Ready Reckoners

Bruce O. B. Williams and Roger G. Johnson
Birkbeck College, University of London

Multiplication is vital to the conduct of commerce but is time-consuming and error-prone. Many aids were developed over two centuries to address these issues. This paper surveys the development of the most widely used of these, the Ready Reckoner. The underlying principles of Reckoner design are explained. To explain their range of use, over 1,250 entries from the major national library catalogues and elsewhere have been classified by application, target user, date, price and format. A sample of different styles are illustrated.

Introduction

Multiplication was for many centuries regarded as a laborious chore, albeit vital for the conduct of commerce. It is only in the last 35 years that we have had electronic calculators capable of multiplying numbers comprising eight or more significant figures and even these cannot directly perform calculations in non-decimal units.

From the seventeenth century onwards, people applied all kinds of ingenuity to the creation of aids for multiplication. The best remembered *mechanical* devices are slide rules, stepped drum machines, pinwheel machines and keyboard machines such as the Comptometer that could multiply by repeated addition.

Almost forgotten now are the *printed* aids, the Ready Reckoners. These were printed books of tables of pre-calculated results of all kinds of multiplication useful for commerce, principally *price per unit* times units or *price per pound* weight times pound weight but also for calculating *wages* and *interest.*

All aids for commerce had to combine high precision, speed, and accuracy with, the ability to handle non-decimal measures and currencies, and be cheap enough to be bought for every day use by clerks and shop assistants.

We aim to show that for commercial use Ready Reckoners were far more important in terms of volume sales than all the mechanical devices put together, and that this was because Ready Reckoners out-performed the other devices on all the *key factors in the buying decision*: which we shall propose to be price, number of significant figures, accuracy, ability to handle non-decimal multiplications, time to learn how use the machine and time per calculation

The term “Ready Reckoner”, according to the Oxford English Dictionary, was first used by Daniel Fenning in 1757 as the title of his publication “The Ready Reckoner; or Trader’s Most Useful Assistant”, [1]. However, there were a number of earlier books of a similar nature such as William Leybourne’s “Panarithmologia: or, the Trader’s Sure Guide”, [2], which in later editions adopted Fenning’s term becoming “The Ready Reckoner: or, the Trader’s Sure Guide”. However, the earliest known such publication may be due to Simon Stevin. According to Ore, [3], “.. shortly before the appearance of *Le Disme* in 1585 Stevin had computed and published a set of interest tables”. An Englishman, William Webster, published a book of tables for simple and compound interest, whose third edition appeared in 1634, [4], see Figure 1 and Figure 2. In France, François Barrême’s published his “Le Livre des Comptes Faits”, whose third edition appeared in 1673, [5]. The charming frontispiece of a later edition of this book, shown in Figure 3, clearly shows that it was targeted at the retail trade. It was still being re-printed in 1862 making it among the longest lasting Reckoners.

Figure 1 Webster Front Page 1634

Figure 2 Webster's 1634 Compound Interest Table

Figure 3 Frontispiece of Barreme, 1762

Despite their long history, very little was written about these aids until the recent book edited by Campbell-Kelly, [6], which devoted just two pages to Ready Reckoners. Earlier standard works such as Smith, [7], are of antiquarian rather than commercial interest, but Smith does include a reprint of Arithmetical Books by De Morgan, 1847, [8], which is of some relevance.

There are other books and articles about *mathematical tables*, but most of them ignore Ready Reckoners as not being of interest to mathematicians working with logarithms, trigonometry, Gamma functions and the like. Glaisher's well known paper on Mathematical Tables, [9], is 175 pages long. It does include a handful of multiplication tables, but on page 2 he writes: "Life-assurance and annuity tables will be excluded. With regard to these last however, although all tables such as Ready Reckoners and common interest tables will in general be omitted, any one that is of value in relation to mathematics as a science will be included". Fletcher, Miller & Rosenhead, [10], do not mention them.

In this paper we review the history of Ready Reckoners. We also position them in the context of other contemporary aids available to business people. It is organised as follows:

1. The complex mix of commercial requirements, including (a) the handling of non-decimal units, (b) six-figure precision and accuracy, (c) low purchase price, and (d) ease of use.
2. The great importance of multiplication for working out prices, wages, interest and commission
3. The relatively small range of aids available for multiplication
4. The dominant position of Ready Reckoners within this range
5. The characteristics of Ready Reckoners: (a) design, (b) preparation and accuracy, (c) prices, (d) printing process, (e) production volumes and (f) examples.

1. The Complex Mix of Commercial requirements for multiplying aids

The preface to the first edition in 1874 of Collins National Ready Reckoner, [11], as quoted in the 1959 edition, summarises the compiler's priorities as: "perfect accuracy in all calculations, simplicity of arrangement, and such fullness of detail as to meet the wants of all business requirements". This summarises most of the issues that are addressed in this paper.

1a. Ability to handle non-decimal units

Non-decimal systems were a fact of life for all businessmen in GB and USA, since most American measures are still largely the old British pre-decimal ones, see Figure 4.

Figure 4 Non-Decimal measures

Figure 5 shows that decimalisation was achieved more slowly in the UK than in Europe and the USA has yet to adopt the metrication of weights and length. At first one might suppose that calculating aids would be most needed in countries with non-decimal systems. However, the calculation of both wages and interest payments involve non-decimal measures because of the use of years, months, days, hours and minutes. So to a considerable extent businessmen in USA had the same needs as those in GB to handle many non-decimal calculations.

Figure 5 Dates of decimalisation or metrication

Many Reckoners included conversion tables and sets of constants to assist users convert between non-decimal measures such as weight, time and distance into decimal fractions of a large unit such as a ton, hour or mile as appropriate. This facilitated multiplication by converting all the amounts into decimal notation. A consequence of regular use of conversion tables was that staff came to carry relatively obscure decimal fractions and constants in their heads.

1b. Six figure precision and accuracy

Precision is the number of significant figures in the result of a calculation. Commercial aids had to be precise in their results to the lowest unit of currency (the amount of payment to settle a transaction): a farthing in GB or a cent in the USA.
One farthing in £1000 was one part in 1000 x 240 x 4 ≈ 1,000,000 as is 1 cent in $10,000. This is six significant figures. Ready Reckoners delivered this precision which is several orders of magnitude greater than anything needed in the calculations for 19th century engineering.

Accuracy in this context meant that every digit in the result had to be correct but even this is a slight oversimplification. The business man wanted to know that in extending an invoice the right price had been multiplied by the right quantity, and that the correct answer had been entered in the right place. For a discussion of the use of check–figures to ensure the accuracy of addition and multiplication in commerce and a classification of errors, see Williams, [14].

1c. Low price for use by clerks, shop assistants

Most calculations in commerce were done by lowly paid clerks and shop assistants. Any aid to help them had to provide a cost-effective solution. A US clerk's wages were about $800 a year in 1920 according to a US Government report, [15]. In the 1920's a Comptometer cost $300-400 according to Martin, [16]. Its annual cost would have been about one fifth of the capital cost, say $80 a year, roughly 10% of a clerk's wage. If there were only one or two clerks there would be no opportunity to reduce staff and make savings. There was no saving until the company was big enough to employ a pool of, say, eight full-time Comptometer operators to do the work previously done by nine or ten clerks. This would have limited sales to larger companies. Worldwide sales of comptometers between 1920-1926 were about 80,000 a year, see below [17]

1d. Easy to learn and use

Business wanted aids that could be used by school-leavers without special training, for which they would have had to pay either by course fees directly, or through increased pay rates. Training in the use of machines could be expensive although details are very sparse. An advertising feature for training Comptometer operators, included on a web site devoted to the Sumlock Comptometer Company [18] says that in 1967 courses to train Comptometer operators lasted 15 weeks and cost 35 guineas (£36.75) in London and 30 guineas (£31.50) outside London. A course lasting over three months and at such a high cost would have been an intolerable burden for smaller companies in addition to the cost of the machine.

2. The great importance of multiplication in business

Much attention has been given to adding machines, for example, in the recent reprint of Martin's 1926 book on calculating machines, [16], and Russo in 2001, [19]. However, before having a list of sums of money to add on an invoice, for example, or in creating columns of Debits and Credits, a price had to be multiplied by a quantity to get the amount of a transaction. Consider what is involved in a typical single transaction represented diagrammatically in Figure 6. This is part of an invoice from a steel warehouse regarding the sale of a square of steel plate, a length of steel joist and a circle of steel, plate. First the area of the pieces of plate had to be worked out, and from this the weight could be derived. The weight of the joist was looked up in a table per linear foot. All these weights then had to be multiplied by the price per ton to give the line value. Consequently this one invoice involved eight multiplications, all non decimal times non decimal, averaging two to three per invoice line. The total weight was later reconciled with the weigh ticket for the total lorry load. Note that Item 2 involves not one multiplication but the squaring of a number, its multiplication by π, with the result being divided by 4. In addition, although the length is shown in ft and inches, this would have to be converted into inches in the head.

Figure 6 Schematic part of a steel warehouse invoice with eight multiplications

Typically, in a similar invoice averaging ten lines there might be thirty multiplications and two additions. Multiplication is very much more time consuming than addition. Multiplying, 4 tons, 8 hundredweight, 2 quarters and 6 pounds by £25.8s 6d per ton by hand would have taken minutes rather than seconds. However, clerks could add a column of, say, 20 £sd amounts in a few seconds.

The 1000 employee family business where one of the authors, BOBW, worked in the 1950's employed between six and ten comptometer operators extending invoices in £sd and tons, cwts, qtrs, lbs and about six book-keepers for the ledgers. Another three to four people worked out wages and salaries, which was essentially a multiplication task. They also employed half a dozen estimators, working out prices, much of the work being multiplication. Roughly then, there were 15 "multipliers" to 6 "adders". So it is not surprising that companies were willing to spend more money on multiplying aids than on simple adders.

A more scientific comparison was made in 1960 in Australia by professional accounting bodies. Tests carried out in connection with the use of decimals were reported in the Office magazine, [20]. These tests were made using "key-driven adding–calculating (non-listing) machines". Figure 7 shows that they found that multiplication was 88 times longer than adding in £.s.d. units.

Figure 7 Comparison of adding versus multiplication time

3. Range of Aids available for Multiplication

The following paragraphs are intended to show briefly that there was little choice for business. The non-mechanical aids below are admirably described in Horsburgh, [21], and the machines in Martin, [16].

3a Non-mechanical aids

The **abacus** was widely used in the East and in Russia until the 1990's. However, although widely used in the West until 250 years ago its use is not even a folk memory, surprisingly even in countries using largely decimal units, see Williams, [22]. However, for most of the 19th and 20th centuries it was by far the cheapest, fastest, and most precise device available anywhere in the world for decimal calculations. For a report of an abacus beating an electrical calculator in Japan in 1946 see Ifrah, [23] p567. For an account of Lee Kai Chen beating an electronic computer in Seattle in 1959 see Dilson, [24], p.84.

Tables of logarithms (see Napier Tercentenary Volume essays, [25]) were produced from 1614 to the 1960s and the advent of cheap electronic calculators. However, the commonly available 4-figure tables lacked the precision needed for commerce, having only four significant figures. For non-decimal amounts the user had to convert them to decimal, carry out the multiplication using logarithms and anti-logarithms, before finally converting the answer back to non-decimal. The most practical way to do these conversions to and from decimals was to use a Ready Reckoner.

Tables of Quarter Squares were printed from 1817 to 1933. These were used in business and were possibly more useful than log tables but still only worked for decimals. These little known devices work on the following principle:

$(a+b)^2 = a^2 + 2ab + b^2$ and
$(a-b)^2 = a^2 - 2ab + b^2$

By subtraction of these two expresssions, the **product** ab = ¼ of $(a+b)^2$ - ¼ of $(a-b)^2$.
Thus to multiply a by b, look up the **quarter square** of **a+b** and subtract the **quarter square** of **a-b** Hence the need for **tables of quarter–squares.** The calculation is claimed to be simpler than using logarithms, because you only need to look up two numbers. See Laundy, [26] and Glaisher, [27].

Mass produced **slide rule**s were available from about 1880 at a reasonable price, see Hopp, [28]. However, their precision was even less than log tables. There were all sorts of attempts to increase the precision with longer scales, as described by Chamberlain, [29]. In the grid-iron types, the scale was cut up into a number of strips. In the helical devices, the scale was wrapped round a cylinder, to give a length up to 500 inches and a claimed accuracy of five significant figures. Lastly, there were the bulky and expensive 500 inch Fuller machines, described in Feely, [30]. They could not readily handle non-decimal systems. Hopp, [28], notes that "at approx. £5/10s/0d in 1938, it was very expensive, and it is doubtful whether many private individuals had the means to afford one".

3b Mechanical devices

Machines for multiplication were expensive, hard to use and not all that easy to learn. The "Britannic" Pin-wheel machine cost £50 (approx $200) in 1928 and the catalogue, Stanley [31], claims: "even a junior can be instructed in its use in less than an hour" but it may have taken longer to attain full proficiency. A machine of

this type was still in use in the Dealing Room at the Bank of England in 1965, see Keyworth, [32], and another at Shell until 1962 (communication from the archivist). The most elaborate multiplication machine was the "Millionaire" designed by Steiger and made by Egli. It is described by Horsburgh, [21]. This was capable of 20 significant figures. About 4700 were sold between 1897 and 1935, according to de Brabandere, [33]. It was very expensive at about $500. These machines produced no printed record of the calculation, so there was no check on the correct entry of multiplier or multiplicand, although these were visible on windows until the machine was reset for the next calculation.

Comptometers were originally adders, but they were good for multiplying by repeated addition. However, as noted above, they were not cheap and required specially trained operators. Comptometers differed from other machines used for multiplication in that there was no temporary record of the multiplicand or the multiplier. Businesses therefore often employed supervisors who only accepted a result when two operators independently arrived at the same answer. They came into use in the UK for multiplication in larger companies such as Shell in the 1920's. (A note in Shell Group Archives GHS/2B/72 records that "we had 4 in 1923, worked by women"). In 1923 a service bureau was set up in London to provide computing services to smaller companies, based on Comptometers and a Hollerith installation. (O*ffice Magazin*e, June, 1923). Comptometers appeared in smaller firms after WWII. The operators still had to learn to decimalise money and measures in their heads. In 1909 Dorr E Felt, the inventor and maker of the Comptometer, took out two British Patents for a Comptometer with an attached cylindrical tabular calculator in an unsuccessful attempt to overcome the £sd problem. For more about the history of Comptometers, see Boering,[17]

Punched card multipliers had little penetration in commerce before WWII, being used mainly for producing analyses of invoices or payroll sheets rather than extending the individual lines, and were used only in a few large organisations. Comrie's very detailed and apparently authoritative 1930 review article, [34], states that multiplication was not offered at that time by Hollerith or Powers in the UK. However, the Science Museum, London has on display photocopies of an invoice dated 1930, with the prices extended, for the Ardath Tobacco Co together with the Powers Samas punched card that generated the invoice lines. The authors have not yet found any information to resolve this apparent contradiction. However, Campbell-Kelly and Aspray, [35], write "Accounting machines only added and subtracted, so that utility companies, for example, who charged customers on unit-cost-times-quantity basis had to perform the necessary multiplication prior to the punching operation. The multiplying punch introduced in the early 1930s was designed to satisfy this need". For a fuller discussion of punch card systems, see Norberg, [36].

4. The Dominant Position of Ready Reckoners

We have suggested that the factors important to business included price, number of significant figures, time to master the machine, and calculation time. We shall now attempt to position the Ready Reckoner against its competitors with respect to these parameters. In Appendix 1 we include a table characterising a representative number of aids representing each major type available. We can summarise the above data by class of aid in Figure 8.

Figure 8 Characteristics of different classes of aids

It is clear that Ready Reckoners were highly successful because they excelled on all the key characteristics:

- Price - cheapest in the West
- Non-decimal capability - ahead of all other aids
- Significant figures - as good as any thing else
- Learner days - the best
- Calculation seconds - excellent

It remains to be more precise on what we mean by "successful". Our tentative estimates of world sales volumes in thousand items per year in an average year between 1900 and 1950 are given in Figure 9. Ready Reckoners are high, followed or bracketed by Comptometers and then pin wheel machines.

Figure 9 Rough Table of Sales Volumes by Aid Class

We now turn to a qualitative discussion of the dominant position of Ready Reckoners in the late nineteenth and early twentieth centuries.

The Victorians were fascinated by Ready Reckoners. Wise, [41], says on p 318:

> *"By the 1860's, the favourite device for lessening the work of the computer (human), the mathematical table, had become an object whose dizzying rows of printed figures would fascinate the Victorian public. These tables displayed the limitless fecundity of numbers, and transformed them into a commodity that would bring the power of calculation within the reach of the ordinary citizen. The centrality of tables of numbers and calculation to mid-Victorian life was famously portrayed by Charles Dickens' character Thomas Gradgrind, who always had a rule and a pair of scales and the multiplication table in his pocket."*

In the 20th century this interest continued. We now provide a series of quotations discussing the use of Ready Reckoners from books and magazines aimed at the business community from 1908 up to the early 1960's.

1908

An early example, in July 1908 issue of *The Organiser* magazine, noted under the heading "Some Useful Ready Reckoners":

> *"We have lately had several queries from subscribers relating to reckonings and rules for reckoning, and we therefore think that it will be useful to many of our readers if we direct their attention to some books published on that subject.…*

1923

Office Magazine June noted that the Commercial Calculating Company "compiled original decimal equivalent tables and business ready reckoners for special trades and professions."

1933

Campbell, [42], wrote in the trade magazine *Office Management* "Before the advent of counting machines, the Ready Reckoner was the only aid we had in the making of office calculations; **many offices have still no other aid**."

1951

Cemach, [43], wrote in a guide to using punch card office equipment:

> *"The {punch card} operator could read the hours and rate from the clock card or time sheet. She would have to obtain the value from a **ready reckoner** (unless somebody else had worked it all out previously on the clock cards) or alternatively she could leave the value column blank and later put all the cards through a Multiplying Punch, if one was available. And not only would she have to do all that, but all her work would have to be repeated by the verifying operator."*

1958

Office Magazine in November 1958 noted under a review of a paper by Unilever entitled *Good ideas from Unilever Ready-Reckoners:*

> *"The authors are firm advocates of **ready-reckoners**, specially prepared to meet the needs of each department. The weakness of the standard-book variety, they say, is that it attempts to cater for too many users. Several drawings are reproduced to show the different format that ready-reckoners can take and how they can be built into a general procedure.."*

1959

An article in *Office Magazine* in January 1959 by A F Warburton on Calculator Terminology observed:

> *"When considering the use of a calculator in one's own office, the first thing to do is to write down in detail the number and the precise nature of the calculations that have to be done, at the same time ascertaining the maximum number of digits normally involved. If this investigation reveals that the bulk of the work consists of one type of calculation, the purchase of **ready-reckoner tables** may prove a better investment than a machine. For some types of calculations within limited ranges, such as barrelage conversion in the brewing industry, suitable tables can easily be prepared. The tables may be drawn up in colours to facilitate quick reference or, if the range of factors is small 'blown-up' tables may be used. Ready-*

reckoner tables are speedy, accurate to the required degree and avoid decimalization in the case of sterling calculations."

1961

An article in *Office Magazine* in September 1960 by LM Nation-Tellery describes the installation of a Class 32 SM (Sterling Multiplier) machine at a British wholesale grocer. The author noted that previously:

*"**ready reckoners** were used for extensions, with the additions done mentally. All the amounts and totals entered by the pricing clerk were handwritten. Because of the volume of work handled, two pricing clerks were necessary, but worked in tandem with two more clerks whose function was to check all the figure work".*

They handled 2,500 extensions a day. Perhaps recognising the limitations of Ready Reckoners, Nation-Tellery took out a GB patent for a Tabular Calculator in 1948.

The reader will note from these quotations that the Ready Reckoner played an important role in many offices from their inception to the 1960s. Nonetheless, while clearly a widely used, cheap, labour saving aid, the book format had limited legibility and row/column identification.

5. Design of Ready Reckoners

The basic concept of a **set of pre-calculated tables** sounds simple enough. But in the other devices, such as mechanical devices, slide rules and logarithm tables, the user can do any calculation, albeit only to the level of precision built into the device, and usually decimal only. With a Ready Reckoner the user can *only do those calculations selected by its compile*r. So the compiler had to understand the likely user needs, and then to optimise the variables at his disposal: which were number and size of pages, font and type size, ranges of values and the steps sizes.

5a Pagination, language and size

Ready Reckoners came in all sorts of sizes from pocket books to hefty desk top tomes, weighing several pounds but still much lighter and potentially more portable than the alternative mechanical devices. The average of 572 items with known pagination is 160 pages, with a median value of 104 pages reflecting the vast diversity.

Reckoners came in many languages. Probably because of the work involved in their initial preparation there is evidence that they were translated from one language to another. Fenning's Ready Reckoner, [47], was originally printed in English in 1757 and went through numerous editions. The 7th edition was translated into German and published in Germantown, PA by the famous pioneer press of Christopher Sower in 1774 alongside an English language version. Both versions were subsequently reprinted a number of times.

Figure 10 Title Page from first American Ready Reckoner 1774

To this day a major activity at the Annual International Book Fair at Frankfurt is the buying and selling of foreign rights for material that is not language specific, such as tables and illustrations. However, we have not yet found any English versions of French or German material although Oehlschlager produced in Winnipeg, Canada, a German/English bilingual version of his earlier German Ready Reckoner, published in Philadelphia circa 1868.

5b Layout

A page from Leybourne's 1798 Ready Reckoner, [44], is shown in Figure 11. This shows how Leybourne displayed the products for one price, 20 pence and 3 farthings, on one page. This page gives results for 1 to 99 items, and then 100 to 900 in hundreds and 1000 to 10000 in thousands The total number of the product cells is therefore (99 +9+10)=118. The main set of tables in this book took 223 pages like this. The number of calculations was thus 223 times 118 = 26,314. The little square at bottom right added more value by giving "*the great or long hundred, viz. 112 lbs, by which most heavy goods are bought and sold; the gross viz. twelve dozen by which Gloves, Buttons, &c .are bought and sold; the Wey of cheese, Salt, &c. which is 256 lbs.; The number of days in a Year, by which the amount of Daily expenses, or Wages may be known; and likewise the number of feet in a solid Rod of Brick Wall, which are 272*."

Figure 11 Page from Leybourne 1798

Formatting of Reckoners was always a challenge for compilers and printers. Suppose a Ready Reckoner was to provide prices, with a range from 6d per ton to £140 a ton, by steps of 6d, for weights from 1lb to 2tons, in steps of 1 lb. This could easily take 5600 pages. So drastic reduction was required. This could be done by breaking up the table into ranges or brackets, for example, making the weight step larger, say, a quarter (28 lbs); and adding one small table for 1 to 27 lbs. This could cut the size down to a manageable 500 pages. To get the price for 3Qtrs and 7lb, the price for 3 Quarters was looked up in the main table and then the smaller table used for 7lb, and finally the partial products added together.

The compiler could also break down the prices into brackets, say 1d to 11d, 1s to 19s, £1 to £10. The user then had to add up several subtotals, for example: number of pence times pounds weight, number of pence times quarters, number of shillings times pounds weight, number of shillings times quarters, number of pounds £ times pounds weight, number of pounds £ times quarters.

In fact, Gall & Inglis addressed this problem by printing several books, stating "Owing to the enormous range required by the increased rates now current, it has not been possible to include them within the limits of a single volume." So they produced volumes for 1-56/-, 56-140/- and 140-224/-. As a consequence the user might have had to consult three volumes, each costing 2/6d. Each volume, with ancillary tables, is just under 200 pages.

There were some other tricks to cut space. In pure multiplication tables, say for 1-100 times 1-100, a half of the cells are repeated (14x68 = 68x14). There were ways to remove the duplication, omitting half the products and then re-arranging the layout of the resulting triangle, as shown in Figure 12.

Figure 12 Triangular Multiplication Table from The Express Ready Reckoner by Gall & Inglis. No date.

"The Readiest Reckoner Ever Invented" compiled by Simpson & Wise and published by William Tegg, London in 1862 claimed a unique approach writing: "The present work differs from every book of this kind: the reference being in the first instance to the number instead of the price: for example, if 103 be the quantity wanted, at 17s 11d per pound, yard, &c., turn to page 103 and opposite 17s11d will be found £92.5s.5d. The answer required." The pages went from 1 to 110 rising one at a time, then went 112, 144, 200, 250, 256, 272, 300, 365, 400, 500, 600, 700, 750, 800, 900, 1000, 1250, 1500, 2000, 3000, 4000 and by 000s to 10000. This system of starting with the number rather than the price was also used in the Ready Reckoner published by Fisher & Brother, Philadelphia, possibly in 1873. It went from 1 to 138 in steps of 1.

There were various attempts to cut a page up into strips. Dunlop's was patented as shown in Figure 13. An example of the Reckoner survives in the Arithmeum Museum in Bonn.

Figure 13 Dunlop's calculator GB Patent 124/1862 Abridgment

Another "completely new system" was by Robert Anlezark, [46]. He managed to make the left hand column act both for days for interest calculations and for units for pricing. Page 1 is shown in Figure 14.

Figure 14 Anlezark's entirely new System 1871

An ingenious Reckoner for simple and compound interest was devised by Remig Rees and called Der stumme Diener (Dumb servant) Universal Schnellrechner, shown in Figure 15. It was published by Merkur Verlag in Wehingen, Germany and is undated.

Figure 15 Universal Schnellrechner

Source Arithmeum Bonn.

The Schnellrechner above is an example of the need with some designs of Reckoner to add up partial products to arrive at the final answer. A logical idea was to attach a small adding device to the Ready Reckoner. Thus the Bergmann Universal calculator of 1920 added a stylus adder, the Correntator. This adder was made in Germany and sold in the US by Universal Calculator Corporation, New York. The combination was made by Firma Continentale Buro-Reform Jean Bergmann, Berlin and is shown in Figure 16.

Figure 16 Multiplication Table from Bergmann Universal Calculator with The Correntator Stylus adder, 1920

5c. Short cuts

There were some application specific short cuts, such as this one for interest calculations from an American Reckoner, [47] of 1911:

> "*The method of reckoning interest generally used by the best accountants and book-keepers is what is known as the sixty day method. By this method 360 days are reckoned as a year and 30 days as a month Six p. c. for 12 months, or 1 year, is equivalent to 1 p. c. for 2 months, or 60 days, and 1 p. c. of any number is easily found by moving the decimal point two places to the left. Therefore, the interest on any amount at 6 p.c. per annum for 2 months, or 60 days, may be found by moving the decimal point two places to the left. Having found the interest for 60 days, in order to find it from that amount for any number of days, simply divide them into aliquot parts of* 60."

In later years devices for interest calculations were developed to handle not only 365 days in a year but also Leap Years, Grace Days, Public Holidays and so on.

Arithmetic short cuts were also a regular feature of introductory sections of Ready Reckoners. They also appear in books such as Pitman's Office Desk Book which gives a range of "Arithmetic Short Cuts" devoted entirely to multiplication, division and closely related calculations, [48], where they are supplemented with a basic set of Ready Reckoner tables and conversions.

6. Preparation and Accuracy of the Tables

Eliminating all errors was always recognised as a major challenge. In the introduction to his early Ready Reckoner, [1], its compiler, Daniel Fenning, states that:

> *"'Tis true that nothing is more liable to Errors than large Tables of any Sort; for though there requires no great Scholarship to make such a plain Book; yet the vast Multiplicity of Figures, and continual Series of different Numbers, render the work much more difficult than Persons in general are aware of; and though it is possible that such a Book may be correct, yet it may naturally be expected that Errors of some Sort or other may slip the Notice of the most attentive single Examiner. This being the real Case of Works of this Sort, I have taken all the Care that Time and Ability would allow of, to prevent it, and can assure the Public that every single and separate Sheet has been examined by three different Persons with all possible Caution and Attention, so that I am apt to think you may depend on the Exactness of the Calculations."*

Notwithstanding the former checking, the 9th edition goes on to record that it has been "carefully revised and corrected by Joseph Moon, Mathematician, Salisbury".

Some Ready Reckoners claim to be the result of two independent sets of calculations. For example, "The Readiest Reckoner Ever Invented", compiled by Simpson and Wise, was first published by Sharpe & Hailes in London in 1811. In the preface it says:

> *"the correctness of the Tables is insured by the circumstance of two sets of them being separately calculated by different individuals, by each of which the other has been checked, and the printed sheets have been revised in the most careful manner from the copy not used in the printing office."*

In 1862, the preface to the 13th edition, by now published by William Tegg in London, states that it was recalculated by Charles Ody Rooks. The preface to the 13th edition says:

> *"The publishers deem it necessary to state that the greatest attention has been given to have the Work perfectly correct; and with this view, besides careful examination with the original (in the*

production of which the most indefatigable pains were bestowed to ensure its correctness), the whole has been submitted to a fresh calculation; it is therefore presumed that it may with safety be relied upon."

There are three principal classes of error in the preparation of Ready Reckoners:

1. The multiplication is wrong because of either a computing error or a printer error.
2. The multiplication is correct, but is placed in the wrong cell by either the human computer or the printer.
3. The row or column label is incorrect due to printer error.

There are some early examples of Ready Reckoners which actually admit "defects and omissions" in previous editions, for example, The Moulders' Ready Reckoner, compiled by Neave, [49]. In a table from this Reckoner one of the authors, BOBW, has verified all the product cells using Excel, but found an example of the third type of error in the Diameter column, where there are two rows marked **6,** but the second one should be **6½.**

An advertisement for *A Series of Metric Tables* compiled by Dowling, 1886, published by Crosby Lockwood & Co quotes from the *Builder:* "Their accuracy has been certified by Professor Airy." (Airy was Professor of Astronomy at Cambridge and later the Astronomer Royal). Crosby Lockwood also published a Discount Guide and claimed that "We have the high authority of Professor J R Young (Late Professor of Mathematics at Belfast College, *Ten editions of whose Rudimentary Treatise on Arithmetic were published by Crosby, Lockwood.,*) that the tables throughout the work are constructed upon strictly accurate principles."

Machine calculation did not eliminate error. There is at least one machine-calculated Reckoner, Shorthose's Commercial Ready Reckoner (10th edition) of 1921, [50], which says on the Title Page: "Stating the value of weights ranging from ¼ Cwt to 50 Tons at Prices extending between one Penny to £3 14/- per ton inclusive. The calculations of prices from £2 10s 3d to £3 14s 0d have been compiled on a Burroughs Calculator Machine by the Burroughs Company Ltd, Cannon St, London E.C.4". Despite the Burroughs involvement, there are several erratum slips. These have survived intact: the copy went from the Standard Telephone & Cable Technical Library to the Science Museum Library in 1972. At some time the corrections have been inked in by hand, as shown in Figure 17.

Figure 17 Three erratum slips - probably due to printer's error

The erratum slips in Shorthose remind one of Babbage's insistence that much of the problem with tables lay with the type-setting rather than the computer. Morrison and Morrison, [51], note on p. xvii that: "He (Babbage) was greatly concerned about the errors introduced in the processes of printing and publishing tables, and listed and analyzed many repeated errors." Finally, the authors of this paper feel bound to observe that despite the care taken over the preparation of the Ready Reckoner, its users still have to note the price for the tons and then the cwts, then the fractional cwts, and finally add the three to get the total price. Inevitably this must also have given rise to errors.

Swade in Campbell-Kelly [6], discusses calculating and checking on pp 149 of his paper. Given Swade's interest in Babbage, Swade's comments mainly relate to classes of table where the use of differences for initial calculation and then checking is particularly relevant. Some of these classes exclude the largely non decimal products in many Ready Reckoners which often have less obviously regular differences between rows. Interestingly in the light of our earlier comments on the double checking of Comptometer results, Swade points out that "The technique of double computation was not foolproof and it was not unknown for computers who, despite insulation from each other, produced the same incorrect result."

The Routledge archive at University College, London throws further light on accuracy and calculation. Tucked in the firm's Publishing Journal is a printed slip showing the corrigenda for the 1921 42nd reset edition of Lawrie's High Interest Tables. This shows over 30 corrections, presumably due either to errors in re-setting the type or errors in the previous edition. There is a note that a new table of ⅛% was inserted into this edition for the preparation of which the Commercial Calculating Co, Ltd was paid £2 2s, while W J Macdougal received £30 for "editorial work on new tables".

Ready Reckoners compiled by Electronic Computer

The Rich Man's Ready Reckoner, [52], compiled by Brown and O'Brien and published in 1970 claims:

> *"Other reckoners leave off at a miserable 10,000. This reckoner is strictly for people who deal in real money - calculations go up to ten million in both sterling and decimals.*
>
> ***Introduction***
>
> *You don't have to be rich to find this book useful. You just have to be tired of working out complicated figures in a hurry. Especially when you're dealing with really large numbers. We were and that's why we make no excuse for putting yet another ready reckoner on the market. Ours include the present currency along with the decimal one, since we know that for a considerable period of time people will need to compare the two. It is also possibly the first book of this type to be compiled entirely by computer."*

Despite the computer the publishers were taking no chances:

> *"While every effort has been made to ensure that the contents of this book are accurate and correct, the publishers do not hold themselves responsible for any loss that might arise through any inadvertent errors contained in the text."*

In the same year, 1970, there appeared *"Financial compound interest and annuity tables. Fifth edition. (Second printing.) Computed by Financial Publishing Company under editorial supervision of Charles H. Gushee. Financial Publishing Co. Boston, Mass. London: Routledge & Kegan Paul".* BOBW used a copy for Discounted Cash Flow calculations for many years, up to the advent of the Scientific Pocket Calculator. The book does not say what computer was used The pages are a mix of a main portion in sans-serif characters that look like a photocopy of a computer print out and elegant type set borders. Gushee provided "*An interpolation plan by the Lagrange method especially adapted to the convenience of modern calculating machines. Publication of precalculated factors of this type for financial use was first made by Mr. Arthur S, Little in 1927"*

Three years later in 1973, we find "Nuttall's metric conversion tables computed by the London University Computing Services Ltd.", [53]. It does not say how it was computed although the company used the London University Ferranti Atlas computer at the time. It is a very small booklet of conversion factors with no multiplications. The pages look like images of computer print out.

7. Printing Process

Swade in Campbell-Kelly, [1], describes printing and the use of stereotypes on pp147-149. A stereotype is a printing plate (usually mounted as a block). Stereotypes were often mass-produced and sent to many printers and newspapers. The stereo was produced by a moulding process. The advantage was that when another edition was needed the stereotype was ready to go, while conventional type might have been unset or knocked about. A stereotype avoided introducing new errors in a new typesetting, but you preserved any errors from the previous edition. Swade concludes that stereotypes provided an economical way of preserving the investment in typesetting and proof reading, and extended confidence in highly reputable tables to subsequent editions. Weedon [54] discusses stereotyping and electrotyping in some detail, but with no specific comments on Reckoners.

The authors have found five Ready Reckoners published between 1814 and 1850 which explicitly state to be printed from stereotypes. In addition to these early Reckoners, nearly all of the 45 editions published by Routledge in the first half of the 20th century, and discussed later, were printed from stereos, as shown by the frequent small charges for repairs listed in the Publishing Journals in the Routledge archive. Tucked into one Journal is the following letter to Routledge from its printer, Brendon & Son Ltd. of Plymouth, dated 19 Feb 1926,

> *"Master's Ready Reckoner - With regard to your suggestion to make a new set of moulds before the plates show signs of wear, we advise you that we already hold a set of moulds for this particular Ready Reckoner, complete with the additional tables at the foot of the pages. The moulds of the tables are separate, but are complete with the folio, and in the event of casting a*

set of plates for any future commission it would be necessary only to join on the stereo of the table to the top portion."

8. Prices of Ready Reckoners

The main sources of data on prices are the Reference Catalogue of Current Literature (RCCL), [55] and the Cumulative Book Index (CBI), [56]. We sought to relate price to usefulness. The number of calculations in the Reckoner seemed a likely measure, and indeed publishers emphasized this measure. For example, the cover of Chadwick's 420 page Weight and Number Calculator, [57], published by Crosby, Lockwood states it contains "250,000 direct calculations producing by a single addition to each a combination of over 20 million calculations!" The cover of Warne's Model Ready Reckoner, pocket size, 288 pages, announced 40,000 calculations, [58]. We found no correlation between price and either the number of pages or of pages and number of calculations. Given the wide range in the number of calculations per page due to variations in page size, layout and font size this was to be expected.

We have also examined the relationship between the number of direct calculations and their price. Data is available for twelve Ready Reckoners published by Delbridge of US from 1911 to 1920. Similarly we have found data for fifteen British Ready Reckoners from 1920 to 1959. The data has been analysed statistically and shows that the regressions are statistically highly significant with a cost of GB £0.0035 per calculation while the Delbridge data gives US$0.0006, both converted to 1914 values.

There is one important complication regarding pricing relating to the nature of the binding and paper. Reckoners had to withstand rough usage. In consequence publishers offered a range of binding, from paper through board to leather. In addition, different papers were used. and India paper was sometimes offered, presumably to give strength and reduce bulk. So in 1915 the Gall & Inglis Gem waistcoat pocket reckoner cost 1s 6d in leather printed on India paper while an abridged plain version was only 1 shilling, or two-thirds that price. The Crosby Lockwood Reckoner cost 30s, a great deal of money at the time, but BOBW's leather bound copy is in perfect condition today apart from slight scuffing of the corners of the cover attesting to its hard working life.

9. Production volumes

9a Titles or "Items"

Searching the Subject Index of the British Library On-Line Catalogue, [59], for "Ready Reckoner" gives 576 items and using the Title Index for "Ready Reckoner" gives 636 items. The Bibliothéque Nationale in Paris, France, [60], lists 730 titles from a search for "bareme". The US Library of Congress, [61] shows about 210 titles for "reckoner". It is possible that the library of Congress holding is less representative than the BL holding. Some Ready Reckoners are listed under "Calculator" but this category covers much other material and the authors have not attempted to extract those that might be of interest to this study.

We have merged the data from the British Library and the Library of Congress with price and publication data from the US Cumulative Book Index (CBI), [56] and the GB Reference Catalogue of Current literature (RCCL), [55] and publisher records. After removing duplications and items that are primarily tax rate tables, we are left with just under 1300 different "items". Each item is a separate edition, but may be one of many editions of the same work. No doubt there are more items to be found in catalogues or lists we have not examined, particularly for those in Germany. We have obviously not examined every item, but have categorised them on the basis of the title and publisher information.

Figure 18 and Figure 19 show that there was a peak in the number of items worldwide about 1890 of 100 a decade, ten per year, and then a fairly steady rate of five per year until 1930, after which there was a decline, but there were still some in the ten years to 1969, then tailing off to one a year. The decimalisation of the Sterling Currency Zone in the late 1960s and early 1970s created a final surge before pocket calculators took over.

Figure 18 World Sales by Decade from 1749

Figure 19 World Items per Decade and Cumulative

In Figure 20 the items are classified by calculation type and in Figure 21 by user type.

Figure 20 Items by Calculation type

Figure 21 Items in 16 User classes

Figure 22 shows that there were some tens of specialist publishers in GB. The top 13 publishers accounted for 175 items from the 854 total for GB. Gall & Inglis were in Edinburgh, but the rest were mainly in London. Nearly all reckoners were published in many editions over many years, and provided a very steady business. Collins, [44], records in their 1959 edition, "Some 85 years ago the first edition of this book was published and it is now the oldest title on our list".

Using the Library of Congress catalogue, there appear to have been fewer US publishers but the prolific firm of Dellbridge of St Louis MO produced over 159 items 1890 to 1947, almost as much as all the GB publishers put together. In a newspaper article in the St. Louis Globe-Democrat of June 20, 1926 Delbridge states that he is 61 years old, born in the state of Alabama, educated in Atlanta, Georgia and New York City. He worked as an auditor for various businesses and railways; developed mathematical tables for making the work of auditors and bookkeepers easier; established a publishing company in St. Louis to issue books on that subject. He is married with three children. He gives the names of two sons, who are working with him.

Figure 22 Output of GB and US Publishers in order of number

One may wonder how Delbridge managed to create so many different items. The answer is that he identified different groups of users and within a group sliced the table into fine brackets. This is clearly reflected in the listing of his works in the Library of Congress catalogue.

9b Print Runs

Weedon, [54], has made exhaustive analyses of the print runs of Victorian books in GB based on individual publishers' records but she points out that her data is skewed because publishers printed short initial runs of books in order to avoid heavy outlay and to test the market.

The direct data for print runs is of two types.

(i) Publishers' claims in advertising material, which are vague and may well be overstated.

- **RCCL** entry for Warne in 1913 advertises Nuttall's Penny Table Book and claimed that over one million copies had been sold – but it is not clear over what period as the title may have changed. If it was ten years, then this was **100,000 copies** a year or per item.
- Cassell's **RCCL** entry for 1924 advertises its Pocket Reference Library and stated that over half a million copies had been sold. The series comprised 12 titles, of which one was a Ready Reckoner, so an average would be **17,000 copies** per item.
- The Multi-Divi, described below, is claimed on F. Diestelkamp's web site, [62], to have sold 50-100,000 copies between 1920 and 1960, which is about one thousand a year for a more elaborate device than a plain book.

These advertising figures would thus suggest print runs of 2,000 to 100,000 copies per item.

(ii) Publisher's records

These are available for Blackie, Gall & Inglis, Pitman and Routledge. So far we have examined only the Routledge archive at University College, London. These record print runs from 1902 to 1941 and comprise details of both new items and reprints. These show 1st editions having small print runs of 500, presumably to test the market and print runs growing over time until during the 1930s they reach 4-5,000 per print run. There appear to have been about 12 different titles and a total of 45 print runs. Laurie's High Interest Tables reached their 14th (and last recorded) impression in 1933. The records show an average print run of almost 3,000 and an average annual print quantity of slightly more than 3,000 over the period.

We can therefore make a very approximate estimate of world sales as follows. First, we note from Figure 19 that GB items from 1870-1930 were about one per year, which at 3,000 copies per item gives three thousand copies per year but Routledge alone produced that number, so the whole of GB could well have been at least five times that number when Warne, Cassell, Gall & Inglis, and so on are taken into account. Assuming the same again in the United States, and we get world sales of up to say 30,000 a year. Although the UK and USA were the dominant economies in this period, plenty of examples of Ready Reckoners exist from Europe. In addition, others are known from elsewhere around the globe. It is therefore clear that the total numbers printed and sold must have far exceeded any other calculating aid available at that time.

10 Conclusion

Given their superiority on all the key characteristics required by users, it is not surprising that Ready Reckoners were the dominant aid used for multiplication in trade from 1800 to 1950. Throughout this period their sales far exceeded any other calculating aid used in trade to assist in making routine calculations.

However, despite all the ingenuity exercised, Ready Reckoners and the other kinds of tables were not in some respects as user-friendly and useful as was hoped, having many pages with small print and allowing the user to work on only one page at a time. So inventors and designers sought to make improvements in legibility and row/column selection by gluing the tables on to a variety of disks, cylinders, rolls, and cards. Such devices are known collectively as Tabular Calculators. These have been briefly described by BOBW in [63] and a more thorough exposition is in hand by the authors.

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Appendix 1

#	Year	Curr	Price	Per£	Type	Company	ND	SF	LD	CS	£ of year	Index	£1914
1	1810	£	0.1	1	Ready Reckoner	Fenning	10	6	1	10	0.10	463.6	0.46
2	1865	$	8	4.9	Tab Calc	Peale	8	8	0.2	5	1.63	120	1.96
3	1880	FFr	500	25	Step Drum	Thomas	0	16	2	160	20.00	118	23.60
4	1885	£	0.05	1	Log Tables	Layton 4 places	0	4	2	15	0.05	102	0.05
5	1885	£	0.3	1	Log Tables	Sampson Low 7 places	0	7	2	15	0.30	103	0.31
6	1895	$	475	4.2	Direct Multr	Millionaire	0	12	1	6	113.10	100	113.10
7	1900	$	30	4.9	Broken scale SR	Thacher	0	6	2	20	6.12	99	6.06
8	1909	$	300	4.9	Step Drum	K&E	0	16	3	160	61.22	92.2	56.45
9	1909	£	15.75	1	Tab Calc	Hines	10	10	2	20	15.75	100	15.75
10	1910	£	25.05	1	Step Drum	Layton	0	16	0.1	160	25.05	100	25.05
11	1912	$	70	4.9	Repeat Adder	Tiumph	0	10	3	10	14.29	92.2	13.17
12	1912	$	200	4.9	Repeat Adder	Burroughs	0	9	2	9	40.82	100	40.82
13	1913	$	30	4.9	Hellical SR	Fuller	0	6	2	20	6.12	100	6.12
14	1913	Fr	1500	15.2	Pin wheel	Sanders	0	12	3	6	98.68	89	87.83
15	1914	M	750	20.4	Pin wheel	Lipsia	0	17	2	8.5	36.76	115.8	42.57
16	1914	£	41	1	Pin wheel	Colt	0	15	2	0	41.00	100	41.00
17	1914	£	65	1	Step Drum	Archimedes	0	20	0.1	200	65.00	100	65.00
18	1915	$	500	4	Pin wheel	Ensign	0	16	2	8	125.00	115.8	144.75
19	1915	$	60	4.9	Repeat Adder	Triumph	0	10	2	10	12.24	115.8	14.18
20	1915	$	70	4.9	Repeat Adder	Triumph	0	12	2	12	14.29	115.8	16.54
21	1918	Skr	650	14.3	Pin wheel	Facit	0	15	2	7.5	45.45	217.7	98.95
22	1920	S	3	4	Ready Reckoner	Delbridge US cheapest	10	6	1	10	0.75	464.6	3.48
23	1920	S	8	4	Ready Reckoner	Delbridge US Dearest	10	6	1	10	2.00	465.6	9.31
24	1920	£	0.1	1	ReadyReckoner	GB Dearest	6	6	1	10	0.10	466.6	0.47
25	1920	£	0.4	1	Ready Reckoner	GB Cheapest	10	6	1	10	0.40	467.6	1.87
26	1920	$	200	3.7	Repeat Adder	Burroughs	2	9	20	9	54.05	225.9	122.11
27	1920	$	400	3.7	Repeat Adder	Comptometer US	0	12	5	12	108.11	225.9	244.22
28	1920	$	300	3.7	Repeat Adder	Comptometer US	0	8	5	8	81.08	225.9	183.16
29	1920	$	350	3.7	Repeat Adder	Comptometer US	0	10	5	10	94.59	225.9	213.69
30	1921	£	0.75	1	Helical SR	Otis King	2	6	2	20	0.75	100	0.75
31	1921	$	200	4.2	Pin wheel	Monroe	0	16	2	8	47.62	178.6	85.05
32	1921	$	400	4.2	Pin wheel	Monroe	0	20	2	10	95.24	178.6	170.10
33	1922	£	0.3	1	Log Tables	Chambers 7 Figure	0	7	2	15	0.30	104	0.31
34	1922	$	265	4.2	Pin wheel	Marchant	0	13	2	6.5	63.10	145.8	91.99
35	1922	$	350	4.2	Pin wheel	Marchant	0	18	2	9	83.33	145.8	121.50
36	1924	£	3	1	Log Tables	Nutt 8 places	0	8	2	25	3.00	101	3.03
37	1924	GM	550	20	Pin wheel	Monos	0	13	2	6.5	27.50	151.7	41.72
38	1925	DM	275	22	Pin wheel	Brunsviga10	0	10	2	5	12.50	148.9	18.61
39	1925	GM	700	20	Pin wheel	Monos	0	20	2	10	35.00	148.9	52.12
40	1925	M	875	22	Step Drum	Archimedes	0	13	2	130	39.77	148.9	59.22
41	1925	M	1100	22	Step Drum	Archimedes	0	20	2	200	50.00	148.9	74.45
42	1927	RM	400	22	Pin wheel	Badenia Peerles	0	12	2	6	18.18	130.4	23.71
43	1928	£	50	1	Pin wheel	Britannic	0	12	2	6	50.00	153	76.50
44	1929	RM	300	20	Step Drum	TIM	0	12	2	120	15.00	153	22.95
45	1941	£	1.1	1	Helical SR	Otis King	3	6	2	20	1.10	178	1.96
46	1950	£	0.1	1	Abacus	Anon	2	12	20	10	0.10	275	0.28
47	1959	DM	890	11.8	Pin wheel	Brunsviga	0	16	2	8	75.42	345.8	260.82
48	1959	DM	845	11.8	Pin wheel	Facit CM	0	16	2	8	71.61	350	250.64
49	1961	$	125	2.81	Pin wheel	Curta 1	0	11	2	5.5	44.48	350	155.69
50	1963	£	3.1	1	Helical SR	Otis King	3	6	2	20	3.10	373	11.56
51	1964	£	355	1	Electronic	Anita	0	12	0.1	20	355.00	365.3	1296.82

Key Characteristics of 51 Multiplying Aids for Commerce 1810-1961

In this Appendix, the Column headings are:

- Year of data
- Curr - Currency of base data FFr = French Francs, SKR= Swedish Kroner, DM =Deutsch Marks
- Price in that currency
- Exchange Rate between local currency and £ in that year, rates from Bidwell, [37]
- Type of aid
- Example, Maker
- ND Non–decimal utility estimated by Williams on a scale 0, none, to 10, excellent
- SF Significant figures in the result
- LD Learner days to acquire proficiency estimated by Williams
- Time - Seconds for one typical multiplication estimated by Williams
- £ of Year - Price divided by exchange rate
- GB Price index 1914 =100
- 1914£ are £ of Year converted to £1914 using the GB Index. An approximation. Not exactly the same as inflating in the original currency at its own Price Index and then converting to Sterling.

Sources

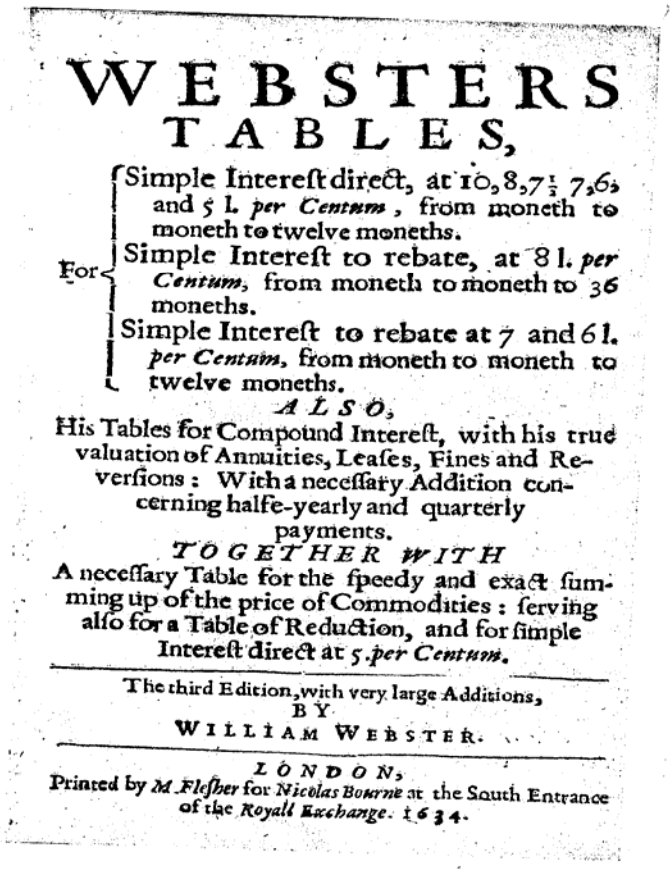
This table is a small part of a large database being assembled by Williams, relying mainly on Martin, [16] and all the volumes of *Historisches Buro Welt* and various Internet documents.

Bibliography

[1] D. Fenning, *The Ready Reckoner, or Trader's Most Useful assistant*. London: Crowder, 1757.
[2] Leybourne.W, *Panarithmologia, or the Trader's sure guide*. London: Dunton & Harris, 1673.
[3] O. Ore, *Number Theory and its history*. New York, 1948.
[4] Webster.William, *Webster's Tables*. London: Flesher, 1634.
[5] Barreme.F, *Le Livre des Comptes Faits*. Paris: Thierry, 1689.
[6] M. Campbell-Kelly, "History of Mathematical Tables," : Oxford University Press, 2003.
[7] D. E. Smith, *Rara Arithmetica - A catalogue of the arithmetics written before 1601*. New York: Chelsea Publishing Co,, 1853.
[8] A. De Morgan, *Arithmetical Books ,,,to the present time*. London: Taylor & Walton, 1847.
[9] J. W. L. Glaisher, "Mathematical Tables," presented at British Association for the advancement of Science, London, 1873.
[10] Fletcher, Miller, and Rosenhead, *An Index of Mathematical Tables*. London: Scientific Computing Service, 1946.
[11] Anon, *National Ready Reckoner*. London: Collins, 1874.
[12] H. A. Klein, *The Science of measurement: A historical survey*, 1988 ed. New York: Dover, 1974.
[13] F. Tapson, "A Dictionary of Units," : http://www.ex.ac.uk/cimt/dictunit/dictunit.htm, 2003.
[14] B. O. B. Williams, "Check Figures- A once ubiquitous Tool for Book-keepers," in *Slide Rule & Calculation Monographs*. Ely: UK Slide Rule Circle, 2002.
[15] U.S . Government, *Historical Statistics of the US Colonial Times to 1970*: US Govt, 2000.
[16] E. Martin, *Die Rechenmaschinen und Ihre Entwicklungsgeschichte*
Calculating Machines: Their History & Development, Calculating Machines : Their History and Development

Cambridge Mass: MIT Press 1992 ed. Cambridge MA: MIT Press, 1924/ 1992.
[17] B. W. Boering, " Comptometer-The Biography of a machine," , vol. 2004: http://www2.cruzio.com/~vagabond/Operators.html, 2003.
[18] Anon, "Sumlock School," *Bell PunchNews and Views*, vol. School http://anita-calculators.info/, 1949.
[19] T. A. Russo, *Antique Office Machines 200 years of calculating devices*. Atglen PA: Schiffer Publishing Ltd, 2001.
[20] Anon, "43% quicker with decimals," *Office Magazine*, Aug 1960.
[21] E. M. Horsburgh, "Handbook of the Napier Tercentenary Celebration," , Reprint 1982 ed. Edinburgh: G Bell & Sons, 1914.
[22] M. R. Williams, "From Napier to Lucas: The use of Napier's Bones in calculating instruments," *Annals of the History of Computing*, vol. 5, 1983.
[23] G. Ifrah, *The Universal History of numbers*. London: Harvill Press, 1998.
[24] J. Dilson, *Abacus The World's first computing system*. New York: St Martin's Press, 1968.
[25] C. G. Knott, "Napier Tercentenary Memorial volume," . London: Longmans. Green & Co, 1915.
[26] S. L. Laundy, *A Table of Products, by the factors 1 to 9 of all numbers from 1 to 100,000, by the aid of which multiplication may be performed by inspection. With an introduction explanatory of its use, etc*. London: Anon.
[27] J. W. L. Glaisher, "Multiplication by a Table of Single entry," *Philosophical Magazine*, 1878.
[28] P. M. Hopp, *Slide Rules, Their History, Models, and Makers*. Mendham, NJ, USA: Astragal Press, 1999.
[29] E. J. Chamberlain, "Long Scale Slide Rules," *J. Oughtred Society*, vol. 8, 1999 Spring.
[30] W. Feely and C. Schure, "The Fuller Calculating Instrument," *Journal of the Oughtred Society*, vol. 4, 1995.
[31] Stanley W F & Co Ltd, *Instruments Catalogue*. London: Stanley W F & Co Ltd, 1928.
[32] J. Keyworth, "Catalogue, Bank of England Museum," , 2003.
[33] L. de Brabandere, *Calculus- Non-electric calculating machines*. Liege: Mardaga, 1994.
[34] L. J. Comrie, "Hollerith & Powers Tabulating machines," *Trans.Office Machine Users Association*, 1929-30.

[35] M. Campbell-Kelly and W. Aspray, *Computer- a History of the Information machine*. New York: Basic Books, 1996.
[36] Norberg, Arthur.L, "Punched card Technology," *Technology and Culture*, pp. 753-779, 1990.
[37] R. L. Bidwell, *Currency Tables- A Hundred Years of Change*. London: Rex Collings, 1970.
[38] P. Faulstich, "Brunsviga,Brain of Steel," *Historische Burowelt*, vol. 37, 1994.
[39] C. Barnes, *Otis King Calculators A history of Production*. Fordham, Ely, Camb.UK: Colin Barnes, 1999.
[40] S. Johnston, "Making the Arithmometer Work," *Journal Scientific Instrument Society*, vol. 52, 1997 March.
[41] M. N. Wise, *The Values of Precision*. Princeton NJ: Princeton University Press, 1995.
[42] W. Campbell, *Office Management*. London: Pitman, 1933.
[43] H. P. Cemach, *Elements of Punched Card Accounting*. London: Pitman, 1951.
[44] W. Leybourne, *Ready Reckoner :or Trader's Sure Guide*. London: Dilly, Rivington, et. al., 1798.
[45] B. O. B. Williams, *Illustrated listing of over 2900 GB Patents for Non-electronic Calculating Apparatus 1780-1999*. Ely Cambridgeshire: UKSRC, 2004.
[46] R. Anlezark, . London: Simpkin Marshall, 1871.
[47] Anon, *The Worlds's Ready Reckoner and Rapid Calculator*. Philadelphia?: Laird & Lee, 1911.
[48] Anon, *Pitman'sOffice Desk Book and Ready Reckoner*. London: Isaac Pitman, Sir & Sons, 1934.
[49] D. Neave, *Moulders' Ready Reckoner*: Aberdeen University Press, 1880 est.
[50] Shorthose, *Commercial Ready Reckoner*. London: George Allen & Unwin, 1921.
[51] P. Morrison and E. Morrison, "Charles Babbage and others on the Development of the Calculator," : Dover, 1961.
[52] G. Brown and C. O'Brien, *The Rich Man's Ready Reckoner*. London: Wolfe Publishing, 1970.
[53] H. Perrin, *Nuttall's Metric Conversion Tables*. London: Warne, 1973.
[54] A. Weedon, *Victorian Publishing- The Economics of Book Production for a Mass Market 1836-1916*. Aldershot: Ashgate, 2003.
[55] Whitaker.J, *Reference Catalogue of Current Literature*. London: Joseph Whitaker, 1875-1932.
[56] M. Burnham, *Cumulative Book Index*. New York: Periodical Publications, 1912-1948.
[57] W. Chadwick, *Combined Number and Weight Calculator*. London: Crosby Lockwood and Co., 1886.
[58] Anon, *Model Ready Reckoner*. London: Warne,Frederick & co., 1888.
[59] British Library, "On- Line Catalogue," : http://blpc.bl.uk/adp0349iFsBlpc.jsp?Userid=3464571084120830709.
[60] Bibliotheque Nationale, : http://www.bnf.fr/pages/zNavigat/frame/catalog.htm, 2004.
[61] Library of Congress, : (http://www.loc.gov/), 2004.
[62] F. Diestelkamp, "The Multi-divi," : http://www.rechnerlexikon.de/wiki.phtml?title=Multi-Divi, 2004.
[63] B. O. B. Williams, "Ready Reckoners and Tabular Calculators," presented at 9th International \Meeting of Slide Rule Collectors, Amsterdam/Breukelen, 2003.



WEBSTERS
TABLES,

For { Simple Intereſt direct, at 10, 8, 7½ 7, 6, and 5 l. *per Centum*, from moneth to moneth to twelve moneths.
Simple Intereſt to rebate, at 8 l. *per Centum*, from moneth to moneth to 36 moneths.
Simple Intereſt to rebate at 7 and 6 l. *per Centum*, from moneth to moneth to twelve moneths.

ALSO,

His Tables for Compound Intereſt, with his true valuation of Annuities, Leaſes, Fines and Reverſions: With a neceſſary Addition concerning halfe-yearly and quarterly payments.

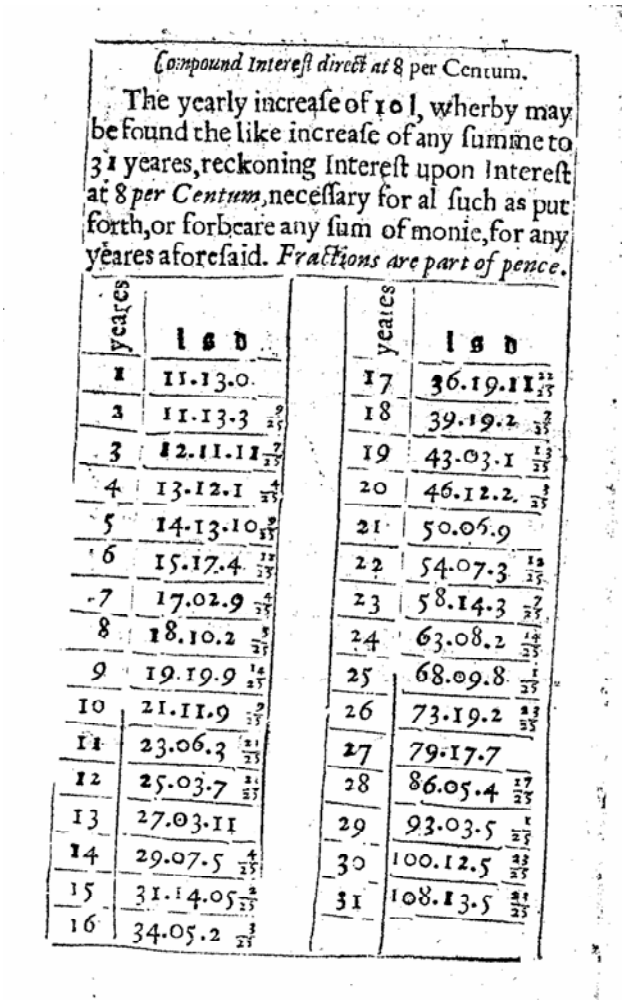
TOGETHER WITH

A neceſſary Table for the ſpeedy and exact ſumming up of the price of Commodities: ſerving alſo for a Table of Reduction, and for ſimple Intereſt direct at 5 *per Centum*.

The third Edition, with very large Additions,
BY
WILLIAM WEBSTER.

LONDON,
Printed by *M. Fleſher* for *Nicolas Bourne* at the South Entrance of the *Royall Exchange*. 1634.

Figure 23 Webster Front Page 1634



Compound Intereſt direct at 8 per Centum.

The yearly increaſe of 101, wherby may be found the like increaſe of any ſumme to 31 yeares, reckoning Intereſt upon Intereſt at 8 *per Centum*, neceſſary for al ſuch as put forth, or forbeare any ſum of monie, for any yeares aforeſaid. *Fractions are part of pence.*

yeares	l	s	d		yeares	l	s	d	
1	11.	13.	0.		17	36.	19.	11	22/25
2	11.	13.	3	9/25	18	39.	19.	2	7/25
3	12.	11.	11	7/25	19	43.	03.	1	13/25
4	13.	12.	1	4/25	20	46.	12.	2.	3/25
5	14.	13.	10	9/25	21	50.	06.	9	
6	15.	17.	4	12/25	22	54.	07.	3	18/25
7	17.	02.	9	4/25	23	58.	14.	3	7/25
8	18.	10.	2	5/25	24	63.	08.	2	14/25
9	19.	19.	9	16/25	25	68.	09.	8	1/25
10	21.	11.	9	9/25	26	73.	19.	2	23/25
11	23.	06.	3	21/25	27	79.	17.	7	
12	25.	03.	7	21/25	28	86.	05.	4	17/25
13	27.	03.	11		29	93.	03.	5	1/25
14	29.	07.	5	4/25	30	100.	12.	5	23/25
15	31.	14.	05	2/25	31	108.	13.	5	21/25
16	34.	05.	2	3/25					

Figure 24 Webster's 1634 Compound Interest Table

Figure 25 Frontispiece of Barreme, 1762

Currency	GB	4 farthings = 1 Penny (d); 12d =1 Shilling (s); 20s = One Pound (£)
Length	GB	12 inches = 1 ft; 3 ft = 1 yard; 22 yards =1 Gunters Chain; 80 chains = 1 Mile = 1760 yds
Area	GB	9 sq ft = 1 sq yd; 4840 sq yd = 1 Acre
Area	US	9 sq ft = 1 sq yd; 4840 sq yd = 1 acre; 640 acres = 1 sq mile = 1 section; 36 sections = 1 township
Weight	GB	16 ounces (oz) = 1 pound (lb); 14 pounds = 1 stone; 2 stones = 1 Quarter (qr); 4 qrs = 1 Hundredweight (cwt); 20cwt = 1 Ton = 2240 lbs
Weight	US	16 ounces = 1 pound; 100 pound = 1 hundred weight (cwt); 20 cwt = 1 ton = 2000 lbs.
Liquid volume	GB	2 Pints = 1 Quart; 4 Quarts = 1 Gallon; 32 gallons = 1Bushel
Liquid volume	US	16 fl. Oz. =1 pint; 42 US gallons = 1 US barrel (petroleum)
Dry Volume	GB	4 gills = 1 Pint; 2 Pints = 1 Quart; 4 Quarts = 1 Gallon; 8 gallons = 1 Bushel; 3 Bushels = 1 Sack
Dry Volume	US	2 pints = 1 quart; 8 quarts = 1 peck; 4 pecks = 1 bushel
Time	All	60 minutes = 1 hour; 24 hours = 1 day; 28-30 days = 1 month; 360/365/365¼/366 days = 1 year.

Figure 26 Non-Decimal measures

Sources : Standard references; A comprehensive historical review is Klein[12]. A useful web site is Tapson, [13].
Notes: 1. US usage of cwt and ton differs from GB. 2. US Gallons are different from Imperial/GB gallons
There were many non-decimal measures in British India, and a number of reckoners were published to handle these.

Commercial units	France	USA	GB
Currency	1799-1803	1786-1792	1971
Length	1801	Not yet	1965
Weight	1801	Not yet	1965
Liquid measure	1801	Not yet	1965
Time	Still sexagesimal Years-Months-Days-Hours-Minutes		

Figure 27 Dates of decimalisation or metrication
(Sources: As Figure 4)

Item	Length	Width	Material	Area Sq in	Weight per Inch or sq inch	Weight T C Q lbs	Price per ton In £ s d	Value £ s d
	A	B	C	D = AxAB or π xAxA/4	G Data	H = DxG or AxG	I Data	J=HxI
1	3 ft 6 in	4 ft 8 in	¼" Mild steel plate	Product 1		Product 3	P	Product 6
2	8 ft 6 in		Rolled steel Joist			W	P	Product 7
3	5 ft	Circle	¼" Mild steel plate	Product 2	W	W	P	Product 8
						Sum of weights		Sum of lines

Figure 28 Schematic part of a steel warehouse invoice with eight multiplications

	Sterling	Decimal
Add column of 150 entries	152 secs	118 secs
Average per item (Seconds)	*1*	*0.8*
Extend 200 stock sheet entries	29 mins 37 secs	16 mins 50 secs
Average per item (Seconds)	*88*	*55*
Ratio Multiply / Add	*88*	*69*

Figure 29 Comparison of adding versus multiplication time

#	Year	Curr	Price	Per£	Type	Company	ND	SF	LD	CS	£ of year	Index	£1914
1	1810	£	0.1	1	Ready Reckoner	Fenning	10	6	1	10	0.10	463.6	0.46
2	1865	$	8	4.9	Tab Calc	Peale	8	8	0.2	5	1.63	120	1.96
3	1880	FFr	500	25	Step Drum	Thomas	0	16	2	160	20.00	118	23.60
4	1885	£	0.05	1	Log Tables	Layton 4 places	0	4	2	15	0.05	102	0.05
5	1885	£	0.3	1	Log Tables	Sampson Low 7 places	0	7	2	15	0.30	103	0.31
6	1895	$	475	4.2	Direct Multr	Millionaire	0	12	1	6	113.10	100	113.10
7	1900	$	30	4.9	Broken scale SR	Thacher	0	6	2	20	6.12	99	6.06
8	1909	$	300	4.9	Step Drum	K&E	0	16	3	160	61.22	92.2	56.45
9	1909	£	15.75	1	Tab Calc	Hines	10	10	2	20	15.75	100	15.75
10	1910	£	25.05	1	Step Drum	Layton	0	16	0.1	160	25.05	100	25.05
11	1912	$	70	4.9	Repeat Adder	Tiumph	0	10	3	10	14.29	92.2	13.17
12	1912	$	200	4.9	Repeat Adder	Burroughs	0	9	2	9	40.82	100	40.82
13	1913	$	30	4.9	Hellical SR	Fuller	0	6	2	20	6.12	100	6.12
14	1913	Fr	1500	15.2	Pin wheel	Sanders	0	12	3	6	98.68	89	87.83
15	1914	M	750	20.4	Pin wheel	Lipsia	0	17	2	8.5	36.76	115.8	42.57
16	1914	£	41	1	Pin wheel	Colt	0	15	2	0	41.00	100	41.00
17	1914	£	65	1	Step Drum	Archimedes	0	20	0.1	200	65.00	100	65.00
18	1915	$	500	4	Pin wheel	Ensign	0	16	2	8	125.00	115.8	144.75
19	1915	$	60	4.9	Repeat Adder	Triumph	0	10	2	10	12.24	115.8	14.18
20	1915	$	70	4.9	Repeat Adder	Triumph	0	12	2	12	14.29	115.8	16.54
21	1918	Skr	650	14.3	Pin wheel	Facit	0	15	2	7.5	45.45	217.7	98.95
22	1920	S	3	4	Ready Reckoner	Delbridge US cheapest	10	6	1	10	0.75	464.6	3.48
23	1920	S	8	4	Ready Reckoner	Delbridge US Dearest	10	6	1	10	2.00	465.6	9.31
24	1920	£	0.1	1	ReadyReckoner	GB Dearest	6	6	1	10	0.10	466.6	0.47
25	1920	£	0.4	1	Ready Reckoner	GB Cheapest	10	6	1	10	0.40	467.6	1.87
26	1920	$	200	3.7	Repeat Adder	Burroughs	2	9	20	9	54.05	225.9	122.11
27	1920	$	400	3.7	Repeat Adder	Comptometer US	0	12	5	12	108.11	225.9	244.22
28	1920	$	300	3.7	Repeat Adder	Comptometer US	0	8	5	8	81.08	225.9	183.16
29	1920	$	350	3.7	Repeat Adder	Comptometer US	0	10	5	10	94.59	225.9	213.69
30	1921	£	0.75	1	Helical SR	Otis King	2	6	2	20	0.75	100	0.75
31	1921	$	200	4.2	Pin wheel	Monroe	0	16	2	8	47.62	178.6	85.05
32	1921	$	400	4.2	Pin wheel	Monroe	0	20	2	10	95.24	178.6	170.10
33	1922	£	0.3	1	Log Tables	Chambers 7 Figure	0	7	2	15	0.30	104	0.31
34	1922	$	265	4.2	Pin wheel	Marchant	0	13	2	6.5	63.10	145.8	91.99
35	1922	$	350	4.2	Pin wheel	Marchant	0	18	2	9	83.33	145.8	121.50
36	1924	£	3	1	Log Tables	Nutt 8 places	0	8	2	25	3.00	101	3.03
37	1924	GM	550	20	Pin wheel	Monos	0	13	2	6.5	27.50	151.7	41.72
38	1925	DM	275	22	Pin wheel	Brunsviga10	0	10	2	5	12.50	148.9	18.61
39	1925	GM	700	20	Pin wheel	Monos	0	20	2	10	35.00	148.9	52.12
40	1925	M	875	22	Step Drum	Archimedes	0	13	2	130	39.77	148.9	59.22
41	1925	M	1100	22	Step Drum	Archimedes	0	20	2	200	50.00	148.9	74.45
42	1927	RM	400	22	Pin wheel	Badenia Peerles	0	12	2	6	18.18	130.4	23.71
43	1928	£	50	1	Pin wheel	Britannic	0	12	2	6	50.00	153	76.50
44	1929	RM	300	20	Step Drum	TIM	0	12	2	120	15.00	153	22.95
45	1941	£	1.1	1	Helical SR	Otis King	3	6	2	20	1.10	178	1.96
46	1950	£	0.1	1	Abacus	Anon	2	12	20	10	0.10	275	0.28
47	1959	DM	890	11.8	Pin wheel	Brunsviga	0	16	2	8	75.42	345.8	260.82
48	1959	DM	845	11.8	Pin wheel	Facit CM	0	16	2	8	71.61	350	250.64
49	1961	$	125	2.81	Pin wheel	Curta 1	0	11	2	5.5	44.48	350	155.69
50	1963	£	3.1	1	Helical SR	Otis King	3	6	2	20	3.10	373	11.56
51	1964	£	355	1	Electronic	Anita	0	12	0.1	20	355.00	365.3	1296.82

Figure 30 Key Characteristics of 51 Multiplying Aids for Commerce 1810-1961

In Figure 30, the Column headings are:

- Year of data
- Curr - Currency of base data FFr = French Francs, SKR= Swedish Kroner, DM =Deutsch Marks
- Price in that currency
- Exchange Rate between local currency and £ in that year, rates from Bidwell, [37]
- Type of aid
- Example, Maker
- ND Non–decimal utility estimated by Williams on a scale 0, none, to 10, excellent
- SF Significant figures in the result
- LD Learner days to acquire proficiency estimated by Williams
- Time - Seconds for one typical multiplication estimated by Williams
- £ of Year - Price divided by exchange rate
- GB Price index 1914 =100
- 1914£ are £ of Year converted to £1914 using the GB Index. An approximation. Not exactly the same as inflating in the original currency at its own Price Index and then converting to Sterling.

Sources

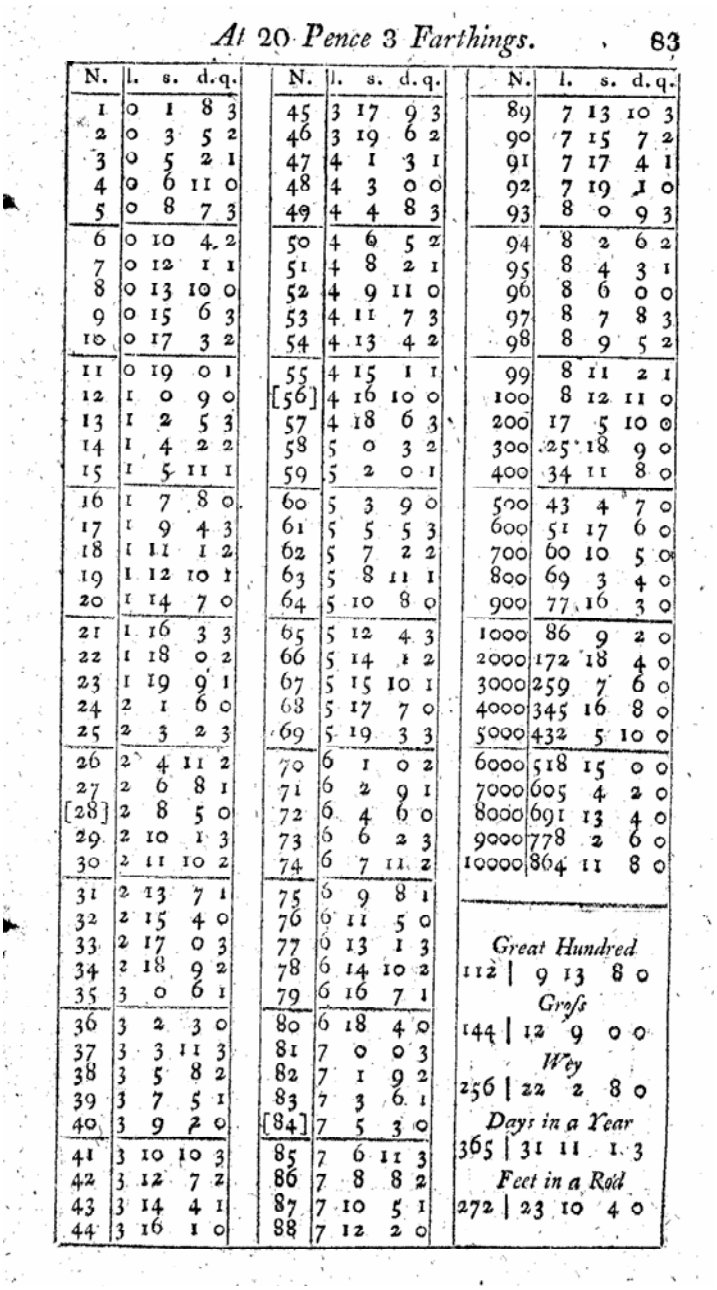
This table is a small part of a large database being assembled by Williams, relying mainly on Martin, [16] and all the volumes of *Historisches Buro Welt* and various Internet documents.

Class	ND	SF	LD	Time	£1914
Abacus	2	12	High	10	£0.20
Pin wheel	0	10	2	12	£50.00
Step Drum	0	16	2	20	£25.00
Repeat Add	0	12	5	8	£150.00
Ready Reckoner	10	6-10	0.1	10	£0.10
Slide rule	0	3-6	2	15	£0.75

Figure 31 Characteristics of aid classes

Class	Sales 000s per year	Sources
Ready Reckoner	20?	See below
Comptometer	8- 80?	"Millions produced between the two World Wars". Campbell-Kelly and Aspray, [35], p38. Boering on his web site, [17], uses serial numbers to suggest 42,300 1915-1920 and 48,500 1920-1926.
Pin wheel	40	Table of Brunsviga production from 1902 to 1952 is in Faulstich [38]
Otis King helical slide rule	5	See Barnes[39]
Step Drum	1- 5?	For the Thomas machine see Johnston[40]

Figure 32 Table of Estimated Sales Volumes by Aid Class



At 20 Pence 3 Farthings. 83

N.	l.	s.	d.	q.	N.	l.	s.	d.	q.	N.	l.	s.	d.	q.
1	0	1	8	3	45	3	17	9	3	89	7	13	10	3
2	0	3	5	2	46	3	19	6	2	90	7	15	7	2
3	0	5	2	1	47	4	1	3	1	91	7	17	4	1
4	0	6	11	0	48	4	3	0	0	92	7	19	1	0
5	0	8	7	3	49	4	4	8	3	93	8	0	9	3
6	0	10	4	2	50	4	6	5	2	94	8	2	6	2
7	0	12	1	1	51	4	8	2	1	95	8	4	3	1
8	0	13	10	0	52	4	9	11	0	96	8	6	0	0
9	0	15	6	3	53	4	11	7	3	97	8	7	8	3
10	0	17	3	2	54	4	13	4	2	98	8	9	5	2
11	0	19	0	1	55	4	15	1	1	99	8	11	2	1
12	1	0	9	0	[56]	4	16	10	0	100	8	12	11	0
13	1	2	5	3	57	4	18	6	3	200	17	5	10	0
14	1	4	2	2	58	5	0	3	2	300	25	18	9	0
15	1	5	11	1	59	5	2	0	1	400	34	11	8	0
16	1	7	8	0	60	5	3	9	0	500	43	4	7	0
17	1	9	4	3	61	5	5	5	3	600	51	17	6	0
18	1	11	1	2	62	5	7	2	2	700	60	10	5	0
19	1	12	10	1	63	5	8	11	1	800	69	3	4	0
20	1	14	7	0	64	5	10	8	0	900	77	16	3	0
21	1	16	3	3	65	5	12	4	3	1000	86	9	2	0
22	1	18	0	2	66	5	14	1	2	2000	172	18	4	0
23	1	19	9	1	67	5	15	10	1	3000	259	7	6	0
24	2	1	6	0	68	5	17	7	0	4000	345	16	8	0
25	2	3	2	3	69	5	19	3	3	5000	432	5	10	0
26	2	4	11	2	70	6	1	0	2	6000	518	15	0	0
27	2	6	8	1	71	6	2	9	1	7000	605	4	2	0
[28]	2	8	5	0	72	6	4	6	0	8000	691	13	4	0
29	2	10	1	3	73	6	6	2	3	9000	778	2	6	0
30	2	11	10	2	74	6	7	11	2	10000	864	11	8	0
31	2	13	7	1	75	6	9	8	1					
32	2	15	4	0	76	6	11	5	0					
33	2	17	0	3	77	6	13	1	3	*Great Hundred*				
34	2	18	9	2	78	6	14	10	2	112	9	13	8	0
35	3	0	6	1	79	6	16	7	1	*Gross*				
36	3	2	3	0	80	6	18	4	0	144	12	9	0	0
37	3	3	11	3	81	7	0	0	3	*Wey*				
38	3	5	8	2	82	7	1	9	2	256	22	2	8	0
39	3	7	5	1	83	7	3	6	1	*Days in a Year*				
40	3	9	2	0	[84]	7	5	3	0	365	31	11	1	3
41	3	10	10	3	85	7	6	11	3	*Feet in a Rod*				
42	3	12	7	2	86	7	8	8	2	272	23	10	4	0
43	3	14	4	1	87	7	10	5	1					
44	3	16	1	0	88	7	12	2	0					

Figure 33 Page from Leybourne 1798

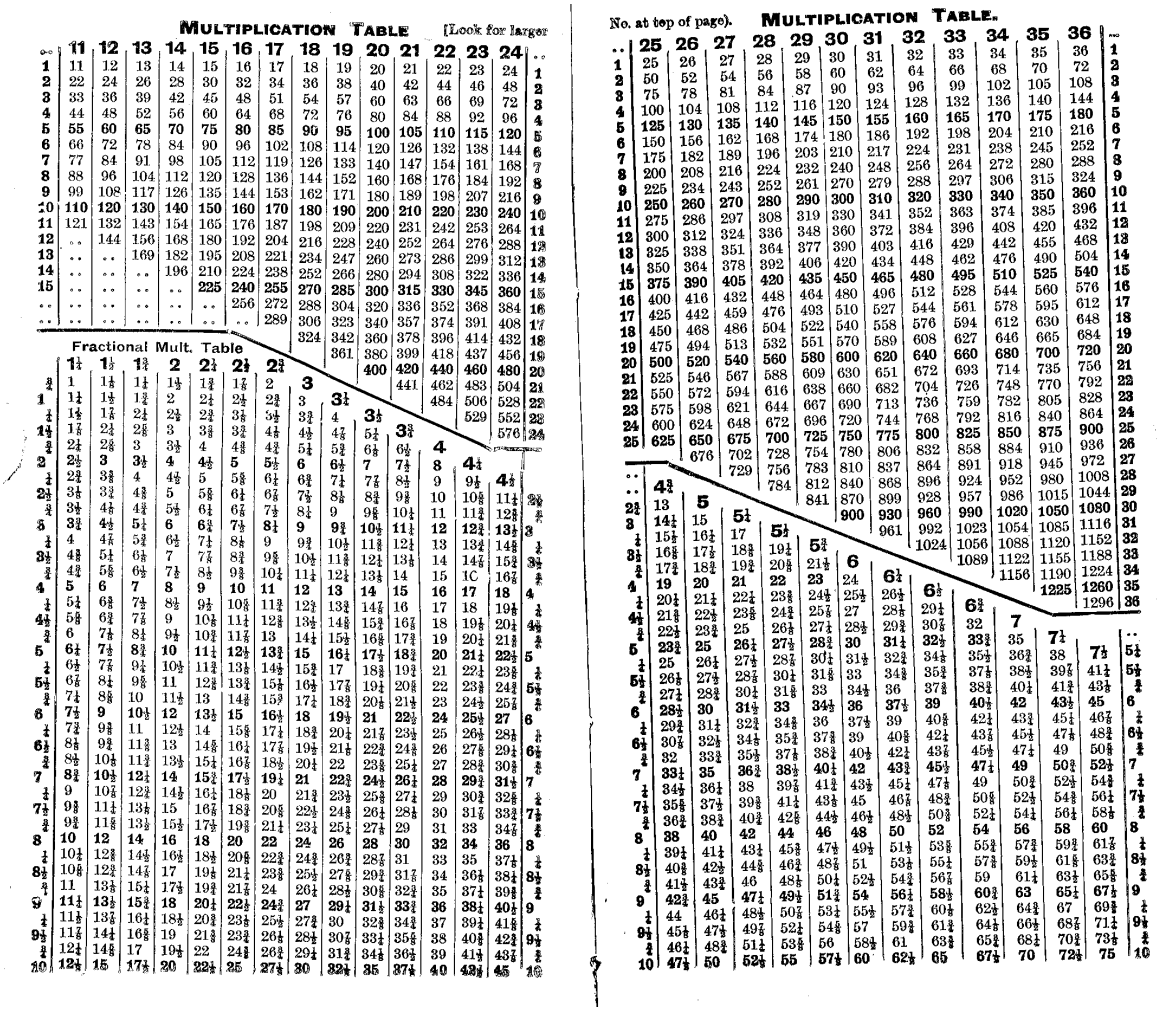


Figure 34 Triangular Multiplication Table from The Express Ready Reckoner by Gall & Inglis. No date.

124. Dunlop, R. Jan. 17. [*Provisional protection only.*]

Calculating-apparatus.—A collection of leaves of paper or parchment is made into a book serving as a kind of ready-reckoner, each leaf of which is divided into a number of sections by cutting or separating them in such manner that the leaves range one above the other or otherwise range together as required. The book may be used for money calculations and for other tables such as weights and measures &c.

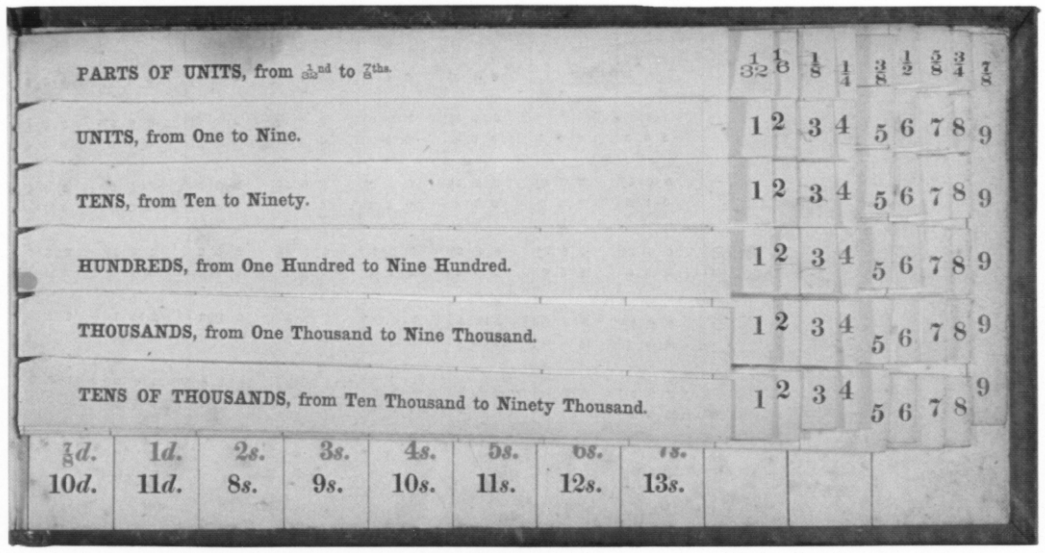
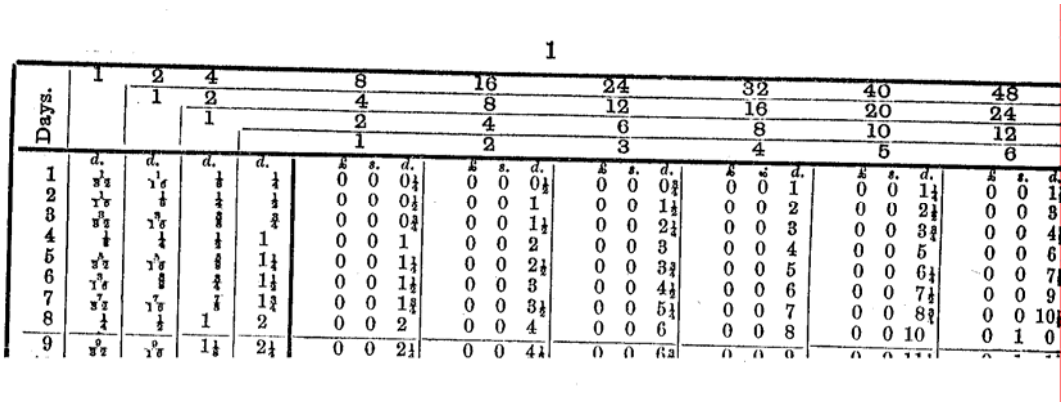


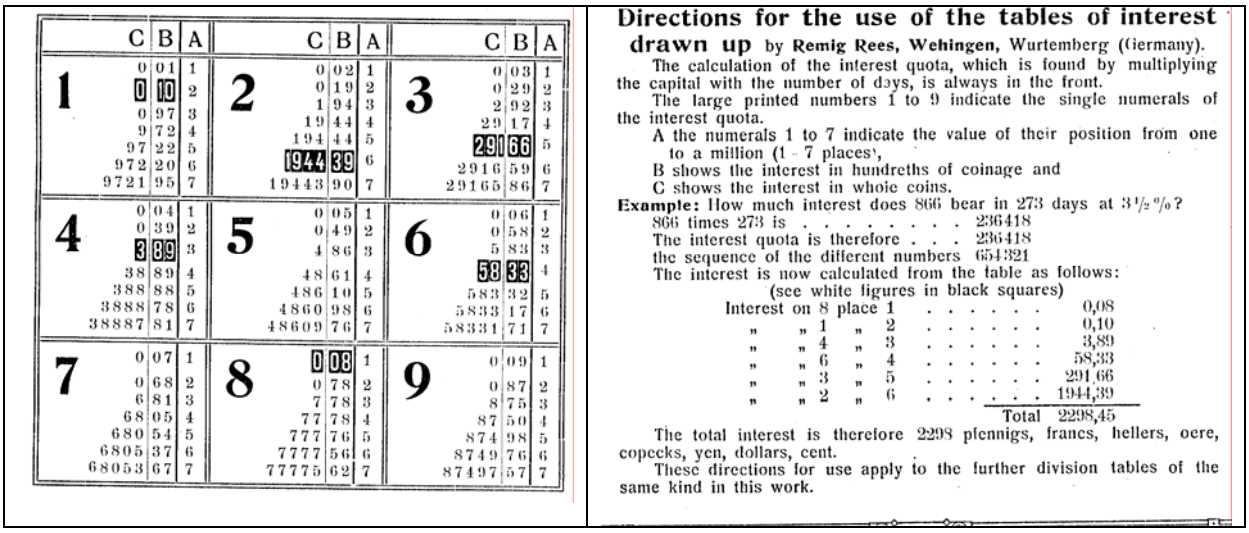
Figure 35 Dunlop's calculator GB Patent 124/1862 Abridgment

Source Williams, [45]



Days.	1	2	4	8	16	24	32	40	48
		1	2	4	8	12	16	20	24
			1	2	4	6	8	10	12
				1	2	3	4	5	6
1	d. 1/32	d. 1/16	d. 1/8	d. 1/4	£ s. d. 0 0 0½	£ s. d. 0 0 1	£ s. d. 0 0 0¾	£ s. d. 0 0 1	£ s. d. 0 0 1¼	£ s. d. 0 0 1
2	1/16	1/8	1/4	1/2	0 0 0½	0 0 1	0 0 1½	0 0 2	0 0 2½	0 0 3
3	3/32	3/16	3/8	3/4	0 0 0¾	0 0 1½	0 0 2¼	0 0 3	0 0 3¾	0 0 4
4	1/8	1/4	1/2	1	0 0 1	0 0 2	0 0 3	0 0 4	0 0 5	0 0 6
5	5/32	5/16	5/8	1¼	0 0 1¼	0 0 2½	0 0 3¾	0 0 5	0 0 6¼	0 0 7
6	3/16	3/8	3/4	1½	0 0 1½	0 0 3	0 0 4½	0 0 6	0 0 7½	0 0 9
7	7/32	7/16	7/8	1¾	0 0 1¾	0 0 3½	0 0 5¼	0 0 7	0 0 8¾	0 0 10
8	1/4	1/2	1	2	0 0 2	0 0 4	0 0 6	0 0 8	0 0 10	0 1 0
9	9/32	9/16	1⅛	2¼	0 0 2¼	0 0 4½	0 0 6¾	0 0 9	0 0 11¼	0 1 1

Figure 36 Anlezark's entirely new System 1871



	C	B	A
1	0	01	1
	0	10	2
	0	97	3
	9	72	4
	97	22	5
	972	20	6
	9721	95	7
2	0	02	1
	0	19	2
	1	94	3
	19	44	4
	194	44	5
	1944	39	6
	19443	90	7
3	0	03	1
	0	29	2
	2	92	3
	29	17	4
	291	66	5
	2916	59	6
	29165	86	7
4	0	04	1
	0	39	2
	3	89	3
	38	89	4
	388	88	5
	3888	78	6
	38887	81	7
5	0	05	1
	0	49	2
	4	86	3
	48	61	4
	486	10	5
	4860	98	6
	48609	76	7
6	0	06	1
	0	58	2
	5	83	3
	58	33	4
	583	32	5
	5833	17	6
	58331	71	7
7	0	07	1
	0	68	2
	6	81	3
	68	05	4
	680	54	5
	6805	37	6
	68053	67	7
8	0	08	1
	0	78	2
	7	78	3
	77	78	4
	777	76	5
	7777	56	6
	77775	62	7
9	0	09	1
	0	87	2
	8	75	3
	87	50	4
	874	98	5
	8749	76	6
	87497	57	7

Directions for the use of the tables of interest drawn up by **Remig Rees, Wehingen,** Wurtemberg (Germany).

The calculation of the interest quota, which is found by multiplying the capital with the number of days, is always in the front.

The large printed numbers 1 to 9 indicate the single numerals of the interest quota.

A the numerals 1 to 7 indicate the value of their position from one to a million (1 - 7 places),

B shows the interest in hundreths of coinage and

C shows the interest in whole coins.

Example: How much interest does 866 bear in 273 days at 3½ %?

866 times 273 is 236418

The interest quota is therefore . . . 236418

the sequence of the different numbers 654321

The interest is now calculated from the table as follows:

(see white figures in black squares)

Interest on	8	place	1	. . . . .	0,08
„	„ 1	„	2	. . . . .	0,10
„	„ 4	„	3	. . . . .	3,89
„	„ 6	„	4	. . . . .	58,33
„	„ 3	„	5	. . . . .	291,66
„	„ 2	„	6	. . . . .	1944,39
				Total	2298,45

The total interest is therefore 2298 pfennigs, francs, hellers, oere, copecks, yen, dollars, cent.

These directions for use apply to the further division tables of the same kind in this work.

Figure 37 Universal Schnellrechner

Source Arithmeum Bonn.

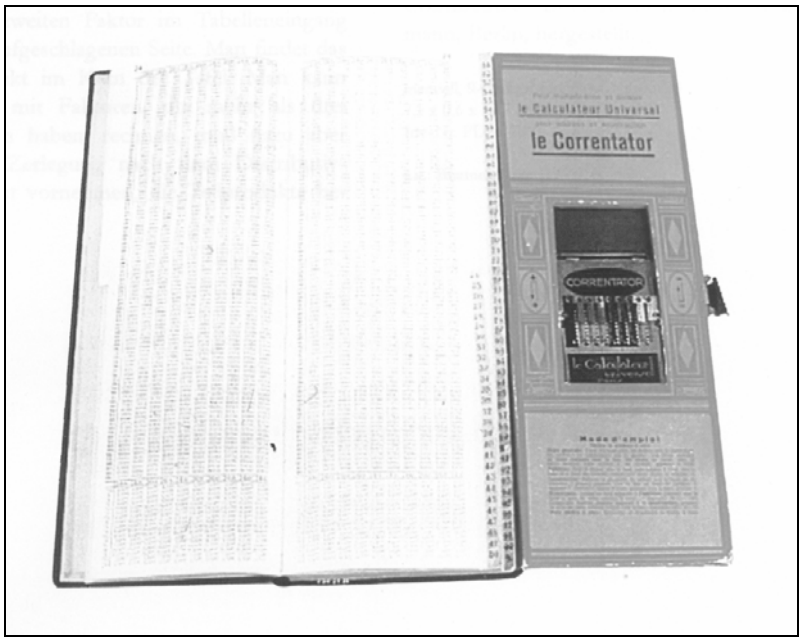
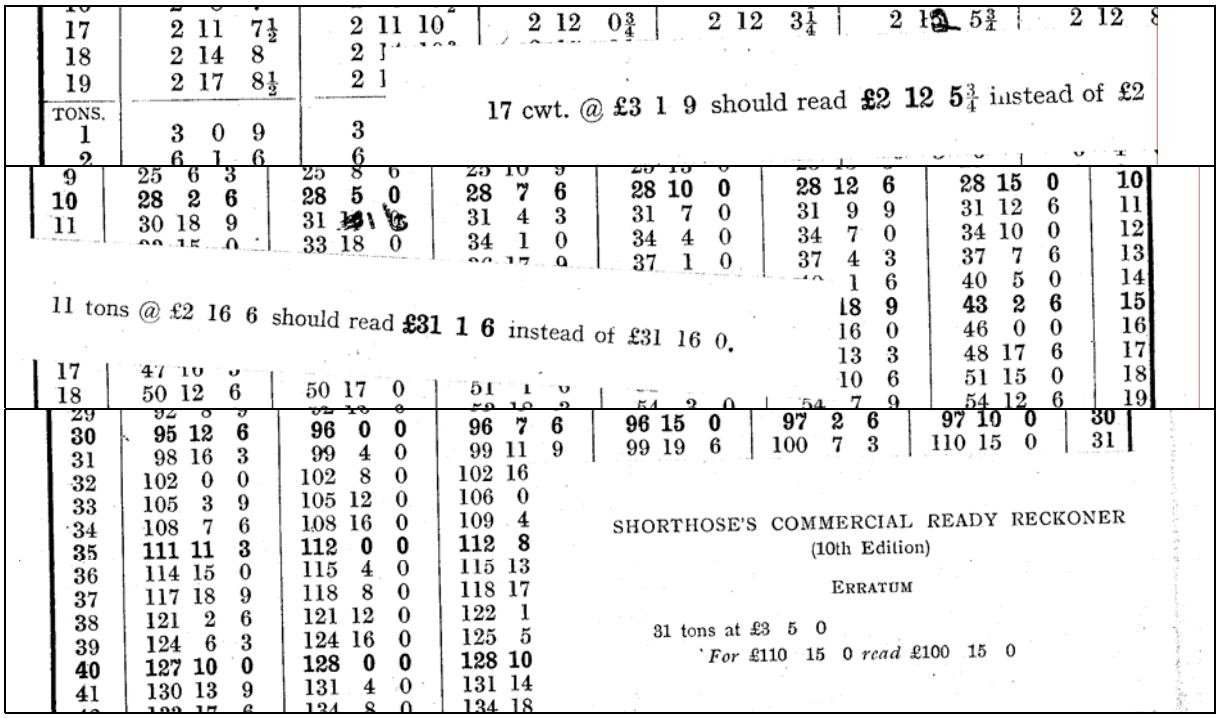


Figure 38 Multiplication Table from Bergmann Universal Calculator with The Correntator Stylus adder, 1920

Source Arithmeum Bonn



17 cwt. @ £3 1 9 should read **£2 12 5¾** instead of £2

11 tons @ £2 16 6 should read **£31 1 6** instead of £31 16 0.

SHORTHOSE'S COMMERCIAL READY RECKONER
(10th Edition)

ERRATUM

31 tons at £3 5 0
For £110 15 0 *read* £100 15 0

Figure 39 Three erratum slips - probably due to printer's error

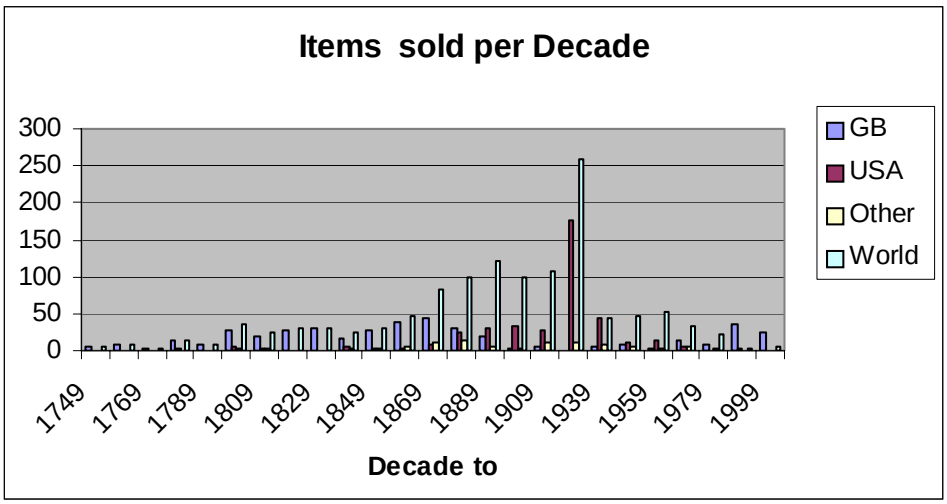


Figure 40 World Sales by Decade from 1749

Decade to	GB	USA	Other	World
1749	5	0	1	6
1759	7	0	0	7
1769	3	0	0	3
1779	13	2	0	15
1789	8	0	0	8
1799	28	6	2	36
1809	18	4	2	24
1819	28	1	1	30
1829	30	0	1	31
1839	16	6	3	25
1849	27	2	2	31
1859	38	4	5	47
1869	43	8	12	63
1879	31	26	15	72
1889	18	29	5	52
1899	2	34	4	40
1909	6	28	12	46
1919	0	175	10	185
1939	6	44	7	57
1949	7	12	6	25
1959	3	15	4	22
1969	15	5	5	25
1979	8	0	3	11
1989	36	2	1	39
1999	24	1	0	25
Total	420	404	101	925

Figure 41 World Items per Decade
Note: Other countries are mainly British Empire, France

Calculation	Items
Accounting	6
Currency Exchange	44
Costing	25
Days between Dates	2
Dimension conversion	197
Discounts	10
Duties, taxes	6
Engineering	1
Freight	1
General	403
Government	3
Interest, simple & Compound	78
Pure Multiplication	9
Price per area	2
Pricing	137
Price per time	1
Price per Unit	44
Price by Weight	73
Timber	6
Wages	43
TOTAL	1103

Figure 42 Items by Calculation type

Items	User
137	Agriculture
12	Alcohol, Customs & Excise
53	Builders
14	Caterers
0	Currency dealers
1	Chemical industry
35	Financiers
40	Freight operators
34	Gaming, Gambling
289	General
13	Government
5	Military
19	Mining, minerals
2	Naval, navigation
23	Textiles
255	Traders
932	TOTAL

Figure 43 Items in 16 User classes

GB Firms	Items	First Year	Last Year
Gall & Inglis	39	1885	1935
Warne	35	1889	1973
Crosby Lockwood	32	1880	1924
Routledge	17	1809	1969
Ward Lock	17	1876	1893
Nelson	9	1830	1885
Seale	8	1888	1926
Pitman	8	1906	1937
Collins	7	1913	1959
Simpkin Marshall	7	1863	1927
Layton	5	1833	1870
Gibson	3	1903	1924
McCorquodale	3	1883	1899
Total GB	190		
USA Firms			
Delbridge	159	1890	1919
Dick	8	1866	1916
Saur	6	1774	1810
Smith J F	5	1912	1917
Laird & Lee	3	1890	1919
Ropp	3	1887	1919
Winston	2	1905	1953
Total USA	186		

Figure 44 Output of GB and US Publishers in order of number