Editor’s Foreward

This version of the Cajori’s important book “The Slide Rule” was photocopied from the one in the library of Whipple Museum of the History of Science at Cambridge University. The copy used had previously been owned by L. H. Cooke, a physics professor at the University (as is the case with many books in the Whipple Collection). Although Cooke did not himself win a Nobel Prize he did work with Owen Richardson who won the physics prize in 1929 and who cited the work he had done with Cook on Thermionic Valves in his formal lecture. This edition was published in 1909.

The book was converted to text using Optical Character Recognition (OCR). Whilst this method can produce a high degree of accuracy there are inevitably some mistakes. I have tried to correct as many as possible but do not guarantee that no mistakes remain. This task was made particularly difficult by the fact that some references are to books in French, German and other languages – even Russian - and the original text was not well edited. Two examples of the lack of consistency in the editing are the fact a name appears as both MacFarlane and McFarlane in the same paragraph and the word French word “règle” for a rule also appears as “régle” and “regle”. I have corrected some of the more obvious errors but do not claim any consistency for my own approach.

I have tried to maintain some of the “flavour” of the original, in terms of font and layout of the chapters, but have made a number of changes. The major ones are that the page numbering is completely different from the original, there is no index, the figures follow the main text and I have added cross-references from the text of the book to the addendum. The last one is important as it is only in the addendum where Cajori clearly identifies Oughtred as the inventor of the slide rule.

In short, this text should be regarded as for general interest; if you wish to do serious historical research I would suggest that either borrow a copy of the original or buy a copy of the modern facsimile edition.

PREFACE

OF the machines for minimizing mental labor in computation, no device has been of greater general interest than the Slide Rule. Few instruments offer a more attractive field for historical study. Its development has reached into many directions and has attracted men of varied gifts. Among these are not only writers on arithmetic, carpenters, and excise officers, but also such practical engineers as Coggeshall, E. Thacher, Beauchamp Tower; such chemists as Wollaston and Regnault; such physicists as J. H. Lambert, Thomas Young, J. D. Everett; such advanced mathematicians as Segner, Perry, Mannheim, Mehmke, and the great Sir Isaac Newton.

And yet the history of this instrument has been neglected to such an extent that gross inaccuracies occur in standard publications, particularly in regard to its early history. Charles Hutton and De Morgan do not agree as to the inventor of the instrument. Hutton ascribes the invention to Edmund Wingate,[1] but fails to support his assertion by reference to, or quotation from, any of Wingate's publications. De Morgan denies the claims made for Wingate[2], but had not seen all of Wingate's works; he claims the invention for William Oughtred, and his conclusion is affirmed in as recent publications as the *International Cyclopaedia*, New York, 1892, and the *Slide Rule Notes*, by H. C. Dunlop and C. S. Jackson, London, 1901. In the present monograph we aim to settle this question. It will be shown, moreover, that the invention of the "runner and the suggestion of the possibility of utilizing the slide rule in the solution of numerical equations are of much earlier date than has been supposed by some writers. We shall also show that the device of inverting a logarithmic line is much older than is commonly believed. A fuller statement than is found elsewhere will be given here of the improvements in the slide rule made in England previous to the year 1800, and an effort will be made to determine more precisely how extensively this instrument was put to practical use at that early time. So far as space permits, we shall indicate the many-sided developments, in the design of slide rules, made during the last one hundred years. Slide rules have been adapted to almost every branch of the arts in which calculation is required. This fact becomes very evident, if one examines the list of slide rules, given near the end of this volume.

By reference to the "Bibliography of the Slide Rule" in the Alphabetical Index the reader will find the principal books which have been written on this instrument.

I have been assisted in the reading of the proofs by Mr. Albert Russell Ellingwood, a student in Colorado College. I extend to him my thanks for this help.

FLORIAN CAJORI.

SCHOOL OF ENGINEERING, COLORADO COLLEGE,
Colorado Springs, Col., 1909.

[1] Hutton's Mathematical Tables, London, 1811, Introduction, p 36, also his Philosophical and Mathematical Dictionary, Art. "Gunter's Line."

[2] Article "Slide Rule" in the *Penny Cyclopaedia*, 1842, same article in the *English Cyclopædia*, Arts and Sciences

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HISTORY OF THE LOGARITHMIC SLIDE RULE

THE INVENTION OF LOGARITHMS AND OF THE LOGARITHMIC LINE OF NUMBERS

THE miraculous powers of modern computation are largely due to the invention of logarithms. We owe this to John Napier (1550-1617), Baron of Merchiston, in Scotland, who gave it to the world in 1614. It met with immediate appreciation both in England and on the European continent. And only a few years later, in 1620, was made a second invention which was a necessary prelude to the invention of the slide rule. In that year Edmund Gunter (1581-1626), professor of astronomy in Gresham College, London, designed the logarithmic "line of numbers," which is simply a straight line, with the digits 1, 2, 3, . . . , 10 arranged upon it from one extremity to the other, in such a way that the distance on the line from the end marked 1, to the figure 2, is to the distance from 1 to any other number, as the logarithm of 2 is to the logarithm of that other number. In other words, distances along the line were not taken proportional to the numbers on it, but to the logarithms of those numbers. Gunter mounted this line, together with other lines giving the logarithms of trigonometric functions, upon a ruler or scale, commonly called "Gunter's scale" (see Fig. 1), by means of which questions in navigation could be resolved with the aid of a pair of compasses. These compasses were used in adding or subtracting distances on the scale, by which, according to the properties of logarithms, products or quotients of numbers could be found. Gunter described his logarithmic "line of numbers" in *his Canon Triangulorum*, London, 1620, as well as in his *Description and Use of the Sector, Cross-Staff and other Instruments*, London, 1624.

GUNTER'S SCALE AND THE SLIDE RULE OFTEN CONFOUNDED

In former years the invention of the slide rule was frequently but erroneously, attributed to Gunter. Thus, F. Stone, in his *New Mathematical Dictionary*, London, 1726 and 1743, says in the article "Sliding Rules," "they are very ingeniously contrived and applied by Gunter, Partridge, Cogshall, Everard, Hunt, and others, who have written particular Treatises about their Use and Application." These very same words are found, according to De Morgan, in Harris' *Lexicon Technicum*, 1716[1] In Charles Hutton's *Mathematical Dictionary*, 1815, we read "they are variously contrived and applied by different authors, particularly Gunter, Partridge, Hunt, Everard and Coggleshall." A similar statement is made in the eighth edition of the *Encyclopaedia Britannica*; 1860. Now, as we have seen, Gunter certainly constructed the first logarithmic line and scale. But this scale, as invented by Gunter, has no sliding parts and is, therefore, not a sliding rule. Confusion has prevailed as to the distinction between Gunter's line and the slide rule. Stone, in both editions of his *Dictionary* (1726, 1743), describes Gunter's line as follows: "It is only the Logarithms laid off upon straight Lines; and its Use is for performing Operations of Arithimetick, by Means of a Pair of Compasses, or even without, by sliding two of these Lines of Numbers by each other." In another place (Art. "Sliding Rule") of his *Dictionary* he says: "Sliding Rules, or Scales, are Instruments to be used without Compasses, in Gauging, measuring, etc., having their Lines fitted so as to answer Proportions by Inspection; they are very ingeniously contrived and applied by Gunter, Partridge, Cogshall, Everard, Hunt and others. . . ." In the final article of the 1743 edition of the *Dictionary*, an article which, he says, is "to be added to the Head of Roots of Equations," he uses the terms "Gunter's Lines" and "Sliding Rule" interchangeably. Thus, he uses the name "Gunter's Lines" to apply to both instruments, but in one article he restricts the name "sliding rules" to instruments "used without compasses," though he still retains Gunter in the list of designers of sliding rules. Since both instruments went in those days often under the same name (" Gunter's Lines"), it is easy to see how the inventor of the Gunter's line proper (without sliding parts) passed also as the inventor of the slide rule. It is not unusual to find the slide rule described under the name of Gunter's line in much later publications. This was done, for instance, by Appleton's *Dictionary of . . . Engineering*, Vol. I., New York, in 1868.

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[1] In 1726 Stone evidently drew from a different source of information than in 1723, when he published in London Bion's *Construction and Principal Uses of Mathematical Instruments* and added descriptions of English instruments. In 1723 he speaks of both "Mr. Windgate" and "Mr. Oughtred," but in 1726 their names are omitted.

CONFLICTING STATEMENTS ON THE INVENTION OF THE SLIDE RULE

De Morgan, in his article "Slide Rule" in *the Penny Cyclopaedia*, 1842, reprinted in the *English Cyclopaedia* (Arts and Sciences), ascribes the invention of the slide rule to William Oughtred (1574-1660), a famous English mathematician, and denies that Edmund Wingate (1593-1656) ever wrote on the slide rule. He repeats this assertion relating to Wingate in his biographical sketch of Wingate, inserted in the *Penny Cyclopaedia* and also in his work, entitled *Arithmetical Books from the Invention of Printing to the Present Time*, London, 1847, p. 42. It will soon appear that De Morgan is ill informed on this subject, although his criticism of a passage in *Ward's Lives of the Professors of Gresham College*, 1740, is well taken. Ward claims that Edmund Wingate introduced the slide rule into France in 1624. What he at that time really did introduce was Gunter's scale, as appears from the examination of his book, published in Paris in 1624 under the title, *L'usage de la règle de proportion en l'arithmétique et géométrie*. We shall see that Wingate invented the slide rule a few years later.
In his *Mathematical Tables*, Hutton expresses himself on Gunter's logarithmic lines as follows (p. 36): "In 1627 they were drawn by Wingate, on two separate rulers sliding against each other, to save the use of compasses in resolving proportions. They were also, in 1627, applied to concentric circles, by Oughtred." Hutton makes the same statement in his *Mathematical Dictionary*, London, 1815, article "Gunter's Line," but nowhere gives his authority for it. A. Favaro, in an article on the history of the slide rule which we shall have occasion to quote very often,[1] cites the following work of Wingate which De Morgan had not seen: *Of Natural and Artificial Arithmetic*, London, 1630. R. Mehmke, in his article in the *Encyklopädie der Mathematischen Wissenschaften*, Vol.-I, Leipzig, 1898—1904, p. 1054, simply refers to Favaro's paper.

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[1] A. Favaro, in *Veneto Istituto Atti* (5) 5, 1878—79, p. 500, abbreviated in Favaro's *Leçons de statique graphique*, 2ième partie, *calcul graphique*, Paris, 1885, translated into French by P. Terrier.

DISENTANGLEMENT OF THE MAIN FACTS

None of the writers on the history of the slide rule has had the opportunity to examine all of Wingate's works bearing on Gunter's scale and the slide rule. This inaccessibility of original sources of information has led to statements that are incomplete and in some cases erroneous. But it so happens that now every one of the early hooks of Wingate has been examined by one authority or another who has been writing on the history of the slide rule. By collecting the findings of these authorities we are able to draw conclusions which, we believe, are final. Did Wingate invent the straight-edge slide rule? If so, when and where did he first publish his invention?

In some of the most recent books it is stated that Wingate published a description of the slide rule in France in a work bearing the title, *L'Usage de la règle de proportion en l'arithmétique et géométrie*, Paris, 1624. But they give no indication of having had the opportunity themselves to examine Wingate's text.[1] That Wingate published on the slide rule in 1624 is an error, writers such as De Morgan[2] and Benoit,[3] who had access to the 1624 publication noted above, and actually examined it, agree that Wingate in 1624 described Gunter's scale only.

English editions of this work of 1624 appeared in London under the title, *The Use of the Rule of Proportion*, in 1626, 1628, 1645, 1658, 1683.[4] The interesting question arises, did the 1626 English edition describe the slide rule? There is no copy of this edition in the British Museum. De Morgan does not refer to it. But the aforementioned French writer on the slide rule, M. P.-M.-N. Benoit, does. Benoit asserts[5] that in the English translation (London, 1626) of Wingate's French work (Paris, 1624) there is explained the use of two logarithmically divided scales, made to slide against each other. But Benoit says nothing to indicate that he speaks from actual inspection of the 1626 edition. On the very same page where he refers to it, he is very careful to add foot-notes regarding the 1624 edition and some other rare books, and to state where copies of them can be found. But no foot-note or reference is given for the 1626 edition. We shall give reasons for our belief that Benoit is in error when he says that the 1626 edition contained an account of the slide rule. Our reasons are as follows:

In Allibone's *Dictionary of Authors*, it is stated that the Paris publication of 1624 came out "in English 1626, 1628, with additions 1645, with an appendix 1658." Hence it would appear that the 1626 edition had no additions or changes. More conclusive are the assertions of De Morgan,[6] and of a present official of the British Museum, both of whom saw the edition of 1645 and found nothing on the slide rule in it. If the 1645 edition is silent on this instrument, it is safe to assume that the 1626 edition is silent too.

Wingate published in 1626 in Paris a work, entitled, Arithmétique logarithmique, 1626. This has been examined by De Morgan [7] and Favaro,[8] and does not contain the slide rule.

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[1] Such statements are found in Maurice d'Ocagne, Calcul sim-plifié, 2e éd., Paris, 1905, p. 113, and in E. Hammer, Der logarithmische Rechenschieber, 4te Aufl., Stuttgart, 1908, p.

[2] Art. "Slide Rule" in the *Penny Cyclopaedia*.

[3] *Règle à Calcul expliquée*, Paris, 1853, p. VI.

[4] *Dictionary of National Biography*, Art. "Wingate, Edmund."

[5] *Bull. de la société d'encouragement pour l'industrie nationale* Vol. 52, 1853, p. 586. The historical part of this article is copied from Benoit's work La règle à calcul expliquée, Paris, 1853, p. VI.

[6] Arithmetical Books, p. 42.

[7] Arts. "Tables" and "Wingate" in the *Penny Cyclopaedia*.

[8] *Veneto Istituto Atti* (5) 5, 1878—9, p. 500

The present writer secured a reader to examine the copies of Wingate's books that are in the British Museum. In the report of this examination, mention was made of a booklet to which none of the writers on the history of the slide rule had alluded, namely, *Wingate's Construction and Use of the Line of Proportion*, London, 1628. It contains the description of a "double scale," called a "line of proportion." Wingate says in the preface: "I have invented this tabular scale, or line of proportion . . . ." It looked as if this "line of proportion" might be a slide rule. To ascertain the exact facts, the present writer had a copy made and sent to him of the entire booklet and of the diagram in it. The perusal of this showed that the "line of proportion " is not a slide rule at all, but merely a tabular scale in which numbers are indicated by spaces on one side of a straight line, somewhat as millimeters are marked on a meter stick, while on the other side of the line there are spaces which indicate the mantissas of the common logarithms of those numbers. On this scale one can read off the logarithm of a given number, or ascertain the number from a given logarithm. The instrument has no sliding parts and is merely a scale which takes the place of a small table of logarithms.

The 1628 publication just mentioned indicates that Wingate was not inclined to rest satisfied with the mechanical devices for simplifying computation, known as Gunter's scale, but endeavored to invent new scales of his own. And it appears that his next book, *Of Natural and Artificial Arithmetic*, London, 1630, actually contains the description of the slide rule. This work is not in the British Museum and we have not been able to procure a copy of it. But Favaro,[1] we take it, examined the book, as appears from the following passage in Favaro's article: (Addenda 1) "Wingate (1593—1656), who was instrumental, in a way, to make public a discovery of Gunter [2] and in making known logarithmic arithmetic in France,[3] especially for dispensing with the use of the compasses, arranged the logarithmical divisions on two rulers, which he made slide, one along the other, and he then developed with all particulars this proposal of his."[4]

If we examine the list of Wingate's publications, as given in Sidney *Lee's Dictionary of National Biography*, or in Allibone's *Dictionary of Authors*, we shall see that we have now considered every book published by Wingate on or before 1632, and we have found that the last is the only one which, on being actually examined by an authority, was seen to contain a description of the slide rule. The conclusion is, therefore, forced upon us, that the earliest publication in which Wingate wrote on the slide rule is the hook, *Of Natural and Artificial Arithmetic*, London, 1630.

But the fact that Wingate did not write on the slide rule in 1624, 1626 or 1628, and that his earliest description of this instrument bears the date of 1630, does not lose him the priority of invention, for we shall see that his only competitor for this honor was Oughtred, an account of whose inventions was not published until 1932

We proceed to show that Oughtred was an independent inventor of the rectilinear slide rule and the first one to propose the circular type. As De Morgan informs us,[5] Oughtred showed his notes and instruments to his pupil, William Forster, teacher of mathematics in London, who obtained his consent to translate and publish the description of the instruments, and the directions for using them. This was done in a work bearing the title *The Circles of Proportion and the Horizontal Instrument*, (Addenda 2.) London, 1632. In 1633 followed an *Addition*, etc., with an appendix under the title *The*

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[1] *Op. cit*., p. 500.
[2] *Construction, description et usage de la régle de proportion*. Paris, 1624.
[3] *Arithmétique logarithmique*, Paris, 1626.
[4] *Of Natural and Artificial Arithmeti*c, London, 1630
[5] Art. "Slide Rule" in the *Penny Cyclopaedia* and in the *English Cyclopaedia* (Arts and Sciences).

Declaration of the Two Rulers for Calculation. As already stated, Hutton says Oughtred applied logarithms to concentric circles as early as 1627, but Hutton does not give his authority. Benoit likewise mentions 1627, but gives no reference. De Morgan quotes the following interesting extract from Forster's dedication to Sir Kenelm Digby:

"Being in the time of the long vacation 1630, in the Country, at the house of the Reverend, and my most worthy friend and Teacher, Mr. William Oughtred (to whose instruction I owe both my initiation, and whole progresse in these Sciences), I upon occasion of speech told him of a Ruler of Numbers, Sines, and Tangents, which one had bespoken to be made (such as is usually called Mr. Gunter's Ruler) 6 feet long, to be used with a payre of beame-compasses. He answered that was a poore invention, and the performance very troublesome: But, said he, seeing you are taken with such mechanicall wayes of Instruments, I will show you what devises I have had by mee these many yeares. And first, bee brought to mee two Rulers of that sort, to be used by applying one to the other, without any compasses: and after that he shewed mee those lines cast into a circle or Ring, with another moveable circle upon it. I seeing the great expeditenesse of both those wayes, but especially of the latter, wherein it farre excelleth any other Instrument which hath bin knowne; told him, I wondered that he could so many yeares conceal such usefull inventions, not onely from the world, but from my selfe, to whom in other parts and mysteries of Art he had bin so liberall. He answered, That the true way of Art is not by Instruments, but by Demonstration: and that it is a preposterous course of vulgar Teachers, to begin with Instruments and not with the Sciences, and so in-stead of Artists to make their Schollers only doers of tricks, and as it were Juglers: to the despite of Art, losse of precious time, and betraying of willing and industrious wits unto ignorance, and idlenesse. That the use of Instruments is indeed excellent, if a man be an Artist; but contemptible, being set and opposed to Art. And lastly, that he meant to commend to me the skill of Instruments, but first he would have me well instructed in the Sciences. He also showed me many notes, and Rules for the use of those circles, and of his Horizontall Instrument (which he had projected about 30 yeares before) the most part written in Latine. All which I obtained of him leave to translate into English, and make publique, for the use, and benefit of such as were studious, and lovers of these excellent Sciences."

The following quotation shows the connection between workers on the theory of logarithms and Oughtred :[1]

"Lord Napier, in 1614, publishing at Edinburgh his 'Mirifici logarithmorum canonis Descriptio' . . . , it presently fell into the hands of Mr. Briggs, then geometry reader of Gresham College in London, and that gentleman, forming a design to perfect Lord Napier's plan, consulted Oughtred upon it, who probably wrote his 'Treatise of Trigonometry' about the same time, since it is evidently formed upon the plan of Lord Napier's 'Canon.' In prosecuting the same subject, be invented, not many years after, an instrument, called 'The Circles of Proportion.' . . . All such questions in arithmetic, geometry, astronomy, and navigation, as depended upon simple and compound proportion, might be wrought by it; and it was the first sliding rule that was projected for those uses, as well as that of gauging."

It may be added that Oughtred cheerfully acknowledges his indebtedness to Gunter for the invention of the logarithmic line.

According to De Morgan,[2] Oughtred used in his circular rule two pointing radii which were attached to the centre of one circle, on which a number of concentric circles were drawn, each charged with a

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[1] *A New and General Biographical Dictionary . . . new edition in 12 vols*., London, 1784; quoted in *Natur*e Vol. 40, 1889, p. 458.
[2] Art. "Slide Rule" in the *Penny Cyclopaedia*

logarithmic scale. “These pointers would either move around together, united by friction, or open and shut by the application of pressure: they were in fact a pair of compasses, laid fiat on the circle, with their pivot at its centre. Calling these pointers antecedent and consequent, to multiply *A* and *B*, the consequent arm must be brought to point to 1, and the antecedent arm then made to point to A. If the pointers be then moved together until the consequent arm points to *B*, the antecedent arm will point to the product of *A* and *B*.” Thus, in Oughtred’s instrument the sliding parts were not circles, but the pointers, pivoted at the centre. He appropriated two of his concentric circles to the logarithms of sines.

De Morgan states that Oughtred gave his right in the invention (as soon as it was settled that it be published) to Elias Allen, a well-known instrument maker, near St. Clement’s church, in the Strand; that in walking to and fro from this shop, he communicated his invention to one Richard Delamain, a mathematical teacher whom he used to assist in his studies. This Delamain not only tried to appropriate the invention to himself, but wrote a pamphlet of no small scurrility against Oughtred, which the latter answered in an Apologeticall Epistle fully as vituperative; which epistle was printed at the end of W. Forster’s translation. De Morgan states further, that Forster’s work was republished in 1660 by A. H. (Arthur Haughton, another pupil of Oughtred), with Oughtred’s consent, but the dedication and epistle were omitted.

The conclusions which we have reached thus far may be summarized as follows: *Edmund Gunter invented a logarithmic line called “Gunter’s line,” but not the slide rule; the straight edge slide rule was first invented by Edmund Wingate and explained by him in several publications, the earliest of which appeared in 1630. Such a slide rule was also given to the world in 1632 by William Oughtred, in a work prepared for the press by William Forster. Oughtred was the first to design a circular slide rule.*

DEVELOPMENT DURING THE SECOND HALF OF THE SEVENTEENTH CENTURY

Hutton informs his readers that a Mr. Milburne of Yorkshire designed the spiral form of slide rule about 1650.[1] Favaro quotes other writers who make similar statements.[2] We have not been able to secure more detailed information relating to Milburne.

According to Wolf[3] a slide rule was put forth about the middle of the 17th century by Horner, in which the straight edge was replaced by several shorter rules, which folded upon each other. This device never became popular, perhaps because it could not be accurately constructed and manipulated.

Stone[4] declares that "Mr. Brown" projected Gunter's line "into a kind of spiral of 5, 10, or 20 Turns, more or less," and used "flat compasses, or an opening index." Stone in 1723 describes quite fully the spiral and the circular form of instrument,[5] but says nothing which would indicate that these forms had attained popularity in his day.

Perhaps the "Mr. Brown" referred to by Stone is the same as the one named by Pepys in his diary. Under the date of August 10, 1664, he says: "Abroad to find out one to engrave my tables upon my new sliding-rule with silver plates, it being so small that Brown, who made it, cannot get one to do it. So I got Cocker, the famous writing master, to do it, and I set an hour beside him to see him design it all, and strange it is to see him, with his natural eyes, to cut so small at his first designing it, and read it all over, without any missing, when, for my life, I could not, with my best skill, read one word or letter of it." To this entry Pepys adds, the next day: "Comes Cocker with my rule, which he hath engraved to admiration for goodness and, smallness of work. It cost me 14s. the doing." Was Pepys' slide rule logarithmic? His diary leaves us in doubt.

More successful than Brown, Horner and Milburne, as a designer of slide rules, was Seth Partridge, whose instruments were constructed in London by Walter Haynes. Partridge describes himself as a surveyor, but his time was mostly occupied in teaching mathematics.[6] In 1657 he completed a small mathematical work entitled*, The Description and Use of an Instrument called the Double Scale of Proportion*, but it does not seem to have been published until 1672.[7] Other editions followed in 1685 and 1692, but were merely reprints of the first edition, except for the title-page. We have not seen any of these editions (**Addenda 3**). De Morgan says that the rules of Partridge "were separate and made to keep together in sliding by the hand; perhaps Partridge considered the invention his own, in right of one ruler sliding between two others kept together by bits of brass." To Partridge we owe, then, the invention of the slide. He did not mention in his book the names of earlier writers on the slide rule.

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1 *Hutton Math. Tables*, 1811, p. 36, and Art. "Gunter's Line "in his *Philos. & Math. Dic*., London, 1815.
2 Favaro op. cit. p. 501, with a reference to G. S. Klügel's *Mathematisches Wörterbuch*, I. Abtheilung, 3. Theil, Leipzig, 1808, p. 587,also to M. P.-M.-N. Benoit's *La règle à calcul expliquée*, Paris, 1853;p. VII; to Ernest Sedlaczek's *Ueber Visir- und Recheninstrumente*, Wien, 18.56, p. 3.
3 R. Wolf, *Geschichte der Astronomie*, München, 1877, p. 354.
4 *Mathematical Instruments*, etc., London, 1723, p. 16.
5 *Idem*, pp. 40, 41.
6 *Dictionary of National Biography*.
7 In *Allibone's Dictionary* the date is given 1671.

We have only meagre biographical data for Hunt and Everard, whose names are associated with the history of the slide rule.

W. Hunt's slide rule is referred to by Leadbetter[1] in the discussion of the area of a circular segment . (**Addenda 4.**
"Upon Hunt's Sliding rule," he says, "there is a line of segments, by which the area of a segment of a circle may be found, as he [Hunt] shews in his *Mathematical Companion*, pages 168 and 169." Some idea of the adaptation of Hunt's instrument is obtained from the complete title of his book: "A Mathematical Companion, or the Description and Use of a New Sliding-Rule, by which many Useful and Necessary Questions in Arithmetick, Interest, Planometry, Astronomy, Fortification, Dialling, etc., may be speedily resolved, without the help of Pen or Compass, . . . 1697." Stone in 1743 mentions the following writers on gauging: Hunt, Everard, Doubarty, Shettleworth.

Leadbetter[2] says that the slide rule "was first invented by Thomas Everard, Esq., in the Year of our Lord 1683, and made by Isaac Carvar of Horsteydown, near London. . . . Everard was then Officer in the Excise at Southampton." Everard wrote a work on *Gauging*, which appears to have been widely used, as Leadbetter refers to the 9th and 10th edition of it . (**Addenda 5.**
Everard's slide rule was described in this work, but I have not been able to secure a copy of the book. Lead-better does not mention Wingate and Oughtred, and erroneously attributes the invention of the instrument to Everard.

Thomas Everard must have had some standing as a mechanic and scientist, for we are informed by Leadbetter[3] that "in February 1696, when a Bill was depending in Parliament for laying a Duty on Malt, Mr. George Tollet, Mr. Phil. Shales, Mr. Tho. Jett, and Mr. Tho. Everard, in the Presence of several Members of the House of Commons, did make an experiment in order to find the true Content of the said Standard Bushel."

Everard's sliding rule was used mainly for gauging. In Edmund Stone's translation from the French of Bion's work on mathematical instruments,[4] this rule is described as follows: .

"This instrument is commonly made of Box; exactly a Foot long, one Inch broad, and about six Tenths of an Inch thick. It consists of Three Parts, viz. A Rule, and two small Scales or Sliding-Pieces to Slide in it ; one on one Side and the other on the other: So that when both the Sliding-Pieces are drawn out to their full Extent, the whole will be three Foot long." (See Fig. 2).

"On the first broad Face of this Instrument are four Lines of Numbers ; the first Line of Numbers consists of two Radius's, and is numbered 1, 2, 3, 4, 5, 6, 7, 5, 9, 1, and then 2, 3, 4, 5, etc., to 10. On this Line are placed four Brass Center Pins, the first in the first Radius, at 2150.42, and the third likewise at the same Number taken in the second Radius, having MB set to them; signifying, that the aforesaid Number represents the Cubic Inches in a Malt Bushel: the second and fourth Center Pins are set at the Numbers 282 on each Radius; they have the letter A set to them, signifying that the aforesaid Number 282 is the Cubic Inches in an Ale-Gallon. . . . The second and third Lines of Numbers which are on the Sliding-Piece . . . are exactly the same with the first Line of Numbers: They are both, for Distinction, called B. The little black Dot, that is hard by the Division 7, on the first Radius, having Si set after it, is put directly over .707,

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[1] Leadbetter, *Royal* Gauger, 4th ed. London, 1755, p. 80
[2] *The Royal Gauger*, 4th ed., London, 1755, p. 27.
[3] *Leadbetter*, op. cit., p. 122.
[4] *The Construction and Principal Uses of Mathematical Instruments*, transl. from the French of M. Bion by Edmund, Stone, London, 1723, p. 22.

which is the Side of a Square inscribed in a Circle, whose Diameter is unity. The black Dot hard by 9, after which is writ Se, is set directly over .886, which is the Side of a Square equal to the Area of a Circle, whose Diameter is Unity. The black Dot that is nigh W, is set directly over 231, which is the Number of Cubic Inches in a Wine Gallon. Lastly, the black Dot by C, is set directly over 3.14, which is the Circumference of a Circle, whose Diameter is Unity. The fourth Line on the first Face, is a broken Line of Numbers of two Radius's, numbered 2, 10, 9, 8, 7, 6, 5; 4, 3, 2, 1, 9, 8, 7, 6, 5, 4, 3, the Number 1 is set against MB on the first Radius. This Line of Numbers hath MD set to it, signifying Malt Depth."

Here we have pointed out an important innovation, to which attention has not been called by writers on the history of the slide rule, namely, the inversion of a logarithmic line—an idea usually attributed to Pearson, who wrote about a century later. The difference between the inversion as made by Everard and that of Pearson is that the former inverted a fixed line, while the latter (for certain operations) inverted the slider.

The second broad face has a slider graduated with a line C of double radius and a line D of single radius. There is also a fixed line D with four gauge-points, and a line E of triple radius. These lines are brought into service in problems involving square or cube root. Finally, there are on this face two lines of segments for finding the ullage of a cask. If the axis of the cask is horizontal, the line marked SL (= segments lying) is used. When the axis is vertical, the line marked SS (=segments standing) is used.

None of the lines on the two narrow faces is logarithmic and there is no slider there.

A slide rule, designed for the measurement of timber, stonework, and vessels, bears the name of Henry Coggeshall. The name of this writer has been variously given as Coggeshall, Cogshall, and Coggleshall. His earliest slide rule was described by him in 1677 in a pamphlet entitled *Timber Measure by a Line of more Ease, Dispatch and Exactness than any other way now in use, by a Double Scale. . . ., London, 1677*. "He soon after improved the rule, and revised the little work in which the mode of using it was set forth, republishing it in 1682, with the heading *A Treatise of Measuring by a Two-foot Rule, which slides to a Foot*. A third, considerably modified edition, appeared in 1722. It was designated *The Art of Practical Measuring easily performed by a Two-foot Rule which slides to a Foot*."[1] **(Addenda 6.**
The instruments of Coggeshall seem to have met with great favor. A fourth edition of this last book, revised by John Ham, was brought out in 1729; a seventh edition in 1767. The Coggeshall slide rule was popular in England as late as the beginning of the 19th century, and was used in 1874 and even later. It has received various modifications in construction. In Stone's translation of Bion, p. 26, it is described thus: "This Rule is framed three Ways; for some have the two Rulers composing them sliding by one another, like Glaziers Rules; and some-times there is a Groove made in one Side of a Two Foot Joint-Rule, in which a thin sliding Piece being put, the Lines put upon this Rule, are placed upon the said Side. And lastly, one Part sliding in a Groove made along the Middle of the other, the length of each of which is a Foot." (See Fig. 3.) The last form has a disposition of the logarithmic lines, which for over a century and a half enjoyed wide popularity. "Upon the sliding Side of the Rule are four Lines of Numbers; three are double Lines, or Lines of Numbers to two Radius's, and one a single broken Line of Numbers."

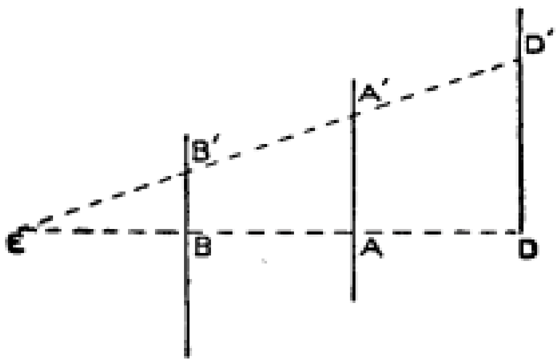
It is not generally known that Sir Isaac Newton ever referred to the Slide rule or discovered how it could be used in the solution of numerical equations. For that reason the following

[1] *Dictionary of National Biography*.

translation of an extract from a letter of Oldenburg to Leibnitz, dated June 24, 1675, may not be without interest: [1]

“Mr. Newton, 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 far 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.”

If our interpretation of this passage is correct, it means, in case of a cubic equation $x^3 + ax^2 + bx = c$, that three rules, A, B, D, 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 straight line BD. Select the point E on this line, so that BE= BA. Through E pass a line ED’ and turn it 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.



The reason for this is readily seen. Remembering that the length of that part of the rule B, which extends below the point B, is equal to log |b|, and assuming BB’= log |x|, it follows that the part of the rule below B’ is equal to log |b| + log |x| = log |bx|. Since AA’= 2 log |x|, it is seen that the part of the rule A, below the point A’, is $\log|ax^2|$. Similarly, DD’ is equal to 3 log |x| or log $|x^3|$, and |x| can be found by moving the scale B up until its lower end reaches B. The number at B’ will then give the numerical value of the root.

The practical operation of this scheme would call for the use of a device to enable one to read corresponding numbers on scales that are not contiguous. Such a device would fulfil some of the functions of what is now called the “runner.” We must therefore look upon Newton as the first to have thought of such an attachment to the slide rule. Sixty-eight years later, Newton’s mode of solving equations mechanically is explained more fully and with some restrictions, rendering the process more practical, by E. Stone in the second edition of his Dictionary (1743).

[1] *Isaaci Newtoni Opera* (Ed. S. Horsley) Tom. IV, Londini, 1782, p. 520: “Dominus Newtonus, beneficio logarithmorum gradua-torum in scalis, παράλλήως locandis ad distantias aequales, vel circulorum concentricorum eo modo graduatorum adminiculo, invenit radices acquationum. 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 à prima regula ac scalae graduatae sunt ab invicem, linea recta iis superextenditur, unà cum praescriptis conformibus genio aequationis; qua in regularum una datur-potestas pura radicis quaesitae. “

De Morgan says that slide rules were little used and little known till the end of the 17th century. He bases this conclusion on the fact that "Leybourn, himself a fancier of instruments, and an improver (as he supposed) of the sector, has 30 folio pages of what he calls instrumental arithmetic in his 'Cursus Mathematicus' (1690), but not one word of any sliding-rule, though he puts fixed lines of squares and cubes against his line of numbers in his version of Gunter's scale."[1]

On the European continent such an instrument was hardly known to exist. The only German writer to be mentioned is Biler, who in 1696 brought out a publication under the title*: Descriptio instrumenti mathematici universalis, quo mediante omnes proportiones sine circino atque calculo methodo facillima inveniuntur*.[2] He called his instrument the *instrumentum mathematicum universale*. The instrument is semicircular in form and differs from that of Oughtred also in dispensing with the sliding indices and using instead the sliding concentric semi-circles. [3]Biler does not state the source whence he obtained his idea of the instrument. A few years later (1699), Michael Scheffelt brought out in Ulm a book, describing an instrument called by him *pes mechanicus*, which was not a slide rule, but employed logarithmic lines of numbers, together with a pair of compasses, as in Gunter's scale.[4]

While in France, Gunter's line was made known by Edmund Wingate as early as 1324, and was again described by Henrion in a work, *Logocanon ou règle proportionnelle* (Paris, 1626), we have not been able to secure evidence that would show familiarity with the slide rule before about 1700.

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[1] Art. "Slide Rule" in the *Penny Cyclopaedia*.
[2] See Johann Bernoulli III., in his article "Logarithmiques" in the *Encyclopédie méthodique (mathématiques)*.
[3] *Favaro*, op. cit., p. 502; Leupold, Theatrum Arithmetico-Geo-metricum, Lipsiae, 1727, p. 77.
[4] *Pes mechanicus artificialis d. i. neu erfundener Maassstab, mi welchem alle. Proportionen der ganzen Mathematik ohne mühsames Rechnen u. 5. w. können gefunden werden. Ulm*, 1699.

DEVELOPMENT IN ENGLAND DURING THE EIGHTEENTH CENTURY

We have seen that in 1726 E. Stone inserted an article of a dozen lines in his *New Mathematical Dictionary* on the slide rule. That this instrument came to be used more extensively in the eighteenth century appears also from the attention given to it by Robert Shirtcliffe in his book *Theory and Practice of Gauging*, London, 1140. On page 27 he says: “Since, as we observed before, the Practice of Gauging almost entirely depends on the Knowledge of the Sliding Rule, it must be of great Importance to the Gentlemen of the Excise to be acquainted, not only with the Method of Operation thereon, but the Reason thereof.” He gives drawings of slide rules and devotes twenty-eight pages to explanations of them. The second edition of Stone’s Dictionary gives evidence of wider interest in this instrument. In the article at the end of the book, to which we referred on p. 4, he speaks of the solution of numerical equations and remarks:

“I shall only mention a way of Sir Isaac Newton’s of finding the Roots of Numerical Equations by means of Gunter’s Lines sliding by one another.” We have already explained Newton’s scheme. In Stone’s description, all coefficients of the equation $x^n + ax^{n-1} +. . . +mx = n$ are assumed to be positive; the logarithmic lines are not graduated alike, and the moveable straight line determining the positions for x^n, ax^{n-1}, . . . mx does not turn about a fixed point, but moves parallel to itself. The function of a “runner” becomes more conspicuous here. As Stone’s Dictionary of 1743 is not generally accessible, it may be worth while to quote here in full the part of the article which relates to the use of the slide rule:

“Take as many Gunter’s Lines, (upon narrow Rules) all of the same Length, sliding in Dove-tail Cavities, made in a broad oblong Piece of 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 all these Lines, and let these Gunter’s consist of two single ones, and a double, triple, quadruple, etc., one fitted to them; that is, let there be a fixed single one a top, and the first sliding one next that, let be a single one, equal to it, each Number from 1 to 10. Let the second sliding one be a double Line of Numbers, numbered 1, 2, 3, 4, 5, 6, 7, 5, 9, to 10, in the Middle, and from. 1 in the Middle to 1, 2, 3, etc., to 10, at the End. Let the third sliding one be a triple Line of Numbers, numbered 1,2,3,4,5,6,7, 8, 9, 1, and again 2, 3, 4, etc., to 10, and again 2, 3, 4, etc., to 100 at the End. The Distance from 1 to 1, 1 to 10 and 10 to 100, being the same; let the fourth sliding one be numbered 1, 2, 3, 4, 5, 6, 7, 5, 9,1; and again 2, 3,4, etc., to 10; and again 2, 3, 4, etc., to 100; and again 2, 3, 4, etc., 1000. The distance from 1 to 1, 1 to 10, 10 to 100, and 100 to 1000, being the same, and so on.

“This being done, take the Coefficient prefixed to the single Value of the unknown Quantity upon the fixed single Line of Numbers; the Coefficient of the Square of the unknown Quantity, upon the double Line of Numbers; the Coefficient of the Cube of the unknown Quantity, upon the triple Line of Numbers; the Coefficient of the Biquadrate of the unknown Quantity, upon the Quadruple Line of Numbers, and so on. And the Coefficient of the first or highest Term (being always Unity) take upon that Line of Numbers expressed by its Dimension, that is, if a square, upon the double Line; a Cube, upon the triple Line, etc. I say, when this is done, slide all these Lines of Numbers so, that these Coefficients be all in a right Line directly over one another, and keeping the Rulers in this Situation, slide the Thread or Hair in such manner, that the Sum of all the Numbers upon the fixed single Line, the double Line, the triple Line, etc., which the Thread or Hair cuts, be equal to the Known Term of the Equation, which may be readily enough done with a little practice; and then the number under the Thread upon that Line of Numbers of the same name with the highest Power of the unknown Quantity of the Equation, will be the pure Power of the unknown Quantity, whose Root may be had by bringing Unity on the single Sliding-Line directly over Unity upon this Line. After this, if you divide the

Equation by this Root, you will have another, one Dimension less; and thus you may proceed to find a Root of this last Equation; which done, if it be divided by this last Root, you will get an Equation two Dimensions less, and by a Repetition of the Operation you will get a third Root, and so a fourth, fifth, etc., if the given Equation has so many, and if any of the intermediate Terms are wanting, the Gunter's express'd by the Dimensions of those Terms, must be omitted.

"But this method only gives the Roots of Equations the Signs of all the terms whereof, except the known one, are Affirmative; that is, of such that have all Negative Roots, but one, which last, the said Method finds. Therefore when an Equation is given, to find its Roots after this manner, whose Signs have other dispositions, it must be first changed into another Equation, whose Signs are all Affirmative; but that of the known Term, which may be done by putting some unknown Quantity y Plus or Minus, some given Number or Fraction, for the Value of the unknown Quantity x in the proposed Equation.[1]

"*Note*, instead of streight Parallel Sliding Rules, you may have so many Gunter's Lines graduated upon Concentrik Circles, each moving under one another, by which Contrivance, you will have as large Divisions for your Logarithm within the Compass of one Foot, as you have upon a streight Ruler of more than three Feet in length. Although perhaps by these Sliding-Rules, you cannot get all the Signs of the Roots exactly, for want of sufficient Subdivisions of the Gunter's Lines, yet if we can get two or three of the first Figures, it will be of good use to find the Roots by Approximation."

The reason for the process described in this passage is readily comprehended. No doubt the necessity of transforming a given equation into a new one, which has all the coefficients of the unknown quantity positive, operated against the general adoption of the process. We have no evidence that slide rules for this special application were ever constructed, or that the real roots of equations were actually determined in this way.

The slide rules which were used most at this time were those of Coggeshall and Everard. Various little modifications in the design and construction of these rules were made from time to time. Thus the instrument described in Coggeshall's *Art of Practical Measuring* of 1722 (third edition) indicates some alterations of Coggeshall's rule described earlier. There are lines on both sides of the flat faces. The new arrangement was probably due to John Warner, a London dealer in instruments; for Coggeshall says, that Warner added "a curious Scheme of both Sides of the Rule, and of the Scale." On one face are two identical logarithmic lines, each with two radii 1—10, 2—10. On the other flat face one line has a double radius like the lines just mentioned, while the second line has a single radius 1—10 and is called the "square line" or the "Girt line." Each face carries, in addition, two lines indicating feet and inches, with decimal subdivisions thereof. On page 50 he speaks also of a logarithmic "cube line" which may be added to the rule.

The 1722 edition of Coggeshall's book mentions Thomas Wright, "mathematical instrument maker to his Royal Highness, the Prince of Wales," as selling slide rules in Fleet Street, London.

Charles Leadbetter[2] made alterations in Everard's rule. He describes a slide rule as "an Improvement on Everard's mentioned by me in the 9th and 10 editions of *Everard's Gauging*." Like Everard, Leadbetter was a government officer, having "had the Credit of an Employment under the Honourable

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[1] The transformation of equations herein referred to is more fully discussed by Lagrange in Note XII of his Work, entitled *De la résolution des équations numériques de tous les degrés*, the first edition of which appeared in Paris in the year VI (1798).

[2] Royal Gauger, 4th ed., London, 1755, p. 27

the Commissioners of his Majesty's Royal Revenue of Excise." Leadbetter gives a plate (see Fig. 4) with "a view of the several lines and gauge-points upon Everard's Sliding Rule, as it is now improved by C. Leadbetter." The improvements did not involve radical changes. The *lines A, B, C, D, E, MD, SL, SS* are the same as in the older Everard rule. But the lines *SL* and *SS* are no longer on a broader face; they are now on one of the narrow faces. Between them is a third slider, narrower than the other two sliders. The older Everard rule has only two sliders. This new slider carries a line of numbers of double radius, marked N. Another innovation are lines of inches and other lines, placed upon the back sides of the three sliders. For ullaging, Shirtcliffe, in his *Theory and Practice of Gauging* (London, 1740), suggests a new line *SR*, and remarks at the end of his book that persons desiring such a rule may have it "made by the ingenious mathematical instrument makers, Mr. John Coggs and Mr. William Wyeth, near St. Dunstan's Church in Fleetstreet," London. We give one example of the use of the Everard rule: To find the number of bushels of malt in an enclosed space of the shape of a parallelo-pipedon, set the length of the enclosure on *B* to the breadth on *MD*, then against the height on *A* is the content in bushels on *B*. In other words, this solves the expression lbh ÷2150.42.

Another modification of Everard's rule was made by a Mr. J. Vero, and is referred to by Leadbetter in the following passage:[1] "Mr. Vero, sometime a collector of the Excise, made an Alteration in Everard's Sliding Rule, so that the whole Length of one Foot contained but one single Radius of the Line of Numbers, and both Sliders do work together on one Side of the Rule in every operation; by which contrivance the Divisions in this Rule are twice as large as on those first made by Mr. Everard." Mr. Vero was the author of a work entitled *Excise and Malt-Examiners' Assistant, useful also for Supervisors and Officers*.[2]

As to the accuracy of computations with the slide rule, there exists diversity of opinion among men of that time. John Ward [3] prefers to gauge a vessel "by the Pen only, viz., without the help of those Lines of Numbers upon sliding Rules, so much Applauded, and but too much Practised, which at best do but help to guess at the Truth, and may justly be called an Idle, Ignorant Way of doing Business, if compared with that of the Pen." Later he explains [4] that he means "only Pocket Rules, viz., such as are of Nine Inches or a Foot Long. . . . But when the rules are made Two, or Three Foot long (I had one of Six Foot) then they may be of some Use, especially in Small Numbers. . . . I must not omit to Recommend a Five Foot Rule, Composed of Six Parts or Legs (viz., Ten Inches each Part) with Brass Joynts, put together with Steel Screws (which I Contrived and Made many Years ago) the Last Leg (viz., one of the Extream Legs) having a Sliding Part put to it . . . very Accurately made by Mr. John Rowley" of Fleet Street, London. A more favorable judgment than that of John Ward was passed by Leadbetter who assures us that computations could be made "as near as is ever required in Practice in the Excise." [5] John Farey, an English engineer, wrote in 1827 [6] that the early slide rules were crudely and inaccurately constructed, but that since 1775 Watt and Boulton in their shops, located at Soho, near Birmingham, used a slide rule of higher type, designed especially for engineers. For their computations in the design of steam engines and other machinery, James Watt himself is reported to

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1 Leadbetter *op. cit*., p. 29. In Hawney's *Complete Measurer*, Baltimore, 1813, p. 247, a slide rule answering this description is given as "invented by Mr. Verie, collector of the excise," this rule being "that which is most used in the excise." The first edition of Hawney's book appeared in London in 1717. Are Vero and Verie the same person?

2 Leadbetter, *op. cit*., p. 44.

3 *The Young Mathematician's Guide . . ., with an Appendix on Practical Gauging*, London, 1707, p. 427.

4 *The Young Mathematician's Guide . . ., with an Appendix on Practical Gauging, London*, 1707, pp. 450, 451.

5 Leadbetter, op. cit., p. V.

6 John Farey, *Treatise on the Steam Engine*, London, 1827, Chap. VII, pp. 531 and 536, referred to in *Zeitsch,. f. Math. u. Phys*., Ed. 48, 1903, p. 134.

have used .this instrument. Who the manufacturer of these so-called "Soho rules" was is uncertain, but it has been surmised that it was the work of William Jones (1775—1852), a very skilled mechanic of the time.[1]

To be noted is a treatise on the slide rule, by Flower, which appeared in London in 1768. Another name, associated with the history of Gunter's scale and the slide rule, is John Robertson (1712—1776), who was at one time master of the Royal Mathematical School at Christ's Hospital, later Headmaster of the Royal Academy at Portsmouth and finally Librarian of the Royal Society of London. In 1775 he published in London a Treatise on Mathematical Instruments [2]. He modified Gunter's scale, for the purposes of navigation, in such a way as to practically make a slide rule out of it. An account thereof was published after his death by his friend, William Mountaine, in a booklet bearing the title *A Description of the Lines drawn on Gunter's Scale, as improved by Mr. John Robertson*, London, 1778. He was not the first, however, to advance this idea. In 1723 E. Stone [3] says that the lines on Gunter's scale ''are also put upon rulers to slide by each other, and are therefore called Sliding Gunters."

Robertson's improved Gunters were mechanically executed under his own inspection by Messrs. Nairne and Blunt, mathematical instrument makers in Cornhill, London. The use of compasses was avoided "by having a proper sliding scale." "If, by choice, . . . any Person wishes to use Compasses, as on the common Gunter, the same may be done here, . . . but it should be observed, that the Compasses have very fine Points, and even then, with the greatest Care, they are apt to indent, and otherwise deface the Sub-divisions."[4]. Like Stone, Mountaine called the new instrument the "sliding Gunter," to distinguish it from the "common Gunter."

A feature of great interest in Robertson's rule is the use of an "index," now usually called a "runner." It will be remembered that the use of a runner was suggested by Newton and Stone, but here we see it for the first time actually constructed. The rule was 30 in. long and 2 in. broad, and contained natural numbers on one face, logarithmic scales on the other. There were twelve logarithmic lines on one face, 9 of them fixed and three sliding together, as follows: The fixed lines 1, 2, 3, 4 were, respectively, lines of sine rhumbs, tangent rhumbs, versed sines, sines; the sliding lines 5, 6, 7 were lines of sines, numbers, tangents; the fixed lines 5, 9, 10, 11, 12 were lines of tangents, numbers, meridian degrees to 50, meridian degrees 50 to 74, degrees of longitude.[5] "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 several Lines the Divisions which are opposite to one another; although the Lines are not contiguous." Here is the runner, usually supposed to be a 19th century invention, in practical operation at a much earlier period. The following details of construction may be of interest:

"The Apparatus at the Right-hand consists of a Brass Box and two Screws; the Slider passes freely through the Box when the perpendicular Screw is eased, and may be readily set by Hand to the Terms given; yet to be more accurate, and to keep the Slider in its true Position, move the perpendicular Screw, which, by a Sub-spring will fix the Slider in the Box, and then by the Motion of the Horizontal Screw, the greatest Degree of Accuracy possible may be obtained."

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[1] *Dingler's Polytech. Journal*, Vol. 32 (1829) p. 455, quoted in *Zeitschr. f. Math. und Phys*., Vol. 48, 1903, p. 317, 318.

[2] Favaro, *op. cit*., p. 504.

[3] *Construction and Prim. Uses of Math'l. Instr's*., London, 1723, p. 42.

[4] W. Mountaine, *op. cit*., p. 3.

[5] Mountaine *op. cit*., p. 3.

This complicated slide rule was never used extensively, and Gunter's scale, with compasses, continued to be the favorite instrument on shipboard.

Allusions have been made to the theory of gauge-points, the idea of the inversion of a logarithmic line and the invention of the runner. This has been in connection with rectilinear slide rules. Thus far, we have said nothing concerning curvilinear slide rules during the eighteenth century. Stone, in 1723, describes both the circular and spiral forms.[1] That the circular type was actually manufactured about this time is evident from the examination of a book by Benjamin Scott, entitled, *The Description and Use of an Universal and Perpetual Mathematical Instrument*, London, 1733. Scott was an instrument maker in the Strand (London); he "Makes and Sells all Sorts of Mathematical Instruments in Silver, Brass, Ivory, and Wood, . . . all Sorts of Sliding-Rules, Parallel-Rules, best Black-Lead Pencils." His "universal and perpetual instrument" was a circular slide rule, over 18 inches in diameter and consisting of 20 circles. "In the first circle is graduated the Line of Numbers;" it is 58.43 inches in circumference. "By this Line is performed Multiplication, Division, the Rule of Proportion, and Extraction of Roots." Everard's sliding rules, says Scott, "fall infinitely short of the Line of Numbers in this Instrument, because of its great Length." Scott's instrument resembles closely Oughtred's design, but Scott mentions no forerunners in this work.

A few years later we encounter a designer and maker of spiral slide rules, in the person of George Adams, the manufacturer of mechanical instruments for King George III. Adams designed spiral rules in 1748.[2] He engraved upon a brass plate, 12 inches in diameter, ten spiral windings. No statement has been handed down as to Adam's indebtedness to earlier workers in his field.

We come now to an English scientist who has given more systematic, painstaking and thoroughgoing study to the various forms that slide rules may take, than has any other worker of the eighteenth century. His suggestions met with no response in his day, but the ideas which he advanced are embodied in many instruments designed during the nineteenth century. We refer to William Nicholson (1753—1815), well known as the editor of *Nicholson's Journal*. He prepared an article,[3] 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. According to his first design, a long logarithmic line was to be broken up into sections of convenient length and these placed parallel to each other on the face of the rule. Nicholson took ten such parallel lines, equivalent to a double line of numbers upwards to 20 feet in length. In place of a slider he used a beam compass, of the shape of the capital E, the middle cross piece of which was movable. With the aid of this compass it is possible to operate with these ten parallel lines and secure results of the accuracy of those gotten from a single line of twenty times the length.

Another rule was designed by Nicholson, "equivalent to that of 28½ in. in length, published by the late Mr. Robertson. It is, however, but ¼ of the length and contains only ¼ of the quantity of division." In the slider *GH*, Fig. 5, "is a movable 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. 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

[1] Stone's ed. of Bion's *Mathematical Instruments*, London, 1723, pp. 40, 41.
[2] *Nicholson's Journal*, Vol. I, 1797, p. 375.
[3] *Philosophical Transactions* (London), 1787, Pt. II, p. 246—252

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. But if the consequent line fall without the rule, the other fixed line on the slider will show the consequent; but on the contrary side of the slider to that where it would else have been seen by means of the first consequent line."

The preference is given by Nicholson to the type consisting of concentric circles. (See Fig. 6.) Nicholson was not aware that Benjamin Scott had described an instrument of this kind as early as 1733, nor did he know at that time of the spiral instrument of George Adams and of the earlier work of Biler and Clairaut on the Continent. Later Nicholson learned that he had been anticipated by Adams and Clairaut,[1] but the circular slide rules of Oughtred, Biler and Scott were apparently never brought to his knowledge.

Nicholson's very remarkable improvements received very little attention. We have not been able to learn that any of his rules were actually constructed and sold. In 1797 he wrote an article on "A method of disposing Gunter's line of numbers, by which the divisions are enlarged and other advantages obtained,"[2] in which he remarked that ten years ago he had communicated to the Royal Society a method of extending the range of the rule which he "still considers less generally known than its utility may perhaps claim." By a yet different disposition of Gunter's lines he now gets a slide rule "equivalent to that of 29½ lines in length, published by the late Mr. Robertson. It is, however, but ⅛ the part of the length and contains only ¼ of the quantity of division." (See Fig. 7.)

"The Sketch No. 1 represents one face or side of the instrument, and No. 2 represents the opposite face. Each contains one fourth part of the lines of numbers. When it is used, the slider must be set so that the line on the piece *AB* may be placed at the antecedent, and one of the end marks *CD*, or *EF*, may be opposite the consequent. After this adjustment of the slider, the whole may be moved at pleasure, till the piece *AB* is set at any other required antecedent; and then the same line *CD*, or *EF*, as before, will indicate the consequent at the same distance or position as before. But if the consequent mark of the slider should fall without the rule, the other line will indicate the required consequent upon the rule, though at the distance of one line on the rule farther off in position than the other consequent. mark would else have shown it."

Fig. 8. shows a spiral slide rule, designed by Nicholson in 1797.

The English astronomer, William Pearson (1767—1847) of Lincoln, made the suggestion that the tongue of the slide rule be inserted wrong side foremost, for certain computations.[3] This feature was not altogether novel. Logarithmic lines on the fixed part of the rule had been inverted long before this in the Everard rules, described by Stone, Leadbetter, and Shirtcliffe. The new feature lay in showing that the slider could be used when inverted, as well as in its ordinary position, and that this inversion is particularly convenient in computing reciprocal proportion and furnishes "a short and easy method of multiplying, dividing, . . . squaring and extracting the square root, at one position of the inverted slider, whereby the eye is directed to only one point of view for the result, after the slider is fixed." It accomplished this without the additional complexity of a new line D, found at that time on some rules for root-extraction. Later, some of the English rules had one of the two scales upon the slider inverted, a suggestion said to have been first made by William Hide Wollaston, while the Frenchman, A. Begin placed an inverted scale as a third scale upon the slider.[4]

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[1] *Nicholson's Journal* Vol. V., p. 40.
[2] *Nicholson's Journal*, Vol. I., 1802, p. 372—5, reprinted from issue of 1797.
[3] *Nicholson's Journal*, Vol. I., 1797, p. 450.
[4] *Encyklopädie d. Math. Wiss*., Vol. 1,1898—1904, Leipzig, p. 1057.

Mr. Pearson adds in his article the significant remark that he entertains no hope that this suggestion will 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.

An interesting, but difficult, question to settle is the extent to which the slide rule was actually used in England during the eighteenth century. As late as 1842 De Morgan complained that this instrument was greatly undervalued, that nine Englishmen out of ten would not know what the instrument was for, if they saw it, and that not one in a hundred would be able to work a simple question by means of it.[1] But granted that only one in five hundred knew how to use the slide rule, would that not be a large proportion, considering how few people are called upon, day after day, month after month, to carry on arithmetical computations which require much more than addition or subtraction?

About the only way of estimating the extent to which the instrument was used is by the frequency of references to the slide rule and of directions for the use, of it.

Robert Shirtcliffe's *Theory and Practice of Gauging*, London, 1740, gives, as we have seen, about thirty pages to the explanation of the slide rule and remarks (p. 27) that since the practice of gauging almost entirely depends on the knowledge of the slide rule, it must be of great importance to the gentlemen of the excise to be acquainted, not only with the method of operation thereon, but the reason thereof. There are many proofs to show that the slide rule was used extensively in practical gauging, though probably not used by all excise officers. "As some writers have attempted to persuade the Publick," writes Leadbetter,[2] "that Tables ready calculated are far more exact and ready in Practical Gauging, than the Sliding Rule, it may not be here amiss to observe, that if Tables happen to be false printed . . . the Officer must act at random, not knowing whether he is right or wrong; whereas, by the Sliding Rule, 'tis impossible he should ever err; for the Use of that instrument being but once well understood, . . . the Officer, with the greatest Dispatch and Certainty, may come to the exactness of the tenth Part of a Unit, which is as near as is ever required in Practice in the Excise." More remarkable yet is the frequency that instructions for the use of the slide rule are found in the popular works on practical arithmetic which touch upon mensuration, published not only in England, but also in North America. Thus "George Fisher" (Mrs. Slack), in her *Arithmetic*, London, 1794, p. 239, as also John Mair, the Scotch writer on arithmetic (1794), and the American arithmetician Nicolas Pike (1788) give rules for the use of the instrument. John Macgregor[3] remarks that "this rule is so well known, that it is unnecessary to give a tedious description" of it.

Certain it is that the slide rule was used much more in England, during the eighteenth century, than in Germany or France. As to other European countries, we have not been able to secure evidence that the instrument was even known to exist. The Italian Professor, Antonio Favaro, has written the fullest history of the slide rule known to us,[4] but not a single Italian author or mechanic of the seventeenth or eighteenth century is brought forward by him. One circumstance which facilitated the wider use of the slide rule in England is the greater attention given in elementary instruction there to the subject of decimal fractions. Decimal arithmetic was emphasized much more in Great Britain than in Germany

[1] Article "Slide Rule" in the *Penny Cyclopaedia*

[2] Leadbetter, *op. cit*., p. IV, V.

[3] *A Complete Treatise on Practical Mathematics*, Edinburgh, 1792, p. 353.

[4] Favaro, *op. cit*., 1879.

or France. A knowledge of it is a prerequisite for computation with the slide rule. As Leadbetter says:[1] "Because the Sliding Rule is calculated for Decimal Fractions, it is requisite the Learner be made acquainted therewith before he proceeds to use of the Rule itself."

[1] Leadbetter, *op. cit*., p. 1.

DEVELOPMENT IN GERMANY DURING THE EIGHTEENTH CENTURY

It has been pointed out earlier in this history that the first German writer interested in the slide rule was Biler (1696), but there is no indication that the slide rule actually acquired a foothold in Germany at that time. Over a quarter of a century later Jacob Leupold (1674-1727) prepared a mathematical work,[1] which was issued immediately after his death, in which reference is made not only to Biler's, but also to a rectilinear instrument resembling modern slide rules. "Wer der Inventor davon sey," says he, "kann ich nicht sagen . . . ich auch dergleichen Linial sonst nirgends angetroffen." Leupold got his information from an old manuscript, gave drawings of the rectilinear instrument, and promised to have it made. From this it appears clearly that the slide rule was, as yet, practically unknown in Germany in 1727. It first became known through the efforts of Johann Andreas von Segner (1704—1777), professor of mathematics in Gottingen and later in Halle, and of Johann Heinrich Lambert (1728—1777), member of the Berlin Academy of Sciences. Segner's efforts in this direction have been forgotten, no reference being made to him by German writers on the slide rule of the present day. Segner described a slide rule in 1750 and had it engraved upon copper.[2] In 1777 he was considering certain improvements in his instrument.[3] Much greater was the influence due to Lambert, who in 1761. brought out in Augsburg a booklet, Beschreibung und Gebrauch der Logarithmischen Reehenstäbe, which reached a new edition in 1772. Lambert realized fully the great practical value of the instrument and published a full and perspicuous account of its theory. Johann Bernoulli III. (1744—1807) based upon Lambert's publication the article "logarithmique," which he prepared for the Encyclopédie Méthodique. Through the medium of this article, Lambert made the theory of the instrument more widely known among French readers. Lambert's designs of the slide rule were executed in Augsburg, in wood and in metal, by the distinguished mechanic, G. F. Brander.[4] These rules were four feet long. There is no evidence to show that the slide rule secured any degree of popularity in Germany during the eighteenth century.

[1] Theatrum Arithmetico-Geometricum, Das ist: Schau-Platz der Rechen- und Mess-Kunst, Leipsig, 1727.

[2] See Segner's letter to Lambert, March 22, 1777, printed in *Lambert's Briefwechsel*, Vol. IV, p. 379.

[3] *Lambert's Briefwechisel*, Vol. IV, p. 380, letter to Lambert, dated April 15, 1777.

[4] See letter from Lambert to Brander in *Lambert's Briefwechsel*, Vol. III, p. 9.

DEVELOPMENT IN FRANCE DURING THE EIGHTEENTH CENTURY

Gunter's scale was introduced into France by Wingate in 1624, yet we have found no reference to any form of slide rule until about seventy-five years later. Lalanne[1] is authority for the statement that about 1700 Sauveur had constructed by the artisans Gevin and Le Bas slide rules having slides like those of Seth Partridge. In 1627 [*sic*, should be 1727] there was mentioned among the machines and inventions approved by the Royal Academy of Sciences of Paris "an instrument of Mr. Clairaut by means of which one can take angles, make arithmetical computations, such as multiplication, division, extraction of roots and the resolution of right triangles. It is a circle of cardboard, 21 in. in diameter, in which Mr. Clairaut has described a large number of concentric circles in order to express by the lengths of these circumferences the logarithms of numbers and those of sines. The instrument appears ingenious and very exact."[2] This Clairaut is Jean Baptiste Clairaut, sometimes called "Clairaut le Père," to distinguish him from his son, who attained great eminence as a mathematician. It would seem from the above extract that the elder Clairaut is the inventor of the instrument described, which is a circular slide rule. The circular form was to him an afterthought. He is said to have made his first designs in the year 1716, which were on a square of one foot, filled with parallel lines, constituting altogether a rule of 1500 French feet; and it was not till the year 1720 that he thought of the curvilinear form.[3] There is nothing to show that he was aware of the similar designs due to Oughtred and Biler. Nor is there any evidence to show that the instrument of Clairaut was ever constructed and used in France.

In 1741 Charles Étienne-Louis Camus (1699—1768) made known his *Instrument propre à jauger les tonneaux et les autres vaisseaux qui servent à contenir des liqueurs*,[4] and published two drawings of it. It was an octagonal rod with a slider, adopted, of course, to French units of measure. Camus makes no reference to earlier writers or earlier instruments. This gauge did not meet with success in France. The statement of Benoit[5] that it was welcomed in England and explained by Leadbetter in the Royal Gauger is incorrect. The first edition of the Royal Gauger appeared in 1739, two years before Camus wrote his article, and the slide rule of Leadbetter is a modification of Everard's, developed entirely upon English soil.

Our failure to find references to Sauveur, Camus, and Clairaut in French works of the eighteenth century leads to the belief that the slide rule was not known even to writers familiar with the "échelle angloise," as Gunter's scale was called in France. Saverien refers in *his Dictionnaire universel de mathematique et de physique*, Tome I, 1753, article "echelle angloise," to R. P. Pezenas as "seul Auteur François, qui ait parlé de ces sortes d'Echelles." Thus not only Clairaut and Sauveur, but also Camus, are overlooked. Saverien refers to two works of Pezenas, his *Elémens du Pilotage* and his

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[1] Lalanne, *Instruction sur les règles et calcul*, 1851, préface, p. VII.; see Maurice d'Ocagne, *Calcul simplifié*, 2e éd., Paris, 1905, p. 114.

[2] *Histoire de l'académie royale des sciences*, année 1727, Méchanique p. 142: "un instrument de Mr. Clairaut par le moyen duquel on peut prendre les angles, faire les calculs arithmétiques, tels que la multiplication, la division, l'extraction des racines, et résoudre les triangles rectangles. C'est un cercle de carton, gradué de 21 pouces de diamètre, dans lequel Mr. Clairaut a décrit un grand nombre de ces circonférences concentriques pour exprimer par les longueurs de ces circonférences, les logarithmes des nombres, et ceux des sinus. L'instrument a paru ingénieux et assez exact."

[3] *Mechanics Magazine*, Vol. V., London, 1802, p. 40.

[4] *Mémoires de l'académie royale des sciences de l'année* 1741, Paris 1744, p. 385.

[5] *Bulletin de la société d'encouragement pour l'industrie nationale*, Vol. 52, 1853, p. 587.

Pratique du Pilotage. According to Saverien, Pezenas speaks not only of ordinary *échelles*, but also "of others more complicated, but more convenient. They are called *échelles doubles*. . . . When you proceed to find the fourth term of a proportion by these rules, you slide one rule against the other." Favaro[1] refers to a later work of Pezenas,[2] of the year 1768, in which the slide rule is described Favaro mentions also Lemonnier,[3] Fortin,[4] and Lalande.[5]

The article "Logarithmiques," written by Johann Bernoulli III., to which reference has already been made, was printed in the *Encyclopédie méthodique* and was translated into Italian in 1800.[6] It contained some historical references to Biler, Scheffelt, Leupold and Lambert, and a good account of the use of the instrument.

The time of the French revolution was a period of intense intellectual activity in France, during which mathematical studies received much attention. The establishment of the metric system gave impetus to the study of decimal arithmetic among the masses. In article 19 of the law of the "18 germinal an III," (April 7, 1795), was prescribed the construction of graphic scales, adapted for the determination, without calculation, of the ratios between the old and the new measures ("échelles graphiques pour estimer ces rapports sans avoir besoin d'aucun calcul").[7] One result of this legislation was the publication of Pouchet's *Arithmétique linéaire*. Due to this cause, no doubt, was also the appearance of *Cadrans logarithmiques adaptés aux poids et mésures*, published at Paris in 1799 by A. S. Leblond (1760—1811). These instruments, designed by Leblond, are circular slide rules, as are also those by François Gattey (1756—1819), who published *Instructions sur 1' Usage des Cadrans logarithmiques*, Paris, 1799, and in after years brought out several publications on this subject and finally changed the name of the instrument to *arithmographe*.[8]

During the eighteenth century, France and Germany produced nothing in connection with the slide rule, which had not been worked out earlier in England. Nor were instruments of this type used there nearly as much as in England. It is also worthy of remark that, so far as we have observed, the early English designers of slide rules (Wingate, Oughtred, Partridge, Coggeshall, Everard) are never mentioned by continental writers of the eighteenth century. While Gunter's scale was known to be of English origin, German and French writers of the eighteenth century do not ascribe the slide rule to England. Even in England, books of the eighteenth century usually fail to mention Wingate and Oughtred in connection with the slide rule. The instruments, as originally planned, were never used extensively. When they were supplanted by new designs, they bore the names of the designers, and the names of Wingate and Oughtred were naturally forgotten.

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1 Favaro, *op. cit*., p. 505.

2 *Nouveaux essais pour déterminer les longitudes en mer par les mouvements de la lune et par une seule observation*, Paris, 1768.

3 *Abrégé du pilotage*, Paris, 1766.

4 *Atlas céleste de Flamsteed*, translated by Fortin (Table 30), 1776.

5 Encyclopédie méthodique (Marine), article "Echelle anglaise."

6 *Dizionario enciclopedico delle matematiche delli signori Ab. Bossut, La Lande ec., Traduzione dal Francese*, Padova, 1800, Art. "Logaritmiche."

7 See G. Bigourdan, *Le Système Métrique des Poids et Mesures*. Paris, 1901, p. 65 69.

8 Favaro, *op. cit*., p. 506.

DEVELOPMENT IN ENGLAND DURING THE NINE-TEENTH CENTURY (FIRST HALF)

The most conspicuous novelty advanced by English writers on the slide rule in the early part of the 19th century was invented by Peter M. Roget, M.D., who communicated to the Royal Society of London *a Description of an instrument for performing mechanically the involution and evolution of numbers*,[1] which solves a^b for integral or fractional values of b. This is done by denoting by the spaces upon the fixed rule, not logarithms, but *logarithms of logarithms*. Roget called it a "logometric scale." "Logometric" logarithms were used by Farey since 1807 in musical calculations.[2] The scale is now usually called a "logolog" or "log log" scale. The operation of this rule may be seen from the following three settings:

Fixed rule	a	a^b	a	$\sqrt[b]{a}$	a	$\sqrt[b]{a^c}$
Slider	1	b	b	1	b	c

The first setting yields a^b, the second $\sqrt[b]{a}$, the third $\sqrt[b]{a^c}$. In the first case we see the space 1-b on the slider to mean log b-log 1 = log b, while the space a-a^b on the fixed rule means log log a^b – log log a. Since the two spaces are equal to each other, we have log b = log log a^b – log log a, or log b + log log a = log log a^b, which relation is readily seen to hold. The instrument was constructed by Rooker of Little Queen Street, London. The logarithmic line representing a^b was divided into two parts, of which one was placed above the slider, the other below. On the middle of the upper scale stood 10; it ended on the right at 10^{10} and at the left at 1.25. The lower scale had 1.25 on the right and 1.0025 on the left. The slider had a double radius.

While, as Roget points out, questions relating to increase in population and the calculation of chances may be facilitated by this instrument, it is readily seen that its application would be limited. This fact explains why this rule was forgotten, being later re-invented as the demand for it in thermodynamic, electrical and other physical calculations arose. Roget applies this rule to two problems of interest to mathematicians: (1) He finds the system of logarithms in which the modulus is equal to the base; inverting the slider he reads off the answer 1.76315; (2) He solves x^x=100, getting x=3.6.

In the same article Roget explains a circular log-log rule and describes a log-log chart for the computation of powers and roots.

Slide rules were also designed by Sylvanus Bevan. In 1817, he explained an economic disposition of the numbers on the logarithmic scales.[3] "Instead of having, like the common sliding rule, a fixed and a movable line of numbers, each reaching from 1 to 10, and repeated to a second 10, mine has one line reaching from 1 to 10, and another reaching from 3 to 10, and thence onward to 3.3 . . . , one of these lines being inverted, or counting from right to left, whilst the other is placed in the usual manner. By this construction . . . the sliding rule is reduced to one half its usual bulk." The inversion of the scale was an old device, while the way of disposing of the logarithmic line was a rejuvenescence of an idea advanced 30 years earlier by Nicholson.

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1 *Philosophical Transactions* (London) 1815, Part I., p. 9.

2 *Phil. Mag*., Vol. 45, p. 387; also art. "Logarithms" in Brewster's *Edinburgh Encyclopaedia*, 1st Am. ed., Philadelphia, 1832.

3 *Philos. Magazine* (London), Vol. 49, 1817, p. 187.

De Morgan refers to another modification of the principle of the slide rule, according to which the divisions are "all made equal, and the numbers written upon the divisions in geometrical proportion. . . . This modification of the principle has been applied in two very useful modes by Mr. McFarlane. In the first, two cylinders moving on the same axis, on one side and the other of a third, give the means of instantaneously proposing and solving any one out of several millions of arithmetical questions for the use of schools and teachers. In the second, one circle revolving upon another gives the interest upon any sum, for any number of days, at any rate of interest under ten per cent." [1] We have been unable to find other references to MacFarlane's designs.

J. W. Woollgar of Lewes, near London, designed different types of slide rules, in particular a six inch "Pocket calculator." With the view of extending the power of the slide rule, he made in another case the slider (or else the rule) bear, not the logarithms of the numbers marked on its graduation, but those of the values of a function of those numbers,[2] enabling him to compute the formula *a. ,Φ(x)*. We are told that about 1860 these rules were no longer made.[3]

Various other modifications of the slide rule were made in different quarters, but, as previously pointed out, the newer designs met with little favor. The rules most commonly purchased failed to embody the use of the runner, suggested by Newton, Stone, Robertson and Nicholson. De Morgan never once mentions the runner in his article of 1842 in the *Penny Cyclopaedia*, which shows that this ingenious device had been completely forgotten. Peter Barlow, in *his Dictionary of Pure and Mixed Mathematics*, London, 1814, describes Everard's rule for gauging and Coggeshall's for timber-measurement, but makes no mention of the new rules of Nicholson and Pearson. Precisely the same course is taken by James Mitchell in his Dictionary of Mathematical and Physical Sciences, London, 1823. The novelties of Nicholson, Pearson and Roget were either ignored or forgotten. It is also worthy of remark that while Oughtred invented the circular rule, Milburne, Brown and Adams the spiral arrangement, and while Nicholson re-invented the circular form, this type of rule never until recently really secured a firm foothold in England.

In fact, the use of the slide rule in England during the second quarter of the nineteenth century appears to have diminished. About 1840 De Morgan complained that the instrument "has been greatly undervalued" in England.[4] This decline is doubtless due, in part, to the alteration in the system of weights and measures, which took place in 1824, introducing, for instance, an imperial gallon one fifth larger than the old wine gallon. Such changes rendered obsolete the old rules bearing gauge-points for the old units of measure. To be sure, new rules were designed. A large supply of new rules for the use of the exercise became necessary. This led a mechanic, Samuel Downing, to invent "more facile means of multiplying the logarithmic and other scales upon them, than by the old tedious method of transferring copies of the original divisions on the stocks and slides of the rules, by the help of the square and dividing knife, and the marking punches, etc., usually employed."[5] Thomas Young set himself to work to change the design of slide rules.[6] We surmise that the difficulty lay not in the design and manufacture of new rules, but rather in getting people to learn how to use them.

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[1] Art. "Slide rule" in the *Penny Cyclopaedia*, 1842. Who was McFarlane? Perhaps he was Donald McFarlane, the lahoratory assistant to Lord Kelvin at Glasgow University, or perhaps he was Andrew Macfarlane, for many years secretary of the Mechanics' Institution of London.

[2] *Mechanics' Magazine*, Vol. 32, London, 1840, pp. 101, 102; "Slide Rule" in *Penny Cyclopaedia*.

[3] W. H. Bayley's *Hand-Book of the Slide Rule*, London, 1861, p. 340.

[4] Art. "Slide Rule" in *Penny Cyclopaedia*.

[5] Gill's *Technological Repository*, Vol. IV., London, 1829, p. 33.

[6] *Quarterly Journal of Science, Literature and Arts*, London, Vol.XVI, 1823, p. 357.

DEVELOPMENT IN GERMANY AND AUSTRIA DURING THE NINETEENTH CENTURY (FIRST HALF).

In Germany the slide rule was little known during the first half of the century. The efforts to popularize it, made in the eighteenth century by Lambert and Segner, bore little fruit. In the early volumes of J. G. Dingler's Polytechnic Journal, founded in 1820, occur numerous accounts of designs of slide rules, made in England,[1] but in 1829,[2] complaint is made that only few architects and Zimmerleute know what a logarithm is. In 1825, appeared in Berlin a book by Fr. w. Schneider, explaining the slide rule, which was modeled after a Swedish text of the year 1824. The English notation A, B, C, D of the four scales is used. On the cover of the book is an advertisement of the Berliner mechanic, F. Dübler, manufacturer of slide rules of boxwood or of brass. In 1847, C. Hoffmann published lectures on the slide rules, delivered by him before the Polytechnic Society of Berlin.[3] He mentions in his preface three makers of slide rules in Berlin, namely, Th. Baumann, C. T. Dörifel, and C. G. Grunow. Notwithstanding this activity, we are informed by a writer in 1859 that the slide rule was little used in Germany. Nor were new patterns of rules or new methods of construction attempted there during the first half of the century.

Hoffmann had drawn his inspiration from Vienna, where Adam Burg had interested himself in the slide rule, and for the popularization of which L. C. Schulz von Strassnitzki, professor at the Royal Polytechnic Institute in Vienna, prepared a small treatise [4] in 1843 and also delivered lectures before the Vienna Polytechnic Institute. In these lectures he used a huge slide rule eight feet long, probably similar to the two meter rules, used later by Tavernier-Gravet in Paris, and supplied for demonstration at the present time by Keuffel & Esser Co. and doubtless also by other manufacturing establishments. Strassnitzki designed a slide rule suited to the Austrian system of measures. Another lecturer in Vienna on this subject was E. Sedlaczek, the author of an important manual (1851) on the slide rule.

In Italy the instrument was first brought to notice in 1859 by Quintino Sella who wrote a text on it.[5] Favaro remarks that before the middle of the century Italy contributed little to its progress.

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[1] Dingler's *Polyt. Journal*, Vol. 47, 1902, p. 489, Art. "Der Rechenschieber in Deutschland."
[2] *Idem*, Vol. 32, p. 173.
[3] *Idem*, Vol. 47, 1902, p. 490.
[4] *Anweisung zum Gebrauche des englischen Rechenschiebers*. Wien, 1843; Dingler's Polyt. Journal, Vol. 47, 1902, p. 490.
[5] *Teorica e pratica del regolo calcolatore*, Torino, 1859; Favaro, op. cit., p. 507.

DEVELOPMENT IN FRANCE DURING THE NINETEENTH CENTURY (FIRST HALF).

In France, the slide rule steadily gained in popularity, during the first half of the nineteenth century, until France became for a time a center of activity in the design and manufacture of rules. We have seen that, after the French Revolution and the adoption of the metric system, circular slide rules came to be appreciated some-what. Nowhere has the circular rule secured as much of a hold as in France. The instruments of Leblond and Gattey, brought out at the close of the eighteenth century, were of the circular type. Gattey proposed a new circular instrument in 1810, with the name of "arithmographe."[1] Benoit says [2] that their construction was similar to the cardboard instrument of Clairaut, but less complete, that this and similar instruments were not much handled until after the National Society for the Encouragement of Industry, under the initiative of Jomard and Francoeur, interested itself in the popularization of the slide rule. It is worthy of notice that even in France the rectilinear rule gained ascendency over the circular type. Jomard described in the publications of this society a straight wooden slide rule, imported by him in 1815 from England.[3] Before this the straight edge type had been seldom described in France. In another volume it is asserted that in 1816 Hoyau, a locksmith and inventor, constructed cylindrical slide rules of superior workmanship.[4] It is perhaps of this that De Morgan writes [5] in 1842, "Twelve or fifteen year sago, an instrument maker at Paris laid down logarithmic scales on the rims of the box and lid of a common circular snuff-box, but either calculators disliked snuff, or snuff-takers calculation, for the scheme was not found to answer, and the apparatus was broken.

About this time a large number of English rules were imported. In 1815 to 1818 Benoit secured rules constructed by the London optician, Bate, 28 and 56 inches long, and also carefully graduated rules from the work-shop of W. & S. Jones in Lower Holborn, London. In 1821 Lenoir made the first of his copper rules, 35 cm. long, and constructed after designs of Jomard and Collardeau a machine which marked the divisions simultaneously upon 8 wooden rules 25 cm. long, and executing work as fine as that of the brothers Jones in London. Rules of different lengths were also constructed in 1821 by Clouet and by Isaac Sargent.[6] The rules of the latter commanded the lively admiration of the mathematician Prony. But all these efforts, says Benoit,[7] would have been long fruitless, if the government had not wisely imposed in its requirements for admission to the schools for public service a knowledge of the slide rule.[8] No doubt the ascendency of the slide rule in France is due mainly to this government provision. It is the experience of all that skill in the use of the rule is not attained, except as the result of considerable practice. But once this skill is acquired, the instrument is loved, and used persistently.

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[1] Gattey, *Explication et usage de l'arithmographe*, Paris, 1810, brought out later under the title *Usage du calculateur, instrument portatif au moyen duquel on peut en un instant, et sans etre obligé d'écrire aucune chiffre, se procurer les résultats de toutes sortes de calcul*, Paris, 1819; Favaro, op. cit., p. 506.

[2] *Bulletin de la société d'encouragement pour l'industrie nationale*, Vol. 52, 1853, p. 588.

[3] *Idem*, p. 588.

[4] *Bulletin de la société d'encouragement pour l'industrie nationale*, Vol. 52, 1853, p. 588.

[5] Art. "Slide Rule," *Penny Cyclopaedia*.

[6] *Idem*, pp. 588,589

[7] *Idem*, p. 589.

[8] *Idem*, p. 589; Favaro, *op. cit*., p. 508.

That French workmanship attained a high degree of skill is apparent from English comment. About 1841 De Morgan[1] received from Paris a circular logarithmic scale in brass, 4½ in. in diameter, consisting of two concentric plates, having a clamping screw on their common axis. De Morgan says that it "is so well divided that it will stand tests which the wooden rules would not bear without showing the error of their divisions. But here arise disadvantages which we had not contemplated. In the first place, no sub-division can be well made or read by estimation, unless the part of the scale on which it comes is uppermost or undermost, which requires a continual and wearisome turning of the instrument. In the next place, to make the best use of it, and to bring out all its power, requires . . . such care in setting and reading, as, unless a microscope and tangent screw were used, makes the employment of the four-figure logarithm card both shorter and less toilsome. For rough purposes, then, a wooden rule is as good; for more exact ones, the card is better." This is an interesting statement of comparative merits. It points out, also, a practical difficulty which has hindered the circular type from attaining wide use. Its vicissitudes in the struggle for existence are brought out in a statement of an Englishman who in 1841 saw in Montferrier's Mathematical Dictionary, article "arithmometre," a remark that these arithmometers were made and sold at the shop of the publisher of that dictionary in Paris.[2] He ordered one of them and received the last one in the shop—their manufacture was to be discontinued on account of insufficient sales.[3]

We have referred to the firm of Lenoir in Paris as skillful manufacturers of slide rules. It is interesting to see how that firm, then prominent in France for its excellent astronomical and geodetic instruments, gradually advanced until, for a time, it held the very first place in the world in the manufacture of slide rules. There were two Lenoirs, father and son. The father outlived his son and died in 1832.[4] The Lenoirs were succeeded by Collardeau and Gravet.[5] According to Maurice d'Ocagne, the name of the firm was first Gravet-Lenoir, then Tavernier-Gravet.[6]

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1 Art. "Slide Rule," *Penny Cyclopaedia*.

2 The first two volumes appeared in "Paris, chez Denain, Impr. do Locquin, 1835—37," "Tome 3. Supplément. Paris, Impr. de Mine Dondey-Dupré, 1840."

3 *Mechanics' Magazine*, Vol. 35, London, 1841, p. 309.

4 Favaro, *op. cit*., p. 507.

5 *Bulletin de la société d'encouragement pour l'industrie nationale*, Vol. 52, 1853, p. 589.

6 D'Ocagne mentions in his *Calcul simplifié*, 2e éd., Paris, 1905, p.116, the following French authors of works on the slide rule: Collardeau (1820), Ph. Mouzin (3e éd., 1837), J. F. Artur (1827, 2e éd., 1845), Aug. Hadéry (1845), L. Lalanne (1851), F. Guy 3e éd., 1885), P. M. N. Benoit (1853), Fr. René (1865), Montefiore Lévi (1869), Labosne (1872), Claudel (1875), Gros de Perrodil (1885), Leclair (1902), Jully (1903), Dreyssé (1903). Lévi's book is a translation from Italian into French of Quintino Sella's work.

DEVELOPMENT IN THE UNITED STATES DURING THE NINETEENTH CENTURY

In the United States, as previously pointed out, brief instructions for the use of the slide rule were printed in a few arithmetics of the latter part of the eighteenth century. An edition of Thomas Dilworth's *Schoolmaster's Assistant* (an English book) was brought out in Philadelphia in 1805 by Robert Patterson, professor of mathematics in the University of Pennsylvania. It devotes half a dozen pages to the use of the slide rule in gauging. Another English work, Honey's *Complete Measurer* (1st ed., London, 1717) was printed in Baltimore in 1813. It describes the Carpenter's Rule as well as "Verie's Slide Rule" for gauging. Of American works, the *Arithmetic* of Nicolas Pike (1788) gives brief directions for the use of slide rules, while Bowditch's *Navigator*, 1802, gives one page to the explanation of the slide rule, but in working examples, Gunter's line alone is used. From these data it is difficult to draw reliable conclusions as to the extent to which the slide rule was then actually used in the United States. We surmise that it was practically unknown to the engineering profession as a whole. There were, no doubt, isolated instances of its use. The Swiss-American geodesist, F. R. Hassler, who was the first superintendent of the U. S. Coast and Geodetic Survey, possessed a slide rule—we shall describe it later. Mr. C. H. Progler, of Ripley, W. Va., informs me that in 1848—50 he was in the employ of Hassler's son in U. S. geodetic work in North Carolina, that they had a slide rule in camp, but did not use it in connection with the survey. I have seen a reference to the slide rule in a book issued about 1838 by a professor of the Rensselaer Polytechnic Institute.

It was in 1844 that Aaron Palmer's Computing Scale appeared in Boston. It was a circular slide rule, 8 in. in diameter. The following year he brought out a Pocket Scale, 2 5/8 in. in diameter. In 1846 the copyright of Palmer's scale was owned by John E. Fuller, who introduced changes in Palmer's original scale by the addition to it of non-logarithmic circles for determining the number of days between given dates. Fuller called this new part a *Time Telegraph* and the modified instrument as a whole a *Computing Telegraph*. Later the instrument may have been modified still further. About 1860 it was sold by subscription in New York under the name of Telegraphic Computer. We are not aware that Palmer's and Fuller's instruments were known outside of Massachusetts and New York. (**Addenda 7.**

An account of the rectilinear slide rule, which probably reached the engineering profession in America more widely than other accounts, is found in *the Mechanics' and Engineers' Book of Reference and Engineers' Field Book* (New York, 1856). This book was written by Charles Haslett, Civil Engineer, and Charles W. Hackley, Professor of Mathematics in Columbia College. It gives five pages to the description of the slide rule.

In spite of the facts just presented it appears that, before 1880 or 1885, the slide rule was little known and very little used in the United States. References to it are seldom found in engineering literature. Appleton's *Dictionary of Engineering*, Vol. I, New York, 1868, does not name the slide rule, but devotes three or four lines to a description of it under the head of "Gunter's line." *Knight's American Mechanical Dictionary*, Vol. II, 1881, describes Gunter's line; then, without naming the slide rule, describes it in four lines and ends with the statement to the effect that these "instruments" "are now common among intelligent workmen."

Wider interest in the slide rule was awakened about 1881. It was in that year that Edwin Thacher, a graduate of the Rensselaer Polytechnic Institute, now a bridge engineer, patented his well-known Cylindrical Slide Rule (Fig. 9). It was in 1881 that Robert Riddle published in Philadelphia his booklet on *The Slide Rule Simplified*, in which he describes a rule of Coggeshall's type. In the preface he points out that, though nearly unknown in this country, the slide rule was invented before the time when William Penn founded Philadelphia. Since 1881 the interest in the slide rule has been steadily increasing in America. Professor Calvin M. Woodwind of Washington University writes that he does not remember having seen a slide rule while an under-graduate student, that his attention was first called to it by Professor C. A. Smith in the '70's and more strongly by Professor J. B. Johnson in the 80's; Johnson required every student in engineering to use it. Its popularity began with the introduction of the Mannheim type about the year 1890. At that time William Cox began his propaganda in the *Engineering News*. In recent years many of the rules for special purposes have originated in the United States. An inquiry instituted by C. A. Holder[1] showed that in about half of the engineering schools of the United States attention is given to the use of the slide rule.[2]

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[1] *Engineering News*, Vol. 45, 1901, p. 405.

[2] For additional data of interest on the use of the slide rule in the United States, *see Transactions of the American Society of Mechanical Engineers*, Vol. VIII, New York City, 1886—7, pp. 707—709.

DEVELOPMENT DURING RECENT TIMES

Our limitations of space do not permit a detailed historical account of the very numerous modifications of the slide rule for special purposes which have been made during the last fifty years. We shall merely endeavor to touch upon a few of the leading facts.

It was about 1850 that a French army officer in Metz, then only about nineteen years old, designed a straight slide rule with a runner and with a disposition of the logarithmic scales, such as experience has shown to be admirably suited to the ordinary every-day uses of a slide rule. This officer was Amédée Mannheim (1831—1906) and his slide rules are known everywhere as Mannheim rules. In 1848 he entered the Ecole Polytechnique in Paris, and then, as lieutenant of artillery, went to Metz and became a student at the Ecole d'Application there.[1]

Mannheim has had a long and illustrious career as Professor of Geometry and Stereotomy at the Ecole Polytechnique in Paris, where he has rendered long service and enriched geometry and mechanics with new researches. Homage was rendered to "Colonel Mannheim" by the Ecole Polytechnique on the occasion of the celebration of his seventieth birthday in 1901.

Mannheim explained his rule and its use in a publication entitled *Règle à calculs modifiée*. *Instruction* (Metz, Imp. et lith. Nouvian, Décembre, 1851). Later an account appeared in the Nouvelles Annales de Mathématiques.[2] It is not generally known that Mannheim designed also a cylindrical slide rule which was more accurate than his straight rule.[3]

Mannheim had the good fortune to have his rectilinear slide rule made by Tavernier-Gravet, a firm of national reputation, and also of having this rule adopted as the one to be used by the French artillery. But many years elapsed before it acquired a foothold in other countries. Not until 30 or 40 years after its invention did it come to be used in England and the United States. Perhaps the first appreciation of it, outside of France, came from the Italian, Q. Sella, who published in Turin, in 1859, an excellent work on the slide rule, which was enlarged in the second edition, 1886. At the close of the last century, the Mannheim rule was known wherever instruments of this class were in use.

Mannheim is the first who succeeded in popularizing the use of the runner. The runner enables one to read corresponding numbers on scales that are not contiguous and also to compute the value of complex expressions without the necessity of reading intermediate results of computation. In England, where the runner was first invented nearly 200 years earlier, it met with slower adoption than in

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[1] See C. A. Laisant: "La Vie et les Travaux d'Amédée Mann-heim" in *L'ensignement mathématique*, IXe année, 1907, 169—179. From the *Journal de l'Ecole Polytechnique*, IIe série, septième cahier, Paris, 1902, p. 223, we quote:
"C'est ainsi qu' à Metz, étant encore éléve à l'Ecole d'Application vous avez imaginé la règle à calculs qui porte votre nom et qui fut adoptée par 1'Artillerie sur la proposition du Capitaine Goulier. Depuis, elle est employée partout l'étranger."

[2] Iére série, tome XII, 1853, pp. 113—116. An exhaustive account of Mannheim's geometrical articles, 224 in number, is given by Gino Lana in the *Remticonti del Circolo Matematico di Palermo*, Tomo 26, 1908, pp. 1—63.

[3] "Règle à calcul cylindrique," described in *Nouvelles Annales de Mathématiques*, Tome XIII, 1854, p. 36.

France, Italy or Germany. That the Mannheim rule was unknown in England 20 years after its invention follows from the fact that the runner was reinvented in England by Erskine Scott in 1870.[1]

In Mannheim's rule (Fig. 10) the upper scale *A* on the rule and the upper scale *B* on the slide are marked alike, each having a double graduation from 1 to 10, as in the older rules. But the lower scale *C* on the slide and the lower scale *D* on the rule are also marked alike, both having a single graduation from 1 to 10, whereas, in the ordinary old Coggeshall's rules, *C* was marked the same as *A* and *B*, and in that form had enjoyed popular favor for 170 years. The new arrangement has its disadvantages in that squares and square roots require the use of the runner, while the use of the two lower scales *C* and *D* involves uncertainty as to the direction of the motion of the slide. Moreover, the inverted slide cannot be used in finding factors. But the rule enjoys the advantage of yielding a double accuracy when the lower lines are used for simple proportion, while the use of the runner in complex operations simplifies matters enormously. Protests against the Mannheim arrangement are seldom heard.[2]

And yet, it is far from certain that the Mannheim type will continue long in its undisputed supremacy as the best portable rule for popular use in ordinary computation to three significant figures. Even now there are signs of divided allegiance. In the technical schools in Paris a modification of the Mannheim rule is now used.[3]

This is called the 'règle des écoles" (see Fig. 11), to distinguish it from the "règle du Colonel Mannheim." Greater simplicity as well as greater accuracy is claimed for the arrangement in the règle des écoles. It has also an adaption to the centesimal division of the quadrant. In this new rule the scales, familiarly known as *C* and *D*, are the same as in the Mannheim rule, being graduated from 1 to 10. But the scales *A* and *B* are different; *A* and *B* bear each a single graduation from 1 to 10, like *C* and *D*, but so placed that the figure 1 is not at the left end, but is in the middle of the scale and slide. From left to right the numbers *A* and *B* read 4, 5, 6, 7, 8, 9, 1, 2, 3. When the slide is so placed that the scales *C* and *D* coincide, then *A* and *B* coincide also. In computation, the slide need not be drawn further than half its length to the right or to the left. Use is made of the runner. The rule is constructed by Tavernier-Gravet, rue Mayet 19, Paris. Rozé remarks that with this rule one can perform multiplications and divisions, one after another, without interruption and with twice the precision possible with the Mannheim rule, that square roots are also gotten more accurately, though not as easily as with the Mannheim rule. Rozé says that in France the règle des écoles is being used more and more, while in England it has not been used until now. In the United States it has not acquired a foothold at all, as yet. In Germany this type of rule is just beginning to be offered for sale.

In France the règle des écoles goes also by the name of "règle Beghin," for it was Beghin [4] who suggested a disposition of the scales as it appears in the règle des écoles. Rozé adds, however, that no priority can be claimed for Beghin, for Professor Cherepashinskii [5] suggested this arrangement several years earlier. Cherepashinskii is a Russian, a professor at the Moscow Polytechnic. He designed the slide rule in 1882 and had the firm Tavernier-Gravet in Paris construct one instrument. The following year (1883) be published at Moscow in Russian a booklet on the slide rule, but his ideas were ignored

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[1] *Zeitschr. f. Mathematik. u. Physik.*, Vol. 48, 1903, p. 134. In France the runner was not wholly unknown in the first half of the nineteenth century. It is mentioned in *Mouzin's Instruction sur la manière de se servir de la règle à calcul*, 3e éd., Paris, 1837.

[2] For a recent protest, see *American Machinist*, Vol. 29, Pt. II, 1906, p. 256.

[3] See P. Rozé *Règle à calculs*, Paris, 1907, pp. 2, 3, 29—58.

[4] A. Beghin, *Règle it calcul, modèle spécial*, Paris, 1898, 2e éd., 1902.

[5] Rozé transliterates the name as "Tserepachinsky," while d'Ocagne gives it as "Tchérépachinsky."

by the public at that time.[1] It is of interest to observe that Cherepashinskii's modification of the Mannheim rule, by discarding the lines of two radii and using in their place only lines of one radius, is exactly the modification which, in the eighteenth century, Vero effected upon the Everard slide rule.[2]

Novelty cannot be claimed even for Cherepashinskii. (**Addenda 8.**
In De Morgan's article "Slide Rule," in the *Penny Cyclopaedia* (1842), we find identically the same scale arrangement as Cherepashinskii's. It is attributed by De Morgan to Sylvanus Bevan (*Nicholson's Journal*, Vol. 49, 1817, p. 187), with the further remark that, thirty years before that, Nicholson had made somewhat similar dispositions (*Philosophical Transactions*, 1787, p. 246). We must remark, however, that while Nicholson employed the runner, this device was apparently unknown to Bevan.

Much ingenuity has been expended in recent years to increase the accuracy of the slide rule without unduly increasing its size. While E. Péraux took a longer scale and mounted it upon the rule in two parts, using two slides, Delamorinière adopted rule one meter long.[3] Following out an idea advanced long before by W. Nicholson, the logarithmic scale was broken up into several parts of equal length and arranged side by side in a plane by J. D. Everett,[4] Hannyngton, Scherer, R. Proell, or upon the surface of a cylinder arranged parallel to its axis, as by J. D. Everett, Mannheim, E. Thacher. Thacher's instrument (Fig. 9) almost attains the accuracy of a five-place table of logarithms and ranks among the most accurate slide rules in practical use. It is the most important single contribution to the design of slide rules made in America.

Working on the plan of Oughtred, other designers adhered to the circular form, as, for instance, E. M. Boucher (Fig. 12), whose instrument resembles a watch, and Hermann or P. Weiss, all the circles being coplanar and fixed, the sliding parts being pointers or hands. In other designs the circles slide relatively to each other as in the old types of J. M. Biler and A. S. Leblond. Modern examples of the latter are the instruments of E. Son, F. M. Clouth, W. Hart, F. A. Meyer, E. Puller, A. Steinhauser, and others. Another variation in design is to place the logarithmic circles upon the rims of wheels, as in the instruments by Gattey and Hoyau at the beginning of the nineteenth century, and as in the more recent ones by MacFarlane, R. Weber, A. Beyerlen. The logarithmic line has also been mounted upon a cylinder in the form of a screw thread, as in designs by G. H. Darwin and Professor R. H. Smith, and in G. Fuller's well-known Spiral Slide Rule (Fig. 13). Still another idea is to place the logarithmic line upon metallic tapes, unwound from one roller or spool upon another, as in G. H. Darwin's designs and in B. Tower's instrument. What constitutes the best mechanical arrangement for accurate curvilinear or multilinear rules for common use is still a matter of speculation.

Generalizations of the slide rule, such as were introduced in the early part of the century by P. M. Roget, in his log-log rule have been re-invented by Burdon in France, by Captain Thomson of the British Army, by F. Blanc in Germany, and again by Professor John Perry of the Royal College of Sciences in London, and by Colonel H. C. Dunlap, Professor of Artillery at the Ordnance College, and C. S. Jackson, Instructor of Mathematics at the Royal Military College in England. When in $a^b = x$, the value of x is between 1 and 0, its logarithm is negative, a case first mechanically provided for by Blanc. Says C. S. Jackson, "The use of a log (— log x) scale for numbers less than unity was one

[1] Maurice d'Ocagne, *Calcul simplifié*, 2e éd., Paris, 1905, p. 116, note 2.

[2] See C. Leadhetter's *Royal Gauger*, 1755, p. 29.

[3] *Bull. de la société d'encouragement pour l'industrie nationale*, Paris, Vol. 62, 1863, p. 656.

[4] The references to the literature of each instrument are given later in the list of slide rules designed and used since 1800.

fondly thought new, but in this idea, which Professor Perry also brought forward, we were all anticipated by Blanc.[1] Similar researches were made by Burdon, who proposed schemes for solving $xy^m = a$, $xy^n = b$, where m, n, a, b are given numbers. The introduction of still different scales, more general than that of log x, was noticed by us in the case of Woollgar, and more recently has been studied by P. de Saint-Robert,[2] who solves equations of the form $f(z) = \Phi(x) + \Psi(y)$ by the use of slide rules graduated to f, Φ, Ψ. Studies along this line have been carried on by Ch. A. Vogler.[3]

With the aid of the ordinary Mannheim and similar slide rules it is possible to solve quadratic and cubic equations. This has been pointed out by E. Bour,[4] Paolo de Saint-Robert,[5] A. Genocchi,[6] Quintino Sella,[7] Favaro and Terrier,[8] W. Engler,[9] H. Zimmermann,[10] H. C. Dunlop and C. S. Jackson,[11] and A. Dreyssé.[12] The computation of $\sqrt{(a^2 \pm b^2)}$, $\sqrt{a} \pm \sqrt{b}$, $(\sqrt{a} \pm \sqrt{b})^2$ and similar expressions with a single setting of the rule was shown by W. Ritter.[13] Fürle's general slide rule gives $\sqrt{(x^2 \pm y^2 \pm z^2)}$.[14] Fürle generalizes the methods of Bour and Burdon and describes a slide rule which has, besides the ordinary scales, also scales for the functions x, x^2, x^3, log-log x. This rule enables him to solve numerical equations not higher than the fifth degree, also trinomial equations of any degree and certain transcendental equations.[15] It will be remembered that Newton out-lined a method for solving equations of any degree by the slide rule, which was described more fully, in some-what modified form, by E. Stone. In recent times this idea has been followed up also by the Spaniard L. Torres for the solution of trinomial and higher equations, as well as by d'Ocagne,[16] and, as we have seen, by Fürle. In the same order of ideas are the modes of solving equations, advanced by F. W. Lanchester[17] and Baines.[18] Slide rules for use with complex quantities, $a + \sqrt{(-1)}\, b$, have been designed by R. Mehmke.[19]

Great activity has been shown during the last forty years in the direction of perfecting the mechanical execution of slide rules. In this, Germany took the lead. After the slide rules used in Germany had been mostly imported from France for a period of twenty or thirty years, German manufacturers gained the ascendency. In 1886,[20] Dennert & Pape in Altona began to mount the scales of numbers upon white celluloid, instead of boxwood or metal. Upon celluloid numbers appear so much more

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[1] *Mathematical Gazette*, Vol. II, London, 1904, p. 337.
[2] *Encyklopädie d. Math. Wiss*. Bd. I, 1898—1904, Leipzig, p. 1064.
[3] *Idem*, p. 1064; also Zeitschr. Vermessungsw. 10 (1881), p. 257.
[4] *Par. Comptes rendus de l'A cad. d. Sci*., 44 (1857), p. 22.
[5] *Mem. dell' Accad. d. Scie. di Torino*, T. XXV, Serie II.
[6] *Giornale di Matem. del Prof. Battaglini*, Napoli, 1867.
[7] *Regolo Calcolatore*, 2 ed. Ital., Torino, 1886, p. 88—94, 140—163.
[8] Favaro-Terrier, *Statique Graphique*, Paris, 1879.
[9] *Zeitschr. Vermessungsw*., Vol. 29, 1900, p. 495.
[10] *Idem*, Vol. 30, 1901, p. 58.
[11] *Slide Rule Notes*, London, 1901, p. 17.
[12] *Règle à calcul Mannheim*, Paris, 1903, p. 151.
[13] *Schweizer. Bauzeitung*, Vol. 23, 1894, p. 37; quoted in *Encyklopädie d. Math. Wiss*., Vol. I, p. 1058.
[14] *Zur Theorie des Rechenschiebers*, Berlin, 1899.
[15] *Zur Theorie des Rechenschiebers*, Berlin, 1899; *Encyklopädie der Math. Wiss*., Bd. I, p. 1065.
[16] d'Ocagne, *Le calcul simplifié*, Paris, 1894; 2e éd., 1905. For fuller references, see *Encyklopädie d. Math. Wiss*., Bd. I, pp. 1007, 1024, 1065.
[17] *Engineering*, Aug. 7, 1896, p. 172.
[18] *Engineer*, April 1, 1904, p. 346.
[19] Dyck's *Katalog, Nachtrag*, p. 21, Nr. 44 d.
[20] *Encyklopädie d. Math. Wiss*., Vol. I, p. 1055.

distinctly that the use of celluloid has become well nigh universal. In America celluloid rules were being sold by the Keuffel & Esser Co. as early as 1888.[1] Since 1895 the Keuffel & Esser Co. manufacture them in Hoboken, N. J. A prominent German firm, engaged in the manufacture of slide rules, is that of Albert Nestler of Lahr in Baden. The firm of A. W. Faber has manufactories in Germany, and houses in England, France, and the United States.[2] Slide rules are now usually engine-divided. Many mechanical devices have been patented by different manufacturers for ensuring the smooth and even workings of the slide in the stock of the rule and allowing compensation for wear, or obtaining material that will show little shrinkage or warping.

For the purpose of securing greater accuracy in the use of the slide rule, without increasing the length of the divisions—of securing, say, the third or fourth figure with a 25-cm. rule—attachments have been made, which go usually under the name of cursors. An early attempt along this line was a vernier applied in 1851 by J. F. Artur of Paris.[3] Similar suggestions were made by O. Seyffert in Germany.[4] Perhaps best known is the Goulding cursor, which allows the space between two consecutive smallest divisions of a rule to be divided into ten equal parts.[5] It is supplied by G. Davis & Son, Ltd., Derby, London, as is also a "magnifying cursor," enlarging by a plano-convex glass. A. W. Faber has a digit-registering cursor [6] with a semicircular scale, enabling the number of digits to be registered, these digits to be added or subtracted at the end of a lengthy operation. A radial cursor for multiplying or dividing a scale length mechanically has been introduced by F. W. Lanchester.[7]

We shall enumerate all the slide rules described and used since 1800, which have come to our notice. The number, though doubtless incomplete, is large and shows many types of rules designed for special kinds of computation, such as the change from one system of money, weight, or other measure, to another system, or the computation of annuities, the strength of gear, flow of water, various powers and roots. There are stadia rules, shaft, beam, and girder scales, pump scales, photo-expurse scales, etc.

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[1] *Railroad Gazette*, Vol. 20, 1888, p. 149.

[2] C.N. Pickworth, *Instructions for the Use of A. W. Faber's Improved Calculating Rule.*

[3] *Bulletin de la société d'encouragement pour l'industrie nationale*, Vol. 50, Paris, 1851, p. 676.

[4] *Encyklopädie d. Math. Wiss*., Bd. I, 1898—1904, p. 1058; *Centralblatt Bauverwaltung 8* (1888), p. 548.

[5] C. N. Pickworth *The Slide Rule*, 10th ed., 1906, p. 91.

[6] *Idem*, p. 92.

[7] *Idem*, p. 87; *Nature*, Vol. 52, 1895, p. 659.

SLIDE RULES DESIGNED AND USED SINCE 1800.

(Arranged approximately in chronological order.)

1. Horton's New Improved Rule.
[Referred to by W. Pearson in *Nicholson's Journal*, London, Vol. I, 1802, p. 452. Reprint of Vol. I, 1797.]

2. Roget's Slide Rule for Involution and Evolution
Philosophical Transactions (London), 1815, Part I, pp.9-29. Describes a linear log log slide rule.

3. Roget's Logometric Circular Rule.
[*Philosophical Transactions* (London), 1815, Part I, p. 26. A log log rule in circular form.]

4. Roget's Logometric Chart.
[*Philosophical Transactions* (London), 1815, Part I, p. 27.A chart with log log lines for computing roots and powers.]

5. Wollaston's Slide Rule for Use in Chemistry.
[*Philosophical Transactions*, London, Year 1814*; Bull. de la Société d'encouragement pour l'industrie nationale*, Vol. 52, Paris, 1853, p. 581; cited by Favaro, op. cit., p. 509, from *Journal des Mi*nes, Vol. 37, 1815, p. 101.]

6. S. Bevan's Engineer's Rule.
[*Penny Cyclopaedia*, 1842, Art. "Slide Rule." This 12-in. rule has slides on both faces and serves for squares, cubes, square roots of cubes, etc. There are scales on the backs of the slides and in the grooves for sines, tangents, interest, annuities at 5%. Made by Cary, Strand. It is probably this rule that is referred to by C. Culmann in his *Die Graphische Statik*, Zürich, I., 1875, p. 75, as bearing the mark "W. Cary, 182 Strand, 1815."]

7. Hoyau, boîtes à calculer.
[Bull. de la société d'encouragement pour l'industrie nationale, Vol. 52, Paris, 1853, p. 588. Constructed these cylindrical instruments about 1816.]

8. The Bate Rules.
[*Bull. de la société d'encouragement pour l'industrie nation*ale, Vol. 52, 1853, p. 588. Bate was an optician in London and his instruments were imported by the French about 1818. See also C. Culmann's Die Graphische Statue, Zürich, I., 1875, p.67, where he gives a drawing of "Bate's Ready Reckoner."]

9. S. Bevan's Improved Slide Rule.
[A 6-in, rule, described in *Philosophical Magazine* (London), Vol. 49, 1817, p. 187. Without reversion of some of the lines that was suggested by Bevan, the rule was made by R. B. Bate of the Poultry. This is probably the rule mentioned by C. Culmann's *Die Graphische Statik*, Zürich, I., 1875, p. 75, as marked "17 Poultry, London, 1824."]

10. B. Bevan's Circular Slide Rule.
[Gill's *Technological Repository*, Vol. 4, London, 1829,p. 37; *Mechanic's Magazine*, London, Vol. 15, 1831,p. 164.]

11. Clouet's règle calcul.

[*Bulletin de la société d'encouragement pour l'industrie nationale*, Vol. 52, 1853, p. 588. This rule was constructed by Clouet about 1821. See Vol. 20, p. 198.]

12. Jomard règle a calcul.
[*Bull. de la société d'encouragement pour l'industrie nationale*, Vol. 52, Paris, 1853, p. 588. Made by M. Collardeau, after 1815. See also *Calcul simplifié* par Maurice d'Ocagne, 2e ed., Paris, 1905, p. 115.]

13. Thomas Young's Sliding Rule for Gauging Casks.
[*Quarterly Jour. of Sci., Lit. and Arts*, London, Vol. 16, 1823, p. 357.]

14. Lamb's Circular Slide Rule.
[Gill's *Technological Repository*, Vol. 4, London, 1829, p. 37. Made by Mr. Lamb, a watch-maker in London.]

15. Downing's Slide Rule.
[Gill's *Technological Repository*, Vol. 4, London, 1829, p. 33.]

16. Saddington's Rules.
[*Mechanic's Magazine*, Vol. 12, London, 1830, p. 122. Rule made by Thomas Saddington of London.]

17. Henderson's Double Slide Rule.
[*Penny Cyclopaedia*, Art. "Slide Rule." Solves at one operation most sets of multiplications and divisions not exceeding five operations. Made by Jones in Holborn, London.]

18. Arithmomètre made by Publisher of Montferrier's Dictionnaire.
[Made and sold by these Publishers in Paris about 1840. See p. 57.]

19. Woollgar's Calculator.
[*Mechanic's Magazine*, Vol. 32, London, 1840, pp. 101, 102. See also Vol. 7, 1827; Vol. 15, 1831, p. 164; Vol. 17, 1832, p. 910. Designed by J. W. Woollgar, of Lewes, in Sussex, and made by Hooker, Little Queen Street, Holborn in London.]

20. Woollgar's Pocket-book Rule.
[*Penny Cyclopaedia*, Art. "Slide Rule." Made by Rooker, Little Queen Street, in Holborn. See also W. H. Bayley's *Hand-Book of the Slide Rule*, London, 1861, p. 340.]

21. Hassler's Slide Rule.
[A wooden slide rule of 25 in. effective length and width of 34 in. Consists of two parts sliding by one another. Brass guides at both ends. Each flat side carries lines of numbers. On one flat side are 21 parallel lines, 11 on one sliding part and 10 on the other. The 11 lines constitute a logarithmic line for numbers 1 to 1000; the 10 lines are a logarithmic line for numbers 892 to 89100. On the other flat side are 20 lines, 10 on each part. One part has logarithmic lines for numbers 1,000,000 to 100,000,000; the other part, for numbers 100,000 to 1,000,000,000. The instrument has the appearance of being hand-made. It was used by F. R. Hassler, the first Superintendent of the U. S. Coast and Geodetic Survey and is now the property of his great-grandson, F. R. Hassler, of Phillipsburg, Kansas.]

22. MacFarlane's Circular Interest Rule.
[Art. "Slide Rule," by De Morgan in the *Penny Cyclop*aedia, 1842.]

23. MacFarlane's Cylindrical Slide Rule.
[Art. "Slide Rule," by De Morgan in the *Penny Cyclopaedia*, 1842.]

24. Palmer's Endless, Self-Computing Scale.

25. Palmer's Pocket Scale.

[These instruments, composed of concentric circles (one movable within the other), appear to he the first slide rules designed, manufactured, and sold in the United States. The title of Palmer's 1844 publication, comprising 50 pages, is as follows: "A Key to the Endless, Self-Computing Scale, showing its application to the different Rules of Arithmetic, etc. By Aaron Palmer, Boston: Published by Smith & Palmer, 1844." On page 3 this scale is declared to be "the result of three years' incessant labor." No reference is made to similar instruments designed by others. Twelve recommendations of Palmer's Scale are printed in the booklet, one of them by Benjamin Peirce, Professor of Astronomy and Mathematics at Harvard University. Pierce says that the scale is "simple and most ingenious." It is stated in the booklet that the scale is made in three different styles and numbers: No. 1, for common business calculations, at $2; No. 2, for higher branches of mathematics at $3; No. 3, for nautical and astronomical calculations, at $5. The circles (two or more) were about 8 in. in diameter. There is also announced the manufacture of metallic scales. In 1845 appeared a new edition of the book: "Palmer's Pocket Scale, with Rules for its use in solving Arithmetical and Geometrical Problems. Boston: Published by Aaron Palmer. D. H. Ela, Printer, 37 Cornhill. 1845." The Pocket Scale is of cardboard and contains two circles, 2 5/8 in. in diameter; it is pasted, inside, against the rear cover of the book. "All the errors which have been discovered in the former editions, have been corrected in this." We have seen only one "former" edition, namely, the one of 1844, quoted above. But Favaro, op. cit., p. 509, names "Palmer's Computing Scale, New York, 1843." I am indebted to Dr. Artemas Martin, of Washington, D. C., for copies of the two editions of Palmer's booklets, described here. For a fuller account of Palmer's Computing Scale, see the Colorado *College Publication*, Engineering Series, Vol. I, No. 6 (1909).]

26. Lalanne, Arithmoplanimètre.

[Cited by Favaro, op. cit., p. 510, from *Comptes rendus des séances de l'académie des sciences*, 1840 (April 27, May 24), and from Lalanne's "Mémoire sur l'Arithmoplanimètre, machine arithmétrique at géométrique donnant facilement les résultats des opérations les plus compliquées do calcul et de planimétrie" in the *Annales des Ponts et Chaussées*. 1er semestre, 1840.]

27. Lalanne, Règle à calcul A enveloppe de verre.

[Favaro, loc, cit., p. 510, cites *Instruction sur les règles it calcul et particulièrement sur la nouvelle règle à enveloppe de verre* par. L. Lalanne, Paris, 1851, 1854, 1863. Translated into English under the title *A Treatise on the slide rule with description of Lalanne's glass slide rule*, London, 1851; transl. into German, *Gebrauchs-Anweisung für Rechenstäbe*, etc., Paris, 1852, and into Spanish, *Instruction sobre las reglas de calculo*, etc., Paris, 1852. This slide rule was designed as a cheap rule.]

28. Lalanne, tableau graphique.

[*Bull. de la société d'encouragement pour l'industrie nationale*, Vol. 45, Paris, 1846, p. 153. Designed by Léon Lalanne, ingénieur des ponts et chaussées. Favaro, op. cit., p. 510, refers to the following publications: *Notice sur les travaux et titres scientifiques*, de M. Léon Lalanne, Paris, 1876, p. 32, and to *Méthodes graphiques pour l'expression des lois empiriques on mathématiques it trois variables, avec des applications it l'art de l'ingénieur et à la résolution des équations numeriques d'un degré quelconque*. Par M. Léon Lalanne, Paris, 1878.]

29. Eschmann-Wild's Tachymeterschieber.

[Cited by Favaro, *loc. cit*., p. 512, from *Der topographische Distanzmesser mit Rechenschieber* von J. Stambach, Aarau, 1872. See also *Engineering News*, New York, Vol. 54, 1905, p. 486; E. Hammer, *Der logarithmische Rechenschieber*, 4te Auflage, Stuttgart, 1908, p. 10. Was used in the Canton Zürich, Switzerland, as early as 1847.]

30. Bradford's Sliding Rule.

[Cited by Favaro, loc cit., p. 512, from a publication *On Bradford's Sliding R*ule, London, 1845.]

31. Porro's Scale Logaritmiche Centesimali.
[Cited by Favaro, op. cit., p. 512, from *La Tachéométrie*, ecc., par J. Porra, Turin, 1850, p. 75.]

32. Regolo Calcolatorio di Oesterle.
[Cited by Favaro, *op. cit*., p. 508, from Ernest Sedlaczek, *Neber Visir- und Recheninstrumente*, Wien, 1856, pp. 3, 4, and from Ernest Sedlaczek*, Anleitung z. Gebrauche einiger logarith. getheilter Rechenschiëber*, Wien, 1851.]

33. Altmütter's Rechenschieber.
[*Zeitschr. f. Mathematik und Physik*, Vol. 47, 1902, p. 491. Designed by G. Altmütter and printed on cardboard in Vienna before 1851.]

34. Werner's Rechenschieber.
[*Zeitschr. für Mathematik und Physik*, Vol. 47, 1902, p. 491. F. Werner was a mechanic in Vienna, about 1850, who made rules of boxwood.]

35. Werner's Tachymetersehieber.
[E. Hammer, *Der logarithmische Rechenschieber*, 4te Aufi., Stuttgart, 1908, p. 10.]

36. Règle Mannheim.
[Mannheim, *Règle à calculs modi*fiée. Instruction, Metz, Imp. et. lith. Nouvian, Décembre, 1851; also in Nouvelles Annales de Mathématiques, 1ère Seri, tome XII, 1853, pp. 327—329. See also P. Rozé, *Théorie et usage de la règle à calculs*, Paris, 1907, pp. 21, 58—82; E. Hammer*, Der logarithmische Rechenschieber und sein Gebrauch*, Stuttgart, 1908, p. 6; Pickworth, *op. cit*., 1906, p. 14; *De Ingénieur* 18e Jaargang, 1803, p. 88, ff.; *Engineering News*, Vol. 25, 1891, p. 16. Made by Tavernier-Gravet of Paris, and goes also under the name of the "Tavernier-Gravet Slide Rule" and the "Gravet Slide Rule." Rules of the Mannheim type are now made and sold by nearly all slide rule manufacturers of the present time. Favaro, *loc. ci*t., p. 511, refers for description to *Teorica e pratica del regolo calcolatore* per Quintino Sella, Torino, 1859, p. 100—109; Win. Cox, The Mannheim Slide Rule, published by Keuffel & Esser Co., New York, 1891, pp. 1—10; C. W. Crockett*, Explanation of the Principles and Operation of the Mannheim Slide Rube*, Troy, N. Y., 1891. See Fig. 11.]

37. Mannheim Règle Calcul Cylindrique.
*[Nouvelles Annales de Mathéma*tiques, tome XIII, 1854, p. 36; *Encyklopädie d. Math. Wiss*., Bd. I. Leipzig, 1898— 1904, p. 1060. Made of wood in 1871, since 1873 in metal.]

38. Lenoir's Règle Calcul.
[*Bull. de la société d'encouragement pour l'industrie nationale*, Vol. 52, 1853, p. 588; also Vol. 20, p. 77, and Vol. 23, p. 129. Lenoir constructed his instruments about 1821 and later. See also E. Sedlaczek, *Anleitung z. Gebrauche einiger logar. getheilter Rechenschieber*, Wien, 1851, who is cited by Favaro, op. cit., p. 509.]

39. Sargent's Règle Calcul.
[*Bull. de la société d'encouragement pour l'industrie nationale*, Vol. 52, Paris, 1853, p. 589; also Vol. 21, p. 12.]

40. Prestel's Arithmetische Scheibe.
[*Mittheilungen des Gewerbevereins f. d. Königreich Hannover*, 1854, p. 169*; Zeitschr. des Architecten- u. Ingenieur-Vereins f. d. Königr*. Hannover, Vol. 10, Hannover, 1864, p. 454.]

41. Regolo di Higgison.

[Cited by Favaro, *op. cit*., p. 509, from E. Sedlaczek, *Ueber Visir- und Recheninstrumente*, Wien, 1856, pp. 3, 4.]

42. Regolo per iscopi costruttivi e geodetici del Prof. L. C. Schulz von Strassnicki.
[Cited by Favaro, *op. cit*., p. 509, from E. Sedlaczek, *Ueber Visir- und Recheninstr*umente, Wien, 1856, pp. 3,4.]

43. Regolo Calcolatorio di Schwind.
[Cited by Favaro, op. cit., p. 509, from E. Sedlaczek, *Ueber Visir- und Recheninstrumente*, Wien, 1856, pp. 3, 4, and E. Sedlaczek, *Anleitung sum Gebrauche einiger logar. getheilter Rechenschieber*, Wien, 1851.]

44. Bouché, Hélice Calcul.
[*Calcul simplifié*, par Maurice d'Ocagne, seconde éd., Paris, 1905, p. 109; *Comptes rendus*, 2e sem. 1857, p. 437.]

45. Regolo di Sedlaczek per i calcoli d'interpolazione.
[Cited by Favaro, *op. cit*., p. 509, from E. Sedlaczek, *Ueber Visir- und Recheninstrumente*, Wien, 1856, pp. 3, 4, and E. Sedlaczek, *Anleitung sum Gebrauche einiger Logarith. getheilter Rechenschieber*, Wien, 1851.]

46. Dubois, Arithmograph.
[Cited by Favaro, *loc. cit*., p. 511, from *Comptes Rendus hebdomadaires des séances de l'acad. d. sciences,* T. LI, 1860, p. 293, and from *Atti dell' Imp. Reg. Istituto veneto di scienze*, etc., Novembre, 1860, all' ottobre, 1861. Tomo sesto, serie terza. Venezia, 1860—61, p. 376.]

47. Carrett's Slide Rule
[W. H. Bayley's *Hand-Book of the Slide Rule*, London, 1861, Preface.]

48. Delaveleye's Règle Calcul.
[*Bull. de la société d'encouragement pour l'industrie nationale*, Vol. 62, Paris, 1863, p. 659. Designed a rule 2.30 m. long.]

49. Delamorinière Règle Calcul
[*Bull. de la société d'encouragement pour l'industrie nationale*, Vol. 62, Paris, 1863, p. 659. Designed an instrument 1.20 m. long.]

50. Burdon Règle Calcul.
[*Comptes rendus*, Paris, Vol. 58, 1864, pp. 573—576. A log- log rule.]

51. Péraux, Echelle Logarithmique.
[*Bull. de la société d'encouragement pour l'industrie nationale*, Vol. 62, 1863, p. 513; *also N. Annales de mathématiques*, 2d S., Vol. 18, Paris, 1869, pp. 283—5. M. Péraux was a merchant in Nancy. Favaro, loc. cit., p. 512, refers to an article *Instruction sur la règle à calcul à deux réglettes*, par E. Péraux (Extrait des Annales du Gènie Civil, juin 1874), Paris, 1874, also Paris, 1885.]

52. Everett's Universal Proportion-table, or Gridiron Slide Rule.
[The Universal-proportion-table was published by Long-mans, Green and Dyer. See Pickworth, *The Slide Rule*, 10th ed., p. 102; *Report British Ass'n* for 1866, p. 2; Philosophical Magazine (4), Vol. 32, 1866, p. 350; C. V. Boys "The Slide Rule" in *Van Nostrand's Engin. Magasine*, Vol. 33, 1885, p. 513. Invented by Professor J. D. Everett, Professor of Mathematics in Glasgow University.]

53. Everett’s Cylindrical Slide Rule.
[Only in model; see references to his “Universal Proportion-table.”]

54. Derivry, Carte Calcul.
[M. d’Ocagne, *Calcul simplifié*, 2e éd., Paris, 1905, p. 120.]

55. Sonne’s Rechenscheibe.
[*Zeitschr. d. Architecten- u. Ingenieur-Vereins f. d. Künigr. Hannove*r, Vol. 10, 1864, p. 451—458. Made by Landsberg and Parisius, mechanicians in Hannover. Favaro, op. cit., 510, refers *to Annales du Génie Civil*. Cinquième année, 1866, and to *Instruments at machines à calculer*, Paris, 1868, p. 75.]

56. Coulson’s Slide Rule.
[J. F. Heather, *Drawing and Measuring Instruments*, London, 1871, p. 144, with a figure of the rule; it has four slides. See also Coulson’s book on the Slide Rule.]

57. Heather’s Cubing Rule.
[J. F. Heather, *Drawing and Measuring Instruments*, London, 1871, p. 147. Three feet long, containing four lines, A, B, C, B.]

58. Kentish Slide Rule.
[J. F. Heather, *Drawing and Measuring Instruments*, London, 1871, p. 144. Was manufactured by’ Messrs. Dring & Fage.]

59. Bayley’s “One-Slide” Rule.
[*English Cyclopedia* (Arts and Sciences), Art. “Sliding Rule.” Was made by Elliot, Strand, in London. See also W. H. Bayley’s *Hand-Book of the Slide Rule*, London, 1861, Preface, and p. 338; J. F. Heather’s *Drawing and Measuring Instruments*, London, 1871, p. 143.]

60. Bayley’s “Two-Slide” Rule.
[W. H. Bayley’s *Hand-Book of the Slide Rule*, London, 1861, Preface, and p. 340. Was made by Elliot, 30 Strand, in London.]

61. The Timber-contenting Rule.
[J. F. Heather, *Drawing and Measuring Instruments*, London, 1871, p. 149. Usually two feet long, one side containing the lines A, B, C, D, and the other side A, B, C, E (inverted).]

62. Hoare’s Slide Rule.
[*The Slide Rule and How to Use it*, by Charles Hoare, G. E., with a slide rule in tuck of cover. Sixth edition, London, 1890. Date of preface, 1867. Rule has two slides.]

63. Ipsologista di Paola de Saint-Robert.
[*Torino Acc. Sci. Memorie* (2), Vol. 25, 1871, p. 53; *Encyklopädie d. Math. Wiss*., Bd. I, 1898—1904, p. 1064. See also Q. Sella *Regolo Calcolatore*, 2 ed., Ital., Torino, 1886, p. 159.]

64. Regolo Soldati per i calcoli di celerimensura.
[Cited by Favaro, *loc. cit*., p. 511, from “Cenni intorno ad un saggio di celerimensura applicata alla compilazione dei progetti ferroviarii e descrizione di tavole grafiche e numeriche pel calcolo delle coordinate, per l’ing. V. Soldati,” in *Atti della Società degli Ingegneri e degli Industriali di Torino*. Anno V, 1871, p. 38. See also Quintino Sella *Regolo Calcolatore*, 2 ed., Ital., Torino, 1886, p. 163.]

65. Routledge’s Slide Rule.

[Cited by Favaro, *loc. cit*., p. 512, from *Catalogue of instruments manufactured by W. F. Stanley*, 14th ed., London, 1877, p. 30. See also J. F. Heather's *Drawing and Measuring Instruments*, London, 1871, p. 142; W. H. Bayley's *Hand-Book of the Slide Rule*, London, 1861, Preface.]

66. Weber's Rechenkreisen.
[R. Weber, *Anleitung zum Gebrauche des Rechenkreises* Aschaffenburg, 1872*; Encyklopädie d. Math. Wiss*., Bd. I, 1898—1904, p. 1063.]

67. Goulier, Règle pour les Levers Tachéométriques.
[*Calcul simplifié*, par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 118. Made by Tavernier-Gravet as early as 1873.]

68. Rechenstab von Dennert und Pape.
[*Deutsche Bauzeitung*, Bd. 8, 1874, p. 136.]

69. Darwin's Slide Rules.
[*Proceed. London Math. Soc*., Vol. 6, 1875, p. 113. G. H. Darwin here proposes two types of slide rules, to be small enough for pocket rules, and yet powerful.]

70. Culmann's Rechenschieber für Distanzmessern.
[Designed by C. Culmann and described in his *Die Graphische Statik*, Zürich, Vol. I., 1875, p. 65.]

71. Coggeshall's Slide Rule.
[J. F. Heather*, A Treatise on Mathematical Instruments*, London, 1874, p. 55. Favaro, loc. cit., p. 512, refers to a publication On Coggeshall's Sliding Rule, London, 1844.]

72. De Montrichard, Règle pour le Cubage des Bois.
[*Calcul simplifié*, par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 118. Made by Tavernier-Gravet in 1876 and later.]

73. Pestalozzi's Rechenschieber.
[See C. Culmann, *Die Graphische Statik*, Zurich, Vol. I., 1875, p. 69. Designed for agiotage by Banquier L. Pestalozzi.]

74. Puscariu's Stereometer.
[Cited by Favaro*, loc. cit*., p. 511, from *Dam Stereometer, Körper-Messinstrument* von Johann Ritter von Puscariu, Budapest, 1877.]

75. Hawthorn's Slide Rule.
[Cited by Favaro, *loc. cit*., p. 512, from *Catalogue of Instruments manufact*ured by W. F. Stanley, 14th ed., London, 1577, p. 30. See also W. H. Bayley's *Hand-Book of the Slide Rule*, London, 1861, Preface.]

76. Mount, Règle Logarithmique pour la Tachéométrie.
[Cited by Favaro, *loc. cit*., p. 512, *from Leves de Plans et la Stadia. Notes pratiques pour études de tracés* par I. Moinot. Troisième édition, Paris, 1877, p. 41—67. Constructed by Tavernier-Gravet as early as 1868; *see Calcul simplifié* par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 118.]

77. Boucher Calculator.
[Pickworth, Charles N., *The Slide Rule; A Practical Manual*, 10th ed., Manchester, London, New York, 1906, p. 93. Manufactured by W. F. Stanley & Co., Holborn, London. It is a circular slide rule with two dials. Is made by H. Chatelain in Paris in improved form; by Messrs. Manlove, Alliott, Fryer and Co.

of Nottingham; by J. F. Steward, Strand, London; also by Keuffel & Esser Co. in New York. See also *La Nature*, 6e année, 8 juin, Paris, 1878, pp. 31, 32. See Fig. 12.]

78. Herrmann's Rechenknecht.
[*Zeitschr. des Vereins Deutscher Ingenieure*, Vol. 21, 1877, p. 455. This circular rule was made by Wiesenthal u. Cie. in Aachen. Favaro, loc. cit., p. 511.]

79. G. Fuller's Spiral Slide Rule.
[Pickworth, Charles N., *The Slide Rule; A Practical Manual*, 1906, p. 100; Blame, R. G., *Some Quick and Easy Methods of Calculating*, 2d ed., London, 1903, p. 91. Made by Stanley. See also Fuller, George, Spiral Slide Rule, Equivalent to a straight slide rule 83 feet 4 inches long, or a circular rule 13 feet 3 inches in diameter. London, 1878. George Fuller, Professor of Engineering, Queen's University, Ireland. See Fig. 13.]

80. J. Fuller's Computing Telegraph.
[This instrument consists of a "Time Telegraph," de-signed by Fuller, which he added to or united with Aaron Palmer's "Computing Scale." The "Time Telegraph" was a non-logarithmic circular scale for determining the number of days between given dates. See *Improvement to Palmer's Endless Self-Computing Scale and Key; with a Time Telegraph, making, by uniting the two, a Computing Telegraph*. By John E. Fuller, New York, 1846. See also the *Colorado College Publication*, Engineering Series, Vol. I, No. 7 (1909).]

81. J. Fuller's Telegraph Computer.
[*Telegraphic Computer, a most wonderful and extraordinary instrument, by which business questions, of every possible variety, are instantly performed; a safe and speedy check to avoid vexatious errors, affording at the same time a greater amount of practical business knowledge than can be obtained for ten times the cost of this work*. Sold only by subscription. John Fuller, New York (about 1860). Cited by Favaro, op. cit., p. 510. A circular slide rule.]

82. Thacher's Calculating Instrument.
[*Thacher's Patent Calculating Instrument or Cylindrical Slide Rule*, by Edwin Thacher, M. Am. Soc. C. E., New York, Keuffel & Esser Co., 1903. An edition of 1884 was brought out by D. Van Nostrand, New York. The rule was patented in 1881, and is manufactured by Keuffel & Esser Co. Approaches closely to a five-place table of logarithms in accuracy. See also Thacher's article in *the Proceeds. Engineers' Society of Western Pennsylvania*, Vol. I, Pittsburgh, Pa., 1880, pp. 289—310. See Fig. 9.]

83. Ruth's Rechenschieber.
[DingIer's *Polytechnisches Journal*, Vol. 242, Augsburg, 1881; *also Theorie der logarithmischen Rechenschieber* von Franz Ruth.]

84. ЧЕРЕПАШИНСКІЙ М. М. Slide Rule.
[Челашинскі М. М., Теорiа и улотребленiе карманной сченой линейки собственной системы. Москва, 1883. See also P. Rozé, *Règle à Calculs*, Paris, 1907, p. 2. See Fig. 11.]

85. Ganga Ram's Special Rules.
[Van Nostrand's Engin. Magazine, Vol. 33, 1885, pp. 516, 517.]

86. Thomson's Log-Log Rule.
[*Van Nostrand's Engin. Magazine*, Vol. 33, 1885, p. 51,6. Thomson was then a British lieutenant, later became captain.]

87. Lebrun, Règle pour les Calculs de Terrassements.

[*Calcul simplifié*, par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 118. Made by Tavernier-Gravet as early as 1886.]

88. Tower's Slide Instrument.
[*Van Nostrand's Engin. Maga*zine, Vol. 33, 1885, p. 516. Mr. Beauchamp Tower, well known in connection with the spherical engine.]

89. Dixon's Rules.
[*Van Nostrand's Engin. Magazine*, Vol. 33, 1885, pp. 515, 517. His "triple radius double-slide rule" allows complex operations.]

90. Hannyngton's Extended Slide Rule.
[Pickworth, *The Slide Rule*, 10th ed., p. 102; C. V. Boys, "The Slide Rule" *in Van Nostrand's Engin. Magazine*, Vol. 33, 1885, p. 513; manufactured by Aston & Mander in Soho, W. London.]

91. Cherry's Calculator.
[Pickworth, *The Slide Rule*, 10th ed., p. 102. Designed by Henry Cherry in 1880.]

92. M. Kloth's Apparat.
[*Encyklopädie d. Math. Wiss*., Bd. I., 1898—1904, p. 1059; D. R. P. Nr. 26695, V. 1883; Dingler's *Polyt. Jour*., Vol. 260, 1886, p. 170.]

93. Toulon, Règle pour les Calculs de Terrassements.
[*Calcul simplifié*, par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 118; Durand-Claye, , 2e éd., p.561.]

94. Rechenschieber von Zellhorn.
[*Dennert & Pape* of Altona was the first firm to manufacture slide rules of white celluloid or Zellhorn, in 1886. Now all manufacturers in the world face the rules with celluloid. *Encyklopädie d. Math. Wiss*., Bd. I, 1898-1904, p. 1055.]

95. Regolo psicrometrico di A. Prazmowski.
[See Q. Sella, *Regolo Calcolatore*, 2 ed., Ital., Torino, 1886, p. 161. Prazmowski was an astronomer of Warsaw in Poland.]

96. Pouch, Echelles Enroulées en Spirales pour les Racines Carrées et Cubiques.
[M. d'Ocagne, *Calcul simplifié*, 20 éd., Paris, 1905, p. 121. Designed before 1890.]

97. Beyerlen's Rechenrad.
[*Zeitschr. f. Vermess*. W., Vol. 15, 1886, p. 382; *Gewerbe-blatt aus Würtemberg*, 1886, pp. 201—206. Designed by A. Beyerlen of Stuttgart and made in Stuttgart by the mechanician Tesdorpf.]

98. Paulin, Règle pour les Calculs Terrassements.
[*Portefeuille des Conducteurs des Ponts et Chaussées*, T. XXI, 1889, p. 133; see also *Calcul simplifié*, par Maurice d'Ocagne, 20 éd., Paris, 1905, p. 118.]

99. Regolo di F. Stapff
[Described by Quintino Sella in his *Regolo Calcolatore*, 2 ed., Ital., Torino, 1886, pp. 163, 164. This rule was used in computing an equation with four variables, expressing the volume of certain excavations of earth.]

100. Sanguet, Règle pour les Levers Tachéométriques.

[*Calcul simplifié*, par Maurice d'Ocagne, 20 éd., Paris, 1905, p. 118. Made by Tavernier-Gravet as early as 1888.]

101. K. & E. Patented Adjustable Slide Rule (Mannheim).
[Win. Cox, *The Mannheim Slide Rule*, published by Keuffel & Esser Co., New York, 1891, p. 12. Patented June 5, 1900.]

102. Hasselblatt's Rechenschieber.
[DingIer's *Polytechnisches Journal*, Vol. 278, 1890, p. 520. Hasselblatt was then docent at the Technological Institute in St. Petersburg. The rule was of cardboard and was made in St. Petersburg. Hasselblatt published, in Russian, a book on his slide rule.]

103. Kern Règle Calcul pour la Stadia Topographique.
[J. Stambach*, Instruction pour la détermination de la distance et de la différence d'altitude d'un objet à un point de Station*, Aarau, 1890. Made by Kern & Cie, Aarau, Switzerland.]

104. Pollit's Hydraulic Slide Rule.
[Designed by C. T. Pollit of Adelaide, South Australia. Made by Elliot Brothers, St. Martins-lane, London. See *Engineering and Mining Journal*, New York, Vol. 54, 1892, p. 130.]

105. Bosramier, Règle pour les Levers Tachéométriques.
[*Calcul simplifié*, par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 118. Made by Tavernier-Gravet in 1892.]

106. Wingham's Slide Rule for Calculating Blast-Furnace Charges.
[Designed by A. Wingham of the British Mint. See *Engineering and Mining Journal*, New York, 1892, Vol. 54, p. 487.]

107. Scherer's Rechentafel.
[*Zeitschr. far Vermessungsw*., 1892, p. 153; also 1894, pp. 54—60; W. Jordan*, Handbuch der Vermessungskunde*, Bd. II. Stuttgart, 1897, p. 134; Scherer's *Logarithmisch-graphische Rechentafel*, Kassel, 1893.]

108. W. H. Breithaupt's Reaction Scale and General Slide Rule.
[*Engineering News*, Vol. 32, 1894, p. 103. Made and sold by E. G. Soltmann, 119 Fulton St., New York City.]

109. A. Steinhauser's Rechenscheibe.
[*Encyklopädie d. Math. Wiss*., Bd. I, 1898—1904, p. 1063; Dyck's *Katalog, Nachtrag*, p. 3, Nr. 11 c. Designed in Münich in 1893.]

110. F. W. Lanchester's Rule for Solving Equations.
[*Calcul simplifié* par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 118; *Engineering*, August 7, 1896, p. 172.]

111. Omnimeter.
[*Engineering News*, Vol. 38, 1897, p. 291. Sold by Theodore Alteneder & Sons, 945 Ridge Ave., Philadelphia, Pa.]

112. J. Crevat, Ruban Logarithmique.
[M. d'Ocagne*, Calcul simplifié*, 2e éd., Paris, 1905, p. 119; Nature, 1893, p. 378.]

113. Cox's Duplex Slide Rules.

[*Catalogue of Keuffel & Esser Co., New York*, 1906, P. 324. Patented October 6, 1897, designed by William Cox. See *American Machinist*, Vol. 27, Pt. II, 1904, p. 1370. See Fig. 14.]

114. Faber's Rechenstab.

114 (a). Faber's Improved Calculating Rule for Electrical and Mechanical Engineers.

[*Der Praktische Maschinen-Constructeur* (Ubland), Vol. 27, 1894, p. 8; originally made by A. W. Faber in Stein near Nürnberg; now this firm has houses also in England, France, and the United States (Newark, N. J.). See C. N. Pickworth, *Instructions for the Use of A. W. Faber's Improved Calculating Rule*, London, E. C.; Rudolf Krause, *Rechnen mit dem Rechenschieber nach dem Dreiskalen-system der Firmen Dennert & Pape*, A. W. Faber, Nestler u. A., Mittwerda (no date).]

115. Gallice, Règle pour les Calculs Nautiques (en employant la division de la circonférence en 240 degrés proposée par M. de Sarrauton).

[Calcul simplifié par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 118. Made by Tavernier-Gravet in 1897.]

116. Johnson's Rule for Unit Strains in Columns.

[*Engineering Record*, 1894, Vol. 30, p. 31. Designed by Thomas H. Johnson, of Pittsburgh, Pa., M. Am. Soc. G.E.]

117. Crane's Sewer Slide Rule.

[*Catalogue of Keuffel & Esser Co., New York*, 1906, p. 328. Patented Oct. 6, 1891. See also *Engineering (London)*, Vol. 62, 1896, p. 655. Designed by A. S. Crane, of Brooklyn, New York, and introduced into England by A. Wollheim.]

118. L. Torres, Machine for Solution of Equations.

[M. d'Ocagne, *Calcul simplifié*, 2e éd., Paris, 1905, pp. 95, 123. Torres is a Spanish engineer who invented this logarithmic machine in 1893.1

119. Schuermann's Computing Instrument.

[*Engin. Ass'n. of the South*, Vol. 7, Nashville, Tenn., 1896, pp. 92—99.]

120. Jordan Rechenschieber.

[Designed by W. Jordan and described in his *Handbuch der Vermessungekunde*, Bd. II, Stuttgart, 1897, p. 130, Fig. 4. It is manufactured by Dennert Pape in Altona.]

121. Landsberg's Rechenscheibe.

[*Zeitschr. f. Instrumentenkunde*, Vol. 20, p. 336. See also W. Jordan, *Handbuch der Vermessungekunde*, Bd. II, Stuttgart, 1897, p. 134. After the design due to Sonne. Landsberg was a mechanic in Hannover.]

122. F. A. Meyer's Taschenschnellrechner.

[*Mechaniker*, Vol. 5, 1897; *Encyklopädie de Math. Wiss*., Bd. I, 1898—1904, p. 1063.]

123. Règle pour les Vitesses, Poids et Calibres des Projectiles.

[*Calcul simplifié*. par Maurice d'Ocagne, 2e éd., Paris, 1905,p. 118. Made in 1895 for La Société des Forges et Aciéries de Saint-Chamond.]

124. Naish's Logarithmicon.

[*The Logarithmicon; A mechanical contrivance for facilitating calculations*. Described by Edmund Naish, Dublin, 1898.]

125. Lallemand, Règle Calcul.
[*Zeitschr. Vermessungsw.*, Vol. 29, 1900, p. 233; *Encyklopädie Math. Wiss.*, Bd. I, Leipzig, 1898—1904, p. 1059.]

126. Hart's Proportior.
[*Techniker*, Vol. 12, 1889—1890, p. 34; *Encyclopedia d. Math. Wiss.*, Vol. I, Leipzig, 1898—1904, p. 1063.]

127. Renaud-Tachet, Règle Circulaire.
[M. d'Ocagne, *Calcul simplifié*, 2e éd., Paris, 1905, p. 121; Génie civil, 21 Janvier, 1893, p. 191.]

128. Clouth Rechenscheibe.
[F. M. Clouth, *Anleitung zum Gebrauch der Rechenscheibe*, Hamburg, 1872; *Dyck's Katalog, Nachtrag*, p. 3, Nr. 11 d; *Encyklopädie d. Math. Wiss.*, Ed. I, Leipzig, 1898—1904, p. 1062.]

129. F. J. Vaes, Règle pour la Traction des Locomotives.
[M. d'Ocagne, *Traité de Nomographie*, Paris, 1899, p. 361: M.d'Ocagne, *Calcul simplifié*, 2e éd., Paris, 1905, p. 119.]

130. Sickman Scale.
[*Yale Scientific Review*, Vol. 5, 1898, p. 47. To determine mill water-power.]

131. F. J. Vaes, Echelles Binaires.
[M. d'Ocagne, *Calcul simplifié*, 26 éd., Paris, 1905, p. 119. Vaes is a Dutch engineer.]

132. Sexton's Omnimetre.
[*Yale Scientific Review*, Vol. 5, 1898, p. 47. This is a circular type.]

133. Piper's Logarithmische Skale.
[Referred to by E. Naish in his *Logarithmicon*, Dublin, 1898, p. 43. Designed by Dr. Piper, of Lemgo, Germany.]

134. Wichmann's Rechenschieber.,
[*Zeitschr. für Mathematik and Physik*, Vol. 47, 1902, p. 491. Paper scales mounted on wood, about 1895; made by Gebr. Wichmann in Berlin.]

135. Honeysett's Hydraulic Slide Rule.
[Pickworth, *The Slide Rule*, 10th ed., p. IV; made by W. F. Stanley & Co., Ltd., Holborn, London. Based on Bazin's formula.]

136. J. Billeter, Rechenwalze.
[M. d'Ocagne, *Calcul simplifié*, 2e éd., Paris, 1905, p. 120; *Zeitschr. f. Vermessungsw.*, Vol. 20, 1891, p. 346; *Encyklopädie d. Math. Wiss.*, Ed. I, p. 1059, Note 558.]

137. Herman's Proportional-Rechenschieber.
[*Zeitschr. Vermessungsw.*, Vol. 28, 1899, p. 660; see also *Encyklopädie d. Math. Wiss.*, Vol. I, 1898—1904, p. 1066.]

138. Hales' Slide Rule for Indicator Diagrams.
[Pickworth, *The Slide Rule*, 10th ed., p. IV; made by W. F. Stanley & Co., Ltd., Holborn, London.]

139. Fürle's Rechenschieber.
[Hermann Fürle, Zur *Theorie der Rechenschieber (Jahresbericht der Neunten Realschule zu Berlin. Ostern, 1899)*; Berlin, 1899. This rule has eleven scales and a runner, and in general construction resembles Robertson's slide rule of 1778. But the scales are differently graduated. Besides the four scales on the Mannheim rule, it has scales for the functions x, x^2, x^3, log log x.]

140. Froude's Displacement Rule.
[Pickworth, *The Slide Rule*, 10th ed., p. IV; made by W. F. Stanley & Co., Ltd., Holborn, London.]

141. Cox's Strength of Gear Computer.
[F. A. Halsey, *The Use of the Slide Rule*, New York, 1899, p. 74.]

142. G. Charpentier's Calculimètre.
[*De Ingenierer*, Vol. 18, 1903, p. 94; F. A. Halsey, *The Use of the Slide Rule*, New York, 1899, p. 66. Fig. 15.]

143. Règle des écoles.
[P. Rozé, *Théorie et usage de la règle a calculs*, Paris, 1907, pp. 2, 22. This rule, used in technical schools in Paris, is after the designs of Cherepashinskii and of Beghin. See Fig. 11.]

144. Mehmke Rechenschieber für Komplexe Grössen.
[Designed by R. Mehmke in Stuttgart. See Dyck's *Katalog, Nachtrag*, p. 21, Nr. 44 d; *Encyklopädie d. Math. Wiss.*, Bd. I, 1898—1904, p. 1065.]

145. Beghin's Règle à Calcul.
[A. Beghin, *Règle à calcul, modèle spècial,* . . . Paris, 1898, 2e éd., 1902. See. *also Encyklopädie d. Math. Wiss*., Bd. I, Leipzig, 1898—1904, p. 1058; P. Rozé, *Règle à calculs*, Paris, 1907, pp. 2, 3, 113.]

146. Peter's Universal Rechenschieber.
[*Instructions for the Calculating Slide Rule*, by Albert Nestler, Lahr, Baden, p. 63; E. Hammer*, Der logarithmische Rechenschieber*, 4te Aufl., Stuttgart, 1908, p. 10.]

147. "Peter and Perry" Rule.
[*Instructions for the Calculating Slide Rule*, by Albert Nestler, p. 56. It has a log-log scale and is manufactured by Albert Nestler in Lalir, Baden.]

148. Pickworth's Power Computer.
[Pickworth, *The Slide Rule*, 10th ed., p. VII. Sold by the designer C. N. Pickworth, Fallowfield, Manchester.]

149. Precision Slide Rule.
[C. N. Pickworth, op. cit., p. 88; *Instructions for the Calculating Slide Rule*, Albert Nestler, Lahr, Baden, p. 32. Made by Albert Nestler in Lahr, Baden.]

150. Puller's Rechenscheibe.
[*Zeitschr. f. Instrumentenkunde*, Vol. 20, 1900, p. 336. Designed by Ingenieur E. Puller in St. Johann (Saarbrücken.]

151. Röther's Rechenscheibe.
[*Zeitschr. f. Instrumentenkunde*, Vol. 20, 1900, p. 335. Manufactured with diameter of 80 mm. and also 220 mm. Designed by Bezirksgeometer Röther in Weiden, Bayern.]

152. Sheppard's Cubing and Squaring Slide Rule.
[Pickworth, *The Slide Rule*, 10th ed., p. IV; made by W. F. Stanley & Co., Ltd., London.]

153. Herrgott, Règle a Deux Réglettes.
[*Calcul simplifié*, par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 116. Designed in 1900.]

154. Simplex Slide Rule.
[Sold now by John Davis & Son (Derby), Ltd.]

155. The Smith-Davis Premium Calculator.
[Pickworth, *The Slide Rule*, 10th ed., p. 104. Made by John Davis & Son, Derby.]

156. The Smith-Davis Piecework Balance Calculator.
[Pickworth, *The Slide Rule*, 10th ed., p. 103. Made by John Davis & Son, Derby.]

157. Sperry's Pocket Calculator.
[Pickworth, Charles N., *The Slide Rule; A practical manual*, 10th ed., Manchester, London, New York, 1906, p. 99. Manufactured by Keuffel & Esser Co., New York. A circular rule with two rotating dials.]

158. Burnham's Circular Slide Rule.
[Designed by the astronomer S. W. Burnham of the Yerkes Observatory, divided for him by Warner & Trasey; is 7½ in. in diameter and divided into 1000 parts, thus giving four places, the last by estimation. Has accuracy of a four-place table. A movable arm (runner) has a lens for close reading and a stop which can be pressed down and movable inner circle brought to coincidence with the arm, without looking at the divisions. This saves time in continuous multiplications, etc.]

159. The Davis Log-Log Rule.
[Pickworth, *The Slide Rule*, 10th ed., p. 79. Made by Messrs. John Davis & Son, Ltd., Derby.]

160. The Faber Log-Log Rule.
[Pickworth, *The Slide Rule*, 10th ed., p. 84. Manufactured by A. W. Faber in Stein near Nürnberg. See also C. N. Pickworth, *Instructions for the Use of A. W. Faber's Improved Calculating Rule*, London, E. C., p. 46.]

161. Hall's Nautical Slide Rule.
[Pickworth, *The Slide Rule*, 10th ed., p. 91. Made by J. H. Steward, Strand, London. This rule is designed by the Rev. William Hall, R.N. It has two slides and eight scales.]

162. Hudson's Horse-power Scale.
[Pickworth, *The Slide Rule*, 10th ed., p. IV. Made by F. Stanley & Co., Ltd., Holborn, London.]

163. Hudson's Shaft, Beam and Girder Scale.
[Pickworth, *The Slide Rule*, 10th ed., p. IV. Made by W. F. Stanley & Co., Ltd., Holborn, London.]

164. Hudson's Pump Scale.

165. Hudson's Photo-Exposure Scale.

166. The Jackson-Davis Double Slide Rule.
[Pickworth, *The Slide Rule*, 10th ed., p. 84. Enables the log-log slide to be temporarily attached to the ordinary rule.]

167. Müller's Hydraulischer Rechenschieber.
[*Oesterreich. Wochensch. f. d. öffentl*. Baudienst, Vol. 7, 1901, p. 72.]

168. Riebel's Geodetiseher Rechenschieber.
[*Oesterreich Wochensch. f. d. öffentl*. Baudienst, Vol. 7, 1901, p.680.]

169. Schweth's Rechenschieber.
[*Zeitschr. des Vereins Deutscher Ingenieure* (Peters), Vol. 45, 1901, Pt. I, pp. 567—8, 720; *Encyklopädie d. Math. Wiss*., Bd. I., Leipzig, 1898—1904, p. 1064, Note 580.]

170. Slide Rule for Electrical Calculations.
[*American Machinist*, New York, Vol. 24, 1901, p. 339. Instrument is made by A. E. Colgate, 36 Pine St., New York.]

171. Thacher-Scofield Engineer's Slide Rule.
[E. M. Scofield, *The Slide Rule*, published by Eugene Dietzgen Co., Chicago, 1902, p. 21. This rule is designed by Edwin Thacher and E. M. Scofield, bridge and consulting engineers. Patented in 1901.]

172. Pierre Weiss, Règle à Calcul.
[*Comptes rendus*, Vol. 131, 1900, p. 1289; *Journal de Physique*, Sept., 1901; *Nature*, Vol. 64, 1901, p. 523.]

173. Baines' Slide Rule for Solving Equations.
[*Calcul simplifié*, par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 118; *Engineer*, April 1,1904, p. 346.]

174. A. Wüst Tasehenrechenschieber.
[*Zeitschr. für Mathematik and Physik*, Vol. 47, 1902, p. 491. Printed on cardboard in Halle about 1880.]

175. Barth's Slide Rule for Lathe Settings for Maximum Output.
[*Engineering News*, New York, Vol. 50, 1903, p. 512; also Vol. 46, 1901, p. 461. A rule designed by Carl G. Barth and Fred W. Taylor in the shop of the Bethlehem Steel Co. It is a rectilinear rule.]

176. Barth's Rule for Strength of Spur Gears.
[*Engineering News*, New York, Vol. 50, 1903, p. 514. A circular rule, according to formula of Wilfred Lewis. by Carl G. Barth. Copyright, 1902.]

177. Barth's Speed Slide Rule (lathe No. 43).
[*Engineering News*, Vol. 50, 1903, p. 514. In *American Machinist*, Vol. 25, 1902, p. 1685, are described Barth's "General Speed Slide Rule" and also his "Special Speed Slide Rule." Copyright, 1902.]

178. Barth's Time Slide Rule.
[*Engineering News*, New York, Vol. 50, 1903, p. 514. Copyright, 1902. A circular rule designed by Carl G. Barth, of Swarthmore, Pa., and Fred W. Taylor in the shop of the Bethlehem Steel Co. See also *Railway and Engineering Review*, Vol. 44, March, 1904, p. 152.]

179. Leven, Règle pour les Reports de Bourse.
[*Calcul simplifié* par Maurice d'Ocagne, 2e éd., Paris, 1905, p. 118. Made by Tavernier-Gravet in 1903.]

180. F. Blanc's Rechenschieber.

[*Zeitschr. des Vereins Deutscher Ingenieure*, Vol. 45, 1901, Pt. I, p. 720. A log-log rule designed in 1890.]

181. Cox's High Pressure Fluid Discharge Computer.
[*American Machinist*, Vol. 25, 1902, p. 1515.]

182. Fürle's Rechenblätter.
[Hermann Fürle, *Rechenblätter (Jahresbericht der Neunten Realschule zu Berlin*. Ostern. 1902), Berlin, 1902. As an example, we mention "Rechenblatt für photographische Zwecke," published by Mayer & Müller in Berlin, which solves the equations for lenses
$1/a + 1/b = 1/f$; $1 + \alpha/\beta$; $b/f = 1 + \alpha/\beta$.]

183. Matthes' The U. S. Geological Survey Topographic Slide Rule.
[*Technological Quarterly*, Boston, Vol. XV, 1902, pp. 250—259. Designed by Gerard H. Matthes and made by Kern & Cie., Aarau, Switzerland.]

184. The Perry Log-Log Rule.
[*Nature*, Vol. 67, 1902, p. 141; Pickworth, *The Slide Rule*, 10th ed., p. 85; R. G. Blaine, *Some Quick and Easy Methods of Calculating*, 2d ed., London, 1903, p. 69.]

185. Proell's Rechentafel.
[*Verhandl. d. Vereins z. Beförderung d. Gewerbefleisses*, Berlin, Vol. 21, 1902, p. 48; *Zeitschr. f. Math. u. Physik*, Vol. 46, p. 218; Pickworth, *Slide Rule*, 10th ed., p. 102. Designed by Reinhold Proell, an engineer in Dresden. See also *Rechentafel System Proell*, Berlin, 1901.]

186. Rietz's Rechenschieber.
[*Zeitschr. d. Vereins Deutscher Ingenieure*, Vol. 47, 1903,p. 1163; C. N. Pickworth, *The Slide Rule*, 10th ed., p. 88. made by Albert Nestler in Lahr, Baden.]

187. Simplex Taschenrechenschieber.
[*Zeitschr. f. Instrumentenkunde*, Vol. 23, 1903, p. 158. Made by Dennert & Pape.]

188. Frank's Einscala-Rechenschieber.
[*Zeitschr. f. Instrumentenkunde*, Vol. 23, 1903, p. 159. Sold by A. Martz in Stuttgart.]

189. Hazen-Williams' Hydraulic Slide Rule.
[*Engineering Record*, New York, Vol. 47, 1903, pp. 321 and 667. Designed by Allen Hazen, of New York, and Professor Gardner S. Williams, of Cornell Univ. For sale by G. G. Ledder, 9 Province Court, Boston.]

190. Knowles' Calculating Scale.
[W. Knowles, *Calculating Scale; a Substitute for the Slide Ru*le, Spon & Chamberlain, 1903; see also Nature, Vol. 69, 1904, p. 485.]

191. Mougnié, Règle pour le Calcul des Conduites d'eau, d'après la Formula de Filament.
[*Calcul simplifié*, par Maurice d'Ocagne, 2e éd., Paris, 1905,p. 118. Made in 1904.]

192. Goldschmidt's Rule with Two Runners.
[*American Machinist*, New York, Vol. 27, Pt. II, 1904, pp. 1303, 1376, 1616. Designed by Daniel Goldschmidt.]

193. Anthony's Improved Circular Hydraulic Calculator.

[See *H. Catalogu*e, 1905, of W. F. Stanley & Co., Holborn, London. Based on Manning's formula.]

194. Fuller-Bakewell Calculating Slide Scale.
[Like Fuller's Calculating Slide Scale, with the additional scales of sin2 and sin X cos on the fixed cylinder. See *H. Catalogue*, 1905, of W. F. Stanley & Co., Holborn, London.]

195. Moehlenbruck's Instrument.
[*Comptes rendus*, Paris, Vol. 138, 1904, pp. 1266—1268. A circular slide rule with double runner, enabling the various change gears for screw-cutting to be selected without computation.]

196. Stanley-Boucher Calculator.
[Differs from the Boucher Calculator in having a third index hand which indicates the total movement of the front hand. See H. Catalogue, 1905, of W. F. Stanley & Co., Holborn, London.]

197. Union Slide Rule (Mannheim).
[L. W. Rosenthal, *Mannheim and Multiplex Slide Rules*, published by Eugene Dietzgen Co., Chicago, 1905, p. 60.]

198. Gravet's Tacheometer Slide Rule.
[See *H. Catalogue*, 1905, of W. F. Stanley & Co., Holborn, London.]

199. Mack Improved Slide Rule (Mannheim).
[L. W. Rosenthal, *Mannheim and Multiplex Slide Rules*, published by Eugene Dietzgen & Co., manufacturers and importers of drawing materials, Chicago, 1905, p. 60. See Fig. 16. This rule has a new mechanical construction, devised in 1898 by Professor John G. D. Mack of the University of Wisconsin, to allow the slide to move freely regardless of weather, temperature, etc. It is manufactured in Chicago by Dietzgen & Co.]

200. Würth-Micha, Règle pour le Calcul des Distributions de Vapeur.
[M. d'Ocagne, *Calcul simplifié*, 2e éd., Paris, 1905, p. 119. Designed in 1904 by Würth-Micha, an engineer in Liège.]

201. Masera's Rechenschieber.
[*Schweizerische Bauzeit*. (Waldner), Vol. 45, Zürich, 1905, p. 189; also *Zeitschr. f. Instrumentenkunde*, Vol. 25, Berlin, 1905, p. 385.]

202. Bell's Stadia Slide Rule.
[Designed by Arthur L. Bell. See *Engineering News*, Vol. 54, 1905, p. 487.]

203. The "R. H. S." Calculator.
[Pickworth, Charles N., *The Slide Rule; A practical manual*, Manchester, London, New York, 1906, p. 101. This rule is designed by Professor . H. H. Smith. The scale line is arranged on a cylinder in a spiral form. It is made by J. H. Steward, Strand, London.]

204. Universal Slide Rule.
[C. N. Pickworth, op. cit., p. 90; *Instructions for the Calculating Slide Rule*, Albert Nestler, p. 42. Made by Albert Nestler in Lahr, Baden. A rule by this name is manufactured by Keuffel & Esser Co. in New York under patent of March 21, 1899. See their catalogue for 1906, p. 326.]

205. Webb's Stadia Slide Rule (cylindrical).
[*Catalogue of Keuffel & Esser Co*., New York, 1906, p. 327.]

206. Colby's Sewer Computer.
[*Catalogue of Keuffel & Esser Co*., New York, 1906, p. 327; *Engineering News*, Vol. 37, 1897, p. 5. Designed by B. H. Colby of St. Louis, Mo.]

207. Cox's K. & E. Stadia Slide Rules.
[*Catalogue of Keuffel & Esser Co*., New York, 1906, p. 327. Designed by William Cox.]

208. Cox's Stadia Computer (circular rule).
[*Engineering News*, Vol. 43, 1900, p. 232. Purchased by W. & L. E. Gurney, Troy, N. Y.]

209. Favorite Slide Rule (Mannheim type).
[*Catalogue of Keuffel & Esser Co*., New York, 1906, p. 323.]

210. Goodchild Mathematical Chart.
[*Catalogue of Keuffel & Esser Co*., New York, 1906, p. 317.]

211. Halden Calculex.
[W. H. Harling's *Drawing Instruments*, 13th ed., London, 1906, p. 75. Manufactured in Manchester, England, by J. Halden & Co. See *also Rules, Tables and Formulae for Patent Circular Slide Rule (Halden Calculex),* Manchester.]

212. W. H. Harling's Calculating Rule.
[W. H. Harling's *Drawing Instruments*, 13th ed., 1906,p. 73.]

213. W. H. Harling's Calculating Rule, Rietz Pattern.
[W. H. Harling's *Drawing Instruments*, 13th ed., London, 1906, p. 74.]

214. Mechanical Engineer Pocket Calculator (Circular).
[W. H. Harling, *Mathematical Drawing and Surveying Instruments*, 13th ed., London, 1906, p. 75.]

215. Miggett's Cost-estimating Slide Rule.

216. Miggett's Cost-estimating Slide Rule in Conical Form.
[*American Machinist*, Vol. 29, Pt. II, 1906, p. 803. Designed by XV. L. Miggett.]

217. Rosenthal's Multiplex Slide Rule.
[L. W. Rosenthal, *Mannheim and Multiplex Slide Rules*, published by E. Dietzgen & Co., Chicago, 1905. Invented and patented by L. XV. Rosenthal, electrical engineer. The manufacture of this rule was begun in Chicago in 1906.]

218. Nickel's Runnerless Slide Rule.
[*American Machinist*, Vol. 29, Pt. II, 1906, p. 256; also *The Runnerless Slide Rule*, by F. F. Nickel. Published by the author, East Orange, New Jersey. This is a protest against the prevailing Mannheim construction.]

219. Roberts' Slide Rule for Wiring Calculations.
[*Electric Journal*, Pittsburg, Pa., Vol. 3, 1906, pp. 116—118. Mr. E. P. Roberts, the designer, says that it was patented in 1894, and sold for a time, though not on the market now.]

220. Slide Rule for Calculating Sag in Wires.
[Designed by R. J. C. Wood. See *Electrical World*, New York, Vol. 50, 1907, p. 402.]

221. Tilsley's Slide Rule for Strength of Gear Teeth.
[*American Machinist*, Vol. 30, Pt. II, 1907, p. 76. A straight rule graduated according to formula of Wilfred Lewis, designed by Harry Tilsley.]

222. Younger's Logarithmic Chart for Computing Costs.
[*American Machinist*, Vol. 30, Pt. II, 1907, p. 91. Designed by John Younger as a substitute for Miggett's Cost-estimating Slide Rule.]

223. Niethammer's Präzisions-Schulstab.
[*Zeitschr. f. Mathem. u. Naturwissensch. Unterricht*, 38. Jahrgang, 1908, p. 528. For articles on the use of the slide rule in German schools, see this *Zeitschrift*, Vol. 3, 1872; Vol. 27, 1897, pp. 568, 594; Vol. 28, 1897, p. 180.]

224. Neuer Präzisions-Rechenstab.
[Made by Dennert & Pape in Altona, "mit federndem Stahlrücken und seitlicher Justierschraube." See *Zeitschr. f. Mathem. u. Naturwissensch. Unterricht*, Vol. 38, 1908, p. 580.]

225. Griffin and Son's Card Slide Rule.
[Made by J. J. Griffin & Sons, Ltd., of Kingsway, London See Nature, Vol. 77, 1908, p. 500.]

226. Malassis, Cercles Logarithmiques.
[M. d'Ocagne, *Calcul simplifié*, 2e éd., Paris, 1905, p. 121.]

227. Viaris, Ruban Calculateur.
[M. d'Ocagne, *Calcul simplifié*, 2e éd., Paris, 1905, p. 122. Marquis de Viaris was a French navy officer.]

228. Chadwick's Improved Slide Rule.
[John Chadwick's *Slide-Rule Instructor for Instruction on Chadwick's Improved Slide Rule*, London (no date).]

229. Dämen-Schmid's Rechenwalze.
[E. Hammer,. *Der logarithmische Rechenschieber*, 4te AufI., Stuttgart, 1908, p. 9. The instrument is sold in Örlikon.]

230. Niehans' Metalltachymeterschieber.
[E. Hammer, *Der logarithmische Rechenschieber*, 4te Aufi., Stuttgart, 1908, p. 10. See also Zeitschr. für Vermess., Vol. 35, 1906, p. 237.]

231. Koppe'sBarometerhöhenrechenschieber
[E. Hammer, *op. cit*., p. 10.]

232. Bischoff's Barometerhöhenrechenschieber
[E. Hammer, op. cit., p. 10.]

233. Vogler's Barometerhöhenrechenschieber.
[E. Hammer, *op. cit*., p. 10.]

234. Hammer's Barometerhöhenrechenschieber
[E. Hammer, *op. cit*., p. 10.]

235. J. L. Hall’s Structural Slide Rule (Column Slide Rule, Beam Slide Rule, and Mannheim Slide Rule in one).
[*American Architect*, February 12, 1908; see also *Slide Rule Manual*, by John L. Hall. Manufactured and sold by the Slide Rule Club, Box 12, Station J, New York City. In use since 1907.]

236. Edge’s Weight Computer for Structural Shapes.
[*American Machinist*, Vol. 31, 1908, p. 613. Sold by Edge Computer Sales Agency, St. Paul Building, New York City.]

237. Perry’s New Slide Rule.
[*Engineering Record*, Vol. 58, 1908, Current News Supplement, p. 37. Devised by John Perry and placed on market by A. C. Thornton of Manchester, England. Solves expressions with fractional indices.]

238. Wynne-Roberts’ Pocket Hydraulic Calculator.
[*Engineering Record*, Vol. 58, 1908, p. 679. A compound circular slide rule devised by R. O. Wynne-Roberts.]

239. Eichhorn’s Trigonometric Slide Rule.
[*American Machinist*, Vol. 31, 1908, p. 818. Put on the market by M. J. Eichhorn, 5759 Aberdeen St., Chicago, Ill.]

240. Celluloid Slide Rules, with spare Logologarithmic Slide, as arranged by H. C. Dunlop and C. S. Jackson.
[*Slide Rule Notes*, by Lt.-Col. H. C. Dunlop, R.F.A., and C. S. Jackson, M. A., London, 1901. Made by John Davis & Son (Derby), Ltd., London.]

241. M. Schinzel’s Logarithmischer Kubizierungsmassstab.
[*Encyklopädie d. Math. Wiss*., Bd. I, 1898—1904, p. 1057.]

242. Scheve’s Artillerist Rechenschieber.
[*Encyklopädie d. Math. Wiss*., Bd. I, 1898—1904, p. 1060; *Arch. Artill. Ingen. Off.* 88; Sonderabdruck dieses Artikels, Berlin, 1881.]

243. Fearnley’s Universal Calculator.
[C. N. Pickworth’s *Slide Rule*, 10th ed., 1906, p. 100.]

244. “Midget” Slide Rule.
[*Catalogue of Drawing Materials*, Kolesch & Co., New York, 1907, p. 88. See also Kolesch & Co., *Slide Rule Instructions*.]

245. “Vest Pocket” Slide Rule.
[*Catalogue of Drawing Materials*, Kolesch & Co., New York, 1907, p. 88.]

246. “Triplex” Slide Rule.
[*Catalogue of Drawing Materials*, Kolesch & Co., New York, 1907, p. 89.]

247. The L. E. Knott Slide Rule.
[Made by L. E. Knott Apparatus Co., Boston, Mass. *Directions for use of rule* by W. B. Carpenter.]

248. The K. & E. Polyphase Slide Rule.
[*Catalogue of Keuffel & Esser Co*., New York, 1909, p. 310.]

249. The K. & E. Adjustable Duplex Slide Rules.
[*Catalogue of Keuffel & Esser Co*., New York, 1909, p. 311.]

250. The K. & E. Adjustable Log-Log Duplex Slide Rule.
[*Catalogue of Keuffel & Esser Co*., New York, 1909, p. 312.]

251. The K. & E. Circular Calculator.
[*Catalogue of Keuffel & Esser Co*., New York, 1909, p. 307.]

252. Nestler's Slide Rule for Wiring Calculations.
[*Electrical Review and Western Electrician*, Vol. 54, 1909, p. 399; *Elektrotechnischer Anz*eiger, 1909. Made by Albert Nestler, of Lahr, in Baden, Germany.]

253. Woodworth's Slide Rule for Electrical Wiremen.

254. Woodworth's Slide Rule for Calculations with Volts, Amperes, Ohms and Watts.
[*Electrical Review and Western Electrician*, Vol. 54, 1909, p. 399. Both rules are designed by Professor P. B. Woodworth, of the Lewis Institute, Chicago.]

255. Nordell's Slide Rule for Computing Run-off to Sewers.
[*Engineering News*, Vol. 61, 1909, p. 266. Designed by Carl H. Nordell of New York City and manufactured by the Keuffel & Esser Co. Based on Kutter's formula.]

256. Schumacher's Rechenschieber mit Teilung in gleiche Intervalle.
[Dr. Soh. Schumacher, Professor am Kgl. Bayer. *Kadettenkorps, Em Rechenschieber mit Teilung in gleiche Intervalle auf der Grundlaged er zahlentheoretischen Indizes. Für den Unterricht konstruiert*, München, 1909. See *also Zeitschr. .f. Math. u. Naturwiss. Unterricht*, Vol. 40, 1909, p. 59.]

BIBLIOGRAPHY OF THE SLIDE RULE

1620. Canon Triangulorum. Gunter (London)
1624. Description and Use of the Sector, Cross-Staff and Other Instruments. Gunter (London)
1624. L'usage de la règle de proportion en l'arithmétique et géométrie. Edmund Wingate (Paris)
1624. Construction, description et usage de la règle de proportion. E. Wingate (Paris)
1626. The Use of the Rule of Proportion. E. Wingate (London). Other editions, 1628, 1645, 1658, 1683
1626. Arithmétique logarithmique. E. Wingate
1626. Logocanon ou règle proportionnelle Henrion (Paris)
1630. Of Natural and Artificial Arithmetic. E Wingate (London)
1632. The Circles of Proportion and the Horizontal Instrument. William Forster. (London)
1633. The Circles of Proportion and the Horizontal Instrument with an Addition, etc., and an Appendix; The Declaration of the Two Rulers for Calculation
1672. The Description and Use of an Instrument called the Double Scale of Proportion. Seth Partridge (Written in 1657)
1677. Timber Measure by a Line of More Ease, Dispatch and Exactness than any other way now in use, by a Double Scale. Henry Coggeshall (London)
1682. A Treatise of Measuring by a Two-foot Rule, which slides to a Foot. Henry Coggeshall (London). (A Second edition of his 1677 book)
1690. Cursus Mathematicus. Leybourn
1696. Descriptio instrumenti Mathematici universalis, quo mediante omnes proportiones sine circino at que calculo methodo facillima inveniuntur. Biler.
1699. Pes mechanicus artificialis d. i. neu erfundener Maassstab, mi welchem alle Proportionen der ganzen Mathematik ohne mühsames Rechnen u. s. w. können gefunden werden. Michael Scheffelt (Ulm)
17—. Arithmétique linéaire. Pouchet
17—. Elémens du Pilotage. Pezenas
17—. Encyclopédia méthodique (mathématiques). Johann Bernoulli III (1744—1807)
17—. Encyclopédia Méthodique (marine), Article "Echelle anglaise." Lalande
17—. Excise and Malt-Examiners' Assistant, Useful also for Supervisors and Officers. J. Vero (London)
17—. Mathematical Companion. Hunt
17—. Pratique du Pilotage. Pezenas
1707. The Young Mathematician's Guide . . . , with an Appendix on Practical Gauging. John Ward (London)
1716. Lexicon Technicum. Harris
1722. The Art of Practical Measuring easily performed by a Two-foot Rule which slides to a Foot. Henry Coggeshall. (A third edition of his 1677 book; a fourth edition, revised by John Ham, was brought out in 1729, and a seventh edition in 1767)
1723. Construction and Principal Uses of Mathematical Instruments. M. Bion (Translated by E. Stone)
1726, 1743. New Mathematical Dictionary. E. Stone (London)
1727. Histoire de l'académie royale des sciences. Jean Baptiste Clairaut
1727. Theatrum Arithmetico-Geometricum. Jacob Leupold (Leipzig)
1733. The Description and Use of an Universal and Perpetual Mathematical Instrument. Benjamin Scott (London)
1740. Lives of the Professors of Gresham College. Ward
1740. Theory and Practice of Gauging. Robert Shirtcliffc (London)

1744. Mémoires de l'académie royale des sciences de l'année, 1741 (Paris)
1753. Dictionnaire universel de mathematique et de physique. Tome I, Saverien
1755. Royal Gauger. C. Leadbetter
1755. The Royal Gauger. Leadbetter. 4th Ed. (London)
1761. Beschreikung und Gebrauch der Logarithmischen Rechenstäbe. Johann H. Lambert (Augsburg). New edition published in 1772
1766. Abridge du Pilotage. Lemonnier (Paris)
1768. Nouveaux essays pour determiner les longitudes en mer par les movements de la lune et par une seule observatione. Pezenas (Paris)
1768. (Treatise on Slide Rule—no name). Flower (London)
1775. Treatise on Mathematical Instruments. John Robertson
1778. Atlas céleste de Flamsteed, translated by Fortin
1777. Lambert's Briefwechsel, Vol. IV., p. 379
1778. A Description of the Lines drawn on Gunter's Scale, as improved by Mr. John Robertson. William Mountaine (London)
1782. Isaaci Newtoni Opera, Tom. IV. Edit. S. Horsley (London)
1787. Philosophical Transactions. William Nicholson (London). Pt. II, pp. 246—252
1788. Arithmetic. Nicholas Pike
1792. A Complete Treatise on Practical Mathematics. John Macgregor (Edinburgh)
1794. Arithmetic. George Fisher (Mrs. Slack) (London)
1797. Nicholson's Journal, Vol. I., p. 375
1798. De la résolution des equations numériques de tous les degrés Lagrange (Paris)
1799. Cadrans logarithmiques adaptés aux poids et mésures. A. S. Leblond (Paris)
1799. Instructions sur l'Usage des Cadrans logarithmiques. François Gattey (Paris)
18—. Dictionary of Authors. Art. "Wingate, Edmund" S
18—. Dictionary of National Biography. Sidney Lee
18—. Dingler's "Polytechnic Journal." (Berlin) .Many references
18—. Dyck's "Katalog Nachtrag"
18—. English Cyclopaedia (Arts and Sciences)
18—. Instructions for the use of A. W. Faber's Improved Calculating Rule. C. N. Pickworth 72
18—. Mem. dell' Accad. d. Scie. di Torino, T. XXV, Serie II
18—; Philosophical and Mathematical Dictionary. Hutton
18—. "Philosophical Magazine," Vol. 45, p. 387 (London)
18—. Theorie du logarithmischen Rechenschieber. Franz Ruth
1800. Dizionario enciclopedico delle matematische delli signori. Art. "Logaritmiche" (Padova)
1802. "Mechanics' Magazine," Vol. 5 (London)
1802. Navigator. Bowditch
1802. Nicholson's Journal, Vol. 1, p. 452
1803. De Ingenieur
1805. "Schoolmaster's Assistant," by Thos. Dilworth, brought out in Philadelphia by Robert Patterson
1808. Mathematisches Wörterbuch, I. Abtheilung, 3. Theil (Leipzig)
1810. Explication et usage de l'arithmographe. Gattey (Paris)
1811. Mathematical Tables. Hutton
1813. Complete Measurer. Hawney (1st Edit. London, 1717) (Baltimore)
1813. Complete Measurer. Hawney (Baltimore) . (The first edition of this book appeared in London in1717)
1814. Dictionary of Pure and Mixed Mathematics. Peter Barlow (London)
1815. Mathematical Dictionary. Charles Hutton

1815. "Journal des Mines," Vol. 37, p. 101
1815. "Philosophical Transactions," Part I (London)
1817. "Nicholson's Journal," Vol. 49, p. 187
1817. "Philosophical Magazine," Vol. 49, p. 187 (London)
1820. (Treatise on Slide Rule—title not given) . Collardean (Paris)
1823. Dictionary of Mathematical and Physical Sciences. James Mitchell (London)
1823. Quarterly Journal of Science, Literature and Arts, Vol. XVI, p. 357 (London)
1827. Treatise on the Steam Engine. John Farey (London)
1827. (Treatise on Slide-Rule—no title given). J. F. Artur (2e éd., 1845) (London)
1829. Gill's Technological Repository, Vol. IV, p. 33 (London)
1831. "Mechanics' Magazine" (London)
1832. Brewster's Edinburgh Encyclopaedia, 1st Am. Ed. (Philadelphia)
1837. Instruction sur la manière de se servir de la règle à calcul. Mouzin. 3e éd. (Paris)
1837. (Treatise on Slide Rule—no title given). 35 éd. Ph. Mouzin (Paris)
1840. "Annales des Ponts et Chaussées"
1840. "Mechanics' Magazine," Vol. 32, pp. 101, 102 (London)
1841. Mathematical Dictionary. Montferrier
1841. "Mechanics' Magazine
1842. Penny Cyclopaedia. (Article on "Slide Rule" by De Morgan)
1843. Anweisung zum Gebrauche des englischen Rechenschiebers. L. C. Schulz von Strasnitzki (Wien)
1844. On Coggeshall's Sliding Rule (London)
1845. Palmer's Pocket Scale, with Rules for its use in solving Arithmetical and Geometrical Problems (Boston)
1845. (Treatise on Slide Rule—no title given). Aug. Hadéry (Paris)
1845. On Bradford's Sliding Rule (London)
1846. Improvement to Pa1mer's Endless Self-Computing Scale and Key; . . . John G. Fuller (New York)
1847. Arithmetical Books from the Invention of Printing to the Present Time. De Morgan (London)
1850. La Tachéométrie. J. Parro (Turin)
1851. A Treatise on Slide Rule. L. Lalanne (London)
1851. Instruction sur les règles à calcul. Lalanne
1851. Règle à calculs modifieé. Mannheim (Metz)
1851. Auleitung z. Gebrauche einiger logarith. getheilter Rechenschieber (Wien)
1852. Gebrauchs-Anweisung fur Rechenstäbe (Paris)
1852. Instruction sobre das reglas de calculo. (Paris)
1853. Règle à Calcul expliquée. M. P. M. N. Benoit (Paris)
1853. Bulletin de la sociéte d'encouragement pour l'industrie nationale
1853. (Treatise on Slide Rule-no title given). P. M. N. Benoit (Paris)
1853. Nouvelles Annales de Mathématiques, 1ére série, Tome XII, pp. 113—116
1854. Nouvelles Annales de Mathématiques, Tome XIII,p.36
1854. Mittheilungen des Gewerbevereins f. d. Königreich Hannover, p. 169
1856. Ueber Visir- und Recheninstrumente. Ernest Sedlaczek (Wein)
1856. Mechanics' and Engineers' Book of Reference and Engineers' Field Book. Charles Haslett and Chas. W. Hackley (New York)
1857. Par. Comptes rendus de 1' Acad. d. Sci. 44, p. 22.
1859. Teorica e practica del regolo calcolatore Quentino Sella (Torino)
1860. Encyclopaedia Britannica. (Eighth Ed.)
1860. Atti dell' Imp. Reg. Istituto veneto di scienze (Venice)

1861. Handbook of the Slide Rule. W. H. Bayley (London)
1863. Bull. de la sociéte d'encouragement pour l'industrie nationale (Paris)
1864. "Zeitschr. des Architecten- u. Ingenieur-Vereins f. d. Königp." Hannover, Vol. 10, p. 454
1865. (Treatise on Slide Rule—no title given). Fr. René (Paris)
1866. Report British Assn. (London)
1867. Giornale di Matem. del Prof. Battaglini (Naples).
1868. Appleton's Dictionary of . . . Engineering, Vol. I (New York)
1868. Instruments et machines calculer (Paris)
1869. (Treatise on Slide Rule—no title given. Translation of Q. Sella's book—1859). Montefiore Lévi (Paris)
1871. Drawing and Measuring Instruments. J. F. Heather (London)
1871. Torino Aec. Sci. Memorie
1872. (Treatise on Slide Rule—no title given). Labosne (Paris)
1872. Der Topographische Distanzmesser mit Rechenschieber. J. Stambach (Aaran)
1872. Auleitung zum Gebrauche des Rechenkreises. R. Weber
1872. Auleitung zum Gebrauch der Rechenscheibe. F. M. Clouth (Hamburg)
1874. "Annales du Gènie Civil" (Paris)
1874. "Deutsche Bauzeitung," Bd. 8, p. 136
1874. A Treatise on Mathematical Instruments J. F. Heather (London)
1875. Die Grahpische Statik. (Zurich)
1875. Treatise on Slide Rule—no title given). Claudel(Paris)
1875. Proceed. London Math. Soc., Vol.6, p. 113 (London)
1876. Notice sur les travaux et titres scientifiques. M. Léon Lelanne
1877. Geschichte der Astronomie. R. Wolfe (München)
1877. Catalogue of Instruments manufactured by W. F. Stanley (London)
1877. Das . Stereometer, Körper-Messinstrument (Budapest)
1877. Notes pratiques pour études de tracés. I. Moinot (Paris)
1877. "Zeitschr. des Vereins Deutscher Ingenieure
1878. Méthodes graphiques pour l'expression des lois empiriques, etc
1878. Veneto Istituto Atti. A. Favaro. . Numerous references
1878. "La Nature" (Paris)
1878. Spiral Slide Rule. George Fuller (London)
1879. Statique Graphique. Favaro-Terrier. (Paris)
1880. Proc. Engineers' Society of Western Penna
1881. Knight's American Mechanical Dictionary, Vol. II
1881. The Slide Rule Simplified. Robert Riddell (Phildelphia)
1881. "Zeitschr f. Vermessungsw"
1881. Dingler's "Polytechnisches Journal" (Augsburg)
1883. (Booklet on Slide Rule—no title given). Prof. Cherepashinskii (Moscow)
1885. Leçons de statique graphique, 2ième partie, calcul graphique. A. Favaro, Translated into French by P. Terrier (Paris)
1885. (Treatise on Slide Rule—no title given). F. Guy, 3e éd. (Paris)
1885. (Treatise on Slide Rule—no title given). Gros de Perrodil (Paris)
1885. Van Nostrand's "Engineering Magazine"
1886. Regolo Calcolatore. Quintino Sella. 2 ed. Ital. (Torino)
1886. Dingler's "Polytechnisches Journal"
1886. Gewerbeblatt aus Würtemberg
1886-7. Transactions of Am. Soc. M. E., Vol. VIII, pp. 707—709
1888. "Centralblatt Bauverwaltung"
1888. "Railroad Gazette." (New York) 72

1889. A New and General Biographical Dictionary. Art. by Oughtred, quoted in "Nature," Vol. 40, p. 458
1889. Portefeuille des Conducteure des Ponts et Chaussées (Paris)
1889-90. "Techaiker," Vol. 12, p. 34
1890. The Slide Rule and How to Use it. Charles Hoare (London)
1890. Instruction pour la determination de la distance et de la différence d'altitude d'un objet à un point de Station. J. Stambach (Aarau)
1890. Dingler's "Polytechnisches Journal"
1891. "Zeitschr. f. Vermessungsw."
1891. "Engineering News" 81
1891. The Mannheim Slide Rule. W. M. Cox (New York)
1891. Explanation of the Principle and Operation of the Mannheim Slide Rule. C. W. Crockett (Troy, N.Y.)
1892. International Cyclopædia. (New York) iv
1892. "Engineering and Mining Journal" (NewYork), Vol. 54, p. 130
1892-4. "Zeitschr. fur Vermessungsw"
1893. Scherer's Logarithmischgraphische Rechentafel (Kassel)
1894. "Schweizer. Bauzeitung," Vol. 23
1894. "Engineering News," Vol. 32, p. 103
1894. Der Praktische Maschinen-Constructeur, Vol. 27,p.8
1894. "Engineering Record," Vol. 30, p. 31
1895. "Nature." (London)
1896. "Engineering," Aug. 7p 172 (London)
1896. Engin. Ass'n of the South, Vol. 7 (Nashville, Tenn.) pp. 92-99
1897. Handbuch der Vermessungskunde. W. Jordan, Bd. II, p. 134 (Stuttgart)
1897. "Engineering News," Vol. 38, p. 291
1897. "Mechaniker," Vol. 5
1898. Règle à calcul, modèle spécial. A. Beghin (2e éd., 1902, Paris)
1898. "Yale Scientific Review," Vol. 5, p. 47
1898. Logarithmicon. E. Nash, p. 43 (Dublin)
1898-1904. Encyklopädie d. Math. Wiss, (Leipzig)
1899. Zur Theorie des Rechenschiebers. (Berlin)
1899. Traité de Momographie. M. d'Ocagne (Paris), p. 361
1899. "Zeitschr. f. Vermessungsw.," Vol. 28, p. 660
1899. The Use of the Slide Rule. F. A. Halsey, p. 74 (New York)
19—. Instructions for the Use of A. W. Faber's Improved Calculating Rule. C. N. Pickworth (London)
19—. Instructions for the Calculating Slide Rule. Albert Nestler, p. 63 (Lahr, Baden)
19—. Slide Rule Instructor for Instruction on Chad-wick's Improved Slide Rule. John Chadwick (London)
19—.. Some Quick and Easy Methods of Calculating. R. G. Blame (London).
19—. The Runnerless Slide Rule. F. F. Nickel
19—. Treatise on a Box of Instruments. T. Kentish (Philadelphia).
19—. Engineers' Slide Rule. W. Tonkes (New York) ...
1900. "Zeitschr. f. Vermessungsw.," Vol. 29, p. 233
1900. "Zeitschr. f. Instrumentenkunde," Vol. 20, p. 336
1900. "Comptes rendus," Vol. 131, p. 1289
1900. "Engineering News," Vol. 43, p. 232
1901. Le Système Métriques des Poids et Mesures. G. Bigourdan (Paris)
1901. Oesterreich. Woch. ensch. f. d. offentl. Baudienst, Vol. 7, p. 72

1901. "American Machinist," Vol. 24, p. 339 (New York)
1901. "Journal de Physique," Sept
1901. "Nature," Vol. 64, p. 523
1901. Rechentafel System Proell (Berlin)
1901. Slide Rule Notes. Lt.-Col. H. C. Dunlop, R.F.A. and C. S. Jackson, M. A. (London)
1901-1903. "Engineering News" (New York)
1902. (Treatise on Slide Rule—no title given). Leclair (Paris) 58
1902. "Journal de l'Ecole Polytechnique" IIe sérié, septième cahier (Paris, p. 223)
1902. The Slide Rule. E. M. Scofield (Chicago)
1992. "American Machinist," Vol. 25, p. 1515
1902. "Rechenblätter" (Berlin)
1902. "Technological Quarterly," Vol. XV, pp. 250-259 (Boston)
1902. "Nature," Vol. 67, p. 141
1902. "Verhandl. d. Vereins z. Beförderung d. Gewerbefleisses" (Berlin), Vol. 21, p. 48
1903. (Treatise on Slide Rule—no title given). Jully (Paris)
1903. Treatise on Slide Rule—no title given). Dryssé (Paris)
1903. Règle à calcul Mannheim (Paris)
1903. "Zeitschr. f. Mathematik. u. Physik." Vol. 48, p. 134
1903. "De Ingenierer," Vol. 18, p. 94
1903. "Engineering Record" (New York)
1903. Calculating Scale; a Substitute for the Slide Rule. W. Knowles (New York)
1903. Some Quick and Easy Methods of Calculating. R. G. Blame (London)
1903. Thacher's Patent Calculating Instrument. Edwin Thacher (New York)
1904. "Engineer," April 7, p. 346 (London)
1904. "Mathematical Gazette," Vol. II, p. 337 (London)
1904. "American Machinist," Vol. 27, Pt. II, p. 1376 (New York)
1904. "Nature," Vol. 69, p. 485
1904. "American Machinist" (New York)
1904. "Comptes rendus," Vol. 138, pp. 1266—1268 (Paris)
1904. Slide Rule. E. M. Scofield (New York).
1905. Calcul simplifié. Maurice d'Ocagne, 2e éd. (Paris)
1905. "Engineering News"
1905. Mannheim and Multiplex Slide Rules. L. W. Rosenthal (Chicago)
1905. "Schweizerische Bauzeit," Vol. 45 (Zurich)
1905. "Zeitschr. f. Instrumentenkunde," Vol. 25, p. 385 (Berlin)
1905. "Engineering News," Vol. 54, p. 487
1906. "American Machinist," Vol. 29, Pt. II, p. 256 (New York)
1906. The Slide Rule: a Practical Manual. C. N. Pickworth (London)
1906. Catalogue of Keuffel & Esser Co. (New York)
1906. Drawing Instruments. W. H. Harling (London)
1906. Mathematical Drawing and Surveying Instruments. W. H. Harling (London)
1906. "American Machinist"
1906. "Electric Journal," Vol. 3, pp. 116—118 (Pittsburg, Pa.)
1907. Règle à calculs. P. Rozé, pp. 2, 3, 29—58 (Paris)
1907. Theorie et usage de la règle à calculs. P. Rozé (Paris)
1907. "Electrical World," Vol. 50, p. 402 (New York)
1907. "American Machinist," Vol. 30, Pt. II, p. 76
1907. Slide Rule Manual. John L. Hall (New York)
1907. Catalogue of Drawing Materials. Kolesch & Co. . (New York)
1907. Complete Mechanical Slide Rule and How to Use it. F. T. Hodgson (New York) .

1908. Der logarithmische Rechenschieber. E. Hammer. 4te Aufl. (Stuttgart)
1908. Rendiconti del Circolo Matematico di Palermo, Tomo 26, pp. 1—63
1908. Der logarithmische Rechenschieber. E. Hammer (Stuttgart)
1908. "Zeitschr. f. Mathem. u. Naturwissensch." (Unterricht)
1908. "Nature," Vol. 77, p. 500
1908. "American Architect," Feb. 12
1908. "American Machinist," Vol. 31, p. 613
1908. "Engineering Record," Vol. 58
1908. How to Use Slide Rules. D. Petrie Palmedo (New York) .
1908. Mannheim and Multiplex Slide Rules. L W. Rosenthal (New York) .
1908. Slide Rule Calculator.
1909. Catalogue of Keuffel & Esser Co. (New York)
1909. "Colorado College Publication," Vol. I, No. 6.
1909. "Electrical Review and Western Electrician," Vol. 54, p. 399
1909. "Elektrotechnischer Anzeiger"
1909. "Engineering News," Vol. 61, p. 266
1909. Ein Rechenschieber mit Teilung in gleiche Intervalle auf der Grundlaged er zahlentheoretischen Indizes. Fur den Unterricht Konstruiert (München)
1909. "Zeitschr. f. Math. u. Naturwiss." Unterricht, Vol. 40, p. 59
1909. History of the Slide Rule. F. Cajori (New York)
1909. "Engineering News," Vol. 62, p. 40

ADDENDA

Addenda 1.

I have received from Professor Antonio Favaro of the Royal University of Padua, whose history of the slide rule we have often quoted, a communication which indicates that he has not had the opportunity himself to examine Wingate's *Of Natural and Artificial Arithmetic*, London, 1630. This fact throws doubt upon the correctness of my conclusion, that Wingate was the inventor of the slide rule, for I went on the supposition that the statement in Favaro's history was the result of his own personal inspection, and could, therefore, be relied upon implicitly. I learned later that a copy of Wingate's text of 1630 is in the Bodleian Library at Oxford in England. I have before me a *verbatim* copy of Wingate's description of the instrument in that book. The instrument is not a slide rule, but a "Line of Proportion" which, as he himself says, is "nothing else but a mechanical Table of Logarithmes." It is the same scale that is described in *his Construction and Use of the Line of Proportion*, 1628. It appears, therefore, that De Morgan's inference, that Wingate never wrote on the slide rule, is certainly correct for those publications of Wingate that appeared before 1632. But De Morgan's inference was drawn from incomplete data and was of the nature of a guess, even if it is applied merely to the period preceding 1632. For he admits never having seen Wingate's book of 1630 and he nowhere mentions the text of 1628, just quoted. But the findings of De Morgan and those due to myself, when taken together, establish conclusively that THE INVENTION OF THE SLIDE RULE IS NOT DUE TO WINGATE, BUT TO WILLIAM OUGHTRED, WHOSE INSTRUMENTS WERE DESCRIBED IN PUBLICATIONS BROUGHT OUT BY WILLIAM FORSTER IN 1632 AND 1653. The question remains, did Wingate write on the slide rule since 1632? I have now received reports on all of Wingate's mathematical books, except his *Use of the Gauge-rod*, 2. ed., 1658, and I have found in them no trace of the slide rule.

Addenda 2.

From the 1660 Oxford edition of Oughtred's Circles of Proportion I copy the description of the circular slide rule and supply a photograph (Fig. 17) of the diagram. This passage is said to be an exact reprint from the 1632 edition, and is of interest as being the description of the earliest slide rule invented. The passage is, pp. 1-3 (using the modern notation for decimal fractions):

"1. There are two sides of this Instrument. On the one side, as it were in the plain of the Horizon; is delineated the projection of the Sphaere. On the other side there are diverse kindes of Circles, divided after many severall waies; together with an Index to be opened after the manner of a paire of Compasses, and of this side we will speake in the first place.

"2. The First, or outermost circle is of Sines, from 5 degrees 45. minuts almost, untill 90. Every degree till 30 is divided into 12 parts, each part being 5 min.: from thence untill 50 deg. into sixe parts which are 10 min a peece: from thence untill 75 degrees into two parts which are 30 minutes a peece. After that unto 85 deg. they are not divided.

"3. The Second circle is of Tangents, from 5 degrees 45 min; almost, untill 45 degrees. Every degree being divided into 12 parts which are 5 min: a peece.

"4. The Third circle is of Tangents, from 45 degrees untill 84 degrees 15 minutes. Each degree being divided into 12 parts, which are 5 min: a peece.

"5. The Sixt circle is of Tangents from 84 degrees till about 89 degrees 25 minutes.

"The Seventh circle is of Tangents from about 35 minutes till 6 degrees.

"The Eight circle is of Sines, from about 35 min: till 6 degrees.

"The Fourth circle is of unequall Numbers, which are noted with the Figures 2, 3, 4, 5, 6, 7, 8, 9, 1. Whether you understand them to be single numbers or Tens, or Hundreds, or Thousands, etc. And every space of the numbers till 5, is divided into 100 parts, but after 5 till 1. into 50 parts.

"The Fourth circle also sheweth the true or naturall Sines, and Tangents. For if the Index be applyed to any Sine or Tangent, it will cut the true Sine or Tangent in the fourth circle. And we are to know that if the Sine or Tangent be in the First, or Second circle, the figures of the Fourth circle doe signifie so many thousands. But if the Sine or Tangent be in the Seventh or Eight circle, the figures of the Fourth circle signifie so many hundreds. And if the Tangent be in the Third circle, the figures of the Fourth circle signifie so many times tenne thousand, or whole Radii. And if the Tangent be in the sixt circle, so many times, 100000 and by this meanes the Sine of 23º, 30' will be found 3987: and the Sine of it's complement 9171. And the Tangent of 23º, 30' will be found 4348: and the Tangent of it's complement, 22998. And the Radius is 10000, that is the figure one with foure ciphers or circles. And hereby you may find out both the summe, and also the difference of Sines and Tangents.

"7. The fift circle is of equall numbers noted with 1 2 3 4 5 6 7 8 9 0, and every of these parts is subdivided into 10 parts; and again each of them into 10: so that the whole circle conteineth 1000 equall parts, beginning the line noted 10, which therefore I call the initiall line. This fift circle serveth for finding the Logarithmes of the true numbers upon the fourth circle, by a right line out of the center. Thus the Log: of 21.6 in circle IV, will be found 1.33445 in circle V. And so contrarily.

"For example if the space betwixt 20 & 21.6 which is also the space betwixt 1 & 1.08 (because 20:21.6: :1:1.08 is to be septuplyed that is multiplyed into it selve for 7 times: Apply the Index unto 1.08 reconed in circle IV from the initiall line; and it will in circle V cut 0.03342, the Log. of 1.08; which multiplyed by 7 makes 0.23396; a Logarithme also: for the valor whereof, apply unto it an Index; and it will be in circle IV cut 1.71382, which 1.08 is the Ratio of 1 to 1.08, or 1.08/1 multiplyed into it selfe for 7 times. And the like manner is to be used in. septupartion of the Ratio 1.08; or multiplying the subratio 1/1.08 into it selfe for 7 times."

In the dedication, printed in the work of 1632 and quoted by us, reference is made to the rectilinear slide rule, but a description was not printed until 1633, in the *Addition unto the Use of the Instrument, called the Circles of Proportion*, where the description is given in an appendix bearing the title, The Declaration of the Two Rulers for Calculation. No diagram of the instrument is given. I quote the description.

"The Rulers are so framed and composed, that they may not only be applyed to *the calculation of Triangles*, and *the resolution of Arithmeticall quaestions*: but that they may also very fitly serve for a Crosse staffe to take the height of the Sunne or any Starre above the Horizon, and also their distances: in which regard I call the longer of the *two Rulers* the *Staffe*, and the *Shorter* the *Transversarie*. And are in length one to the other almost as 3 to 2.

"The *Rulers* are just foure square, with right angles: and equall in bignesse: they are thus divided.

"The *Transversarie* at the upper end noted with the letters, S, T, N. E, on the severall sides hath a *pinnicicle* or *sight*: at the lower edge of which sight is the *Line of the Radius*, or *Unite line*, where the divisions beginne.

"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 containe. And on the right edge of the same side is set the *Line of Sines* from 90 to 1 degree. Those 33 degr. 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 goeth upward from 1 to 45 degr. and that on the left edge goeth downward 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, 2,1, 9,8,7,6,5,4,3,2,1.8.

"In the fourth side on the right edge is the *set line of Æquall 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, 2½

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

"Then applying your *Transversarie* to the *Staffe* with the lower end set to 90, mark on the foure sides of the staffe the *line of the Radius* or *Unite*: at which on every left edge must begin *the single line of Sines, Tangents*, and *Numbers*, the very same which were in the *Transversarie* (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 Staffe, by turning your transversary that way.

"And on the fourth side of the staffe in the middle are *double divisions*: that on the right hand *is a line of Æquall* parts to 100, reaching the whole length of the Staffe: 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 Staffe and Transversarie, and also of the Sines and Tangents may be divided into 6 parts which containe 1 minutes a piece: or rather into 10 parts containing 6 minutes a piece: for so they may serve also for decimals.

"Thus have you on the *two Rulers* the very same lines which are in *Circles of Proportion*: and whatsoever can be done by those Circles, may also as well be performed by the two Rulers." The rulers were kept together by the hand.

Addenda 3.
I have secured a copy of Seth Partridge's *Double Scale of Proportion*, London, 1662. The copy in the British Museum is dated 1671. His instrument was of brass or box. "It consisteth of three pieces, or Rulers, each one about half an inch in breadth, and about a quarter of an inch in thicknesse, more or lesse, as the Maker and User of them pleaseth; and for their length, they may be made to what length you will, either one foot, two foot, three foot, or more or lesse. . ." (p. 2). The rulers had "at each end a little plate of Brasse, or wood fitted to hold them close together, & so fastened to the two out-side pieces, that they may be kept steady, and the middle Ruler to slide to and fro between them" (p. 3). The instrument was of the duplex type. It had four pairs of logarithmic lines. The lines in each pair were identical and contiguous, one line being on the fixed part of the rule, the other on the slide. On the front side was the pair with the logs. 1—10, 1—10, and a second pair with the log, sine 1º. .. 90º. On the back side was a pair with logs. 1—10, 1—10, and a pair with log, tan. 1º (89º).,. 45º. Partridge tells how to solve $a:b = c:x$, $a:b = \sin C : \sin X$, a:b = tan C : tan X, tan A : tan B = sin C : sin X. There is no diagram of the instrument. On p. 188 he mentions Anthony Thompson in London as the maker of it.

Leupold in his *Theatrum Arithmetieo-Geometricum*, Leipsig, 1727, Cap. XIII, p. 71, gives a description of a slide rule which is almost word for word that of Partridge. Leupold said he did not know who the inventor was, that he possessed a MS. of 10 sheets describing it.

Addenda 4.
Hunt describes his rule in his *Mathematical Companion*, London, 1697, p. 7, thus:

"This *Rule* consists of three Peices, viz. One fixed, called the *Stock* (which is twelve Inches long) in which the other two Slide, and the *Lines* graduated thereon are these:

"I. Upon one *Edge* on the *Stock* is a *Double Line of Numbers* marked *D*, and a *Triple Line of Numbers* marked *E*.

"And on the *First Side* of this *Slider* are two *Single Lines of Numbers* marked *C*, one Facing *D*, and the other Facing *E*.

"On the *Second, Third*, and *Fourth Sides*, are six *Lines of Segments*, viz. Three for the *three Forms of Casks* in the *Clavis Stereometrice*, Lying, marked 1.*L*; 2.*L*; 3.*L*; to Slide by *D*, and Three for the three *Forms of Casks Standing*, marked 1.*S*; 2.*S*; 3.*S*; to Slide by *A*.

"II. Upon the opposite Edge on the *Stock* is a *Line of Artificial Sines* marked *SS*, and *a Double Line of Numbers* marked *A*.

"And on the *First Side* of this *Slider* is a *Line of Sines* marked *S*, Facing *SS*, and *a Double Line of Numbers* marked *B*, Facing *A*.

"On the *Second Side* is a *Line of Tangents* marked *T*, to Slide by *SS*, and a Line for finding the *Perifery of an Ellipsis* marked *0*, to Slide by *A*.

"On the *Third Side* are two *Lines of Segments*, one of a *Cone*, marked *A*, Facing *D*, the other of a *Parabolick Spindle Standing*, marked ( ) Facing *A*.

"On the *Fourth Side* are two *Lines of Segments*, one of a Sphere marked o, to Slide by *D*, the other of a Circle marked *0*, to Slide by *A*." There is no diagram of the instrument. It is worthy of notice that, on page 87, Hunt finds the length of rectangle whose area is unity and whose breadth is known, *by inverting the slider*. Hunt did this exactly one hundred years before Pearson taught the use of the inverted slider. Using the lines B and D (both double lines of numbers) Hunt says: "Draw out the Slider marked BS, and put it in the contrary way, setting 1 on B to 10 on D; Then against any *Bredth* in *Feet*, or *Yards* on one Line (it matters not which) is the *Length* on the other."

Addenda 5.
I have secured the 5th ed. of *Everard's Stereometery, or, The Art of Gauging Made easie, by the Help of a Sliding-Rule*, London, 1705. From the preface:
". . . many Thousands that have been Sold, and a Fifth Edition of this Tract, are so good evidence of its Utility, that it is as needless as unbecoming for me to say any thing in its Commendation. . . . the Principal Lines upon this Instrument are put [also] upon a Ton ACCO-Box, to slide one by another, as they do upon the Rule.
." Thus, the English anticipated the French in the effort to interest in the slide rule those who use snuff. Everard and Hunt appear to be the first to use the term "sliding-rule." Both used lines of single, double and triple radius, convenient for square and cube root. Everard gives no diagram.

Addenda 6.

The 5th edition (London, 1732) of Coggeshall's work has the title . changed *to The Art of Practical Measuring by the Sliding Rule*. On page 25 we read: "This rule is different from that described by Mr. *Coggeshall*, and which was all along made use of in the former Editions, but now is laid aside, as not being so compleat; for his made use of both Sides of the Rule in working Proportions, whereas this makes use but of one..." Mark the departure from the duplex type. The lines described are as follows: Three log, lines (two of them on the slide) are graduated 1—10, 2—10; the fourth (on the fixed part) carries the figures 4, 5, 6, 7, 5, 9, 10, 20, 30, 40.

Addenda 7.

Later there appeared the following publications on Palmer's and J. E. Fuller's instruments:

Fuller's *Computing Telegraph*, New York 1852 (copy in the New York Public Library); *Fuller's Time Telegraph*, (*Palmer's Improved by Fuller*) *Computing Scale*, Boston, 1852; *Fuller's Telegraphic Computor* (being letter press description of above), New York, 1852. The copy in the New York Public Library (1852) gives a reference to a London edition of the work. The instrument appears to have been used later in England than in America, as is shown by the following publications:

Fuller's. *Multiplication Chart*, London, 1870, 1880, 1885; *The Computer*, London, 1871, brought out by G. V. Marsh of Manchester and explaining Fuller's instrument.

Addenda 8.

Recently the following details about the slide rule in Russia have been received from Professor Cherepashinskii of the Imperial Technical School of Moscow. He says that he wrote his booklet, *Instruction in the Use of the Slide Rule, New System*, in 1878, that it was published in 1880 and was exhibited that year in the educational department of the Industrial Exposition in Moscow. He has no knowledge of Russian publications on the slide rule earlier than his own. His rule was introduced in 1886 in the intermediate schools of the Russian Communication-Ministerium. Now it is used quite extensively in Russian technical schools and in offices of engineers. Directions for the use of the slide rule in tacheometric work were issued by Professor Bogustawski in a book in the Russian language. In 1890 Professor Gasselblatt (elsewhere transliterated Hasselblatt) of St. Petersburg brought out a publication which we have mentioned earlier, in which a cardboard slide rule of the old type, without a runner is described. Also in 1890, A. Berle brought out in Wyshni Wolotchek (city near St. Petersburg) a work entitled *Systematic Collection of Exercises and Problems on the Slide Rule*, System Cherepashinskii. A second edition of Cherepashinskii's book of 1880 appeared in 1898

FIGURES

Fig. 1. – GUNTER'S SCALE
From a drawing in Edmund Stone's edition of M. Bion's *Construction and Principal Uses of Mathematical Instruments*, London 1723. Usually Gunter's scale was two feet long and had on it the following logarithmic lines: *S. R.* (sines of rhumbs), *T. R.* (tangents of rhumbs), *Numb.* (numbers), *Sines*, *V. Sine* (versed sine), *Tangents*, *Merid.* (meridian line), *E. P.* (equal parts).

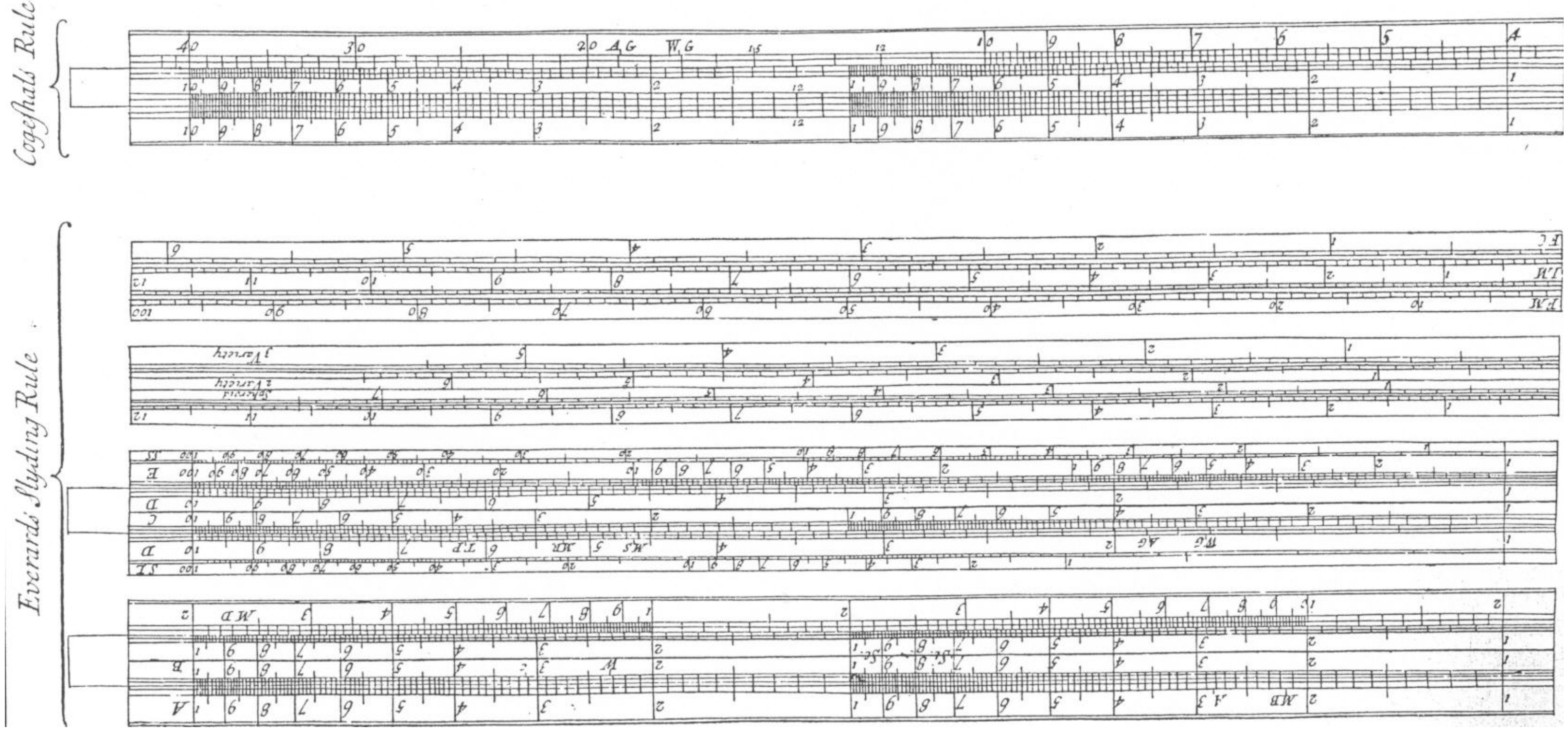


Fig 2. – EVERARD'S SLIDE RULE FOR GAUGING
Fig 3. – COGGESHALL'S SLIDE RULE
From a drawing in Edmund Stone's edition of M. Bion's *Construction and Principal Uses of Mathematical Instruments*, London 1723

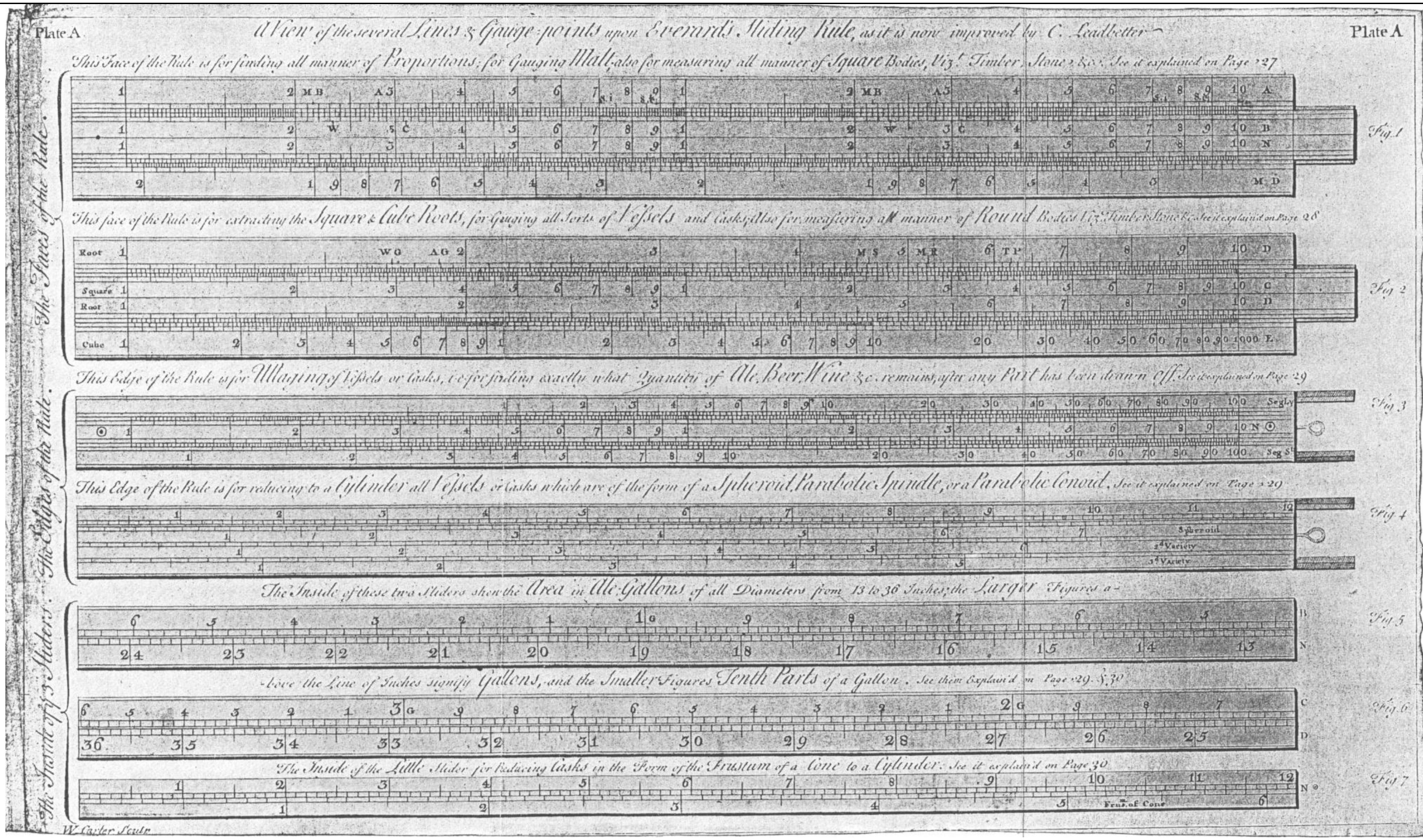


Fig 4. - EVERARD’S SLIDE RULE, AS MODIFIED BY C. LEADBETTER

Taken from C. Leadbetter’s royal Gauger, 4th. edition, London, 1755.

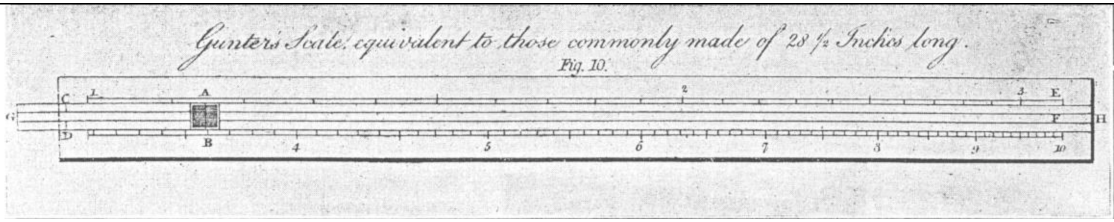


Fig 5. – ONE OF NICHOLSON'S SLIDE RULES OF 1787.
From the *Philosophical Transactions* (London), Vol. 77 (1787), p. 246. To solve $m : n = p : x$ put *CD* or *EF* at *n* and the runner *AB* at *m*. Then, by moving the slide, bring *AB* to *p*, and *CD* or *EF* gives *x*. Notice that *p* and *x* lie on the same side or, opposite sides of the slide, accoarding as *m* and *n* lie on the same side or on opposite sides of the slide.

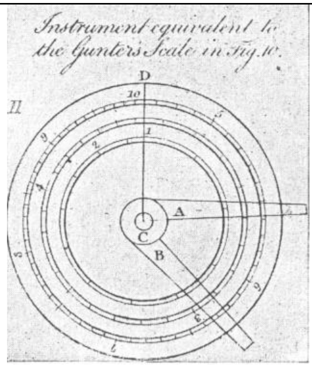
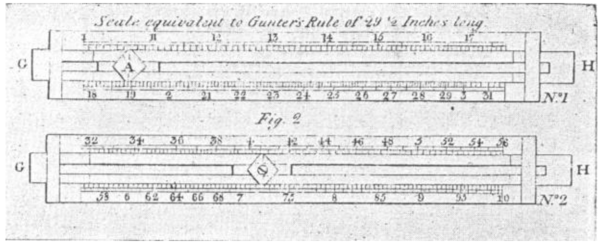
	

Fig 6. - NICOLSON'S CIRCULAR SLIDE RULE OF 1787 From the *Philosophical Transactions* (London), Vol. 77 (1787), p. 246. To solve *m* : *n* = *p* : *x*, place one leg at *m*, the other at *n*, and fix them to that angle. Then move first leg to *p*, and the second leg indicates *x*.	**Fig 7. - ONE OF NICHOLSON'S SLIDE RULES OF 1797** For *Nicholson's Journal of Natural Philosophy, Chemistry and the Arts*, London, Vol. I (1979), p.373. No.1 is the upper side of the instrument, No. 2 is the under side. By spreading the lograithmic line over both sides, the rule could be made shorter without sacrifice of accuracy. To solve *m* : *n* = *p* : *x*, put *CD* or *EF* at *n* and *AB* at *m*. Then move the slide until *AB* is at *p*; *CD* or *EF* indicates *x*. The relative position of *p* and *x* is the same as the relative position of *m* and *n*.

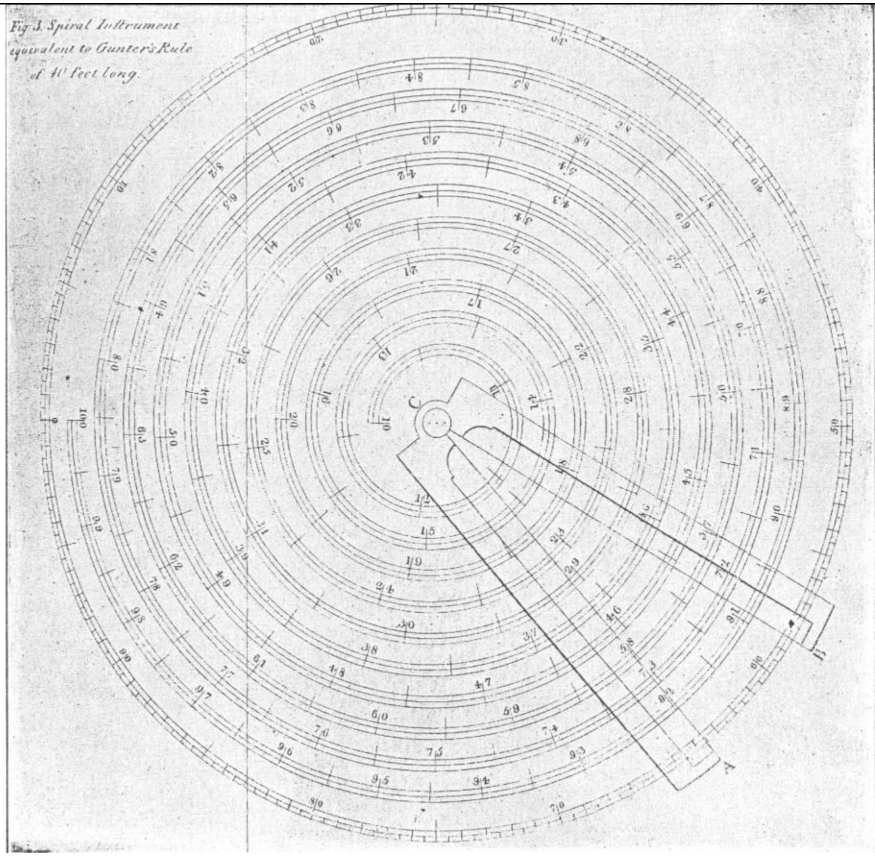


Fig 8. - NICHOLSON'S SPIRAL SLIDE RULE OF 1797
From Nicholson's Journal, London, Vol I (1897), p.372. To solve $m : n = p : x$ move one thread to m, the other to n, and fix them to that angle. Then move the first thread to p, and the second thread indicates x.

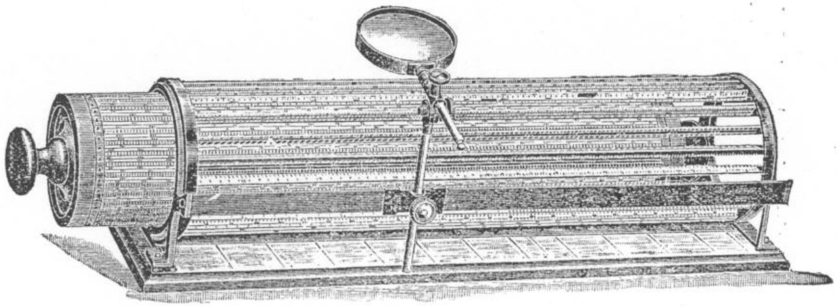
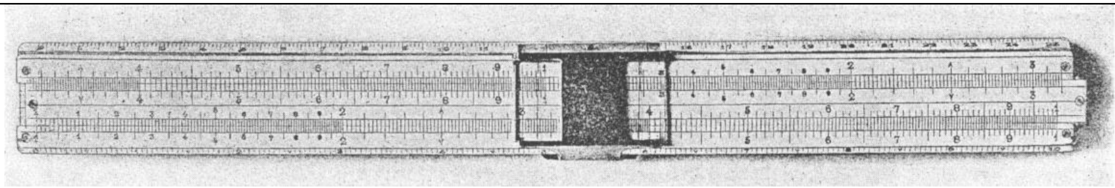


Fig 9. – THACHER'S CALCULATING INSTRUMENT



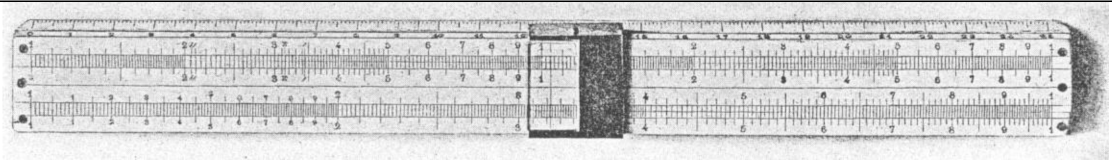


Fig 10. – RÈGLE DU COLONEL MANNHEIM (Lower illustration)
Fig 11. – RÈGLE DES ÉCOLES (Upper illustration)
From P Rozé, *Théorie et usage de la règle à calculs*, Paris, 1907

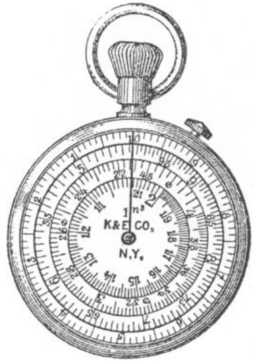


Fig 12. – BOUCHER CALCULATOR.

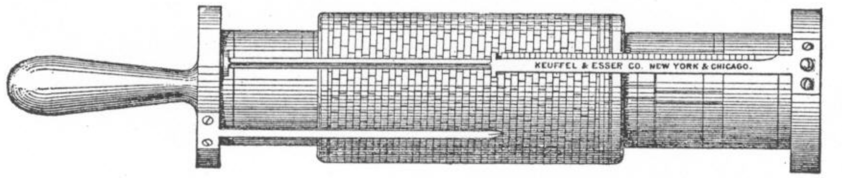


Fig 13. – G.FULLER'S SLIDE RULE

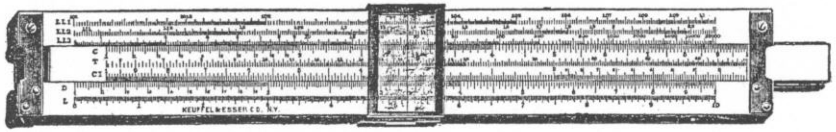


Fig 14. – COX'S DUPLEX RULE

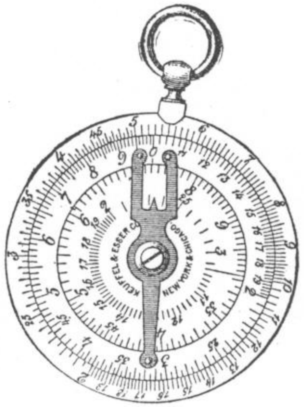


Fig 15. – CHARPENTIER CALCULIMETRE

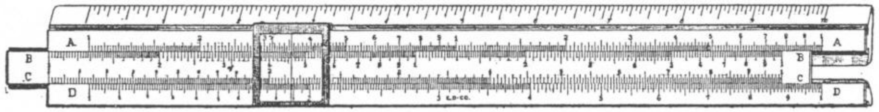


Fig 16. – THE MACK IMPROVED SLIDE RULE (MANNHEIM)

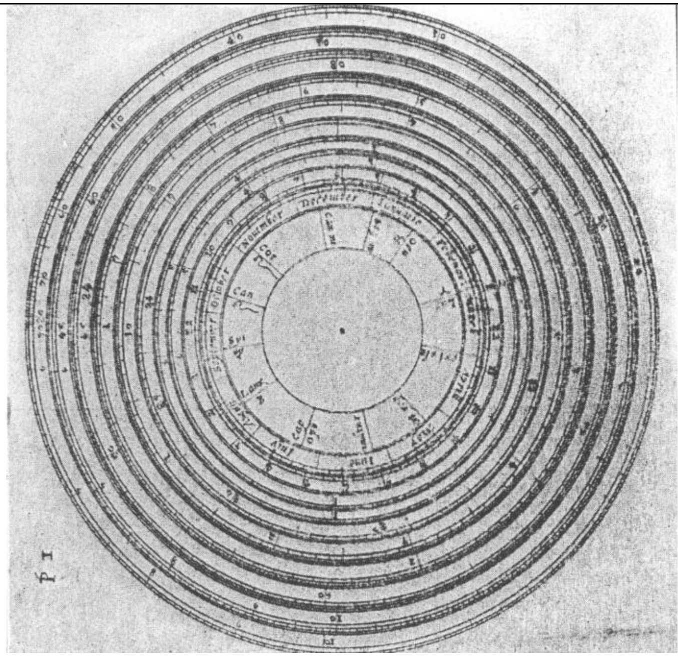


Fig 17. – OUGHTRED'S CIRCLES OF PROPORTION, 1632