Pencil Slide Rules: Part 3 – The Schauer Scale Revisited

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Background

In 1997, Ed Chamberlain[1] reported on a pencil slide rule that he called the Voith and which I have suggested be renamed the Schauer, after the inventor[2]. The final form of the Schauer pencil slide rule has conventional A/B C/D S L T scales. However, Chamberlain called attention to a novel scale configuration that Schauer defined in three of his four patents. Chamberlain described the Schauer scale configuration and how the scales were to be used. In this article I will expand on the topic.

The Problem

In his patents, Schauer proposed a combination mechanical pencil and slide rule. The basic design was a C-sleeve on a cylinder (See Figure 1). Schauer realized that this design was plagued by one vexing problem. When such a slide rule is used with the usual one-cycle C and D scales, about half of the settings require that the C-sleeve (the "slide") be moved to the left of neutral. When that happens, the pencil point becomes covered by the sleeve. The result of the calculation must be memorized, and the sleeve must be moved back to the right before pencil point can be used to record the result. In his patents, Schauer actually described three scale configurations that would avoid this problem.

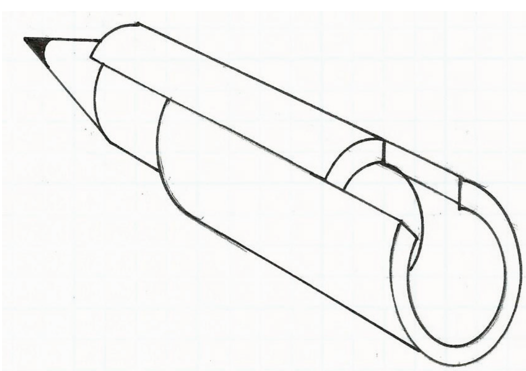

FIGURE 1. The C-Sleeve Design. Schematic Representation
Note that when the sleeve is moved to the left of neutral, the pencil tip is covered and unusable.

Schauer's Solutions

Schauer's three solutions all involved a short sleeve that would not need to be moved to the left of neutral. At this point the determined reader is urged to create working models of the Schauer's three solutions in order to gain a full appreciation of their advantages and limitations[3].

His First Solution

Schauer's first solution[4] was to attach a two-cycle logarithmic scale to the barrel of the pencil and use a short sleeve with only one of the two cycles found on the barrel (See Figure 2a). When such a combination of scales is used for multiplication of two numbers, the sleeve is always moved to the right of neutral. Furthermore, when the product xy is very close to 10, the result can always be read without resetting the sleeve. Also, if the barrel has a coordinated inverse two-cycle BI scale, then three numbers can be multiplied with one setting. The disadvantage of Schauer's first solution is that the scale cycle is only half the length of the space available (typically 10 cm/2 = 5 cm) on a slide rule that is combined with a mechanical pencil. Thus the scale suffers some loss of precision. Also the numbers and markings are more crowded and can be more difficult to set and to read.

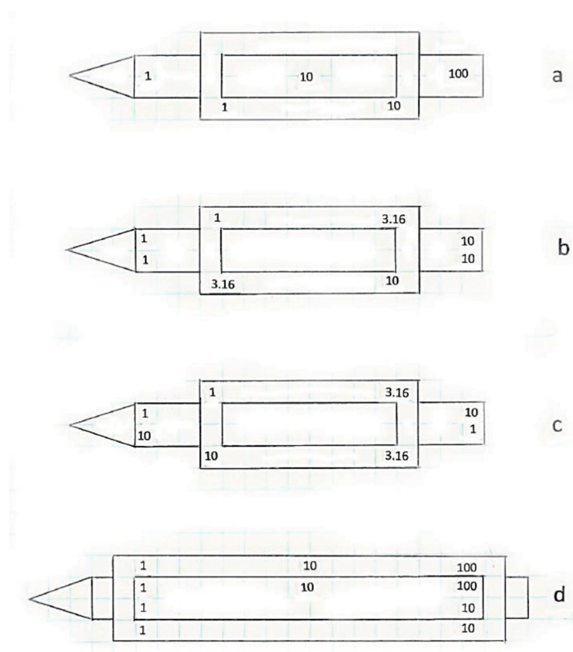

FIGURE 2. Schematic Scale Configurations
The frames represent sliding sleeves. Configurations *a* and *b* were proposed in Schauer's first patent. Four months later he added c to his patent application. Surviving specimens have a long sleeve and the scales shown in *d*.

His Second Solution

Schauer's second solution[5] was to adopt one-cycle scales. Furthermore he broke the scale on the short sliding sleeve into two short scale segments. One ran from 1 to 3.162 (i.e., the square root of 10, which is the midpoint of a one-cycle scale). The second segment ran from 3.162 to 10. These scale segments interfaced with two one-cycle scales on the barrel (See Figure 2b). This arrangement permitted the use of longer, more precise one-cycle scales. Also, this arrangement avoided operations that would require moving the sliding sleeve to the left of neutral.

When used for multiplication of two numbers in the range 1 to 3.16, the upper sliding segment (ranging from 1 to 3.16) was moved to the right of 1 in the usual manner. When used for multiplication of two numbers in the range 3.16 to 10, the lower sliding segment (ranging from 3.16 to 10) was moved to the left of 10 in the usual manner. Because this second sliding scale was missing a segment ranging from 1 to 3.16, the sliding sleeve did not project to the left of the stator and, therefore did not cover the pencil tip. However, this scale configuration was still problematic when the calculation involved multiplying one number from the range 1 to 3.16 by a second number from the range 3.16 to 10. These calculations involved anticipating whether the result would fall below or above 10. (Ask yourself whether each of the following combinations results in a product greater than 10: 3.15 x 3.17, 3.18 x 3.14, 3.12 x 3.25.) In cases such as this, i.e., when factors x and y were both near 3.16, using the 1-to-3.16 sliding scale for the first setting might produce a result that exceeded 10, and the calculation would have to be set up again using the 3.16-to-10 scale. Likewise, using the sliding 3.16-to-10 scale first might prove to be the wrong choice.

Also, Schauer's second solution could not be used to multiply three numbers with one setting.

Finally, Schauer's second solution had another limitation. The two scales on the sliding sleeve are offset from one another by the factor 3.16. (For example, when the index of the 1-to-3.16 scale is set opposite 2 on the coordinated one-cycle scale, the index 10 on the 3.16-to-10 scale appears opposite 2 x 3.16 = 6.32 on the coordinated one-cycle scale.) This relationship is dependable but not very useful. However, as will be seen below, Schauer soon discovered a similar relationship that is both dependable and useful.

His Third Solution

Schauer's third solution[6] was to modify the second solution in the following way: The second scale segment on the sleeve was inverted and that inverted scale segment was aligned with an inverted one-cycle scale on the barrel (See Figure 2c). This preserved the advantages of a one-cycle scale and, as will be seen, dealt with the disadvantages of the second solution.

How Did the Third Solution Work?

Schauer's third solution worked as follows: When two factors both lie in the first half of a one-cycle scale, e.g., 1.5 x 2 = 3, the upper scale on the sleeve and the upper scale on the barrel can be used in the usual way to carry out the calculation. Likewise when two factors both fall in the second half of a one-cycle scale, e.g., 7 x 8 = 56, the lower two scales can be used in the conventional way, but upside down.

However, when a number in the range 1 to 3.16 is to be multiplied by a number in the range 3.16 to 10, the Schauer third scale configuration functions in a way that is strange but intriguing.

At this point in my discussion, we must agree on some scale designations. Let the scales on the sliding sleeve be designated C and CI, and let the scales on the barrel or stator become D and DI[7]. Therefore the scale configuration is C/D DI/CI where D ranges from 1 to 3.16 and DI ranges from 10 to 3.16. Note that the indices on C and CI are aligned, and the indices on D and DI are aligned.

Now consider the problem 2 x 4. First, the factor that is closest to the left indices on the barrel is identified. In this case that factor is 2 on D. The index 1 on C is set at 2 on the D scale (See Figure 3). Next find the factor 4 on the DI scale. The product 8 appears on the CI scale opposite the factor 4 on the DI scale. Note also that the factor 2 on DI appears opposite the product 4 on the CI scale; the factor 2.5 on DI appears opposite the product 5 on CI; the factor 3 on DI appears opposite the product 6 on CI; and so on.

The relationship is symmetrical. For example, Figure 3 can be also be used to illustrate multiplication of a factor by 5. Note that the index 10 on CI is set on 5 on DI. The results of multiplication by 5 appear on D opposite other factors on C.

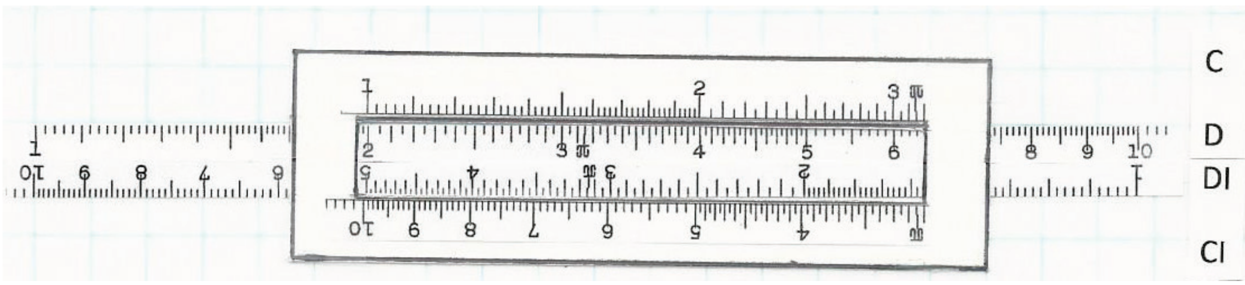

FIGURE 3. Schematic Representation of the Schauer Scale Configuration
Applied to multiplication of 2 x 2, 2 x 4, 2 x 3, 2 x 4, and 2 x 5.
Indices on the sleeve are set at 2 and ½=0.5 on the stator.

Notice that no combination requires the sliding sleeve to be moved to the left of neutral where the sleeve might cover the pencil tip.

Schauer's third solution often can be used to multiply three numbers with one setting. Returning to Figure 3, consider 5 x 4 x 1.5 = 30. To carry out this operation with one setting set 5 on CI opposite 4 on D. Essentially, this setting divides 4 by 1/5 and yields the intermediate product 5/(1/4) = 20, which is found on D opposite 1 on C. The intermediate product 20 on D is multiplied by 1.5 on C. The result 20 x 1.5 = 30 is found on D below 1.5 on C. Note if the factors are reversed (i.e., 1.5 x 4 x 5 = 30) the slide rule must be turned upside down[8]. Schauer cautiously points out that this "generally" works. However, in some cases (e.g. 3 x 6 x 7 = 126) the result will fall off scale.

Why Does This Configuration work?

At this point, a brief review of certain relationships may be helpful. When the indices on any C scale are set against the indices on a CI scale of the same length, each number on one scale is aligned with the reciprocal of that number on the opposite scale. Just as x is represented on the C scale by the distance from 1 to x, the reciprocal 1/x is represented by the distance from 10 to x on CI scale. The same holds for D and DI scales.

The product of 1/x and 1/y is represented on an inverted scale as the sum of the distance 10 to 1/x plus the distance 10 to 1/y. This combined distance from 10 represents 1/xy.

Some slide rule operations take advantage of the relationship x/(1/y) = xy. This corresponds to:

$$\log x - \log(1/y) = \log xy.$$

On logarithmic scales this involves subtracting the distance log (1/y) from the distance log x.

In the case of the Schauer scale configuration, whenever the index 1 on the C scale is set against any factor x on the D scale, the index 10 on the CI scale is also set on 10/x on the DI scale. This sets up two options. If the second factor y is in the range 1 to 3.16, the C scale can be used to set off the logarithmic distance representing the factor y. The combined distance (the product xy) is read on the D scale opposite y on the C scale. If y is in the range 3.16 to 10, then the index 10 on CI scale is already set at 1/x on DI, and the CI scale can be used to set off the distance 1/y. The combined distance (the product 1/xy) is read off the DI scale opposite y on the CI scale. In both cases the sliding scale is moved to the right of neutral, and the pencil tip remains unobstructed.

Epiphany or Plagiarism?

Did Schauer invent his scale or did he "borrow" the scale from someone else? For two reasons I favor the view that he originated the Schauer scale. First, I am unaware of a comparable scale that was published or patented before Schauer first described his scale in 1925. The Schauer scale is uniquely suited to pencil slide rules, and I would expect this scale to appear in a patent for a pencil slide rule. I have had access to a large number of patents for pencil slide rules, and I have seen the Schauer scale mentioned only in his patents.

Second, he behaved like he originated his scale. In his first patent application[4], Schauer acknowledged the problem that he needed to solve and proposed two tentative solutions, but he did not mention his third solution. Yet less than three months later he proposed his third solution in a patent amendment[6]. This suggests to me that he did not know of the third solution when he applied for his first patent. However, he may have been understandably dissatisfied with his first two solutions and probably was still actively exploring various other solutions at that time. His third solution is clearly a modification of his second solution. He easily could have discovered his third solution through trial and error soon after he submitted his first patent application, and he would still have had time to prepare and submit his patent amendment less than three months after his first patent was submitted.

Why Was the Scale Abandoned?

Schauer went to the trouble of obtaining German, British, and United States patents for his third scale configuration[6,9,10]. Yet the surviving Schauer pencil slide rules all have the conventional A/B C/D S L T scale configuration and a full-length sliding C-sleeve (See Figure 2d), a configuration that causes the very problems that Schauer was seeking to avoid. Why is the Schauer scale configuration not found on surviving specimens? Here I can only speculate. Field tests of the Schauer scale configuration probably suggested that this configuration was too novel and that potential users had difficulty adapting to Schauer's scales. This theory might be supported if evidence of such a field trial, e.g., a Schauer pencil slide rule with a short sleeve and Schauer scales, were to be discovered. Furthermore, adapting the T, S, and L scales to Schauer's novel configuration could have been daunting. Alternatively, Schauer may have sold or otherwise lost control over his patents. The new owner may have been less committed to the Schauer scale than the inventor was, and the new owner may have decided to implement a tried and true scale configuration. This might also explain why Schauer's name does not appear on any of his slide rules. I hope answers to these questions will be forthcoming someday.

Conclusion

The Schauer slide rule configuration was a truly creative solution to a vexing problem with design of pencil slide rules. Sadly, this solution was never implemented.

Acknowledgements

I am indebted to the following colleagues for reviewing drafts of this article and offering very helpful suggestions: Bruce Babcock, Ed Chamberlain, Richard Davis, Curtis Jones, Kate Matthews, and David Rance.

Notes

1. Chamberlain, E.J., *The Voith Slide Rule and Mechanical Pencil Combination,* Journal of the Oughtred Society, 6:1, March 1997, pages 27-28.
2. Shepherd, R.M., *Pencil Slide Rules: Part 1 – An Overview,* Journal of the Oughtred Society, 23:2, Fall 2014, pages 33-43.
3. I suggest Xeroxing three sets of the A and B scales on a 10 inch Mannheim with cursor removed. The resulting paper scales can be cut and mounted on stiff paper "stators" and "slides" to simulate the Schauer's three solutions. Figure 3 in this article illustrates such a "paste up" working model.
4. German patent 423,733. Submitted 9/16/1924. Granted 1/11/1926, See Figure 2 in this patent application.
5. *Ibid*. See Figure 3 in this patent application.
6. German Patent 426,200. Submitted 1/1/1925. Granted 11/9/1926. See Figure 2 in this patent application.
7. These scale designations differ from those used by Schauer, by Chamberlain, and by whomever made the Schauer pencil slide rule. In Schauer's German patent (426,200) he labeled his scales d/C D/c. In his British and US patents he labeled them S/C D/R), and Chamberlain adopted these designations. However, the scales on Schauer slide rule itself are labelled Ho/o u/Hu. (H may stand for *Hülle*, o for *oben*, and u for *unten*.) In view of this confusion I feel justified in proposing scale designations that are more conventional and more familiar to current readers.
8. This is described in Schauer's US patent, and Chamberlain's article (*op cit*) calls attention to this advantage of the Schauer's third solution.
9. British Patent 259,112. Submitted 3/8/1926. Granted 10/7/1926.
10. US Patent 1,599,102. Submitted 3/23/1926. Granted 9/7/1926.