The Lost Scales of Unknown Riches[1]

Your eyes can deceive you, don't trust them[2]

It takes something exceptional to excite die-hard collectors. Most of us reach a point when acquiring yet another plastic slide rule is boring and unlikely to enhance our collection. However, this trait has a downside – there are always exceptions and sometimes we only see what we want to see. I still dream of finding a rare slide rule in a jumble sale or discovering something different. Sadly my "discoveries" usually expose how little I know. But on this occasion something genuinely unusual lurked unseen in my collection for years.

Surprises can come in small packages

Most of the slide rules ever made are of the 25 cm/10″ rectilinear variety. Next in popularity are the Pocket sibling versions. But to me the even smaller, typically 10 cm/4″, Lilliput models have always had a strange appeal – possibly because they are the dichotomy of the giant Desktop models. Originally thought of as toys these "tiddlers" have panache and even if horizontally challenged, they still qualify as miniature analogue calculators.

Although rarely shown in their catalogues most major slide rule makers made Lilliput models – e.g. Faber-Castell, Nestler, etc. But tellingly most Lilliput's are attributable to Japanese makers. However, I was caught out by a well-made unassuming specially commissioned Lilliput slide rule from UK maker: *A.G. Thornton*.

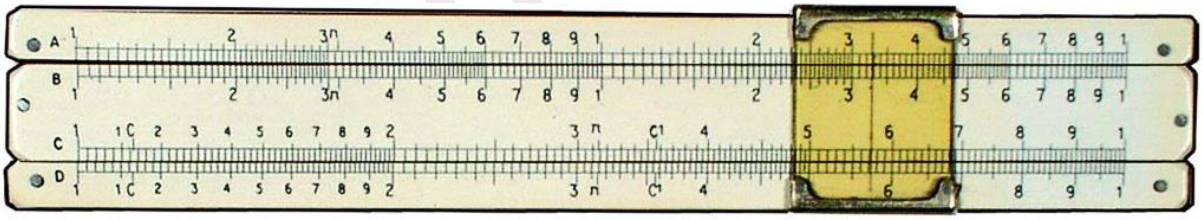

Figure 1. A.G. Thornton made wooden 5″ Lilliput slide rule with a chrome & yellow plastic cursor

Reciprocal illusion

Although unbranded, the tell-tale aluminium pegs used either end for extra secure pinning of the celluloid facings to the mahogany closed frame stock are indisputable proof it was made by *A.G. Thornton*. Instead of a model number "ENGLISH ELECTRIC" and "PAT.APPLN. 304121/38" are stamped into the well of the stock. Untypically for a Thornton made slide rule there is no blind date stamp – just "MADE IN ENGLAND" is also stamped into the well of the stock.

[1] Conjointly published in the UKSRC *Slide Rule Gazette* Issue 17, Autumn 2016.
[2] Jedi master Obi-Wan (Ben) Kenobi's immortal advice to Luke Skywalker in the original *Star Wars* film.

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The original application was made in 1938 and the full patent, **GB520442**, was granted in 1940. This is an aid to dating and as the Lilliput model in Figure 1 carries the patent application number, it must date from the late 1930s. But sadly warranting a patent was not enough to stop me missing something unusual. When originally cataloguing the item I suspect I simply flipped it over and slid the slide out just enough to note the scales on the back. But in doing so I mistook the $\mathbf{B_1}$ and $\mathbf{C_1}$ scale annotations for **BI** and **CI** or the inverse versions of the conventional **B** and **C** scales - i.e. respectively the reciprocal functions: $1/x^2$ and $1/x$.

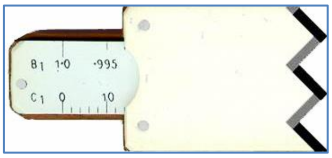

Figure 2. "Optical illusion"

My mistaken cataloguing meant this charming but otherwise unremarkable mini calculator was destined for obscurity. It stayed lurking in a drawer until a fellow collector asked for details of Lilliput models in collections. While preparing an inventory I discovered how I had been fooled by an "optical illusion". In my defence because both the $\mathbf{B_1}$ and **BI** scales run down from 1.0 it was an easy mistake to make. The pair of lost $\mathbf{B_1}$ and $\mathbf{C_1}$ scales was devised by **Albert John Riches** when working at the Stafford works for the UK industrial manufacturer: *The English Electric Company Limited*.

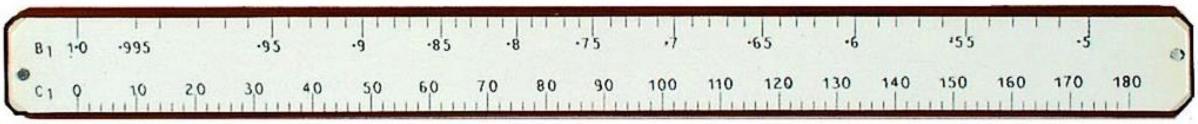

Figure 3. Easily mistaken scales on the back of the slide

The $\mathbf{B_1}$ scale is logarithmic (1.0 - 0.5) but the $\mathbf{C_1}$ scale (0 - 180) is linear. Together they can determine how efficiently power is being used within an electrical system. This is done by calculating the "**Power Factor**" in an alternate current (a.c.) circuit.

Power Factor efficiency

An a.c. system, as the name suggests, uses alternating current – i.e. the polarity or the direction of the flow of electric current continually reverses. The rate it alternates is controlled by the inherent frequency of the system. This is standardised but varies around the world. For example, in Europe it is 50 cycles/second but in the United States of America it is 60 cycles/second. In some countries like Japan, different regions use different frequencies.

But whatever the frequency of an a.c. circuit, electrical power is used efficiently when the current to drive any connected equipment is aligned, as in Figure 4, with the voltage cycle or "electrical potential". However, in practice because of the many motors and other inductive loads most electrical equipment draws current from a circuit with a degree of delay. This means, as in Figure 5, it is no longer ideally aligned with the voltage cycle and expensively draws more current than is strictly needed. The Power Factor (PF) is an industry recognised standard for measuring how efficiently (or not) a piece of equipment is drawing power.

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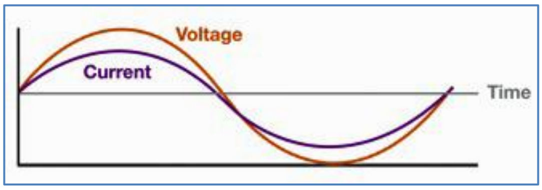

Figure 4. Aligned voltage & current cycles

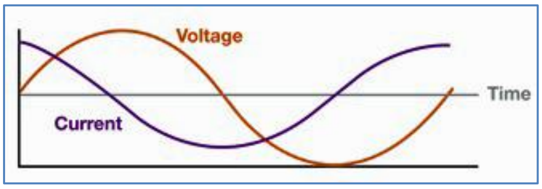

Figure 5. Current cycle slightly delayed

So to be meaningful the PF calculation must take into account the relationship between the various components of electric power in an a.c. circuit. These are:

- **Real (or active) Power (kW)**
  the power in Kilowatts needed (or consumed) to run the equipment
- **Reactive Power (kVAr)**
  the power in Kilovolt-amperes needed to magnetise and start up the equipment
- **Apparent Power (kVA)**
  the combination of real and reactive power in Kilovolt-amperes

Therefore the resulting formula is:

$$\textbf{Power Factor} = \frac{\textbf{Real Power (kW)}}{\textbf{Apparent Power(kVA)}} = \frac{\textbf{kW}}{\sqrt{(kW)^2 + (kVA)^2}}$$

However, the easiest way to understand how the formula works is to consider the ratio of the three components as a triangle.

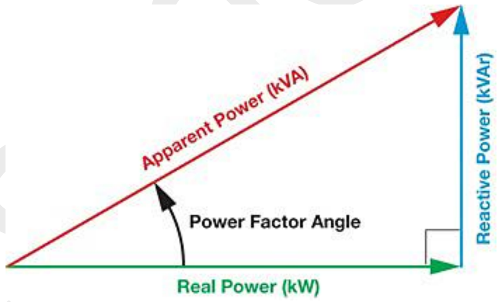

Figure 6. Right-angled triangle showing the PF angle

Albert Riches obviously appreciated this way of showing the relationship and used it to get a patent for his design. The $\mathbf{B_1}$ scale is the **trigonometric cosine function** (Cos x) of the angle shown in Figure 6 - i.e. the **Power Factor Angle**.

Calculating Power Factors

The slide needs reversing in the stock before the **PF** scales can be used. But uncommonly after that calculations using the special $\mathbf{B_1}$ and $\mathbf{C_1}$ scales are fully self-contained. So apart from the right-hand index lines providing arbitrary line up points, the conventional **A** and **D** scales on the upper and lower front face of the stock play no part in any PF calculation. This is reflected in the billing used in a set of instructions for a later version of the mini calculator: *"Combined Slide Rule and Power Factor Calculator"*.

The challenge for any power systems engineer is to get the PF angle as small as possible as any PF less than or greater than 1 means that the circuit's wiring has to carry more current than necessary and therefore additional losses proportional to the current squared will occur in the supply circuits. The $\mathbf{B_1}$ and $\mathbf{C_1}$ scales are for calculating the changes needed to improve the PF for a given load on a power system. For example:

- **What kVAr increase is needed to raise a known PF to given value?**
  Set the known PF of 0.7 on $\mathbf{B_1}$ against the right-hand index line of **A**
  Set cursor hair-line over the desired PF of 0.85 on $\mathbf{B_1}$ as in Figure 7
  Set left-hand index line on $\mathbf{C_1}$ under the cursor hair-line
  Read off $\mathbf{C_1}$ the improvement needed by right-hand index line of **D** as in Figure 8

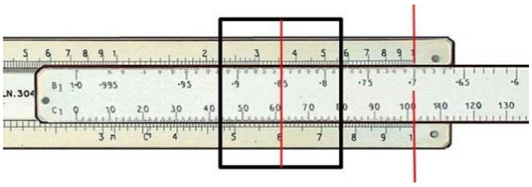

Figure 7. Setting known & desired PF's

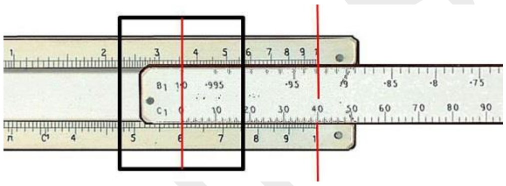

Figure 8. Reset C_1 index line to find %

Answer: *To raise an existing 0.7 PF to 0.85 the* ***kVAr*** *(inductive) needs reducing by 40%.*

To achieve the desired 40% reduction a power system engineer's would normally add suitable capacitance to the circuit. But the worked example shown is simple – reducing the inductive volt-amperes by adding capacitive volt-amperes. In practice both real power and apparent power can be either positive (lagging) or negative (leading) and power system engineers need to resolve such problems for circuits with multiple kW loads of different magnitude and PF's. Such calculations are much more complex, requiring many interim steps, but all can be done easily using just the $\mathbf{B_1}$ and $\mathbf{C_1}$ scales.

Who was Albert Riches?

Sadly it is impossible to put a face to the name. He is no known relation of *UKSRC* member and renowned collector: David M Riches. But genealogy records show he was born in London on 5th November 1899. He married Maud nee Gillam in 1924. Census records for the West Midlands area of the UK confirm that by this time he was living in Stafford. From the bibliographic data in the patent application it is clear he

Figure 9. Long-service Awards Ceremony

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was working for the *English Electrical Co*. in their Stafford Works in the late 1930s. But he probably joined the company in the early 1920s as he was a loyal long-serving company employee. Figure 9 shows an award ceremony held in Stafford on 23rd December, 1963. The Works Manager, Mr J.R. Scully (front row, 3rd from the left), presented the awards to *English Electric* employees who had worked for the company for 40 years or more. Sadly the Award Ceremony programme only lists recipients alphabetically. Mr A.J. Riches is listed but unfortunately as the recipients are unlikely to have lined up alphabetically for the photograph, it is unknown which of the award winners in the photograph he is. After retirement he stayed in Stafford. He died in 1975.

Was it useful?

Surprisingly the **B_1** and **C_1** scales are unique to the *English Electric* Lilliput. No other slide rule exists with such **PF** scales. The closest are slide rules with a specially chosen scale layout to make the solving of trigonometric problems easier – e.g. the Trigonometry Calculator by UK maker *Fearns*. This could suggest such scales and PF calculations were of little use to electrical professionals. However, it is more a case of a missed opportunity.

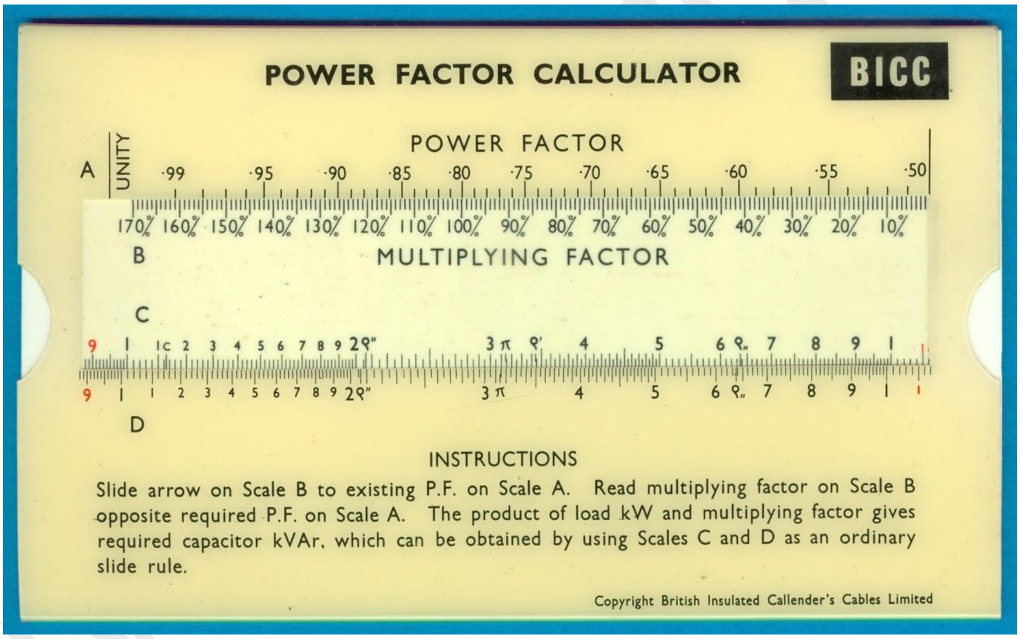

Figure 10. Example of a PF Calculator specialist slide chart

Notably various specialist slide charts like the one shown from the 1960s were marketed for solving PF calculations. They did what the **B_1** and **C_1** scales could do and are proof that the electrical industry clearly needed and used PF calculation aids. Moreover, “Principal Strategist in Network Strategies” for *ElectraNet SA* and leading expert on Electro slide rules, Robert Adams, has assured me he would, with hindsight, include a pair of **B_1** and **C_1** scales on his theoretical “ideal” Electro slide rule.

But was it a success?

No production numbers are known for the original *English Electric* Lilliput but it was more than a specially commissioned "one off" slide rule. Two decades after producing an unbranded version, *A.G. Thornton/PIC* issued an almost identical branded plastic version.

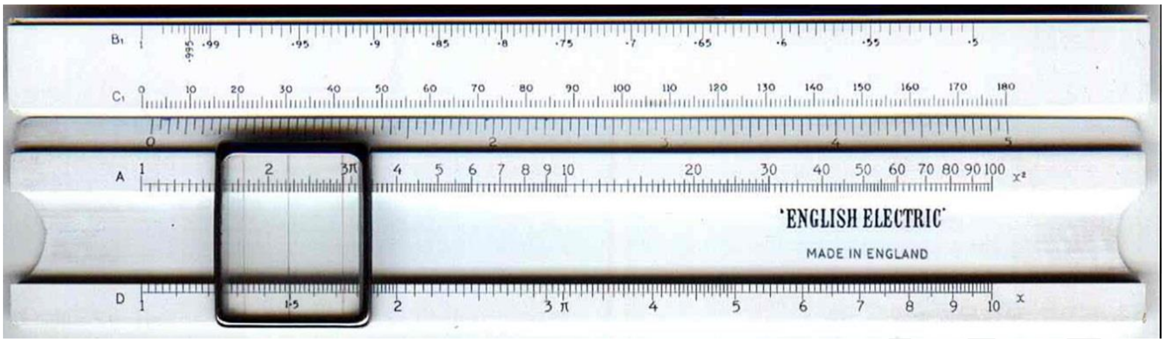

Figure 11. Later A.G. Thornton/PIC plastic 5″ Lilliput slide rule with slide reversed

Again there is no model number but apart from a top bevelled edge inch scale and a PIC "pickaxe" logo on the front of the slide, the scale layout is identical. Mysteriously on this blind date-stamped version from 1959, reference to the Riches patent has been dropped. There is also no mention of it in the accompanying instructions. This could indicate that sometime in intervening years *English Electric* stopped paying the annual patent renewal fees. What is more surprising is that *Thornton/PIC* did not use a wider body on this later version. Repositioning the **PF** scales in between the **B** and **C** scales on the front of the slide would have saved the need to reverse the slide. Revealingly such a layout improvement is even suggested by Riches in the patent application. But the bigger mystery has to be why such **PF** scales were never part of any Electro slide rule. For most leading makers the specialist type of slide rule they all had in their product line was one or more ubiquitous Electro models. On such models electrical engineers, if they were lucky, could use the rarely included Pythagorean function $\sqrt{(1-(0.1x)^2)}$ or **P** scale for such calculations. But compared with the elegant simplicity of using the **PF** scales, doing the same calculations with the **P** scale was a clumsy and awkward.

Ironically now, eight decades later, the *English Electric* Lilliput PF slide rule would probably be a "best-seller". Carbon dioxide emissions as the cause of global warming were only confirmed in 1987. So these days limiting the burning of fossil fuels and energy efficiency is as much a personal as a business challenge. In electrical engineering the PF is still the industry recognised standard for measuring how efficiently a piece of equipment is drawing power. Although these days an extra way of measuring efficiency of an a.c. circuit is to compare power input (watts) to power output (watts). What has changed is that now utility companies will often fine or charge a higher cost to industrial or commercial electricity users if their systems are drawing power below a set PF limit. Typically the limit is set at a PF of **0.9** or **0.95**. The required automatic PF efficiency monitoring is part of the modern digital electricity meters issued to industrial or commercial users.

Currently such fines or surcharges are not levied on residential electricity users – but it might come. There is already pressure for suppliers of modern electrical devices and household electrical white goods to comply with the *Energy Star*™ standard. This internationally adopted stringent rating system originated in the US. It helps consumers judge how much, on average, it will cost to run a consumer appliance for a year. Therefore it is a measure of an appliance's energy consumption rather than its PF rating – the lower the consumption the more stars an appliance gets. However, since 1995 there is also the European **EN 61000-3-2** standard. Essentially it stipulates the power quality (for harmonics) electrical and electronic equipment should adhere to when connected to public low voltage distribution systems. PF efficiency is part of how the standard defines the quality such equipment needs to meet. It already covers many consumer appliances such as PC's and TV equipment. But outside the European Union national governments can discretionally decide whether to adopt it as a standard or just as a guideline. Had the EN 61000-3-2 standard been around back in the 1930s it would have the undoubtedly raised the sales potential of the *English Electric* Lilliput PF slide rule.

In the 21st century the "green lobby" cannot be ignored. However, the PF efficiency benchmark is not the "silver bullet" many greens are looking for. But it is likely that utility companies will increasingly use PF efficiency to show they are doing their bit and coincidently help them put off having to invest in ever larger transformers and upgraded power cables.

So look out for Lilliput's and especially any with the unique **PF** scales. But the moral of this story must be: *"you never can be sure what you have until you have had a really good look!"*

Postscript - *"In a galaxy far, far away[3]…."*

Or as Obi-wan Kenobi would surely have said to any apprentice Jedi knight: *"do not be misled by the scale of the (un)inverse, it is just the power factor of the force!"*

Acknowledgments and Bibliography

First I need to thank **Armand Chatfield**, son of one the *English Electric* long-service award winners in 1963, for the photograph and background information on the ceremony. But when it comes to electricity my knowledge does not extend much past fitting a plug to a household appliance. So I needed help. Fellow collector and friend, **Bob Adams**, patiently guided me through the technical aspects and made sure everything made electrical engineering sense. I must also thank another fellow collector and friend: **Pete Hopp**. He told me about the later A.G. Thornton/PIC branded version of the *English Electric* Lilliput and magnanimously admitted to also having wrongly catalogued the **PF** scales on his version!

[3] Part of the credit line that crawls up the screen at the start of every *Star Wars* film.

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Fellow collector and UKSRC member, Ian Lodge, kindly provided the genealogy facts for the updated version of this article.

- **Hopp, Peter M**: *“4" or 10 cm. Tiddlers - Calculator or Toy”*, UKSRC Slide Rule Gazette ISSN 1472-0000, Issue 11, Autumn 2010, Pg. 49.

- **Hopp, Peter M**: *“4" or 10-cm Tiddlers (Contd.) - Definitely Calculator!”*, UKSRC Slide Rule Gazette ISSN 1472-0000, Issue 12, Autumn 2011, Pg. 89.

- **English Electric Co. Ltd.:** *“Combined Slide Rule and Power Factor Calculator”*, instruction booklet, c1959.

- **Orange and Rockland Utilities Incorporated:** Power Factor webpage - www.oru.com/energyandsafety/electricdelivery/powerfactor/index.html

- **Chatfield, Armand A:** *“Long Service Presentation, English Electric, Stafford”*, Staffordshire Past Track online archive of material representing the cultural identity and community history of Staffordshire, http://tinyurl.com/jpawor4%20 .

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- **Hoffman, John S:** developer of the Energy Star programme while working for the US Environmental Protection Agency (EPA), 1992 - https://www.energystar.gov/ .

- **International Electrotechnical Commission:** International Standards and Conformity Assessment for all electrical, electronic and related technologies - http://www.iec.ch/index.htm .

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