A Letter of 1638 From William Oughtred to Elias Allen

Edited by Peter Hopp and Bob Otnes

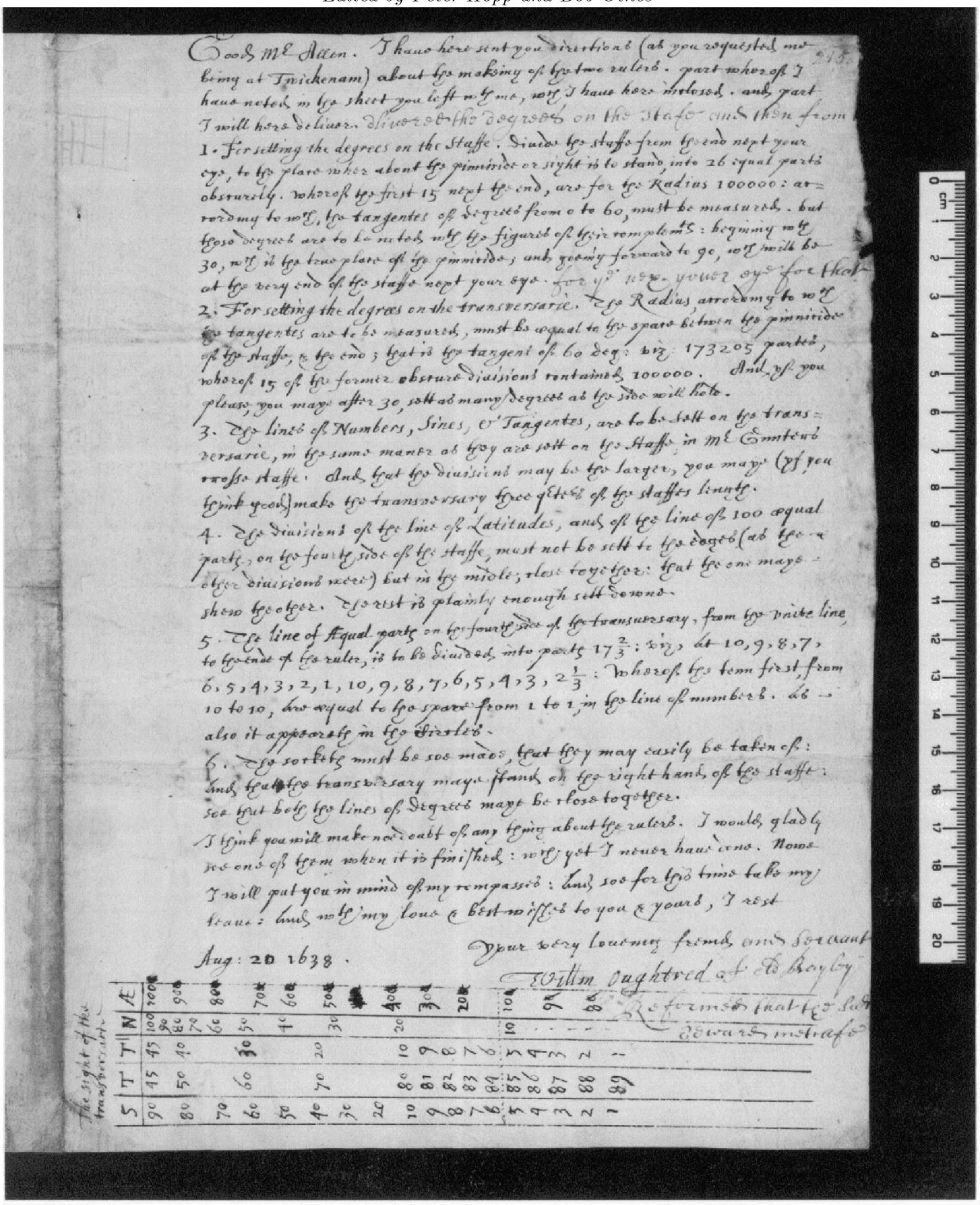

Figure 1. The letter from William Oughtred to Elias Allen.

Editor's Introduction

In a 1638 letter, William Oughtred discusses changes that he wants made to a cross staff that Elias Allen is making under his direction. Oughtred was a famous mathematician of the 17th century and the Oughtred Society is so named in his honor. Allen was famous in his own right as the premier instrument maker of the 17th century.

The letter in question is in the Macclesfield Collection of the Cambridge University Library, which was kind enough to provide us with photocopies of the letter and its attachments for the purpose of this article. Our thanks to the Library for this courtesy.

In the letter shown in Figure 1, Oughtred describes an improved version of the cross staff that may also be worked as a *slide rule*, and gives directions (corrections?) on the making of improvements in the current version.

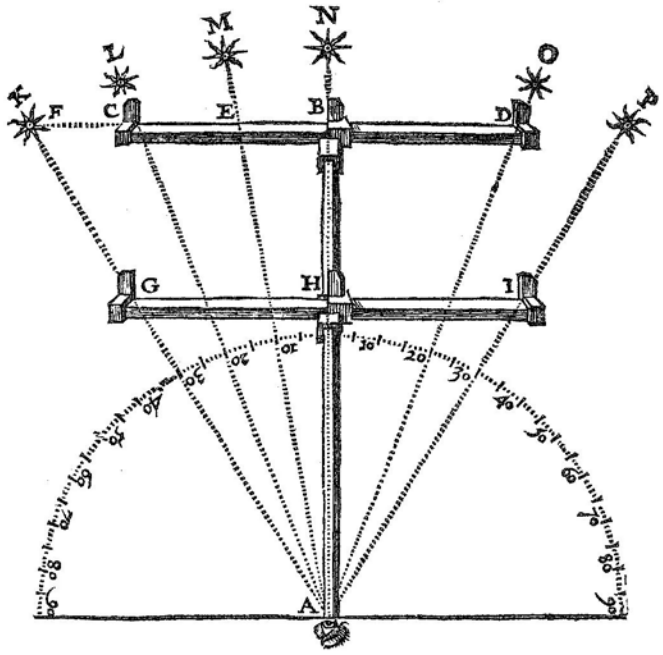

Figure 2. The Gunter Cross Staff.

Figure 2 was taken from Edmond Gunter's book of 1624 and shows his cross staff. The Gunter cross staff is a device for measuring angles and would have been used by mariners to measure the height in degrees of the sun above the horizon at noon for navigational purposes and for other applications where angle measurements were required. The Gunter version of the cross staff has on the main (vertical piece) the lines of numbers, sines, tangents, etc., which can be used to make necessary calculations from the angle measurements with the aid of a compass of the drawing type. It is not a slide rule.

Terms employed in the letter:

pinnicle The peephole at the (bottom) end of the staff where the eye is employed.

ruler Either the *stafe* or the *transversarie*.

sorketz Wooden blocks that fit on the transversarie, such as L, D, G, and R in Figure 2. The position of these set the range that the instrument is to have for a particular observation. When in use, the transversarie, shown horizontal, is vertical. By moving the transversarie backwards or forward, the user can sight across the bottom sorketz on the horizon and the top one on the sun.

stafe This is the vertical ruler of the instrument shown in Figure 2. It is suggested by Oughtred to be 50% longer than the transversarie.

transversarie The horizontal member of the instrument in Figure 2. Gunter shows two; Oughtred writes only of one in his version of the instrument. Figure 3 is the transversarie as shown in Oughtred's letter.

The Letter

Good Mr Allen.

I have here sent you directions (as you requested me being at Twickenam) about the making of my two rulers, part wherof I have noted in the sheet you left [with] me, [which] I have here inclosed, and part I will here deliver.[2]

1. For setting the degrees on the staffe. Divide the staffe from the end next your eye, to the place where about the pinnicle or sight is to stand, into 26 equal parts obscurely. Wherof the first 15 next the end, are for the Radius 100000: according to which, the tangents of degrees from 0 to 60, must be measured. but those degrees are to be noted with the figures of their [complemts]: beginning [with] 30, which if the [template] of the pinnicle, and going forward to 90, [which] will be at the [very] end of the staffe next your eye.[3]

2. For setting the degrees on the transversarie, the Radius, according to which the tangentes are to be measured, must be æqual to the space between the pinnicle of the staffe, as the end; that is the tangent of 60 degs: viz 173205[4] partes, wherof 15 of the former obscure divisions contained 100000. And if you please, you may after 30, sett as many degrees as the side will hold.

3. The lines of Numbers, Sines & Tangentes, are to be sett on the transversarie, in the same maner as they are sett in the staff in Mr [Gunter's] crosse staffe, And that the divisiens may be the larger, you may (if you think good) make the transversary three quarters of the staffes ligth.

4. The divisions of the line of Latitudes, and of the lines of 100 æqual parts, on the fourth side of the staffe, must not be sett to the [edges] (as those]

[2] Fragment with a different person's writing: "...on the degrees on the stafe and then from..."

[3] The following text occurred at this point but in a different person's writing: "for [if] [now] youor eye for that...".

[4] This is the tangent of 60° in the manner (scale) of the time.

other divisions now) but in the [midle] close togethr: that the one may show [the other]. The rest is plainly enough sett downe.

5. The line of Æqual parts on the fourth side of transversary, from the unite line, to [the end] of the ruler, is to be divided into parts $17^2/_3$(sic): [viz] at 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 10, 9, 8, 7, 6, 5, 4, 3, $2^1/_3$: wherof the tenn first, from 10 to 10, [be] æqual to the space from 1 to 1, in the line of numbers. As also it appeareth thus in the [??].

6. The sorketz must be soe made that they may easily be taken off: and that the transversary maye stand on the right hand of the staffe: soe that both the lines of degrees may be close together.

I think you will make no doubt of any thing about the rulers. I would gladly see one of them when it is finished: [which] yet I never have done. [Nowe] I will put you in mind of my compasses: [and] soo for this time take my leave: and [make] my [love] & best wishes to you and yours, I rest

Aug: 20 1638 Your so very [loving] friend and servant

William Oughtred of etc. [Old Bayley]
[Reformed] that the [Sub]
[dewards] [mostrato]

End of material on the face of the letter.

The following was on the back of the letter as an address:

To my very [loving] friend Mr
Elias Allen [dwelling] over against
The great South doore of St
Clementz church

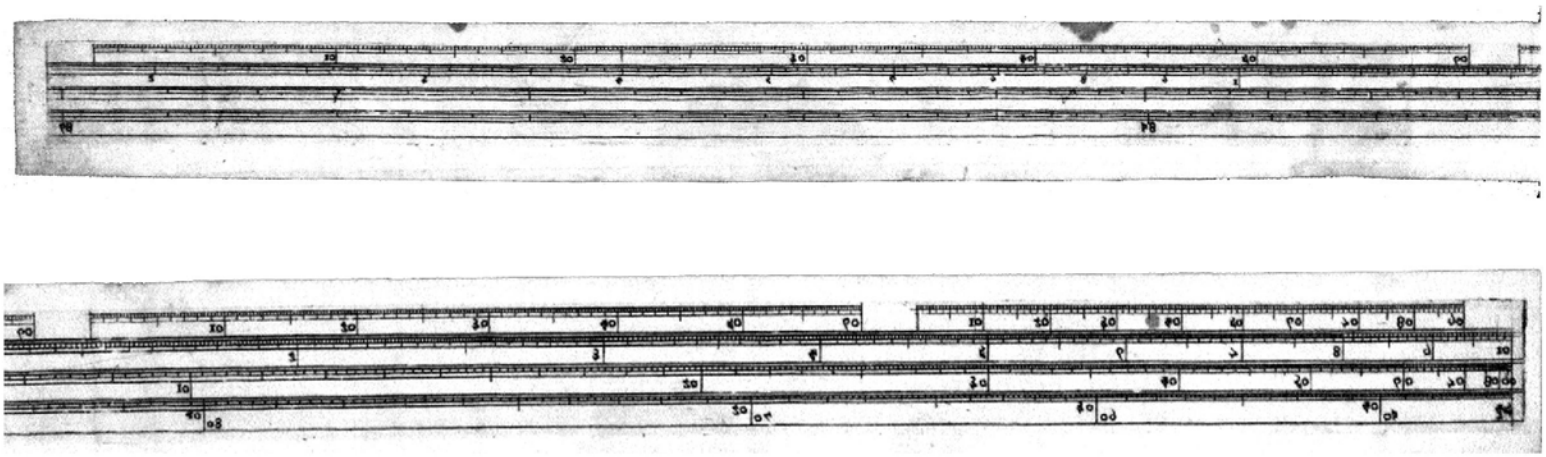

Figure 3. The drawing in Oughtred's letter.

Notes on an Excerpt from Oughtred's Book, Version of 1660.

This material is intended to supplement the adjacent transcription and clarification by Peter Hopp of an important letter from William Oughtred the mathematician to Elias Allen his instrument maker.

In his book *The Circles of Proportion...* [1], Oughtred discusses the type of elementary slide rule described in the above mentioned letter. This starts on page 241 of [1]. An excerpt of Oughtred's description and use of this rule is given below in order to clarify the above letter. In doing the transcription much of the typography and spelling has been modified in the hope that this modernization of the language will make it clearer to our readers. Note that this type of rule appears to have been made for navigational calculations.

The other reference [2] is a short booklet by Oughtred describing another instrument related to the above mentioned one that was specially designed for cask gauging calculations. Thus, in 1633 there were two important versions of the slide rule described by Oughtred.

There do not seem to be any surviving examples of either type of rule. *The Editors*

References

1. Oughtred, W., *The Circles of Proportion and the Horizontall Instrument &c.,* W. Hall, Oxford, 1660. This is a later printing of Oughtred's work in Latin of 1632. In 1633 another edition included the chapter titled "The Declaration of the Two Rulers for Calculation". The quotation below was taken from the edition of 1660 in English, beginning page 241.

2. Oughtred, W., *The New Artificial Gauging Line or Rod: Together with rules concerning the use thereof,*

Printed by Aug. Mathewes, 1633. This book concerns a pair of brass rulers, each 32 inches long by $\frac{1}{2}$ and $\frac{1}{4}$ inches in cross section. Attached together, they made a rod for measuring the depth of a cask or barrel and taking other measurements; laid side by side, they could be used as a slide rule for computing the number of gallons in the container.

Excerpts from the booklet appeared in *The Journal of the Oughtred Society*, 7:2, Fall 1998.

The Declaration of the Two Rules for Calculation[5]

William Oughtred

The rulers are so framed and composed, that they may not only be applied to the *calculation of Triangles,* and the resolution of *Arithmetical questions:* but that they may also very fitly serve for a Cross Staff to take the height of the Sun or any Star above the Horizon, and also their distances: in which regard I call the longer of the *two Rulers,* the *Staff* and the *Shorter* the Transversal. And are in length one the other almost as 3 to 2.

The rulers are just four square, with right angles: and equal in bigness: they are thus divided.

The *Transversal* at the upper end noted with the letters S,T,N,E, on the several sides has a *pinnicide* or *sight:* at the lower edge of which sight is the *Line of the Radius,* or *Unit line,* where the divisions begin.

On the left edge of one of the sides are set the *Degrees* from 0 to 33 degrees, or as many above 30 as the side can contain. And on the right edge of the same side is set the line of *Sines* from 90 to 1 degree. Those 33 degrees are tangents measured according to a Radius of 173205, which is the tangent of 60 on the staff.

In the next side are set *two lines of Tangents,* that on the right edge go upward from 1 to 45 degrees, and that on the left edge go downward from from 45 to 89 degrees.

In the third side, on the right edge is set the *line of Numbers,* having these figures in descent 1,9,8,7,6,5,4,3,2 L,9,8,7,6,5,4,3,2,1.

In the fourth side on the right edge is the set line of *Equal parts:* And on the left edge are diverse chords for the dividing of Circles.

10,9,8,7,6,5,4,3,2,1,10,
9,8,7,6,5,4,3,2:

The Staff at the farther end of it has a *Socket* with a *pinnicide* or *sight:* at which beginneth the 30 degree, and so goeth on to 90 degrees at the end of the *Staff* next your eye: which degrees from 30 to 90 are set on the right edge of one of the sides of the Staff.

Then applying your *Transversal* to the *Staff* with the lower end set to the 90, mark on the four sides of the Staff *the line of the Radius or Unit:* at which on every left edge must begin the single line of *Sines*, *Tangents*, and *Numbers*, the very same which were in the *Transversal* (that of the Sines being on that side where the degrees are) only the line of *Tangents and numbers* are continued beyond the line of the *Radius* to the further end of the Staff, by turning your transversal that way.

And on the fourth side in the middle are *double divisions:* that on the right hand is a *line of Equal parts* to 100., reaching the whole length the Staff: And on the left hand contiguous to the former, is the line of *latitudes or Elevations of the Pole* unto 70 degrees marked with the letter L.

The *degrees* both of the Staff and Transversal, and also of the Sines and Tangents may be divided into 6 parts which contain 10 minutes apiece: or rather into 10 parts containing 6 minutes apiece for so they may serve also for decimals.

Thus have you on the two Rulers the very same lines sl which are in *Circles of Proportion:*[6] and whatsoever can be done by those Circles, may also as well be performed by the two Rulers: and the Rules which have been formerly set down, for that Instrument, may also be practiced upon these: so that you, be carefull to observe in both the different propriety in working. It will not therefore be needfull, to make any new and long discourse concerning these rulers, but only to show the manner, how they are to be used, for the calculation of any proposition given.

In working a Proportion by the Rulers, *hold the Transversal* in your left hand, with the end at which the line of the Radius or Unit line is, from you ward: turning that side of the Rule upward, on which the line of the kind of the first term, is whether it be Number, Sine or Tangent: and therein seek both the first term, and the other which is homogene to it. Then take the Staff in your right hand with that side upward, in which the line of the kind of the fourth term sought for is: and see in it the term homogene to the fourth. Apply this to the first term in the Transversal: and the other homogene term shall in the staff show the fourth term.

As if you would multiply 355 by 48: Say

$$1 \cdot 355 :: 48 \cdot 17040$$

For if in the line of Numbers on the Staff you reckon 355, & apply the same to 1 in the line of numbers on the Transversal, then shall 48 on the Transversal; show 17040 on the Staff.

[5] See item 1 in the References immediately above

[6] Oughtred is here referring to his circular slide rule. *Ed.*

Again if you would divide 17040 by 48: Say

$$48 \cdot 1 :: 17040 \cdot 355$$

For if in the line of Numbers on the Transversal you reckon 48, and to the same apply 1 in the line of Numbers on the Staff: then shall 17040 on the Transversal show 355 on the Staff.

The true value of the fourth term found, may be had by the 5th and 6th sections: 2. chapter 1 part.

Some Examples of working proportions we will borrow out of 3 chapter 1 part.

Example 1. If 54 elnes[7] of Holland be sold for 96 shillings: for how many shillings shall 9 elnes be sold? the worke shall be thus for if in the line of numbers on the transversal you seek the first term 45 elnes, and in that line on the Staff: you seek 96 shillings; and apply one to the other: then shall 9 elnes saught out on the Tranversal point out 16 shillings on the Staff.

Example IV. There is a Tower whose height I would measure.

I take two stations in the same right line from the Tower: and at either station having observed the height by the sights of the Staff, I find the nearer station 28 deg: 7. min: almost: and the further station 21 degr. 58 minutes almost: and between both the Stations the difference was 76 feet.

The rule of measuring heights by two stations is contained in these *Theorems.*

Theorem: *As the difference of the tangents of the arches cut in either station, is to the difference between the Stations: so is the Tangent of the lesser arch to the nearer distance from the Tower.*

Again

Theorem: *As the Radius is to the Tangent of the greater arch; so is the nearer distance found to the height.*

&Etc.

Appendix

Peter M. Hopp

The Macclesfield Collection consists of the papers of William Jones and John Collins, who corresponded with the major scientific figures of the 17th and 18th centuries. It documents Sir Isaac Newton's writings and ideas, in holograph letters and manuscripts: on gravitation, calculus, the *Principia Mathematica*, optics, chemistry, comets and other subjects.

Notes on the transcription of "Good Mr Allen"[8]

1. The information came to me as four sheets of paper with images printed out from enormous files that had been sent to Bob Otnes by the British Museum.

2. The first sheet (Good Mr Allen) is the letter dated Aug 20 1638 contained on a sheet of paper approximately 29 cms. long x 21.3 cms. folded into an envelope.

3. In addition, two separate sheets of paper contained scans of the two halves of a scale. These have been scanned onto a single image.

4.1. The letter appears to have writing by two people. Oughtred wrote the majority of the document. However, at line 4 is the first example of the second hand, followed by a second example at line 11; and then the end there are two further lines following Oughtred's complimentary close, his signature, (lines 37 and 38) and then two further lines (lines 39 and 40) that are quite difficult to decipher. I have assumed that they may be by Allen, but have no good reason for stating this, or indeed can see no good reason why this was done, particularly at the end of the letter. Nevertheless the ink and the writing are quite different.

4.2. In the transcription, words in square brackets [...] are words I (and others who helped with the transcription) can not be certain exactly what the word should be. In one case I have guessed at "Gunter". This could affect the sense considerably should it become obvious that another's design of cross-staff has been used.

4.3. The transcription also contains explanations of some of the words. The most obvious is "pinniricle" which I believe is Oughtred's idiosyncratic spelling of what we would recognize as pinnacle, a fairly large protuberance, or sight, on the staff. The other explanations are more obvious.

[7] The meaning of this word is unknown to us. The OED definition is of a *quality*, something that cannot be quantified.

[8] A letter written by William Oughtred to Elias Allen on August 20, 1638.