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Autor: **Cajori, Florian** (1859–1930)

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Slide Rules with „Runners“

by FLORIAN CAJORI (Colorado Springs, Colorado U. S. A.).

In the Enzyklopädie der Mathematischen Wissenchaften, erster Band, Seite 1055, we read as follows: „Bis auf die, allerdings wesentliche Anbringung eines ‚Läufers‘ (curseur) . . . durch A. MANNHEIM (gegen 1850), welcher zum Festhalten irgend eines Punktes einer Skala und zum Aufsuchen entsprechender Punkte auf parallelen Skalen dient, war damit in der Hauptsache die endgültige Form erreicht.“ This passage expresses the idea which has prevoiled relating to the invention and the time of the introduction of the „Läufer“ or „runner“ as a part of the ordinary slide rule. It was pointed out, soon after the appearance of the article from which we have just quoted, that MANNHEIM cannot be regarded as the first inventor of the runner, since this device is described as early as 1837 in a work by PH. MOUZIN which appeared in Paris under the title „Instruction sur la manière de se servir de la règle à calcul, dite règle anglaise ou sliding rule, 3 édition, Paris, 1837.“ [1])

While it is doubtless true that MANNHEIM is the first designer of a slide rule with a runner attachment, whose instrument has met with widespread adoption in Europe and America, it is to be noted that both MANNHEIM and MOUZIN were anticipated in the invention of the „runner“ by the English. It is the purpose of this paper to point out that the first suggestion of the use of the „runner“ was made in the seventeenth century, that several English writers of the eigteenth century described the runner, but that the device did not meet with popular favor and in the first half of the nineteenth century came to be completely forgotten in England.

It is of no small moment, that Sir ISAAC NEWTON, at one time, interested himself in the slide rule and that he outlined a method of solving numerical equations by a slide rule of special design, which embodied

1) Zeitschr. für Mathematik u. Physik, Bd. 48 (1903), S. 134.

the use of the runner [1]). The following is a translation of an extract from a letter of OLDENBURG to LEIBNIZ, dated June 24, 1675: [2])

Mr. NEWTON (fortunately I am am able to quote from his letters on this point) with the help of logarithms graduated upon scales by placing them parallel at equal distances or with the help of concentric circles graduated in the same way, finds the roots of equations. Three rules suffice for cubics, four for biquadratics. In the arrangement of these rules, all the respective coefficients lie in the same straight line. From a point of which line, as for removed from the first rule as the graduated scales are from one another, in turn, a straight line is drawn over them, so as to agree with the conditions conforming with the nature of the equation; in one of these rules is given the pure power of the required root. Indeed we would gladly know whether you, most learned man, and our own NEWTON have lighted upon the same device."

In replying to OLDENBURG, about a mouth later, LEIBNITZ expressed himself as follows: „The method of the celebrated NEWTON, of finding the roots of an equation, differs from mine. For I do not see in mine what either logarithms or concentric circles contribute. And yet, since I see that the subject is not displeasing to you, I will try to think it out and will let you know as soon as I have sufficient leisure."

If our interpretation of the passage from OLDENBURG is correct, it means, in case of a cubic equation $x^3 + ax^2 + bx = c$, that three rules

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1) See my History of the Logarithmic Slide Rule and Allied Instruments, New York 1909, Engineering News Publishing Co.

2) LEIBNIZENS mathematische Schriften, herausg. v. C. I. GERHARDT, 1. Abt., Band I, Berlin 149, p. 78: „DN. NEWTONUS (ut hoc ex occasione literarum suarum addam) beneficio Logarithmorum graduatorum in scalis παραλλήλως locandis ad distantias aequales, vel Circulorum Concentricorum eo modo graduatorum adminiculo, invenit aequationum radices. Tres Regulae rem conficiunt pro Cubicis; quatuor, pro Biquadraticis: In harum dispositione, respectivae coefficientes omnes jacent in eadem linea recta, a cujus puncto, tam remoto a regula prima, ac graduatae scalae sunt ab invicem, linea recta iis super extenditur, uno cum praescriptis consentaneis genio aequationis, qua in regularum una potestas pura datur radicis quaesitae. Lubentes equidem cognosceremus, num Tu, Vir Doctissime, et NEWTONUS noster in artificium idem incideritis." This Latin passage is given also in NEWTON'S works. See ISAACI NEWTONI OPERA (Ed. S. MORSLEY), Tom. IV., Londini 1782, p. 520, but the wording is slightly different there. On page 80 of the volume of LEIBNIZ which we have just quote is given LEIBNIZ'S reply to OLDENBURG, containing the following paragraph:

„Methodum Celeberrimi NEUTONI, radices Aequationum inveniendi per Instrumentum, credo differre a mea. Neque enim video in mea quid aut Logarithmi aut Circuli Concentrici conferant. Quoniam tamen rem vobis non ingratam video; conabor absolvere, ac tibi communicare, quamprimum otii sat erit."

A, B, D, (Fig. 1) logarithmically graduated, must be placed parallel and equidistant. On rule A find the number equal to the numerical value |a| of the coefficient a of the equation; on rule B find |b|, and on rule D find 1. Then arrange these three numbers on the rules in a straigth line BD. Select the point E on this line, so that EB = BA. Through E pass a line ED′ and turn is about E until the numbers at B′, A′ and D′, with their proper algebraic signs attached, are seen to be together equal to the absolute term c. Then the number on the scale at D′ is equal to $|x^3|$, and x can be found. We are not aware that rules of this type we actually constructed and used in the solution of numerical equations. But it is readily that the pratical operation of this scheme whould call for the use of a device which would make it possible to read the numbers B′, A′ D′ on the scales, which lie at the places where the line ED′ crosses the scales. Such a device would sulfil the functions of what is now called the runner.

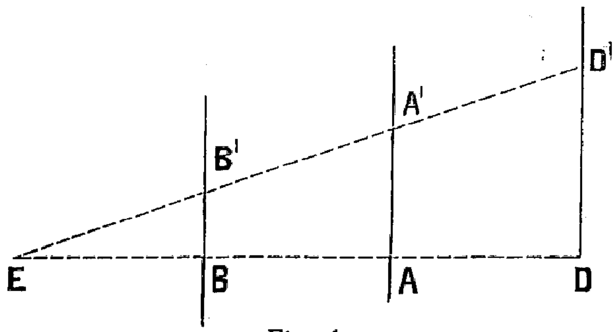

Fig. 1.

We must, therefore, look upon NEWTON as the first to have thought of such an attachement to the slide rule.

NEWTONS mode of solving equations mechanically is explained more fully and with some modifications rendering the process more practical, by E. STONE in the second edition of his New Mathematical Dictionary, London, 1734, in an article at the very end of the book and bearing the heading „To be added to the Head of **Roots of Equations.**" STONE assumes that the equation to be solved is transformed so that all its coefficients are positive. All rules are of the same length, but differently graduated, the first rule having the single radius 1, 2, 3, . . . , 10; the recond rule having the double radius 1, 2, . . . , 9, 1, 2, . . . , 10, and so on for the other rules. Whith this mode of graduation, the straight line toking the position of the „runner" would not be inclined to the rules, in the same way, as is ED′ in Fig. 1, but it would be at right angles tho the rules. The exact words used by STONE, in describing what we call the runner, are as follows:[1])

„Take as many GUNTERS Lines (upon narrow Rules) all of the same Length, sliding in Dove-tail Cavities, made in a broad oblong Piece of

1) In my History of the Logarithmic Slide Rule, New York 1909, STONE's article is copied in full.

Wood, or Metal; as the Equation whose Roots you want the Dimensions of, having a Slider carrying a Thread or Hair backward or forwards at right Angles over allthese Lines.“

This „Slider carrying a Thread“ is evidently a „runner“.

The third time that we have encountered the use of the runner is in a modification of GUNTERS scale, for the purposes of navigation, effected by JOHN ROBERTSON, an account of wich was published after his death by his friend, WILLIAM MOUNTAINE, in a booklet bearing the title A Description of the Lines drawn on GUNTERS Scale, as improved by Mr. JOHN ROBERTSON, London 1778. ROBERTSON's improved GUNTERS were really slide rules and were mechanically executed under his own inspection by Messrs. NAIRNE and BLUNT, who were mathematical instrument makers in Cornhill, London. Each rule was made 30 inches long, 2 inches broad, and about half an inch thick.“ On one face of the instrument were twelve logarithmic lines, nine of them fixed and three of them sliding. A contrivance, named the „index“, now called a runner, is described in the following passage (p. 3):

„Along this Face an Index or thin Piece of Brass, about an Inch broad, is contrived to slide, which going across the Edge of the Scale at right Angles thereto, will shew on the everal Lines the Divisions which are opposite to one another; although the Lines are not contiguous.“

Infortunately no diagram of the instrument is given. As for as we know, it is the earliest design of a slide rule with the „runner“ attachment, that was actually constructed and placed on the market. There is nothing to indicate that it enjoyed an extensive sale. On ship board, the old GUNTERS scale, which had no sliding parts, and required the use of compasses for the transference of distances from one part of the scale to another, continued to be the instrument in regular use. And yet, it appears that ROBERTSONS general idea, which he he carried out in his modification of GUNTER's scale for navigation, was not altogether lost sight of in England at the beginning of the new century, as is evident from the title of the following book by Dr. ANDREW MACKAY: „The Description and Use of the SLIDING GUNTER in Navigation, Leith, 1812“. We have not yet had the opportunity to see this book, the first edition of which appeared in 1802. The earliest use of the term „Sliding Gunter“, known to us, is in „The Description and Explanation of Mathematical Instruments . . . by THO. TUTTELL, Mathematical Instrument-maker to the King's most Excellent Majesty . . . , London, 1701“, but the diagram of the instrument does not show a runner.

Probably the most able and thorough student of the slide rule problem, during the eighteenth century, was WILLIAM NICHOLSON, the well-known

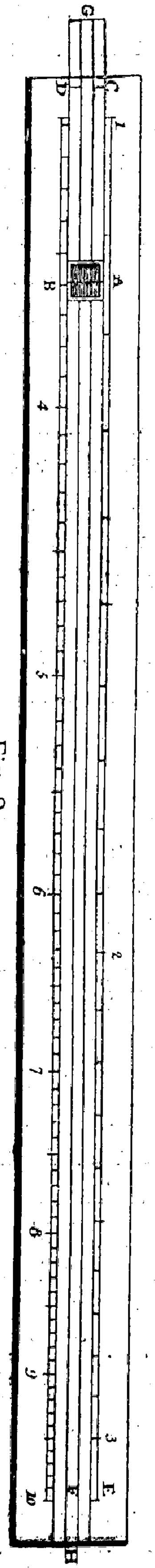

Fig. 2.

editor of Nicholson's Journal. He prepared an article [1]), in which different types of rules are described and the important problem is taken up, to increase the accuracy of the slide rule without increasing the dimensions of the instrument. We shall not attempt to describe the different designs. We only refer to one type, which was, in the language of NICHOLSON, „equivalent to that of 1/2 inches in length, published by the late Mr. ROBERTSON. It is, however, but 1/4 of the length and contains only 1/4 of the quantity of division". Our Fig. 2 is taken from the Philosophical Transactions and shows this rule. It will be seen that the morable piece AB is a runner. NICHOLSON explains that in the slider GH „is a morable piece AB, across which a fine line is drawn; and there are also lines CD, EF drawn across the slider at a distance from each other equal to the length of the rule." In using the instrument, „the line CD or EF is to be placed at the consequent, and the line in the piece AB at the antecedent; then, if the piece AB be placed at any other antecedent, the same line CD or EF will indicate its consequent in the same ratio taken the same way; that is, if the antecedent and the consequent lie on the same side of the slider, all other antecedents and consequents in that ratio will lie in the same manner, and the contrary if they do not, etc."

NICHOLSON's remarkable article received very little attention. We have not been able to learn that any of his rules were actually constructed and sold. Ten years later he wrote an article containing still further studies on the design of slide rules [2]), in which he took occasion to remark that the method he explained in 1787 of extending the range of the slide rule, he „still considers less generally known than its utility may perhaps claim." In NICHOLSON's designs of 1797 the runner again appears. But his work of 1797 met with no more appreciation than did that of 1787. Significant is the remark of the English astronomer PEARSON who, about this time, explained what could be done by inverting the slider, and then added that he entertained no hope that his suggestion

1) Philosophical Transactions (London), 1787, Pt. II, 246-252.

2) NICHOLSON's Journal, Vol. I, 1802, p. 372—375, reprinted from issue of 1797.

would be adopted in practice, for mechanics do not like innovations, as is evident from the fact that twenty of the old fashioned COGGESHALL'S rules are sold to every one of the more recent and improved designs.

We have seen that the use of the runner was suggested by NEWTON STONE and NICHOLSON, also that ROBERTSON actually had constructed slide rules with runner. Nevertheless this ingenious invention failed to meet with appreciation to such a degree, that in 1842 so alert a writer as Professor AUGUSTUS DE MORGAN wrote an extended article on the slide rule for the Penny Cyclopaedia, and yet did not once refer to the runner. In the latter half of the nineteenth century the English were slower in introducing slide rules with runners than were the other leading nationalities in Europe.
