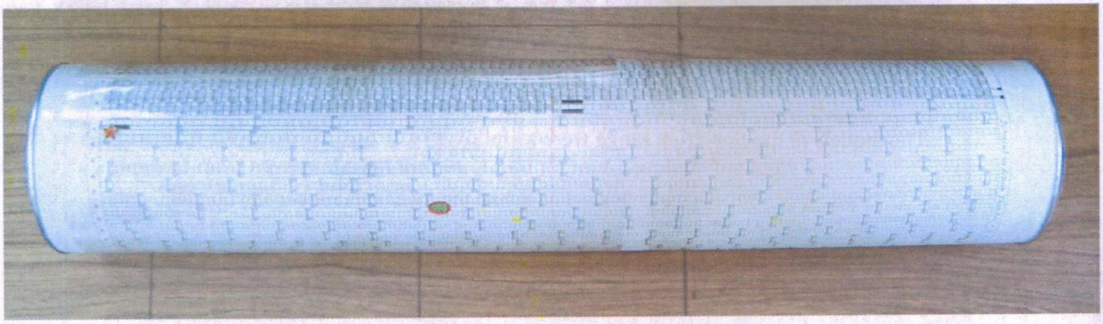
Thacher Accuracy with Unique Expenditure

Tina Cordon

Tina's Thrupenny Slide Rule is a homemade slide rule which anyone can make, mostly from recycled materials for a miniscule cost whilst still achieving 4 or 5 significant figures (S.F.) of accuracy.

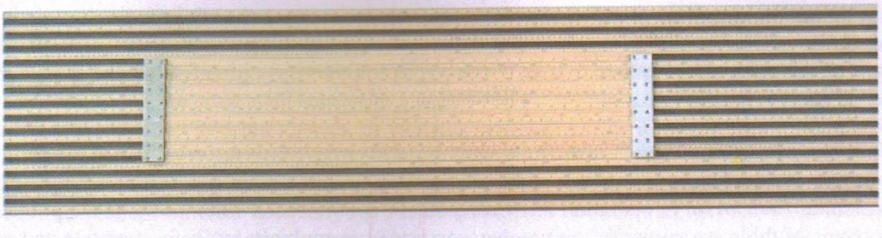


Background

The scale used is the base (A) scale of Thacher's Calculating Instrument which can be downloaded from the Slide Rule Museum (http://sliderulemuseum.com/) in Adobe Acrobat format kindly provided by Wayne Harrison so that skilled enthusiasts can build their own Thacher Calculator. Very fine examples of these homemade Thachers can also be seen on the same web page, built by David White and Bob Wolfson. This scale consists of two identical 30 foot logarithmic scales each laid out on forty 9 inch scale segments. These two scales are placed side by side with the right hand scale, one scale segment (9 inches) ahead of the left so that the scale is continuous across the rule. The author downloaded these scales with the intention of attempting to build a Thacher but lacking one of the main requirements, that being skill. However serendipity came to the rescue. Whilst reading about Gridiron slide rules such as Hannyngton's Extended Slide Rule in C.N.Pickworth's Slide Rule Manual a reference to H.Cherry's (1880) observation that only the base scale was needed and that it was not necessary to have a second scale sliding over it, caught the author's eye. It became clear that the base scale of the Thacher would serve very well as the base scale of a Hannyngton and that a clear sheet marked with cross hairs at appropriate points utilised as the cursor was all that would be needed to perform calculations.

Thacher's claculator

When using this cursor sheet above a flat scale it is very difficult to prevent the two sheets becoming skewed with respect to each other whilst moving the cursor without including a mechanism to keep the two sheets aligned. Hannyngton's slide rule does of course provide such a mechanism.
In action one of the crosshairs on the cursor would be set to 1 on the base scale, a marker would then be placed on the cursor at the position of the multiplier, the crosshair would then be moved to the multiplicand and the result read off next to the marker. When using a normal linear slide rule the result is sometimes off the end of the scale, the same problem occurs with this type of device. It is of course possible to use this scale in reverse as one would a linear slide rule when results are off the scale. The circular slide rule solves this problem by making the scales continuous around a circular path. The cylindrical slide rule does the same for the flat gridiron slide rule. This is, of course the way in which Thacher's, Nestler's and Loga's cylindrical slide rules work.



Hannyngton's Extended Rule

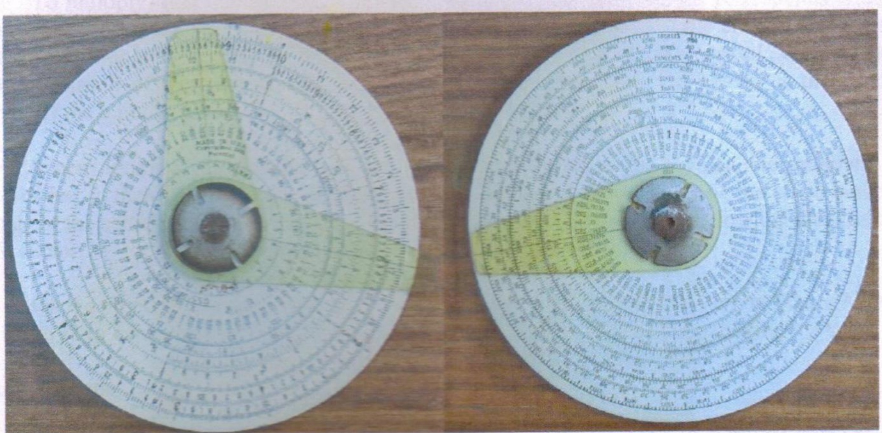
The author, therefore, went back to the cylindrical format. Utilising a cylinder solves both the problems previously stated. The scale is continuous around the cylinder therefore the results can't be off the scale and utilising a clear cylindrical cursor overlying the base scale solves the problem of skewing whilst still negating the need for a second scale sliding above the first.

Fabrication

Having solved the problem it was then necessary to put together a working model to prove the concept. It was shortly after Christmas so there were empty Hula Hoops cartons in the house which hadn't been discarded because they looked useful. It became apparent that these cardboard cylindrical cartons were of almost exactly the required diameter (4") for the Thacher scale. They were of the right diameter when a sheet of paper was wrapped around them, which the author needed to do anyway whilst connecting three cartons together to produce the required length. The Thacher Scale was then sellotaped to the tube taking care to keep the scale aligned at the join. The clear cursor is a sheet of clear celluloid wrapped around the scale. This sheet needs to be a little more than half the width of the Thacher scale with a crosshair marked close to the left hand edge. The first version utilised stickers to mark the position of the multiplier when initially setting up the slide rule, this was found to be unwieldy therefore a second strip of celluloid about one inch wide was wrapped around the first cursor with a crosshair marked on it. This second cursor is free to move with respect to the first. The slide rule at this point is complete. The only costs were the printer ink, printer paper and sellotape. It took me about an hour to put together.

Description of use.

When multiplying, the crosshair on the main cursor is set to 1 (the origin), the crosshair on the second smaller cursor is then moved to the multiplier without disturbing the main cursor. The main cursor is then moved so that its crosshair coincides with the multiplicand. The result is found under the crosshair of the second cursor, which does not move with respect to the main cursor as the main cursor moves. In this respect, these two cursors are used in the manner of the two cursors on a Gilson circular slide rule.



Gilson circular slide rule

When dividing, the crosshair on the main cursor is set to the divisor, the crosshair of the second cursor is then moved to the dividend without disturbing the position of the main cursor. The crosshair of the main cursor is then moved to the origin and the answer read below the crosshair of the second cursor.

Gauge points are very easy to apply with this slide rule. Move the crosshair of the main cursor to the origin, place a gauge point mark at the required point on the main cursor. For example mark the main cursor at Pi=3.1416. In operation the second cursor is not needed when using gauge points. Move the crosshair of the main cursor to the number you intend to multiply by Pi for example and read the answer under the Pi Gauge point. To divide by Pi, place the Pi gauge mark above the dividend and read the answer under the crosshair under the main cursor.

You can choose your own set of gauge marks. The author has applied those which she uses most often at work, most of which aren't normally found on a slide rule.

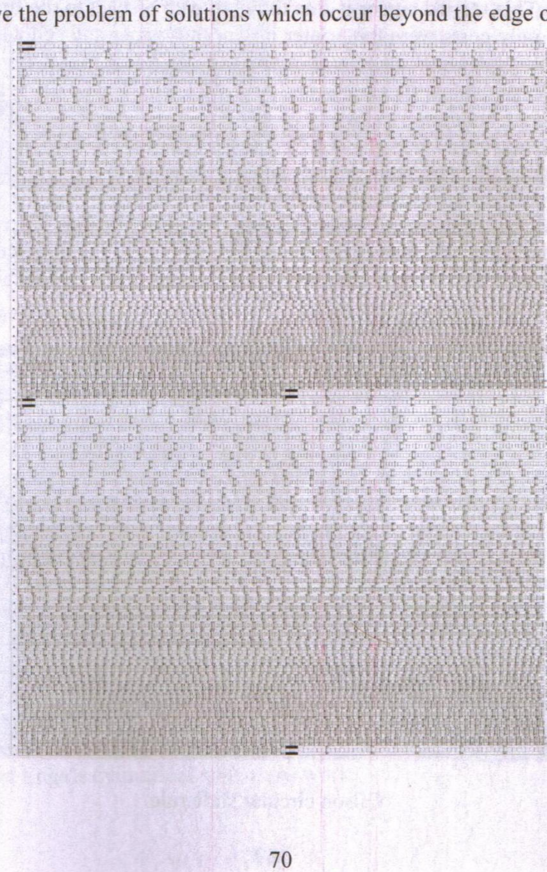
Reciprocals are found by setting the main cursor's crosshair to 1 and the crosshair of the second cursor to the number for which the reciprocal is desired. Move the main cursor until the crosshair of the second cursor is over the second instance of the number 1, in the centre of the scale. The reciprocal is found under the crosshair of the main cursor.

Even with her unskilled construction the author has still been able to gain the 4 or 5 S.F. accuracy intended for a Thacher Calculator at a very small fraction of the cost.

Tina's Gridiron Slide Rule

Returning to the Gridiron Slide Rule, it is of course possible to use the Thacher base scale to create a working Gridiron Slide Rule. Two Thacher base scales need to be attached, one above the other on an appropriate flat surface, with their scales continuous at the join.

This will solve the problem of solutions which occur beyond the edge of the first scale.



A desk was recently being thrown out at the author's office in Gabon and it occurred to her that by attaching the two Thacher scales described to the underside of the top drawer of the desk's drawer unit, the inward and outward motion of the drawer as it was opened and closed would provide the means of moving the scale with respect to a cursor rail set to move only at right angles to this. The cursor rail was made out of a broomstick, to which a static cursor and a mobile cursor are attached. In practice any construction which allows the mobile cursor to mark any point on the upper of the two scales and remain stationary with respect to the scales when the scales are in motion, will serve the purpose. I have chosen a clear arm carrying a sliding cursor. The arm can be rotated about a position on the cursor rail close to the static cursor. The static cursor is made out of an old bottle opener, also screwed to the cursor rail. The result is a working Gridiron Slide Rule.

How to use it

To multiply, pull out the scale until the crosshair of the static cursor corresponds with 1 (the origin). Rotate the mobile cursor and move the sliding cursor along it until the crosshair of the sliding cursor corresponds to the multiplier. Push the scale back in and move the cursor rail across to the right until the crosshair of the static cursor corresponds to the multiplicand. The answer is then under the crosshair of the mobile cursor.

When dividing, the crosshair on the static cursor is set to the divisor, the crosshair of the mobile cursor is then moved to the dividend without disturbing the position of the static cursor. The crosshair of the static cursor is then moved to the origin and the answer read below the crosshair of the mobile cursor.

Gauge points aren't dealt with as conveniently on the gridiron as they are on Tina's Thrupenny Slide Rule. They can be marked directly on the scale or on a sheet of celluloid covering the scale.

A note on Roots

If the cursor rail is removed from the Gridiron and a straight edge placed on the scale between the origin and a number for which the roots are required, the advantages and disadvantages of the gridiron for extracting roots become apparent. By numbering the scale lines of the gridiron from 0 (the line which includes the origin) to 39 (79 for both scales) the reading of roots is easy. For example, place a ruler along the diagonal line between the origin and the number 211 (2.11) on the twelfth line of the gridiron, then the twelfth root, the sixth root (2/12), the fourth root (3/12) etc up until the eleven/twelfths root can be read directly where the ruler crosses the intervening lines of the scale. Unfortunately, no other roots can be obtained using this method on a gridiron. The number 211 (2.11) occurs twice on the upper scale, once on the twelfth line and once on the eleventh, thus allowing the eleventh root, the two elevenths root etc to be obtained as well. Take care, of course to remember that the significant figures of the square root of 211 are not the same as those for 21.1. For this reason, for the roots of 21.1 and other numbers between 10 and 100, place the straight line between the origin and the corresponding number of the second scale, not the first.

Square roots can be obtained for every number on the scale, very simply, using the method described above. Every number on the scale appears on both an odd and an even numbered scale line. Utilising the number on the even scale line allows the square root to be found on the scale line of one half the original. For example 211 in the example above was found on the twelfth line so the square root is found where the diagonal line crosses the sixth.

There are of course two square roots, three cube roots, etc of every number. This and any other slide rule will only give the magnitude of these roots not the real and imaginary parts. By adding appropriate gauge points to the scale and multiplying the magnitude (M) found by its corresponding gauge point, the other roots can be found. For example, the imaginary cube roots are $M(-0.5\pm0.866i)$ Placing the gauge points 0.866 and 0.5 on the scale will allow these values to be found. This is not something the author intends to do in practice but the readers may have other ideas.

To find the square of a number just extend the diagonal line from the origin through the number to twice the distance from the origin. For example 211 is on the Twelfth line, therefore its square is on the twenty-fourth line. Similar rules are true for cubes, etc. Referring to the picture of the scales above it can be seen that the number 100 (1.0 the origin) occurs six times. By using the central origin, it is possible, not only to find squares and square roots by extending the diagonal line forwards but by extending it backwards one finds reciprocals and reciprocals of squares etc.

Tina's Thrupenny Gridiron.

If you have an old A2 or larger drawing board and tee square in your loft, set up the Thacher scales on this. Print out two Thacher scales as large as they will print on A3 paper and splice them together on your drawing board. Use a variable angle set square supported on the tee square, to set out the distance from the origin to the multiplier. Mark these positions on the set square. Move the tee square vertically and the set square horizontally until the point on the set square which formerly marked the origin corresponds to the multiplicand. The answer will appear under the second marker.

High Tech Gridiron

If you own a computer and it is possible to output graphics to that nice big flatscreen television in your living room then you can have a High Tech super accurate slide rule at no extra cost. You do need one potentially expensive item however and that is a copy of the Adobe Acrobat writer (not the free reader, unfortunately). Open the Thacher base scale file in your copy of Adobe Acrobat and display it as large as possible on your television. Adobe Acrobat includes a line drawing utility. Use this to draw a line between the origin and the multiplier. This line can then be dragged using the mouse so that the end formerly at the origin is at the multiplicand. The answer will be found at the other end of the line.

Tina's Guinea Slide Rule

David White on the Slide Rule Museum site clearly describes how those who have some skill and would like to spend a little more money should complete the first steps to make Tina's Guinea Slide Rule, the version for the more discerning. The first step would be to download the Thacher base scale and get it printed on good quality paper by a professional printer. This same printer should be able to accurately guillotine the top of the scale to make scale alignment easier. The next step is to find a cardboard or plastic tube of the correct 4" diameter and 22" length for the scale. Remember to take the thickness of the paper you use into account when finding your tube. If you have a wide variety of well placed friends it may even be possible to print the scale directly onto an appropriate tube, after all, it is possible to print pictures of Hula Hoops on them. The author would like to find a cursor in the form of a clear cylinder with an internal diameter just large enough to fit the slide rule; this would be about 4.125" Internal Diameter and about 11" long. The dream solution would be a correctly dimensioned Perspex cylinder and a second smaller cursor running on the surface of that. The author has not found evidence of a slide rule of this design having been commercially produced before[1]. If any of the readers know of one, let the author know because having used hers she would very much like a professionally produced version in her collection.

A bit of Arithmetic

These slide rules clearly work, but why? Using the example 2.11 previously used, this number appears 360xLog(2.11) inches along the scale if the scale were continuous rather than a grid. This gives a distance of 116.742 inches. Dividing 116.742 by 9 gives the number of scale sections needed to accommodate this distance. This gives us 12.9713 scale lengths. Therefore 2.11 is 12 scale sections down and 0.9713x9=8.742 inches to the right of the origin. For these slide rules to work the result of the multiplication of any number by 2.11 must be 12 scale sections down and 8.742 inches to the right of that number. Using the number pair, 2 and 4.22, we will see if this holds true. The number 2 is 108.371 inches along the scale, 12 scales down and 0.371 inches across. The number 4.22 is 225.112 inches along the scale, 25 scales down and 0.112 inches across. It looks, immediately as if it has failed, since 25-12 does not equal 12, but in operation the slide rule does not find the answer on the left hand scale but on the right on the 24th scale down and 0.112 inches from the centre line, 9.112 inches from the left hand side. Now 24-12 definitely equals 12 and 9.112-0.371=8.742 therefore the example shows that it works and perhaps also indicates why Edwin Thacher chose to use two scales side by side when building his rule.

Conclusions

The Author finds Tina's Thrupenny Slide Rule to be much easier to use for multiplication, division and the use of gauge points than Tina's Gridiron. The author's main purpose in building Tina's Gridiron was to explore the extraction of roots. The limitations found show this to be of little use but great fun nevertheless. The author has had a great deal of fun with Thacher's base scale, she hopes you do too.

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[1] The cylindrical calculator by Rafael Fischer, UK Patent No. 778,556, closely resembles this description. These calculators were made in small numbers by Carbic Ltd. [Ed.]