The System Wern Slide Rule

Conrad Schure

Like so many things in life, "Timing is everything". We often hear that something, or someone, was ahead of its time. Well, the subject of this article may just be the antithesis of these cliches.

The System Wern Slide Rule, which was not invented until 1965, solves the age-old problem of decimal point placement. If it had been developed earlier in the twentieth century it might well have revolutionized slide rule design and production. However, because of its appearance during the decline of the life of this venerable calculating tool, it is little known and virtually unrecognized today.

The System Wern was invented in Sweden in 1965 by an engineer named Wern. The example at hand (see below) was made in 1967, in Germany, and is marked IWA 1633, and Pat.Pend.[1]

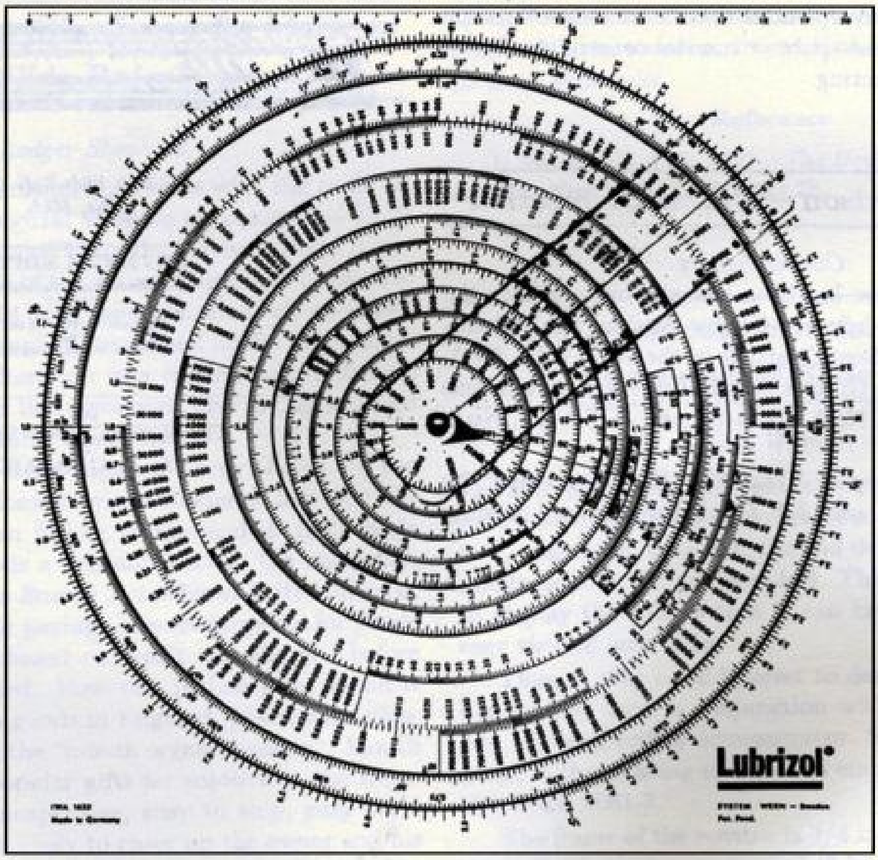
Physically, it is made of a heavy plastic, with a square base measuring 8.25", a single rotating 6" disc, and a cursor with a scribed hairline and 20 "gauge marks" corresponding to their intersection with the various scales on both the base and the rotating disc.

Describing the complexity of the scales becomes much more difficult. The square base has only three scales outside of the rotating scale. These scales are: a single radius logarithmic scale, a circular degree scale (from 0 to 90), and a dual scale that runs from 0.001 to 1,000,000 and from 10^{-4} to 10^{12}. The rotating beige disc contains only four scales: one scale which runs from 0.001 to 1,000,000 in a counter-clockwise direction, and another similar scale running in the clockwise direction, plus a scale from 1.0 to 10 in both the clockwise and counterclockwise directions; all four scales are logarithmic, but it also has five windows revealing additional scales, such as: a helical scale with values from 1.0010 to 10^{40} (for Log-Log calculations), squares, cubes radians, trigonometric functions, and 31 different conversion factors/scales, exponentials, and more.

According to the literature provided with this unusual slide rule, it provides the capability for "DIRECT READ-OUT", and answers to a rather wide range of applications, without having to deal with the bothersome chore of where to place the decimal point in the result.

Ironically, the material supplied with this System Wern ABC Slide Rule notes that it was "Prepared by an electronic computer, it is precision graduated for maximum clarity and long-life accuracy." Unfortunately, it is possible this same quote might also be used for its epitaph.

The Wern Calculator



[1]The company is still in existence. Indeed, the paper "The Development of the Data Rules from 1920 to Today" by Harald Riehle, was presented at The Third International Meeting of Slide Rule Collectors (and included in the *Proceedings*) by Mr. Riehle, who is the owner of IWA. The version number of this rule as referred to in the paper appears to be 1638.

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System Wern Circular Slide Rules – A Collector's Dream Come True

Gunnar Englund

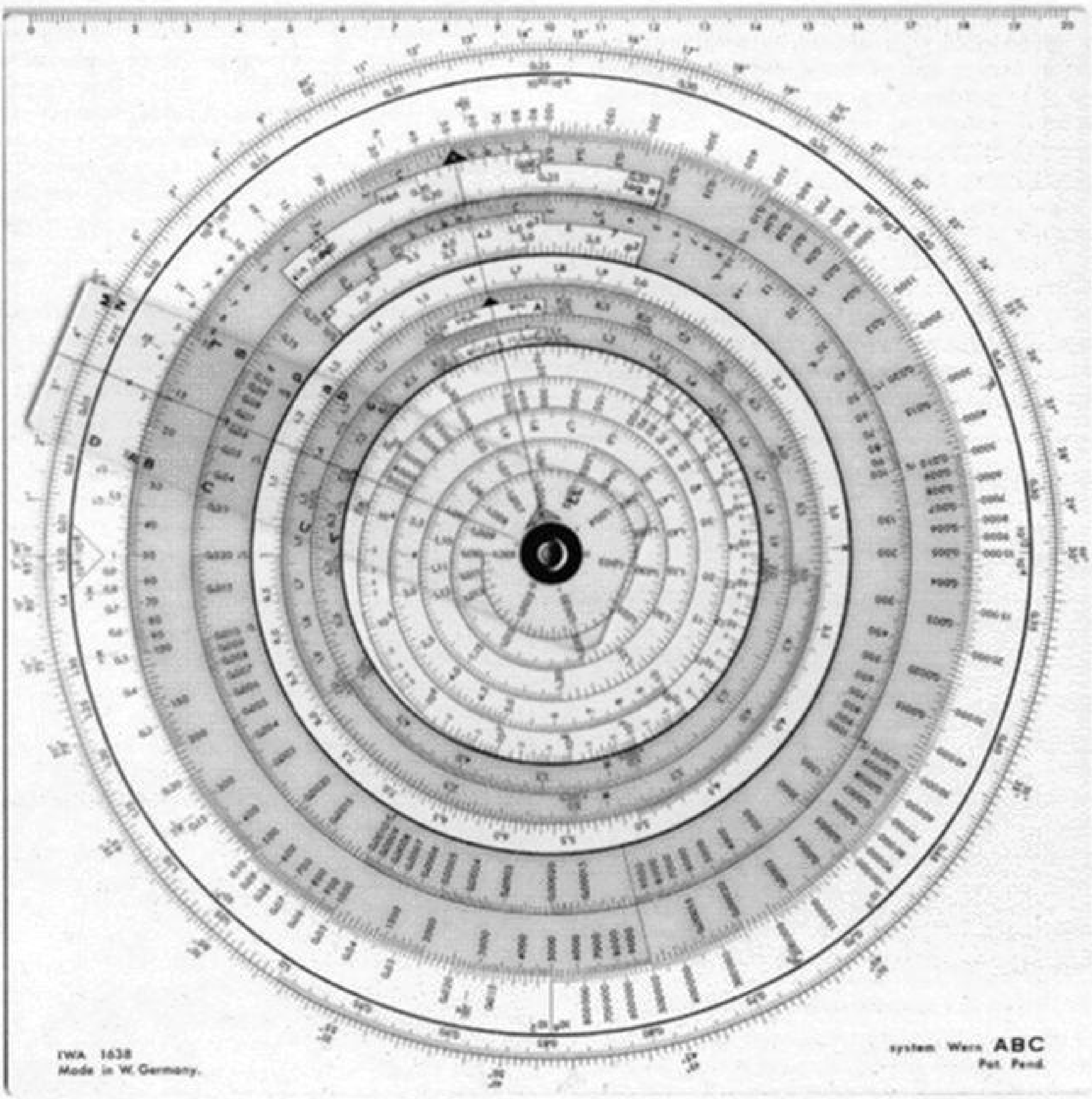

Figure 1. The IWA 1638 System Wern ABC

This is about slide rule collecting and a collector's dream come true. It is also about an interesting circular slide rule design, its development and background. And it is about being just on time, but too late.

The Background

I have always, from about twelve years of age, used slide rules, and I still do. My first was an SH pocket size, then the FC 62/82 in engineering school and later an East German Reiss 3227 that I acquired in Lutherstadt Wittenberg somewhere back in 1973. So, when I (semi)retired at age 65, I already had a small collection of slide rules, and when I found an Aristo 968 MIB in a flea market for little more than a dollar, I immediately realised that I should start collecting slide rules. And so it is. I have been very lucky. I have found caches in old book stores. I have been given slide rules, and I have won auctions on eBay. My wife and I have turned slide rule hunting into "an act of art". We visit historical places and art exhibitions, and raid the book and stationery shops in the area. I now have a nice collection, still missing the 2/84N, but I have the 2/83N in triplicate. I am now looking for circular rules and less common straight ones.

The Find

On one occasion, we visited the historical little town of Sater in Sweden and, of course, there was a little book shop. The shopkeeper was not at all surprised when we asked if he perhaps had some slide rules? He brought out a box with SH, FC, and a couple of circulars that I never had seen before; two IWA 1638 System Wern ABC.

Some money and some slide rules were exchanged, and I sat down to find out what all those unknown scales were for. There were scales covering an unusual range of values, from 0.0001 to 1000 and an LL scale covering 1.001 (not so special) up to 10^{40} (which was not so expected). The LL scale was arranged in a spiral and made excellent use of the space available at the center of the device. (See Figure 1 for an overview of the Wern 1638.)

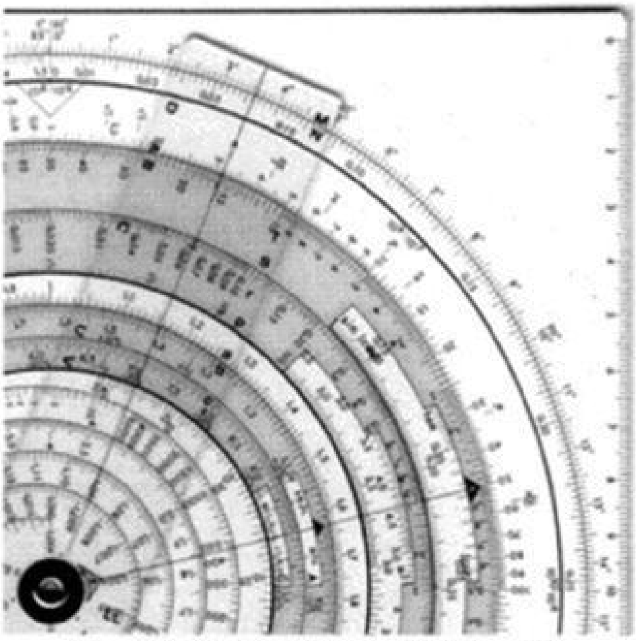

Figure 2. Quadrant showing 3.14 times 16.

I also found important constants like π, $180/\pi$, g_0, etcetera, scattered around the outer scales. And Centigrade to Fahrenheit conversion scales! At last! That's when my wife asked the shop owner for how long the shop was open that night, and I realized that we ought to find the car and go to the hotel. Of course, the parking meter was on deep red, and there was a ticket on the windshield. I regard such little inconveniencies as a mere trifle under these circumstances, but my wife remarked that the slide rules weren't such a bargain after all. Women seem to have a slightly distorted view on certain things.

I couldn't continue the examination until after dinner. A perfect trout for dinner made up for the parking incident, and the slide rule examination continued. My wife found some intriguing dots and circles that kept her busy for a while and I researched the functions. After some time, I had the rather unusual idea to read the accompanying manual. Well, "read" is not the correct word. "browse" isn't good either. "Take an IQ test" seems to be the right expression. The folded DIN A4 sheet had its inner two pages (see Figure 3) crammed with functions, all different, that makes even an HP or Casio calculator look limited in their abilities. Wow! This was really something! Once you grasp the thinking behind system Wern (which took me about 30 minutes using the manual) you find it just beautiful and a joy to explore. No button-pushing, no 2^{nd} functions, no mistakes, no limits. It is a pity that the calculators took over. Wern handles it all, and much faster.

The Insight and the Search

There's always something new to learn, and in this case, I had a complete vacuum to fill. Googling IWA soon gave me some information. One of them was a short passage in a presentation of the history of the IWA slide rules in the Proceedings of the Third International Meeting of Slide Rule Collectors, 1997. It said about the IWA 1638: *"This disk was developed by the Swedish engineer Wern."*

Interesting. I live in Sweden. I had a look at the 1638: no date on it, nor on the "How to use" sheet. I phoned a dealer, I. Sater, and he informed me that he had kept the 1638 in stock until around 1968 or 1969. Again, interesting. That's quite a long time ago. But still, there might be an engineer named Wern somewhere in Sweden. Someone that might be able to tell the story. Wern is not the commonest name in Sweden, but there are still many of them. I had to narrow down the search. My wife came to the rescue: "Phone women named Wern" she said. "There are not so many of them (phones are still mostly registered in husbands' names in Sweden, land of emancipation and equal rights), and women tend to care more about relatives than men do." Good advice from my good wife. And it worked! After six or seven phone calls, I was lucky: "That must be Uncle George" the woman at the other end said. "He lives in Stockholm. He and Uncle Carl still have their little office there". I tele-kissed the charming lady, got the phone number for George Wern, phoned him, and had a long and interesting conversation with him. We decided to meet as soon as possible.

After the phone conversation, I sat down, thinking: isn't this all a collector can hope for? Finding a unique slide rule, and then finding the man who created it? It is like having a conversation with Lieutenant Mannheim, Dr. Rietz, or Professor Walther of Darmstadt. Some guys have all the luck, and for once it happened to be me.

The History

Carl and his brother George had a company that specialized in heating, ventilation, and sewage consulting. The company was started in 1946, and it seems that the brothers did a lot of specialized calculations that involved Bernoulli's equations and the Mollière relationships, all rather involved calculations that were not easily solved with the equipment available at that time.

No.	Calculation	Scales	Result	Result scale
1.	$3 \cdot 5 =$	A B ▶	15	A
2.	$3 : 5 =$	A C ▶	0.6	A
3.	$0.03 \cdot 5000 =$	A B ▶	150	A
4.	$30 : 500 =$	A C ▶	0.06	A
5.	$1.22 \cdot 1.58 =$	a b ▶	1.928	a
6.	$4.37 : 1.775 =$	a c ▶	2.46	a
7.	$15000 \cdot 200 = 0.03 \cdot 10^{8} = 3 \cdot 10^{6}$	A B ▶A		D
8.	$3 : 5000 = 60000 \cdot 10^{-8} = 6 \cdot 10^{-4}$	A C ▶A		D
9.	$7400 \cdot 5\% =$	A B ▶	370	A
10.	$3.50 - 30\% =$	a b ▶	2.45	a
11.	$3.50 + 30\% =$	a b ▶	4.55	a
12.	$3.50 - 25\% - 10\% =$	a b c	2.36	a
13.	$6 \cdot 150 = X \cdot 2000$	A B A B	X= 0.3	
14.	$3 : 150 = 15 : X$	A C A C	X= 750	
15.	$30 \cdot 5 \cdot 40 =$	A B C	6000	A
16.	$30 \cdot 5 : 40 =$	A B B	3.75	A
17.	$3 : 5 : 40 =$	A C B	0.015	A
18.	$1 : 50 =$	B	0.020	C
19.	$68^{\circ}F = X^{\circ}C$	U V	X= 20°C	
20.	50 KG. = X LB.	U V / A C	X= 110 LB.	
21.	$3^{2} =$	a	9	p
22.	$3^{3} =$	a	27	r
23.	$\sqrt[2]{3} =$	p	1.732	a
24.	$\sqrt[3]{3} =$	r	1.442	a
25.	$\sqrt[2]{3} \cdot 5 =$	p b ▶	8.66	a
26.	$\sqrt[2]{3} : 5 =$	p c ▶	0.346	a
27.	$\sqrt[3]{3} \cdot 5 =$	r b ▶	7.21	a
28.	$(1.3 \cdot 2.5)^{2} =$	a b ▶	10.6	p
29.	$(1.3 \cdot 2.5)^{3} =$	a b ▶	34.3	r
30.	$^{10}\log 5 =$	a	0.699	S
31.	$^{10}\log (1.3 \cdot 2.5) =$	a b ▶	0.512	S
32.	$^{10}\log (5 : 3) =$	a c ▶	0.222	S
33.	$\sin 50^{\circ} =$	N	0.766	S
34.	$\cos 40^{\circ} =$	N	0.766	S
35.	$\tan 50^{\circ} =$	N	1.19	T
36.	$\cot 40^{\circ} =$	N	1.19	T
37.	Arc-sin 0.350 =	S	20.5°	N
38.	Arc-cos 0.350 =	S	69.5°	N
39.	Arc-tan 0.350 =	T	19.3°	N
40.	Arc-cot 0.350 =	T	70.7°	N
41.	Arc 40° =	N	0.698	S
42.	1.20 rad =	N	68.8°	N
43.	Sin 0.450rad =	N	0.435	S
44.	Tan 1.30rad =	N	3.60	T
45.	$2^{5} =$	LL c ▷—	32	LL
46.	$2^{50} =$	LL c ▷—	10^{15}	LL
47.	$2^{0.5} =$	LL c ▷—	1.414	LL
48.	$\sqrt[4]{625} =$	LL / b ▷—	5	LL
49.	$\sqrt[40]{625} =$	LL / b ▷—	1.174	LL
50.	$\sqrt[400]{625} =$	LL / b ▷—	1.0162	LL
51.	$^{e}\log 5 =$	LL ▷—LL	1.61	c
52.	$^{e}\log 50 =$	LL ▷—LL	3.91	c
53.	$^{e}\log 500 =$	LL ▷—LL	6.21	c
54.	$^{3}\log 5 =$	LL ▷—LL	1.465	c
55.	$^{4}\log 5 =$	LL ▷—LL	1.16	c
56.	$^{8}\log 5 =$	LL ▷—LL	0.774	c
57.	$4^{3 \cdot 1.5} =$	LL b / c	64	LL
58.	$4^{5/8} =$	LL c / c	2.38	LL
59.	$^{2}\log 0.05 = -{}^{2}\log (1 : 0.05) = -{}^{2}\log 20 =$	B / C / LL ▷—LL	−4.32	c
60.	$0.2^{5} = 1 : (1 : 0.2)^{5} = 1 : 5^{5} = 1 : 3100 =$	B / C / LL c ▷— LL / B	0.00032	C
61.	$\sqrt[5]{0.4} = 1 : \sqrt[5]{1:0.4} = 1 : \sqrt[5]{2.5} = 1 : 1.257 =$	B / C / b LL ▷— LL / b	0.796	c

Figure 3. From the accompanying manual.

Figure 4. The Wern brothers: Carl (left) and George demonstrating their slide rules

Carl developed several straight and circular slide rules to solve specific problems, and being the engineer he was he left the orthodox limitations of the

scales in engineering units, with end values corresponding to real-world data.

The data points were calculated manually and the masters were drawn by hand on mylar film. There are some interesting details regarding both the substrate, the calculation, and the drawing; more about that later.

The idea of a general circular slide rule grew steadily, and the ideas and insights accumulated in the brothers' heads. Essentially they were (my interpretation):

- A: Eliminate the DPP (Decimal Point Problem).
- B: Force the user to use the fastest method to calculate the answer.
- C: Extend the LL scales to include the largest practical number.
- D: Arrange the scales for the best precision.
- E: "Sprinkle" with important data points.
- F. Include unit conversion.
- G. Include built-in quality control/verification.

The different features, and how they were imple-

Oughtred Society2006.3.jpg

A: Eliminate the Decimal Point Problem (DPP)
Most engineers develop a sense for the correct answer, but they still have to keep track of the decimal point. And that is often a problem. Some methods (pointers on the cursor, counting +/- when moving right/left, doing mental exponent calculation, etc.) were in use, but a satisfactory solution was still to be invented. For some problems, the use of A and B scales kept track of the decimal point for a limited range, sometimes sufficiently large, sometimes totally inadequate. The Wern brothers extended the idea of a large range and simply made the range 0.01 through 1000000 on the A scale and—watch this, it is brilliant—0.0001 through 10000 on the B scale. So, both scales have eight decades, but they have different ranges. Why? Simply because it was a very practical solution. I have tested the system in lots of practical electronic problems and it is just brilliant. You never seem to get out of range.

B: Force the User to Use the Fastest Method to Calculate the Answer

This is the main feature in the patents registered by the brothers. It works like this: Put cursor on A. Turn B on inner scale to mark on cursor. Read AxB (or A/B) where the index points. The trick is that there are two marks on the cursor, the dot '·' and the division symbol ':' and these symbols guide you to the right answer with as few movements as possible. See Figure 3.

C: Extend the LL Scales to Include the Largest Practical Number

There is a number in Archimedes "The Sand Reckoner" and it is somewhere between $10^{59}$and 10^{63}. The brothers, being more practical, decided that 10^{40} was a reasonably large number and made the LL scale into a continuous spiral covering 1.010 to 10^{40}. That is a sufficient large range, even when dealing with Avogadro's number and other data down there where atoms and electrons live.

D: Arrange the Scales for the Best Precision
This is not a problem on a straight slide rule. All scales are the same length. No problem, and no possibilities. Slide rules like the FC 2/83 N have a W (Wurzel=root) scale that effectively doubles the precision, but otherwise it is not possible to increase precision once the length of the slide rule has been laid down. The 1638 has scale diameters ranging from less than 40 mm to 190 mm. That is a five-to-one range, and even if it were possible to put all scales on a diameter range from about 160 to 190 mm, it would make a hopelessly cluttered and not very practical device. The solution chosen by the designers shows a good balance between available space and the desire for precision and readability. Putting the LL scale in five spiral turns close to the center utilizes this otherwise difficult space optimally.

E: "Sprinkle" with Important Data Points
Most engineers know the numerical vaue of $\sqrt{2}$ and electrical engineers even know $\sqrt{3}$ by heart. But what about $\pi/180$? Or the gravitational constant g_0? All these data and many more can be found around the perimeter of the main scale. That is a great way of speeding up calculations: whenever one of these common ratios or numbers appear in a formula, you simply start the calculation with that number and then multiply/divide as needed. Some calculations can be reduced from four to one operation using that possibility. It not only speeds up the work, it also conserves precision.

F: Include Unit Conversion
Unit conversion is probably what calculating devices are used for most of all. Putting unit conversion on a straight slide rule is usually limited to the "gauge points" on the cursor (the "Disponent" is an exception, but hardly useful for technical purposes). Gauge points can be used for diameter/area conversion and HP/kW, but not much more. The 1638 has direct unit conversion covering litres/cubic inch at the low end, to square meters/acre at the high end, with US and British gallons to metric, as well as BTU to kcal, and dozens of others in-between. There's also a set of Fahrenheit/Celsius scales covering -40F/-40C to +212F/+100C. Now, isn't that something you always looked for? You do not even find it in many modern calculators, unless you write a program to do the conversion.

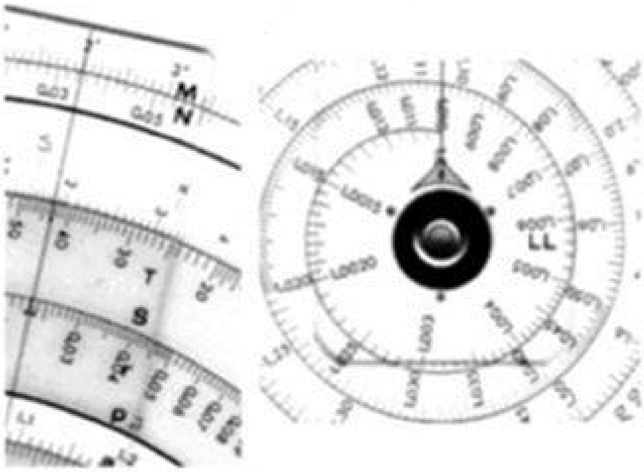

Figure 5. Quality Control.

G: Include Built-In Quality Control/Verification.
Quality starts at home, and home was George's drawing board and Carl's calculating sheets where all data were calculated. But after the masters were sent to IWA and production running, there were subtle problems that could ruin accuracy, the more important being excentricity. A very effective and simple self check was devised and included in the design. By centering three little circles around the hub on the stationary base and three dots on the rotating, translucent disk, it was an easy matter to check that all dots were well centered within the circles. This simple check increased the user's confidence in the 1638. See Figure 5.

The Whole Is More Than the Sum of the Parts

Putting all these new features together in one calculating device resulted in a remarkably fast and comfortable slide rule. Chain calculations with lots of terms and constants can be performed without the need for a "split mind" where one half concentrated on the decimal point and the other half worried about the numbers. The dot and the division sign made the procedure automatic, and the data points made frequent reference to tables unnecessary. All this was enhanced by smooth rotor operation and a cursor that stayed put until moved by the operator. Using a 1638 today is a little like getting into a classic sports car, pure driving, er... reckoning pleasure.

But There Must be a Hitch Somewhere?

Must it? I am hard pressed to find that hitch. Precision? Perhaps. The eight decades on a 162 mm diameter scale (500+ mm perimeter) makes each decade about 64 mm long. So precision could be better. But there's help: a 330 mm-long pair of scales for better precision, if needed. But the reduced number of operations resulting from having common data points available seems to compensate for the 64 mm/decade scale length, and doing electronics work usually means that your input data are not more accurate than one to five percent. So the end result is satisfactory in these applications.

What else could it be? "It is not a slide rule. It is a Calculating Disk" Yes, that's probably it. Can't put a 21 by 21 cm disk in a holster attached to your belt. Can't put the "junior" 1639 (10.5 by 10.5 cm) in your shirt pocket. You will not be recognized as a "real engineer" by carrying that cake tray around.

I think that psychology played a big role. Also, what real engineer would admit he could need help keeping track of the decimal point? We were all trained to do just that, i.e., accepting the convenience of the 1638 would be admitting a weakness. And that was absolutely out of question in the post-WW II days.

Why Wasn't System Wern an Instant Success?

It is hard to understand why. It covers all calculations you are ever likely to do even in advanced engineering work. It eliminates the DPP (Decimal Point Problem) as long as you stay in practical value ranges like 0.01 to 1000000. It is fast. Reliable. Needs no batteries. It is even fun to use! So, what kept it from a breakthrough?

The problem it solves (the DPP) may also be the problem behind its limited market success. It was considered an unfair advantage using the 1638 in schools. So it was not allowed for school use in some European countries, and therefore didn't get the exposure that the "straight guys" like Aristo, Sun Hemmi, and Faber Castell got. No exposure in schools translates into less market share and less acceptance on the whole. The same old problem that new ideas always have. No matter how superior it is, there's an initial resistance to be overcome before success is a fact. It is a historic irony that electronic calculators took over before the System Wern had overcome that initial resistance.

But I sure am pleased to have a collection of the Wern disks. I use one of them for fast, reliable calculations and keep the others under glass, for coming generations to explore and admire.

Slide Rules—Gone but Not Forgotten

Tom Wyman

It seems that every few months an article appears in the pages of some technical magazine commenting on the increasingly long-gone era when slide rules dominated. However, comments from one reader suggest that some continue to rely on slide rules. The nicely illustrated article, "When Slide Rules Ruled", by Cliff Stoll that appeared in the May 2006 issue of *Scientific American* attracted several interesting observations from readers of that magazine. First Lt. Christopher Lusto, USMC, wrote from Fallujah, Iraq, saying, "Well, I—a 24 year-old artillery lieutenant—should like to inform you that the slide rule is alive and well in the artillery in the form of the graphic firing table. Despite having $40,000 fire-direction computers to calculate data, we still use our trusty "sticks" to double-check the solutions. And should our high technology fail, we retain the effort to deliver accurate and timely fire support, all thanks to a few dollars' worth of wood and plastic. I'm happy we can do our part to keep a little piece of scientific history out of the museum and in the field."

With reference to calculators with eight-place displays as well as those with 12- and 13-place readouts as compared to the three-place "readout" of slide rules, David F. Siemens, Jr. of Mesa, AZ, observed, "Indeed, current scientific calculators are more precise than the available data." This is a sound observation that reintroduces the entire question of spurious accuracy in technical calculations. It leads one to wonder: how often would the accuracy of an answer that could be obtained using a slide rule be entirely adequate? In the same vein, how much time is spent, that is to say wasted, in making calculations that are more accurate than is warranted by the data or required for the task at hand?

Commenting on the same article, Kevin Dixon-Jackson of Macclesfield, England, wrote, "As a user of both a Faber-Castell 2/83N and a Hewlett-Packard HP-35, I believe that the slide rule wasted less lab time, because, unlike a calculator there was no display to turn upside down to show 'funny' words, nor could you play 'get all the integers using only the top three rows of buttons'. Also, it was a straightedge, a T-square and a reach extender for flicking distant switches and manipulating live electrical wires!" (And he might have added, how much time is spent looking for replacement batteries when those in use run down?)

Another article on slide rules that appeared in the December 2005 issue of *Mechanical Engineering* prompted L. Skip Johnson, Canyon Lake, TX, to write, "In college, I progressed to a 10-inch Dietzgen Log Duplex Deci Trig. I still used the 20-inch K&E as a backup, as in warmer months in Texas, hand sweat would sometimes freeze up the slide (in 1960, there was no air conditioning in most of the engineering classrooms), and without a second slide rule you might not complete the exam. Yes, 'slide rules have earned a permanent place in the hearts and minds of engineers', especially this one."

Have readers of this *Journal* any slide rule memories they'd