How did A.W. Faber-Castell Mark their 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, by Colin Tombeur and myself, is based on our research collaboration and the resulting development and analysis of a database of slide rule specimens, as described in [1]. Here, I consider the numeric scales on Faber slide rules from three angles: what forms they took, the dating of the changes, and how they were produced. The time period covered by this investigation runs from the start of Faber slide rule production in 1892 [2] to the time (1920) when dating information appeared on the rules themselves [7].

My Nomenclature

Slide rule scales contain information of two main types. There are lines, which are the means of calculating, and there is text which provides other information such as the numerical values of the lines, the maker's name, etc. Examples of each are shown in illustrations throughout this article.

Scale lines fall into two categories. Some run the length of the rule, and were used in the construction by hand of the other lines as well as by end users. These attract various names, for example gauge lines, limit lines, embellishment lines, lateral lines, and **railway tracks** or simply **tracks** (my choices here). These tracks may consist of a single or a double line. Alternatively there may be no tracks: such examples are described as **plain**. The other scale lines, at right angles to the railway tracks, divide the scale into sections, logarithmically or otherwise. These are referred to as graduations, division lines, marks, **divisions** (my choice), etc.

*The **text**ual information also falls into two categories. The first type, always present, identifies the **numerical values** of the divisions. Others of an **alphanumerical** nature provide additional information such as the maker's name, the meanings of the scales, and gauge mark identifiers.*

Divisions have different lengths. The main calculating scales (ABCD) typically have divisions of three lengths. For example, where railway tracks exist all divisions run up to the railway tracks: where the tracks are double lines some stop at the first track while others go on to the second track. Which ones go where is almost an industry-wide standard for scales of a particular length. Usually, some divisions project beyond the tracks: I will call these extra bits **"ticks"**, and these display considerable variation. For example, sometimes ticks are used to emphasise the major divisions of the scale, whereas at other times the lesser intervals are ticked (for example, 4.5 may be ticked when 4 has no tick). These different styles of tick can be used for dating purposes. Note that by definition ticks only occur where there are railway tracks.

The Appearance of the Scales

I will concentrate here on the principal calculating scales which are found on almost all of our specimen slide rules, namely the ABCD scale arrangement introduced by Amédée Mannheim in 1851 [2], and so provide a near-universal means of dating Faber slide rules before they were date stamped. Our database enables the development of the various markings on Faber slide rules to be examined in detail. They reveal interesting information regarding the application of these markings as well as the years when key changes in the appearance of the scales took place. I will present these changes later in the article in a chronological sequence. This sequence subdivides naturally into several **groups** of slide rules, those in each group displaying the same set of scale characteristics. These groups usually coincide with changes in other slide rule features which are covered elsewhere in the series of articles. Note that the groups defined in this article relate only to this article and not to any other article in the series.

Because our collection of specimens consists mainly of slide rules with scales having a length of 25 cm, I will concentrate on this type of slide rule as providing all of the evidence to be used.

Chronology

Colin and I have investigated a large number of slide rule features, which has enabled us to date slide rules with, we believe, a useful degree of correctness and accuracy. Scale features as discussed in this article do not provide much chronological evidence in themselves, partly because the changes are not well-documented and partly because they appear to follow no meaningful pattern. The timings of the changes to the scales has in fact been deduced mainly by obvious links between scale features and changes to various other features, most of which can be dated [5]. Nevertheless, the dating evidenced by the scales does provide a conveniently simple overall chronology which serves as a useful introduction to the subject, so justifying this article, and which will be followed by more in-depth articles in this series.

Several general factors affecting the chronology of the scales which cut across the groups should be noted. Firstly, slide rules with celluloid scales were developed much faster than those where the scales are marked directly on the wooden surfaces. The more leisurely development of the all-wood rules leads to cases with a mixture of "old" and "new" characteristics, even in one case where the top cursor groove is in the "new" position while the bottom groove is of the "old" style. The rarity of such rules in our database supports the idea of a more leisurely and perhaps less structured development than that followed by celluloid-faced rules: only 11 all-wood rules occur out of a total of 182 dated from the introduction of celluloid facings in 1895 [8] to the end of our period.

Secondly, from about the year 1899, Faber began to develop two parallel series of slide rules, displaying certain digits on the scales differently. For example, the original "with decimal" rules display the numbers 1.1, 1.2, 1.3 etc. on the ABCD scales, whereas the newly-introduced "no decimal" rules display these numbers simply as 1, 2, 3 etc. Compare the slide rules shown in figure 5 to see more complete differences. I will have occasion later to refer to each of these two sets separately.

The third such situation arose when Faber offered users an option of plain scales without railway tracks, where their normal scales had these tracks (group 2 onwards). Our evidence suggests strongly that this option existed only for slide rules destined for sale in the USA, which were marked "MADE IN GERMANY". All 7 of our specimens that lacked tracks were found in the MADE IN GERMANY group.

Production of Scales

Because slide rule scales can reveal certain information about methods of manufacture, this article touches upon the methods of applying the scales to the slide rule surfaces. As slide rule manufacturers were notoriously secretive about the production methods they used, in particular for producing the scales [4], this section is largely speculative. My methodology relies on the fact that manual methods lead to end products with random variations in appearance, whereas some sort of automation shows itself in a much more regular appearance, or systematic differences from one slide rule to another.

The scales on Faber's early slide rules were printed without incisions, using a process (the details of which are not known) that simply deposited ink on the surface of the slide rule material instead of incising or cutting the surface with a knife, as was normal in many other areas of measuring rule and slide rule production. Incised scales were introduced on Faber slide rules in group 5 (see below).

I will deal first with the numeric component of the scales. Initially, numbers were printed by hand on the surface of the slide rule. For each number an individual "stamp", with the appropriate character at the business end, was used to print the character on the rule. Some variation in the positioning of the numbers can be clearly seen, which does not affect the use of the slide rule. Evidence suggests that hand-printed numbers were created one digit at a time, so that 20 for example was printed with a 2 punch and a 0 punch,

often poorly aligned. Punches with multiple characters were used for special purposes, such as the A.W.FABER logo and messages such as MADE IN BAVARIA. These were usually incised rather than surface-printed.

From group 5 onwards, the use of number templates was apparent. Think of a template much like a line of type. They enabled the numbers for a particular scale to be printed in one operation, and so made a clear improvement to the appearance of the rules as well as the speed of production. In a large company such as Faber there would have been several templates for each scale, identical except possibly for subtle accidental differences, to enable higher rates of production to be achieved. These accidental differences, several of which are mentioned below, could have created noticeable effects on finished slide rules that otherwise appear identical in their features. For example rules A, D, and E might all have the same configuration on a particular scale, but this is different from rules B and C. Sometimes, all the numbers on a particular scale are aligned slightly to the left or right, which is a good confirmation of the use of a template.

Different factors are at work with the scale lines. Unlike numbers, the accurate positioning of the divisions on a slide rule is of the utmost importance, as indeed it is in standard measuring rules. By the 1880s, slide rules had been produced manually in fair numbers for hundreds of years. A straightforward method of marking the scales, known as a dividing board, was in common use and enabled the required level of accuracy to be achieved. As explained in [3]:

"The longitudinal lines (gauge or limit lines) were scribed with a tool akin to a woodworkers' marking gauge. "The rule was then placed in a jig, usually described as a dividing board, alongside a pattern, i.e. a master rule, and using a scribing knife against a dividers' square, the graduations were cut. In its simplest form the square was aligned to the pattern by eye. In the more developed form the pattern was made with some form of register to help the operative quickly and accurately position the square for striking each line. The divisions were made from the gauge lines outwards; at the edge of the rule the knife ran out onto a piece of scrap."

End of quote. This shows that each division would be made by hand, and the dividing board would ensure a high degree of accuracy in the hands of a skilled worker. Early Faber slide rules would, I assume, have been made by a similar method to this, except that some sort of printing technique would have replaced the cutting tools for the earliest slide rules, which were not incised.

The vital scale divisions were routinely positioned to the highest standard. But the use of a pattern, where each division on the scales was applied in one manual operation, left room for minor random differences ("operator error"). For example the lengths of the divisions which, if not significantly in error, would have passed through Quality Control unhindered and so be visible on rules in the public domain. Such trivial errors are visible in our database. Templates, where all the scale lines are applied in a single manual operation, replaced the dividing board from group 3 onwards and in theory leave no room for random differences between one rule and another. Where multiple templates are used and the templates differ, then this should show up in our database as repeated rather than random variations. Group 3 shows the first evidence of this – see below. Check out figure 3, which shows three group 3 slide rules under magnification: repeatable differences in the lengths of the divisions of the top and bottom rules suggest that the templates themselves were (not particularly accurately) hand-made.

However, later groups (after group 2) still show signs of random variation which are hard to reconcile with the use of templates. Even in my final group, group 8, random blemishes commonly appear, such as railway tracks aligned too far left or right, or long sections of the scales where the divisions do not quite reach the tracks or extend beyond them. Such errors, apparently random, would be hard to explain if templates as opposed to patterns had been used for all of the lines. However, if a template had been used for the divisions only, leaving the tracks to be marked separately, it would be easy to explain many of the inconsistencies and I believe that this dual-application approach was used in our chosen time period wherever Faber used scale line templates. If the tracks were inscribed directly using a solid straight edge, and the divisions were applied separately from a template, then random operator error is possible. Another piece of evidence supports this dual-application suggestion. One of the examples in group 4 of our collection has very faded scales, probably as a result of poor conditions of storage in an early life. On this example, the vertical scale divisions and the numbers have

disappeared without trace in places, whereas clear remnants of the tracks, more permanently marked, remain visible throughout.

This dual-application approach gives rise to several types of minor errors on slide rules. Firstly, the systematic differences which naturally occur when several slightly-different templates were used have been discussed above. Secondly, slight mismatches may occur randomly where the tracks and the division lines were not applied in precisely the correct positions relative to each other during manufacture (see figure 2a for examples of this). And lastly, mismatches such as these can appear randomly in a continuous stream, typically five or more centimetres long, which seems to be the result of a template that was liable to flexing (no details of which are available). An example of this latter error is shown in the lower slide rule in figure 5.

Quirks

One benefit a collection such as ours provides is the ability to distinguish between features which are one-offs, possibly caused by slight errors by workers on the production line, and apparent manufacturing errors which persisted for many years. One example of the latter can be seen on "no decimals" examples, where the "1", representing "1.1", is malformed on the D scale: the lower part of the digit is missing. This fault can be seen on most examples (excluding all-wood models) in groups 6, 7 and 8 over the time period c1905-20.

Another long-lasting hiccup appears in the division for 1.8 on the C scale ("C1.8"). Often this division does not extend, as it should, to the outer railway track (see figure 3). This glitch can be seen on some slide rules in group 3, but is rare in group 4. However, in this latter group there are many examples of a short division at D7.35 instead, although I have seen one example in group 4 where D7.35 is normal but C1.8 is short. In group 5, the short C1.8 is commonplace. What is going on? Most users would not notice these changes, and would not care even if they did. Systematic errors such as these do not affect the working of a slide rule, but perhaps, as well as providing evidence of templates, they offer further subtle clues to the complete marking process. As yet I am not aware of any explanation for this phenomenon except – could it be that Faber were setting copyright traps or even playing a little joke?

It would be difficult to label my final quirk as a joke, as it affects the accuracy of calculations. For details, refer to the group 3 and group 4 sections below, and consider the inaccuracies, both random and systematic, in the positioning of the c_1 gauge mark.

The identification features discussed above, visible on a slide rule though sometimes only with the aid of a magnifying glass, are too small to be visible on most internet photographs. In such cases I have relied upon examples in the possession of Colin or myself, and the less-common enlargements on the internet, to provide evidence for this section.

Findings

Here I present more detailed descriptions of the various groups of slide rules that I have identified. Please note that the descriptions that follow are not comprehensive: they include only the more useful or interesting features.

Group 1, c1892 (figure 1a) contains the earliest known examples of Faber slide rules. From the scales point of view, it is distinguished by a complete absence of railway tracks. The small size of this group (two examples) makes the identification of any construction techniques uncertain, but although the quality of the end product is excellent there are indications that each numeric character and each scale line was marked by hand. There are small random variations, as can be seen in some of the numbers in figure 1a: for example the number 9 on the A scale is slightly raised, and the 4 on the B scale is imperfect, suggesting that the stamp used to form the number was not held absolutely vertically. All but one of the markings on each example is made without incising the surface in any way – the surface of the rules is smooth to the touch. The one exception to this is the logo "A.W. FABER." which is incised and was probably printed with a single hand-punch. All printing is in black, apart from the logo which is gold.

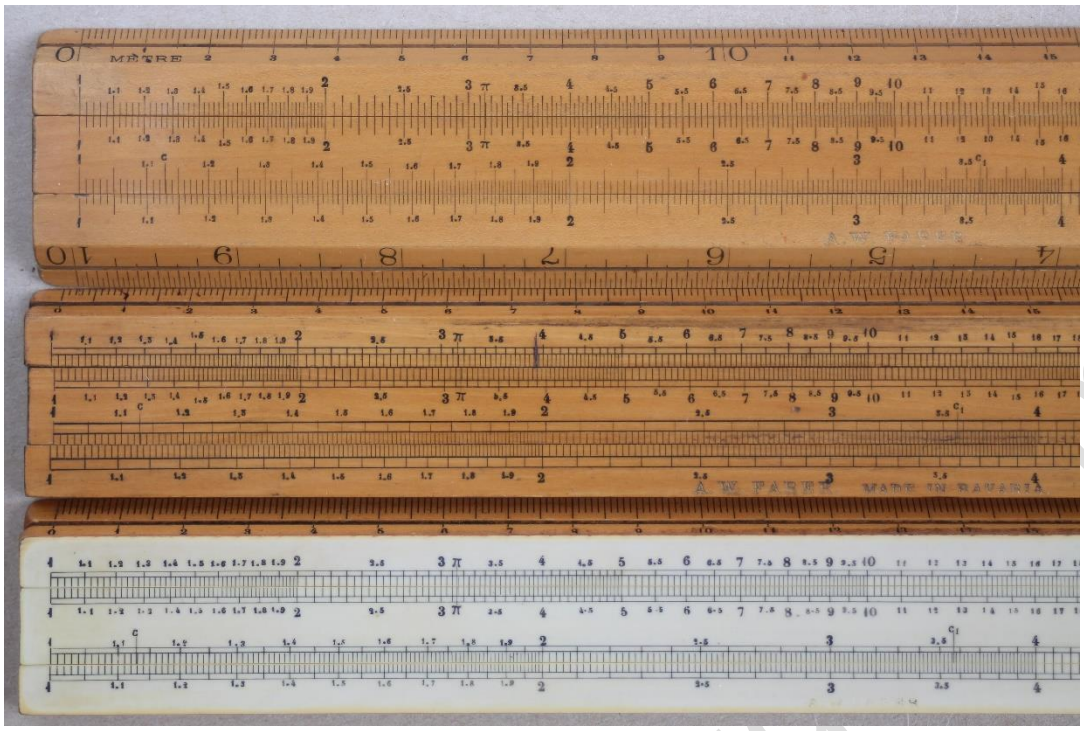

Figure 1. Top (1a) Group 1. Middle (1b) Group 2. Bottom (1c) Group 3

Group 1 presents a particular difficulty for our manufacturing deductions in that there are no railway tracks. I imagine that the dividing board used would have contained an extra guide piece that enabled the beginning of each division to be positioned in the absence of railway tracks. Group 1 items are also unique in Faber slide rules of the stated size, in that the scale length is 25.4 cm. As explained in [2], page 33, 'American- and English-made slide rules tended to deviate slightly from the standard metric lengths and conform to the corresponding lengths in inches. For example, the American and English "10 inch" slide rule could be 25.4 cm (not 25.0 cm) long from 1 to 10 on scales C and D.' Later groups adhere to the standard slide rule length of 25.0 cm. The possibility that these very early rules were produced in England (or, less likely, America), has to be considered, although it is perhaps more likely that they were made in Germany but with "borrowed" English patterns for the scale lines.

Finally for group 1, notice in scales A and B, how the numbers 1.5 and 15 stand proudly above (A) or below (B) the numbers to either side of them. This configuration persists to the end of group 2, after which the numbers are aligned normally.

Group 2, c1892-5 (figure 1b) shows the introduction of double line tracks. All examples contain small random differences which show them to be hand-marked. As a rule, ticks appear on A&B only, and the railway tracks are narrow on A&B and wide on C&D. But one example has the wide tracks on A&B and the ticks on C&D only. This pair of differences from the group norm suggests an error in production, and confirms the recognition of manual methods. Another example, the earliest slide rule we have seen with celluloid scale facings and the only one in group 2, has a different set of ticks.

In this group, trigonometric scales, a feature of the "Enhanced Mannheim" design [6], appear on the rear of the slide. These have single rather than double railway tracks. These scales remain virtually unchanged throughout our period, and will not be referred to again in this article.

Group 3, c1896-9, contains slide rules with no ticks at all on the ABCD scales (figure 1c). This feature is unique in this article's time period (if we ignore group 1 where ticks are irrelevant), and so is a good dating aid. Three other noteworthy features are to be found on the C scale, and I will address these one by one.

Figure 2a. Untidy lines at C10.

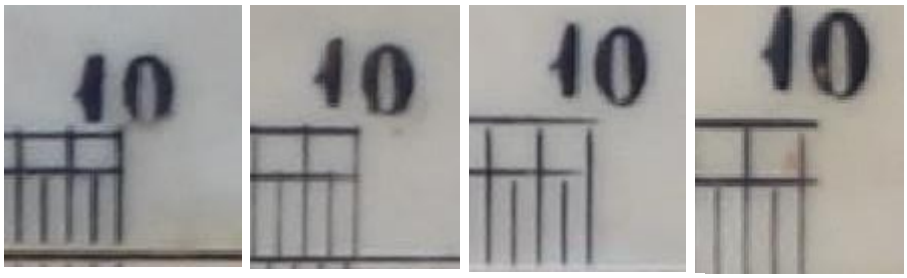

Figure 2b. Examples of varying c1 gauge mark positions.

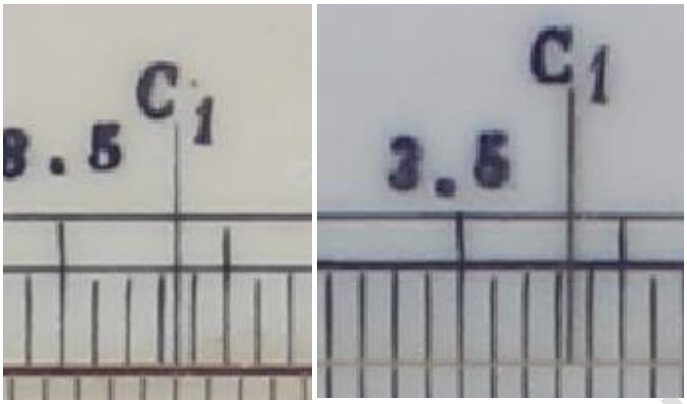

Figure 2. Group 3 imperfections

Looking at the right hand end of the C scale, where the railway tracks reach (or do not reach) the 10 division, the line endings do not meet tidily. In several of my own group 3 examples the lines meet differently (figure 2a). These all support the notion that the dual-application process was introduced for scale lines in this group, although scale numbers remain randomly oriented indicating that they were still added individually by hand.

My second noteworthy feature in group 3 from the construction point of view is demonstrated in figure 3. Roughly half of the rules in this group have a C1.8 division which is very slightly shorter than it should be, which I attribute to the subtle template differences discussed earlier. The top and bottom examples in figure 3 show this “feature”. The middle example has a normal C1.8 division. As further confirmation of the template theory, the left and right rules also have a faint C1.64 division: the middle rule has a normal C1.64 division.

Lastly, the lines for the c_1 gauge point (square root of 40/pi, at 3.568) are in slightly different positions (one of the quirks I mentioned earlier) in my own group 3 examples (figure 2b), which is an indication that they were applied independently of the main scale divisions. Other gauge marks found on Faber slide rules in this period are pi on the A and B scales, and c (square root of 4/pi, at 1.128) on the C scale. These are all very close to a scale division and as a result show less distinctive evidence of variation than c_1.

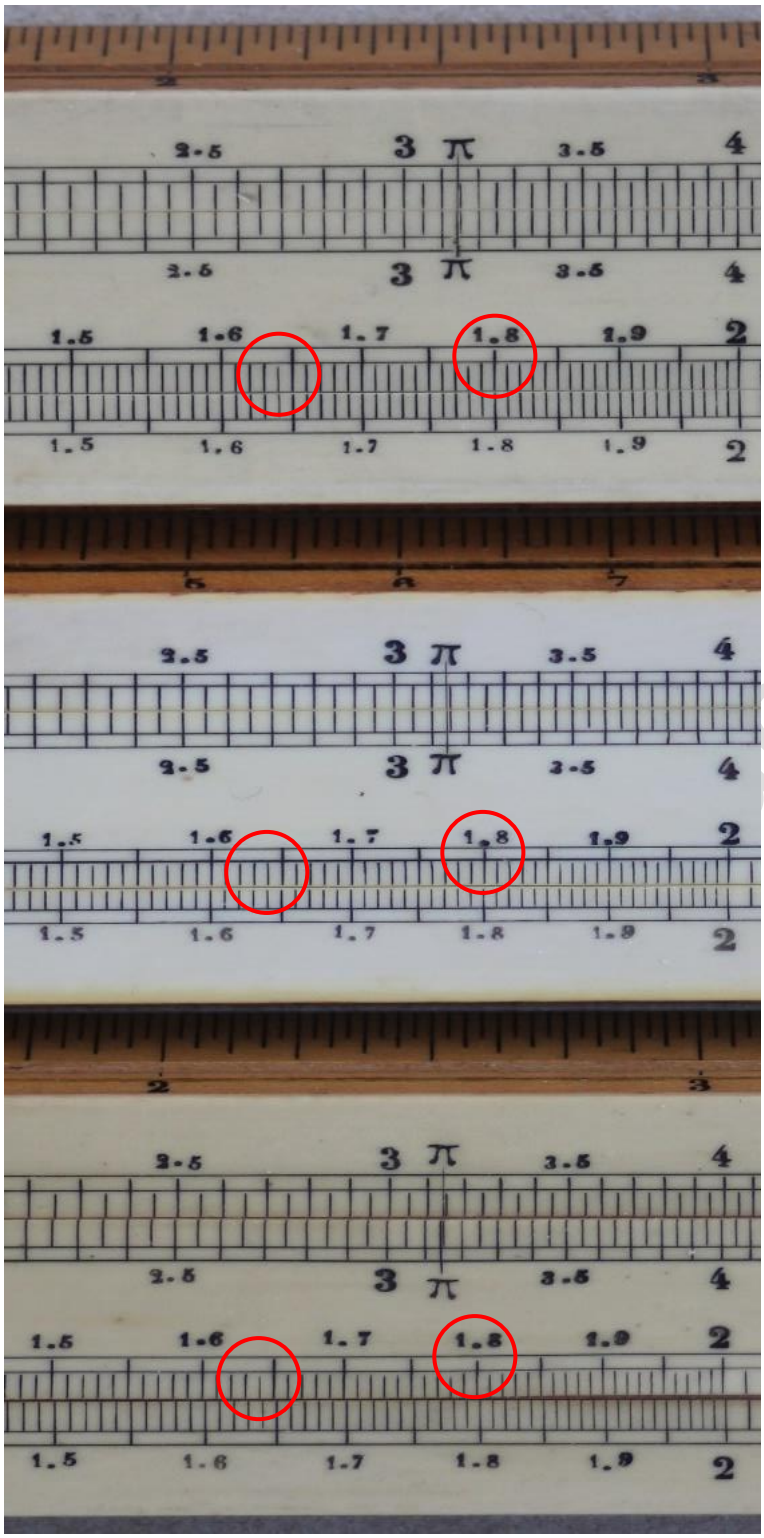

Figure 3. Support for the use of templates in group 3

Figure 4. Group 4, showing a full complement of tick marks

Group 4, (c1899-1903), shows the re-introduction of the ticks, though in different positions to the second group (figure 4). These ticks appear on all four of the main scales (A through D) and continue unchanged into later groups. I have seen just one example of the short C1.8 glitch in this group.

Regarding the c_1 gauge mark, most of my group 4 examples have this in the same position, unlike group 3. This suggests either an improved method of printing the gauge marks, or the addition of gauge marks to the scale template. However, this consistent c_1 mark is in the wrong position, too far to the left to be a true reading of 3.568. I am unable to explain this apparent conundrum, or quirk as I referred to it earlier.
Several group 4 examples in our collection exhibit a significant fading on the scale markings, sufficient to make the slide rules in question unusable. Where the markings are missing, no incisions or other impressions remain, thus confirming our assertion that these models were marked by a surface-printing technique.

Group 5, (c1903-5), indicates clearly the point where a new script was introduced for the scale numbers (figure 5a: this does not apply to all-wood slide rules). Compare the "1" digits especially in the old and new scales. The scale markings are now faintly incised for the first time, although this is easy to miss on many examples. I have five rules in this group, and ALL of them have the short C1.8 line. Also: templates appear to have been used for numbers as well as lines. Besides the generally improved appearance, regular differences can be noticed. For example, in the "with decimal" rules, the extra numbers appear to have been printed separately from the other numbers and are aligned imperfectly, with the same imperfections appearing in several rules. These are systematic errors, not random ones, and are repeated many times in group 7 also (group 6 is too small for the effect to be noticed).

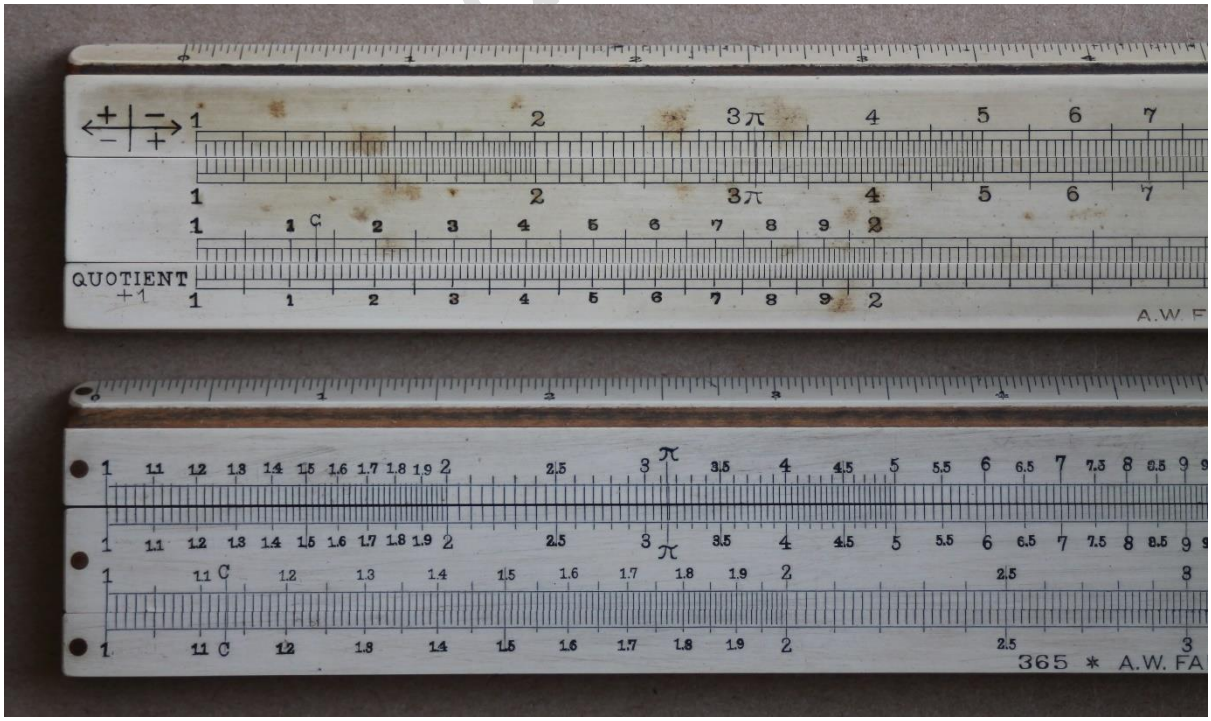

Figure 5. Top (5a) Group 5. Bottom (5b) Group 7. Note the minor differences between the number styles

Group 6, (c1905-6), shows another new script for numbers (figure 5b) which is not very different from the group 5 script, and has deeper and more obvious incisions (again, these features do not apply to all-wood rules). The clearest differences in the script are in the horizontal strokes of the numbers 2 and 7, which are straighter in the new script. Also apparent is the appearance of gauge marks c and c_1 on the D scale as well as the C scale. The collection has only three examples of this group. Several imperfections appear in the new printing style, the most interesting of which is the number 1 (representing 1.1) on the D scale of rules with the "no decimals" notation. As mentioned earlier, this "1" has the lower portion missing (see figure 6).

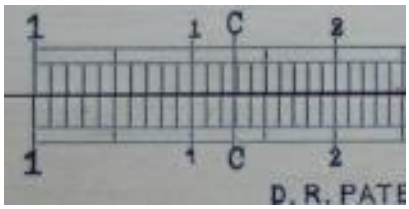

Figure 6. The malformed (1.)1 on the D scale commonly seen in group 6 onwards

Group 7, (c1906-14) has single line tracks (figure 5b), except for the four all-wood models discussed below. With the single tracks, two types of tick appear. Lines which terminate at the outer track of the double tracks now appear as short ticks, while lines which appeared as ticks before are now long ticks. On the whole the overall appearance of the rules within this fairly large group remains unchanged. For example, even the poorly-printed 1 (for 1.1) on the "no-decimals" D scale persists throughout. And although the numbers from 1.1 to 1.9 on A and B scales with decimals seem very uneven, close inspection reveals that the unevenness of these numbers is far from random. Only a few (perhaps no more than four) different sets of these numbers have been recognised on the A and B scales, which suggests that that each set was produced from one of only a few templates. Besides these phenomena, many examples of both systematic and random glitches occur in group 7. The nature of many of these confirms my dual-application suggestion.

Four all-wood examples in our database have double tracks but are recognised as belonging in group 7 because of other features. This is just one indication that the markings on all-wood rules did not develop in tandem with those on celluloid faced rules, as mentioned previously. However, this is not the place to investigate this phenomenon in any detail.

Group 8, (c1914-1920) sees the railway tracks revert from single back to double lines. Besides this there are few differences of note from group 7. The poorly printed 1 (for 1.1) on the D scale continues to appear.

Up to group 8, the templates for the numbers and scale lines appear to have been constructed to print one scale (A, B, etc.) at a time. But in group 8, for the first time I have seen a hint that scales C and D were printed together. Some divisions on these scales have associated errors: if the C line is short, the D line is long, and vice versa.

Conclusion

Following group 8, date numbers appear on Faber slide rules, and this marks the end point of our investigation. Although this article ends here, there are a number of areas, mostly to do with the manufacturing process, where uncertainties remain. Further research may resolve these issues. If any of our readers can provide additional information, do please contact us. Our contact details may be found in the UKSRC Membership Directory.

A Quick-Reference Table for the Groups

Group	Period	Tracks	Ticks	Line printing	Number printing	Number script	Application
1	c1892	none	n/a	pattern	hand	Old	Surface
2	c1892-5	double	A&B	pattern	hand	Old	Surface
3	c1896-9	double	no	dual	hand	Old	Surface
4	c1899-1903	double	all	dual	hand	Old	Surface
5	c1903-5	double	all	dual	templates	New	Light incised
6	c1905-6	double	all	dual	templates	Modified new	Deeper incised
7	c1906-14	single	all	dual	templates	Modified new	Deeper incised
8	c1914-1920	double	all	dual	templates	Modified new	Deeper incised

References

[1] *Every Slide Rule Tells a Story - Establishing an Early A.W. Faber-Castell Chronology* (Colin Tombeur), United Kingdom Slide Rule Circle (UKSRC), Slide Rule Gazette, Issue 17, Autumn 2017, page 15

[2] *Slide Rules: a Journey through Three Centuries* (Dieter von Jezierski), Astragal Press, 2000

[3] *The Rule Book: Measuring for the Trades* (Jane Rees and Mark Rees), Astragal Press, 2010

[4] A good example of this secrecy appears in the so-called Yellow Book. The employees of the Dennert and Pape company at their Gartenberg site produced a staff report in 1962 describing the step-by-step slide rule manufacturing process used at the site. Even at this late stage in the development of the slide rule the illustration showing how the black scales were produced was replaced in the final report by a white rectangle. See *Dennert & Pape ARISTO 1872-1978* (Editors: Klaus Kühn, Karl Kleine), W. Zuckschwerdt Verlag GmbH, 2004

[5] *Overview of A.W. Faber-Castell Slide Rule Dating Chronology 1892-1920* (Colin Tombeur), United Kingdom Slide Rule Circle (UKSRC), Slide Rule Gazette, Issue 17, Autumn 2017, page 49

[6] *The Oughtred Society Slide Rule Reference Manual -Second Edition* (Editors: Ted Hume, Bob Koppany), Oughtred Society, 2010

[7] *Rechenschieber Slide Rules A.W. Faber A.W. Faber-Castell* (Peter Holland), self-publication, seventh revised edition, 2014

[8] *Transition from boxwood to celluloid on boxwood within A.W. Faber* (Dieter von Jezierski), Skid Stick 11, June 2002, page 7

A full bibliography of sources used in the development of this article can be found in [1].