

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.

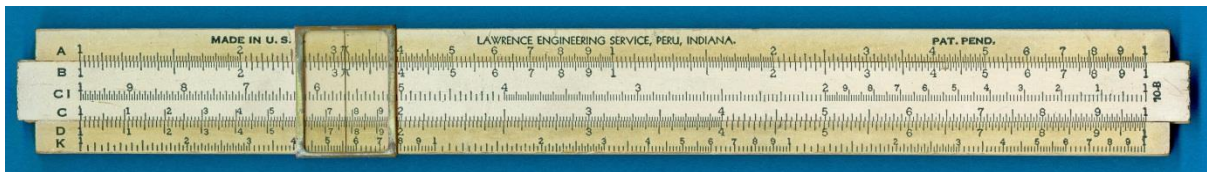


Fig. 1: **classic Lawrence 25¢ painted Enhanced Mannheim 10-B**

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 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 in Ottawa and is the great-great-grandson of his Prussian ancestor. A decade after marrying Alice nee Herendeen (1861-1930) in 1890, George senior

moved over 70 miles to Illinois' largest city: Chicago. George Lee and his 10-year older brother, Raymond Welcome, were both born in Chicago. In 1891 George senior opened the *Lawrence Portrait Studio*. He went on to build the largest known camera and develop an innovative process for flash photography. Later in life he started an aircraft company with partner Harry Lewis: *The Lawrence-Lewis Aeroplane Co.* The company built biplanes from 1913 to 1919. But he is best remembered as the world famous Chicago-based pioneer photographer who took 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. In the same year Lee's father married Adele nee Page (1894-1962). The timing of his parents' bitter break-up might explain why there is no record of Lee ever gaining a college degree.

His father's success as a professional photographer and builder of biplanes was most probably behind the two Chicago-based businesses Lee started around 1930. Sadly no examples are known to have survived from the *Lawrence Slide Rule Company*. It made and sold photography related slide rules/charts. But a second business, *Lawrence Airplane Models*, flourished. The company sold a series of balsa wood kits of model planes of "unusual flying ability" – see Fig. 3. The kits, with impressive wing spans of 24 inches or more, included replicas of popular aeroplanes of the day such as the *Sopwith Camel*. The experience Lee gained cost-effectively manufacturing the many wooden parts need for such kits may well have paved the way for his later successful second attempt at manufacturing slide rules.

In 1935, five years after starting his Chicago-based businesses, Lee uprooted and moved over 160 miles south and out of state to Wabash, Indiana. This move may have been the result of an earlier marital breakup. Lee married the first of his eventual three wives in 1922. She was Ada nee Zimmer (1903-1975). Within two years the marriage was blessed with the birth of a son, Lee junior (1924-2012). Needless to say the marriage did not last and by 1929 Ada and her son had started a new life in Philadelphia.

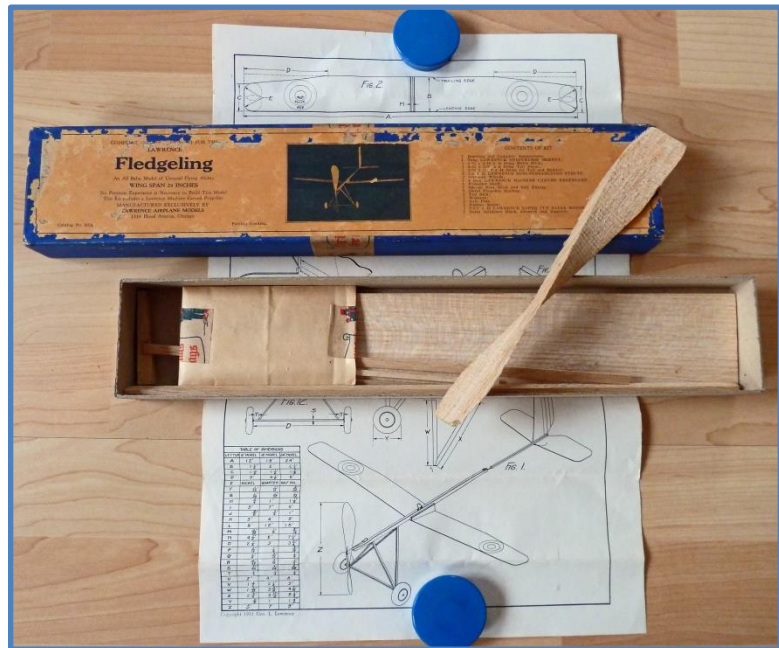


Fig. 3: **Boxed (15½ x 3 x 1¼ inch) kit © 1931 for building a “Fledgeling” – with a 24 inch wingspan requiring no previous model building experience**

In Wabash Lee founded *Lawrence Engineering Services* to make and sell slide rules. By now he was married to his second wife: Vivian nee Breyer (1915-1973). They met in Chicago but were married in Indiana in 1934. But Vivian did not immediately move with Lee to Wabash. She was ambitious and clever and, at first, may have been reluctant to leave Chicago. When she did eventually join him she took an active part in the business – particularly sales and promotion. Mike Konshak’s “poster” succinctly summarises the evolutionary path of the Lawrence slide rule. But unlike some company success stories, this one revolves more around marriage and divorce than technology!

Flourishing sales is the most likely reason that three years after start-up 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 attributed to *Lawrence Engineering Services* from the mid-1940s onwards – see Tables 1 and 3.

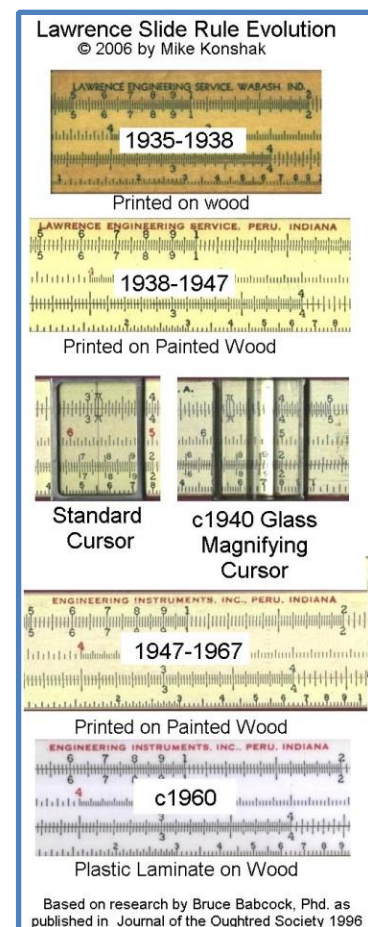


Fig. 4: **Lawrence slide rules through the years³**

Instigated by his second 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 from Vivian Lee remarried for the third and last time to divorcee Nellie Donaldson nee Mowbray (1911-1990). They had met through the company as Nellie had previously been the wife of the sales manager at *Lawrence Engineering Services*. Having lost the slide rule business Lee 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 more durable and cheaper plastic versions. He clandestinely removed the machines when he realised he was going to lose the slide rule business to his second 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.

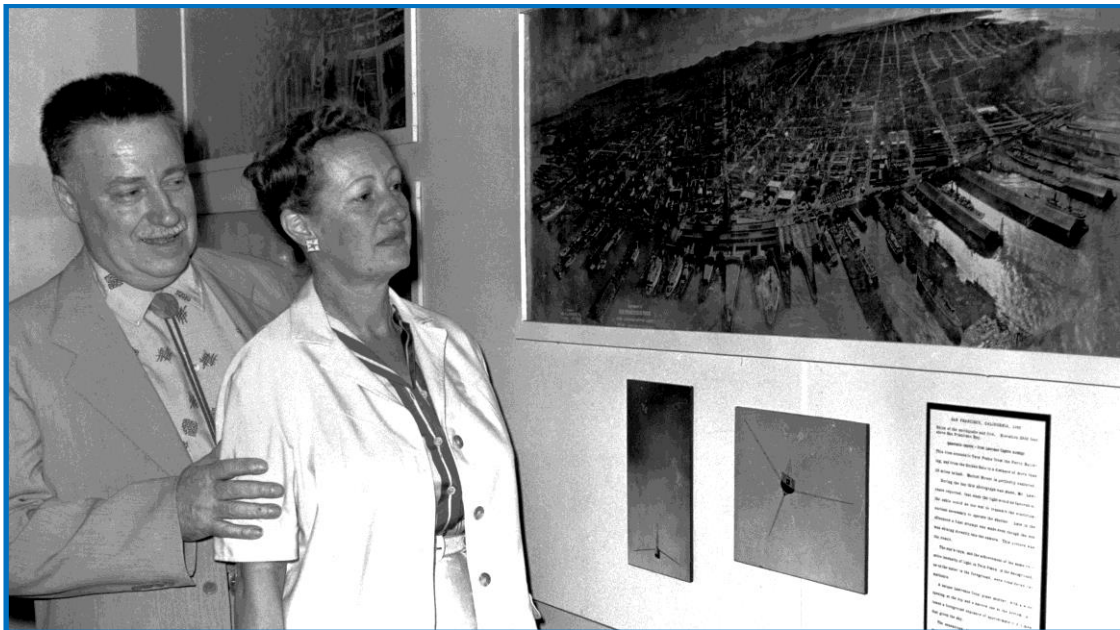


Fig. 5: **August 5th 1960: Lee and Nellie at the opening of "*Aerial Photography 1900-1910*" - an exhibition of his late father's work⁴**

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 than \$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, phenomenal cost-efficiency stands out. In his working life Lee was considered a bit eccentric and short-tempered. But he was undoubtedly an “ideas man” with a sound 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.

If Lee was the “ideas man” it was Ed Snyder, a long-standing employee, who usually 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 standard wooden blanks. The company started by making two types of an 8-inch⁶ slide rule – a Mannheim and an Enhanced Mannheim (but without the trigonometric scales). The scales were printed in monochrome onto a solid frame 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 1⅞ 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 ⅛ inch**
- **top and bottom side edges (never bevelled) always had tracks for a one-size cursor – even if one was not needed**
- **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 was left 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 solid frame 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*. However, not all the slide blanks were interchangeable. Most Lawrence/Engineering Instruments models were simplex models carrying no scales on the back of the slide. So for simpler rabbeting the rails along edges

of the slide are at the bottom. But some models did have scales on the back of the slide (see Table 2). For such models the rails were naturally centred.

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)
10-D 10-Do	LUMBER CALCULATOR (© 1946)	No No	For lumber volume in board feet ⁷ (set thickness & width, result on “D” for given length)
10-F	PRICING AND INVENTORY RULE (versions © 1945 and © 1946)	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

Model #	Type/Name (© yyyy)	Cursor	Scale layout/Use
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
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)
10-N	PRINTER'S PROPORTION RULE (© 1946)	Yes	For moving between inches & picas ⁹ when printing/publishing
6-Op	Calculator for PHOTOFLASH LAMPS (© 1946)	No	Early generic version for correct lens aperture (set film speed & lamp, result on "D" for distance)
6-Op	FLASHRULE (© 1946)	No	For GE or Westinghouse type of flashbulbs.
6-Ow	FLASHRULE (© 1946)	No	For WABASH flashbulbs

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 – i.e. why has no type E or type M ever turned up? Maybe they were prototypes that never made it to market.

The decoding of the metric range model numbering was possible thanks to a tip 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 T 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 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. 6: **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.* resold 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



Fig. 7: **Code-Maker boxed set**

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 emblazed 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).

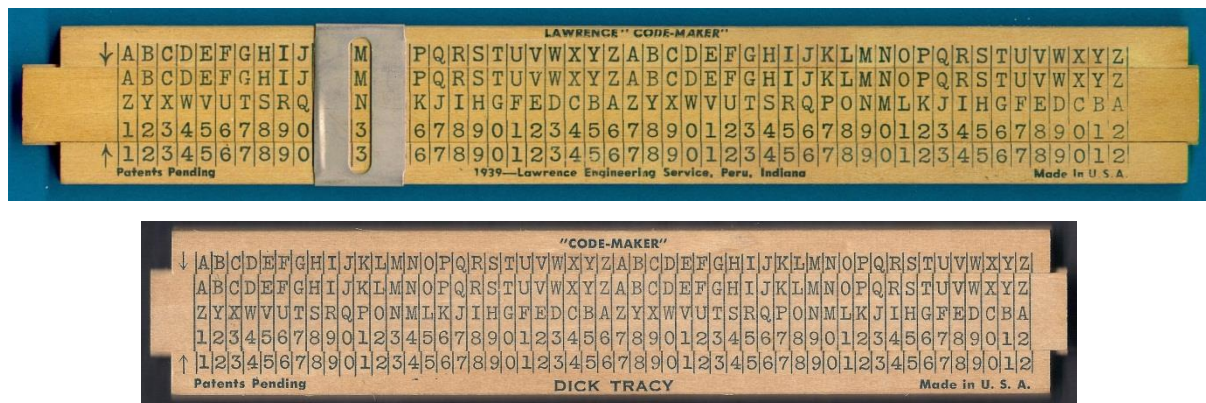


Fig. 8: 8-inch Beich and 6-inch Dick Tracy “Code-Maker’s”

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

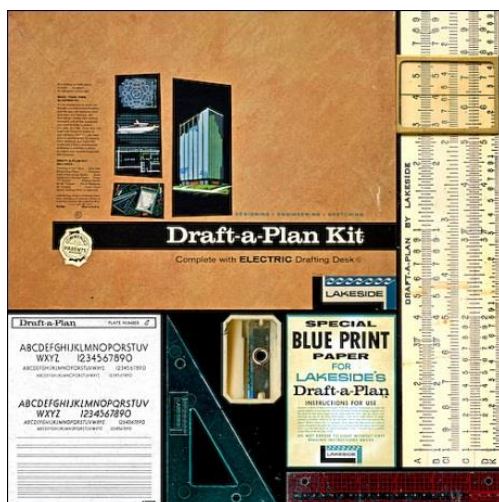


Fig. 9: Lakeside *Draft-a-Plan Kit*TM set for a teenager

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.

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. But 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. However, any named model could easily have been commissioned by more companies/parties than those listed in the table.

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 and Terre Haute (8" version © 1941, 12" version © 1945)	8" & 12"	Gas Pipe Line Slide Rule for calculating the gas flow capacity/hour through a pipe of a given diameter
B.F. Grizzle , Washington and Terre Haute (© 1941)	8"	Gas Displacement Meter Calculator for calculating gas rates through displacement meters @ various pressures
B.F. Grizzle , Washington (© 1941)	8"	Gas Low Pressure Line Flow Capacity Slide Rule for calculating the pressure drops for a given line flow & gas line size needed to deliver a given amount of gas
B.F. Grizzle , Washington (© 1944)	8"	Pipe Open Flow Capacity Slide Rule for calculating open flow rates based on pilot tube pressure readings
B.F. Grizzle , Washington (© 1939)	8"	Pipe Orifice Meter Calculating Rule for calculating the size of conduit/restriction needed to create a required pressure drop
B.F. Grizzle , Washington	8"	Water Line Capacity Slide Rule for calculating the friction loss in a section of

Commissioned by (© yyyy)	Size ⁶	Model Name/Use
(© 1944)		pipe & head loss for a given pipe diameter, length & flow
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 <u>M</u> ulti-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 and Statham Laboratories Inc , California (© 1950 Ideas Unlimited)	6" & 10"	Poker Meter for 5 & 7-card Stud or 5-card Draw poker. Based on the value the cards held, a colour code band recommends the advance play for each round of betting - i.e. " Get Out ", " Stay " or " Raise "
PIC Walsh Freight Co. & Plaza Express Company Inc. (© 1939 M.T. Brockman)	9½"	Traffic Manager's Slide Rule for checking freight shipping charges or shipping rates or shipping truck/carload breaking points and calculating storage costs
US Army (DeYOE)	10"	Artillery Range Finding ("Graphic Table") for calculating how many guns and how many rounds of high explosive shells are needed to be sure of hitting a target
Murphy & Murphy Inc. , Texas & Caprock Materials Co. , Texas & Warren E. Fennell , Indiana	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

Commissioned by (© yyyy)	Size ⁶	Model Name/Use
L.E. Waddington , (© 1947)	12"	Music & Music Acoustics for adjusting relative vibration rates, degrees of scale, intervals, chord structures, scale indications & transposition data against piano keyboard
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 (address unknown) and Adler Communications Laboratories , New York (© 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 radio antenna

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 or different versions of the same themed slide rule. So this series proves, yet again, how Lawrence/Engineering Instruments successfully used their standard blanks to make an enormous variety of interesting and ground-breaking slide rules – often (re)selling the same design to multiple clients. An example of all the listed models can be found 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.

Just 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 design of the *Antenna Slide Rule* for calculating radar antenna beam patterns being considered so strategically important that both the British and American governments had it classified and kept it classified long after WWII had finished.

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 Lawrence rules to 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 coding of 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,
- **Cyron 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.

A special postscript mention should go to **Louis Block**. While researching his family history he discovered that his maternal grandmother, Ada Verbit nee Zimmer, was Lee Lawrence's first wife. This led him to my article. In late 2016 he contacted me. With the information he kindly shared I could correct and supplement aspects of the convoluted Lawrence family history as part of a major update to this article in 2017.

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Appendix-A: Lawrence/Engineering Instruments branded slide rules

Imperial Range:

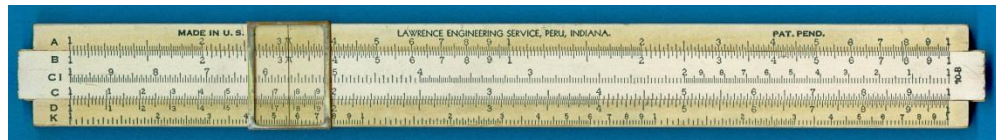
8-A



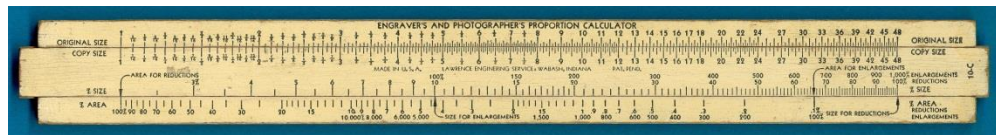
8-B



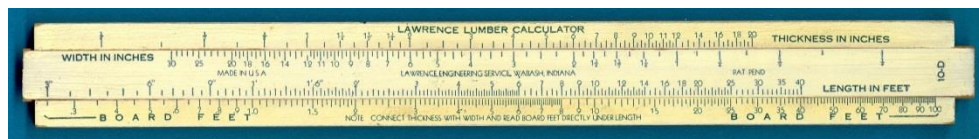
10-B



10-C



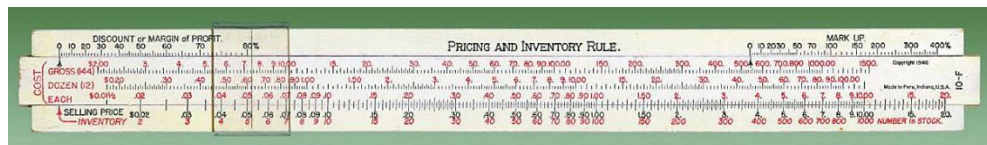
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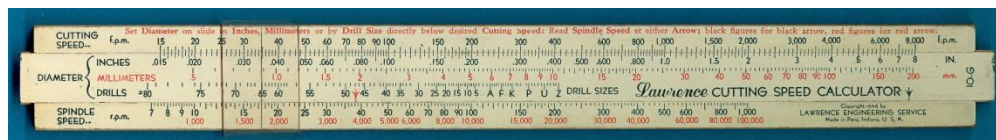
10-D0



10-F



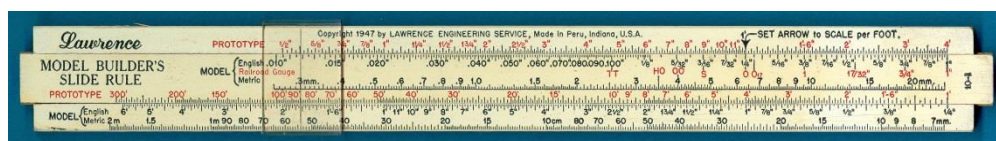
10-G

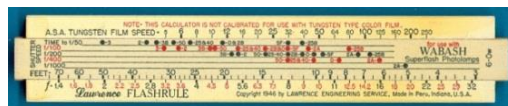
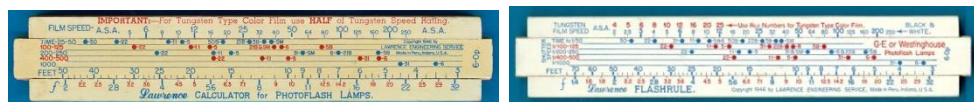
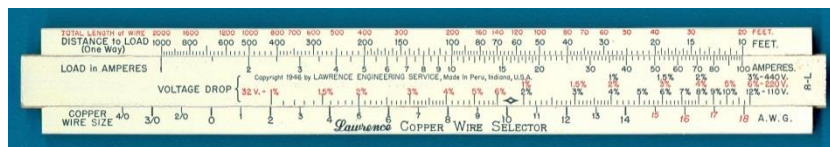
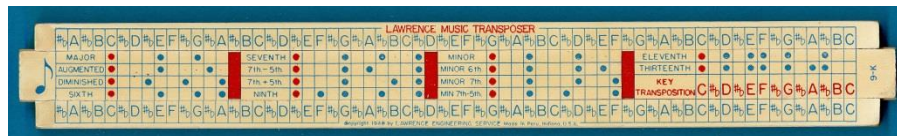
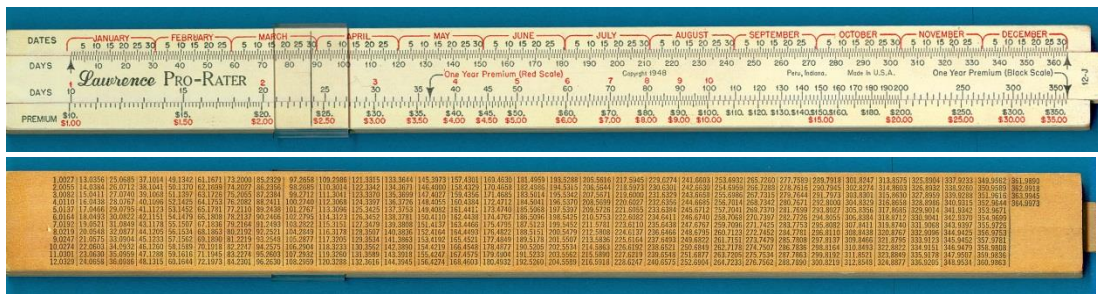


12-H

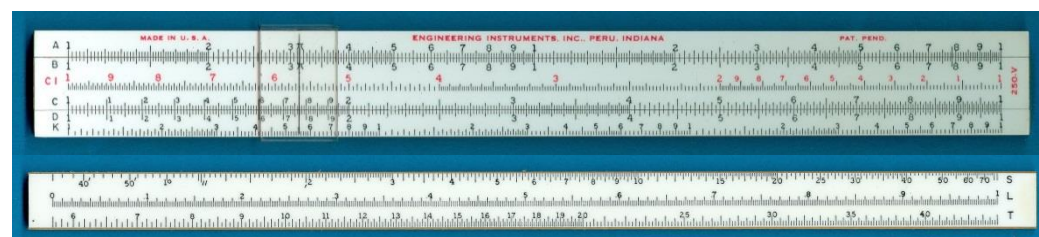
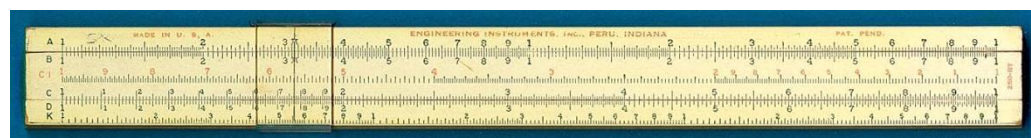
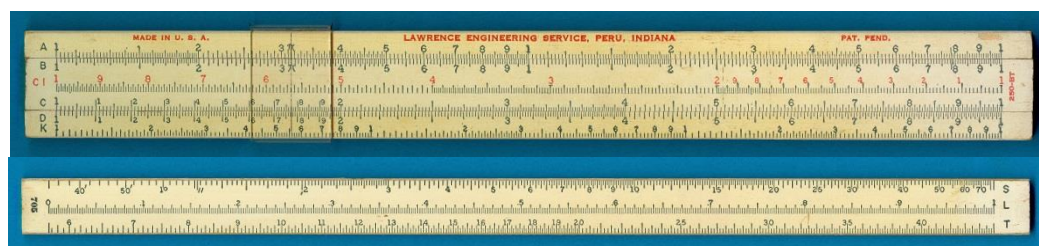


10-I

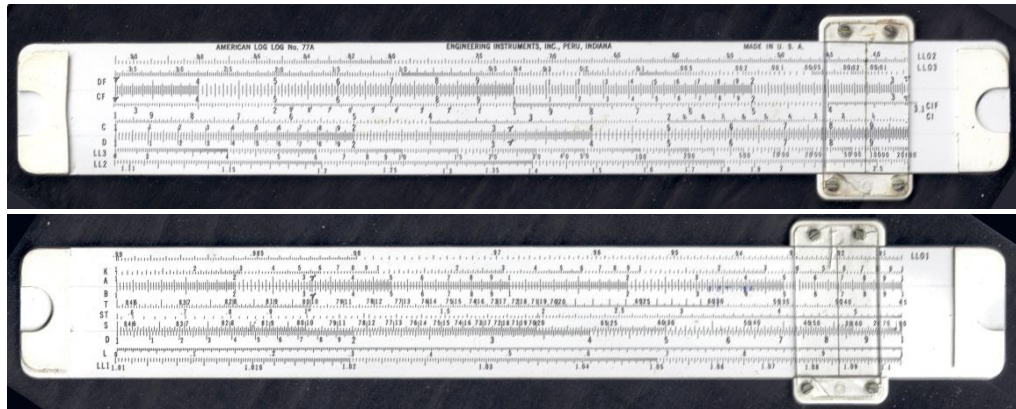




Metric Range:



77A

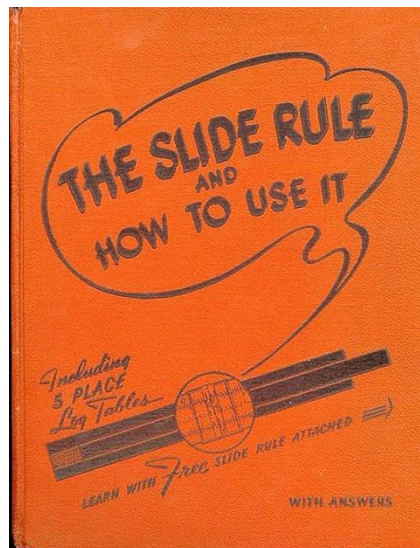


Sets & Books Range:

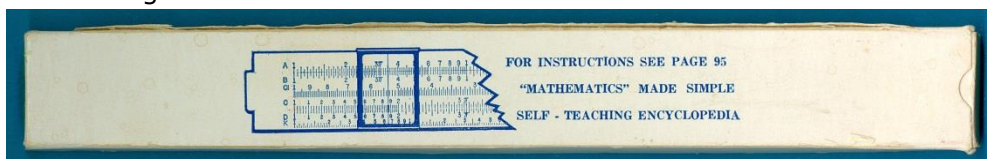
Secret "Code-Maker"



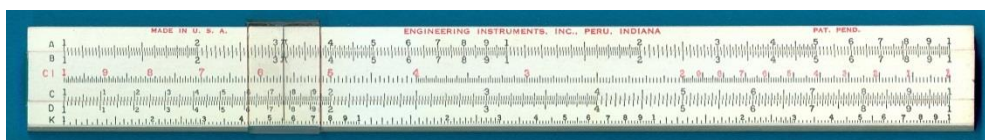
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Cadillac Publishing Co.



Plain Range:



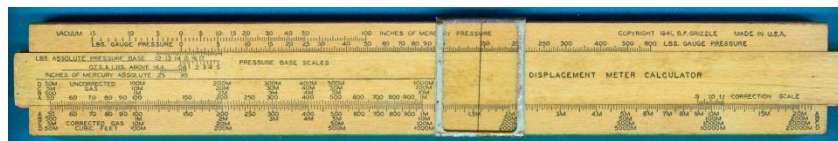
Appendix-B: Lawrence/Engineering Instruments unbranded slide rules

Specially Commissioned Themed slide rules:

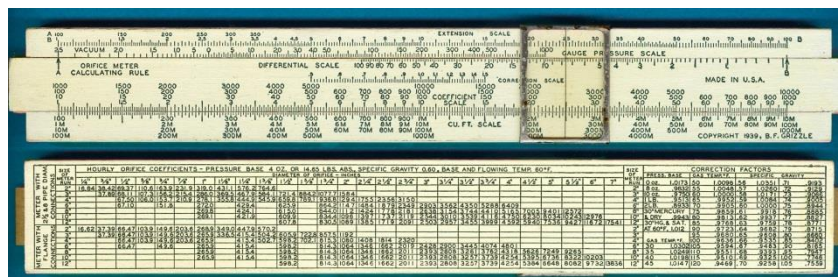
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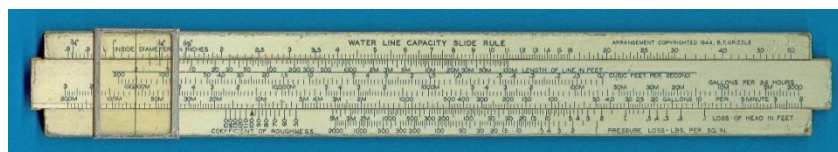
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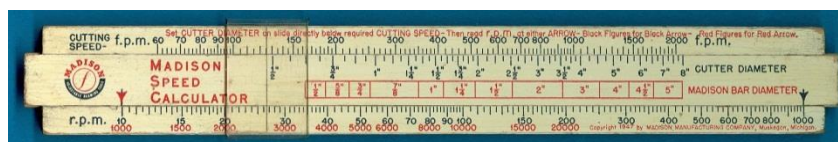
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Water



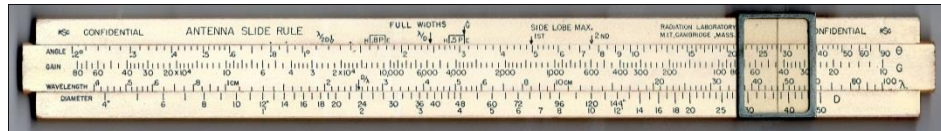
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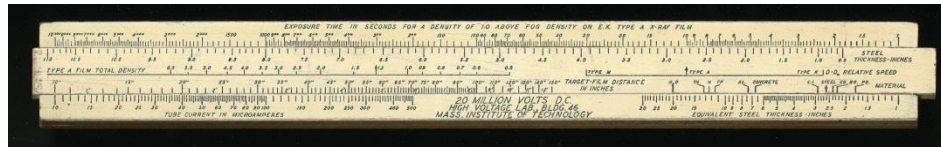
Music



Antenna



Exposure



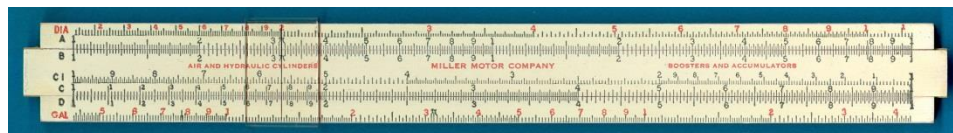
S-M



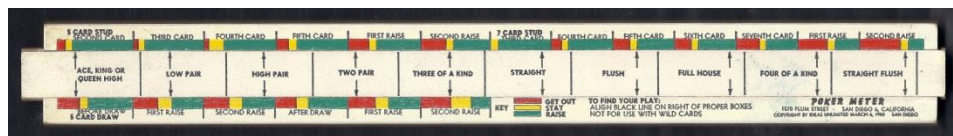
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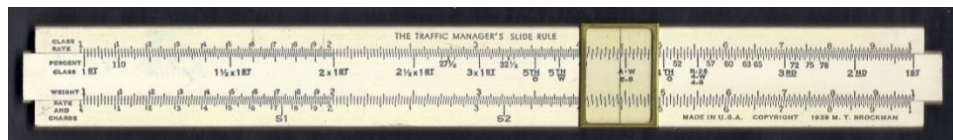
Air/Hydraulic



Poker



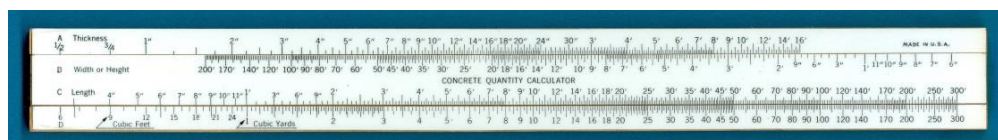
Traffic



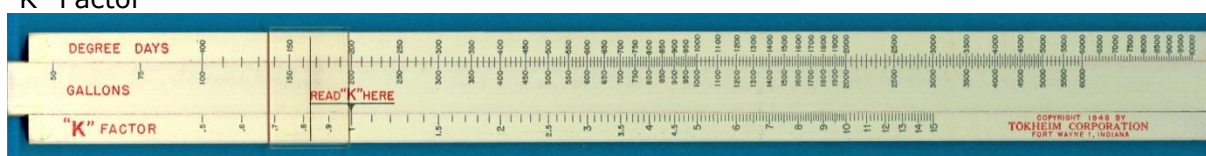
US Army



Concrete



"K" Factor



C GALLONS CORRECTED TO 60 DEGREES

B GALLONS DELIVERED

A PROPANE TEMPERATURE

TENBROOK ENTERPRISES • 324 NORTH BUCKEYE STREET • KOKOMO, INDIANA

The image displays several musical reference charts:

- Chromatic Scale:** A horizontal scale showing the 12 notes of the chromatic scale (A through B) with their corresponding chromatic notation and piano key numbers (e.g., A=1, B=2, C=3, etc.).
- Chords:** A grid showing the construction of major, minor, augmented, and diminished chords across the 12 notes. It includes a visual representation of the chord structure (e.g., whole, half, quarter notes) and the resulting chord name.
- Harmonic Series:** A chart showing the first 19 harmonics of a fundamental note (C). It lists the harmonic number, the corresponding note name, and the interval between the fundamental and the harmonic.
- Scale of Vibration:** A chart showing the 12 notes of the scale of vibration (A through B) with their corresponding scale numbers (e.g., A=1, B=2, C=3, etc.) and the interval between the fundamental and the scale number.

The COPYFITTER

MEASURE 0 1 2 3 4 5 6 7 8 9 10 11 12

LENGTH OF LINE IN PICAS 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

NUMBER OF LINES 0 50 100 150 200 250 300

CHARACTERS (or Running Picas) 0 100 200 300 400 500 600 700 800 900 1000

Type Size in Points 0 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36

GPP 0 1 2 3 4 5 6 7 8 9 10

C.P.P. 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560 570 580 590 600 610 620 630 640 650 660 670 680 690 700 710 720 730 740 750 760 770 780 790 800 810 820 830 840 850 860 870 880 890 900 910 920 930 940 950 960 970 980 990 1000

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COPYRIGHT 1944 BY ALBERT J. BERT

[illegible][illegible]

Examples of “Rebranded” OEM slide rules:

Charvoz-Roos SR-31 (BT)



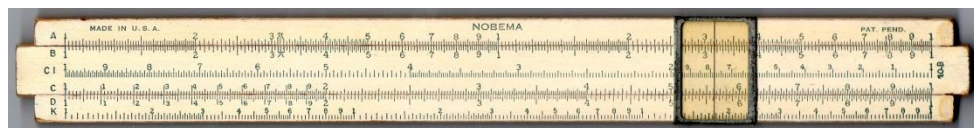
A. Lietz Company No. 2974N (BT)



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.