Letters

Dear Editor

I was interested to read Bruce Babcock's article reporting an error that he found in one of the tables stamped on a Routledge-pattern engineers' sliding rule. Kenneth Roberts and I have made a study of these rules and their tables (see references [1], [2] and [3], below), and I can assure Mr. Babcock that the error which he noted is far from unique.

This pattern of 2-foot, 2-fold rule which he describes was developed around 1811 by Joshua Routledge (1773-1829), of Bolton, England. One leg had a logarithmic slide let into its surface, allowing it to function as a slide rule; the other was marked with a collection of five tables (one of which is the PUMPING ENGINES table). These five tables attempted to summarize the constants and data most needed by the mechanic (engineer) of that day, organized so as to allow its ready use in calculations performed with the slide. Other patterns of engineers' rule (Armstrong's, Slater's, Carrett's, and Hawthorne's) were also available for use in the machine and textile trades, but Routledge's was the first and most widely used, and is the one commonly encountered today.

These engineers' sliding rules, like the more common carpenters' sliding rule, were not made by scientific instrument makers, but by the manufacturers of artisans' tools, such as Rabone and Preston in England, and Stanley and Stearns in the United States. Their construction, and the level of finish was identical to that of the more common 2- and 4-fold measuring rules which were these companies' main product: the rule sticks were clear-lacquered boxwood; the joints, trim, and slides were brass.

Routledge-pattern rules were offered by various English and American makers for over l 00 years. The last known makers in this country were the Stanley Rule & Level Co. and the Chapin-Stephens Co., who offered this rule in two different levels of trim until just before the First World War.

The logarithmic scales on the brass slide and the adjacent wood surface were cut in by hand, using a square to transfer the locations from a pattern (two descriptions of this hand-graduating process can be found in references [4] and [5], below). This was the practice right up until the end of production, even after the use of graduating machines for cutting linear scales had become commonplace. The figures on the rule and slide were stamped into the surface, by hand, using small steel number stamps, as were the numbers in the data tables.

The data tables, which contain 168 numbers composed of 501 separate digits, are prone to errors. In my research I have found an average of about one random error on every rule examined. The steel stamps had figures only about 5/64" high, making it easy to inadvertently invert or mix them up during use. Also, there would be a tendency for the workers doing the marking to work from

memory after a while, and if their concentration wavered, they could get confused and forget or misplace a number. The entire process certainly had large opportunities for random error.

The error found by Mr. Babcock is not random, however. It is what I call a "common" error, an error which occurs on so many examples of this rule as to defy coincidence. Study of a number of Routledge-pattern rules has allowed me to identify no fewer than nine errors of this type. The one he found (406 for 106 in the PUMPING ENGINES table) is the most widely encountered; but two others, the substitution of 235 for 255 in table I (volume conversion factors), and 218 for 278 in Table II (weights of materials), occur almost as often. The other six are less common, occurring only on some rules, and in some cases only on rules from certain makers.

The most likely cause of these "common" errors is copying; that is, the use by one maker of a rule made by another, or the tables from someone's set of instructions, as a prototype, when making his own rules. Any error, random or common, in the sample would thus be perpetuated as a common error in every rule which he then produced (and, subsequently, in every rule produced by another maker who used one of his rules as a pattern and so forth). Over 100 years, and who knows how many generations of copying, a number of common errors gradually accumulated in the tables.

As far as I can determine, the error Mr. Babcock observed, 406 instead of 106 in the PUMPING ENGINES table, is the oldest and most widely copied. It originated some time before the publication of the 6th edition of Routledge's instructions in 1823, and can be found on every rule and in every book of instructions!

To answer Mr. Babcock's second group of questions:

1. **Why seven pounds per square inch?**

   At the time Routledge developed his rule, the steam engine was still in its infancy, and low pressure steam (5 to 10 psi) was the norm. The table was calculated for a steam pressure of 7 psi, but, as Routledge's instructions make clear, a suitable multiplier could be introduced during the calculation to adjust the gauge point for a whatever pressure actually existed. Because the tables could thus be used for any pressure, it was never necessary to update them, and they were left as designed into the 20th century.

2. **Was there adequate demand, given that there were only 2000 or so steam engines in Cornwall?**

   Water in mines was not just a problem in Cornwall but in the coal mines in the Wales, the Midlands, and elsewhere. Also, remember that the need for data was not really a function of the number of engines in place, but more

the rate at which they were being installed. In the early 1800s pumping engines were being installed in large numbers, and the need for data on how to size and operate them was very high.

3. **Was the PUMPING ENGINE table really practical, given that its values seem to ignore the weight of the engine and pump components?**

   The normal practice in the early 19th century was to operate the engine and pump cylinders vertically, connecting them by a horizontal beam pivoted in the middle. Counterbalance weights were placed on the beam to create a system which was balanced, or nearly so. Under those conditions the table gauge points were probably acceptable.

4. **Were these engineer's rules really used that much, or were they just status symbols?**

   My guess would be the latter. The rules were bought because the tables looked impressive, but once purchased, those same tables were rarely referred to. The fact that the "common" errors noted above were never corrected would seem to support this. If you want a good modern analogy, consider the exotic functions and features of modern hand-held electronic calculators. After the purchase, most of this functionality is wasted, with the average buyer rarely using anything more than the four basic functions and a word or two of memory.

REFERENCES:

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2. Stanley, Philip E. "Carpenters and Engineers Slide Rules (Part II, Routledge's Rule)", *Chronicle of the Early American Industries Association,* 37:2 (June 1984), pp. 25-27.

3. Stanley, Philip E. "Carpenters and Engineers Slide Rules (Part III, Errors in the Data Tables)", *The Chronicle of the Early American Industries Association,* 40:1 (March 1987), pp. 7-8.

4. Rabone, John Jr. "Measuring Rules," *Birmingham and the Midland Hardware District, the Resources, Products, and Industrial History,* pp. 628-632, Samuel Timmins, Editor. London: 1866.

5. Unknown. "Common Graduation" (reprinted from an article in Rees' Encyclopedia, Ca. 1875), *Mensuration* (the newsletter of the Rule Collectors Association) I:2 (Fall 1988), pp. 1-4.