

THE UNIQUE LAWRENCE¹

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The ubiquitous and much maligned originators of the "25¢ slide rule" are not all what they seem!



Why Lawrence?

It is easy to think that slide rule innovation and creativity in the 20th century was largely the domain of commercial greats like Nestler, Faber-Castell, Keuffel & Esser, etc. But like its maligned UK "counterpart" **Unique**, the ubiquitous Lawrence is wrongly and unfairly just seen as a "*pile 'em high and sell 'em cheap*"² maker of slide rules.

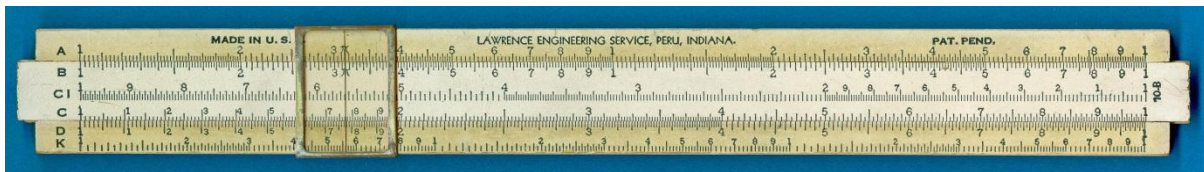


Fig. 1: classic Lawrence 25¢ painted Enhanced Mannheim 10-B

In so many ways the American *Lawrence Engineering Service* was a kindred spirit of the *Unique Instrument Company of Brighton Ltd.* Both makers had a charismatic founder and a colourful company history. Bruce Babcock's 1996 article in the *Journal of the Oughtred Society* (JOS) recounted the Lawrence company history. This article covers new and previously unreported revelations - the company's European roots, bitter family disputes, its unmatched cost control, the mystery behind the Lawrence model numbering and the many innovative and highly inventive slide rules Lawrence made.

European roots!

George Lee Lawrence, the founder of the Lawrence family slide rule business was born in Ottawa, Illinois on 6th September, 1901. For many Europe-based collectors there is nothing more quintessentially American than a Lawrence-made slide rule. But it may surprise collectors on both sides of the Atlantic to learn that the Lawrence family are direct descendants of **John Philip Lorenz** (1727-1800) who emigrated to the States from Niederhausen, Prussia (now Western Germany) in 1748. So the company has traceable European rather than exclusive American roots.

George's father, **George Raymond Lawrence** (1868-1938), was born on his parents LaSalle County farm and is the great-great-grandson of his Prussian ancestor. A decade

after marrying for the first time in 1890, George senior moved over 70 miles with his wife Alice nee Herenden (1869-1934) and their two sons (George Lee and his 10-year older brother, Raymond) to Illinois' largest city: Chicago. Later in life George senior remarkably started an aircraft company but he is better known as the world famous Chicago-based pioneer photographer – developing a process for flash photography and taking remarkable aerial pictures with cameras slung under giant kites or large hydrogen-filled balloons.



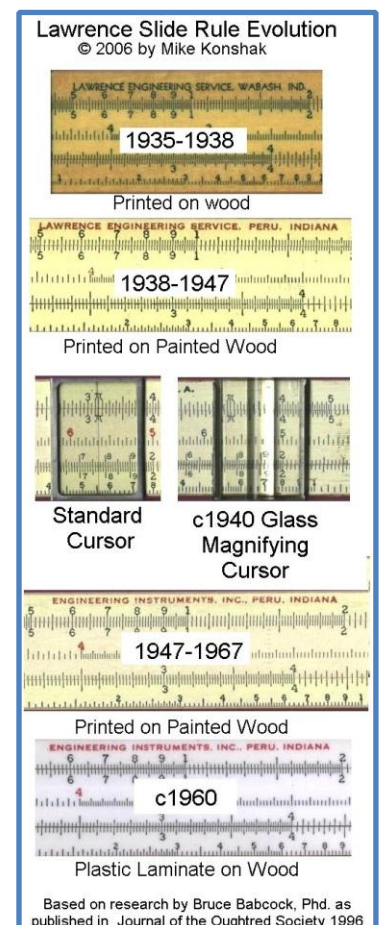
Fig. 2: **George Raymond Lawrence’s iconic aerial shot from 2000 feet of San Francisco in ruins after the earthquake in May 1906**

Lawrence “family” of companies

Like his UK counterpart, Burns Snodgrass (1881-1954) who founded **Unique**, Lee (he never used George – favouring his middle name) became an entrepreneur. His education was interrupted in 1909 when his mother Alice found out that his father had been having an affair and soon after they split up. It was so acrimonious that claims and counterclaims of kidnapping young Lee by both parents were first reported in the *Chicago Daily Tribune* newspaper on 17th February 1911. It was still newsworthy a year later when it featured in the *Oakland Tribune* in both the 31st March and 16th April editions. The divorce became final in 1913. The bitterness surrounding his parents break-up might explain why there is no record that Lee ever gained a college degree.

His father’s success as a professional photographer was most probably behind the Chicago-based *Lawrence Slide Rule Company* Lee started in 1930. Sadly no examples are known to have survived but Lee’s first business venture was making and selling photography related slide rules/charts.

Fig 3: **Lawrence slide rules through the years**³



Mike Konshak's 2006 "poster" succinctly summarises the evolutionary path of the company history. But unlike some company success stories, this one revolves around marriage and divorce rather than just technology!

In his working life Lee was considered a bit eccentric and short-tempered. But he was also a great "ideas man" with a good engineering brain. For example, he inexpensively rejigged the working practices so that the company could go on to make many innovative slide rules. This leveraged the company out of their "*pile 'em high and sell 'em cheap*" niche market. In 1935, five years after starting his Chicago-based business, Lee uprooted and moved over 160 miles south and out of state to Wabash, Indiana. This may have been prompted by a sad event. Little is known about his 1st wife but I believe it was Ada nee Shaver (1899-1931) who died, possibly tragically, in her early thirties. In Wabash Lee founded *Lawrence Engineering Services* to make and sell slide rules.

By now he was married to the second of his eventual three wives: Vivian nee Breyer (1916-1973). Lee met his 2nd wife in Chicago but she did not immediately move with him to Wabash. She was an artist in her own right and, at first, may have been reluctant to leave Chicago.

Flourishing sales is the most likely reason that three years later the operation and the Lawrence family moved 13 miles west to larger premises in the neighbouring city of Peru. This accounts for either a Wabash or a Peru provenance being printed after the company name on all of their branded slide rules. Apart from adding plastic veneers in the late 1950s, this is the start of the most innovative era of the company. "PAT. PEND." can be found on many of the Wabash-made slide rules and on some later Peru-made models. But no corresponding registered patent exists. Like many other slide rule makers, Lee probably found it too time-consuming and too costly to get full patent protection – especially as the process involved annual renewal fees. It was more cost effective to make a patent application to get some initial protection and then let it lapse. However, apart from those credited to 3rd parties, a whole series of copyrighted designs are credited to *Lawrence Engineering Services* from the mid-1940s – see Tables 1 and 3.

Instigated by his 2nd wife, Lee and Vivian were divorced in 1947. Vivian cited Miss Louise Huber, an old family friend, as co-respondent in the action. Lee always fiercely denied she was anything but a friend. But an inexplicable part of the divorce settlement was that Lee "let" the slide rule business go to his ex-wife. Directly afterwards Vivian's soon to be new husband, the Rev. Frank Bozarth, became President of the company and it was renamed: *Engineering Instruments Inc.* Twenty years later the business abruptly folded after a major fire on July 5th 1967 burnt everything down. Despite being insured, Frank Bozarth decided it was time to call it a day and the "Lawrence" family business stopped trading after being in business for 37 years.

A year after his divorce Lee remarried for the 3rd and last time to Nellie nee Mowbray (1911-1990). Having lost the slide rule business he threw his energies into a plastics company he had founded in 1945: *AGP Corporation*. Lee's initial interest in plastics stems from the high breakage/waste rate in making and shipping Lawrence glass cursors – especially the glass magnifying cursors for the DeLuxe version of the 10-B. Lee had bought his own plastic moulding machines so he could replace glass magnifying cursors with durable cheaper plastic versions. He clandestinely removed the machines when he realised he was going to lose the slide rule business to his 2nd wife. This is borne out by no plastic magnifying cursor ever appearing on any of the models sold by *Engineering*

Services Inc. But Lee's entrepreneurialism could not be dampened by family strife. With the *AGP Corporation* he ended up as the OEM manufacturer for many highly successful plastic toys. For example, the hit toy of the 1950s/1960s: "*Etch-a-Sketch*". In 1963 he became part-owner of another Peru-based company: *Precision Ceramics*. He died on 21st March, 1976 while on holiday with Nellie in the British Honduras. He is buried at the Mount Hope Cemetery in Peru, Indiana. Fourteen years later Nellie was laid to rest alongside him.



Fig. 4: **August 5th 1960: Lee and Nellie at the opening of "*Aerial Photography 1900-1910*" - an exhibition of his late father's work⁴**

Lawrence standard "blanks"

Margins for the originator of the **25¢⁵** slide rule must have always been tight! In "money-of-the-day", a comparable retail price now would be no more \$4. Sadly because of the fire in 1967 there is no way of knowing for sure the shop floor set-up and working practices. However, after comparing over 50 different Lawrence/Engineering Instruments slide rules a major cost saving practice stands out.

Lee was the "ideas man" but it was Ed Snyder, a long-standing employee, who turned them into something practical for the shop floor. It must have been soon after they started manufacturing in Wabash, that they hit on the idea to use solid frame standard blanks. The company started by making two 8-inch⁶ slide rules – a Mannheim and an Enhanced Mannheim scale layout (but without the trigonometric scales) monochrome printed onto a wooden stock (see: Table 1). Later for better contrast the front face and sometimes the back of the slide were first painted white before the scales were added. Lawrence/Engineering Instruments ended up with an eclectic mix of model sizes. The portfolio included stock lengths of 5, 6, 7½, 8, 8½, 9, 10, 10½ and 12-inches. However, despite the variety of stock lengths, certain unique dimensions and characteristics never changed. Whether it was a Lawrence/Engineering Instruments branded slide rule, a specially commissioned themed slide rule or even an Original Equipment Maker (OEM) slide rule the:

- **width of the stock was always 1 1/8 inch**
- **thickness of the stock was always 5/16 inch**
- **width of the slide was always 9/16 inch**
- **thickness of the slide was always 1/8 inch**
- **side edges (never bevelled) always had tracks for a one-size cursor**
- **no scale was ever added to a side edge**
- **the back of the stock was never painted**
- **cursor (if needed) was always metal framed glass/plastic or all-plastic**
(n.b. not all models came with or needed a cursor and for those that did come with a cursor, more than often it broke or was lost)

On some models the slide would be slightly longer than the stock. Conversion tables or instructions were often printed on the back of the stock. Some even had a promotional advert for a 3rd party on the back. But the unique tooling dimensions and characteristics are always a sure-fire way of telling if a "look-alike" slide rule was made by Lawrence/Engineering Instruments or by someone else.

The uniformity of the dimensions suggests all models were milled from standard 12-inch blanks as the 10/10½-inch models were the most popular size. However, if a single-sized 12-inch blank created too much wastage, they may have opted for several different sized standard blanks – e.g. 12, 10/10½ and 6-inch⁶. To keep costs as low as possible the wooden blanks were probably milled from the readily available and inexpensive poplar trees - genus: *Populas*.

Lawrence/Engineering Instruments made many different models that carried the company name – i.e. branded slide rules. But they made many more specially commissioned themed and Original Equipment Manufacturer (OEM) slide rules. However, identifying such unbranded slide rules can be tricky because the distinctive but unpatented Lawrence style was often copied.

Lawrence/Engineering Instruments branded slide rules

Previously published Lawrence related articles felt there was no rhyme or reason to the model numbering. Now having had the chance to examine first-hand almost all the branded Lawrence slide rules ever made, I have found a way of making sense of the cryptic model codes printed on the right-hand end of the slide. First it is important to realise that all the slide rules carrying a *Lawrence Engineering Services, Wabash/Peru* or *Engineering Services Inc., Peru* brand name belong to one of four distinct ranges:

1. **Imperial range with n[n]-x[x] alphanumeric model no.'s**
2. **Metric range with nn[n]-x[x] alphanumeric model no.'s**
3. **Set & Book range**
4. **Plain range with no model no.'s**

Most branded rules were part of the imperial range. The **n[n]** numerical prefix part of the model number is the length of the stock in inches – hence the name: "imperial range". The first **x** alphabetical suffix is for all the different types within the range. The optional extra last character **[x]** was for different versions of the same type.

Model #	Type/Name (© yyyy)	Cursor	Scale layout/Use
8-A	Mannheim	Yes	A/B,C/D
8-B	Enhanced Mannheim	Yes	A/B,CI,C/D,K but <u>no</u> S,L,T
10-B & DeLuxe	Enhanced Mannheim (DeLuxe only on the box)	Yes Yes	A/B,CI,C/D,K but <u>no</u> S,L,T DeLuxe version = magnifying cursor
10-C	ENGRAVER'S AND PHOTOGRAPHER'S PROPORTION CALCULATOR	No	For area % up & down scaling (reduction/enlargement arrows point to results - no cursor needed)
10-D	LUMBER CALCULATOR	No	For lumber volume in board feet ⁷
10-Do	(© 1946)	No	(set thickness & width, result on "D" for given length – no cursor needed)
10-F	PRICING AND INVENTORY RULE (© 1945/46)	Yes	For discount or profit margin mark- up per gross/dozen/each in \$'s and value of stock in \$'s
10-G	CUTTING SPEED CALCULATOR (© 1946)	Yes	For recommended cutting speed in f.p.m. ⁸ for given drill speed & size
12-H	COPYFITTER (© 1946 but credited to Owen T. Taylor)	Yes	For font size and letter/word/line spacing in points and picas ⁹ when typesetting (also version in Table 3)
10-I	MODEL BUILDER'S SLIDE RULE (© 1947)	Yes	With the special tables on the back it scaled down railroads/trains according to various railway gauge sizes to make replica size models
12-J	PRO-RATER (© 1948)	Yes	For calculating days between two dates and the pro-rata premium for a given number of days (pro-rata table to four decimal places on back)
9-K	MUSIC TRANSPOSER ¹⁰ (© 1947)	No	For constructing chords in any key & transposing one key to any other (red/blue dots – no cursor needed)
8-L	COPPER WIRE SELECTOR "Voltage Drop Calculator" (© 1946)	No	For minimum wire size in A.W.G. ¹¹ (set length & load, result on "D" for 440/220/110 voltage drop – no cursor needed)
10-N	PRINTER'S PROPORTION RULE (© 1946)	Yes	For moving between inches & picas ⁹ when printing/publishing
6-Op	FLASHRULE (© 1946)	No	For correct lens aperture per type of GE or Westinghouse flashbulbs.
6-Ow	FLASHRULE (© 1946)	No	Ditto but for WABASH flashbulbs (set film speed & lamp, result on "D" for distance – no cursor needed)

Table 1: **Imperial range of Lawrence/Engineering Instruments branded models**

As shown in the Appendix-A picture gallery, apart from the "everlasting" model 10-B, this range came out long before the Engineering Instruments Inc. era. But it remains a mystery why two letters in the model sequence were skipped – e.g. why has no type E or M ever turned up? Maybe they were prototypes that never made it to market.

The idea for the metric range came from fellow collector David Green. With one dubious exception, it covers all Lawrence/Engineering Instruments branded slide rules with model numbers that do not conform to the syntax of the imperial range. This time the **nn[n]** numerical prefix part of the model number refers to the length of the "D scale"¹² in millimetres rather than the length of the stock in inches - i.e. 250mm. Therefore the name: "metric range". The **x[x]** alphabetical suffix cryptically depicts the different types in the range. "BT" may stand for a model B from the imperial range and the I for the three extra trigonometric scales on the back of the slide. Likewise "V" may stand for veneered scales. The A on the "77A" could correspond to the name on the slide rule: "American Log-Log."

Model #	Type/Name (© yyyy)	Cursor	Scale layout/Construction
250-BT	Enhanced Mannheim	Yes	A/B, CI , C/D, K//S, L, T Front face and back of slide lacquered/painted
250-V	Enhanced Mannheim	Yes	A/B, CI , C/D, K//S, L, T Front face and back of slide veneered with hard white plastic
77A	Log-Log Decimal Trig	Yes	LL02, LL03, DF/CF, CIF, CI, C/D, LL3, LL2 //LL01, K, A/B, T, ST, S/D, L, LL1 Duplex all plastic (? OEM made rule)

Table 2: **Metric range of Lawrence/Engineering Instruments branded models**

Now the back of the slide was also part of the scale layout, a small clear plastic insert was added into well of the stock at the right-hand end. With the hairline in the insert it

ENGINEERING INSTRUMENTS, INC.
Factory and General Office - PERU, INDIANA

PLASTIC FACE RULE
Precision manufactured from seasoned hardwood. Entire face and back of slide accurately calibrated on handsome white plastic. Accurate and durable. This 10" rule carries scales A-B-C-D-CI-K-S-L-T. Contact hairline index on back of rule insures accurate reading of Trig scales.
Packed in a simulated leather case, handsome, durable, flexible. Clear plastic frameless indicator for 100% scale visibility. 32 page instruction booklet included with each rule.
Only \$2.00
Model 250-V

STUDENTS SPECIAL
Always Available
This 10" rule, carrying the same scales as the 250-V, has a white lacquer coated face, same instruction book, indicator, leather case and contact hairline index on back of rule.
\$1.25
Model 250-BT

Budget Slide Rule
Smoothly machined from well seasoned lumber. This 10" rule has a white lacquer coated face and carries scales A-B-C-D-CI-K. Metal framed indicator. 28 page instruction booklet. Packed in individual pocket carton.
60¢
Model 10-B

CIRCULAR SLIDE RULES
8".....\$3.00 4-3/8".....\$1.00
Diameter slide rules made of heavy, dimensionally stable "Vynilite" plastic. Equivalent to a straight type slide rule over 20" in length. It contains A-B-C-D-CI-L-K scales.

was possible to set or read off results from using the trigonometric scales without having to reverse the slide. Also on many, but inexplicably not all 250-BT's, there is another 3-digit number printed under the slide on the left-hand end. Speculatively this might have been a batch or production-run number. The models in the metric range predominantly come from the post Lee Lawrence *Engineering Services Inc., Peru* era – see the Appendix-A picture gallery.

As shown by the only company-issued flyer I have ever been able to find, by the late 1950s more internationally orientated marketing and printing the scales on white plastic veneers to increase legibility were now part of the business philosophy.

Fig. 5: **Front page of a 4-page marketing flyer from ca. 1958**

By now the \$2.00 250-V was the top end model with the \$1.25 250-BT their "Students Special" and the old faithful 10-B reduced to being their 60¢ budget slide rule. Being all plastic, duplex and not conforming to the unique dimensions and characteristics of all Lawrence/Engineering Instruments made slide rules, the 77A is an oddity. It is, suspiciously, identical with the *Acu-Math* model 150 Duplex Log Log Deci Trig slide rule. I believe the 77A is an OEM slide rule made by *Acu-Math* for *Engineering Instruments Inc.* The front cover of the flyer also boasts two circular slide rule made of "vinylite". Clearly by this time *Engineering Instruments Inc.* were reselling all-plastic slide rules and a wide assortment of drawing instruments – none of which they could have made in-house.

The set and book range shows how Lee forged new partnerships with other companies. Copyrighted in 1939 Lee first came up with the novel idea of marketing a toy: *the Lawrence Secret Code-Maker*.

The boxed set contained two (i.e. also one for your "best mate") identical 7½-inch *Secret Code-Maker* slide rules without cursors and a 16-page "*Make Your Own Secret Codes in a Flash*" instruction booklet. From the image on the box it was aimed at teenagers but intriguingly the image on the instruction booklet is of an adult. Perhaps Lee was trying to play to both the childhood "secret agent" fantasy and the prevailing WWII adult nervousness about secrecy? The A-Z, inverted Z-A and 5-cycle 0-9 scales make it easy to create or decode a Vigenère cipher¹³. This is a method of encrypting text messages with a simple one-step substitution, reversed substitution, mixed substitution or a more complex transposition code using a mixture of substitution methods. The Lawrence booklet incorporates and greatly extends a pamphlet written by W. St. John Maloney¹⁴ and copyrighted by the *Cole Corporation* of Chicago in 1939. Unlike other Lawrence slide rule guides¹⁵, this booklet is much more educational – including many code-related historical facts going back as far as the days of Julius Caesar. There were at least two variants of the code-maker. One was called: *The BEICH Secret Code-Maker*. This was an 8-inch⁶ Lawrence branded rule with a thin metal "fisheye" cursor and a simplified 4-page leaflet. It was part of a loyalty scheme and could be won by collecting Beich *Whiz*¹⁶ chocolate bar wrappers. So Lee was doing a "Willy Wonka" decades before Roald Dahl published "*Charlie and the Chocolate Factory*" in 1964 and Gene Wilder starred in the 1971 film of the book. The other version was the 6-inch⁶ *Dick Tracy Code-Maker*. Like the original 7½-inch⁶ model, the Dick Tracy version had no cursor. It came with a Dick Tracy emblazoned simplified 4-page version of the booklet and was presumably marketed in cooperation with the "*Chicago Tribune New York News Syndicate*", the publishers of the comic strip book hero created by Chester Gould (1900-1985).



Fig. 6: **Code-Maker boxed set**

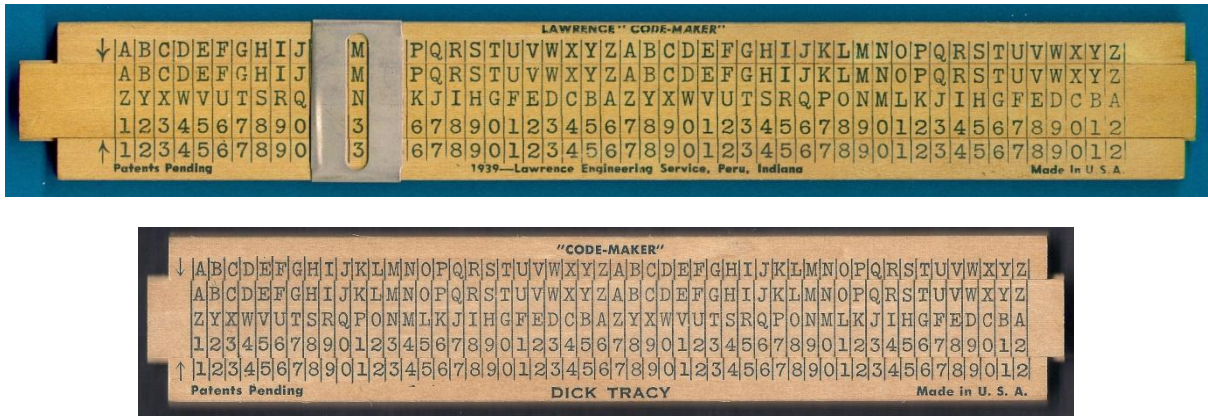
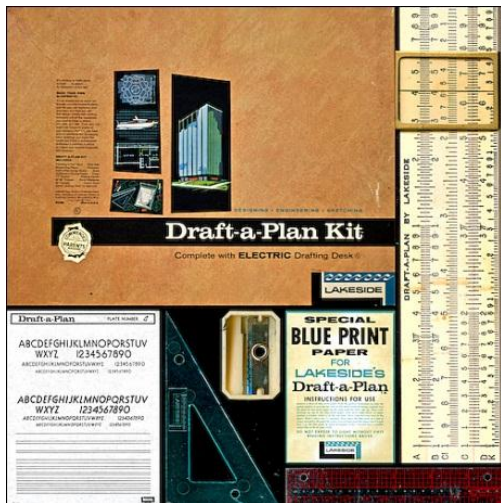


Fig. 7: 8-inch Beich and 6-inch Dick Tracy "Code-Maker's"

In 1942 the Austin Publishing Company copyrighted an idea for a "teach yourself" workbook on how to use a slide rule. The US Letter sized hard-backed book came with a Lawrence DeLuxe (magnifying cursor) 10-B slide rule. The authors were Hobart H. Sommers, Harry Drell and T.W. Wallschlaeger and it was published by two companies. The *Grosset & Dunlap* version had a dirty orange and black cover and was published in New York (208 pages incl. Tables of Logarithms, Trigonometric Functions of Angles and the Answers). The *Wilcox & Follett Co.* edition had a dark-green and gold cover and was published in Chicago (same 208 pages but with an extra loose-leaf Answers addendum).

Much later, in 1961, *Lakeside Toys* brought out a *Draft-a-Plan Kit*TM. This large boxed



drafting set came with a plastic electric-powered drawing slope, many drafting related aids and an Engineering Instruments Inc. made "5-B" pocket Enhanced Mannheim slide rule. The "*Drafting is Fun*" guidebook has a chapter on how to use the slide rule. Finally, in 1966, the *Cadillac Publishing Company* started publishing a 33-volume (7¼ x 10½ inch) *Self-Teaching Encyclopedia*. Volume 1 was "*Mathematics Made Simple*" and the publishers proudly sold it with a "free" model 10-B slide rule. Later, despite all the illustrated examples being based on the model 10-B, the company replaced it with a shorter (and cheaper) 6-inch⁶ version.

Fig. 8: Lakeside *Draft-a-Plan Kit*TM set for a teenager

The final plain range of branded slide rules is chronologically probably some of the last wood/painted slide rules Lawrence/Engineering Instruments sold. Apart from coming from the Peru factory, I can think of no good reason for leaving off a model number on any branded slide rule. Almost without exception, one did have "10-BK" on the box, all the branded slide rules without a model number are identical with one of the classic models – the 10-B or the later 250-BT. Maybe the model number was left off to give the slide rules fashionable cleaner lines for the "swinging sixties". An example is part of the Appendix-A picture gallery.

Lawrence/Engineering Instruments specially commissioned themed slide rules

Nearly all are unbranded and have no model number. Most have non-conventional scale layouts and are so innovative that almost all the designs were copyrighted. They came in various sizes (occasionally different sizes of the same model) and most, but not all, had a cursor.

It is easy to mistake many unbranded themed slide rule as being made by Lawrence/Engineering Instruments. However, many are just "look-alikes" - similar in style but made by someone else. The listed examples all conform to the unique dimensions and characteristics of a Lawrence-made rule.

Commissioned by (© yyyy)	Size ⁶	Model Name/Use
Lakeside Toys – Draft-A-Plan, Minneapolis (© 1961)	5"	Students <i>Learner</i> pocket slide rule – Enhanced Mannheim ("5-B" on box) with A/B,CI,C/D,K but no S,L,T
B.F. Grizzle, Washington (© 1941)	8" & 12"	Gas Pipe Line Slide Rule for calculating the flow capacity hour according to SG/pressure through a pipe of a given diameter
B.F. Grizzle, Washington (© 1944)	8"	Water Line Capacity Slide Rule for calculating the loss of head for a given elevation, pipe diameter/length & pressure
Madison Manufacturing Company, Michigan (© 1947)	8"	Madison Speed Calculator for calculating drill & cutting speed for a given diameter
Thomas Specialities, California (© 1948)	8½"	Music Transposition for composing, transposing or creating harmonies
Massachusetts Institute of Technology (MIT), Cambridge Radiation Laboratory – c1941 Roy C. Spencer	10"	Antenna Slide Rule (confidential and classified) for calculating radar antenna beam patterns - beam width, gain, etc.
Massachusetts Institute of Technology (MIT), Cambridge High Voltage Laboratory – 1943 W.W. Buechener & E.A. Burrill Jr.	10"	Exposure Slide Rule (possibly for the US Navy in WWII) for calculating exposure times of super high-voltage steel penetrating X-rays of castings & munitions
C.V. Ore, Illinois (© 1955) (n.b.: Acu-Rule made an OEM plastic version of this rule)	10"	The S-M Slide Rule (DS/CI,C/D/DM) a Simplified Multi-purpose type of Enhanced Mannheim teaching rule supposedly making it easier to learn how to multiply/divide, etc
Canadian Radium & Uranium Corp., New York (© 1942)	10"	Gamma-Ray Radiographic slide rule for commercial (steel) rather than medical use
Miller Motor Company, Illinois (© 1950)	10"	Air and Hydraulic Calculator (DIA,A/B,CI,C/D,GAL) for calculating flow rates through different sized pipes
Fun Incorporated, Illinois & Ideas Unlimited, California (© 1950)	6" & 10"	Poker Meter for 5/7 card stud or 5 card draw poker. Based on number and value of cards held, a colour code recommends the best play – "Get Out", "Stay" or "Raise".
PIC Walsh Freight Co. & Plaza Express Company Inc.	10"	Traffic Manager's Slide Rule for checking freight charges or rates or truck/carload

Commissioned by (© yyyy)	Size ⁶	Model Name/Use
(© 1939 M.T. Brockman)		breaking points and computing storage charges
Murphy & Murphy Inc. , Texas & Caprock Materials Co. , Texas	10½"	Concrete Quantity Calculator for calculating cubic yards of concrete needed for or in a wall of certain dimensions
Tokheim Corporation , Indiana (© 1948)	12"	"K" Factor – using high & low outdoor temperatures and gallons of household fuel oil left, the K factor = days of supply left
Tenbrook Enterprises , Indiana	12"	L.P. Gas – for calculating the temperature correction (°F) needed when making bulk deliveries of propane
L.E. Waddington , (© 1947)	12"	Music & Music Acoustics for transposing chords, interval ratios, harmonic series, octaves and frequencies
Taylor Publishing Co , Ohio (© 1946 credited to Owen T. Taylor)	12"	Copyfitter for font size and letter/word/line spacing in points and picas ⁹ when typesetting (copy of the 12-H)
United States Aviation Underwriters Inc. (© 1944 Albert J. Smith)	12"	Underwriters slide rule for calculating the risk duration (in days) for aviation related ventures (table on back has cancellation ratio's/days)
Pioneer (© 1952 J.B. Epperson)	12"	Epperson TV Coverage Calculator for calculating VHF and UHF signal coverage based on a signal strength, FCC propagation curves and antenna height (UV/M and DB conversion table on back)
Radio Corporation of America (RCA) , New Jersey	12"	F.M. COVERAGE CALCULATOR for estimating (according to FCC propagation curves) coverage of FM radio stations according to the type of RCA antennae

Table 3: **Lawrence/Engineering Instruments unbranded specially commissioned themed slide rules**

As shown by the *Poker Meter*, *Traffic Manager's Slide Rule* and the *Concrete Quantity Calculator* entries, different companies often commissioned different sizes and different versions of the same themed slide rule. This series proved, yet again, how Lawrence/Engineering Instruments successfully used their standard blanks to make an enormous variety of interesting and groundbreaking slide rules. All the listed models are in the Appendix-B picture gallery.

Lawrence/Engineering Instruments OEM slide rules

By its nature this section is subjective and, in part, controversial. Lawrence/Engineering Instruments made OEM slide rules are, by definition, unbranded although some do have recognisable model numbers. One of the more easily made mistakes is to confuse them with certain early models from the St. Louis based *Festus/Acu-Rule Mfg. Co.* - in

particular their model 10-D. Because of the model numbering it is often mistaken for a Lawrence/Engineering Instruments 10-B. They are similar in size, have the same solid frame wooden construction and the same scale layout - an Enhanced Mannheim without the trigonometric S,L,T scales. But the telltale difference is that the Acu-Rule 10-D has a bevelled top edge inch scale – a feature never used on any Lawrence/Engineering Instruments slide rule.

Over the years it has been speculated that the budget-range models of some American commercial slide rule greats are OEM slide rules made by Lawrence/Engineering Instruments. The favourite nominations are:

- **Keuffel & Esser** model: N4058W
- **DIETZGEN** models: 1767/68/69P
- **POST** model: 1446-D
- **Charvoz-Roos** model: SR-31
- **A. Lietz Company** model: 2974N

All are Enhanced Mannheim’s and all are “Lawrence-like”. But only the **Charvoz-Roos SR-31** and the **Lietz 2974N** are OEM rules from Lawrence/Engineering Instruments - both rebadged 250-BT’s. The main OEM customers were businesses, government bodies and resellers of scientific or office/drawing equipment.

Made for:	Rebadged
DUPONT - Neoprene, Rubber Chemicals and Colors , Delaware	250-BT
U.S. Navy	250-BT
DU MONT , Ohio	250-BT 8-B
Burger Scientific Supplies , Boston	250-BT
W. M. Welch Scientific Company , Illinois	250-BT 250-V 10-B
NOBEMA Products Corp. , New York	10-B
PAULL INSTRUMENTS	10-B
LARCH , New York	10-B
Coyne Electrical School , Chicago	10-B
GENE LOEWY PRODUCTS , New York	10-B
ANCO PRODUCTS Co. , Ohio	8-B

Table 4: **Lawrence/Engineering Instruments “rebranded” OEM slide rules**

As in the past businesses often used such OEM slide rules as promotional gifts, many more unlisted examples undoubtedly exist. Nevertheless the listed examples do show how Lawrence/Engineering Instruments found yet another successful avenue to reuse/rebrand their popular Enhanced Mannheim and Mannheim type slide rules. The Charvoz-Roos, the Lietz and some of the examples listed in the table are part of the Appendix-B picture gallery.

Toys or calculating aids for professionals?

The two most well-known models, the 10-B and the 250-BT, were their flagship "*pile 'em high and sell 'em cheap*" slide rules for everyday/school use and the budget market. But most of the other Lawrence/Engineering Instruments branded slide rules from the imperial range and all the specially commissioned themed slide rules are superb examples of innovation and inventiveness. But who were the target customers?

The *Secret Code-Maker* series and the 5-inch⁶ pocket slide rule in the *Draft-a-Plan Kit* were aimed at the teenager/toy market. The hobby market was the most likely target for the 10-I (MODEL BUILDER'S) and the 6-Op/w (FLASHRULE) models. The remaining models from the imperial range and nearly all the specially commissioned themed slide rules had a serious use and could have easily found their way into a tradesman's toolbox or onto a professional's desk. But the most convincing examples are the WWII war effort related specially commissioned Antenna and Exposure slide rules made for MIT. The confidential *Antenna Slide Rule* for radar control systems being considered so strategically important that both the British and American governments had it classified.

Slide rules from Lawrence/Engineering Instruments are often ridiculed because of their cheapness and basic construction. But perhaps without realising their provenance, many were used and appreciated by professionals from many, many trades and professions.

The Lawrence legacy

Family acrimony was the reason why "Lawrence" was purged from the company name after 1947. However, Lee Lawrence was the charismatic inspiration for the company's most inspired 1935-1947 era and the reason for the company's success and longevity.

It is certainly true that all Lawrence/Engineering Instruments slide rules were cheaply made when compared with the likes of K&E, Pickett & Eckel, Faber-Castell, Nestler, etc. They also probably never made it on to NASA's shortlist for slide rules to go on five of the Apollo missions. But this is like expecting an OPEL/General Motors family saloon to be built to the same engineering standards and build quality as a Mercedes-Benz S-class. So when only accuracy to a couple of decimal places was needed, Lawrence/Engineering Instruments produced fit-for-purpose slide rules for a price that no other manufacturer matched. Their low-cost was a unique advantage allowing the company to develop an impressive range of slide rules for the professional, hobby, toy and budget markets.

Unenlightened slide rules collectors may dismiss Lawrence/Engineering Instruments slide rules as "uninteresting" and not worth bothering with. In reality their esteemed peers could not match their low-cost business model and their ability to continually find new partners and avenues for new innovative slide rules. In the post Lee Lawrence years by moving to plastic veneered scales for the model 250-V shows Engineering Instruments Inc. wanted to embrace technological improvements. But this meant the 250-V ended up retailing for three times more than the original painted 10-B they were still selling.

Like **Unique**, Lawrence/Engineering Instruments slide rules are often maligned but for a modest investment any determined collector can find some amazing and colourful models that would certainly grace any slide rule collection. The Lawrence legacy is undoubtedly an unsurpassed portfolio of surprisingly innovative and inventive slide rules rightly earning it the accolade of: **"The Unique (Lee) Lawrence"**.

Acknowledgements

Without help this story would have been, at best, hopelessly incomplete. I need to thank:

- **Richard Rose:** for donating many of the Lawrence rules now in my collection and unselfishly acting as "*my agent for all things Lawrence*" in the States,
- **Bruce Babcock:** for sharing his detailed Lawrence/Engineering Instruments knowledge and for images from his impressive Lawrence collection,
- **Mike Konshak/ISRM:** for images and permission to use the Lawrence related information from his ISRM website,
- **David Green:** for providing the crucial tip that enabled me to unravel the Lawrence model numbering,
- **George Keane:** for information on the *Festus MFG* and *AcuRule MFG* companies and how their slide rules relate to Lawrence,
- **Sandra Bird:** for information relating to the Lawrence family and company,
- **Tom Dilatush:** for encouragement and helpful suggestions,
- **Peter Hopp:** for information on Lawrence slide rules sold in the UK and images,
- **Cyril T. Lawson:** for information on his Lawrence collection,
- **Paul J. Tarantolo Jr.:** for information and images of his Lawrence collection,
- **Michael Frey & Philip Stanley:** for providing two previously unseen models,
- **Deborah Douglas:** for information and images from the MIT Museum.

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5. **International Slide Museum (ISRM):** a museum dedicated to the students, educators, scientists and engineers of the past and those still present, and to promote the lost art of numeracy - www.sliderulemuseum.com/ .
6. **Engineering Instruments Inc.:** Factory and General Office supplies catalogue, 4 pages, ca. 1958.
7. **W.M. Welch:** Scientific apparatus and supplies catalogue, 1959.
8. **Berger Scientific Supplies:** catalogue B, 1958.
9. **Family Search:** new official genealogy website of *The Church of Jesus Christ of Latter-day Saints* - www.familysearch.org/ .
10. **Random Acts of Genealogical Kindness:** Internet based organisation of volunteers established in 1999, www.raogk.org/ .
11. **Find A Grave:** a website for: (i) registering graves, (ii) recording memorials or tributes and (iii) genealogical information - www.findagrave.com/index.html .
12. **ProQuest Historical Newspapers:** *Chicago Daily Tribune* (1872-1922) February 17th, 1911.
13. **Family Link:** newspaper archive for the *Oakland Tribune* - www.familylink.com/stream .
14. **Wikipedia Foundation:** online free encyclopedia - www.wikipedia.org/ .
15. **Massachusetts Institute of Technology/MIT Museum:** exhibition "*The Most Important Instrument: Slide Rules and the Making of the Modern World*" <http://web.mit.edu/museum/exhibitions/sliderules.html> .
16. **Guerlac, Henry C:** "Radar in World War II" Vol. 8 "The History of Modern Physics, 1800-1950" Tomash, US, 1987, pp. 580.
17. **Burchard, John Q.E.D.,** "*MIT in World War II*", John Wiley & Sons Inc., New York, 1948, pp. 204-205, 208.

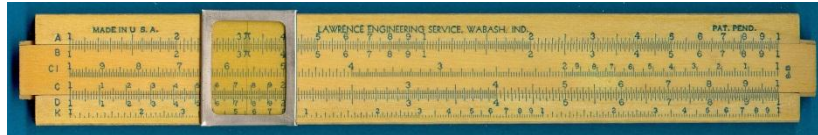
Appendix-A: Lawrence/Engineering Instruments branded slide rules

Imperial Range:

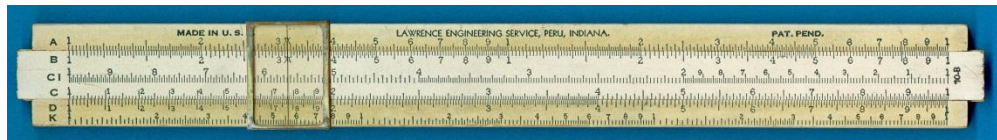
8-A



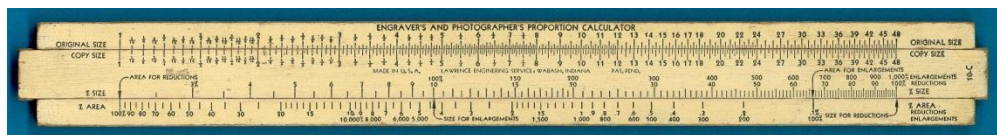
8-B



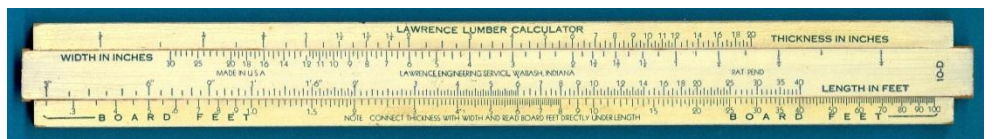
10-B



10-C



10-D



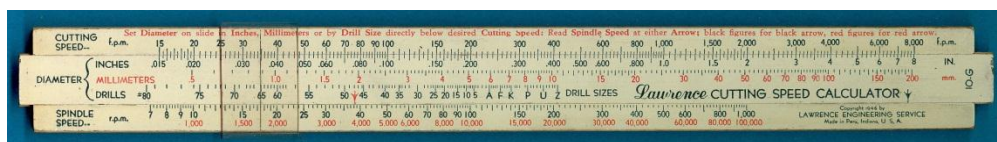
10-D0



10-F



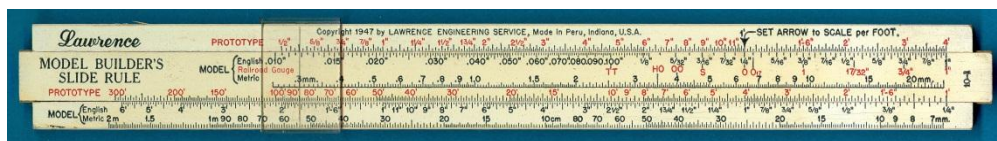
10-G



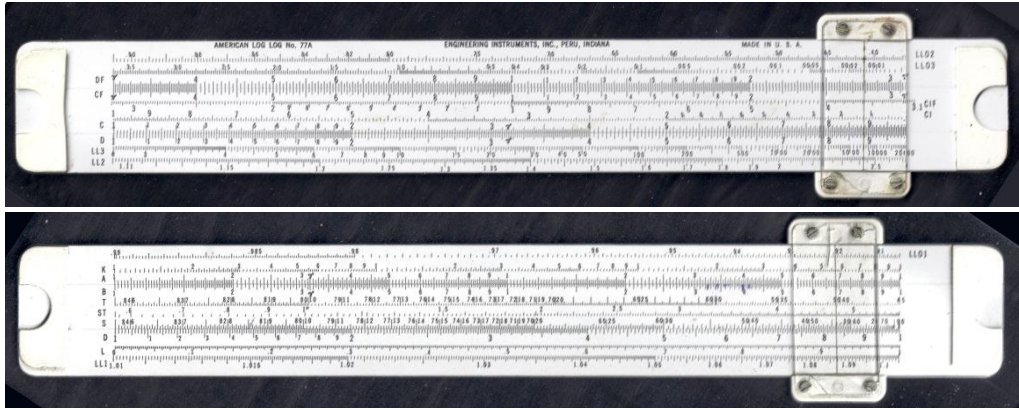
12-H



10-I



77A

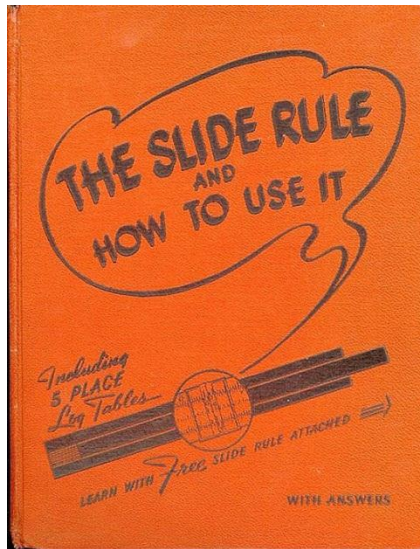


Sets & Books Range:

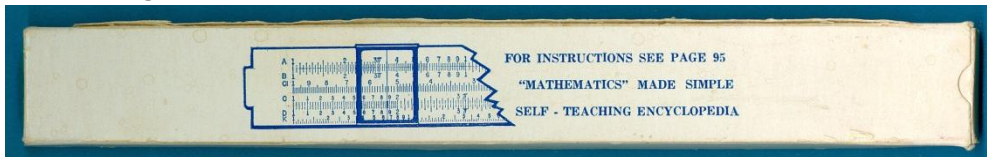
Secret "Code-Maker"



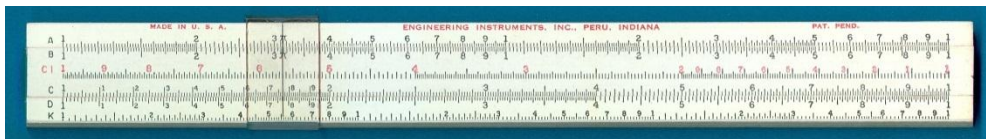
Austin Publishing Co.



Cadillac Publishing Co.



Plain Range:



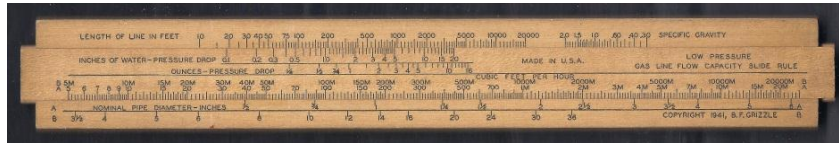
Appendix-B: Lawrence/Engineering Instruments unbranded slide rules

Specially Commissioned Themed slide rules:

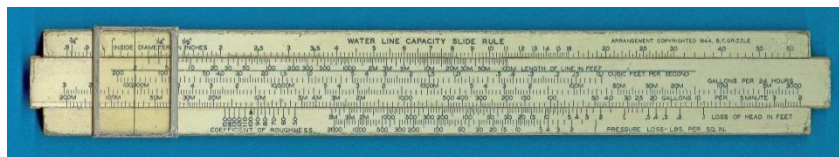
Students Learner



Gas



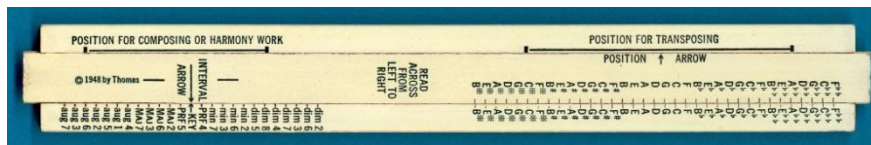
Water



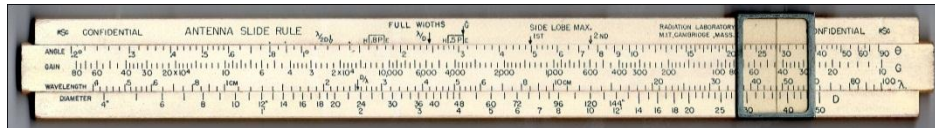
Cutting



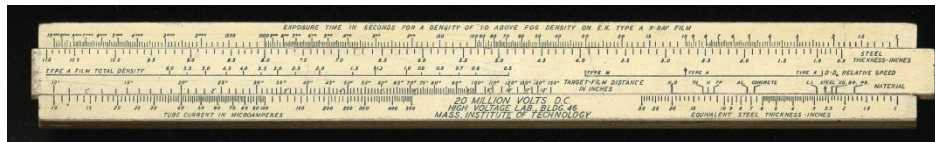
Music



Antenna



Exposure



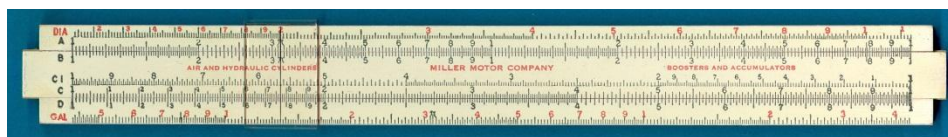
S-M



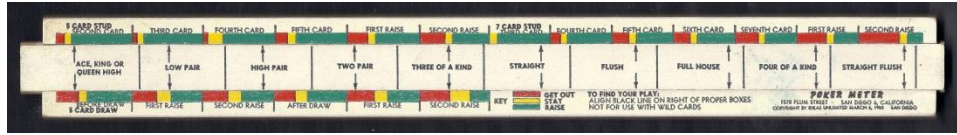
Gamma-Rays



Air/Hydraulic



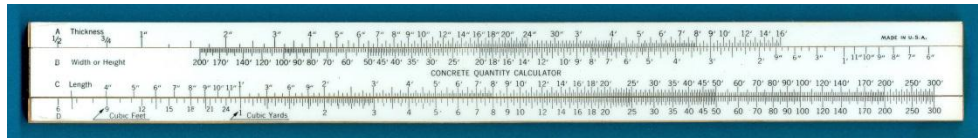
Poker



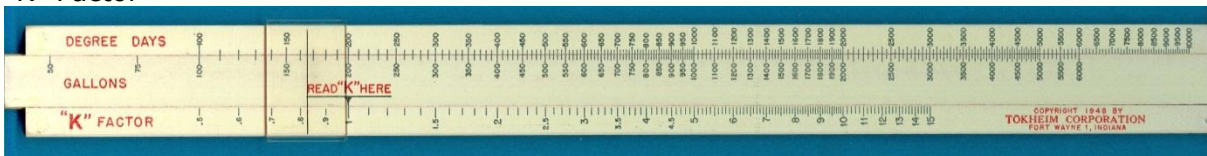
Traffic



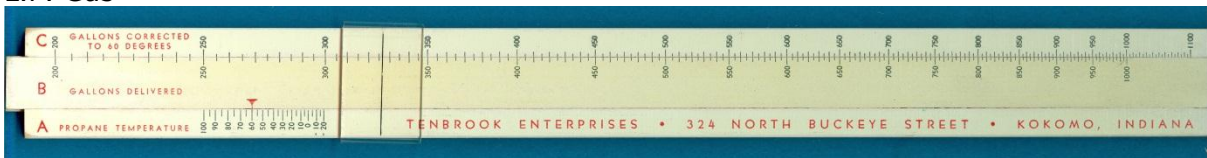
Concrete



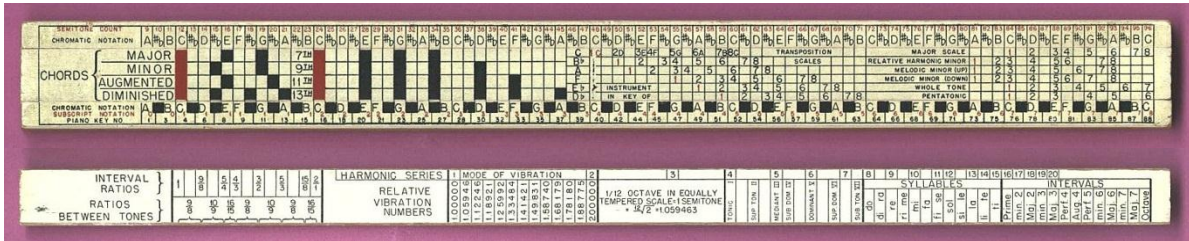
"K" Factor



L.P. Gas



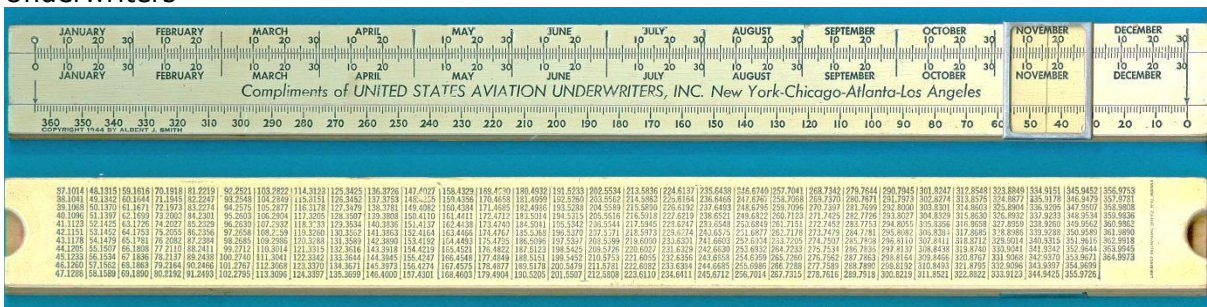
Music & Music Acoustics



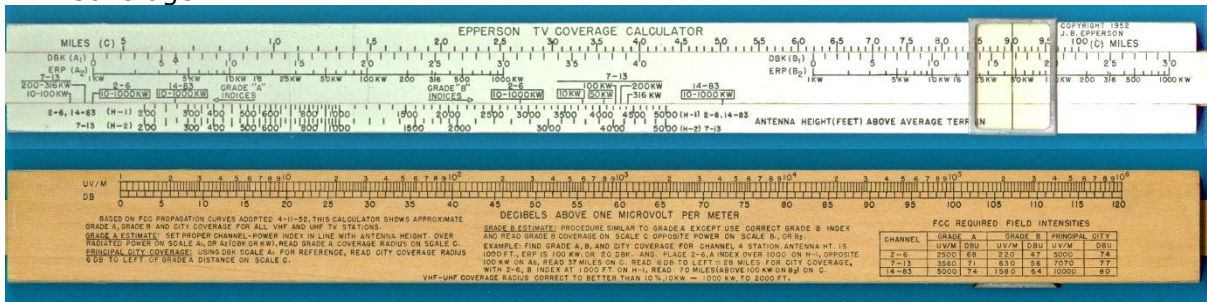
Typesetting



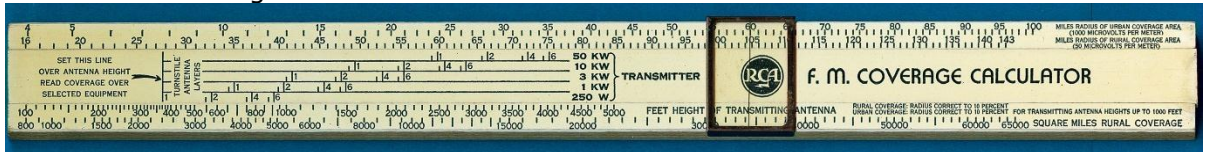
Underwriters



T.V. Coverage



F.M. Radio Coverage

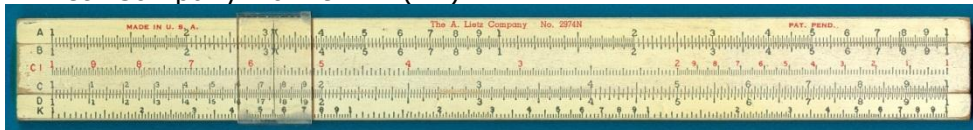


Examples of "Rebranded" OEM slide rules:

Charvoz-Roos SR-31 (BT)



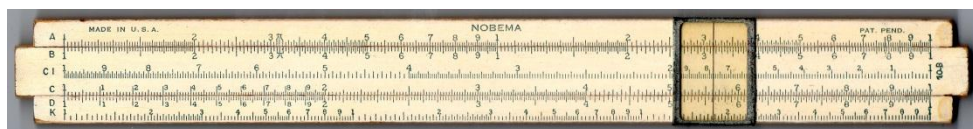
A. Lietz Company No. 2974N (BT)



ANCO



NOBEMA



US NAVY (BT)



¹ Revised and extended version of a paper first presented at the IM2011, Boston, USA.

² Motto attributed to Jack Cohen (1898–1979) founder of the supermarket chain: TESCO.

³ Source: ISRM.

⁴ Source: Chicago History Museum - negative number "ICHI 17490".

⁵ Astonishingly, when allowing for shipping costs, the pre WWII sales price in UK High Street retailer WOOLWORTHS for a Lawrence slide rule was 6d pre-decimal pence. In "money-of-the-day", the comparable retail price in 2011 would still be no more than £1.25 GBP or about €1.50 – clearly a "loss leader" of its day.

⁶ Physical length of the stock – the US still use imperial units for length, area, volume and mass.

⁷ Specialised unit of measure used for the volume of lumber in the US and Canada. It is the volume of a one-foot length of a board, one foot wide and one inch thick.

⁸ f.p.m. = feet per minute.

⁹ French, American & Anglo-Saxon versions exist -1 American pica = 0.166044 inch.

¹⁰ See JOS Vol. 15 No. 1: "*Slide Rules Are ... Music To My Ears!*", 2006, Pg 20.

¹¹ A.W.G. = American Wire Gauge.

¹² Convention adopted by many slide rule makers to quote the length of a full cycle main scale, usually the D scale, of their linear slide rules in flyers, catalogues, etc.

¹³ A coding method described by Giovan Battista Bellaso in his 1553 book: "*La cifra del. Sig. Giovan Battista Bellaso*". Later, in the 19th century, it was misattributed to Blaise de Vigenère and has since been incorrectly called the "Vigenère cipher".

¹⁴ A reputed writer of detective stories and a specialist in cryptography.

¹⁵ Early versions of the distinctive red and blue (orange and blue also existed) instruction guides were © 1939 to W. Stanley Marshall jr. and called: "*Stanley's Slide Rule Instructions*". Later in the same year Lawrence copyrighted their own version (but using the same colours) calling it "*The Quick and Easy Lawrence Slide Rule Instruction Book*".

¹⁶ Popular American 1920/30/40s chocolate "candy bar" made by Beich Co. of Bloomington, Illinois.