Slide Chart Calculators

David Sweetman

Introduction

Slide rules are manufactured in a variety of forms and styles. Some are linear, usually 5, 10, or 20 inches long; others are circular, with diameters varying from ~ 1 inch to greater than 12 inches; others are cylindrical, with a variety of lengths and diameters. Additionally, some slide rules are called slide charts. The classic slide rule performs a number of mathematical functions; the specialty slide rule performs specific calculations for a specific application, as well as the basic mathematical functions. The common slide chart does tabular conversions, e.g., English to metric measurements. The slide chart calculator performs a function similar to a specialty slide rule in calculating a specific mathematical output for a specific application. A linear calculating slide chart is somewhat similar in concept to the use of two of Gunter's rules. Although not universally true, a simple convention to identify a slide rule vs. a slide chart is the use of a cursor; linear or circular slide rules have cursors, linear or circular slide charts that perform tabular conversions do not; a labeled linear or circular slide chart with a cursor should be called a slide rule; a linear or circular slide chart that performs a calculation should be called a slide chart calculator or just a calculator.

Basic Operation

The linear slide chart calculator contains one or more sliding elements that are aligned with one or more fixed scales. Sometimes the slide chart calculator is used with a mathematical slide rule to complete the calculation.

Both the fixed and sliding scales are based on the logarithm of an equation, just as the major scales on a slide rule are based on the logarithms of numbers. The equation may be a linear, polynomial, or power expression and includes the applicable constants. When the appropriate input values on the applicable scales are aligned, the output value is calculated according to the applicable equation. The alignment of the scales performs multiplication (or division) by the addition (or subtraction) of the distances between the scale marks. Gauge marks are used to identify fixed results or to find the applicable location for the result of a calculation.

A simple single slide chart calculator is the *Concrete Calculator*, manufacturer and date unknown, but provided by a variety of concrete suppliers. This calculator computes the volume in cubic yards of concrete for given a given thickness and width in inches and a length in feet.

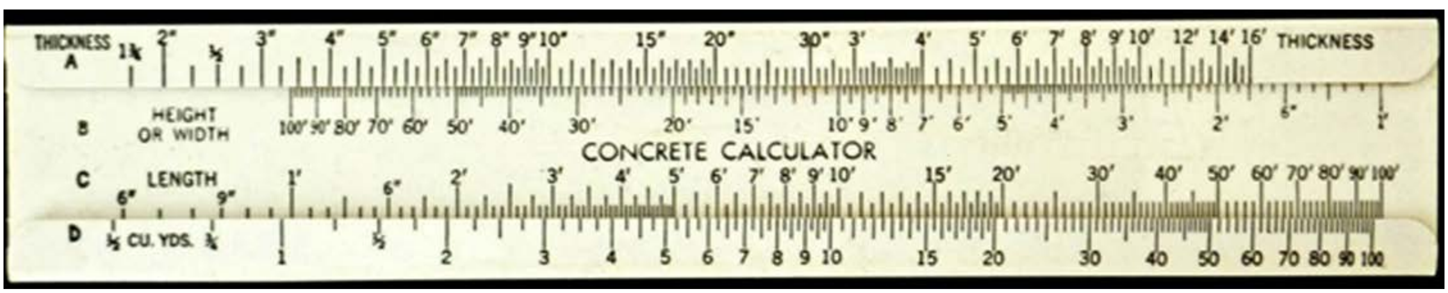

FIGURE 1.
Concrete Calculator

To manually calculate cubic yards one multiplies the thickness, width, and length measured in yards. Since thickness is normally measured in inches, width in inches or feet, and length in feet, the calculator contains the appropriate conversion factors. One aligns the thickness in inches with the width in inches, and then reads the cubic yards under the length in feet.

A more complex single slide chart calculator is the *Simpson Casting Weight Calculator* provided by the National Engineering Company and manufactured by Perrygraf Corp., Maywood, IL in 1966. The calculator computes the weight per inch of length of rings, flats, or triangles of various materials. The equation combines a standard mathematical operation (calculation of area) with an experimentally determined constant (material density). In order to accommodate a large variety of ring diameters, three separate calculators use the same physical slide.

To manually calculate the weight of a ring, one determines the area of the ring, which is $\pi \bullet (R_o^2 - R_i^2)$ where R_o is the outer radius and R_i is the inner radius. The calculator result is the weight per inch in pounds. Then one multiplies by the length to get the weight. Since the given baseline uses steel at ~ 490 lb/ft^3 density, there is a table provided for a multiplication factor for the relative densities of other casting materials.

To use this calculator, one moves the single slide, aligning the outer and inner diameters in inches and reads at the gauge mark the weight (of steel) per inch in pounds. One

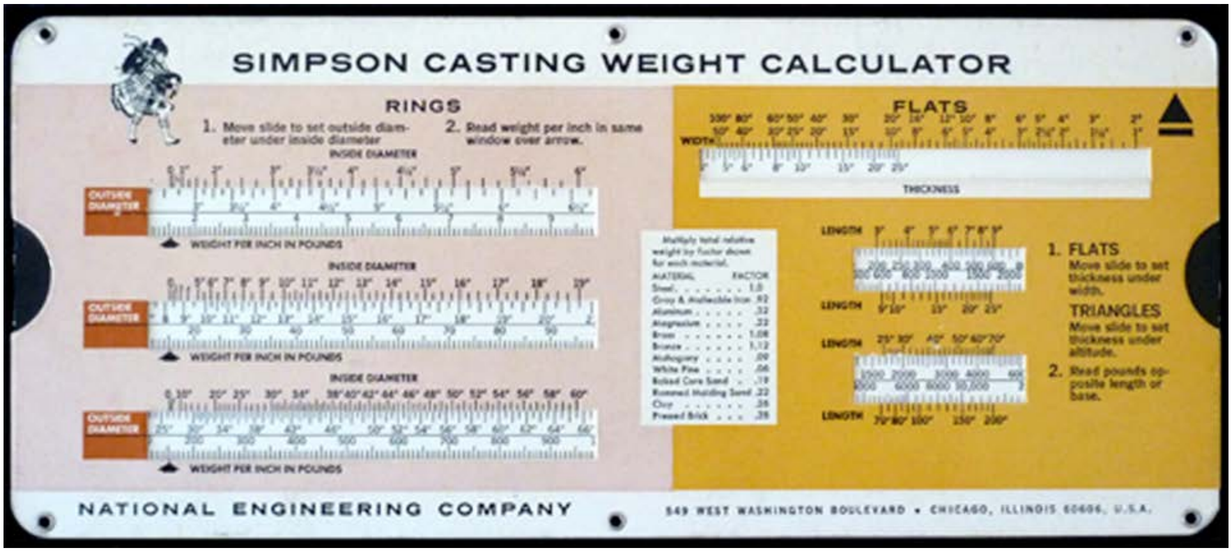

FIGURE 2.
Simpson Casting Weight Calculator

then can use a standard slide rule to calculate the total weight by multiplying the actual length times the calculator output. A table is provided for a factor for other materials (common in the casting industry), where again one would use a slide rule to multiply this factor times the total calculated weight. A similar calculator is provided for flats (rectangles) and triangles. Essentially one enters two variables to get the result, but then must use a slide rule to enter the third and fourth variables (the fourth may not be required).

A dual slide chart calculator is the *Gamma Radiation Exposure Calculator* provided by South Manufacturing Company, Inc. manufactured in 1995. This calculator computes the exposure times for films for industrial x-rays of steel structures. There is a reversible slide for use with Cobalt^{60} or Iridium^{192} as the source. This calculator manipulates experimentally derived constants to find the result.

To manually calculate the exposure time, one needs the source type, the source strength, the source age, the steel thickness, the distance from the source to the film, and the radiation exposure rate. The radiation exposure rate is in Roentgens (or Milli-Roentgens) per hour. A Roentgen is the deposition of 100 ergs per gram of material (the term is now deprecated for SI units). The source strength is in Curies (or Milli-Curies); a Curie is $3.7 \cdot 10^{10}$ disintegrations per second. Each disintegration provides an ~ 1.33 MeV gamma (or X) ray for Cobalt^{60} or an ~ 0.316 MeV gamma ray for Iridium^{192}. The source strength will decrease with age, e.g., the half-life of Cobalt^{60} is ~ 5.27 years and for Iridium^{192} is ~ 73.8 days, so after every half-life in time the strength of a given sample size is one-half of the previous value. The amount of radiation received by the film will be reduced by the thickness of the steel. These are experimentally determined constants called the half-value or tenth-value thickness (HVT or TVT), the thickness required to reduce the intensity by ½ or $^{1}/_{10}$. Typi-

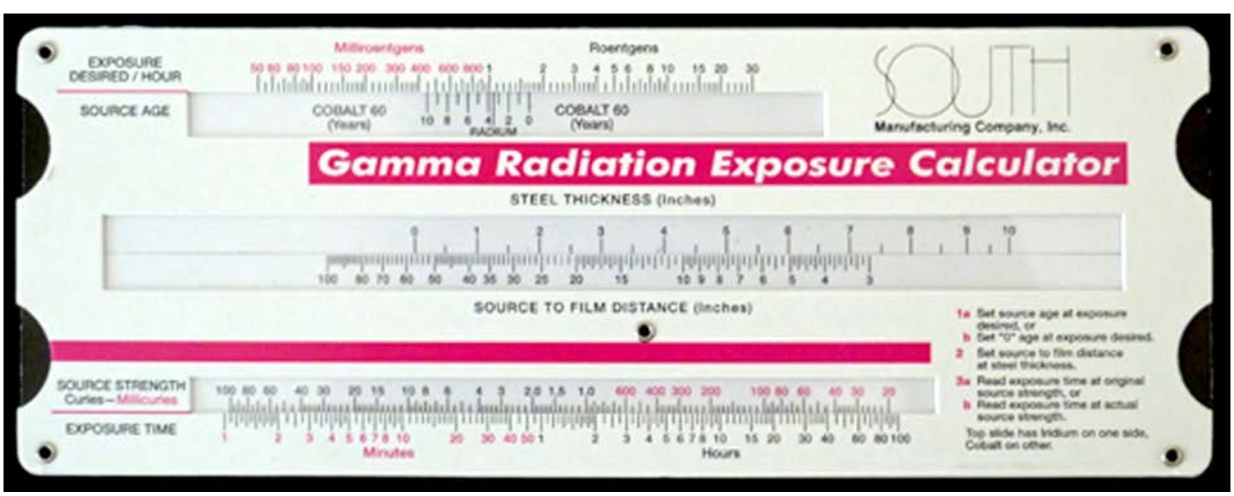

FIGURE 3.
Gamma Radiation Exposure Calculator

cal values for stainless steel are the HVT = 2.04 cm and the TVT = 6.778 cm, noting the actual HVT and TVT will vary with the density of the steel. The distance from the radiation source to the film reduces the intensity in accordance with the inverse square law.

To operate the calculator one aligns the source age (by type) with the desired exposure rate. Then one aligns the source to film distance with the steel thickness. One then aligns the source strength to determine the exposure time (this final operation could use a cursor). One essentially enters five variables to obtain the output.

Summary

Slide Chart Calculators are extremely useful tools. Often, manipulating the slide chart calculator is faster and more convenient than using a computer, while still providing results of sufficient accuracy for meaningful performance. Use of a slide chart calculator does require one to be familiar with the units for the values to be manipulated, which often aids understanding of the results. Slide chart calculators are often provided as sales tools to help customers to better understand the use of the associated product; thus they are constantly being developed for new applications.

Slonimsky's Multiplying Device, an Impressive Example for Applied Mathematics

JOS Plus

Stephan Weiss

Introduction

This article presents multiplying devices from the middle of the 19th century, which are based on the so called Theorem of Slonimsky. With his theorem Slonimsky succeeded in solving the problem of tens carry in a simple device with no gears. He did it in a surprising way, but at the same time the multiplying device is an interesting and impressive example of application and usage of a rather complicated proposition in numerical mathematics.

The inventor and the base problem

Hayyim Selig Slonimsky[2] (born 1810 in Byelostok or Belostok, Russian Empire, now Bialystok, Poland, died 1904 in Warsaw) was a knowledgeable Talmudist and author of science books about mathematics and astronomy in Hebrew for Jewish people. As a publisher he produced the science magazine Hazefirah (Ha-Tsefira) from 1862 on, also in Hebrew, which continued until 1931. Furthermore Slonimsky invented at least two calculating aids, an adding device and a multiplying device. The article in the Leipziger Illustrierte Zeitung from 1845 [2] mentions a third calculating instrument, similar to an abacus. It is worth noting that the clockmaker and inventor of a calculating machine, Abraham Jacob Stern, was his father-in-law.

For a better understanding of what is new in Slonimsky's invention, I regard it useful to repeat briefly some historic methods for tens carry in multiplying devices.

In his *Rabdologia,* John Napier (1550 – 1617) broke a simple multiplying table into vertical columns. With these stripes, mounted on square rods which were called *Napier's rods* or *bones,* multiplication tables for any multiplicand may be composed (Figure 1, to ease comparison here I continuously use the multiplicand 274). Figures of the partial products are arranged in triangles so that the user may obtain the required product only digit by digit by adding diagonally from right to left [8, 15].

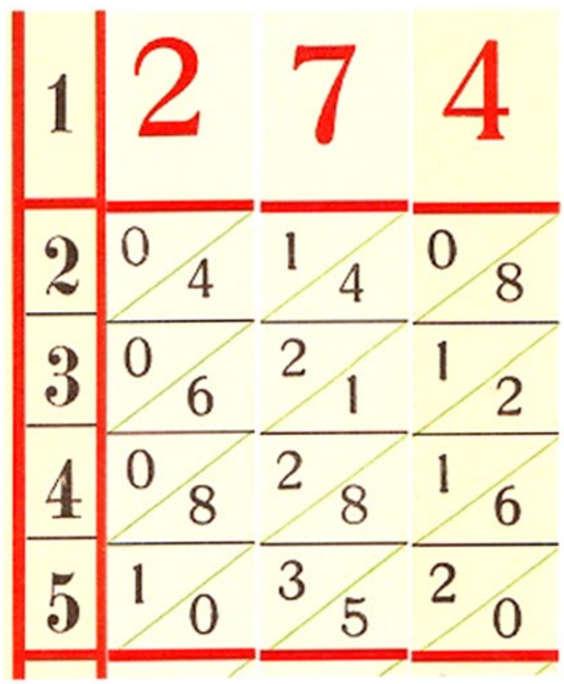

FIGURE 1
Napier's rods, here used in Theutometer (Germany), about 1910, shortened

In 1885 Henri Genaille and Edouard Lucas published their *Réglettes multiplicatrices* in France. The partial products are arranged on stripes or rods similar to Napier's. A partial product is replaced by a black triangle or arrow with a column of figures on the right side. The right corner of an arrow covers the unit figures of a partial product added to a possible carry from right. The left corner of the arrow is placed in height corresponding with the tens figure of the partial product (Figure 2). Instead of making additions the user only has to follow these arrows and to read the figures which are indicated [12, 14].