Early Faber Log-Log Scales

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Introduction

This article is one of a series which details the early slide rules of A.W. Faber-Castell (hereafter referred to as Faber). The series is based on our research collaboration (whimsically named TOMCAT) and the resulting development and analysis of a database of slide rule specimens, as described in [1].

Faber introduced log-log (LL) scales in about 1906, as a facility associated with the "Electro" scales on the new model 368. They chose a different approach to other manufacturers of the time, and continued with this go-it-alone approach until about 1924 when they fell into line with the rest of the industry.

This article sketches the early history of LL slide rules and then explains both the basic method of using LL scales and the reasoning behind Faber's unique approach. It goes on to cover the early history of Faber's model 368 "Electro" and describes its further development. We include some seemingly little-known details that, it would appear, have not previously been published.

Origin of the LL idea

The idea behind LL slide rule scales came from the English physician Peter Roget in 1815 [2]. This is the same Roget who devised the eponymous "Thesaurus" of English words. As Florian Cajori explains, "[t]he instrument was constructed by Rooker of Little Queen Street, London … While, as Roget points out, questions relating to increase in population and the calculation of chances may be facilitated by this instrument, it is readily seen that its application would be limited. This fact explains why this rule was forgotten, being later re-invented as the demand for it in thermodynamic, electrical and other physical calculations arose." ([3] pages 48-49). Roget's design had an LL base of 10 (more about LL bases later).

We have seen little further mention of LL scales in the 19th century. Hopp ([4] pages 38 and 64) relates how the makers Rooker and Carey used Roget's design as a basis for their own implementations. It would appear that Captain J.H. Thomson may have been the first to realise, perhaps counterintuitively, that the base of the LL scales need not be the same as that of the main calculating scales on the slide rule, which is of course 10. Otnes [5] provides some details of Thomson's British patent 5540 in 1881 for a "calculating apparatus" with an LL base of about 1.0136, and von Jezierski [6] describes a pioneering example by Dr. J. Perry (LL base 2.51) which received British patent 23,236 in 1901. Perry's slide rule is mentioned by Hopp ([4] page 255) as being available in 1901, and the design was adopted by Nestler in about 1908.

John Davis & Son (Derby) Ltd. made a significant move in 1901. Already slide rule manufacturers of some note (Barnes [7]), they took the decision to market an LL slide rule from a design by Lt. Col. C. Dunlop and C.S. Jackson, and this was introduced in 1905 with an LL base of 2. As related by Wyman and Otnes [8], this slide rule was actually manufactured by Dennert and Pape (D&P) with whom John Davis had a close relationship until WW1. D&P introduced their own LL slide rule (Hopp [4] page 158) also in 1905: this too had an LL base of 2. Faber introduced their first LL model in about 1906 (more details to follow), thus completing the trio of notable manufacturers entering the LL field at this time. Keufell and Esser's first LL model appeared in 1909 [9, 10], with an LL base of *e* (2.7183). From this time onwards (noting that the above list of early makers is certainly not complete), many other manufacturers introduced LL rules into their repertoire, and *e* gradually became the LL base of choice.

Explanation of the LL idea

In this section we will confine ourselves to the basic principles of LL scales, as required in order to understand early Faber LL slide rules. With LL slide rules, numbers may be raised to a power P (also known as involution) or taken to a root R (evolution) with ease. The numbers involved, including P and R, may be integers or non-integers within a wide range of values, the range being dependent on the chosen LL base(s).

LL scales have values which are simply the logarithms of the numbers on the normal slide rule calculating scales which in the context of LL scales can be called the Z scales. On a slide rule, values on both sets of scales are represented as distances from an origin, the value 0.

The LL scale may appear in just about any position on a slide rule. An article by Paulin [11] gives a flavour for this situation. There is no standard for this: anywhere on the stock, or anywhere on the slide, may be used as the site for the LL scale. The golden rule, however, is that if this site is on the stock then it must work in conjunction with a Z scale on the slide (usually C, which we will call X), and vice versa (usually working with D as X), because the LL and X scales work together in calculations (even though their logarithmic bases are probably quite different as already shown) just like the C and D scales work in normal operation.

The decimal points of LL numbers are fixed, not variable. So, for example, the LL of 20 (our shorthand for which is LL20) is, to base 10, log (1.3010) or 0.1143, and bears little relation to LL200 or LL2. The implication of this is that the LL scale must cover the whole range of numbers to be used on a slide rule, unlike the Z scales where the range from 1 to 10 can accommodate numbers that are as small or as large as you like. As a result the typical LL scale is spread over two or more physical sub-scales.

As is well known, adding the logarithms of two numbers gives the log of the product of the two numbers. The resultant product is simply the antilog of this. But can you usefully multiply logarithms? Yes you can, in the following way.

Multiplying the log of a number, for example log (12), by another number, for example 2, gives the log of (12 raised to the power 2). So log (12) * 2 gives log (144). Not all such sums are as simple as this, so slide rules can usefully be employed. For this to work on an LL slide rule to enable the multiplication to be treated as an addition, we need to take logs again and this expression becomes (using logs to the base 10):

$$\log(\log(12)) + \log(2) = \log(\log(144))$$
or $$\log(1.079) + 0.301 = \log(2.158)$$
or $$0.033 + 0.301 = 0.334$$

This calculation is possible, if rather tedious, with log tables. We will see shortly how easy it is with an LL slide rule. But before proceeding with a worked example we must note the following attributes of LL scales.

Initially, remember that the expression:

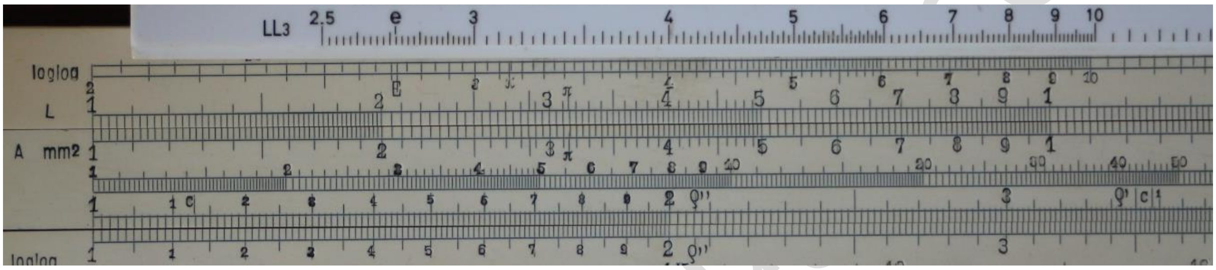
$$\log_B(N) = x$$
implies $$B^x = N$$

From which it is easily seen that for any base B, the log of that base is 1 and the log of 1 is 0.

The common 25 cm single-decade log scale design for Z scales uses a base of 10 and has 1 as its lowest value with 10 as its highest value. Log (1) = 0 for any base of logarithms, so 1 provides a convenient origin point for calculations. When the base is 10 then log (10) = 1. The 25 cm log (Z) scales are divided accordingly. So 25 cm represents a range of 1 (1 minus 0) unit. Each number on the Z scale is the appropriate distance from the origin (0), so 2, for example, is represented by a number log (2) * 250 mm, or 0.301 * 250 or 75.25 mm from the origin.

Turning to the LL scale, we need to know the origin from which to measure the position of a number on the scale. Here we benefit from the behaviour of logarithms shown above: **for any base, log (base) = 1 and log (1) (i.e. LL (base)) = 0.** For any base we may choose for the LL scale, the number log (1) has the value 0 and so can be used conveniently as the LL origin. On LL slide rules, it is normal to align the value of the base on the LL scale with 1 on the Z scales, as both equate to 0. Choosing 10 as a convenient LL base for our example, LL10 is 0. The number 20 has a log of 1.3010 and a log-log of 0.11428, which must appear at 0.11428 * 250 = 28.5749 mm from the origin. But if we choose *e* as our LL base (for which we can probably measure lengths on our common LL slide rule), our origin is 0 as before, LL*e*. 10 is about 90.5 mm from the origin, and 20 is about 119 mm. 119 – 90.5 is about 28.5 mm, as before. In fact, for all LL slide rules with an X scale as a single-decade 25.0 cm example, whatever their LL bases, any given numbers on their LL scales are always the same distance apart.

The composite graphic in shows this effect pictorially. At the top is a section of a slide having an LL scale with base *e*, coloured white. Immediately below it is an LL scale of another slide rule, with base 2, in a greyer shade, and at the bottom is this rule's D scale. The two LL scales are aligned at *e*/E to demonstrate their similarity, although this is not perfect because the D scales of the two models have slightly different lengths.



As there is some variation on slide rules concerning the labelling of LL scales and sub-scales (sometimes they are not labelled at all) then in this article we will use "LLtop" to refer to the high-end LL sub-scale, easily recognisable by increasingly closely packed numbers reaching anywhere from 1000 upwards at the top end. To the sub-scale with the next-smaller set of numbers we will give the label LLpret (for "pre-top"). These are the only LL sub-scales that are relevant to the Faber Electro slide rules.

Using the LL scales

In order to get a feel for using the LL numbers, we will begin by performing the above calculation, $12^2 = 144$, on the slide rule. We use the standard slide rule multiplication technique. The number to be operated on, 12, must lie on the LL scale, and the "power", 2, on the X scale. So use the cursor hairline to align 12 (not 1.2 or 120!) on the LL scale (probably the LLtop sub-scale on your model) with X1. Then, aligned with X2, 144 appears on LLtop. 144 is the desired answer.

Keeping the slide in the same position, notice how X3 matches with 123 on the LL scale, and X4 with 124 (close to 2*104). But X5 is off the end of the LL scale on most side rules. 125 (not an everyday number) is too large to be calculated in this way on the slide rule. But you can examine smaller numbers, by aligning X10 with LL12 and looking under X5. This point on LLtop is to the left of 12, and so must be less than 12. What is it? In this situation we need a little judgement. We must mentally divide the X-scale numbers by 10, so 5 becomes 0.5, and the corresponding LL scale number (3.46) is seen to be 12 raised to the power 0.5, or the square root of 12.

Another common scale-overflow situation occurs when raising 2 (usually found near the right of LLpret) to a power of 2 or greater. Use X10 again, aligning it with LLpret2, and remember that LLtop is simply an extension of LLpret. So now, over any X number you will see the corresponding power of 2 on LLtop. Aligned with X5 you see 32 (25) on LLtop, whereas on LLpret you'll find 1.414 which is the square root, the 0.5th power, of 2.

Here is a tip. Keep an eye open for utilising the much less crowded LLpret scale instead of LLtop for greater resolution whenever we can. The range of this scale typically encompasses numbers from about 1.1 to 3.0.

Compare 162 on LLtop with 1.62 * 102 on LLpret for example. Finding the 5th power of 12, as we tried to do earlier on LLtop, defeated us. We should treat 125 as 1.25 * 105 on LLpret to get 2.49 * 105 (approximately). A variety of similar mathematical operations may be used to obtain other off-the-scale values.

Although the C or D scale is often used in conjunction with the LL scale for calculations (we call this scale X here), we must not forget that another scale (D or C) is identical to it. Moreover, this third scale, which we will call Y, will often be fixed in alignment with the LL scale. In summary, **X represents the C or D scale used in LL calculations, Y represents the *other* C or D scale, and Z represents C and D scales generically.**

If that is the case on your slide rule, the base of the LL scale will be aligned to Y1, as $\log_B B$ is 1: see above. But if not, the LL base is normally marked on the LL scale (usually towards the left end of LLtop) and you can align it with X1 and then treat X1 as Y1. And naturally, because LLpret and LLtop are consecutive, the base also sits at the high end of LLpret, at Y10 (=Y1 on LLtop; see above). Now look at the LLtop number opposite Y2. It is the square of the base. And so on. The base appears on the LL scale and so behaves just like any other number, except that in many cases the alignment of the LL base with Y1 is automatic rather than the result of a manual operation. So, opposite Y10 is the tenth power of the LL base. Look at this number on LLtop. If your base is *e*, this will be approximately 2.2×10^4, which is a convenient number for many applications. But if the LL base is 10, as it was in Roget's design, this number would be 10^{10}, which is virtually impossible to handle for most applications. Perhaps that is why Roget's idea didn't catch on for a while. Similarly, with an LL base of 2, the top number on the LL scale is only 1024 - not always adequate. Consequently an LL base is usually chosen to be or be close to *e* and not 10 or 2. An additional reason for choosing *e* precisely is that, unlike 2.623 or 2.891 for example, it is a very particular number and many users will benefit from having a table of powers of *e* at their fingertips (using scale Y) without needing to adjust the slide to use scale X. And conversely of course, setting the cursor to an LL value N gives ln (N) on scale Y so ln (25) = 3.22 for example.

To find roots, we carry out these operations in reverse, as we do with straightforward slide rule division. For example, another way to find the square root of 12 is to align LL12 with X2, and find 3.46 on LLtop under X1. But this is as far as we wish to go with worked examples, although it is recommended that you "play" with your LL slide rule for a while, making up calculations until you are confident that you understand the principles involved. For more information, consult your slide rule's instruction manual or other such documents.

Faber's initial implementation: 1 – design and development

UK 10,230	1903	Log-log scales and a cursor to index them
DRGM 197 393	1903	Slide rule with scales on a bevelled edge and a cursor extension for reading them, 368
DRGM 247 514	1905	Slide rule with an extension to the slide for reading off values, 368
DRGM 271 169	1906	Side flanges close to slide *(we assume that this DRGM also covers the hook cursor, but this is not explicit in the title). See text.*

Table 1. Faber's LL-related Design Registrations (German DRGMs: English translations taken from Holland [12]) and a British Patent

Now we turn to Faber's model 368. The first clue we have for dating the model 368 is the UK patent from 1903-4 (see table 1). It describes two LL scales on the top bevelled edge of the slide rule containing "… the numbers from 1.1 up to 100,000 … arranged in two parallel rows … the lower row containing the numbers from 1.1 to 2.9 and the upper row the numbers 2.9 to 100,000" which are read by a specially-modified cursor (Figures 1 and 2). This critical arrangement of the two LL scales, which allowed them both to be read by one small cursor extension, was to remain a feature of Faber's model 368 and we will refer to it as the "LL Grid". There is no mention of bases for the LL scales in the patent. Perhaps these were not yet finalised in the design, but as will become clear the bases of the two rows must be different. The Date of Application for this patent is 5th May 1903 and it was accepted on 17th March 1904. We believe that this is the UK equivalent of the German DRGM 197393 (see Table 1).

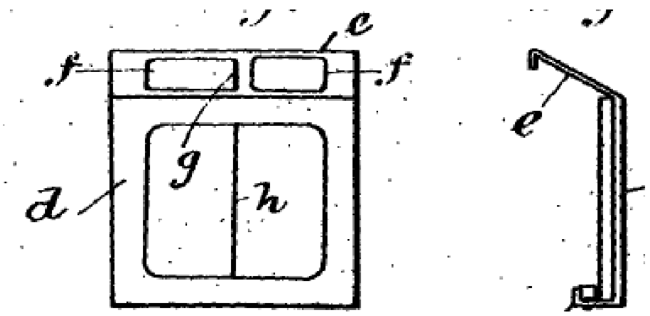


Figure 1: The cursor as drawn in the 1903 patent UK 10,230. "e" is the extension for reading the LL scale. "g" marks the edge against which the LL scale is read. "h" is the hairline.

The grid (with LLpret lying below LLtop, though never labelled on the model 368) is designed to protrude beyond both ends of C and D scales, as shown in figure 3. This is an efficient use of precious space at the ends of the slide rule, which in turn allows the LL scale to extend to 100,000 compared to about 22,000 [9] on an equivalent scale with a base of *e* and no C/D scale extensions. The LL scale operates in conjunction with the C scale, which can of course slide so as to cover all parts of the longer LL sub-scales. Choosing two 2-digit numbers (1.1 and 2.9) for the aligned left-hand ends of the grid sub-scales allowed the relative positioning of the two sub-scales to be achieved very accurately. We already know that the two sub-scales will match accurately whatever their bases. With these matters attended to, all that remained to be determined was the relative positioning of the D and LL scales. This positioning would then determine the values of the two LL bases, which were simply the values of LLpret and LLtop which aligned with D10 and D1 respectively. These bases are generally reckoned to be 2.74 and 3.08 [11] (both are close to the value *e*) but Günter Kugel [14] has calculated them more accurately.

It seems Faber simply positioned the grid roughly symmetrically with respect to the D scale, possibly for aesthetic reasons or perhaps to put the scales centrally in the field of view of the user. Both criteria probably played a part, but the resultant determination of bases was not a major consideration. As explained above, the lengths of the LL sub-scales over given ranges are not dependent on the bases. The difference between the two bases, rather than the actual bases themselves, was the critical factor, and this difference relied on not needing to align the end values of the LLpret and LLtop sub-scales to the 10 and 1 values of Z as was necessary when one base was used for the whole of the LL scale.

We suggest that this rule was at least 2 years in development before it was finally released. Holland's release date is 1906 [12] and the TOMCAT date is c1906. TOMCAT provides good evidence that Faber produced no other LL slide rule before 1906. The 1903 Faber Annual Report does not mention the 368 or log-log scales at all.

We don't believe that this version of the cursor was ever put into production, partly because we have never seen one, and partly because there were variations that followed that we also have never seen.

Two series of books by Charles Pickworth are a valuable source of information here, especially considering the loss of the DRGM content (for a summary of our source information, see [1] pages 17-19). What we refer to as **"Faber Pickworth"** was the series researched and described by Rodger Shepherd [13]. They were issued in several editions between 1895 and 1921. Pickworth wrote them for, or in collaboration with, Faber. What we refer to as Pickworth's **"Practical Manual"** was a series of 24 editions lasting 60 years, and were actually called "The Slide Rule - A Practical Manual". Unlike Faber Pickworth they were not Faber-specific. These editions are best dated by their prefaces although we cannot be sure whether these were written before or after other material in the edition.

The 8th edition of Pickworth's Practical Manual, with a preface dated July 1903, was the first edition that contained a section on LL scales and rules. It describes what LL scales are and how to use them, and includes several designs of LL slide rules. In particular he describes the Davis rule, where the LL scales are on a separate slide and are indexed using the D scale. He also describes the scale arrangement by J. Perry where the LL scales

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replace the D scale and are indexed using the C scale. The manual also contains a brief section on Faber's LL rule: "The arrangement adopted by Mr. A. W. Faber comprises a double LL scale, extending from 1.1 to 10^5, which is used in conjunction with the D scale … ". The D is probably an error, intending C, because it implies that the LL scales are on the slide in contradiction to the UK patent. Pickworth does not mention the "bevelled edge" nor any other position for the LL scales, and he does add that the Faber arrangement "has the advantage of leaving the standard form of the rule quite intact, while avoiding the use of a separate slide". We are firmly of the opinion that Faber never had any intention of placing the LL scales on the slide. Note that the term "Electro" is not mentioned, either in the patent, the DRGM, or Pickworth.

Based on our TOMCAT evidence, we also believe that Pickworth was here a little premature. Pickworth was obviously involved with Faber at this time (evidenced by his collaboration in their comprehensive instruction manuals) and must have known they were developing an LL rule, so he included it in this edition although, as it turned out, it took Faber much longer to "perfect" it for sale – about another 2 years or so.

Pickworth must have realised later that he had been overhasty with his inclusion of the Faber LL slide rule in the 8th edition of the Practical Manual before the rule was available. We believe this is evidenced by the fact that he did not include the LL in his 1904 update of his Faber Pickworth (Shepherd's version 3.5, [13]) that Shepherd dated to 1904, as one may have expected if it was available. The fact that it was not in v3.5 we think adds weight to our thinking that the 368 was not yet available in 1904.

The next information that we have on record concerning the 368 is the 1905 DRGM 247514 (see table 1), which is the first evidence we have that Faber was turning its LL rule design into an "Electro" by adding the dynamo/motor and volt scales in the well and so requiring an index on the end of the slide. This evidence is matched by the LL section of the 10th (1906) edition of Pickworth's Practical Manual (the 9th was identical to the 8th regarding the LL section). In this edition Pickworth has re-written his short Faber reference and included a drawing of the 368 (although not explicitly numbered). The Faber section mentions the two scales in the well for electrical calculations with an index on the end of the slide for referencing them, confirming DRGM 247514 although this is not mentioned. There is still no mention of the term "Electro".

Faber's initial implementation: 2 – a possible first release

Pickworth's drawing is interesting for several reasons. His drawings (both in the Practical Manual and the Faber manuals) are nicely detailed and we believe they were made from actual rules or perhaps Faber drawings, and can probably be relied upon as accurate representations – at least at the time they were made. We know they were not always updated in a timely manner (or at all in some cases!). We imagine them to be indicative rather than completely reliable, but here we will use, with caveats, the information they contain about the unconfirmed "first release".

The index end of the slide depicts a solid bevelled "bar" rather than the more familiar two-pronged index. Was this ever produced? We have never seen this in an actual rule, only the two-pronged index, but we wonder if this was the first, very short lived, version? We think it may have been. Pickworth would have re-written this section before the preface in 1906, possibly in 1905 when the 368 may have been first produced like this, and not bothered to update it when it changed after a very short time – the drawing came from something!

The cursor is a "wrap-around" design like the 1903 patent design (where the top flange locates under the back of the top edge of the stock), but it is clearly a different "improved" version. Whereas the 1903 patent design featured a "barred window" to index the LL scales on the top edge, this version features a window with a "tongue" (mentioned in the text) for indexing. Was the barred-window cursor ever produced on a commercial rule? We doubt it, however the tongue version may have been, for the same reasons as the bar-index end to the slide (above). The tongue is a possible precursor to the hook that was to become a regular feature of 368 cursors.

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A 2.9 index mark (further details below) is clearly visible to the left of the D scale, and it must be assumed that there is another such mark at the right-hand end, although there is no mention of them in the text. All we see there is that "…they [the two LL scales] are used in conjunction with the C scale in the manner previously described", though the exact meaning of this is unclear.

The combination of the 2.9 indexes (seen in production), and the early tongue-cursor and bar-index on the slide (not yet seen) implies that this is how the first incarnation of the production rule might have been produced, c1905, although without actual examples we don't know if this configuration was actually commercially available. The inconsistencies in Pickworth's drawings probably reveal as much about Faber's indecisiveness over design issues as about Pickworth's accuracy or inability to "keep up". If readers have or have seen examples of slide rules such as those described here, we would be pleased if they could contact us.

Faber's initial implementation: 3 – first known releases, 368 v0 and v0a

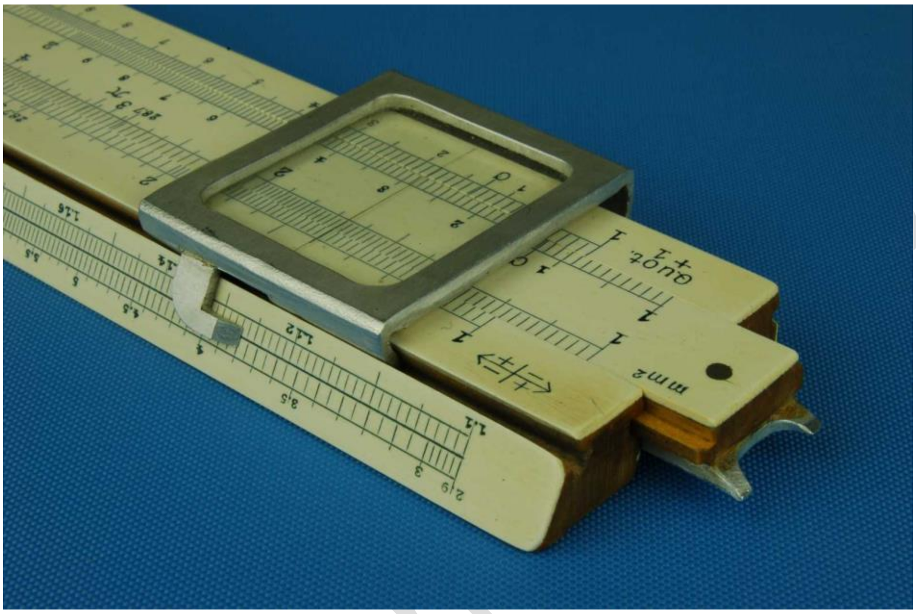

Figure 2. The cursor as found on the 368 version 0a. Note the slide extension/index.

The next item of note is the 1906 DRGM 271169 (see Table 1). This is not well titled, but (implicitly) refers to a new design of cursor with a hook instead of a window to read the top-edge LL scales, and its new flange position cutting into the stock at a deep angle at the meeting of the front and top faces (Figure 2). All 368 examples we know of have this version of the cursor (or its mirror image for the later version with scales on the bottom edge). Critically, they all have the DRGM 271169 number printed on the rule. For this reason we date them from 1906, beginning here with our version 0 (because it precedes Holland's 368 version 1) with a bevelled top edge and right-angled bottom edge. Also, we deduce that DRGM 271169 included the hook cursor in its missing description although its title does not make this clear. All our 368 examples also display the DRGM for the index slide extension, but none have the Electro name.

When an arithmetic operation required the use of just one of the LL grid scales, the 368 operated in an equivalent way to the method described in section "Using the LL scales". But the two different bases required the user to make an adjustment when a calculation operated over both scales in the LL grid. A special mark, labelled "2.9", was placed at each end of the D scale, corresponding to the two occurrences of 2.9 in the grid (see Figure 3). These marks facilitated the alignment of both sub-scales to the 2.9 points, which occurred automatically when the sub-scales aligned to X1 or X10 as on single-base LL slide rules. In order to raise 2 to the power 3 for example on the 368 v0, the user was required to use the following unbelievable improvisation.

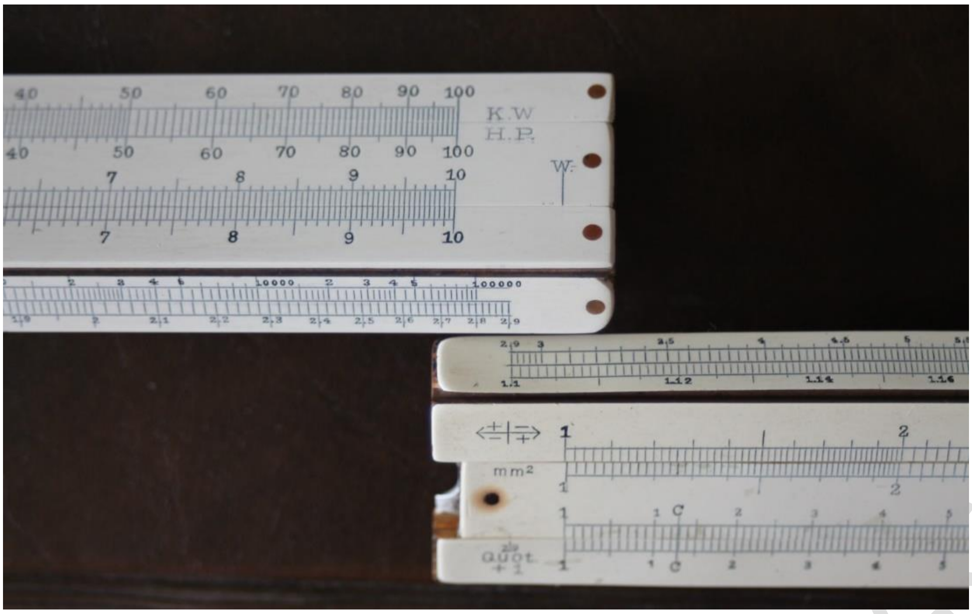

Figure 3. This shows two 368s, angled to display both Z and LL scales. The upper model is a version 2, the lower one is a version 0. Note that the LL points 2.9 are aligned, resulting in a gap between the two sets of Z scales, and see how the W on the upper rule reflects this gap. See the (faint) 2.9 mark left of the v.0 D scale.

Place the cursor's hook by the 2 on LLpret. Then set C1 under the cursor hairline, and having realised that C3 is off the scale, read the resultant value 1.53-and-a-bit on the C scale above the right-hand special 2.9 mark on the D scale. Next, move the slide so that the same 1.53-and-a-bit value on C appears above the left-hand special 2.9 mark on D. Then set the cursor hairline over C3, and the answer 8 appears by the cursor hook on LLtop. We have not seen this arrangement of marks and the method of operation documented anywhere except in a Faber instruction leaflet distributed with the version 0 368's.

Within a short space of time a better method was devised and introduced, probably in response to users' reactions. This method required no more slide rule operations than a single-base model would have needed. Instead of the two 2.9 marks on the D scale, a "W" mark (for "Wechsel", German for "change") was provided near the right-hand end of the C scale (see Figure 3) such that the distance from C1 to W was equal to the length of the LLpret grid-scale from 1.1 to 2.9, or in other words the distance between C10 and W was the difference in length between the LLpret scale and the C scale. This was the first major production change, resulting in a version which we call version 0a which still precedes Holland's version 1. The W mark remained on the 368 to the end of its life and continued for a while on its successor the 378. It was simpler to use; basically the user is required to use the W mark instead of C10 to set or mark the right-hand end of the slide when the user changes or envisages having to change from one grid scale to the other. When the calculation requires the use of both grid scales then we must proceed as in the following example. The calculation of 26 begins by setting the W mark above the LL2 mark (which is on LLpret) using the cursor. Then move the cursor hairline over C6 and the answer, 64, appears beneath the cursor hook on LLtop. To find the 6th root of 64, on the other hand, place the cursor hook over LL64 on LLtop, align C6 under the cursor line and move the cursor line over the W mark. The answer (2) appears on LLpret under the cursor hook.

This design change probably occurred late 1906 or early 1907. Interestingly, there is a version of Faber Pickworth (v4.1) that Shepherd dated to 1907 that shows two drawings of an identical 368 with the hook cursor, the slide index DRGM 247514 and two 2.9 indexes (no W index) BUT the text refers to using the W index for the calculations. We suspect that Pickworth used a "current" drawing, then the rule changed and he updated the text but not the drawing for publication in 1907. This is also evidenced by the fact that this drawing also has DRGM 197393 (1903, LL scales and cursor) printed on it but shows a hook cursor! We take this as being a drawing from a rule after the hook cursor was implemented but before its DRGM 271169 (1906) was registered, and after the tongue cursor and therefore early 1906. This is the only place we have ever seen the early 1903 DRGM – never on a rule, our examples are too late - and in no other drawings. We think Faber did not renew this 1903 DRGM after 3 years as it was superseded by the improved design of the hook cursor, whose design was then registered with the DRGM in 1906. The drawing also shows the more familiar "pronged" slide index as in Figures 2 and 4 rather than the "bar" form in the 1906 Practical Manual, indicating that if the bar index was ever produced it was as short-lived as the tongue cursor. Rather jocularly it has been suggested that Faber, as an option, provide a stiff leather glove to protect the user's left hand from the rather sharp prongs on the index.

Faber's next implementations: – 368 v1 and v2

Then comes the second major production change (our and Holland's version 1), later but still in c1907. The rule was lengthened from 28 to 28.5 cm and the bottom edge containing the ruler was bevelled. We will see the reason for this in a moment.

The third major production change (our and Holland's version 2) occurs in c1908 when the LL grid switched to the bottom bevelled edge and the ruler to the top bevelled edge, necessitating the hook cursor becoming a mirror image of its former self (Figure 4). The only reason we can think of for doing this is so that the ruler can be used more easily without turning the rule "upside-down". The change makes no difference to the LL function. If this is the case it is interesting because Faber are still viewing the slide rule as a combination device here (not just slide rule, but straight edge and measuring device as well), as they had been since they started making slide rules, and looking to improve all aspects of its functionality. Indeed, improved ruler function is the only reason we can think of for making the bottom edge bevelled for the rule from v0a to v1.

Version 2 also displays a different arrangement for the markings on the high end of the LLtop scale. Figure 3 shows the new version. The previous version of LLtop showed fewer numbers and fewer divisions after the 100 point. However, the numbers that were there were shown in full (200, 500, 1000) whereas version 2 had 2, 3, 4, 5, 6, 7, 8, 9, and 1000. The extra markings in version 2 were welcomed, we are sure, however these came at a cost. Because of space constraints, the multi-digit numbers over 50 were left-justified to their divisions whereas every other number on the rule was centred to the divisions. This may have caused some confusion, but was obviously preferred because the same arrangement appeared on the later model 378.

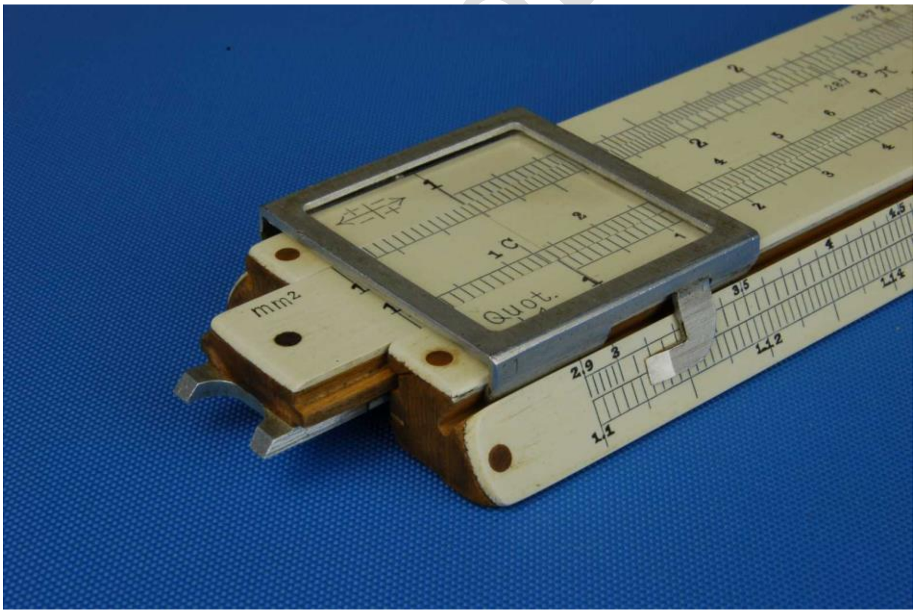

Figure 4. The cursor as found on the 368 version 2.

Here is a summary of 368 LL features, with version numbers and dates of introduction

V0	c1906	LL on top edge, square bottom edge, hooked cursor, 2.9 marks on D scale
V0a	c1906	2.9 marks replaced with W mark on C scale
V1	c1907	bevelled bottom edge
V2	c1908	LL on bottom edge, new LLtop numbering style
V2	c1911	retirement of 368

Dating the transitions between versions

Model-368-related DRGM issues help to determine the timings of the various pre-production activities, with a little help from Pickworth. We don't have any 368s in the TOMCAT collection until v0, obviously. However, for v0, v0a, v1 and v2 the collection provides excellent potential for dating the major transitions, by comparison with the larger and well-studied population of other Faber rules. The reverse is sometimes also true, although care must be taken to avoid circular arguments. We summarise the main points of interest in Table 2. Interestingly, the 368 version changes correspond closely with some of the more general feature changes, many of which are linked to DRP or DRGM issues and have been reliably dated in TOMCAT.

We can see that the introduction of a new 368 version almost always coincides with the dateable introduction of new general features or the removal of old ones. This observation might not hold true in all cases as TOMCAT is only a subset of the overall population of Faber slide rules in the marketplace until 1920, but the "coincidences" do suggest that our subset really is a representative sample.

368 Version	**0**	**0a**	**1**	**2.0**	**2**	**Notes**
number of TOMCAT examples	**4**	**3**	**8**	**1**	**8**	
Matching Features with Dates						
DRGM 271169 (1906) Side flanges close to slide (DRGM stated)	*	*	*	*	*	
DRGM 98350 (1898) Wooden springs in the stock to guide the slide (removed c1908: TOMCAT))	*	*	*	.	.	3
DRGM 296340 (1907) Springy laminated well of the stock	.	.	.	*	*	2
DRGM 306107 (1907) Springy laminate in base plate	.	.	.	*	*	2
Model Number stated (c1908: TOMCAT)	.	.	.	*	*	
DRGM 371190 (1908) Wooden pegs to pin laminated celluloid veneers (DRGM not stated)	.	.	.	*	.	1
DRGM 371190 (1908) As above (DRGM stated)	.	.	.	.	*	1
DRP 206428 (1908) metal inserts (DRP stated)	.	.	.	.	*	
Later changes (up to c1911, based on all TOMCAT evidence)	.	.	.	.	*	4

Table 2: Guides to dating the model 368 transitions (English translations taken from Holland [12])
** = all examples of this model carry this feature*
. = no examples of this model carry this feature

Notes:

1. All the v2s (and no others) have the wooden pegs which were introduced generally by Faber in c1908, and all but one of those have the DRGM 371190 stated on them. Since this odd one (which we designate as a v2.0: at the time, the DRGM either hadn't been applied for or granted) shares other early general design features which later changed, it seems logical to assume that it came before the 1908 DRGM, but as there is only one out of nine v2 examples, probably only just before. Hence we date the change from v1 to v2 to c1908 (before the DRGM which we don't know exactly when in 1908 this was granted), and this then allows a bit of time for the seven v0 examples (with the 1906 DRGM) and eight v1 examples before the change to v2. Since we have a similar number of v0 and v1 examples, we set the v0 to v1 change as c1907.

2. We don't have any details of the springy laminate DRGMs and these DRGMs have never appeared on any examples that we have seen, so we don't really know exactly how they fit.

3. Some other models such as the 363 and 367 continue to have both slide springs and a celluloid sprung stock (springy laminate) for a couple more years before they are removed.

4. There are no changes to the v2 in its life from c1908 to c1910-11 other than the removal of the "QUOT +1"/"PROD -1" printing and the ± arrow mnemonics on the left and right ends of the front face.

Further Faber development

The period c1910-11 marked the end of the 368 and the introduction of its successor the 378. Holland [12] puts the end of the 368 v2 at 1912 and the introduction of the 378 in 1908, indicating that there was a definite period of overlap. Our own researches agree with the overlap but question the exact timings.

With the 378, Faber had a significant re-design of its Electro model, reverting back to the more traditional bevelled top edge and perpendicular bottom edge. The two sub-scales of the LL grid were retained but separated, LLpret being placed above the A scale on the front face and LLtop below the D scale. This necessitated widening the front face (from approx. 27 to 32mm) to accommodate them (We think this is the first significant width increase of a Faber 25cm scale rule). Faber also increased the overall length from 28.5 to 29.5cm. The cursor became a "normal" one as the hook was no longer necessary, but the bases of the LL scale did not change and so the necessary "W" index on the C scale remained.

Currently in the TOMCAT database we have nine 368v2's, three 378's before steel sprung stocks and the change to "Castell", and five 378's with steel sprung stocks and "Castell". Our date ranges for these are c1908-11 for the 368 v2's, c1910-13 for the early 378's, and c1914-20 for the later 378's. Our sample sizes are not large and therefore we have turned to other sources to confirm or refine our dating, and this dating survey forms the bulk of this section. 1920 represents the end-point of TOMCAT, and not the end of the 378.

The 378 initially had a celluloid sprung stock putting it before the introduction of the steel sprung stock DRGM 452965 (1911, "Connecting frame for laminated steel floor" [12]) and DRGM 522689 (1912, "Springy laminated floor" [12]), although these DRGMs were never printed on the rules. Interestingly, despite the celluloid sprung stock, slide springs were re-introduced for this model until the celluloid sprung stock was replaced with the steel sprung version. Possibly Faber felt this to be necessary because of the increased width of the rule and limited movement of the celluloid sprung stock.

The first edition of Pickworth's Practical Manual to show the 378 (with celluloid sprung stock) was edition 12 (preface December 1910), so it was either available or soon-to-be-available at that time. His Faber manual v5.2 (c1910-12, Shepherd), also shows the 378 but NOT the 368 in the catalogue pages. Interestingly the drawings between the two publications are different. The slides and cursors are in different places. Faber shows wood pegs where Practical doesn't; Practical shows Quot/Prod and ± arrows where Faber doesn't, and the slide index ends are different (Practical shows "stubs" where Faber shows a larger "U" shape). We suspect there were tweaks to the 378 after its release, but that is beyond the scope of this article.

There is a German price list (without "Castell") actually with a printed date of 1913 that has the 378 but no 368 so it appears that the 368 had definitely gone by then. 1913 was also the year when Faber began adding "Castell" to the brand on the slide rules [12] (and we have no example of a 368 with "Castell".) We also have no 368s with a steel sprung stock. However, Faber Pickworth 6.1, confidently dated to 1913 by Shepherd, has "Castell" and steel sprung stocks mentioned as well as the 378.

It is likely then that the 378 was introduced before 1912 (steel sprung stock DRGMs) but how much before? Was there overlap with the 368? In theory the 378 could have appeared any time after the celluloid sprung stock and wood pegs c1908, but that was about the time that the 368 v2 was introduced, and we think this

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unlikely. First of all, Faber had just re-vamped the 368 and it is unlikely they would be developing a completely new LL rule for release at the same time or shortly after. We suspect the 378 would have taken a little time to develop after the 368 v2 was introduced. Pickworth then updated Practical Manual in c1910 and the 378 was launched in c1910 or perhaps early 1911.

There is a catalogue (that on the ARC site [17] is dated to 1910 but it is not clear how) that shows both the 368 and 378. This is the only place we have seen the two listed together, but is proof that they did co-exist at least for a short time. This catalogue is certainly 1909 or later based on the DRGMs it contains and before steel sprung stocks. This catalogue also mentions that both the 368 and 378 are available with a digit registering cursor upgrade.

Based on the evidence provided here, we think that the 378 was introduced c1910 and the cross-over existed for a year or so with the 368 being retired c1911.

Finally the model 379, a pocket-sized, 12.5cm scale version of the 378 with the same scale layout, was introduced in 1913 [12]). In fact this positioning of the LL scales remained on all single-sided models of this type until Faber ceased slide rule production c1977. Other models such as the DISPONENT series for businessmen/managers (with an LL scale starting at 1.01 for interest rate calculations) which became available later had a variety of LL scale positions.

Faber joins the mainstream

The only significant later changes occurred in c1924 [12]. The LL scales of the 378 and 379 were re-based to use the 1 and 10 index ends of the C scale, making the W index mark redundant. This also saw the end of Faber's innovative two-base configuration which was replaced by what was by then the industry standard LL base of e after a lifetime of some eighteen years.

Conclusion

We have seen no examples of electrical calculations in the model 368 and 378 literature that use LL scales. It seems that Bob Adams [16] was accurate with his summary which we present here:

"Although the specialty scales of elektro rules provided answers to some common problems within the industry, these problems were in themselves trivial, and could be handled by simple calculation with the standard Rietz or Darmstadt rules. Then why were these rules ubiquitous and produced right to the end of the slide rule era? We have no answer to this question, except to add that maybe the simple Rietz layout with the addition of a couple of LL scales produced an inexpensive and efficient rule that many people were comfortable with."

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