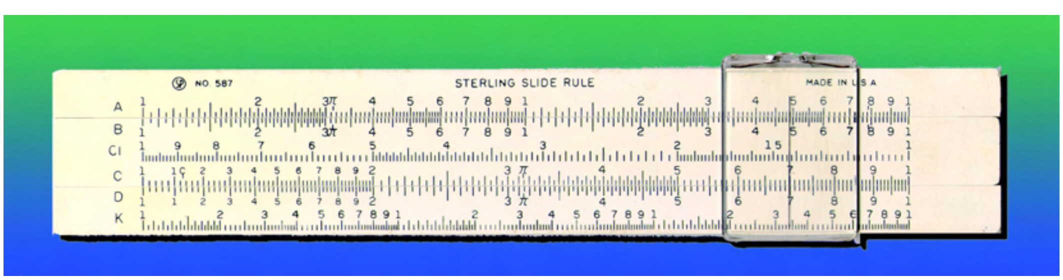
Answer: 0.25 on C at left index of D

Or place left index of C at 4 on D

Answer: 0.25 on C at right index of D

## Squares and Square Roots

### The A and B Scales




Sterling 587, 12.5 cm scale length, plastic, simplex, USA

The A and B scales are used for squares and square roots.

Numbers on the A and B scales are squares of numbers on the C and D scales.

Numbers on the C and D scales are square roots of numbers on the A and B scales.

Note that the A and B scales are in 2 sections … 2 "decades"… or 2 halves … 2 scales beginning and ending with the digit one (or on some rules the second section begins with 10 and ends with 100). The number you seek will be on one of these sections only … and not on the other.

If your number has an odd number of digits before the decimal point, it will be on the first section of the A or B scale. (If it is less than 1 and has an odd number of zeros after the decimal point, also use the first section of the A or B scale).

If your number has an even number of digits before the decimal point, it will be on the second section of the A or B scale. (If it is less than 1 and has no zeros or an even number of zeros after the decimal point, also use the second section of the A or B scale).

Find: 7 squared (see photo above)

Cursor to 7 on D

Answer: 49 on A at cursor

Find: 18 squared

Cursor to 18 on D

Answer 324 on A at cursor

(The last digit, 4, is hard to read precisely, but we know that our answer ends with a 4 because the last digits in our problem [8 and 8] end with a 4 when multiplied)

Find : Square root of 25

Cursor to 25 on second half of A (since 25 has an even number of digits before the decimal point)

Answer: 5 on D at cursor

Find: Square root of 625

Cursor to 625 on first half of A (since 625 has odd number of digits before the decimal point)

Answer: 25 on D at cursor

Find: Square root of 0.625

Which section of the A scale should we use? The second section … because 0.625 has no zeros after the decimal point.

Cursor to 0.625 on A

Answer: 0.791 on D at cursor

Find: Square root of 6.25

Cursor to 6.25 on first section of A

Answer: 2.5 on D at cursor

Try: Square root of 0.0625

Cursor to 0.0625 on first section of A

Answer: 0.25 on D at cursor

Find: Square root of 0.00625
Cursor to 0.00625 on second section of A

ANSWER: 0.0791 ON D AT CURSOR

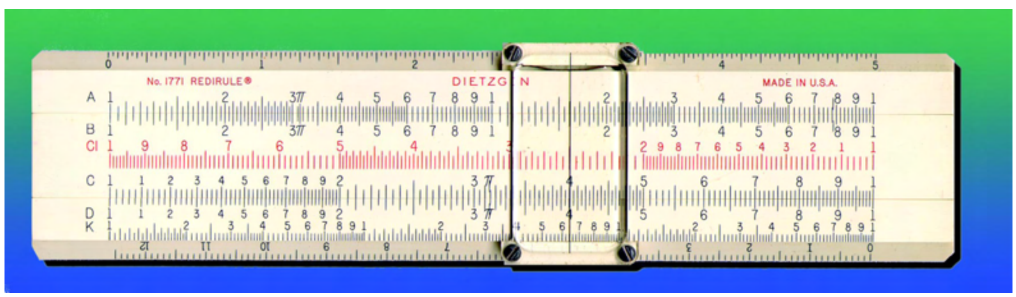
If you prefer not to deal with the zeros after the decimal point, and would prefer to work with whole numbers, simply shift the decimal point to the right 2 places at a time until you have a whole number.

Then use the rules for whole numbers to locate the proper section of the A or B scale to use. In this last example, shifting the decimal point two places to the right twice (a total of 4 places), the whole number would be 62.5, an even number of digits before the decimal point, which tells us to use the second section of the A or B scale.

The square root of 62.5 is then 7.91. Shift the decimal point back to the left 2 places (since we are dealing with the square root, this compensates for our shifting the decimal point 4 places to the right before we started) to obtain the answer 0.0791.

## Cubes and Cube Roots

### The K Scale



DIETZGEN 1771, 12.5 CM SCALE LENGTH, PLASTIC, SIMPLEX, USA

Numbers on the K scale are cubes of numbers on the D scale.
Numbers on the D scale are cube roots of numbers on the K scale.

The K scale consists of 3 sections, or "decades".

The first section is numbers from 1 to 10 ... numbers with one digit before the decimal point ... or 1000 or 1 million, etc. times those numbers (numbers with 4 digits or 7 digits, etc. before the decimal point) ... or one thousandth or one millionth, etc. of those numbers (2 zeros or 5 zeros, etc. after the decimal point).

The second section is numbers from 10 to 100 ... numbers with 2 digits before the decimal point ... or 1000 or 1 million, etc. times those numbers (numbers with 5 digits or 8 digits, etc. before the decimal point) ... or 1 thousandth or 1 millionth, etc. of those numbers (1 zero or 4 zeros, etc. after the decimal point).

The third section is numbers from 100 to 1000 ... numbers with 3 digits before the decimal point ... or 1000 or 1 million, etc. times those numbers (numbers with 6 digits or 9 digits, etc. before the decimal point) ... or 1 thousandth or 1 millionth, etc. of those numbers (no zeros or 3 zeros or 6 zeros after the decimal point).

The number you seek will be on only one of these 3 sections.

Find: 4 cubed (see photo above)
Cursor to 4 on D

Answer: 64 on second section of K at cursor

Find: 8 cubed

Cursor to 8 on D

Answer: 512 on third section K at cursor

To precisely determine the last digit in our answer, we use our old trick of multiplying the last digits in our head 8 X 8 = 64 .. and the 4 in 64 X 8 is 32. So our answer ends with 2.

Find: Cube root of 216

Cursor to 216 on third section of K

Answer: 6 at cursor on D

Find: Cube root of 12,167

Cursor to 12167 on 2nd section of K. We use the 2nd section because 12,167 is 1000 times 12.167... and 12 is on the 2nd section of the K scale.

Answer: 23 on D at cursor

Find: 85 cubed

Cursor to 85 on D

Answer: 614,000 on 3rd section of K at cursor

Actual answer is 614,125. Our margin of error is about 0.02%... more than good enough for any practical application. Even if we read 613,000, our margin of error is less than 1%. We determine our decimal point by estimation. 100 cubed would be 1,000,000 ... easy to estimate because the cube of 10 squared is 10 to the 6th power (multiply the exponents) ... or 1,000,000. Our answer must be a bit less than that ... somewhere in the hundred thousands.

Find: Cube root of 0.0067

Which section of the K scale should we use? Hmmmm ... 2 zeros after the decimal point. See instructions above. Use the first section.

Cursor to 67 on first section of K

Answer: 0.189 on D at cursor

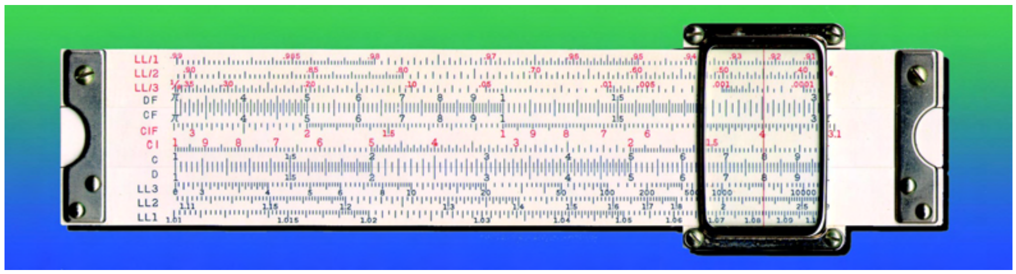
Don't like dealing with numbers less than one? We neither. So ... shift the decimal point to the right 3 places at a time until you reach a whole number.

In the last example, one such shift reaches the whole number 6.7

Using the first section of the K scale per the instructions above, we find the cube root to be 1.89 on D. Now shift the decimal back to the left 1 place (since we are dealing with the cube root, this compensates for our shifting the decimal point 3 places to the right before we started). Our answer is again 0.189.

# Dealing with Pi ($\pi$)

## The CF and DF Scales, and the CIF Scale




HEMMI 149A. 12.5 CM SCALES, CELLULOID ON BAMBOO CORE, DUPLEX, JAPAN

The CF and DF scales are C and D scales which begin at $\pi$ instead of 1. They are "folded" at $\pi$ and are referred to as folded scales. Thus, all numbers on them are the corresponding numbers on C & D multiplied by $\pi$. The CF and DF scales may be used for multiplication and division in the same manner as the C and D scales.

It is no accident that the slide rule is arranged this way. Two good reasons are: Folding at $\pi$ puts the folded scale indices near the center. This facilitates computations which involve numbers near an index without going off scale so easily. And of course, multiplying by $\pi$ is frequently used for circle and sphere problems.

Solve: 8 X $\pi$

The hard way:

Right index of C to $\pi$ (3.14) on D

Cursor to 8 on C

ANSWER: 25.12 ON D AT CURSOR

How do we know that the last digit is 2? The cursor is between 251 and 252. The product of the last 2 numbers in our problem (the 4 in 3.14 and the 8) is 32, which ends with 2. So our answer ends with 2.

The easy way: (See photo above)

Cursor on 8 on D

ANSWER: 25.12 ON DF AT CURSOR

Solve: 27.2 divided by $\pi$

Cursor to 27.2 on DF

ANSWER: 8.66 ON D AT CURSOR

Find: Area of circle of diameter = 4

Cursor to 4 on D

Slide to 1.128 on C at cursor (1.128 is the gauge point "c" marked on the C scale on some slide rules, and is the "square root of 4/$\pi$")

ANSWER: 12.56 ON A AT INDEX OF B

This uses the formula : Area = $\pi d^2/4$. When dividing by the constant "square root of $4/\pi$" in the example above, we are multiplying by "square root of $\pi/4$". When we use the B scale for our answer, we are squaring this value and thus obtain the value $\pi/4$ and the square of the diameter, completing the formula.

Another method:
Slide left index of C to 1.128 on D
Cursor to 4 on D

Answer: 12.56 on B at cursor

Another method ... a direct use of the formula: Area = $\pi r^2$
Slide center index of B under $\pi$ on A
Cursor to radius 2 on C

Answer: 12.56 on A at cursor

Find: Radius of circle with area = 85
Cursor to 85 on A (on second section of A. See Page 35 for instructions for the A & B scales)
Slide to $\pi$ on B at cursor

Answer: 5.2 on D at left index of C

Find: Diameter of circle with area = 85
Slide right index of B to 85 on A
Cursor to Gauge Point "c" on C

Answer: 10.4 on D at cursor

Find: Radius of circle with area = 680
Cursor to 680 on A (on first section of A)
Slide to $\pi$ on B at cursor

Answer: 14.71 on D at left index of C

Find: Circumference of circle of diameter = 8
Cursor to 8 on D
This is the same as our first example above.

Answer: 25.12 on DF at cursor

## Additional Information about Using a Slide Rule

*Mathematical Foundations of the Slide Rule* by Professor Joe Pasquale explains WHY a slide rule works. Click Here.

*Slide Rule Seminar* is a series of 27 slides explaining how to use all the scales on a common slide rule. Click Here. Courtesy of International Slide Rule Museum.

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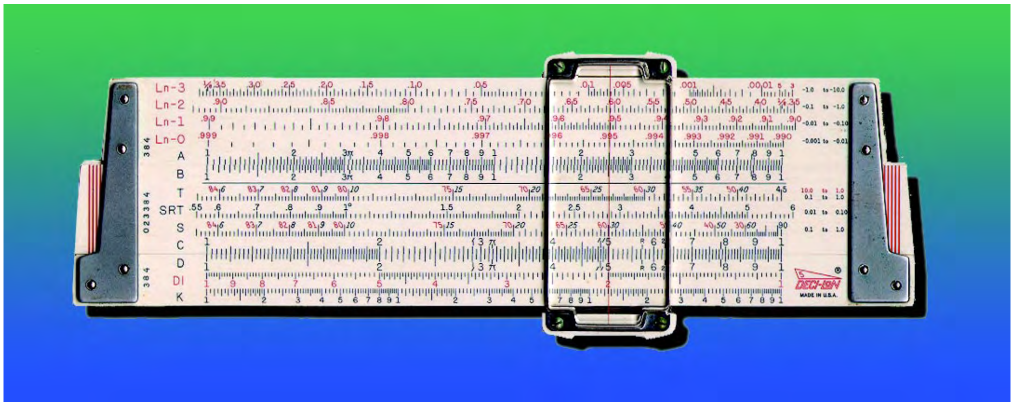
# How to Use a Slide Rule for Advanced Calculations

## Trigonometry

### The S and T Scales and Their Variants



K&E 68 1130
Deci-Lon, 12.5 cm scales, plastic, duplex, USA

### The S (sine) scale

This is a 2 section scale. The first section is usually for angles from about 5.8 degrees to 90 degrees. The second section, labeled ST, is for angles from about 0.58 degrees to about 5.8 degrees. See below for details of the ST scale.

Sine values are read on the C or D scales. Many sine scales are also labeled in reverse with red or other color numbers, which are, of course, the cosines. Cosine is the complement of sine, meaning Sin 30° = Cos 60°, or Sin X = Cos (90°-X).

Find: Sin 30°
Cursor to 30° on S

Answer 0.5 on C at cursor ( see photo)

Find: Sin 60°
Cursor to 60° on S

Answer 0.866 on C at cursor

Find: 15 Sin 30°
Cursor to 30° on S
Slide to 15 on CI (on some rules, it may be necessary to flip them over)

Answer 7.5 on D at right index of C

Find: Sin 30° divided by 2
Cursor to 30° on S
Slide to 2 on C at cursor

Answer 0.25 on D at left index of C

Find the acute angle in a triangle whose hypotenuse is 3.5 and opposite side is 1.5.

Since the sine is opposite side divided by hypotenuse, we can use the S scale to solve this problem directly.

Left index of C to 1.5 on D

Cursor to 3.5 on CI (sine is 0.428 on D at cursor)

Answer 25.4° on S at cursor (may need to center the slide on some rules for this step)

## The ST (sine and tangent) scale

The scales on ST run from about 0.50 to 5.8 degrees.

The ST scale is for both sines and tangents, since they are very nearly the same for small angles.

Thus, on the ST scale, sin 4° = 0.0698 = tan 4°. Values are read on the C or D scales.

### The T (tangent) scales

#### Single Tangent Scale

The tangent scale is commonly found as a single scale on many rules ... and as a 2 section scale on many others.

In its simplest form, the graduations run from about 5.8 to 45 degrees. (Tangents of angles smaller than 5.8 degrees are found on the ST scale.) Tangent values are read on the C or D scales.

Find: Tan 30°

Cursor to 30° on T

Answer 0.577 on C at cursor

Find: 15 Tan 30°

Cursor to 30° on T

Slide to 15 on CI (may need to flip your rule over for this step)

Answer 8.66 on D at right index of C

Find: Tan 60°

Since our single T scale ends at 45 degrees, we must use a different method to find tangents of angles greater than 45 degrees. We will use the complement (30°) of the given 60° angle and find the inverse of its tangent, the cotangent, which is the same as tangent of 60°. This works because tan 60° = cot 30°= 1/tan 30°.

Cursor to 30° on T (your rule may have a red 60° marking beside the mark for 30°.)

Answer 1.732 on CI at cursor (may need to flip your rule over for this step)

Find acute angle in triangle whose opposite side is 4.8 and adjacent side is 12.4

Right index to 4.8 on D

Cursor to 12.4 on CI (tangent is 0.387 on D at cursor)

Answer 21.2 degrees on T at cursor (may need to flip your rule and center the slide)

#### Double Tangent Scales

Some larger slide rules have two T scales on the body of the rule, often labeled T1 and T2. T1 runs from about 5.8 degrees to 45 degrees. T2 runs from

45 to about 84.3 degrees, at which point the value of the tangent becomes greater than 10 and is off the scale of the slide rule.

These scales often have the complementary angles labeled in red every ten degrees, running in reverse, which represent the cotangent values for these angles.

To find tangents using these scales you simply set the cursor on the angle and read the tangent directly on the D scale at the cursor. To multiply the resulting tangent by a number, using only one movement, use the CI scale.

## Logarithms

### The L Scale

Remember that logarithms have 2 parts. the characteristic and the mantissa.

• The characteristic tells us how large the number is. It defines a range into which our number fits. The mantissa tells us where in that range the number is.

• In the system of common logarithms (Base 10 logarithms)…

• A characteristic of zero means 10 to the zero power ($10^0$), which is 1.

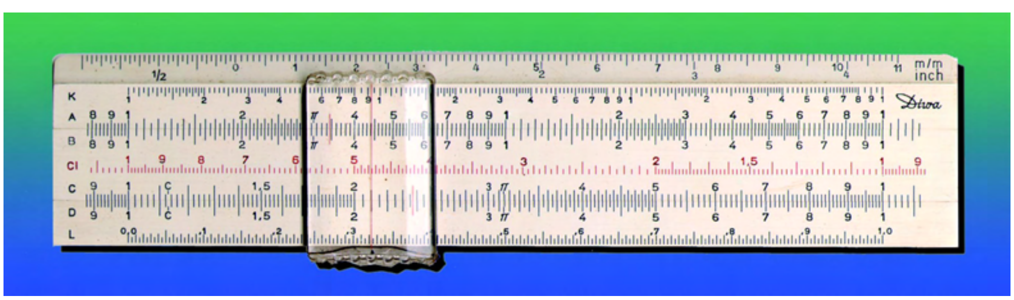
• A characteristic of 1 means 10 to the first power ($10^1$), which is 10.

• A characteristic of 2 means 10 to the 2nd power ($10^2$), or 10 squared, which is 100.

• A characteristic of minus 1 means 10 to the minus 1 power ($10^{-1}$), which is 1 divided by 10 to the first power ($1/10^1$), which is 1 divided by 10, which is 0.1.

• A characteristic of minus 2 means 10 to the minus 2 power ($10^{-2}$), which is 1 divided by 10 to the 2nd power ($1/10^2$), which is 1 divided by 100, which is 0.01.

The L scale gives us the mantissa of the logarithm to the base 10 (the common logarithm), which tells us where in the specified range the number actually is.



Diwa 601, 12.5 cm scales, plastic, simplex, Denmark

Find: The common logarithm of 21 (Log 21)

Cursor to 21 on D

Mantissa = .322 at cursor on L

Logarithm is 1.322 (Characteristic is 1, because 21 is between 10 (whose characteristic = 1) and 100 (whose characteristic = 2).

Or we can say 10 to the 1.322 power = 21.

Find: Log 2100

Mantissa is still .322

Characteristic is 3, because 2100 is between 1,000 (Characteristic = 3) and 10,000 (Characteristic = 4).

Logarithm is 3.322

10 to the 3.322 power is 2100.

Find: Log 2.1

Mantissa is still .322

Characteristic is now 0

Logarithm is 0.322

Find: Log 0.21

To determine this logarithm, we must subtract 1 from Log 2.1. Subtracting 1 from the logarithm is the same as moving the decimal point one place to the left ... or the same as dividing by 10.

Log 0.21 = 0.322 – 1.000 = – 0.678

Find: Log 0.00021

We now have a decimal point 4 places to the left of 2.1.

Thus, we subtract 4 from Log 2.1

0.322 – 4.000 = – 3.678

General procedure for determining logarithms of numbers less than 1:

Determine the mantissa of the number as if it were between 1 and 10, using your L scale. Then subtract the characteristic for the number of places the decimal point of your actual number is to the left of the whole single digit number.

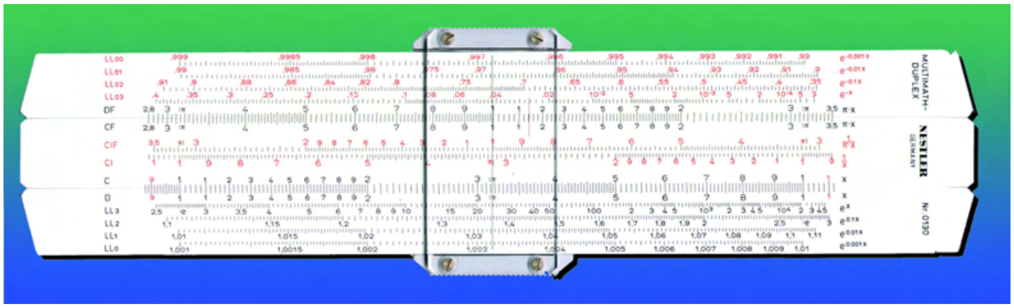
In the example above, the decimal point for 0.00021 is 4 places to the left of the whole single digit number 2.1. So we subtract 4.

You may note that the L scale is linear, from 0 to 10, with even divisions just like a ruler. In some 10" scale designs, it can actually be used as a ruler, but its purpose is to convert the logarithmic distances of the C and D scales to their linear equivalent, which we then read as the logarithm's mantissa.

We multiply and divide by adding and subtracting logarithmic distances on the A, B, C, D, CI, DI, CIF, CF and DF scales. In fact, we could also add and subtract using two L scales if they were present on the rule. The problem with this technique would be very limited dynamic range (perhaps 3 decades), but it is possible. Some children's math aids are in fact made exactly this way, with two sliding linear scales (which to us are L scales) to add and subtract.

## Exponentiation
### (Fractional Powers, Roots and Other Calculations)

#### The LL Scales



Nestler 0130, 12.5 cm scales, plastic, duplex, Germany

The LL scales may be used to raise any number to any power ... or to extract any root from any number. Other uses are calculation of hyperbolic functions, exponential equations, compound interest and time credit payments. These are obviously very versatile scales.

The LL scales are used with the D scale.

On large slide rules, there are 8 Log Log scales, covering numbers from 0.0005 to about 20,000. Only 3 scales appear on some smaller rules. Others have 6. Some have only one.

The numbers on the Log Log scales of most slide rules are based on natural logarithms. They represent powers of ***e***, the base of natural logarithms, as related to the D scale.

***e*** = 2.718281828...

Why such a strange number? ***e*** is a fundamental constant, like pi ($\pi$). It is defined as the area under a hyperbolic curve with certain boundaries.

The natural logarithm (designated by the abbreviation "ln"), with ***e*** as its base, is especially useful in calculus because its derivative is given by the simple equation $d/dx \ln x = 1/x$. Also, ***e*** has the following unusual properties in calculus $d/dx\, e^x = e^x =$ integral of $e^x\, dx$. So, most of our slide rules have LL scales with the Base ***e*** because of calculus! Numbers on the D scale are logarithms, or powers, of numbers on the LL scales. Example: Cursor to x on LL, read natural logarithm of x (ln x) on D at cursor.

A few slide rules use common logarithms (Base 10) on their Log Log scales. On the well-known Pickett N4 (Image) you will read the common logarithm on D. Cursor to x on LL, read common logarithm of x [abbreviated as log x] on D.

Scales LL0, LL1, LL2 and LL3 are called the log log scales. They represent positive powers of ***e***. Scales LL/0, LL/1, LL/2 and LL/3 (or on some rules LL00, LL01, LL02, LL03) represent negative powers of ***e*** and are thus called reciprocal log log scales.

The relationship of successive adjacent log log scales is that of one-tenth powers of ***e***. For example, if we set the cursor to 2 on D, we read $e^2 = 7.4$ on LL3, $e^{0.2} = 1.2215$ on LL2, $e^{0.02} = 1.0202$ on LL1, $e^{-2} = 0.135$ on LL/3, $e^{-0.2} = 0.8187$ on LL/2, etc.

Since $e^{-x}$ is the reciprocal of $e^x$, any number on an LL scale has its reciprocal directly opposite on the corresponding reciprocal log log scale. In the example above, the reciprocal of 7.4 on LL3 is therefore 0.135 on LL/3 and the reciprocal of 1.2215 on LL2 is 0.8187 on LL/2, etc.

## Powers and Roots of Numbers

Try: 8.87 to the 3.48 power
  Cursor to 8.87 on LL3
  Left index of C to cursor
  Cursor to 3.48 on C

ANSWER: 1990 ON LL3 AT CURSOR

Note that 8.87 to the 0.348 power can also be read ... as 2.135 on LL2. 8.87 to the 0.0348 power is 1.0788 on LL1. 8.87 to the 0.00348 power is 1.00762 on LL0.

Find: The 2.5th root of 148
  Cursor to 148 on LL3
  2.5 on C to cursor
  Cursor to left index of C

ANSWER: 7.38 ON LL3 AT CURSOR

Try: The 7th root of 148
  Cursor to 148 on LL3
  7 on C to cursor
  Cursor to right index of C

ANSWER: 2.042 ON LL2 AT CURSOR

Find : 64 to the 0.027 power
  Cursor to 64 on LL3
  Right index of C to cursor
  Cursor to 27 on C

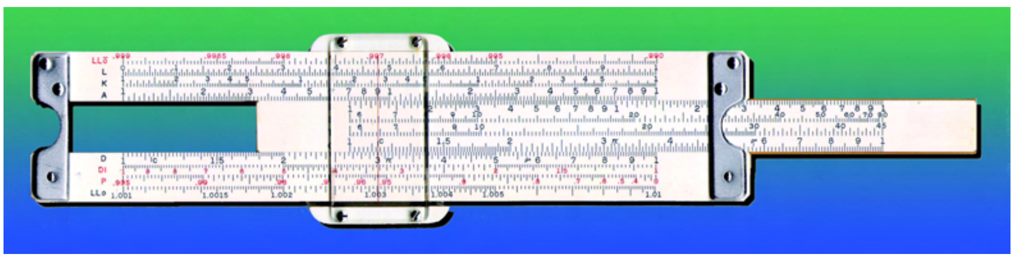
ANSWER: 1.1188 ON LL2 AT CURSOR

# Tricks and Time Savers

### Area of circle with A and B scales

Example: Diameter of circle =3 (See photo below)
Cursor to diameter 3 on D
Slide to 1.128 on C at cursor (1.128 is the gauge point "c" marked on the C scale on some slide rules to facilitate circle calculations, and is the square root of $4/\pi$).
Answer 7.07 on A at any index of B

(This uses the formula : Area = $\pi d^2/4$. When dividing by the constant "square root of $4/\pi$" in the example above, we are multiplying by "square root of $\pi/4$". When we use the B scale for our answer, we are squaring this value and thus obtain the value $\pi/4$ and the square of the diameter, completing the formula.)



Ricoh 551, 12.5 cm scales, celluloid on bamboo core, duplex, Japan

Another method:
Slide left index of C to 1.128 on D
Cursor to diameter on D (diameter = 3 on rule above)
Area on B at cursor

Another method:
Slide left index of C to 1.772 on D (1.772 is the square root of $\pi$)
Cursor to radius on C
Area on A at cursor

Another method ... directly using the formula $\pi r^2$
Move any index of B under $\pi$ on A.
Cursor to radius on C
Area on A at cursor

Once the first step is done in the last 3 methods above, you can find the area of any circle with only a cusor movement.

Another method:
Cursor to $\pi$ on A

Slide to radius on CI
Area on A at index of B

## Quick area of circle with folded square root scales RI & R2 or WI & W2

With a Post Versalog or Versatrig ... or a Faber-Castell 2/83N or any rule with folded square root scales ... to get the area of a circle (good old $\pi r^2$), just place your cursor on the radius on R1 or R2 ... or W1 or W2 ... and the area is at the cursor on DF. No slide movement needed.

## Decimal Point location

We recommend the rough estimate method of determining the location of the decimal point. For example, if you are multiplying 402 X 0.071, the digits for the answer on your slide rule are 285. Rough estimate is 400 X 0.1 = 40. Answer is thus 28.5, not 2.85 or 285.

The following methods can also be used to locate the decimal point:

- Position of slide relative to body of rule
- Position of answer
- Scientific notation
- Decimal tracking scales and cursors

See Ron Manley's excellent website for explanations of these methods:
http://www.sliderules.clara.net/a-to-z/decimal-point.htm

## Squares and cubes

Find: Square root of 4.37 cubed
Cursor to 4.37 on A

Answer: 9.14 at cursor on K

Find: Cube root of 12.4 squared
Cursor to 12.4 on K

Answer: 5.36 at cursor on A

## Inverse of squares and cubes

Find: Inverse (reciprocal) of 0.85 squared (same as the square of the inverse of 0.85)
Cursor to 0.85 on CI

Answer: 1.38 at cursor on B

Try: Inverse of the square root of 0.625 (same as square root of the inverse of 0.625)
Cursor to 0.625 on B

Answer: 1.265 at cursor on CI

Find: Inverse of the cube of 1.22 (same as cube of the inverse of 1.22)
Cursor to 1.22 on CI

Answer: 0.55 at cursor on K

Find: Inverse of the cube root of 0.444 (same as cube root of the inverse of 0.444)
Cursor to 0.444 on K

Answer: 1.31 at cursor on CI

### 4th and 5th powers using the A, B and K scales

Find: 3.7 to the 4th power
Right index of C to 3.7 on D
Cursor to 3.7 on C

Answer: 187 at cursor on A

Find: 2.75 to the 5th power
Cursor to 2.75 on D
Slide to 2.75 on CI at cursor
Cursor to 2.75 on B

Answer: 157 at cursor on A

### Reciprocals using the LL scales

Find: Reciprocal (inverse) of 1.2215
Cursor to 1.2215 on LL2
Answer 0.8187 at cursor on LL/2. No slide movement needed.

Any number on an LL scale has its reciprocal directly opposite on the corresponding reciprocal Log Log scale, because ***e*** to the x power is the reciprocal of ***e*** to the minus *x* power. Numbers on LL2 are reciprocals of numbers on LL/2. LL3 and LL/3, LL1 and LL/1, LL0 and LL/0 have the same relationship.

Note: On some silde rules, the reciprocal Log Log scales are called LL00, LL01, LL02, LL03.

### Inverse of Product

Find: $\frac{1}{4 \text{ X } 0.07}$
Cursor to 4 on D
Slide to 7 on CI

Answer: 3.57 on C at right index of D

### Inverse of Number

Find: Inverse of 0.144
Left index of C to 144 on D

Answer: 6.94 on C at right index of D

Find: Inverse of 8
Right index of C to 8 on D

Answer 0.125 on C at left index of D

## Use of 5-4-5

This is easy to remember and is good for practice. It also serves as a nice "test drive" of a slide rule. Choose any number and multiply it by 5 X 4 X 5 as a chain calculation. If you end up at your starting number, you did the problem correctly and the slide rule is accurate "in your hands".

Example: Choose 3. Compute 3 X 5 X 4 X 5

Cursor to 3 on D 5 on CI to cursor Cur-
sor to 4 on C 5 on CI to cursor

ANSWER: 3 ON D AT LEFT INDEX OF C. NOTE: OF COURSE THE REAL ANSWER IS 300.

Another method:

Right index of C to 3 on D
Cursor to 5 on C
4 on CI to cursor
Cursor to 5 on C

ANSWER: 3 ON D AT CURSOR

Try this using the folded scales:

Cursor to 3 on D 5 on CI
to cursor Cursor to 4 on
CF 5 on CIF to cursor

ANSWER: 3 ON D AT RIGHT INDEX OF C

## Proportions

Solve: If 2.5 tons of material costs $36, what will 4 tons cost? This is a direct proportion problem.

It is written thus: $\frac{2.5}{36} = \frac{4}{x}$

Cursor to 36 on D
Slide to 2.5 on C at cursor
Cursor to 4 on C

ANSWER: $57.60 ON D AT CURSOR

Note that you can now determine what any quantity of material costs by changing only the last cursor move to any other quantity, i.e., 2 tons would cost $28.80… 7.5 tons would cost $108.00 (use the CF and DF scales).

## Inverse Proportions

Solve: If 6 men can do a job in 4 days, how long will it take 9 men to do it? This is an inverse proportion problem.

It is written thus: $$\frac{6}{\left(\frac{1}{4}\right)} = \frac{9}{\left(\frac{1}{x}\right)}$$

A direct solution can be obtained on your slide rule by reversing the slide. Remove it and switch ends, with the same side facing you. Your slide is now upside down.

Cursor to 4 on D
Slide to 6 on C at cursor
Cursor to 9 on C

Answer: 2.67 on D at cursor

## Pendulum oscillations

Cursor to 375 on D
Slide to pendulum length in inches on B at cursor
Answer on D at index of C, in oscillations per minute

Try: How many oscillations per minute will a 39" long pendulum make?

Cursor to 375 on D
Slide to 39 on B at cursor (Note: 39 is the second section of the B scale)

Answer: 60 oscillations per minute on D at right index of C ... one per second.

What if you want your pendulum to oscillate only 30 times per minute? How long would it need to be?

Cursor to 375 on D
Slide to 30 on D at left index of C

Answer: 156" on B at cursor.

How about 120 times per minute?

Cursor to 375 on D
Slide to 120 on D at left index of C

Answer: 9.8" on B at cursor.

It is quite interesting to see the drastic length change required to double or halve the oscillation rate.

## Useful constants

$$\frac{\text{Diameter of circle}}{\text{Side of inscribed square}} = \frac{90}{70} = \frac{\text{diagonal of square}}{\text{side of square}} = \text{square root of 2}$$

$$\frac{\text{Pounds per square inch}}{\text{Feet of water}} = \frac{26}{60}$$

Note: Once these ratios are set up on your slide rule, you can, of course, use them to find any circle and its inscribed square ... or the pressure from a column of water of any height by moving only the cursor. This is true of any ratio because of the "parallel" nature of the slide rule as a calculating device.

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# List of Common Slide Rule Scales

## Scales usually calculate in conjunction with the C or D scales

A Scale (value relative to C/D = X squared). Scale of Squares. Typically found on the top stator. Used with the D scale on the bottom stator. The square of a number on the D scale can be read on the A scale. Likewise, square roots of numbers on the A scale can be read on the D scale.

B Scale (value relative to C/D = X squared). Scale of squares. Found on the slide. Used with the C scale to read squares and square roots like the A and D scales. Can also multiply with the A scale.

C Scale (value relative to C/D = X). Fundamental scale on the Slide. Most calculations with other scales are done in conjunction with the C and D scales.

CF Scale (value relative to C/D = $\pi$ x X). Folded Fundamental scale on the slide. Usually begins at Pi (sometimes the square root of 10). Considered to be "folded" at Pi. For multiplication and division without resetting the index, or multiplication by Pi. Typically found on duplex type slide rules.

CI Scale (value relative to C/D = 1/X). Reciprocal scale on the slide. Gives reciprocal of C. Is C scale running backward. Useful in chain calculations without resetting the slide.

CIF Scale (value relative to C/D = 1/$\pi$ x X). Folded reciprocal scale on the Slide. Usually begins at Pi. For multiplication/division by Pi and for calculations without resetting the slide.

D Scale (value relative to C/D = X). Fundamental scale on the body. Most calculations with other scales are done in conjunction with the C and D scales.

DF Scale (value relative to C/D = $\pi$ x X). Folded Fundamental scale on the Body. Usually begins at Pi. For multiplication and division by Pi and for calculations without resetting the slide.

DI Scale (value relative to C/D = 1/X). Reciprocal scale on the Body. Gives reciprocal of D. Is D scale running backward. Useful in chain calculations without resetting the slide.

K Scale (value relative to C/D = X cubed). Scale of cubes on the body. Used with D scale to determine cubes and cube roots. Commonly found on many types of rules.

L Scale (value relative to C/D = log X). Mantissa scale. Logarithms to base 10. Linear scale used to determine the log values (mantissa only) of other scales. Commonly used on many types of rules in conjunction with the C & D scales to determine the mantissa of logarithms.

R1 / R2 or Sq1 / Sq2 or W1 / W2 Scale (value relative to C/D = square root X). This scale is basically a D scale that has been "stretched" to twice its former length. A number that is set on the D scale will have its square root on the SQ or R or W scale. If the number has an odd number of digits (or leading decimal zeroes), then the odd numbered scale (Sq1 or R1 or W1) is used. If the number has on even number of digits (or leading decimal zeroes), then the even numbered scale (Sq2 or R2 or W2) is used. If a number is set on the Sq or R or W scale, then its square can be read on the D scale.

S Scale (value relative to C/D = sin X). Scale of sines. Used to determine sines/cosines of angles, usually between 5.7 and 90 degrees. This is a single line double use scale, with the increasing numbers (black/ blue)being used for sines and the decreasing numbers (red/green) being used for cosines. Post and K&E reverse which appears on the left and right of the scale marks, but in all cases, the numbers given in the default scale color are the sines. K&E rules also tilt the numbers to show which direction to read the scale. Read this value (from 0.1 to 1.0) against the C or D scale.

ST or SRT Scale (value relative to C/D = sin/tan X or sin/radian/tan X). Scale of sines / tangents on the slide or body. (The R refers to radians.) Used to determine sines and tangents of angles between 0.57 and 5.7 degrees. This is really just an extension of the S scale, which precedes the S scale values. The sines and tangents of small angles are nearly equal; thus a single scale can be used for both. The cotangents of angles between 84.3 and 89.43 can be read on this scale if the complement of the angle (90 - angle) is set on this scale. Read this value, (from 0.01 to 0.1) against the C or D scale.

T Scale (value relative to C/D = tan/cot X). Scale of tangents and cotangents on the slide or body. Used to determine tangents and cotangents of angles between 5.7 and 84.3 degrees. There are 2 variations of this scale. The first is a "single scale" where the angles from 5.7 to 45 degrees are printed in increasing order (in black or blue), and angles between 84.3 and 45 degrees being printed in decreasing order (usually in red). When this arrangement is used, then tan(5. 7) to tan(45) is read on the C or D scale (0.1 to 1.0), and tan(45) to tan(84.3) is read on the CI scale (1.0 to 10). Conversely, cot(5.7) to cot(45) is read on the CI scale, and cot(45) to cot(84.3) is read on the C scale. You may need to flip your rule over to read the CI scale.

The second arrangement is known as a “double scale” whereby the angle is set above the line if it is between 5.7 and 45 degrees, and below the line if it is between 45 and 84.3 degrees. Tangents are then read on the C or D scale, and cotangents read on the CI scale.

LL0, LL1, LL2, LL3 Scale (value relative to C/D = $e^x$). Log Log scales. Exponential power scales used for raising a number to any power or extracting any root that is greater than one.

LL00, LL01, LL02, LL03 or LL/0, LL/1, LL/2, LL/3 Scale (value relative to C/D = $e^{-x}$). Reciprocal Log Log scales. Exponential power scales used for raising a number to any power or extracting any root that is less than one.

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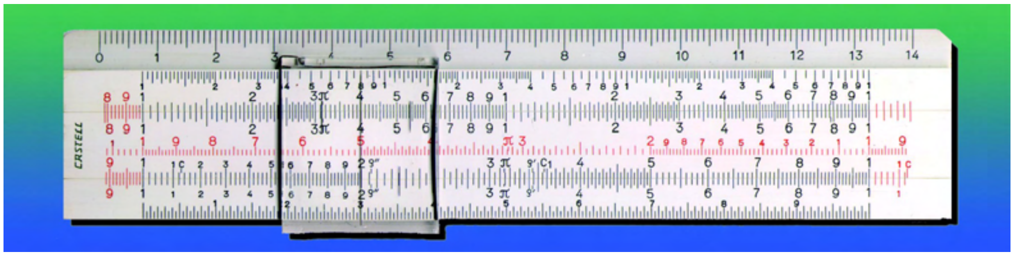
# Advanced Slide Rule Features

## Gauge Marks

Various gauge marks appear on many models of slide rules. These marks identify the location of an often used constant number... like $\pi$.




Faber-Castell 67/87 Rietz, 12.5 cm scales, plastic, simplex, Germany. Note various gauge marks on C and D scales.

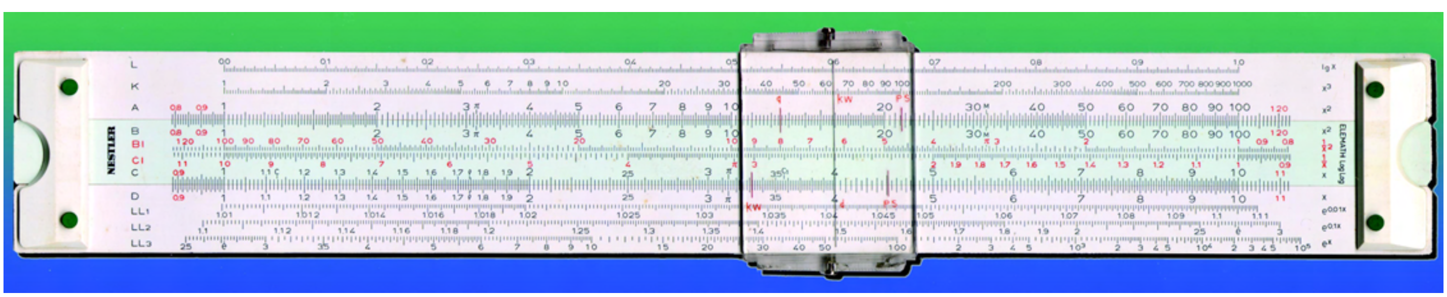
| Gauge Mark | Meaning | Value | Use |
|---|---|---|---|
| c | Square root of (4/$\pi$) | 1.128 | Circles and cylinders |
| g | Gravitational constant | 32.2 | Gravitational acceleration, ft/sec$^2$ |
| g | Gravitational constant | 9.81 | Gravitational acceleration, m/sec$^2$ |
| L | Natural log of 10 | 2.3026 | Logarithm of 10 to the base ***e*** |
| M | 1/$\pi$ | 0.3183 | 1/Pi |
| p or r | 180/$\pi$ | 57.3 | Degrees in a radian |
| p' | 60 (180/$\pi$) | 3438 | Minutes in a radian |
| p" | 3600 (180/$\pi$) | 206265 | Seconds in a radian |
| $\pi$ | 3.1416 | 3.1416 | Circles and cylinders |
| Q | $\pi$/180 | 0.01745 | Radians in a degree |

## Multi-Line Cursors

Many European slide rules have more than one hairline on their cursor. These extra lines permit direct reading of the area of a circle or conversion from kilowatts to horsepower, etc.

| Value | Associated Scales | Uses |
|---|---|---|
| 0.7854 | A, B | $\pi$/4 |
| 0.8862 | C, D | Square root of ($\pi$/4) |
| 746 | A, B | Watts per British horsepower |
| 736 | A, B | Watts per French horsepower |
| 1.128 | C, D, A, B | Same as gauge point "c" |

Nestler Elemath Log Log, 25 cm scales, plastic, duplex, Germany



Example: Find area of circle with diameter = 4 (See photo above)

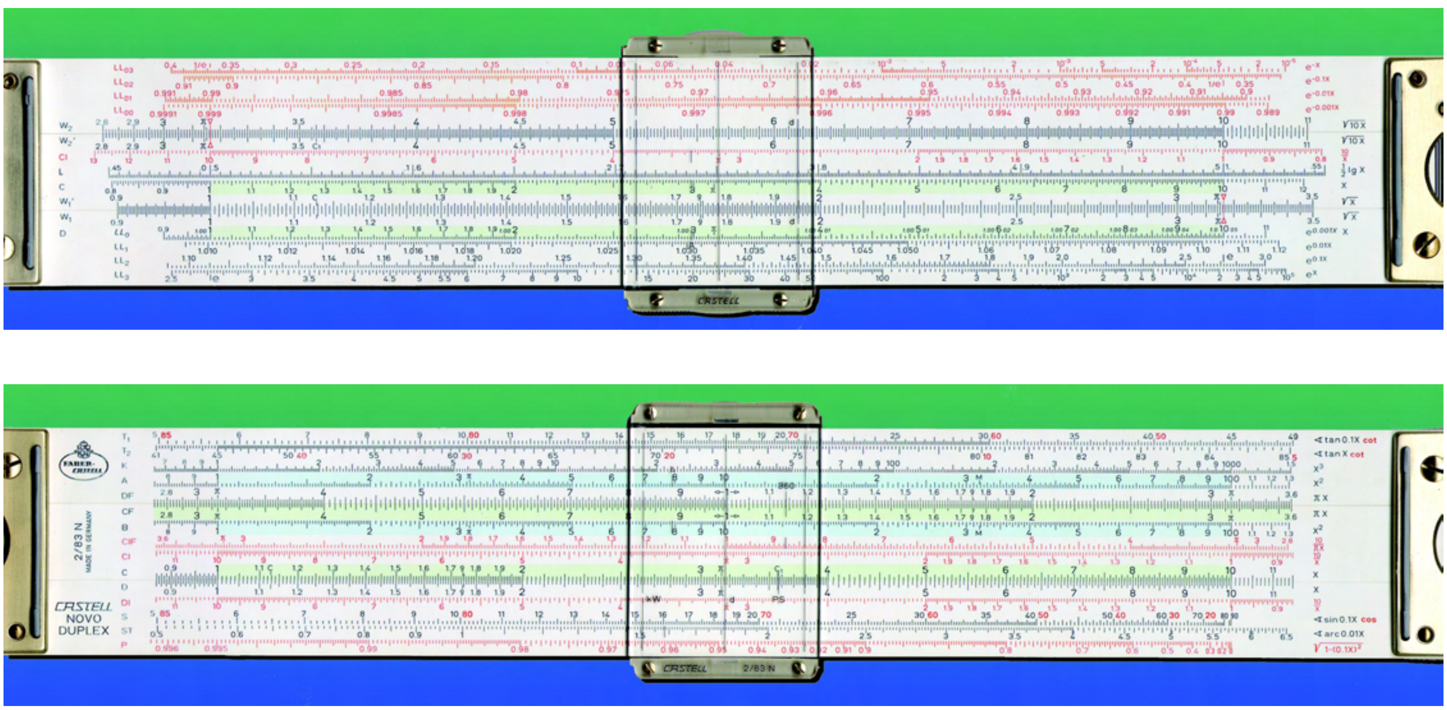
Cursor to 4 on D

ANSWER 12.56 ON A AT SHORT RED HAIRLINE IN UPPER LEFT PART OF CURSOR

### Color Coding

Scales and their labels are sometimes color coded. A scale may be highlighted along its length with a soft color. Faber-Castell is noted for its lime green and pale blue scale highlights; Aristo for its yellow; Nestler for its blue-green. Hemmi used blue on some of its later plastic models. Pickett is noted for its "eye-saver yellow" rules, where the entire rule was yellow.

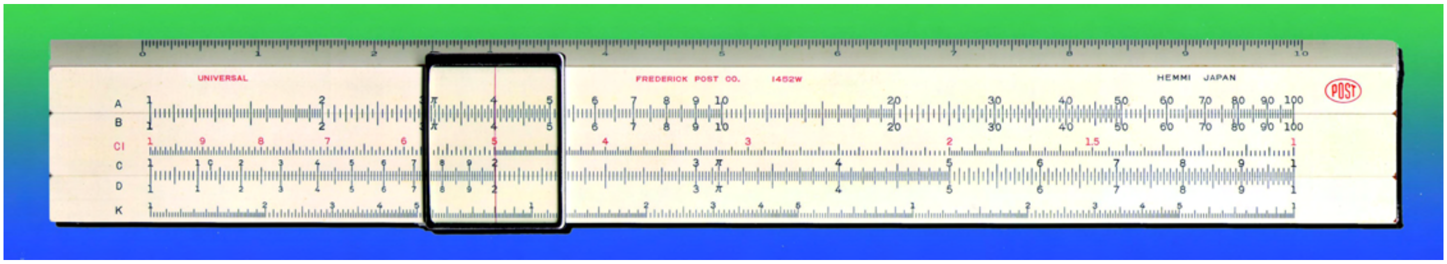
Scale labels and markings basically are black, with some scales labeled in red or green to facilitate following them during calculations.




FABER-CASTELL 2/83N, 25 CM SCALES, PLASTIC, DUPLEX, GERMANY. CONSIDERED BY MANY TO BE THE OVERALL BEST SLIDE RULE EVER MADE. FRONT AND BACK VIEWS.

### Rulers

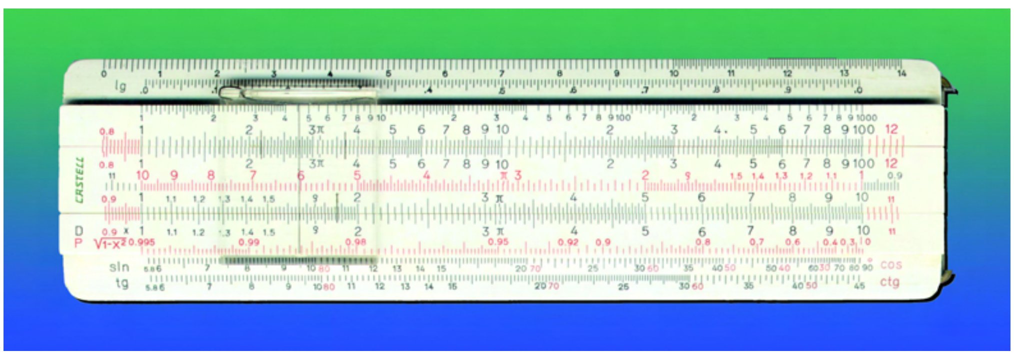
Many slide rules have measuring scales (rulers) on their edges ... sometimes one edge ... sometimes both. Often the top edge is beveled. The bottom edge is usually square. Scales are in centimeters and/or inches. Some Faber-Castell wood body slide rules have an additional centimeter measuring scale in the gutter, which enables the rule to measure distances greater than its body length.

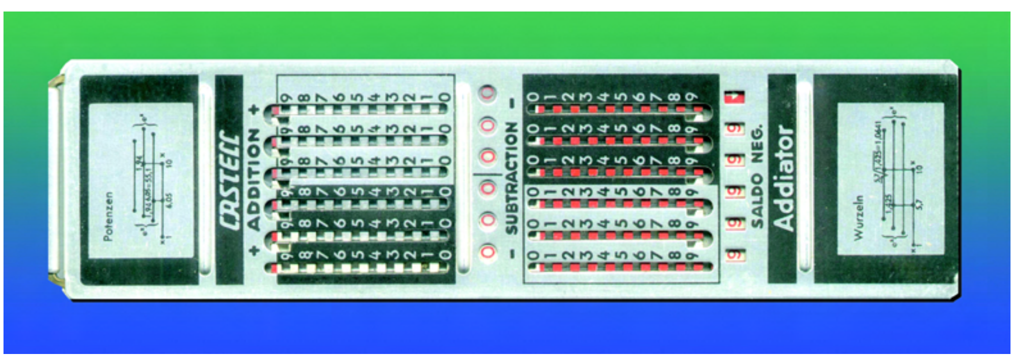



Post 1452W, 25 cm scales, celluloid on bamboo core, simplex, USA

## Addiators

Faber-Castell made several models of simplex (one-sided) slide rules with an addiator on the back, in both 6” and 10” models. This enabled the slide rule to add and subtract numbers up to 6 digits. Some of these Faber-Castell models are 1/22A, 111/22A, 1/54A, 111/54A, 1/87A, 111/87A, 63/22R, 63/39R, 63/98R, 67/22R, 67/22Rb, 67/54R, 67/54Rb, 67/87R, 67/87Rb, 67/98R, 67/98Rb. The “1” prefixes are 25 cm rules; the “6” prefixes are 12.5 cm rules.

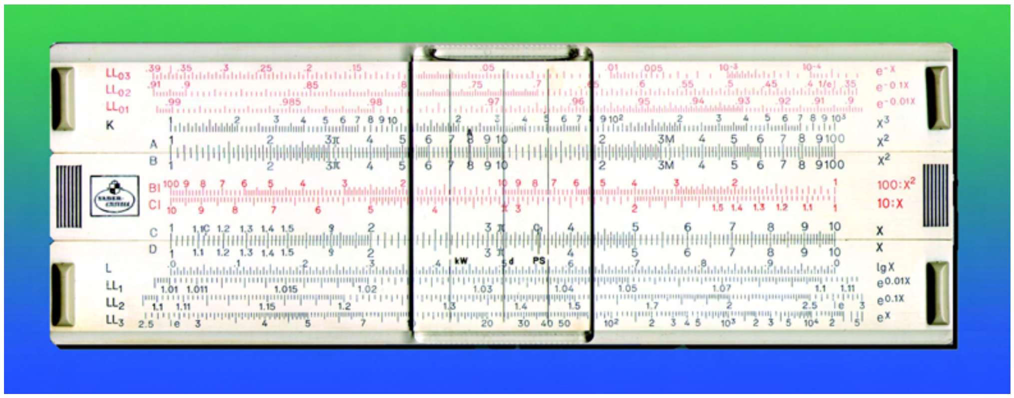



Faber-Castell 67/54R, 12. 5 cm scales, plastic, with Addiator on back, Germany. Front and back views.

## Electronic Calculators

Faber-Castell made slide rules in the 1970's with an electronic calculator on the back. These are quite rare. Model numbers are TR1, TR2 and TR3.

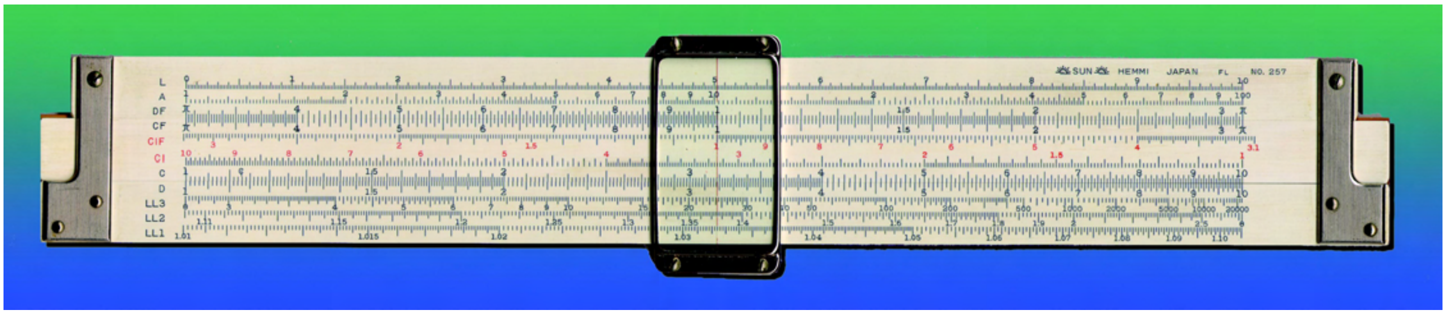


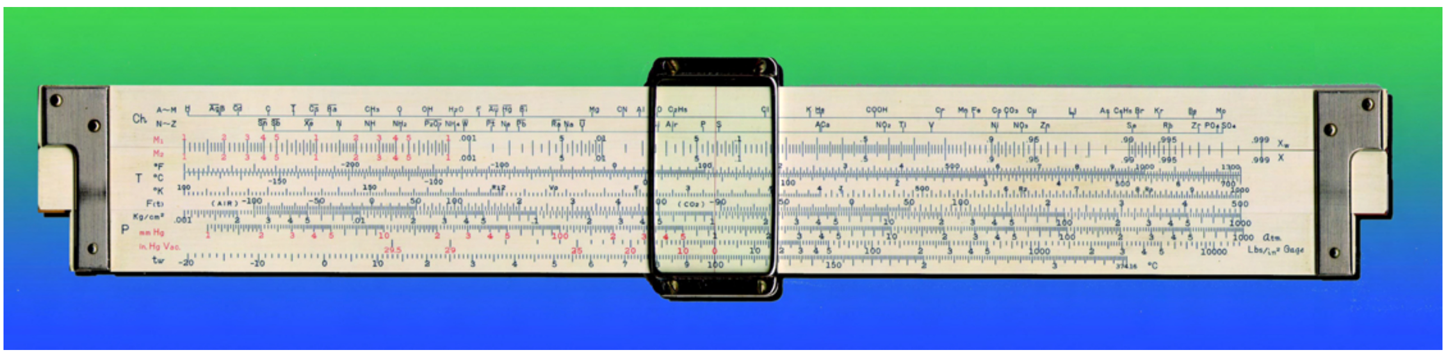
FABER-CASTELL TR3, 12.5 CM SCALES, PLASTIC WITH ELECTRONIC CALCULATOR ON BACK, GERMANY. FRONT VIEW.


FABER-CASTELL TR3, 12.5 CM SCALES, PLASTIC WITH ELECTRONIC CALCULATOR ON BACK, GERMANY. BACK VIEW.

# Slide Rules for Special Applications

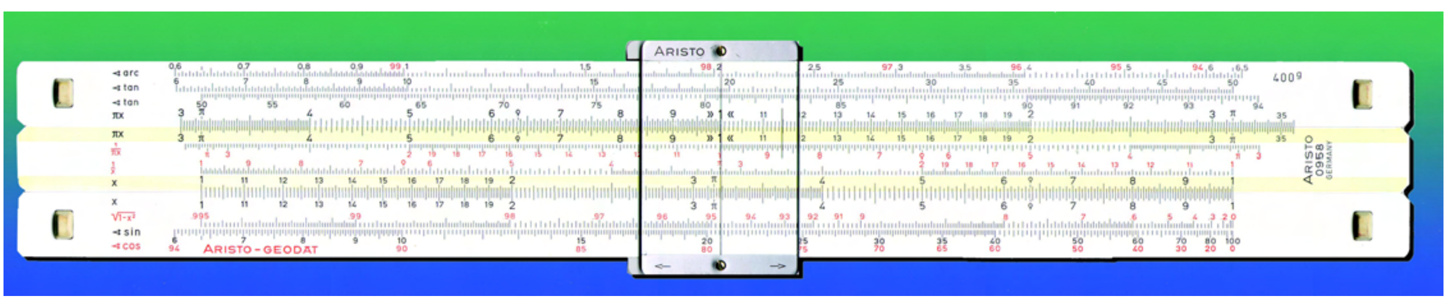
## Chemistry



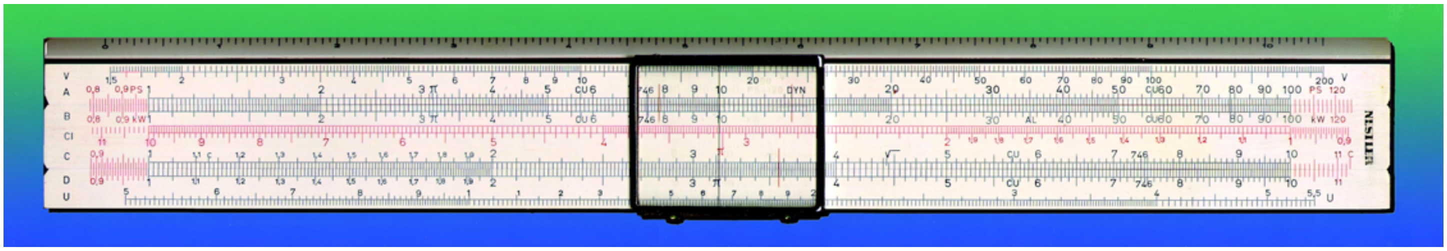
Hemmi 257, 25 cm scales, celluloid on bamboo core, duplex, Japan. Front and back views

## Surveying



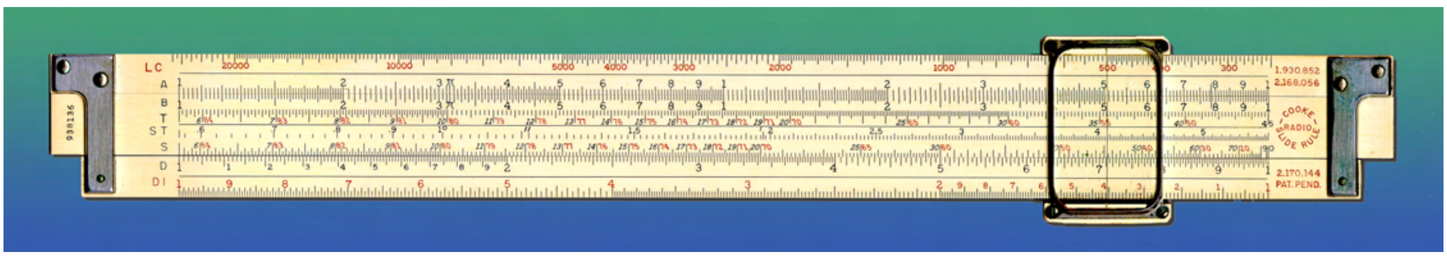

Aristo 0958 Geodat, 25 cm scales, plastic, duplex. Germany

## Electricity



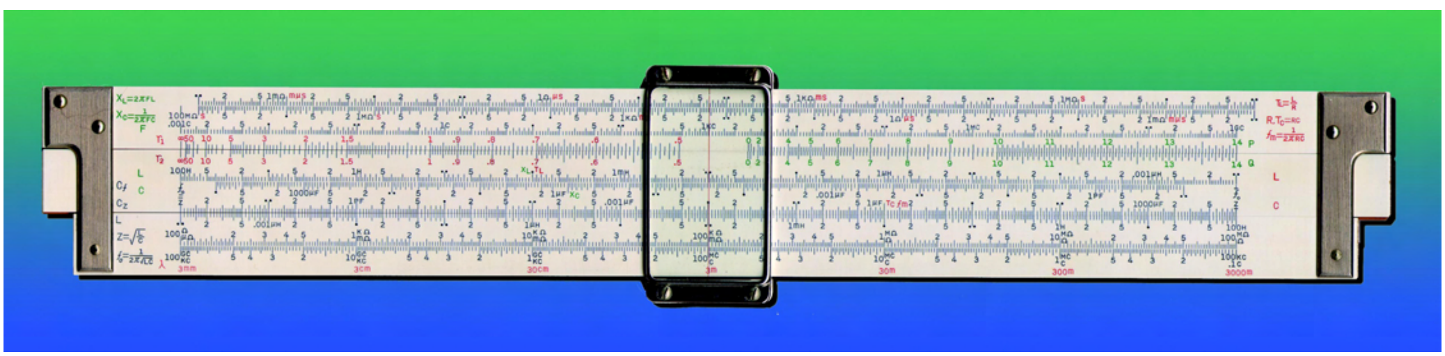
Nestler 0370 Electro, 25 cm scales, cellu- loid on wood core, simplex, Germany

## Radio



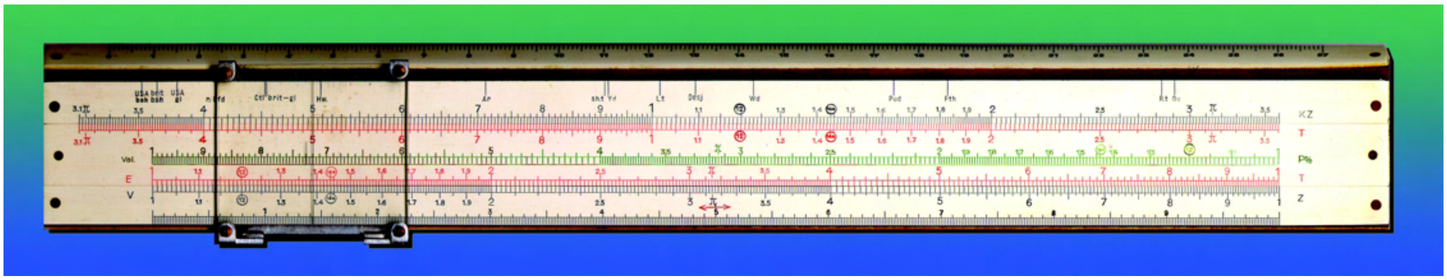
K&E 4139 Cooke Radio, 25 cm scales, celluloid on mahogany core, duplex, USA

## Electronics



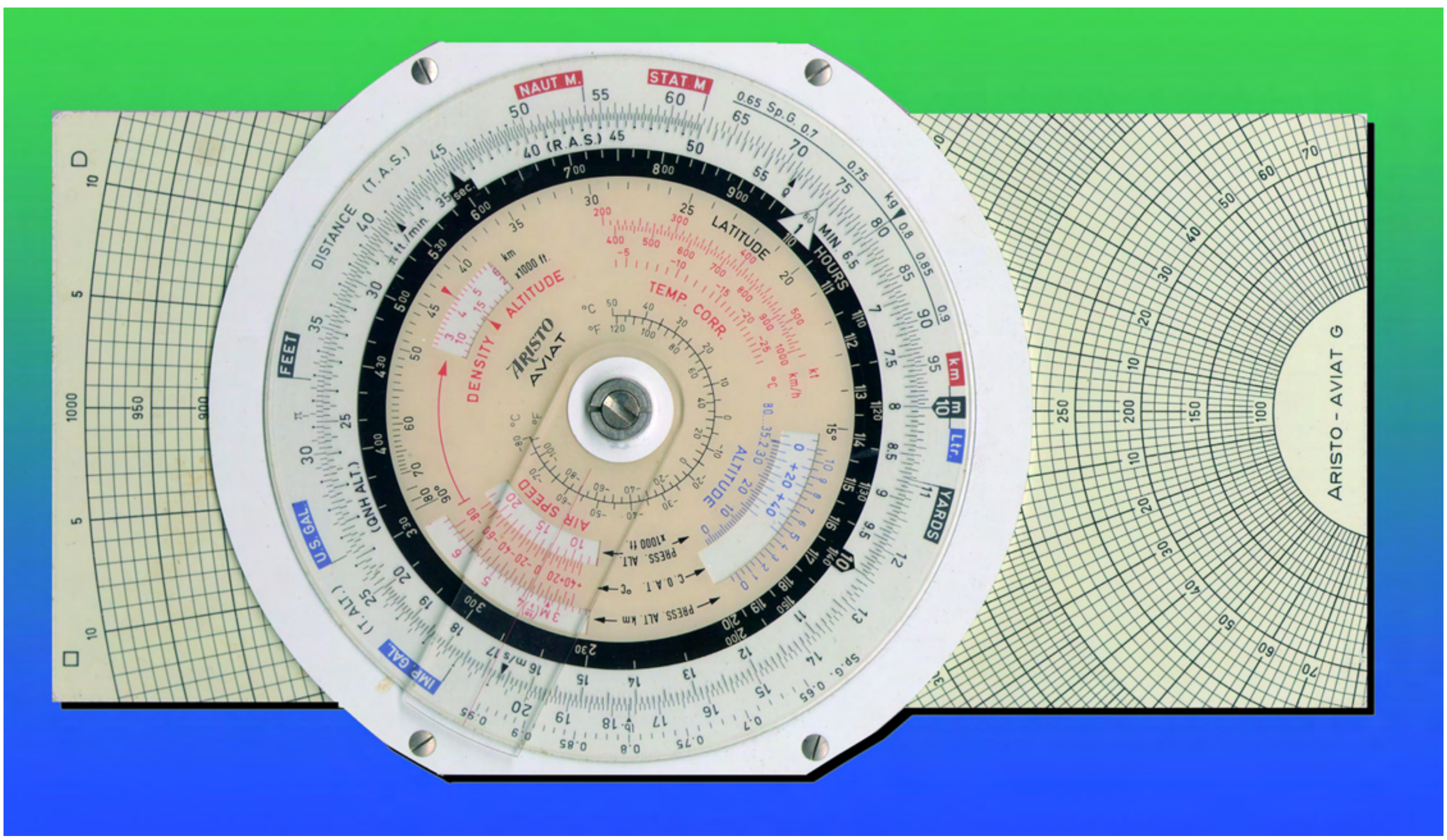
Hemmi 266, 25 cm scales, celluloid on bamboo core, duplex, Japan.

## Business and Finance

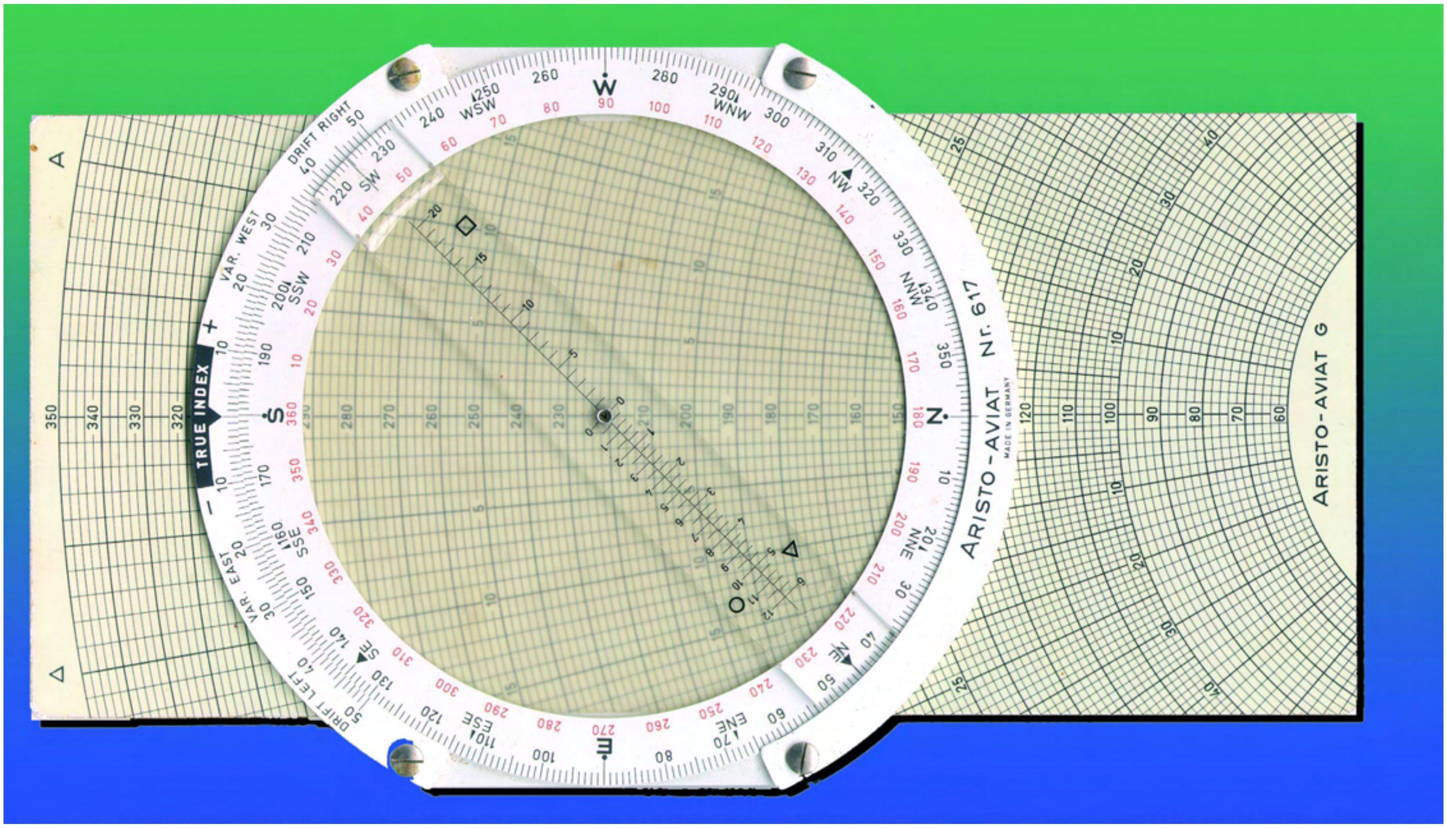


Faber-Castell 1/22
Disponent, 25 cm scales,
celluloid on wood core,
simplex, Germany

## Navigation

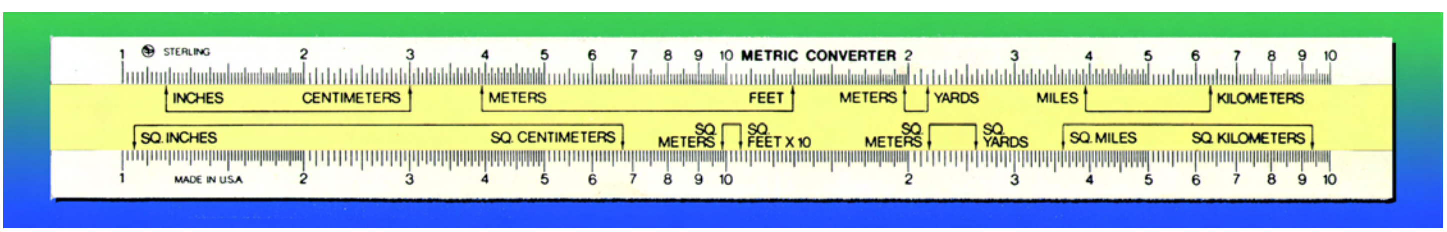



Aristo 617 Aviat, metal
and plastic, Germany,
Front view.




Aristo 617 Aviat, metal and plastic, Germany, Opposite view.

## Metric Conversion




Sterling Metric Converter, 25 cm scales, plastic, simplex, USA

# Major Slide Rule Companies and some of their Common Models

## United States

### Eugene Dietzgen Co.

Model N1725 Microglide (10") Celluloid on mahogany. Image
Model 1732 Maniphase Multiplex (10") Celluloid on mahogany. Image
Model 1765 Basik (10") Plastic. Image
Model 1771 Redi rule (5") Plastic. Image

### Gilson

Binary (8" diameter circular) Metal. Image
Midget (4" diameter circular) Metal. Image

### Keuffel & Esser (K&E)

Model 4053-3F Polyphase (10") Celluloid on mahogany. Image
Model 4081-3 Log Log Duplex Decitrig (10") Celluloid on mahogany. Image
Model 4181-1 Jetlog (5") Plastic. Image
Model 68 1100 Deci-Lon (10") Plastic. Image
Model 68 1130 Deci-Lon (5") Plastic. Image

### Lawrence Engineering Service (also Engineering Instruments Co.)

Model 10B (10") Wood. Click here.

### Pickett

Model N4-ES (10") Aluminum. Image
Model N1010-ES (10") Aluminum. Image
Model N600-T (5") Aluminum. Image.
Model 160 (5") Plastic. Image
Model 120 (10") Plastic. Image

### Frederick Post Co. (all models shown by Hemmi of Japan for Post)

Model 1460 Versalog (10") Celluloid on bamboo. Image
Model 1461 Versalog (5") Celluloid on bamboo. Image
Model 1447 Student Mannheim (10") Celluloid on bamboo. Image
Model 1452 Universal (10") Celluloid on bamboo Image
Model 1444K Pocket Mannheim (5") Celluloid on bamboo. Image
Model 1441 Vest Pocket (4") Celluloid on bamboo. Image

### Sterling Plastics (also Acu-Math)

Sterling Model "Precision" (10") Plastic. Image
Sterling Model 587 (5") Plastic. Image
Sterling Metric Converter. Image
Acu-Math model 400B Plastic. (10") Image

# Japan

## Concise
Model 28(3.5" circular) Plastic. Image

**Relay - Ricoh** (sold under many brand names such as Alvin, Compass, Eagle, Engineers, Jason, Lafayette, Lietz, Lutz, Micronta, Omega, Palco, Relay, Ricoh, Sans & Streiffe, SIC, Skyline, Wallace & Wallace)
Ricoh Model 551 (5") Celluloid on bamboo. Image
Lafayette 686(10") Celluloid on bamboo. Image

## Sun Hemmi
Model 259D duplex (10") Celluloid on bamboo. Image
Model 34RK (5") Celluloid on bamboo. Image
Model 149A Duplex (5") Celluloid on bamboo. Image
Model 32 (4") Celluloid on bamboo. Image

# Germany

## Aristo
Model 0969 Studio Log (10") Plastic. Image
Model 0968 Studio (10") Plastic. Image
Model 0906 BiScholar (10") Plastic. Image
Model 867U Darmstadt (5") Plastic. Image
Model 89 Rietz (5") Plastic. Image

## Faber-Castell
Model 2/83N Novo-Duplex (10") Plastic. Image
Model 1/54 Darmstadt (10") Celluloid on wood. Image
Model 1/87 Rietz (10") Celluloid on wood. Image
Model 52/82 Duplex (10") Plastic. Image
Model 67/87 Rietz (5") Plastic. Image

## Nestler
Model 0292 Multi Math Duplex. (10") Celluloid on wood. Image
Model 0210 Darmstadt (10") Celluloid on wood. Image
Model 23R Rietz (10") Celluloid on wood. Image
Model 0130 Multi Math Duplex (5") Plastic. Image

## Reiss
3223 Progress Duplex (10") Aluminum. Image
3214 Darmstadt Record Duplex (10") Plastic. Image

# England

### Thornton

AD150 (10") Plastic. Image
P271 (10") Plastic. Image

### Unique

Universal (10") Plastic on wood. Image
5/10 (5") Plastic on wood. Image

# France

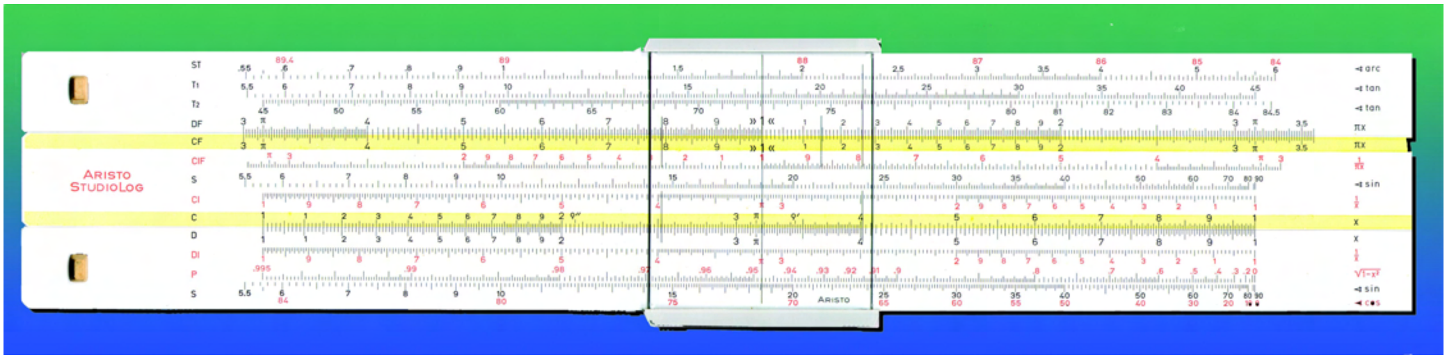
### Graphoplex

Model 615 (6") Plastic. Image

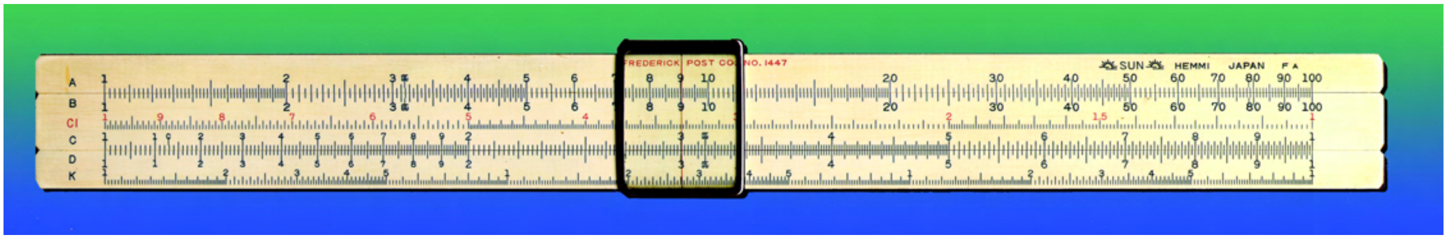
# Denmark

### Diwa

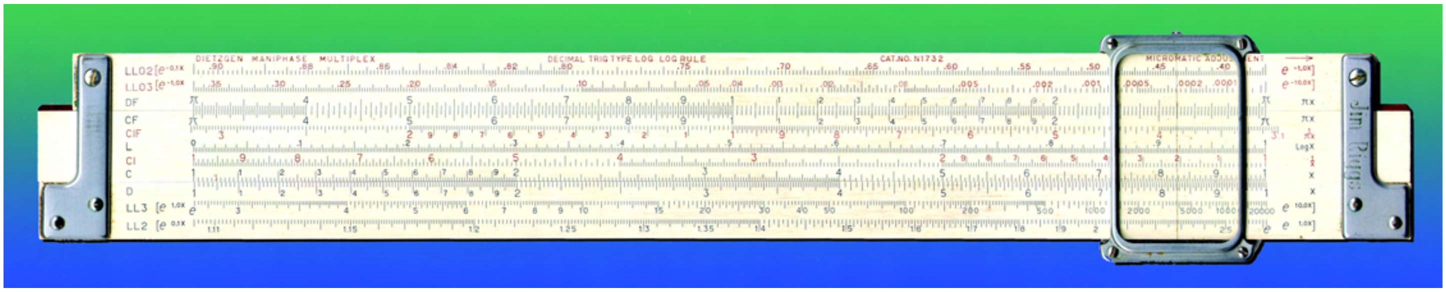
Model 601 (5") Plastic. Image



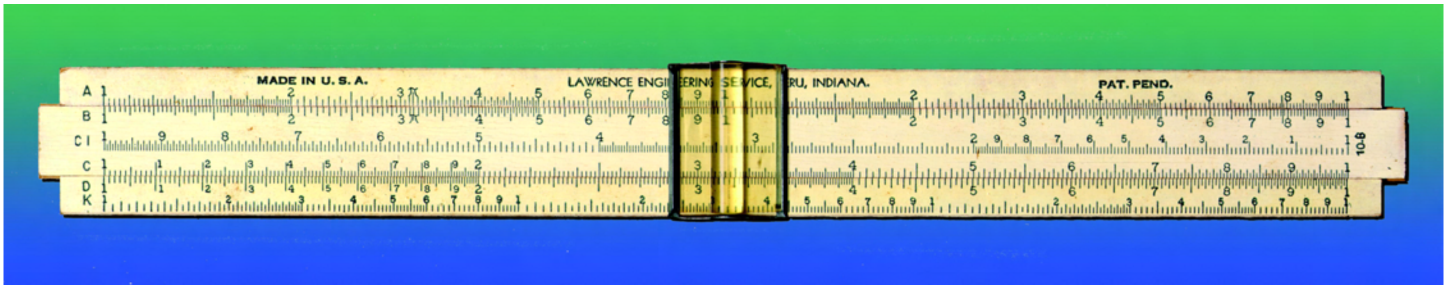

Aristo 0969, 25 cm scales, plastic, duplex, Germany



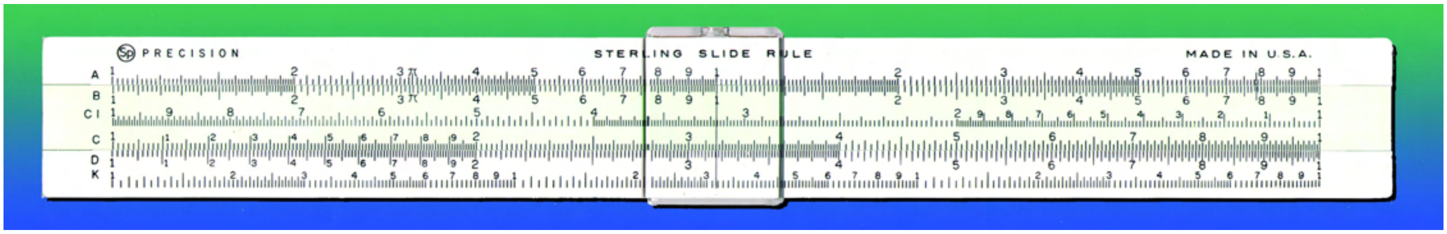

Post 1447, 25 cm scales, celluloid on bamboo core, simplex, USA



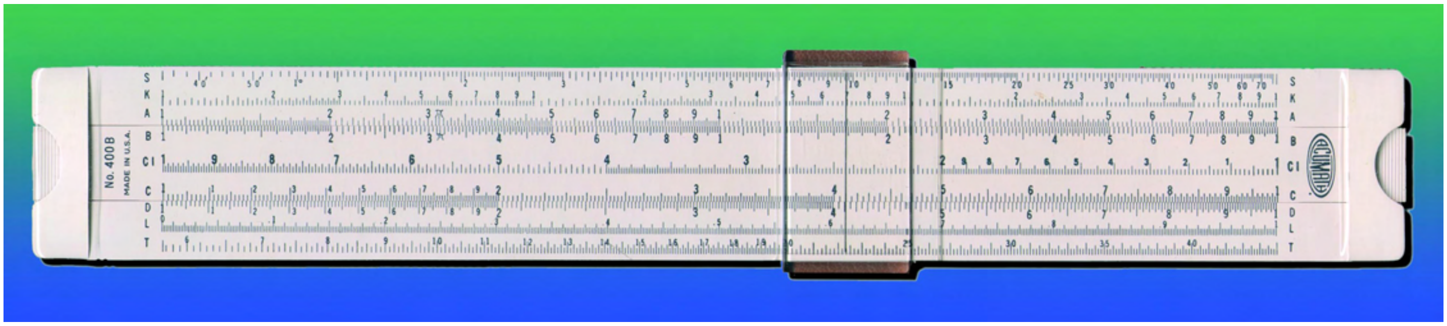

Dietzgen 1732, 25 cm scales, celluloid on wood core, duplex, USA



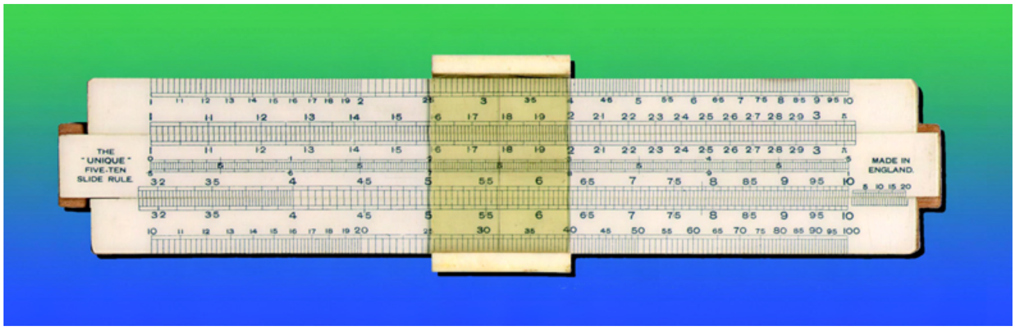

Lawrence 10B, 25 cm scales, wood, simplex, USA



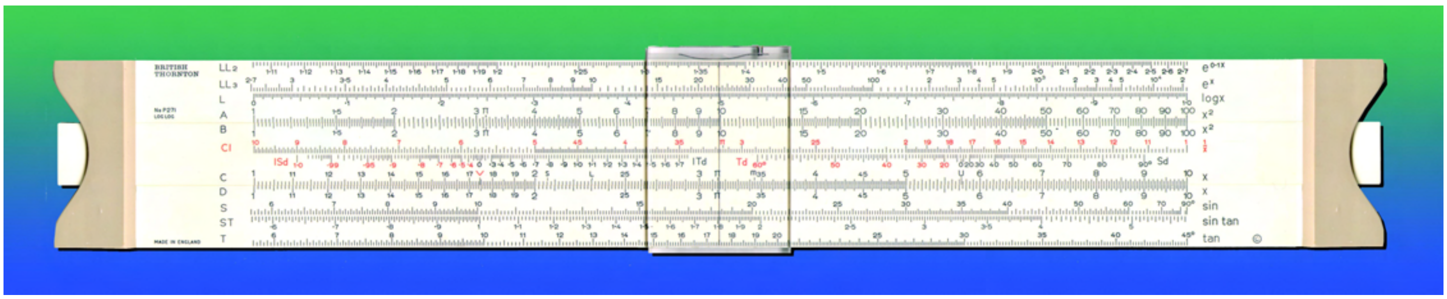

Sterling Precision, 25 cm scales, plastic, simplex, USA



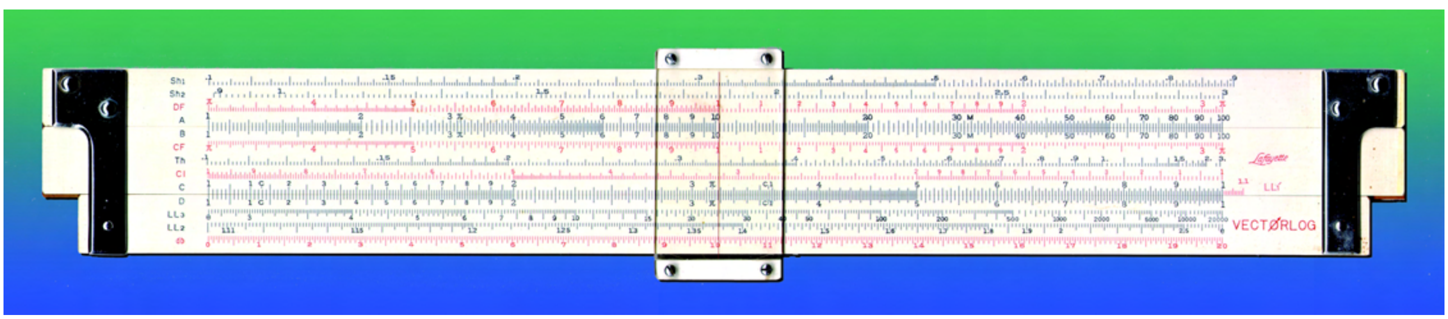

AcuMath 400B, 25 cm scales, plastic, duplex, USA



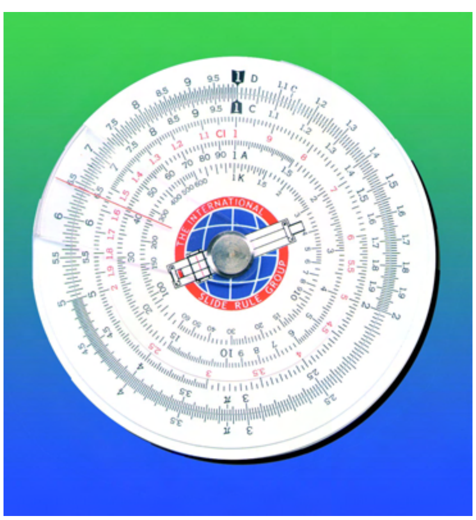

Unique 5/10, 12.5cm scales, plastic on wood core, simplex, England



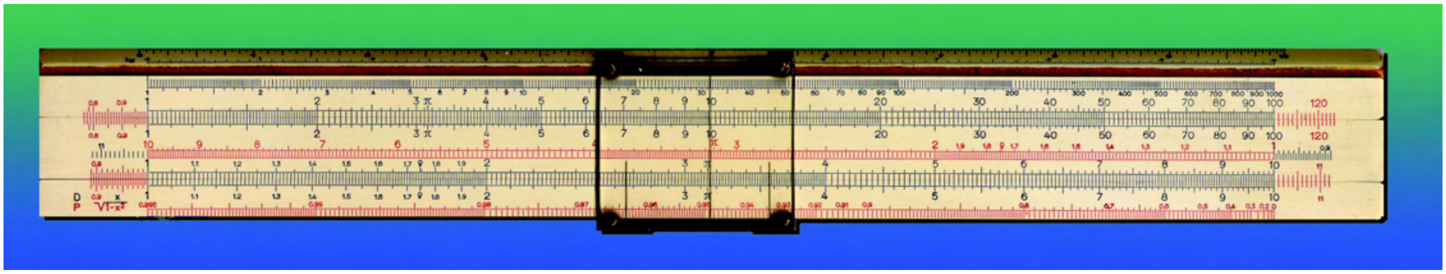

Thornton P271, 25 cm scales, plastic, simplex, England



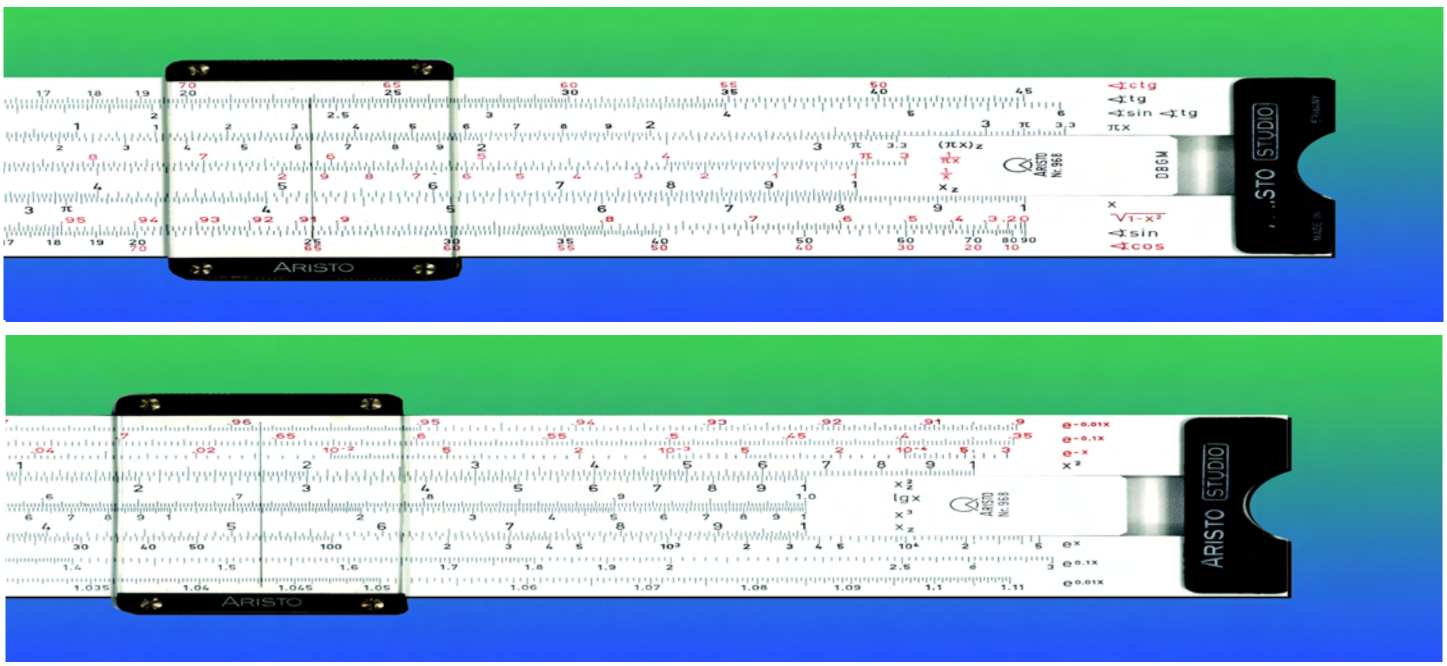

Lafayette 686, 25 cm scales, celluloid on bamboo core, duplex, Japan



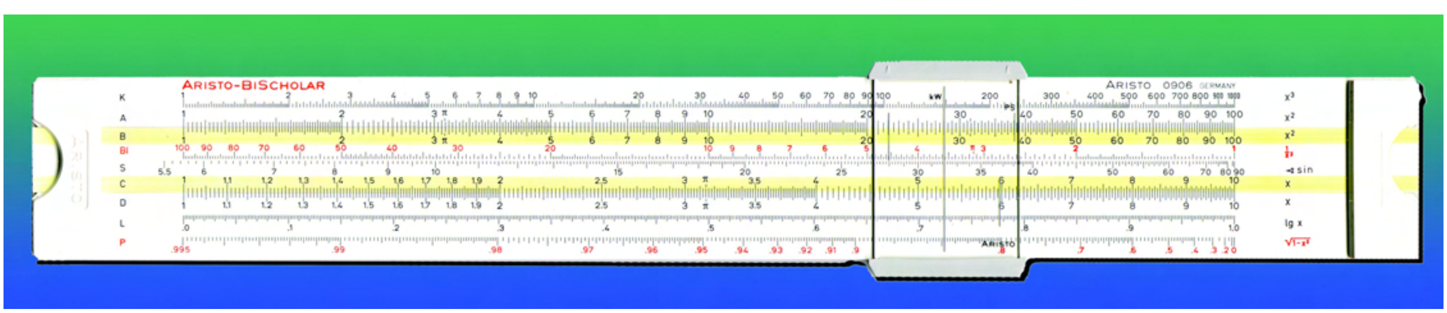

Concise 28N, 84 mm (3 3/8") diameter, plastic, Japan



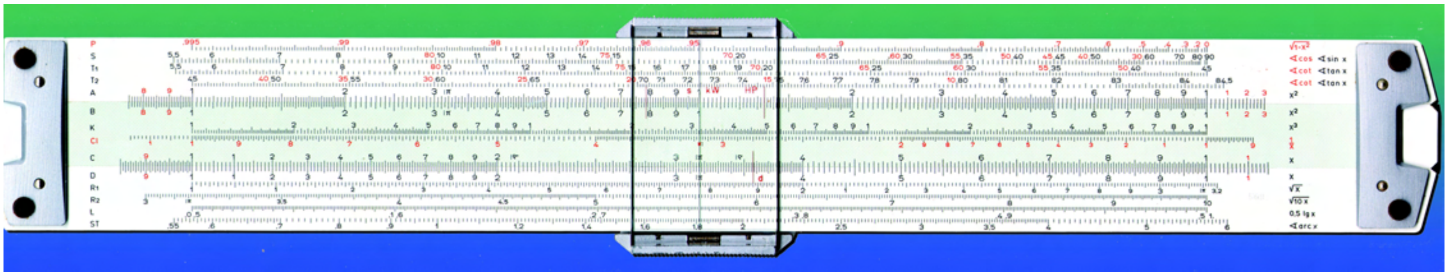
Faber-Castell 1/54 Darmstadt, 25 cm scales, celluloid on wood core, simplex, Germany



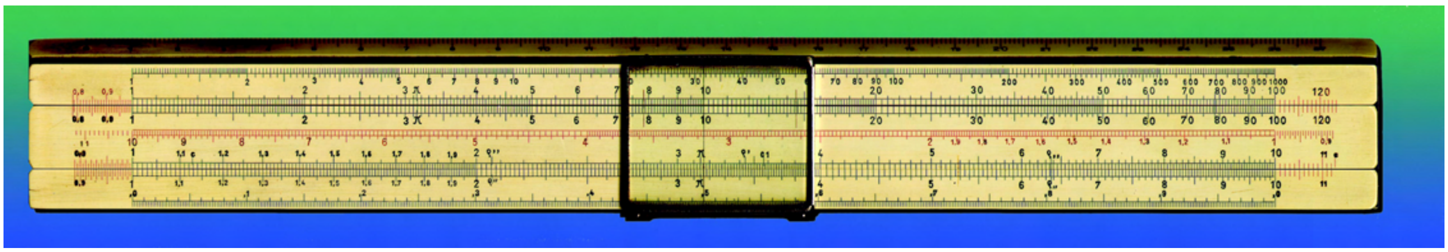

Aristo 968 Studio, 25 cm scales, plastic, duplex, Germany. Front and back views



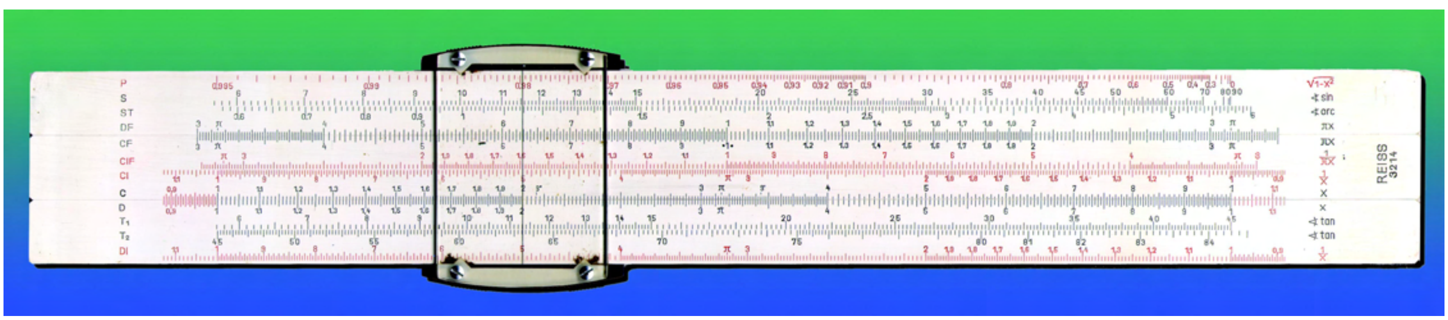

Aristo 0906 BiScholar, 25 cm scales, plastic, duplex, Germany



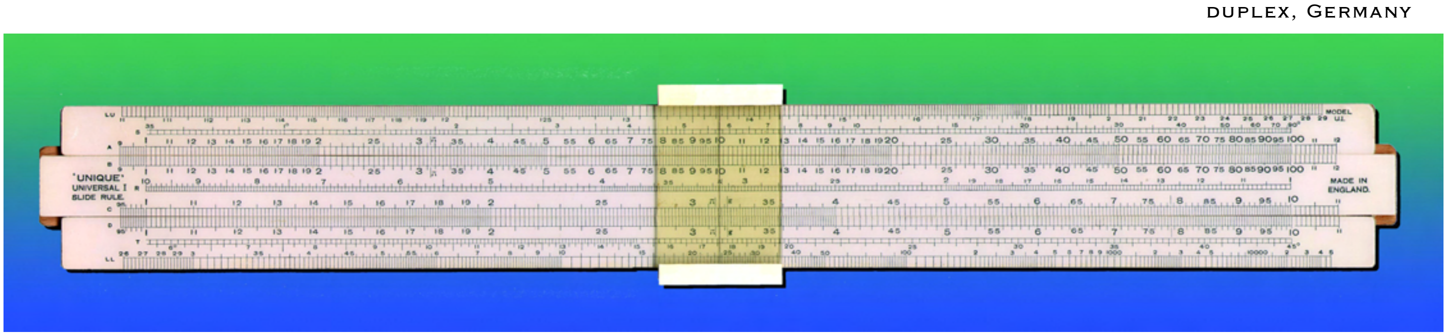
Nestler 0292 Multimath Duplex, 25 cm scales, plastic, duplex, Germany



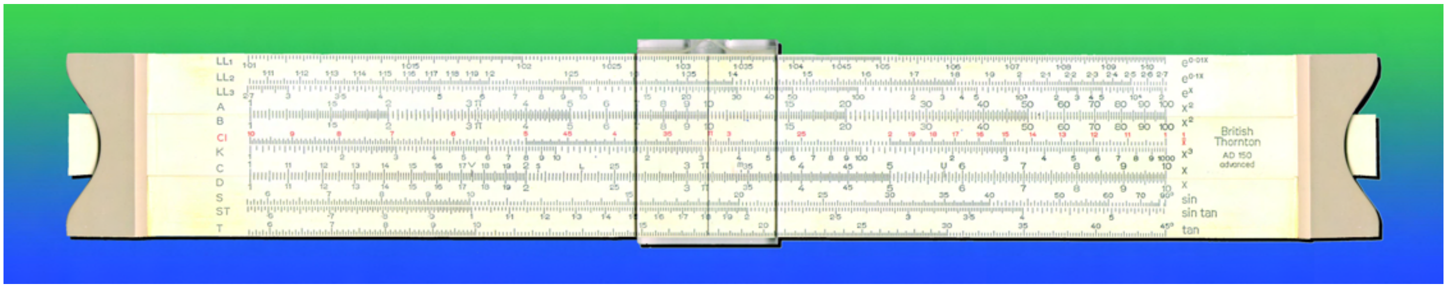
Nestler 23R Rietz, 25 cm scales, celluloid on wood core, simplex, Germany




Reiss 3214 Darmstadt Record Duplex, 25 cm scales, plastic, duplex, Germany




Unique Universal, 25 cm scales, plastic on wood core, duplex, England




Thornton AD 150, 25 cm scales, plastic, simplex, England

# Books, Manuals and Articles

If you would like to have a book containing information similar to the 17 chapters presented in *All About Slide Rules* please consider the purchase of *The Oughtred Society Slide Rule Reference Manual, Second Edition* available at www.oughtred.org

## Books About Slide Rules

**Prologue**
Altough many of the listed books are out of print, some may be found on the Internet, at antiquarian book stores, or in antique stores. Other books are still in print or reprints are available at bookstores or on the Internet. Many books and manuals in electronic format (typically PDF) may be downloaded from various websites.

**Journal of The Oughtred Society**
The Journal of the Oughtred Society is the primary source of information regarding slide rules and many other calculating instruments and methods. The index of past articles may be found at http://www.oughtred.org/jos-index.shtml. All past issues of JOS are available for purchase from The Oughtred soociety. There are links on the Oughtred Society website (www.oughtred.org/srlinks.shtml) to other websites with reference materials (e.g., UKSRC *Gazette*). The *Proceedings of the International Meetings for Collectors of Historical Calculating Instruments* (1995-2011) contain relevant papers (some Proceedings are still available on CDROM).
A thorough list of technical references (many are much harder to obtain than those listed herein) is available within: Hopp, Peter M., *A Slide Rule Bibliography*, The Oughtred Society, 1994.

**General History Books** about slide rules, the associated mathematics, discoverers, and inventors; and other related calculating instruments:


- Asimov, Isaac, *Biographical Encyclopedia of Science & Technology*, Avon Books, New York, 1976.
- Asimov, Isaac, *Chronology of Science & Discovery*, Harper & Row, New York, 1989.
- Baxandall, D., Pugh, J., *Calculating Machines and Instruments, Catalogue of the Collections in the Science Museum* (1926)*, London*, Science Museum, London, 1975.
- Berger, C.L., *Hand-Book and Illustrated Catalogue of the Engineers' and Surveyors' Instruments of Precision* (1900), Astragal Press, Mendham, NJ, 1993.
- Bion, N., *The Construction and Principal Uses of Mathematical Instruments* (1758), Astragal Press, Mendham, NJ, 1995.
- Cajori, Florian, *A History of the Logarithmic Slide Rule and Allied Instruments* (1910), Astragal Press, Mendham, NJ, 1994.
- Clifton, Gloria, *Directory of British Scientific Instrument Makers 1550-1851*, London, Zwemmer (Philip Wilson Publishers, Ltd.) and The National Maritime Museum, 1995.
- Cragon, Harvey G., *The Fleet Submarine Torpedo Data Computer*, Cragon Books, Dallas, TX, 2007.
- De Brabandere, Luc, *Calculus: Non-Electric Calculating Machines*, Pierre Mardaga, Belgium, 1994.
- Donners, J.H., *Mijnheer van Dalen Krijgt Antwoord*, private publication, 2002.
- Eves, Howard, *An Introduction to the History of Mathematics*, Holt, Rinehart and Winston, New York, 1961.

**General History Books, cont'd.**
- Graham, Frank D., *Audels Mathematics and Calculations for Mechanics A Ready Reference*, Theo. Audel & Co., New York, 1951.
- Helfand, Jessica, *Reinventing the Wheel*, Princeton Architectural Press, New York, 2002.
- Horsburgh, E.M., *Modern Instruments and Methods of Calculation, a Handbook of the Napier Tercentenary Celebration Exhibition*, Edinburgh, 1914, 344 p., Reprint: Los Angeles, San
- Francisco (Charles Babbage Institute), 1982.
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- Kühn, Klaus, and Shepherd, Rodger, *Calculating with Tones: The Logarithmic Logic of Music,* The Oughtred Society, 2009.
- Martin, Jean, *Historie des Instruments et Machines à Calculer*, Hermann, France, 1994.
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- Riddell, Robert, *The Slide Rule Simplified, Explained, and Illustrated for the Mechanical Trades*(1881), Astragal Press, Mendham, NJ, 2002.
- Robertson, John, *A Treatise of Mathematical Instruments* (A Reprint of the 1775 Third Edition with Notes by David Manthey), Flower-de-Luce Books, The Invisible College Press, Arlington, VA, 2002.
- Russo, Thomas A., *Antique Office Machines – 600 Years of Calculating Devices*, Schiffer Publishing Ltd., Atglen, PA, 2001.
- Schuitema, I.J., van Herwijnen, H., *Calculating on Slide Rule and Disc*, Astragal Press, Mendham, NJ, 2003.
- Thacher, Edwin, *The Slide Rule* (1880), The Oughtred Society, 1995.

**Books about Slide Rules and Manufacturers**
- Barnes, Colin, *John Davis & Son (Derby) Ltd. – A Chronology of Slide Rule Production*, private publication, 1997.
- Barnes, Colin and White, Tedford K., *OTIS KING Calculators – A History of Production 1919-1977*, private publication, 2012.
- Craenen, Guus, *Albert Nestler – Innovation und Qualität – Die Rechenstabe von Nestler in ihrem internationalen Umfeld*, private publication, 2001.
- Craenen, Guus, *Albert Nestler – Innovation und Qualität – Zusammenarbeit mit anderen Herstellen und mit Erfindern*, private publication, 2004.
- Craenen, Guus, *Rechenscheiber im Wandel der Zeit – 1787-1905*, privat publication, 2009.
- Hopp, Peter M., *Slide Rules Their History, Models, and Makers*, Astragal Press, Mendham, NJ, 1999.
- Hopp, Peter, *Joint Slide Rules: Sectors, 2-foot 2-fold and Similar Slide Rules*, Jeremy Mills Publishing, 2009.
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- Holland, Peter, *A.W. Faber A. W. Faber-Castell Slide Rules*, 5th Edition, Brühl, Deutschland, 2011.
- Kühn, Klaus, and Kleine, Karl, *Dennert & Pape - Aristo - 1872-1978, Rechenschieber und Mathematisch -Geodätische Instrumente*, Zuckschwerdt Publishing, Munich, Vienna, New York, 2004.

**Books about Slide Rules and Manufacturers, cont'd.**

- Rudowski, Werner H., *Scheffelt & Co. – Frühe logarithmische Recheninstrumente im deutschen Sprachraum*, Bochum, 2012.
- Schreiber, Georg, *Koch, Huxhold & Hanneman – Der Unbekannter Rechenstabhersteller aus Hamburg*, private publication, 2011.
- Schuitema, IJzebrand, *The Slide Rule – Technical Cultural Heritage*, Rijnja Repro, The Netherlands, 2003.
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- Soper, Joseph L., *K&E Salisbury Products Division Slide Rules*, The Oughtred Society, 2007.
- van Herwijnen, Herman, *Graphoplex Breveté S.G.D.G.*, private publication, 1999.
- vanHerwijnen, H., Soole, Peter, *Blundell Harling Limited*, 1999.
- Venetsianos, Panagitis, *Pocketbook of the Gauge Marks*, 2nd Edition, The Oughtred Society, 2011.
- von Jezierski, Dieter (translated by Rodger Shepherd), *Slide Rules A Journey Through Three Centuries*, Astragal Press, Mendham, NJ, 2000.

**Books about How to Use a Slide Rule**

- Asimov, Isaac, *An Easy Introduction to the Slide Rule*, Fawcett Books, New York, 1965.
- Bayley, William Henry, *Hand-Book of the Slide-Rule*, BiblioBazaar, 2009.
- Bishop, Calvin C., *Slide Rule How to Use It*, 3rd Edition, Barnes & Noble, New York, 1955.
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- Hoare, Charles, *The Slide-Rule, and How to Use It* (1868), Nabu Public Domain Reprints.
- Hume, Ted, and Koppany, Bob, *The Oughtred Society Slide Rule Reference Manual*, Second Edition, Striking Impressions, Hawthorne, CA, 2010.
- Johnson, Lee H., *The Slide Rule*, D. Van Nostrand Co., New York, 1949.
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- Marks, Robert W., *Simplifying The Slide Rule*, Bantam Unifact, New York, 1966.
- Pickworth, Charles N., *The Slide Rule: A Practical Manual*, 15th Edition, The Riverside Press Ltd., Edinburgh, Scotland, 1917.
- Snodgrass, Burns, *Teach Yourself the Slide Rule,* English Universities*,* 1958.
- Stanley, W., *Instruction for Using a Slide Rule*, Fili-Quarian Classics, 2010.
- Young, Neville W., *Complete Slide Rule Manual*, David & Charles, 1973.

**Manufacturers' Manuals -- How to Use a Specific Slide Rule**

- Breckenridge, William E., *The Log Log Duplex Slide Rule*, Keuffel & Esser Co., New York, 1932.
- Dietzgen, *Self-Teaching Instruction Manual No. 1771 Redi-Rule® Pocket Slide Rule*, Eugene Dietzgen Co., Chicago, IL.
- Fiesenheiser, E.I., *Versalog Slide Rule Instruction Manual*, Frederick Post Co., Chicago, IL 1963.
- Hartung, Maurice L., *How to Use the Deci·Log Log Slide Rule*, Pickett & Eckel Inc., Chicago, 1947.

**Manufacturers' Manuals -- How to Use a Specific Slide Rule, cont'd.**

- Hartung, Maurice L., *How to Use Trig Slide Rules*, Pickett, Inc., Santa Barbara, CA, 1960.
- Hartung, Maurice L., *How to Use Log Log Slide Rules*, Pickett, Inc., Santa Barbara, CA, 1953.
- Hartung, Maurice L., *How to Use Dual Base Slide Rule Exponential Ln-L Scales*, Pickett, Inc., Santa Barbara, CA.
- Hemmi, *Instruction Manual for Hemmi 257 Slide Rule*, Hemmi Slide Rule Co., Ltd., Tokyo.
- Hemmi, *Instruction Book for the Use of "Hemmi" Bamboo Slide Rules (Mannheim Type)*,
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**Slide Rule Articles**

- *Kilderkins. Hogsheads & Dipping Rods : A Brief History of the Slide Rule,* Tom Wyman, Journal of The Oughtred Society, Vol. 10, No. 2, Fall 2001, page 2. Excellent concise article of slide rule history. Many useful references listed in its bibliography notes.
- *The Beginning Collector*, Herman van Herwijnen, Journal of The Oughtred Society, Vol. 9, No.2, Fall 2000, page 6. Fine advice for beginners and experienced collectors as well. Provides specific systems for rating slide rule rarity and condition.
- *Thousands of Rules and Millions of Bytes Later - The Slide Rule Universe and Other Internet Stories,* Walter Shawlee 2, Journal of The Oughtred Society, Vol. 9, No. 2, Fall 2000, Page 13. Fascinating account of Walter's experiences in collecting and dealing in slide rules. Interesting discussion of how his extensive website, Slide Rule Universe, came into being.

For additional articles, see http://sliderules.lovett.com/extendedlitsearch.html

**Additional Lists of Slide Rule Books**

- The United Kingdom Slide Rule Circle (UKSRC) has more than 200 reprints available at low cost. See the List of Reprints. To order, Contact the UKSRC by e-mail at"peter.hopp@clara.co.uk". Or visit the UKSRC's Web site.
- The German Slide Rule Group (Rechenschieber-Sammler-Treffen) maintains a recommended book list on their RST Web site
- The Dutch Circle of Slide Rule Collectors maintains a recommended book list on their Circle Web site
- Rod Lovett maintains a searchable database of slide rule literature published in:
  - The *Journal of the Oughtred Society*.
  - The United Kingdom Slide Rule Circle's *Skid Stick* and *Slide Rule Gazette*
  - *Proceedings* of the International Meetings of Slide Rule Collectors

# Cleaning and Caring for your Slide Rule

## General Comments

A very common problem is restoring a dirty slide rule to usable condition. Because of the materials used in making slide rules, different techniques and methods are needed with different rules in order to avoid damage to the scales or action.

Not all dirt and damage can be repaired, and some collectors may prefer to leave the rule as found, so keep that in mind as you read the following information.

It is unwise to attempt to clean a slide rule that is extremely old, unless you are quite comfortable with the process, as the rule may be quite fragile and the cursor in particular may be easily damaged by careless work.

Every manufacturer makes a point of the importance of keeping the rule clean. Considerable damage is done by not following these rules, as the cursor and body will become badly streaked and often permanently damaged. The cursor is the most vulnerable part of the rule, and it should not be allowed to become dirty on any surface.

All of the techniques listed here work in real life and have been thoroughly tested, but the risk is all yours once you start to work on the rule.

## Some things to keep in mind

EXCESSIVE SUNLIGHT will fade colors and turn the body yellow on virtually all rules.

PETROLEUM SOLVENTS can strip colors off the scales and can remove the colors in the engraved lines and may damage the cursor material.

HEAT can warp any rule.

WATER will be absorbed by both wood and plastic rules and it may warp or bind the rule.

DON'T SIT ON A POCKET SLIDE RULE ... it will probably be badly warped or broken.

TEST the cleaning technique on a non critical rule before applying it to a valuable specimen.

## Wood Body Slide Rules with Celluloid Surface

Wood body rules should be stored in a case, out of any severe temperature or humidity changes. The bodies are made of mahogany or boxwood or pearwood or other woods, which are relatively stable, but can be distorted by prolonged exposure to water or sunlight and heat, especially if applied to only an exposed portion of the rule. The scales are made of celluloid (not ivory as many people think), and can delaminate if the rule is soaked or exposed to large temperature changes.

## Windex or Dishwashing Liquid

You can often successfully clean the surface of a rule with a rag dampened with "Windex" or a weak solution of a mild dishwashing liquid. This will help to clean ink stained and dirty surfaces, as well as the edges of the slide and body. There should be no dirt in the sliding portion of the rule, and a rag with a bit of Windex on it will help to remove accumulated dirt and abraded material.

Certain ballpoint ink stains which resist Windex will dissolve in rubbing alcohol. But be careful ... some engraving inks are also alcohol soluble.

In either case, use a lightly dampened rag. Do not spray Windex directly onto your ruIe or immerse your rule in liquid!

## The ScotchBrite Scouring Pad ... and Steel Wool

For celluloid faced rules with engine divided (engraved) scales, cleaning is often best accomplished with a dry fine grade "ScotchBrite" pad or steel wool (K&E says steel wool, but we prefer the pad.) Gentle rubbing along the body and slide will remove any surface grime, discoloring and ink marks. This will not harm the engraved and filled scales. Many people are reluctant to do this, but keep in mind, this is what K&E recommends, and it works very well if you are careful and patient. Avoid spot rubbing by this method, as it will cause patches of different body color. Once you start this method, you should rub down the entire side of the rule to maintain a consistent appearance. Some celluloid will be removed, and you will be able to smell its distinctive odor.

## Sandpaper

A badly discolored rule can be restored to bright white with vigorous rubbing with a ScotchBrite pad ... or even sandpaper. You can use fairly coarse sandpaper if you need to remove a lot of discoloration or ink marks or names scratched into the rule, graduating to finer paper and finishing with the Scotch Brite pad. On severe cases we have used successfully No. 100 emery paper (the black type), followed by No. 220, followed by No. 320 (the finest of the three), followed by the ScotchBrite pad. This will remove some celluloid from the surface, which you can smell.

On quality slide rules like Hemmi and K&E and others, the engravings are deep enough to resist damage from this removal of some of the celluloid surface. In fact, during the manufacturing process, the engravings were filled with color, covering the entire surface of the rule in the process. After drying, the rule was sanded clean as the finishing step, leaving the colors in the engravings.

**Caution!** Leave the slide in the rule to prevent uneven sanding pressure from removing excess material and eating too far into the engravings at the edges where slide or body meet. We learned this the hard way by damaging a nice Versalog. Ouch!

Don't try ScotchBrite pads or sandpaper on a Pickett or other rules with printed scales ... or any rule which does not have engraved scales… the markings will come right off!

## Erasers

Another good method for cleaning is to use a white vinyl eraser ... the kind that is rather soft and has no grit in it. This will remove many kinds of grime and will not scratch a shiny surfaced slide rule. It is slower than a ScotchBrite pad, but it eventually does an almost equal job.

This method was used recently to clean Michelangelo's famous statue of David in Florence.

If you are cleaning a Hemmi or K&E rule which has a semi-matte finish, you can use a regular old Pink Pearl eraser. It contains some abrasive material, but it will not seriously alter the semi-matte finish. You can touch it up afterward with a ScotchBrite pad.

## Sunlight

Limited exposure to sunlight can help to return an aged yellow colored rule to its original white/ivory color. Start with one hour exposure; then try another hour, etc. Too much exposure, say more than 4 hours, can possibly affect the inked colors in the engravings. Use this technique after cleaning your rule using the preceding methods.

## Wax

We do not recommend using wax on the rule edges or face (as it collects and traps dirt, especially under the cursor). But you may wish to lightly rub the faces and edges with a very small amount of hard wax or "Pledge" to give a shiny appearance if the rule is mainly for display. Wax will often bring out the wood highlights in a very attractive way on edges of exposed wood.

Anything in the sliding area of a wood rule generally increases friction and binding, and the best possible technique is to have this area as clean as you can. If this area is rough and sticks, and it has already been well cleaned and the gap is correctly set, a very light rub with a hard wax may improve the action, but often makes the rule stick after it has been unused for some time. If anything is used, here, we prefer a light rub with a rag or piece of paper towel lightly dampened with Pledge furniture polish, and nothing else. An almost imperceptible amount of Pledge can work wonders for a stubborn slide.

## Plastic Body Slide Rules

These rules should be stored in a case and should not exposed to any severe temperatures or extreme sunlight. Plastic rules can be distorted or discolored by prolonged exposure to water or sunlight or heat. Unlike wood rules, plastic body rules cannot delaminate and are made of a single solid material.

Except for the painted scales on some plastic rules, cleaning the engraved scales on a plastic body rule can be done with a fine ScotchBrite pad or steel wool as with a wood body rule. You can also generally use a rag dampened with Windex, per above.

Some plastic body rules used a scale fill material that dissolves in Windex, resulting in a smeared appearance when the rule is washed with Windex. Apply Windex to a rule only by means of a rag dampened with it. Don't spray Windex or other cleaners onto your rule. Erasers work equally well on plastic rules as on celluloid covered wood body rules. Vaseline is recommended by many users to lubricate the slide of plastic slide rules.

## Bamboo Body Slide Rules

Hemmi and other bamboo core rules are very similar to wood body rules … and the same techniques work well on these rules. A gentle abrasive pad like ScotchBrite will restore the face of most rules and remove many marks. The entire surface or side usually has to be done at one time, to keep the appearance uniform.

Bamboo is naturally self-lubricating, so nothing is really required to keep motion uniform and smooth, BUT the surfaces can become rough after long storage (ends of fibers become exposed), and rubbing the sliding surfaces with that same ScotchBrite pad will restore the smooth surface and improve the action. If the bamboo is severely dried out, a gentle rub with a cloth dampened with a bit of Pledge will usually restore the action. You may need to adjust the body frame if action is too loose or tight. This is done by slightly loosening the two top body screws and bringing the scales into alignment … and then adjusting the width to produce the desired action.

## Cleaning Cursors

Cleaning the cursor is much simpler if it can be removed easily and wiped with a soft cloth or paper towel, dampened with warm water. If it is a duplex rule, you may not wish to remove the cursor. Slide a piece of white paper under the glass, and gently press on the glass, while moving the cursor along it. This will generally rub any accumulated dirt off of the cursor and onto the paper. You can help this with a drop of water or Windex on the paper in stubborn cases.

A word of caution: Windex will sometimes dissolve the ink used to mark the cursor hairline, and can create more problems, so be careful with the engraved line when cleaning the window of the cursor.

## Repairing Cursors

A common problem with slide rules is that the cursor may get broken or the hairline disappears. These problems can both be fixed with some care. If the cursor has glass faces, the only workable solution for a broken lens is a new one, and spare parts do exist for many rules. If a spare part can't be found, often another rule in poor condition can be scrapped to salvage the required parts. In some cases, a larger cursor glass can be sanded to make a smaller glass. Some K&E cursor runner bars are notorious for deteriorating and salvage parts will be needed, because new replacement parts are near non-existent.

See the chapter titled *Slide Rules on the Internet* for dealers who sell slide rule parts. Click here

If the cursor hairline disappears, disassemble the cursor and clean it well. You can refill the line with a grease pencil (like those used to mark china or glass), or a soft colored pencil, or a fine tipped permanent marker like a Staedtler-Mars Lumocolor ... and then rub off any excess outside the line or wipe it clean with a soft cloth and some Windex. This can restore the hairline to new condition. Be careful using a felt marker on plastic cursor windows, as it may penetrate the plastic around the line and ruin the window.

Plastic cursors found on most Picketts and on rules from many makers are more susceptible to scratching than glass cursors. Surface scratching can sometimes be eliminated by hand polishing with Novus plastic polish (available in 3 grades). Novus Inc. Item PC-20 is recommended. It is available from Industrial Plastics and other plastic distributors. Call 1-800-548-6872 for local dealers.

Careful use of a buffing wheel on a bench grinder, with a bit or rouge or fine polishing compound on it, will also work wonders on scratched plastic cursors and cases. Take care to buff lightly and slowly to prevent overheating and damage therefrom.

## Cleaning Metal End Braces

Cleaning metal end braces must be done carefully, as many are plated, with brass as the typical underlay material, with typically nickel top plating (sometimes with a copper flash underneath). If the cleaning or abrasion is too aggressive, the brass will be exposed, ruining the appearance of the rule. Some K&E models are lightly plated and easily damaged.

Metal end braces can often be cleaned with a rag dampened with Windex. Gentle rubbing with a ScothBrite pad, or a toothbrush with a bit of water and abrasive cleanser like "Ajax" or "Comet", is a generally safe method, but do not go too far.

If more cleaning power is needed, try a brush with fine brass bristles. These can be found at the hardware store, about the size and appearance of a toothbrush. Add Windex if needed. The vigor with which you brush can be determined by the degree of polish on the surface of the end brace. If it has a mirror-like finish it may be plated ... be careful and use only a plastic bristle brush!

For Hemmi end braces with their striated finish, you can use a stainless steel bristled brush, often found at the hardware store in a three pack with the brass and plastic bristle brushes. Use it vigorously and your Hemmi end braces will return to new appearance. Hemmi end braces usually are a stainless alloy and are not plated. One benefit of using these brushes is that they clean the areas immediately around the rivets and screws, which are very hard to clean by other methods.

Pickett end braces are all aluminum and can be wire brushed to restore their appearance. A Dremel tool works very well for this, and with a fine brush and later polishing wheel, can restore the parts to like new condition.

Faber-Castell end braces are anodized aluminum (gold colored), and any attempt at cleaning beyond a wipe with windex or a light scrub with a toothbrush wetted with Windex will destroy the anodized finish.

## Leather Cases

The case should be cleaned with a damp cloth and some Windex for stains and marks, and once dry, rubbed with a good leather polish or hard wax, and shined. Leather will dry and crack if not moisturized by some method, so don't ignore the case. Lexol appears to produce good results with little change to case color.

It is possible to remove some markings on the inside of the flap by using coarse sandpaper to remove the top layer of the leather, but this is not for the faint of heart. This is quite safe on a heavy leather case like the Versalog cases. The thinner the leather, the more careful you must be! Sandpaper may also be used on the exterior of the case, but it will change the appearance of the finish and must be done over the entire case to maintain uniformity.

Do not attempt to remove markings with any solvent, or you will almost certainly stain the case.

Leather cases often get "collapsed" and make inserting and removing the rule almost impossible ... plus they usually crack when flexed.

In an experimental moment, we used a tea kettle with lots of steam coming out the spout to send a clean jet of steam into the case and let it warm up. In about 10 seconds, the case becomes very pliable, and can be gently squeezed back into shape. When it cools, the case is now fixed in the "good" position. The steam helps to soften the case and restore some life to the material. This can help make the case look literally like new. Use Windex to clean off any dirt or grease, then rub Pledge or Lexol into the case to restore the shine, especially on the flap.

NEVER FORGET ... all slide rule makers advise you to always keep your slide rule clean and in good repair. If the rule gets dirty, it will mark up the back of the cursor and the rule will be hard to read and operate.

# Slide Rules on the Internet

*If you would like to have a book containing information similar to the 17 Chapters presented in All About Slide Rules, please consider the purchase of The Oughtred Society Slide Rule Reference Manual, Second Edition, available at www.oughtred.org.*

## General Information on Slide Rules

### The Oughtred Society

Interested in Slide Rules? Join The Oughtred Society! International organization dedicated to the preservation and history of slide rules and mechanical calculators. Wealth of information about slide rules. Large collection of links to other slide rule websites. Publishes the renowned biannual Journal of the Oughtred Society. New members are welcome. Cost is $35 annually in the USA, $45 International. Members receive the biannual Journals and a Membership Directory, and can attend the three annual meetings, West Coast, East Coast, and Southwest where hundreds of slide rules are displayed and auctioned.

http://www.oughtred.org

### International Slide Rule Museum

The world's largest free digital repository of all things concerning slide rules. Vast photo archives of slide rules, over 7000 images. A not-for profit commercial free museum dedicated to the students, educators, engineers and scientists of the past and those still present, and to promote the lost art of numeracy by providing resources and free loans of slide rules to schools and other historic institutions. Extensive library of instruction manuals to download. Maintained by Mike Konshak, ISRM curator, exhibitor and preservationist.

www.sliderulemuseum.com

### Slide Rule Universe

Very comprehensive website about slide rules. Contains detailed archives of slide rule models from many manufacturers. Vast amounts of slide rule information of all kinds. The more time you spend here, the more you will learn. Proprietor Walter Shawlee also sells many varieties of slide rules, both new and used, also parts, manuals and books.

http://www.sphere.bc.ca/test/sruniverse.html

### Ron Manley's Slide Rule Site

Volumes of basic slide rule information and photos.

http://www.sliderules.info

### Rod Lovett's Slide Rules

Large site that contains three searchable databases, one for eBay prices, one for published slide rule articles, and one for message archives of the International Slide rule Group. Many photos of his extensive collection. A favorite resource of slide rule collectors.

www.sliderules.lovett.com

### Clark McCoy's Keuffel & Esser Slide Rule Site

Extensive K&E catalog archives and thorough K&E information. Detailed spreadsheet listing of all known K&E models, over 600 of them! The place to go for K&E information. Many photos of slide rules.

www.mccoys-kecatalogs.com

### Greg's Ozmanor

Best source for free download slide rule manuals -- 53 of them. Many photos of Greg Scott's collection. Great resource.

http://sliderule.ozmanor.com

### Eric's Slide Rule Site

Great variety of both general and specific slide rule information by Eric Marcotte. Many photos of his collection. Very interesting site.

http://www.sliderule.ca/index.shtml

### Slide Rule Trading Co.

Paul Ross has on his website the Complete Hemmi Catalog, the most comprehensive archive on Hemmi slide rules. See "Dealers" listing below for additional information on this excellent website.

http://www.srtco.us

## Slide Rule Organizations

### The Oughtred Society

Interested in Slide Rules? Join The Oughtred Society. See above.

http://www.oughtred.org

### The International Slide Rule Group

Online discussion group hosted by Yahoo. Over 1600 members worldwide exchange slide rule information by Email. Average of about 15 messages per day. Members may opt to receive individual Email messages, or a once daily digest of messages, or no messages (they can read messages on the Group's website). Open membership. Messages are moderated. This is "the" slide rule discussion site.

http://www.groups.yahoo.com/group/sliderule

### The Slide Rule Trading Group

"Sister" group for members of The International Slide Rule Group above. For posting messages about slide rules for sale, for trade or wanted. 575 members.

http://www.groups.yahoo.com/group/sliderule-trade

### Dutch Circle of Slide Rule Collectors

Here you can see a range of rules which were common in the Netherlands as well as other areas of Europe. In addition to the pictures of special samples there is also a history as well as a calendar of events of the group. The site is in Dutch, German, French and English. Has about 40 members. Hosts International Meetings of slide rule and instrument collectors.

http://www.rekenlinialen.org

### United Kingdom Slide Rule Circle

Goal is to promote interest in slide rules. About 50 members. Publishes triannual newsletter. Interesting links to other slide rule websites. Hosts International Meetings of slide rule and instrument collectors.

http://www.uksrc.org.uk/

### German Rechenschieber Sammler Treffen

Active German slide rule group. Literature recommendations, links, various slide rule information, meeting schedules, etc. Hosts International Meetings of slide rule and instrument collectors.

www.rechenschieber.org

### ARC: Amigos de las Reglas de Calculo

ARC is the only Spanish speaking association of slide rule collectors. It includes Spain and many other countries and is open to any Spanish speaking collector.

http//:www.reglasdecalculo.org

## Dealers — Places to Buy Slide Rules

### Slide Rule Universe

Very large website about slide rules. Large inventory of new and used slide rules for sale. Also sells slide rule parts, manuals and books.

http://www.sphere.bc.ca/test/sruniverse.html

### Vintage Instruments

Dick Rose has thousands of slide rules for sale. Also drafting tools, planimeters, mechanical calculators, books, manuals. Great resource.

http://www.rose-vintage-instruments.com/newlook/links.php

### Slide Rule Trading Co.

Paul Ross has a large selection of slide rule parts. Also a nice selection of new slide rules ... Hemmi and other brands... and used slide rules. His site is the home of the Complete Hemmi Catalog, the most comprehensive listing of Hemmi slide rules anywhere. Paul has the most complete collection of Post slide rule models and probably the most complete Hemmi collection.

http://www.srtco.us

### The Gemmary

Rick Blankenhorn's site offers a wide selection of antique scientific instruments of all kinds, books and slide rules.

http://www.gemmary.com

**David Crate's Quality Slide Rules**

Nice selection and an interesting website.
http://www.davidcrate.com/

**Gilai Collectibles**

A fine selection of scientific instruments, collectibles and slide rules.
http://www.gilai.com

**Antiques of a Mechanical Nature**

Larry Meeker has many nice antiques and slide rules.
http://www.patented-antiques.com

**eBay**

Approximately 2000 slide rules and realted items are listed for sale by auction at any given time. Most auctions are 7 days duration, meaning that almost 300 slide rules and related items per day are sold on eBay. Buying on eBay can be, of course, a bit more risky than buying from a reputable dealer.
http://www.ebay.com

## Private Slide Rule Collections

Several collectors' websites appear in the General Information list above. Additional collectors' websites are :

**The Slide Rule Guy** (Jay Francis) http://www.slideruleguy.com
**Chris Gillings** http://chris.gillings.com/collect/slide/index.html
**Peter Holland** (Collector in Germany) http://www.peterholland.de
**Giovanni Pastore** (Collector in Italy)
http://www.giovannipastore.it/index_english.htm
**Atsushi Tomozawa** (Collector in Japan)
http://www5b.biglobe.ne.jp/~tomozawa/en/sliderule/sliderule.htm

## Slide Rule Museums

**International Slide Rule Museum**

www.sliderulemuseum.com

**Hewlett-Packard Museum of Calculators**

www.hpmuseum.org

**Computer Museum**

http://www.syssrc.com/html/museum/html/slide.html

**The Collection of Dr. Joern Luetjens**

http://www.joernluetjens.de/sammlungen/rechenschieber/rechenschieber-eng.htm

**Museum of Pocket Calculating Devices**

http://www.calculators.de

**Macleay Museum**

http://sydney.edu.au/museums/collections/macleay_scientific.shtml

## Slide Rule Manufacturer

**Concise Co. Ltd.**

Tokyo, Japan

http://www.concise.co.jp/eng0731/slide.html

This company, established in 1954, continues to make and sell several models of its high quality circular slide rules. No linear rules made. You can purchase via their website with a credit card. Service and delivery are fast and excellent.

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# Collecting Slide Rules

## Why collect slide rules?

People collect slide rules for many reasons. Perhaps they used a slide rule in the past. Perhaps they like old instruments. Perhaps a friend stirred their interest. Perhaps they want to learn more about this fascinating instrument.

## What slide rules to collect?

There are as many types of collections as there are collectors. You can expect that your focus will change as you gain experience and as your interests change over time. Known collections range from a few rules to more than 5,000.

Some of the more often seen types of collections are:

1. General, consisting of whatever pleases you at the time.

2. As many different models as possible from one maker. This objective becomes increasingly difficult and expensive as one obtains the more common models and seeks the scarcer ones. Some collectors have the objective to obtain one of every model from a certain manufacturer. It is unlikely that anyone has yet succeeded with this objective or possibly ever will! For example, more than 600 different models of Keuffel & Esser slide rules exist. In addition, many makers produced special rules on special order for a variety of companies and uses. These rules did not appear in the makers' catalogs and many such rules are unknown.

3. One rule from as many different makers and brands as possible. This is an ambitious objective, for almost 400 different makers have been identified.

4. One type of slide rule. There are collectors who specialize in electricity or electronics rules... surveying rules ... chemistry ... rules with hyperbolic trigonometry scales, etc.

5. New in box rules. Often abbreviated as "NIB". These rules can be expected to include all "extras" such as original case, instructions, and any other related packaging or materials. New in box slide rules are avallable in many brands and models. Some dealers sell such rules. (See list of dealers in the chapter *Slide Rules on the Internet*, page 93). Also, new slide rules appear on eBay from time to time.

6. Pocket rules ... those with 12.5 cm ("5 inch") scales.

7. 19th century rules.

8. Most complex model from many makers ... top of the line rules, so to speak.

When collectors decide the basis of their collecting, they can then determine the importance of quality of the slide rules they buy. One person may want only mint or new specimens. Another may want normal used slide rules, which are, of course, much less costly.

## What makes a slide rule valuable?

There are many factors which can increase (or decrease) a slide rule's value. Here are some key concepts to consider:

*Rarity*. Some slide rules were manufactured by the millions, while others were only made in short runs or for a short period of time. Some had such peculiar and limited applications that only a few were ever manufactured or sold. Rarer rules are generally considered to have a higher value than more commonplace ones.

*Quality*. Some slide rule manufacturers made beautiful high quality instruments designed to last more than a lifetime, while others made inexpensive low-quality throw-aways. Like other types of ephemera, some of the "throw-aways" have gained value over time because though once common, they are now rare. However, generally speaking, lower quality rules have less value than higher quality ones. High quality rules have accurate legible scales and are made from durable materials such as mahogany, boxwood, ivory and bamboo. They are designed to withstand temperature variations and hard use.

*Historical Significance*. The development of slide rules paralleled other technological advances. Slide rules that reflect significant changes in calculating methodologies, or ones made or used by historically significant figures generally find greater popularity with collectors.

*Condition*. As with any antique, condition of the rule and its case really counts. Significant condition issues include broken cursors, scratches, blemishes, cracks, "sticky" slides and extraneous writing.

*Complexity*. In general, more the complex a slide rule is, the more scales it will have and the higher its value will be.

*Visual Interest*. Some slide rules have great aesthetic appeal while others appear clunky and odd.

*Size*. Many collectors and users prefer rules small enough to fit in a pocket. These rules are commonly called 5 inch rules (although their scales are almost always 12.5 centimeters long ... not exactly the same as 5 inches). The standard slide rule size is generally referred to as 10 inch, which represents the length of a single scale from end to end (although the actual length is almost always 25 centimeters).

*Personal Significance*. Many users and collectors seek to replace their slide rule from high school or college. Others seek rules that were used in their specialized field of endeavor.

## What to Do With My Slide Rule Collection

See article *What to Do with My Slide Rule Collection -- Suggestions and Aternatives* by W. Richard Davis in the Joural of the Oughtred Society, Vol. 21, No. 1, Spring 2012, p. 2.

## The Oughtred Society

The Oughtred Society was founded in 1991 by a group of slide rule collectors and is dedicated to the preservation and history of slide rules and mechanical calculators. In the past 21 years, it has evolved to an international organization of some 400 members in 23 countries. It is noted for its highly acclaimed *Journal of The Oughtred Society*, published twice annually. The Society's activities are carried out by members who volunteer to do various jobs and projects. Membership is open to anyone.

Objectives of the Society include the dissemination and sharing of information about slide rules and mechanical calculators, and encouragement for collectors and researchers. The Society is a non-profit educational organization and is affiliated with similar organizations in Great Britain, Germany and The Netherlands.

Benefits of membership include:

• Subscription to the *Journal of The Oughtred Society*, published twice annually. This internationally acclaimed journal is the most authoritative source on slide rules and mechanical calculators, with each issue containing a wealth of information about makes and makers, models, uses, history and more. Members are encouraged to submit articles.

• Members can acquire back issues of the Journal from its inception in 1991.

• Annual Members Directory, a great resource for locating and communicating with other collectors, aficionados and dealers.

• Annual meetings and auctions for members occur on the West Coast in June, the East Coast in November, and the Southwest in February. Southwest meetings have been held in Las Vegas, Los Angeles, and Tucson. At meetings, members exchange information, display items from their collections, and have the opportunity to participate in an auction in which many kinds of slide rules and calculators are sold, from the ordinary and inexpensive to the rare.

**Are you interested in slide rules or in mechanical calculators?**
**Join The Oughtred Society!**

Membership cost is $35 annually in the USA and $45 internationally. You may join using your credit card via PayPal on the Oughtred Society website. Click Here. Or mail your check to The Oughtred Society, 9 Stephens Court, Roseville, CA 95678

Please include your Email address if you have one.

For more information, contact us by Email at: secretary@oughtred.org

If you would like to have a book containing information similar to the 17 chapters presented in *All About Slide Rules* please consider the purchase of *The Oughtred Society Slide Rule Reference Manual, Second Edition,* available HERE for the price of $35 plus shipping.

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