THE CHARLES BABBAGE INSTITUTE

HISTORY OF COMPUTING

TITLES IN SERIES

1. *The Preparation of Programs for an Electronic Digital Computer* (1951), by Maurice V. Wilkes, David J. Wheeler, and Stanley Gill, 1984

2. *Babbage's Calculating Engines: A Collection of Papers* (1889), by Henry Prcvost Babbage, 1984.

3. *Handbook of the Napier Tercentenary Celebration, or Modern Instruments and Methods of Calculation* (1914), edited by E. M. Horsburgh, 1984.

4. *High-Speed Computing Devices* (1950), by Engineering Research Associates, Inc., 1984.

5. *Punched Curd Methods in Scientific Computation* (1940), by W. J. Eckert, 1984.

6. *Calculating Machines: Recent and Prospective Developments and Their Impact on Mathematical Physics* (1947) and *Calculating Instruments and Machines* (1949). by Douglas R. Hartree, F. R. S., 1984.

7. *Proceedings of a Symposium on Large-Scale Digitul Calculating Machinery* (1947), jointly sponsored by the Navy Department Bureau of Ordnance and Harvard University Computation Laboratory, 1985.

8. *A Manual of Operation for the Automatic Sequence Controlled Calculator* (1946), by the Harvard University Computation Laboratory. 1985.

9. *The Moore School Lectures* (1946). edited by Martin Campbell-Kelly and Michael R. Williams. 1985.

10. *A. M. Turing's ACE Report of 1946 and Other Reports*, edited by B. E. Carpenter and R. W. Doran, 1986.

11. *Lr Calcul Simplifié*, by Maurice d'Ocagne, translated by J. Howlett and M. R. Williams. 1986.

12. *Papers of John von Neumann on Computing and Computer Theory*, edited by William Aspray and Arthur Burks, 1986.

13. *Memoir of the Life and Labours of thr Lute Charles Babbage, Esq. F. R. S.* by H. W. Buxton, 1987.

14. *The Early British Computer Conferences*, edited by Michael R. Williams and Martin Campbell-Kelly. 1989.

15. *Rabdology* (1617), by John Napier, translated by William Frank Richardson. introduction by Robin E. Rider, 1990.

16. *The Calculating Machines (Die Rechenmaschinen): Their History and Development*, by Ernst Martin, translated and edited by Peggy Aldrich Kidwell and Michael R. Williams. 1992.

THE CALCULATING MACHINES

(DIE RECHENMASCHINEN)

VOLUME 16

IN THE

CHARLES BABBACE INSTITUTE

REPRINT SERIES FOR THE HISTORY OF COMPUTING

THE CHARLES BABBAGE INSTITUTE REPRINT SERIES FOR THE HISTORY OF COMPUTING

This volume is one of a series of works selected for reprinting by an editorial board of the Charles Babbage Institute. The Charles Babbage Institute for the History of Information Processing was founded in late 1977 to promote study of the technical and socioeconomic aspects of the development of information processing. To this end, the Institute serves as an archive of the history of information processing; as a clearinghouse for information about historical material and interested persons; and as a foundation that fosters research and writing in the field of information processing through the use of historical materials. In 1980 the Institute moved to its permanent home at the University of Minnesota.

The principal aim of the reprint series has been to make the key literature of the history of computing more accessible. Until now, the scarcity of many significant works has been a handicap to serious study. Reprinted items include classic textbooks, influential reports, and conference proceedings that have proved to be significant steps in the development of the subject. If original editing or print quality now seems unsatisfactory, new editions of some works are to be offered. In addition. non-English works are translated. Most volumes are provided with an authoritative introduction to afford insight and context for the present-day reader.

In selecting works for reprinting, the editorial board has consciously endeavored to produce a balanced collection of material that is representative of the full spectrum of the history of computing. The complete series will thus form a sound basis for studies in the history of computing, and will be of value both to active historians and to computer practitioners interested in the origins of their subject.

THE CALCULATING MACHINES

(DIE RECHENMASCHINEN)

THEIR HISTORY AND DEVELOPMENT

Ernst Martin

translated **and** edited by Peggy Aldrich Kidwell and

Michael R. Williams

The MIT Press
Cambridge, Massachusetts
London, England

and

Tomash Publishers
Los Angeles/San Francisco

This book was set in Times Roman by Asco Trade Typesetting Ltd., Hong Kong, and was printed and hound in the United States of America.

Library of Congress Cataloging-In-Publication Data

Martin. Ernst
[Rechenmaschinen. English]
The calculating machines (Die Rechenmaschinen) : their history and development / Ernst Martin ; translated and edited by Peggy Aldrich Kidwell and Michael R. Williams.
p. cm. — (The Charles Babbage Institute reprint series for the history of computing; v. 16)
Translation of: Die Rechenmaschinen.
ISBN 0-262-13278-8
1. Calculators. I. Kidwell, Peggy Aldrich. II. Williams. Michael R. III. Title. IV. Series.
QA75.M3513 1992 91-25450
681'.14—dc20 CIP

Editors' Foreword

This volume, the sixteenth and last in the current series produced for the Charles Babbage Institute Reprint Series for the History of Computing, was one of the first to be suggested by the editorial board but last to be published because of the extreme difficulty of doing a proper translation and because the rarity of the book hindered our efforts to find a copy that would provide the quality of illustrations that we wanted. The original 1925 German edition is all but unknown in North America, extremely rare in Britain, and difficult to obtain on the European continent.' A photographic reprint was produced in Germany several years ago, but an attempt to produce third-generation copies of the illustrations, many of which originally came from poorly produced advertising copy in the first place, was out of the question.* Thus the project languished for several years until the editor-in-chief asked us if we could complete the project, which had been started and abandoned several times.

The copies we have seen are in very poor shape. They were printed on high acid paper and both the paper and bindings are deteriorating rapidly. The pages are yellowed, becoming brittle, and the book may not be used freely without serious danger of damage.

Office Machines in the Workplace

During the first quarter of the twentieth century, the use of office machines became common in American and European business, government, and science. Typewriters. calculating machines, and filing systems, which had first become commercial products in the nineteenth century, gradually were adopted by actuaries, government officials, scientists, and businesses. Even small shopkeepers came to keep accounts and purchased cash registers and adding machines to record transactions. Larger concerns invested in bookkeeping and tabulating machines.'

From its inception, the office machine industry was international in character. The first calculating machines sold regularly were the arithmometers of the Frenchman Charles Xavier Thomas, introduced in 1820. An 1879 article on the arithmometer indicates that some 60 percent of Thomas's machines were exported from France.[4] By 1900, much of calculating machine manufacture had shifted to Germany and the United States. A tally of the inventors and manufacturers listed by Martin, grouped by date of founding and nationality, suggests this trend:

	Number of new manufacturers or inventors		
Time period	Germany	United States	Other nationality or nationality unknown
1871–1880	2	6	3
1881–1890	7	8	8
1891–1900	6	4	4
1901–1910	18	31	15
1911–1920	16	15	11
[1921–1925]	23	10	5

These data are at best a very rough indication of the relative importance of the German and U.S. calculating machine industries in the periods indicated. As we will suggest further, Martin's selection of nineteenth-century machines apparently was heavily influenced by the historical accounts available to him and may have overemphasized German and American contributions as a result. Nonetheless, the importance of Germany and the United States to calculating machine production in the period is confirmed independently by looking at trade literature and surviving machines.

As one would expect, national and international politics affected trade. Of particular relevance here are the severe restrictions on the import of typewriters and calculating machines into Germany that were in effect from 1914 until 1925.[5] Once the immediate impact of World War I had abated, this undoubtedly fostered the creation of new companies in Germany. At the same time, the loosening of German import restrictions in 1925 almost certainly fostered interest in Martin's review of calculating machines available throughout the world.

Early manufacturers of business equipment had sold their machines directly or through a few agents. If a machine broke, the owner could hire a local mechanic to repair it or return the instrument to its maker. As the market for office equipment grew, shops specializing in repairs and in the sale of used machines appeared. At the same time, some dealers came to sell more than one kind of machine.

Long before 1925, the expansion of the office equipment business, the diversity of products on the market. and the emergence of firms that repaired and sold several different kinds of machines had created a demand for journals. handbooks, directories, and other literature on office machines. Manufacturers published advertisements, manuals for users, booklets for factory workers, guides and magazines for salesmen, and instructions for repairmen. In the 1920s, Burroughs Corporation even published a more general magazine, entitled ***Business,*** intended for potential and existing customers.

Publishers in several countries saw a need for more independent trade journals. For example, in 1898 Otto Burhagen of Hamburg, the author of a book on typewriters, founded *Schreibmaschinen-Zeitung* (Typewriter News). The journal's title soon was expanded to ***Zeitschrift fur Burobedarf*** (Magazine for Office Supplies). When Burhagen died in 1906, his journal was carried on by other family members.[6]

In 1908, Friedrich von Schack founded the weekly ***Büro-Bedarf-Rundschau*** (Office Supply Review) in Berlin. This publication was closely associated with national organizations of office machine dealers and stationers. Yet a third German journal, ***Büro-Industrie*** (Office Industry), began in Berlin in 1913 as the house organ of a German association of manufacturers and dealers.

Similar magazines emerged in the United States. In 1904, G. H. Patterson and E. M. Best of New York started the ***Typewriter Trade*** Journal. The following year, E. C. Thurnau bought out Best's interest in the journal, moved it to Chicago, and changed the name to ***Office Appliances.*** This magazine emphasized use of office equipment in the United States. Convinced that some readers were more interested in the international trade, Best founded ***Typewriter Topics: The International Office Equipment Magazine.*** Both journals survived into the 1920s, although they would suffer in the depression years.' Similarly, in 1909, the Frenchman Gaston Ravisse established ***Mon Bureau*** (My Office).

The editors of these journals encouraged the office machine business in other ways. In addition to the weekly B. B. R., von Schack published an annual office appliances directory that, in 1928, included 6500 German office appliance, typewriter, calculating machine, and stationery manufacturers and dealers. For a time, Best edited a journal for the U.S. office equipment trade, entitled ***Business Equipment.*** In 1927, he encouraged James H. McCarthy's publication of ***The Business Machines and Equipment Digest,*** a compendium describing typewriters, calculating machines, and related products. Moreover, both his ***Typewriter Topics*** and other trade journals routinely reported on office equipment fairs. Ravisse went one step further, and organized an exhibition to be held regularly in Paris.[8]

Johannes Meyer, a publisher in the German city of Pappenheim, was well aware of the new interest in office machines and set out to give full credit to German contributions in this area. Several titles he distributed are mentioned by Martin. Two concerned specific calculating machines, namely those of Phillip M. Hahn and C. X. Thomas.[9] The third was a general account of calculating machines and machine calculation by K. Lenz.[10] As Martin indicates in the preface to *Die Rechenmaschinen*, office machine dealers were not primarily interested in either the achievements of eighteenth- and nineteenth-century inventors or the general principles of calculating machine design. They needed to know how old various machines were, what they could do, how much they cost, and where they could be ordered.

To answer these specific questions, Martin wrote two books, both of which were published by Meyer. The first, *Die Schreibmaschine und Ihre Entwicklungsgeschichte* (The Typewriter and Its Developmental History). was published in 1921. Regularly updated, it had reached its fifth edition in 1934 and was revised and reissued as late as 1949. Martin's second endeavor, the volume translated here. was his developmental history of calculating machines. It first appeared in 1925 and was republished, with an appendix, in about 1937.

Martin's *Die Rechenmaschinen*

In his preface Martin says that he has been collecting information about calculating machines for the past twenty-five years. His compilation of this information makes for a curious book. After an introduction that describes the seven major types of machines that had been produced by 1925, he offers a list of specific makers, arranged by the date when they first patented or produced a calculating machine. These entries appear to be notes Martin took in the course of his researches. They do not have a standard format, nor does information always follow in logical sequence. Several of the entries for the more advanced equipment show unmistakable signs of being purposely written for this volume, but the majority are obviously lightly edited versions of his notes, with no regard for having a consistent set of facts for each machine.

For the period before 1900, Martin relied heavily on earlier books. Some of these were accounts of specific machines, such as the works on Thomas and on Hahn mentioned above. Another important source appears to have been *Le Calcul Simplifié* by the French professor P. Maurice d'Ocagne.[11] For American machines. Martin apparently relied heavily on J. A. V. Turck's *Origin of Modern Calculating Machines*.[12] He also could draw on L. L. Locke's accounts of the work of F. S. Baldwin.[13] As one might expect, the machines Martin included reflect his sources. For example, Turck was closely associated with Dorr E. Felt, inventor of the key-driven comptometer. His book, and hence that of Martin, included an account of several early patented key-driven machines that never sold in quantity. Martin included these, but made no mention of perhaps equally obscure but more sophisticated machines patented in the United States by Edmund Barbour (patent 1872) and Ramon Verea (1878).[14] We mention this simply to suggest that Martin himself made no systematic attempt to research patent records but rather relied on the work of others.

Perhaps the most glaring omission from Martin's historical remarks is the machine of Schickard. However, it seems more appropriate *to* commend Martin for drawing together the information he could find than to fault him for neglecting machines that were essentially unknown in his time. There are several occasions when Martin obviously knew of the existence of a particular machine but was unable to locate any details. For example, he described machines in the private collection of the American Dorr E. Felt, but apparently did not know that they still existed. Two examples of machines in this class are the Schilt adding machine and one of the Bollée calculating machines. For most important machines prior to 1900, Martin attempts to provide us with details of the development of the device, and particularly of the people involved. He occasionally cites secondary sources at length and sometimes even acknowledges them by title. We have simply translated Martin's German rendering of these sources as best we could, without attempting to locate. and work from, the original documents. The reader should therefore be cautious in accepting this translation as representing the original from which Martin obtained his data.

The machines on the market in the years 1900 to 1925 are the ones Martin obviously knew best. When describing these devices, he is usually sure of his facts and often quotes market prices. He sometimes provides little extra notes, which could only have come from personal knowledge and experience of their use. It is this section of the work that provides the most reliable data and will be most useful for both scholars of the history of this subject and the collector of these devices wishing more information on their use or restoration.

This volume provides a very fine German picture, frozen in time, of the state of the mechanical calculator industry in 1925. However, like ail such pictures, it is subject to a little distortion. Martin does not claim to be complete in his coverage of the field. Several machines produced by small firms, particularly those outside of Germany and variations on a theme or different models produced by one firm, may very likely have been missed. One surprising omission is the new accounting machine that had been introduced by National Cash Register of Dayton, Ohio, and would become one of that company's most important products. Otherwise, considering the restrictions on imports in effect during the time he was writing, Martin gives remarkably good coverage of contemporary American machines. At the same time his pride in German achievements is evident.

Some of Martin's statements could have been taken directly from promotional literature. For example, he wrote that "simple operation and safeguards; which rule out any calculating errors, make the Rema a first class calculating machine," described Brunsviga's Trinks Triplex R model as "practically indispensable for scientific calculations," and commented that the Mercedes-Euklid machine "has not only overcome the defects of other machines, but possesses a multitude of other improvements." Indeed, he may well have been pressed to include extra material on machines produced by those firms that helped to sponsor the book. A glance at the advertisements following the index will show that this publishing venture was partially underwritten by several of the largest producers of this kind of equipment. One should note, however, that only one of the three machines just mentioned was advertised in the book.

Translation and Editing

Ernst Martin produced an updated version of this work in about 1937, which was actually the original work with an appendix containing information on more recent machines. We decided to translate only the original 1925 edition for several reasons. First, the later edition is even rarer than the original, and this made the effort of obtaining a copy with figures suitable for reproduction much more difficult. Moreover, the later volume contains little that is new—the machines included were mostly minor modifications of ones described earlier. The National accounting machine is still not mentioned, and new machines like the Friden are omitted. Those seriously interested in American calculating machines of the period would do better to seek out the volume published by the Office Machine Research Service between 1937 and 1940.[15] If necessary, the material Martin published in his appendix can be found in the photographic reprint already mentioned.

As we mentioned, translating this volume presented several serious difficulties. The first was that Ernst Martin's German, while undoubtedly acceptable. was not always consistent. He was fond of using mechanical engineering terms that were dated by the turn of the century; he often used his own quaint descriptive phrases for parts of the machines and did not keep to a consistent style in his notes. All of these factors add to the difficulties of reading, to say nothing of translating, this work. We attempted to find German speakers to help us with any questionable points, but there were several occasions when native German speakers, knowledgeable in the subject area, frankly admitted that they could not understand what Martin was trying to say. Faced with difficulties of this nature, we produced a translation that we believe makes technical *sense* although *it* is **not** always truthful to the original. There were several occasions when we were forced to admit complete defeat, and these are noted in footnotes.

We were very fortunate in having access to the extensive collection of calculating machines and equipment in the National Museum of American History at the Smithsonian Institution. When particularly difficult translation problems occurred, we could occasionally resolve the matter by inspecting a machine, or one similar, from the collection. Although we have made every effort to provide accurate translations, we can not guarantee that all statements are in accord with the actual nature of the equipment being described. We know that Martin often worked from secondary descriptions and drew together a scattered literature. In addition to the translation problems, we have no guarantee that he was always entirely correct.

Ernst Martin used footnotes in his original German text. We have consistently incorporated them into the main text in order to leave the footnote space available for us to use. We have used footnotes to provide extra information on a device, provide some clarification as to the present (1991) whereabouts of a device, correct blatant errors, and simply to admit defeat in the translation process.

We have not attempted to polish the English version to remove all traces of Martin's rather difficult style. While this has occasionally resulted in a work that would give the shudders to an English grammar teacher, we feel that it is indicative of the original and thus should be left to give at least some feeling of what the original was like.

The figures retain the same numbers as in the original text. Where Martin had obviously missed, or decided later to add, additional illustrations, he

simply put the letter "a" or "b" **after the number to differentiate** it **from an earlier figure. Rather than attempting to renumber all** figures **and their references, we have simply kept, with one exception, his system. The single exception concerns two figures that were obviously interchanged—we have corrected them and noted the correction in a footnote.**

Notes

1. The authors know of three copies of Martin's book that reached the United States. One. used in preparing a microfilm edition of the book. was in the library of the National Bureau of Standards (now the National Institute of Standards and Technology). A second was in the personal library of Dorr E. Felt of Felt and Tarrant. A third was owned by Rurroughs Corporation. The second and third copies are now in the collections of the National Museum of American History. Smithsonian Institution. Curiously, there is no copy of Martin in the surviving library of Leland L. Locke, perhaps the leading American historian of computing of his day. We thank the library of Grove City College in Pennsylvania for this information. We have made no systematic attempt to discover copies of the book.

2. Published by Wolfgang Koentopp. Meierfeld 4, D-4817, Leopoldshoehe, Germany.

3. On the transformation of U.S. government offices, see C. Stephens and S. Lubar, "A Place for Public Business: The Material Culture of the Nineteenth-Century Federal Office," *Business and Economic History*, 1986. ser. 2. IS:165–172. On the rise of accounting practices in U.S. business. see S. Strasser. *Satisfaction Guaranteed: The Making of the American Mass Market*, New York: Pantheon. 1989. On tabulating equipment, see M. Campbell-Kelly, "Punched-Card Machinery." *Computing before* rhe Compurer, ed. W. Aspray, Ames: Iowa State University Press, 1990, pp. 122–125. See also A. L. Norberg, "High-Technology Calculation in the Early 20th Century: Punched Card Machinery in Business and Government." *Technology and Culture*, 1990, 31:753–779.

4. Sehert, "Rapport . . . sur la machine a calculer, dite arithmometre." *Bulletin de la Societe d'Encouragement pour l'industrie Nationale*, 1879, 78:406.

5. See R. Siering. "German Industry and the Markets of Germany." *Typewriter Topics*, 1925, 59: 19–20: A Zeiss, "The Importance of Business Machinery Thoroughly Recognized in Germany." *Typewriter Topics*, 1925, 59:28–29; and M. L. J.. "Germany as a Market for Office Equipment." *Typewriter Topics*, 1925, 61:12.

6. E. Martin. *Die Schreibmaschine* . . ., Aachen: Peter Basten, 1949, p. 437.

7. Apparently American office supply dealers did not organize as early as those in Germany. The National Office Machines Dealers Association (NOMDA) was founded in 1926 and first published a journal in 1938. See: *The Parade of Progress. NOMDA's First 60 Years*, Kansas City: NOMDA, ca. 1986.

8. "'Twenty Years for 'Mon Bureau'." *Typewriter Topics*, 1929. 73:11. On the later years of Ravisse. see the obituary "Gaston Kavisse," *Bureau-Bedarf-Rundschau*, 1935, 28:271.

9. M. Engelmann, *Leben und Wirken des . . . Philipp Matthaeus Huhn,* Berlin: Schmidt & Co., 1923; and F. Reuleaux, *Die sogenannte Thomas' sche Rechenmaschine*, Leipzig: A. Felix, 1892 (this is the second edition). It is not clear whether Meyer published new editions of these hooks, or simply distributed copies available to him.

10. K. Lenz, *Die Rechenmaschinen und das Maschinenrechnen*, Leipzig & Berlin: B.G. Teubner. 1915.

11. P. M. d'Ocagne, Le *Calcul Simplifié par les procedes mecaniques et graphiques* . . ., Paris: Gauthier-Villars, 1894. A second edition appeared in 1905 and a third in 1928. An English edition of the 1928 volume, prepared by J. Howlett and M. K. Williams, appeared as Volume 11 of this Charles Babbage Institute Reprint Series for the History of Computing.

12. J. A. V. Turck, *Origin of Modern Calculating Machines*, Chicago: The Western Society of Engineers. 1921.

13. L. L. Locke, "The History of Modern Calculating Machines, An American Contribution," *American Mathematical* Monthly, 1924, 31:422–428.

14. L. L. Locke, "The First Direct-Multiplication Machine." *Typewriter Topics*, 1926, 64:16–20.

15. Office Machines Research, Inc., *American Office Machines Research Service*, vol. 3, 1937–1940.

THE **CALCULATING MACHINES**

(DIE RECHENMASCHINEN)

Introduction

What do we mean by the term ***calculating machine?*** We all know, from our early schooling, about those primitive calculating machines, consisting of strings of wooden beads, that were used in antiquity in Egypt and nowadays are used not only in Germany but in all civilized countries and beyond. It is, erroneous to term this instrument a calculating machine because it lacks the characteristics of a machine. This is also true for a series of devices such as calculating drums, calculating disks, slide rules, and adding machines with hook-operated tens-carries, all of which lack the characteristics of a machine. Devices such as these should not be termed calculating machines, although manufacturers sell them as such.

In the calculating machine trade. particularly in European countries and in the United States, it has become customary in recent years to call only those products that possess automatic tens-carry by the term calculating machine: if this feature is missing, the term *calculating aid* is more appropriate. This book will describe only the former, while the latter will be dealt with exhaustively in a separate volume under the title *Andere Mechanische Rechenhilfsmittle* (which is to appear in 1925).[1]

It should be noted that among these calculating aids there are many that are very useful in performing calculations, be they additions and subtractions or multiplications and divisions, or all four basic calculation types together. These *calculating aids* have the particular advantage of usually being unexpensive, whereas the cost of *calculating machines* usually runs into the hundreds of Marks, depending on their ability to perform different operations. Some calculating aids may even be more useful than calculating machines because they permit various results to be read without special operations being performed.

It is necessary to discuss the term calculating machine still further in order to avoid misunderstandings and errors. In the broadest sense, calculating machines are understood to be machines that are equally suited for the performance of multiplication, division, addition. and subtraction. The term also applies to machines that are normally intended for addition and subtraction only and do not permit the operation of multiplication, or. if they do, only as a makeshift or less advantageous operation. In a narrower sense, however, we term only the former ones calculating machines. with the latter ones forming a separate class under the term adding machines. *Adding machines* are

1. *Other Mechanical Calculating Aids*. The editors can find no evidence that this volume was ever published.

primarily intended for adding and usually, although not always, for subtracting. Such machines may permit the operations of multiplication and division, but in this respect they cannot compete with calculating machines proper. *Calculating* **machines** are able to carry out all four fundamental operations with great rapidity.

Adding machines have, nevertheless, found a much wider distribution than the more comprehensive calculating machines. This is due to the fact that, in commercial life, the addition operation plays a significant role and is much more important than the operations of multiplication and division. This is most easily seen in the long series of additions required in the columns of the accounting books of industrial enterprises, trading companies, banks, and so on. Adding machines, especially the printing ones,? frequently were developed into bookkeeping machines, and still others are employed for writing out monthly balance sheets and the like.

It is not my intention to develop a classification of machines, because even if **a** relatively large number of classes were established, a considerable number of machines would remain that still did not fit into any one of them. It is intended, however, to describe in detail, in what follows. the basic principles of

- calculating machines with stepped drums,
- calculating machines with pinwheels,
- full-keyboard adding machines with printing mechanisms,
- ten-key adding machines with printing mechanisms,
- small adding machines with stylus setting, key setting, **or** direct setting mechanisms.

These categories cover most of the existing calculating machines, and anyone familiar with these basic principles will find it easy to understand the brief descriptions of the individual systems that are to follow in chronological order. Machines that materially differ from those listed will be dealt with in greater detail.

2. Martin'!: English-speaking contemporaries described adding and calculating machines with a printing mechanism as *listing* machines. We have chosen to stick with *printing* as being closer to Marlin's original German.

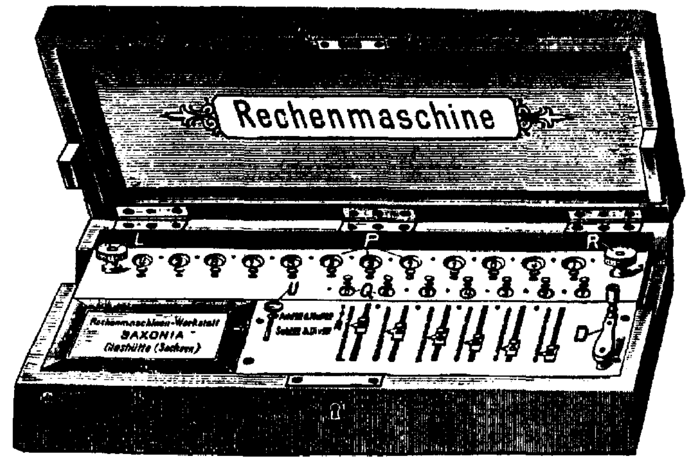


Figure 1

The Stepped Drum Machine

This is usually called the Thomas machine, the Glashutter machine, or **(es**pecially in France) the arithmometer. The term Thomas machine is, however, only justified to the extent that Thomas improved the machine according to his own ideas and manufactured and marketed it commercially on a relatively large scale. The Thomas machine is not a separate or new system; it exhibits the main characteristics of an older machine by Parson Hahn still in existence today.

Originally the stepped drum machine was furnished in a wooden chest having a lid with lock and key. Today it is usually built into an iron frame with legs. Figure 1 shows an older model of the Saxonia machine, one type of stepped drum machine.

The main parts are the cover or setting plate with the setting slides mounted in slots, two rows of windows, the crank, and the reversing or control lever **for** the *Add-Mult* and *Subtr-Div* settings. Below the cover plate are mounted the staggered or stepped drums, a single-digit example of which is shown in figure 2, from which the machine (and in fact the whole **class** of machines) derives its name. Figure *2* also shows the setting gear, which may be moved along a square shaft and is connected by a fork to **a** setting slide mounted above the cover plate, and the result mechanism. The revolution counter and

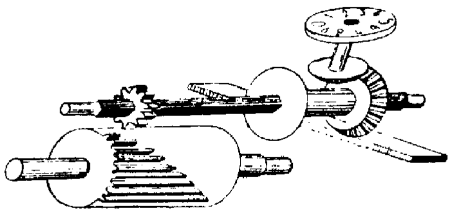


Figure 2

the drive mechanism, although integral parts of the machine, are not shown in figure 2. A machine having eight setting slides and an equal number of setting slots requires the same number of setting gears and square shafts, an equal number of stepped drums, and at least as many windows in the result mechanism (probably it will have several more), while the revolution counting mechanism is usually less extensive. A single crank imparts rotational motion to all stepped drums at once. There are machines having six, seven, eight. nine. ten, eleven, and even more decimal places.

As may be seen from figure 2, the stepped drum possesses nine teeth staggered in longitudinal direction and disposed over a third of its circumference. The drum turns about the shaft upon which it is mounted. The square shaft positioned above each drum is mounted to rotate freely, and on this shaft is the setting gear, capable of sliding back and forth to engage different numbers of teeth on the drum. Two larger vertical bevel gears are also mounted on this square shaft toward the end containing the result mechanism. These bevel gears may be shifted so that one or the other will engage the teeth of a horizontally positioned gear and this will, in turn, rotate a numeral dial. mounted above, either to the left or to the right so that any one of the ten digits on the dial may appear in the window of the result mechanism.

Returning to the setting plate on the top exterior surface of the machine, to the left of the setting slides there is a control knob or lever that may be moved into either of two positions. When the lever is set to *Add-Mu/[.* the machine adds (multiplication is nothing but continued addition). and when the lever is set to *Subtr-Div*. the machine subtracts (division is nothing but continued subtraction). In the following example. the lever is to remain in the *Add-Mult* position.

The digits 0 to 9 may be seen alongside the setting slide slots. Let us, for example, shift one of the slides on the cover plate so that it is positioned opposite the numeral 3. The slide shifts the setting gear below the cover plate

by the same distance. If we now turn the crank, we will simultaneously turn all stepped drums of the machine. There is no significant resistance to this movement because only one of the drums, namely, the one above which the value 3 was set. has to turn a setting gear shortly after rotation commences,., that is, as soon as the corresponding tooth of the drum comes against the setting gear. The setting gear, in turn, rotates the square shaft and transmits rotational motion to the rear-most of the vertically positioned bevel gears, which. in turn, acts upon the horizontally positioned gear and thus turns the dial three teeth, or digits, ahead. In the window positioned above the dial. which had previously shown a "0," now shows the digit 3. All the other stepped drums participate in this rotational movement blindly. If we wish to add 5 to the value 3 appearing in the window, we only have to shift the previously used setting slide to the digit 5, turn the crank once, and then we may read the result 8 in the window. Since the machine shown in figure 1 is arranged for six decimal places, we may set up and add six-digit numbers. However, for very small values, for instance single-digit values or two-digit numbers, it actually takes more effort to use the calculating machine than to do the job by hand.

As previously mentioned, the cover plate possesses two rows of windows through which are visible a result mechanism and a revolution counting mechanism. (The action of the result mechanism has been explained.) However, having set up the digit 3 with the slide and having set this value into the result window above the corresponding row of digits by a clockwise turn of the crank, the window of the revolution counting mechanism (below the result window) will show the numeral 1, which indicates that the crank has been turned once. The revolution counting mechanism is not actually required for addition or subtraction—it may, at best, serve as an item counter because only one turn of the crank is necessary for every item to be added or subtracted. However matters are quite different with multiplication and division, as will be explained.

Let us assume we are to add 4 to the value 8 that appears in the result window. This does not seem possible because the result counting mechanism exhibits the digits 0 to 9 only. When we move the slides of the respective setting slot to 4 and turn the crank. the tens-carry mechanism, provided on the dial between the digits 0 and 9. engages the next decimal place to the left and advances its dial by one digit, so that the left window will show the value 1 and the right one will show the value 2, i.e., 12. All decimal places in the machine are, of course. provided with the tens-carry mechanism. and it should now be clear why the machine possesses more counting mechanisms than setting slides.

It may be mentioned that the tens-carry mechanisms in the different places do not act simultaneously, they act successively, and it is for this reason that the circumference of the stepped drums is materially larger than the provision of nine teeth would require. It is not until after all the drum teeth have finished interacting with the setting gear that the carry of a ten at a preceding place occurs, if necessary. The tens-carry is the most critical point of any calculating machine. and when buying a machine it is advisable to check whether its tens-carry mechanism is truly reliable. Unless the machine is provided with a tens-carry mechanism' for its last digit position, one should check that it is equipped with what is termed "tens-warning," so that the operator may assist in carrying the tens as necessary.

The digits 0 **to 9** are indicated on the revolution counter twice, once in white digits and once in red digits. The white (addition) digits appear in the windows during addition and multiplication, and the red (subtractive) digits appear during subtraction and division. The reason for this is that the revolution counter does not have a tens-carry mechanism, like the result counter mechanism. Thus, such machines do not properly indicate the multiplier during the operation usually termed *shortcut multiplication* (although it does in ordinary multiplication), for which reason an appropriate correction must be made, namely subtraction of the red digits from the white ones.

It only remains to mention the two knobs at the right and at the left of the row of windows—the left knob is the handle that allows lifting of the result mechanism carriage' (during the operations of multiplication and division4 and shifting it from one digit position to the next. By turning the right knob to the right, all windows of the result mechanism can be set to zero. The windows of the revolution counter have to be individually turned to zero, in the machine illustrated in figure 1, by setting knobs above these windows. It should be mentioned, however, that this zero-setting mechanism has long been replaced by something better. In the stepped drum machines of today the result mechanism and revolution counting mechanism may be set to zero by pressing a lever.

3. The original German term was *lineal*, which means *ruler* or *guide*—we have chosen to translate this as *carriage*.

Addition

As an example of a nontrivial addition operation, consider the problem of adding together the following two six-digit numbers: 245,377 + 835,576. The digits 7, 7, 3, 5, 4, 2 are set in the slots with the setting slides, commencing with the right-most slide, and then the crank is turned, which sets the respective digits into the result mechanism. The digits 6, 7, 5, 5, 3, 8 are successively set up commencing with the last digit position on the right, and again the crank is turned, whereupon the total of the two items (namely 1.080.953) appears in the result mechanism without any further manipulation. In the same way any number of additional items may be added to the extent allowable by the number of digit positions of the machine. After the whole calculating operation has been completed, and when a new operation is to be commenced, the two counting mechanisms are set to zero as described. The result would, of course, have been the same if the individual digits had been set from left to the right instead of right to left, as described in the preceding example.

Subtraction

Let us return to the inner mechanism of the machine (figure 2), and remember that *so* far we have only explained the operation of the rearmost of the two vertically positioned bevel gears on the square shaft and have ignored the one in the most forward position. This, too, performs a rotational movement when the crank is turned but, being mounted in the opposite direction, it turns the result dial in the opposite way, that is, in the subtractive direction. For instance. if it is desired to subtract 3 from the value 9, the reversing or control lever on the cover plate is first set to *Add-Mult*, then the value 9 is set up with the aid of the setting slide, the crank is turned, and the value 9 will appear in the window directly above the setting mechanism. Now subtraction begins: first the reversing lever is to be set to ***Subtr-Div***, which disconnects the rearmost of the vertically positioned gears on the square shaft while connecting the front one. Now the value to be subtracted, *3*, is set up with the same setting slide just used, the crank is turned in the same direction as in addition, and the respective result window will show the remainder *6*.

As an example of subtraction, consider that of the four-digit numbers 47.32 minus 28.56. The larger value (that is 47.32) is set up by means of the setting slide as it was for addition, then the crank is turned once. The machine is then set for subtraction, the amount 28.56 is registered with the setting slide, the crank is turned once, and the result (18.76) may be read in the result windows. It should be clearly understood that the crank must always be turned in the direction of the arrow and never in the opposite direction, and that, as during addition, the tens-carry occurs automatically during subtraction.

Multiplication

It has been stated that multiplication is nothing but continued addition; basically it is, therefore, unimportant whether we calculate $4 \times 6 = 24$ or $6 + 6 + 6 + 6 = 24$. If we intended to calculate this small problem with the machine, the machine would be set for addition. the value 6 set up with the aid of the setting slide, and the crank would be turned four times, whereupon the result, 24, could be read from the two windows. However. if we intended to multiply 21×15, it would be necessary to turn the crank fifteen times after having set up 21 on the setting slides. With the aid of the shiftable carriage. however, there is an easier way to perform this operation. After 21 has been set into the slide mechanism, it is possible to calculate 21×15 with only six turns of the crank. If we choose to initially place the value 15 into the mechanism and to multiply it by 21 (which yields the same result), the calculation could be performed with only three turns of the crank. This is possible because the part of the machine that contains the result and counting mechanisms is mounted so that it may be shifted from decimal place to decimal place, and as a result, five turns of the crank will be sufficient for the units position and one for the tens position if the multiplier is IS. However. if 21 is chosen as multiplier, a single rotation of the crank would be required for the units and two rotations for the tens; thus, in the first case six turns of the crank would be sufficient instead of 15 and in the latter case 3 instead of 21 as would be required by continued addition. In case of larger values. the saving is. of course, even more conspicuous.

Upon completion of a multiplication, the multiplier is stored in the revolution counting register. This enables the operator to check the calculation. because the value that was multiplied may still be found registered in the setting mechanism by the setting slide. and if these two items agree with those of the problem, the result is bound to be correct. (The shifting of the carriage is simple: it is easily lifted a little with the aid of a knob provided for this purpose, moved left or right as required, and then lowered again.)

Division

Division is simply continued subtraction. In division, the dividend is introduced by means of the setting slides, the machine set for addition, and the crank turned once—this transmits the value set up onto the result mechanism. After this initial step, the revolution counting mechanism will show the value 1 as an indication that one revolution has been made. This has to be eliminated so that all places of the revolution counter again show zero. The divisor is then set up by means of the setting slides, and the control lever is moved to subtraction. The carriage is shifted so that the divisor is positioned precisely below the two first decimal places of the dividend—provided this latter value is larger, in other words provided the divisor can be subtracted from the dividend. If this is not the case, the carriage must be shifted one position to the left. Now the crank is turned until the subtractions being performed reduce the dividend to a value which is smaller than the divisor. The carriage is then shifted one more decimal place to the left, and the crank operation is continued until once more nothing further can be subtracted. This shift and subtract operation is continued until eventually the whole division has been completed. If the divisor goes into the dividend without remainder, the result mechanism shows zeros in all windows and the revolution counter exhibits the number of crank revolutions performed in the individual digit positions—which will be the same value as the quotient. However. if the divisor docs not go into the dividend equally, and the remainder appearing in the result mechanism is to be divided still further so as to obtain a quotient with decimal places. then the remainder appearing in the result mechanism must be cancelled and must be reintroduced *n* places to the left, or with *n* zeros to the right. if *n* decimal places are desired in the final result, whereupon division may be continued in the manner described above. The best procedure, however. is to set up the dividend from the very beginning with as many zeros as decimal places are desired for the quotient. If it should happen that the crank is turned once too often during division (in other words, if there has been *over-division*, which is indicated by a bell being automatically rung), such an error may be corrected by shifting the control lever to addition and turning the crank once.

This description of the stepped drum machine and its operation will be sufficient for our purposes. It adequately describes the device as first manufactured in France and also. since the end of the seventies. in Germany.

Meanwhile, many companies, especially in Germany, have taken up the manufacture of such machines and, of course, every one of them has tried to make their model more competitive by incorporating improvements. It is not intended *to* go into details regarding the smaller improvements because this would go far beyond the scope of this book. However, it **is** necessary to briefly mention some of these improvements now so that the later descriptions of individual stepped drum machines will make more sense.

Setting Control Windows: After an amount has been set up by means of the setting slides on the cover plate, it is advantageous to check if it is correct before transmitting it to the calculating mechanism by rotating the crank. Since it is not convenient to read values registered on the zigzag lines of the setting slides, all recent machines are provided with separate rows of windows that show the amount set up in a straight line.

Overthrow: Means are now provided to prevent the so-called overthrow of individual rotating parts in calculating machines.[4] This condition, which might yield erroneous results, **is** caused by hasty and jerky rotation of the crank.

Machines With Two Result Mechanisms: **For** certain multistep calculations, it is advantageous to have a second result mechanism in the carriage. This second result mechanism may be connected, by a lever, with the other result mechanism, or it may be used separately—it permits the reading of intermediate results. Calculations of the following kind can readily be performed on such a machine:

2.65 kilograms @ 3.25 = 8.6125
3.15 kilograms @ 2.17 = 6.8355
7.30 kilograms @ 1.25 = 9.1250
24.5730

The multiplications arc carried out in the first result mechanism. their values are transferred to the second result mechanism, and the first **is** cleared for the next multiplication. The second multiplication is performed in the same manner, and its result is added to that of the earlier multiplication appearing in the second result mechanism, and so on. In the same way items such as

4. Overthrow is caused by applying excessive force to the drive lever so that the momentum given to the internal mechanism causes the gears to rotate past their normal stopping point.

discounts may be computed in the first result mechanism and then may be deducted from the amount appearing in the second mechanism.

Setting knobs beneath the windows **of** the result mechanism serve to set up the dividend or to correct the result (rounding off). They may readily be turned to the left **or** to the right when the carriage is raised. The revolution counter may also have this type of setting knob. The oldest stepped drum machines were provided with such setting knobs, but they served merely for setting the two counting mechanisms to zero, whereas nowadays all machines are provided with instantaneous zero-setting mechanisms that allow for faster operation.

Various manufacturers market stepped drum machines having complete tens-carry in the revolution counter so that the operator always calculates with white digits. never with red ones, no matter whether he adds, multiplies, subtracts, **or** divides. This is an advantage in the shortcut form of multiplication, as has previously been mentioned.

Sliding Decimal Point Markers: Today all windows are provided with sliding decimal point markers that permit easy reading of decimal places.

Machines with Keyboard Setting: Adding machines with full keyboard (Burroughs. Wales, etc.,) have always been superior to the stepped drum machines as regards the speed with which they permit items to be set up in the addition of columns of numbers. Setting slides require rather careful handling and, in a way, take up too much time because the operator's hand has to travel over relatively large distances. Therefore stepped drum machines have been designed with keyboard setting mechanisms. This may allow them to achieve speed in addition and subtraction equal to that of a keyboard adding machine while, at the same time, retaining the superiority of the stepped drum machine over the full-keyboard adding machine doing calculations involving multiplication and division.

Electric Drive: Since standard adding machines are frequently manufactured with an electric drive that supersedes the operation of a crank or lever, now stepped drum machines likewise are provided with electric drive mechanisms. **To** date, however, the stepped drum machine has not been modified to print the result, as do the full-keyboard adding machines. The only exception **is** the machine known as the XxX, and today even that machine **is** now manufactured and marketed as a nonprinting model only. However. stepped drum machines that will print the result on paper are due to appear on the market.

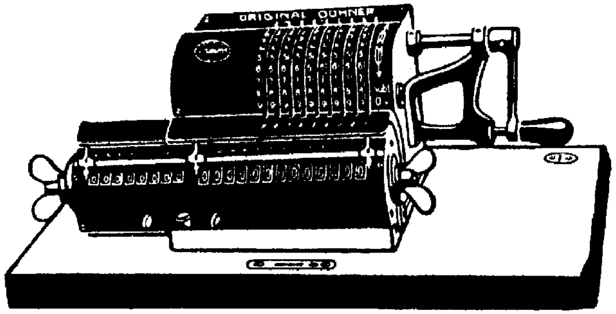


Figure 3

The Pinwheel Machine

In Germany this is frequently called the ***Odhner** machine* because Odhner was the first in Europe to employ the pinwheel mechanism in calculating machines. By *pinwheel* I mean a gear with a variable number of teeth. Odhner may, in fact. have reinvented this mechanism, but this has not been definitely established yet. It should be noted that prior to Odhner, the variable toothed gear had been patented by Frank Stephen Baldwin in America and had been used in devices for a number of years. It seems also to have been known to Leibniz,[5] Poleni. and Dr. Roth. **Two** of Roth's machines are still in existence in Paris. However none of these three constructions went beyond the experimental stage.

The main parts visible externally are a metal casing with slide slots and slides, two rows of windows beneath the **slots** and slides, a crank, two winged screws, and the bell. **In** the interior of the machine are the pinwheels, i.e., wheels with a variable number of teeth (one wheel for each decimal place of the machine). These wheels are mounted on a crank shaft. Below the wheels, in a movable carriage at the right side. is the result mechanism and at the left side the revolution counter.

Figure *3* shows an older type of pinwheel machine while figures 4, **5**, **6,** and 7 give an idea of the pinwheel mechanism. **As** shown in figure **6,** the pinwheel consists mainly of parts ***A*** and *B*. Part ***A*** is fixed to the crankshaft

5. Martin may well he referring **to** an early attempt by Leibniz **to** convert Pascal's adding machine to a device capable of multiplication. This did not use the true variable-toothed gear but rather **a** series of gears **with** different numbers of teeth.

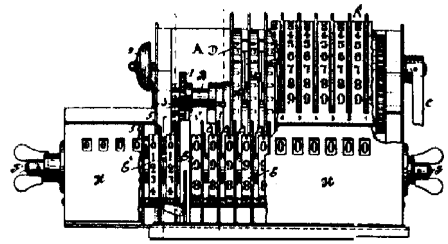


Figure 4

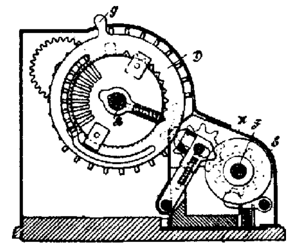


Figure 5

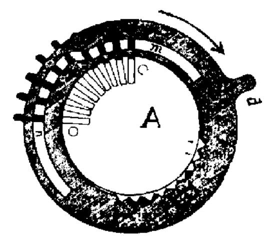


Figure 6

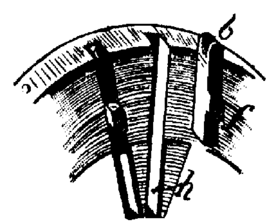


Figure 7

and thus rotates with it. Part A possesses nine pins that are gathered together in approximately one-third of the wheel circumference. These are more clearly seen in figure 7 where they are labeled ***b.*** They are mounted, radially, in notches *h*, each pin capable of projecting out from the edge of the disk. Part *B* may be shifted around part ***A*** with the aid of a small handle ***d.*** Part ***B*** contains an arched channel *m* extending over half its circumference and which is offset in the middle. Projections *f* slide in this channel. When these projections arrive at the offset line during rotation, they are compelled to successively project from or disappear in the circumference of the wheel, depending upon the direction of rotation. Handle ***d*** is the setting slide or setting lever and projects beyond the slot of the metal casing. The digits 0 to 9, designating the possible positions of the setting levers, may be found at the left of the individual slots. When a setting lever is positioned adjacent to the number 2, then two pins will project from the wheel and remain in this position. If the crank is now rotated in the forward direction, the two projecting pins engage the result gear positioned in the carriage and turn it by two teeth or digits. If the affected result window originally indicated 0, it will show the digit 2 after the crank has been rotated. At the same time, the revolution counter (positioned adjacent to the result mechanism) will indicate the value I because it counts the revolutions of the crankshaff. The wheels of the revolution counter have two sets of revolution numbers. The white digits appear during forward rotating (additive) operations, and the red ones appear during backward rotating (subtractive) operations. Every decimal position requires a setting slot, a pinwheel with setting lever, a result counting wheel, and a revolution counting wheel. The result counting mechanism has, of course, successively operating tens-carry mechanisms.

Addition

If 365 and 278 are to be added, the first number, that is 365, must be set in the three last slots at the right (it is immaterial whether the operator commences with 3 or 5) by positioning the respective setting levers opposite 3. 6. and 5. The crank is then turned forward (as indicated by an arrow that points in the *Add-Mult* direction), whereupon the amount may be read from the result windows. Now the setting levers are shifted to **2,** 7, and 8, the crank is turned as before, and the sum of the two values, namely 643. may be read in the windows of the result mechanism while the revolution counter indicates the value 2. Further additions take place by simply repeating this procedure.

Subtraction

The larger item is registered, as with the stepped drum machines, upon the setting mechanism in the manner described for addition. The crank is rotated forward in order that the value will be entered into the result mechanism. The item to be deducted is set up, the crank is turned in the opposite direction (toward the operator), whereupon the subtraction is performed and the remainder may be read in the result mechanism. Thus subtraction takes place in the same way as in the stepped drum machines with the exception that the crank is turned in the opposite direction—in exchange for this, the machine does not need to be adjusted from ***Add-Mult*** to ***Subtr-Div.***

Multiplication

The amount to be multiplied is set up by means of the setting levers and is transferred to the result mechanism by turning the crank forward (that is, in the additive sense). If this amount is to be multiplied, **for** instance, by 24, four additive rotations of the crank are made, the carriage is then moved one digit position to the right, and two additional rotations of the crank are made—the **result** mechanism shows the product, and the revolution counter indicates the multiplier. Thus, multiplication is carried out in essentially the same manner as in the stepped drum machine.

Division

If 7,533 is to be divided by 28, the **first** step is to set up the dividend on the setting levers and to put it into the result mechanism by a single turn of the crank. Then 28 is set up on the levers, and the carriage is shifted in such a way that the first two digits of the dividend, 75, are positioned below the set divisor ***28,*** and the crank is turned twice in the subtractive direction. The carriage is shifted back by one digit position because 28 cannot be deducted from the remainder 19. Now **193** appears below the divisor, and after having turned the crank **six** times, 25 remains. Again the carriage is shifted, and now 253 appears under the divisor, the crank is turned nine times whereupon **I** is left as the reminder, while the result 269 appears.in the revolution counter. It is, of course, possible to continue the division over a number of decimal places by leaving a corresponding number **of** zeros at the right **of** the dividend from the very beginning. If the crank has inadvertently been turned once too often ***(niter-dividing.*** as indicated by the bell ringing), the mistake may be immediately corrected by turning the crank once in the opposite direction.

Zeroing of the result mechanism takes place by turning the wing screw on the right end. Division thus takes place in the same manner as in the stepped drum machine, but the crank is turned in the opposite direction with the machine requiring no particular adjustment to a *Subtr-Div* setting.

As was the case with stepped drum machines, pinwheel machines — which were, especially in Germany, manufactured in large numbers — have been continuously improved. Provision has been made to prevent overthrow of the numeral wheels when turning the crank in a hurried **or** jerky fashion. In order to make it easy to check the correctness of an amount set before it is transmitted into the calculating mechanism, most machines are provided with a setting control mechanism that shows the value entered onto the setting mechanism in a straight row of windows. **All** rows of windows are provided with shiftable decimal points. The red digits in the revolution counter (which create problems with the shortcut method of multiplication as mentioned earlier) have been avoided in certain models by providing the machine with a special reversing lever, usually labeled ***Multiplicution-Division,*** and by equipping the machine with tens-carry in the revolution counter.

Most manufacturers make their pinwheel machines in two models, namely with and without tens-carry in the revolution counting register, and this enables them to satisfy the wishes of most of their customers. There are also machines with complete tens-carry in the revolution counter, in which reversing is carried out automatically and which are still provided with white additive and red subtractive digits.

For special operations there are machines with two revolution counters, one of which possesses tens-carry. In carrying out a series of multiplications, this arrangement renders it possible not only to add the products but also to add the multipliers at the same time and, in ***so*** doing, to provide a check on the individual multipliers. Some manufacturers also supply machines that have two result mechanisms, and there are also machines with double setting and result mechanisms; they are basically nothing but two complete machines that are, or may be, coupled with one another and thus allow the solving of certain problems that previously required two individual machines, **or** where it was necessary to interrupt the operation of the machine to perform a subsidiary operation before the main calculation could be continued.

In the area of different setting mechanisms, there are machines with long setting levers, instead of short ones, that may be conveniently grasped and do not participate in the movement of the pinwheel. There are also products

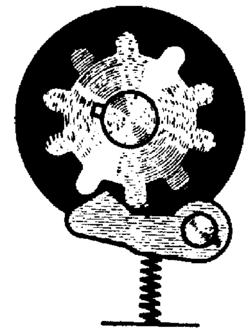


Figure 8
Older **catch mechanism. (Source:** Facit-Katalog, Atvidaberg)

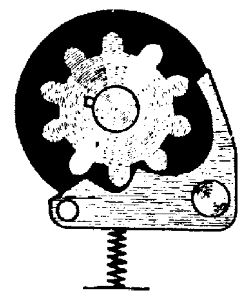


Figure 9
Newer catch mechanism. (Source: Facit-Katalog, Atvidaberg)

with keyboards that. in a sense, render the machine equal in efficiency **to** the full-keyboard adding machines while still keeping their superior design as far as the operations of multiplication and division operations are concerned. Additional models of such keyboard machines are in preparation. There is also a system that prints the items set up, the result, and ***so*** on; and several systems have been provided with an electric drive that supersedes the turning of the crank, which becomes rather tiresome during long calculations. Miniature machines arc also available. They accomplish the same tasks **as** the larger machines but are more convenient for various purposes. Finally there is also a machine in which transfer from the result mechanism to the setting mechanism may occur so that multiplications with three **or** morc factors may bc performed. This machine finds particular use in the timber trade.

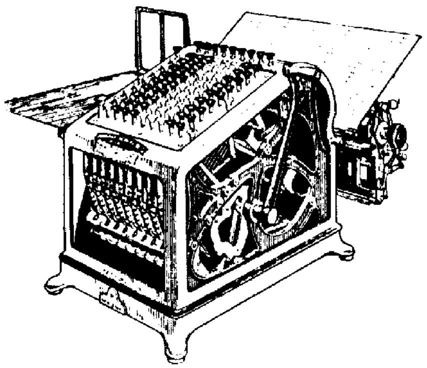


Figure 10

The Printing Full-Keyboard Adding Machine

Printing full-keyboard adding machines always have keyboards with individual columns of keys numbered 1 to 9 for each of the units, tens, hundreds, thousands, tens of thousands, etc. Such machines are usually built with nine digits in the setting mechanism.[6] For dealing with currency, rows of units and tens express pennies, and so on. To distinguish them easily. these two rows of keys arc usually of a different color from the following three rows of keys, which are capable of recording monetary values up to 999. The following three rows of keys, which express values up to 999 thousand, are again in the color of the first two rows of digits. and so on. Numbering begins with the smallest digits at the bottom of each column. There are no keys available for zeros, nonetheless, they are in fact automatically printed and appear in the result. It is possible to enter a number by pressing keys starting from either the left or the right end of the number.

Addition

For example. in setting up the value 3.75 marks on such a machine, it is necessary to first look for the 3 in the third column of digits and press this key down. Similarly the 7 key in the next column and the 5 key in the rightmost column should be pressed. It is important to press all the keys down far enough so that they remain locked in this position on the keyboard. One can now check whether the correct numbers have been pressed. If a number has been incorrectly entered, the error can be corrected by simply pushing the correct keys. Once the amount has been correctly set up, the crank is operated—it should be pulled forward and then let loose to freely return to its original position. Through this action the value is transferred from the setting keys to the result mechanism and printed on paper. Any additional items can be added to the value already in the result mechanism by repeating the above procedure. In order to print the final sum in the result mechanism, the sum key or total key must first be pressed and then the crank again activated. After each pull on the crank. all the keys that have been pressed return to their normal position automatically.

6. Various manufacturers introduced machines to add nondecimal combinations of quantities such as hours and minutes. shillings and pence. and inches and eighths of an inch. Fur hours and minutes the two rightmost rows of figures would only have to express quantities up to lifty-nine. Because one shilling contained twelve pence. there were eleven keys in one row to represent pence. Similarly there were seven keys to represent quantities from ⅛ to ⅞.

Subtraction

On each of the keys, next to the digits 1 to 9, it is common to find smaller digits. perhaps in another color. These are the so-called complementary digits or subtraction digits. Their relation to the larger digits is such that, if added together, the small and the large numbers on a key total nine. These small digits are complementary to the value to be subtracted, so that if a small number is pressed, its value is added to the value found in the result mechanism, and this process actually carries out a subtraction. With the printing full-keyboard machines there is usually no direct subtraction, such as we saw with the stepped drum and pinwheel machines. Here subtraction, and also multiplication and division, is carried out by means of addition, as the following example shows.

In order to subtract 444.44 from 777.77 (which is already in the result mechanism), you start by using the small subtraction digits. When keying in the number, it is necessary to subtract one unit in the last position on the right, i.e., 444.43. Then the nines keys in all the unused columns of keys are pressed,[7] the crank is pulled, and the result is given in the result mechanism. In subtraction, it is always necessary to take one less in the last position, except when the last position is zero.

7. In order to arrive at the correct result. the nines keys must be pressed in all the unused columns of keys. Otherwise the adding of a complement may produce an unwanted 1 in the leftmost position of the result.

Multiplication

Multiplication is performed as continued addition. If we consider, for example, 424 x 232 = 98,368, the first step is to enter 424 on the keyboard and press the repeat key so that the value entered is not canceled when the crank is moved. Then by moving the crank twice, the multiplication is carried out by the last digit of the multiplier, namely **2.** The key setting is then canceled by pressing the correction key. The same value, 424, is entered again, but this time all the numbers are shifted one position to the left. Following the procedure just described, one pulls the crank three times corresponding with the second digit, **3,** of the multiplier. When the key setting has again been canceled, the same value is entered again but shifted another column to the left. Two pulls of the crank then multiply the value by 2. The result can be read from the windows and, if required, can be printed in the manner described. This is multiplication from right to left. It is also possible to do this from left to right. Fractions can be multiplied by converting them into decimals; for example, $7/8 = 0.875$, and so on.

Division

Division is performed by continued subtraction. For example, consider the problem 3685 ÷ 54. The first value is entered in the last four columns of keys and transferred to the result mechanism, with the keys returning to their normal position. The divisor, 54, cannot be subtracted from the first two digits; thus, the value must be taken from the first three digits, 368. It is now necessary to enter the divisor, lowering its last digit one place (as with subtraction); that is, 53 instead of 54 is pressed. This is done by using the values on the small (complementary) digits, and in such a way that 53 comes under 68 of the result mechanism. The repeat key is then pressed, as well as the 9 key in the fourth row from the right.[8] Then, while moving the crank, it is necessary to watch the result mechanism so that the crank is moved only as often as needed until the amount in the result mechanism becomes small enough that 54 can no longer be subtracted from it. This condition occurs after the sixth turn of the crank, when there will only be 44 left in the result mechanism. The correction key is pressed, and this causes all the keys that have been pressed to return to their normal position. After this, 53 is entered,

8. Although the small (complementary) digits are used for the 5 and 3, it is the normal digits (4 and 6) that appear in the windows of the mechanism. Thus the 53 entered using the complementary digits leads to the 46 in the display.

via the small digits, in the last two rows, and the digit 9 in the third row. The crank is then turned eight times, as described, after which **13** remains in the result register. The zero in the third place signifies the border between the sum total and its fraction. The result is thus 68 $^{13}/_{54}$.

Certain machines print only on narrow strips of paper. The paper roll is mounted behind the machine and the paper strip is fed through to the position for printing. Other machines are equipped with a wide carriage (patented by Felt, 1889) and are especially good for use in bookkeeping. These machines are also usually provided with narrow paper rolls, so that they can carry out the usual sort of additions of columns. One can then tear off the strip of paper with the addition and store it. Machines with wide carriages are usually, like typewriters, equipped with tab stop mechanisms; pressing on the tabulator key brings the machine to the next column. There are also machines in which the carriage return is performed automatically with each pull of the crank, and others where it must be moved by hand. Machines with automatic carriage return usually have adding and subtracting tabulator stops. An adding stop is set under a column that is to contain only debits and a subtracting stop is usually set under a credits column. If, by turning the crank or pressing the motor key, the carriage comes to an adding stop, then the machine is automatically set for addition: similarly. it is automatically set for subtraction when it moves to a position containing a subtracting stop (see the topic of direct subtraction which is dealt with later in this introduction).

Besides the keys for setting values, printing full-keyboard adding machines contain a number of auxiliary or supplementary keys. We are already familiar with the repeat key used during the process of multiplication. When executing the operations of multiplication or division, this key must be pressed before the crank is pulled so as to lock the numerical keys in place when the crank returns to its original position. The correction key is used in order to release the keys after the crank has been pulled the necessary number of times. Another such special key is the **sum** key or total key, which must always be pressed before the total in the calculating mechanism can be printed. In some models. the total key serves both as the total printing key and the correction key. By pressing this key, all the digit keys that have been pressed return to their normal positions. Clearing the machine is done by means of the sum key or total key and one pull of the crank; this results in the gears of the machine being set to zero, so that the machine is free for the next calculation. In other models a special device is needed for setting the result mechanism to zero. The intermediate subtotal or carryover key may be used if the total (or the remainder of the numbers in the machine) is to be printed but at the same time must remain in the calculating mechanism for the continuation of the calculation. Intermediate subtotals or full totals are usually automatically printed in another color or marked by means of special signs. At the beginning of a new calculation. some machines also print a special sign to signal that the calculating mechanism is set on zero (patent: A. Macauley—Burroughs, 1906).

If a key has been pressed in error and must be canceled, it is usually enough to press the correct key in the same column, which will cancel the first key. Machines equipped with this device are called self-correcting (patent: Felt and Wetmore, 1904).

It may be the case that an operator wishes values or dates to be printed in the list of items, but not added up. In this situation, the non-add key may be used (patent: H. C. Peters—Burroughs, 1904). Such nonaddition items can be recognized on paper by a special printed sign (patent: Jeffe G. Vinvent, 1906). There are also cases in which a value is to be added up but not printed, and for this the nonprinting key is used (patent: Fred A. Niemann, 1907). The error key or correction key has already been mentioned; it is used to raise all the keys that have been pressed (patent: Burroughs, 1893). In addition, many machines have a row of unlabeled keys above or below the digit keys. These serve to cancel single columns of keys or, rather. to reset them to zero. Earlier machines had a keyboard lock—if a second key in any column of keys was mistakenly pressed, this and all other keys in the column were then locked (patent: W. H. Pike, Jr.—Burroughs, 1908).

An invention of Felt, who was the first person to create the Comptograph. was an indicator for marking the end of the paper. Cross addition and subtraction can also be traced back to Felt (1901). This, together with the wide carriage. first enabled adding machines to be used in bookkeeping. From that time on it became possible to write on the pages of account books with machines; that is, to print the balance, debit, credit. and new balance. Out of this developed, in the course of time, automatic bookkeeping for different purposes by means of adding machines. From the same inventor came the automatic item counter (1905). which made it possible to set up the number of items that can be listed under one another in one column of a page. If the corresponding number of items has been printed. then the machine is automatically locked and thereby prevented from allowing any more items to be entered because they would no longer fit on the paper. In this case it is necessary to set up a new column.

According to a patent filed by C. W. Gooch (1906), a section device can be built into a machine, which divides it into two, so that it is possible to both print and add two columns next to one another. This device permits the zeros on the right side to be switched off and thus makes it possible to print and add a special column separate from the others. The device was improved (1907) by Wetmore and Niemann (Comptograph) with the result that four different section devices were constructed to be inserted whenever necessary by the user himself. Since Niemann's patent of 1912, a machine can be divided between any pair of digit positions.

For many machines the printed digits are visible, while with others they are hidden. Most of the machines now on the market can be operated by means of an electric motor instead of a hand crank (patent: Frank C. Rinche, 1901). A motor operation key is usually attached to the right side of the keyboard. Motor power in itself affords no time saving, since it takes the same amount of time to move the hand crank. As a timesaving device, McFarland (1906) constructed a means by which a new value could be entered while the motor was processing the previous one.

Many machines have two calculating mechanisms coupled together. The first mechanism returns to zero when a sum prints, while the second remains unaltered. If one finally wishes to print the grand total from the second mechanism, the calculating gears of this mechanism must be connected to those of the first mechanism and the sum printed in the usual way.

Subtraction and division with the aid of complementary digits, as explained, makes operating a machine difficult for the layman. As a result, in 1910, William E. Swalm (of Burroughs) constructed a machine in which subtraction and division, like addition and multiplication, were carried out by means of large digit keys, with only a lever changed over to a subtraction position beforehand. Models with this adjustment are available today in great numbers. They are called direct subtracting machines.

Special keys for printing monthly statements and abbreviated bookkeeping symbols (like credit, debit, balance, etc.) have also been built into printing full-keyboard adding machines. Furthermore, they are set up to draw up and print balances of accounts automatically and are equipped with electric carriage return and automatic change of print color so that, for example, debit items are printed in black, credit items in red, or else single items appear in black and the totals in red.

There are also machines with two calculating mechanisms in which simultaneous or alternating addition or subtraction can be carried out. Debit and credit values can also be entered together in one column, and both types can be added separately simultaneously and the smaller value subtracted from the larger one.

Finally, there are machines built with a paper feeder and dispenser (patent: **F. C.** Rinche, 1913). With this device it is possible to handle large numbers of forms very quickly.

Usually full-keyboard adding machines are heavy and are fixed to movable iron stands. In fact, there are also the so-called portable machines, although these are so heavy that they can only be moved short distances. They cannot, like small portable typewriters, be taken home or on a journey.

The improvements to the printing full-keyboard adding machines just described originally referred only to certain makes. In the meantime, however, some of the patents have expired, and now a few factories pay or have paid some inventors for licenses. Other manufacturers have managed, in the end, to avoid certain patents. The result is that today all factories that manufacture printing adding machines equip them with all the above listed improvements, insofar as they have not already been superseded.

It remains now only to briefly explain the internal workings of such machines. The simple fact that a printing full-keyboard adding machine costs hundreds of marks provides evidence that they are made up of thousands of parts and are rather complicated. A full description of the complete internal structure is, of course, not possible here. Such a description would necessarily be too detailed and furthermore would probably not be understood by the average machine dealer, even assuming he had the relevant technical education. The older Burroughs (the tall, hidden printing machine) is used as a basis for the following brief description. The other Burroughs products. as is well known, are built lower, and consequently the printing is immediately visible. However their structure does not correspond to the machine illustrated.

In figure 11 the digit key operates on a revolving knee piece and in this way tightens the tie rod, shifting it from its position **of** rest (*d*) into the opening that lies behind. At the same time, the metal bar ***(e)*** is also moved backward into the position shown by the dotted sketch, whereby the hook (*f*) is pulled back and the cogged arch (*g*) **drops** far enough down that it turns itself around the **axle** (*h*), until the protruding front piece ***(k)*** is stopped by the bent-under end of the tie rod (*b*) that was moved into this stopping position by pressing the digit key. Simultaneously, the back end of the cogged arch is raised, and this brings one of the ten printing digits ***(l)***(the one corresponding to the pressed key) up adjacent to the printing platen (*m*). If the crank (*n*) is

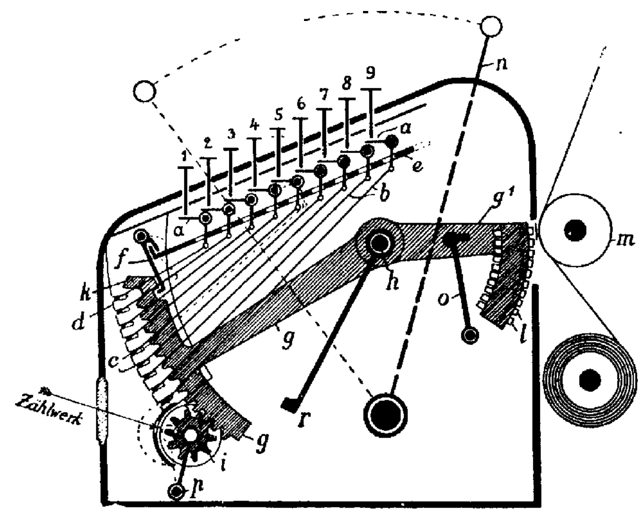


Figure 11
(Source: Lenz. Die Rechenmaschine und das Maschinenrachenen. Leipzig-Berlin: B.G. Teubner.)

pulled (as shown by the position of the dotted line) and let loose, the printing hammer (*o*) pushes against the back of the number type head and presses it against the colored ribbon and the paper lying behind so that the printed digit appears on the strip **of** paper.

The calculating mechanism (*i*), which until this point had remained in the position denoted by the dotted semicircle, is then shifted to the back so that it meshes in the cogs on the edge of the arch. Lever ***(r)*** raises the arch, so that it again returns to the rest position. This turns the corresponding calculating mechanism gear (*i*) so that it now shows, through the front window, the number of the key that was pressed and has now already been printed. Of course every column position of the keyboard has such a gear rim. calculating mechanism gear, printing digits **0** to 9 and printing lever (*o*), while the printing lever (*r*) shifts all the gear rims into rest position after the crank has been operated.

The Printing Ten-Key Adding Machine

These are certainly equal in efficiency to the full-keyboard machines. However, when a number is set on a full-keyboard machine, the units digit is set in the units column of keys, the tens in the tens column of keys, the hundreds

Figure 12

in the hundreds column of keys. etc. (so the value is already classified on the keyboard). With the ten-key adding machines the actual internal setup mechanism moves one more position to the left every time a key is struck, just like a typewriter. When a value is entered, the crank must be pulled for it to be added and printed. This action connects the calculating and printing mechanisms with the internal setup mechanism and causes the entered value to be transferred into the calculating mechanism and printed. The same action returns the internal setup mechanism back to the initial starting position, so that it is possible to immediately enter the next value. There are also machines. similar to some forms of typewriter (Elliott-Fisher, etc.), in which the setup mechanism does not move when each digit is entered but the keyboard moves sideways: these are in the minority. The movement, which in the full-key-

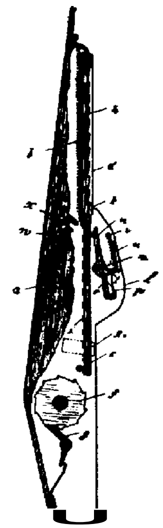


Figure 13

board adding machines is carried out by the hand that sets up the digits, is carried out in the interior of the ten-key adding machines without the operator doing anything.

Supplementary keys, broad carriages, etc., like those described for the full-keyboard machines, are for the most part also available for ten-key adding machines. The same operations that can be carried out on full-keyboard machines can for the most part be carried out on ten-key machines; it is therefore unnecessary to repeat all the details here.

Small Adding Machines

The small adding machines can be divided into three groups: machines with stylus setting, direct manual setting, and key setting. The first group divides into three subclasses: machines driven by toothed racks, by chains, and by cogged disks.

Toothed Rack Drive

Figure 12 gives a complete picture of a rack drive machine, and figure 13 shows a cross section through it.[9] The racks serve to set up the values to be

9. A rack is a bar with pegs or teeth on one edge

added. They are chamfered downward so that the adding stylus does not slip out. In adding up a series of numbers, the user sets a stylus on the digit to be added and moves the rack down until it reaches the fixed crosspiece at the bottom of the device. The digit thus set up can be read and checked from the lowest row of digits, the so-called control row. The rack that has been pulled down has, by means of the lower cogs (*l*), turned the corresponding digit gear (*f*), so that this also shows the digit just entered, assuming that this digit gear initially stood on zero. If the digit gear had not originally been showing the value zero, the entered value would be added to that which was originally on this calculating gear. The corresponding rack stays drawn down because it is held fast by the catch lever ***(m)***. If the digits in a number have been set up in this way, and the entry has been checked, then the lever on the left side is pressed; this releases the catch lever and the racks are sent back to their rest position by means of the spiral spring ***(b)***.The next value can then be set up. Many rack machines have the disadvantage that the result row is not freed until the racks have sprung back into their rest position. It is therefore often not possible to read the entry and result at the same time. Zeroing the result is brought about simply by pulling out the knob on the right side of the machine and turning it forward. Subtraction is carried out with the aid of complementary digits found on both edges of the machine. With such machines, however, subtraction is rather difficult because the nines must be pulled down in all the unused positions on the left. Multiplication can be carried out via either the counting or multiplication table method.

The Counting Method: The lever attached to the left of the machine, which causes the lowered racks to spring back to the rest position, may be fastened down so that the racks immediately spring back to position each time the adding stylus has released them. To multiply 489 x *23.* the number 489 is first set up three times in succession (the **9** in the first position from the right). Then, moving over one, the number 489 is set up twice so that the 9 comes in the second position from the right, as the first position on the right is no longer used. It is then possible to read the product 11,247 from the result window.

Multiplication Table Method: Consider the multiplication of 789 x 79. The operator must first mentally calculate $9 \times 9 = 81$ and set this result in the two positions on the far righthand side. He should then calculate $9 \times 8 = 72$ and set up this result in the second and third positions from the right. Similarly, he needs then to work **out** $9 \times 7 =$ **63** and set up this value in the third and fourth positions from the right. The multiplication by **9** has now been done and what remains then is the multiplication by 70. **As** above, the operator must first calculate $7 \times$ **9** $=$ **63** and set up this value in the second and third positions from the right, then $7 \times 8 = 56$ in the third and fourth positions from the right, and finally $7 \times 7 = 49$, the value of which is kept in the fourth and fifth positions. The multiplication is then complete and the result **62.331** can be read from the result windows.

Division: Division can be done by such a machine. but the procedure **is** too involved; therefore no explanation will be given here.

Cogged Chain Drive

These machines are similar to the machines with rack drive. The adding digits are attached to loops made from chain, but because they are covered by the digit plates, it is not possible to see the links of the chain. Usually these machines have, in addition to a result mechanism, a setup control mechanism so that items can be checked for accuracy each time they are entered. Addition. subtraction, and multiplication can be carried out according to the procedures outlined. These machines are not considered suitable for division.

Machines Driven by Cogged Disks, with Horizontally Mounted Gears and Numeral Disks

These machines originally stem from the Pascal Machine **(1642)** and have since been principally manufactured in America (Pangborn, Lightning Calculator. Calcumeter, Figurator, etc.). The different makers have not improved these machines significantly during the last years, so their sales have declined.

The setup gears lie flat. next to one another, in the machine casing and are covered by cover plates with windows. Every decimal place of the machine requires a numeral disk, which usually has small, round holes or basin-shaped indentations for receiving the calculating stylus, the digits being engraved on the cover plates. If, for example. the number 7 is to be set up, then the calculating stylus is placed in the small hole of the number disk lying next to the number 7, and the gear is turned in a circle until it stops. It is then possible to read the digit set up from the viewing window, which is found either underneath, above. or inside the numeral disk; that is, provided that another number is not already there. If the number 6 is to be added to the 7 already in the viewing window. then the stylus is placed next to the digit **6,** and the numeral disk is turned as far as it will **go.** After this action it is possible to read a digit 3 in the window, while the window on the left shows the digit 1. Subtraction is carried out by turning the numeral disks in the opposite direction and is done with the aid of Complementary digits. Special viewing windows are sometimes available for the results of subtraction; on some machines they appear in different colors. The setting gears must be individually returned to zero, which is rather time consuming.

It was Michel Baum-Miinchen who first made significant improvements to this model in that he reduced the setup circle to half a rotation, introduced a setup control with control windows, equipped the machine with an immediate zero setup device, and finally added a subtraction disk to it, so that the machine could be used not only for addition but just as easily for subtraction without having to worry about any sort of complementary digits. Multiplication can be carried out far more quickly and quietly with the Baum-Miinchen. There is no longer any need for the racks to return after every entry has taken place. The circular gears allow for a continuous operation.

All the small adding machines mentioned here are especially suited for the addition of columns of numbers, as in ledger books. The machines can be laid on the book and shifted down item by item. This is not really a great timesaving device, but in any case it does save on nervous energy and keeps the mind free for more important matters. On the other hand, if it is a case of adding up items such as accounts or checks, which must first be written down so that they can be then added with pen and ink, or of cross additions, which are often necessary in bookkeeping, these small adding machines represent a considerable saving of time.

The small adding machines are often treated disdainfully by skilled operators, but unjustifiably so. With most of the small adding machines, output is just as rapid as with key-driven adding machines, because there is no continuing need to pull the crank, etc.

Direct Adding Machines

These are equipped with a cogged chain or lever drive. An adding stylus is not necessary as the links of the chain can be touched directly, as can the protruding lever, handle, or knob. These are either pulled down as far as they will go, or else the handle of the lever or indicator must be directed to the number to be set up (the latter naturally means a delay in the calculation). Such machines, however. do not belong to the class of full-keyboard machines for they totally lack a keyboard. Nonetheless they closely resemble

these machines in size. Also they do not come up to the full-keyboard machines in efficiency and usually lack a printing mechanism. The method of operation is similar to that of the small adding machines, but there are such machines able to carry out multiplication just as easily as the full-keyboard machines.

Small Adding Machines with Key Setup Mechanisms

These have nothing to do with the ten-key adding machines described earlier, which, as is well known, are the greatest rivals to the full-keyboard machines. They all have only nine keys, and it is not possible to set up complete multidigit numbers but only to add single rows of digits. For example, if such a row of digits has been added and if the result window shows 125, then it is necessary to make a note of the 5 on paper and set up 12 again in the machine, after the calculating mechanism has first been reset to zero, and then add up the second row and so on. There are quite a few of such small machines (Adder, Gab-Ka, Adix, Diera, Kuli, Heureka, etc.), but all have remained of little significance, for they represent neither a great saving of time nor do they have any other advantages to offer. Production, therefore, always stopped after only a short time, so that the machines always had a limited distribution. They could not be used for subtraction, multiplication, or division.

Main Text

This part of the book is a description of the calculating machines produced since **1642** in chronological sequence.

Pascal (1642)

In 1918 an unknown author wrote an article about Pascal's machine in the Bureau *Industrie* (number *5)* in Berlin under the title "275 *Jahre Addiermachine*."[10]

The inventor Blaise Pascal was born at Clairmont in the Auvergne on June 19, **1623.** His father, Etienne Pascal, was the first president of the court in that city. His mother's name was Antoinette. and she came from a wealthy family by the name of Begon. Blaise had an older sister who died and two younger sisters, one of whom played a significant part in his life: Gilberte, born in **1620,** and Jacqueline, born in **1625.** In **1626,** his mother passed away and five years later the father moved with his motherless children to Paris, so as to let them have an adequate scientific education.

Especially with Blaise, this move bore outstanding fruit. At the age of eleven, he delivered a thesis about the beginning and discontinuation of sound. In this thesis, he investigated such questions as why a key if struck with a knife produces a sound, and why this sound ends immediately when the key is touched with the hand. He later discovered and proved on his own initiative the fact that the sum of the angles of a triangle equals two right angles. His father feared that the child's education in foreign languages might suffer because of his great interest in mathematical and physical problems. He therefore told his friends, who regularly met with him for the purpose of learned discussions, that in the future they would refrain from discussing mathematical and physical problems in the presence of his son. However Blake, although thus

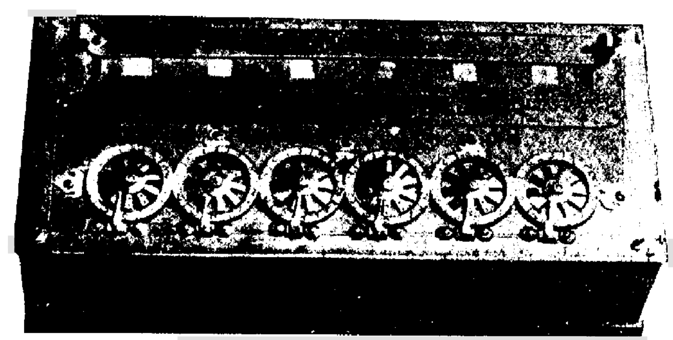


Figure 14
Older six-place machine

10. "275 Years of Adding Machines"

excluded, no longer required outside stimulation to promote his studies. On the floor of his lonely room, where his father had sent him to get on with his study of languages, he drew all sorts of geometrical figures, the proper names of which he often did not even know, and discovered for himself all those fundamental rules that are nowadays the subject of early mathematical education. After his father surprised him in this activity, he was accepted as a full-fledged member in the private circle of the older scientists. There he diligently continued to study, so that at the age of sixteen he was in a position to deliver a thesis on conic sections, which was recognized as having scientific merit.

In **1638,** the municipality of Paris partly discontinued payments of its debt from municipal bonds. This led to great unrest among the owners of the bonds. The elder Pascal was thought to be one of the main ringleaders of the malcontents. Although the charges were untrue, they were not unlikely, because when moving his family to Paris, he had invested a large part of his fortune in such municipal obligations. **A** warrant for the arrest of Etienne Pascal was issued, and only timely flight saved him from imprisonment in the Bastille.

On 3 April **1639** a private theater performance took place before Cardinal Richelieu. *L'Amour Tyrannique*, a tragicomedy by Scudern, was directed by the Duchesse d'Aiguillon who had chosen Jacqueline Pascal for the main part. After the performance, during which the Duchesse presented the fifteen-year old Blaise Pascal to the cardinal as a "great mathematician," Jacqueline submitted to the cardinal a petition on her father's behalf. written in verse. Richelieu was charmed with the small actress and replied, "Write your father that he may return in perfect safety." When Pascal returned, the cardinal received him very graciously and made him superintendent in Rouen **(1641).** where his main task was to collect taxes. It was necessary to go into some detail regarding the history and origin of his father's office, because it seems that it was his father's office alone that was the cause of the son inventing the adding machine that bears his name. Its purpose was obviously to facilitate his father's managerial tasks.

Even today, quite a few of Pascal's machines are still in existence. We are, therefore, well informed about the details of its construction. The first written description of this machine may be found in Diderot's *Encyclopaedie*, dated 1751. Pascal's invention **was** an eight-place adding machine in which the lowest place (derniers) could accommodate twelve units, the second lowest place (sols) twenty units. and the remaining six places ten units each. The first two places were intended for the two lowest denominations of small coinage then in use. The remaining six places were designed to keep track of from one to hundreds ***of*** thousands of full pieces of gold. Depending on the place value ***of*** the amount to be added, the individual wheels were to be moved by as many tooth positions **as** corresponded to the value of the digit concerned. This turned the numeral disks in the interior and caused the resultant sum to appear in the window. According to today's view, the principle, whose discovery **was** unquestionably Pascal's achievement, was not properly carried through. Nevertheless, his invention must be regarded as the basis of innumerable adding machine systems of a later date.

Undoubtedly it will be of interest to give **a** more detailed description of this remarkable machine. The machine to be described is the oldest model in existence—the model the designer dedicated to the Chancellor Seguier.

The machine is 36 cm long, 13 cm wide, **8** cm high; thus it is the size of a shoe box and may easily be carried under the arm. The surface is metal. There are eight windows and visible through them are the result digits. In front of the windows are the eight setting mechanisms. These have the form of a wheel, the spokes of which turn around the axle but whose rim is attached to the surface of the box and is inscribed with the setting digits. The first wheel from the right has twelve spokes, the second wheel has twenty, and each of the remaining wheels has ten spokes—the first serves for adding the *derniers*, the second for the ***sols,*** the additional ones are **for** the ***livres*** (at that time the system of English currency was still in use in France). **If** the machine is to be used for purposes other than the addition of the national currency, only the third. fourth, and subsequent setting wheels are used. Machines were also constructed in which the setting wheels for the derniers and **sols** were missing, so that they only possessed six setting wheels for the livres.

Addition **is** very easy. After any value that may still remain from a preceding operation has been eliminated from the windows by setting the digits to zero (by rotating the individual digit wheels), entering the amount to be added may begin. For example, to set the value f3.15.7, a calculating stylus (or finger) is introduced **into** the space between the spokes next to the digit 7, in the last place from the left, and the wheel is rotated until the stylus strikes against the fixed stop mounted at the lower edge. This transmits the value **of** *7d* into the first window from the right. Next, one begins the setting of the **sols** in the space between the spokes next to the digit 15 of the second setting wheel from the right. This setting wheel is rotated around to the stop that transmits the digit 15 into the corresponding (second) window. Finally, the value ***3*** (livres) is entered in the third wheel from the right in the same way. In this manner, any selected additional amounts may be added to the result wheels, the conversions ($12d$ = 1 sol, **20 sol** = £1) being carried out by the tens-carry mechanism without any need for the operator to concern himself about the matter. In this connection it must be pointed out, however, that the tens-carry is not complete but **is** limited to a few places. The black digits **that** appear in the windows are printed on small rollers or drums at the end of the gear train connecting them to the setting wheels.

Pascal's machine is also suited for subtraction. The drums just described not only possess black additive digits but they also have a second row with red subtractive digits. When it is desired to change from addition to subtraction, the black additive digits are covered up by a cover slide extending over the whole length of the machine, as shown in figure 14, which exposes the red subtractive digits and permits the machine to be used in exactly the same way for subtraction as for addition; thus it is unnecessary to enter subtractions in the opposite direction."

Even multiplication is possible, but in multiplication the two first positions from the right—that is, the derniers and sols—must be ignored. If an amount is to be multiplied by 52, it is entered twice in succession, commencing with the third wheel from the right. The hand is moved one position to the left, and, starting with this position, the amount is entered five times in succession; the correct product should now appear in the windows. It must be admitted that this form of multiplication is rather complicated. Actually the machine is not a calculating machine but an adding machine: in fact all similar machines with stylus setting mechanisms should be called adding machines rather than calculating machines because in such machines multiplication takes place in the same somewhat complicated way.

In about 1647 Pascal heard that a clockmaker in Rouen was copying his machine. He attempted to prevent the clockmaker from doing so by sending one of his own machines to Chancellor Seguier, petitioning him for protection of his invention. This machine is still in existence and is currently the property of a partner of a well-known French shipping company (Chargeures Reunis, in Bordeaux). It bears the following dedication.

Illustrissimo et integerrimo Franciae cancellario, D. D. Petro Seguier, Blasius Pascal, patricius arvernus inventor D. D. D. Pascal.[12]

M. Fortunat Strowski of the Sorbonne reports in the *Revue Dactylographique* of 1908 (p. 243), that more than fifty models of the Pascal machine are still in existence. He also reports that they are

tous différents, les uns composés de verges ou de lamines droites, d'autres de courbes, d'autres avec chaines, les uns avec des rouages concentriques, d'autres avec des excentriques, les uns mouvant en ligne droite, d'autres circulairement, les uns en cônes, d'autres en cylindres, et d'autres tout différents, de ceux-la, soit pour la matière, soit pour la figure, soit par le mouvement. L'ivoire, le bois, le fer, le cuivre, seuls ou combinés, furent essayés.[13]

11. In fact it is impossible to rotate the mechanism in the opposite direction because of the way Pascal implemented the carry mechanism. Subtraction was performed using complementary digits by methods described later in this work.
12. To the most illustrious and honorable Chancellor of France, Pierre Seguier, Blaise Pascal, a nobleman of Auvergne, gives this as a gift. Pascal.

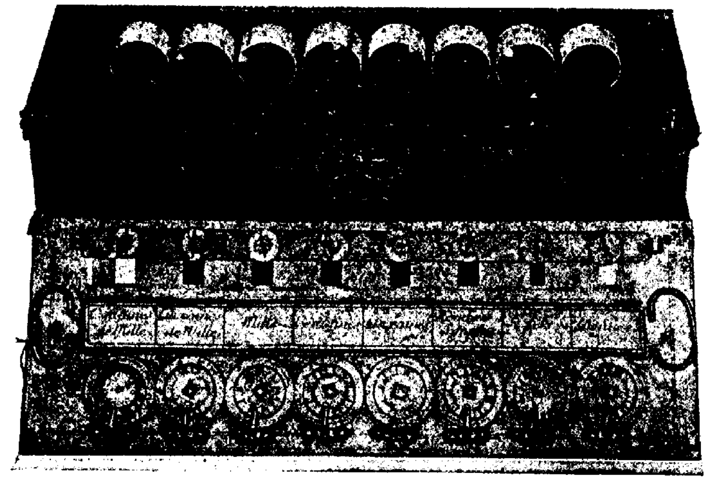


Figure 15

Pascal also sent an example to Queen Christina of Sweden. Two machines are reported to be in Clermont-Ferrand; another example (from 1652) may be seen in the Conservatoire des Arts et Métiers of Paris. It bears the following dedication on the inside of the casing:

Celeberrimae scientiarum academieae Parisiensi instrumentum hoc arithmeticum a D. Blasio Pascal inventum et probatum offerebat nepos ejus ex matre, anno MDCCXI. Perier, presbyter, Canonicus Ecclesiae Claromontensis.[14]

Figure 15 shows an eight-place machine with the lid removed and set in front of the machine proper. Figure 16 shows the interior of a ten-place machine that can be found in the Mathematical-Physical Salon in Dresden. Replicas of Pascal's machine may be found in the calculating machine museum

13. ". . . all different, some are made of rods or of straight plates, others curved, yet others use chains, some with concentric wheels and others with eccentric wheels. some move along straight lines, some in circles, others in cones, yet others in cylinders and yet others completely different from these, be it in material, configuration, or movement. Ivory, wood, iron, copper, or combinations were all tried."
14. To the celebrated Paris Academy of Sciences: this arithmetic machine, invented and constructed by Blaise Pascal, is offered by Perier, priest and canon of the church in Clairmont and grandson on his mother's side, 1711.

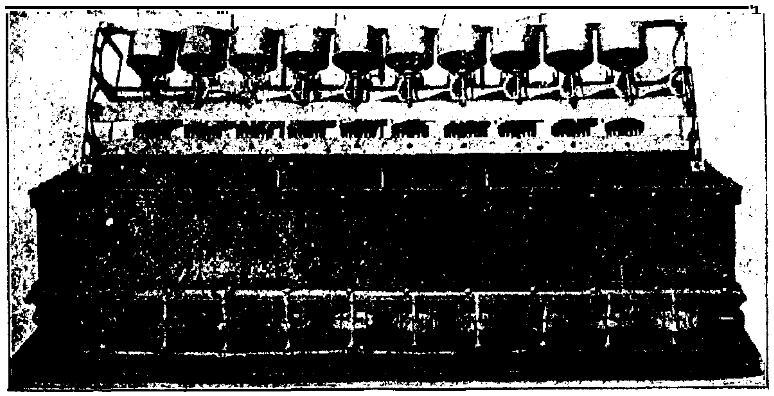


Figure 16
(Source: Engelmann. Phil. Matthäus-Hahn)

of Grimme,[15] Natalis and Company, and also in the Deutsches Museum in Munich.

Sam Morland (1666)

Morland constructed an adding machine that can at best be regarded as an improvement of Pascal's machine,[16] and also a multiplication machine based upon the principle of Napier's calculating rods.[17]

Leibniz (1672–1712)

Indignum enim est excellentium virorum horas servili calculandi labore perire, qui machina adhibita vilissimo cuique secure transcribi posset.[18]
—Leibniz

In 1672 the famous mathematician and philosopher Gottfried Wilhelm Leibniz began to occupy himself with the design and construction of a machine

15. Now in the Braunschweigisches Landesmuseum. Braunschweig. Germany.
16. This machine did not incorporate a proper carry mechanism—all carries were recorded on separate dials and the user then had to manually add the contents of these dials to the next digit. It is. thus. difficult to see how it could be classed as an improvement on Pascal's machine.
17. More commonly known as Napier's bones.
18. It is beneath the dignity of excellent men to waste their time in calculation when any peasant could do the work just as accurately with the aid of a machine.

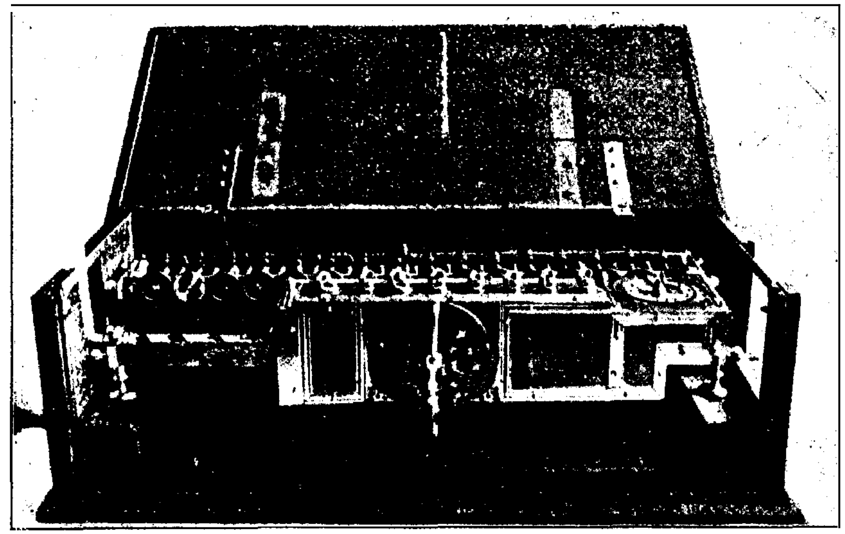


Figure 17
Machine in its case.

for the four fundamental operations of arithmetic. Thinking he would find more competent help in Paris,[19] he moved there and employed the mechanic, Olivier, from 1676 until 1694. For ten more years Professor Wagner and the mechanic Levin in Helmstedt worked on the machine and, after 1715, the mathematician Teuber in Leipzig did the same. It is not known how many machines were completed, but it may be assumed that there were three; two were once sent to Helmstedt to be repaired and since then nothing has ever been heard of them. The third is the one shown in our figures. This one is now in the Kaestner Museum in Hanover, but it is not in usable condition. Neverthcless. it still clearly shows the method of operation.

The mechanism is 67 cm long, 27 cm wide, and 17 cm high and is housed in an oak case. It was this machine that first used the stepped drum mechanism upon which, as is generally known, Hahn's machine, the Thomas machine. and the numerous imitations of same are based. Inside are two rows of stepped drums, one in the setting mechanism and the other one in the calculating mechanism. The calculating mechanism (with its sixteen places) was stationary, but the eight-place setting mechanism may be shifted along

19. In fact. Lcibniz had at the time a diplomatic posting that required his presence in Paris.

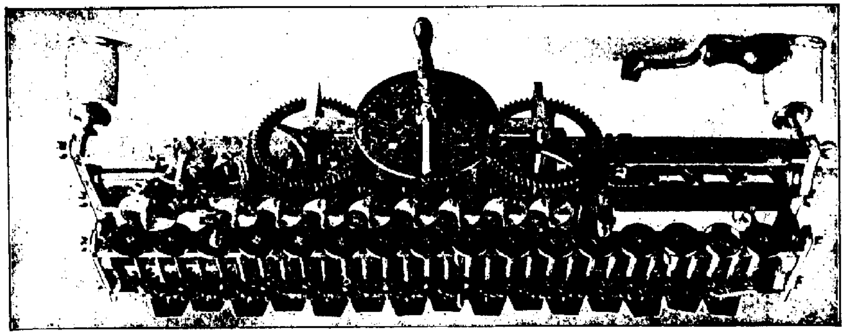


Figure 18
Complete machine, without its case

the individual places of the calculating mechanism with the aid of a crank. The transmission of the amount set up into the calculation mechanism likewise occurs by rotation of a crank. Subtraction and division are carried out by similar rotations of the numeral wheels with the exception that all readings must be taken from the red subtractive digits rather than the normal black additive digits. The machine also possesses a tens-carry and a zero setting device.

The setting mechanism consists primarily of eight numeral dials bearing the numbers 0 to 9 and having pointers by means of which the multiplicand is set up. To the right of the small setting dial there is a large dial consisting of two wide rings and a central plate—the central plate and outer ring arc inscribed with digits. while the inner ring is colored black and is perforated with ten holes. A crank is located in the center. if one wishes to multiply a number on the setting mechanism by 742. a stylus is inserted into hole 2 of the black ring and the crank is turned; this turns the black ring until the stylus strikes against a stationary stop between the 0 and 9 positions. The result of the multiplication by 2 may then be seen in the windows. The next step requires that the setting mechanism be shifted by one place, the stylus inserted into hole 4, and the crank turned, whereupon the multiplication by 42 is completed and may be read from the windows. Again the setting mechanism is shifted by one place, the multiplication by 7 is carried out in the same manner, and now the final result of the multiplication by 742 appears in the windows.

Division is done by setting the dividend in the result windows and the divisor on the set-up dials, whereupon a turn of the crank is performed and the quotient may then be read from the central plate of the large dial.

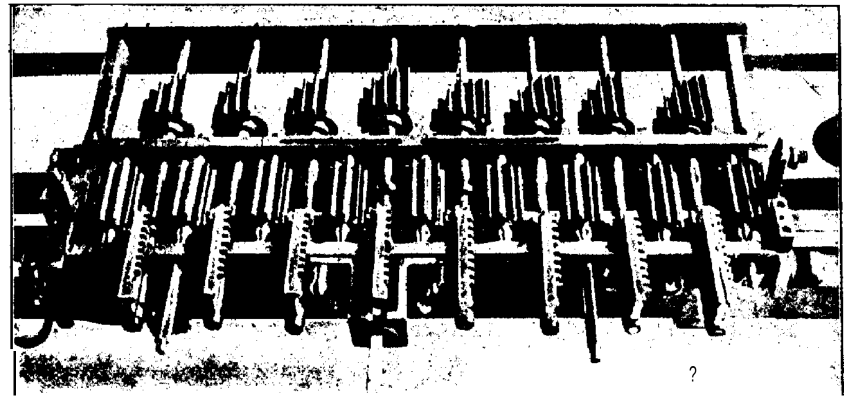


Figure 19
Setting mechanism and stepped drums

The machine had been lying for 250 years in an attic at the University of Göttingen until it was found when the roof was repaired. In 1893 it was sent to Arthur Burkhardt in Glashutte (Burkhardt is well known as the senior designer of calculating machines in Germany) to be put into operable condition. However, parts of the machine were missing. When the machine was returned, the following notes were made:

> All material parts of the Leibniz calculating machine are in operable condition. With the aid of a crank, the eight stepped drums may be rotated to the left and to the right. At the same time the quotient moves correctly. The stepped drums can be shifted axially. but some of them are too short, so that when the control drums are completely shifted from 0 to 9, the gears driving the drums, which are arranged upon the same shaft, become disengaged. The control mechanism may be moved to all positions by the screw spindle. The digit carriage operates correctly in part. Certain parts engage completely. The tens-carry from one element to the adjacent one is correct. We do not question Mr. Burkhardt's conclusion that, the way the machine is arranged, tens-carry to two, or more than two, adjacent elements was not possible. Under this assumption, the machine would not have been able to perform multidigit calculations entirely mechanically. Mr. Burkhardt's treatment of the machine is nevertheless valuable because it brought proof that the Leibniz machine possesses all the fundamentals for the manufacture of a usable machine.

A detailed report by Burkhardt describing his repair work on the machine may be found in the *Zeitschrift Fur Vermessengswesen*, **1897,** p. ***392.***

Leibniz concerned himself with the task of constructing a calculating machine over his whole lifetime, and he sacrificed for this purpose 24,000 talers, which was a very large sum of money at the time. The written testament always mentions an operating machine, which might be an additional proof that the existing machine was not the only one built. Professor Mehmke is of the opinion that one of the Leibniz machines was based on a wheel with a variable number of teeth,[20] a device that was to be employed much later by Baldwin and Odhner. (In 1673 Leibniz submitted the plan of his calculating machine to the Royal Society in London and somewhat later he submitted the completed machine to the Academie des Sciences in Paris.)

As long as no properly functioning model of the Leibniz machine can be produced, or at least no real proof of a properly functioning Leibniz calculating machine can be found, it seems that Hahn deserves the credit for having designed the first practically usable machine for the four fundamental operations of arithmetic.

Grillet (1678)

This is an adding machine similar to Pascal's machine.[21] It has three rows of seven dials, the rows lying below one another. Numbers are set on the dial by turning them with a stylus. The machine possesses no control mechanism, thus it has no need of any device, such as a crank, wheel, or band. to power it. It is described in the *Journal des Scavans*, (1678).

Poleni (1709)

In 1709 Poleni, a mathematician and professor in Padua, published a description of a calculating machine he invented. It is described, complete with diagrams, in Poleni's book, *Miscellanea*, 1709, p. 27,[22] and also by Leupold in his book, *Theatrum Arithmetico-Geometricum*.[23] The machine is made of wood and is rather large, but is reported to have a gear with a variable number of teeth. Weights were employed instead of springs. The machine was later destroyed by Poleni himself.

20. See the note concerning this point in the introduction. under the heading "The Pinwheel Machine."
21. René Grillet's machine had no carry mechanism and was simply a set of dials that could be rotated to record numbers and the results of mental arithmetic operations.
22. Poleni. Giovanni. marchese. 1709. *Miscellanea*. Venice.
23. Leupold. Jacob. 1727. *Theatrum Arithmetico-Geometricum*. Leipzig.

Figure 20
Poleni's machine

Lepine (1725)

This is an adding machine without keys, essentially a simplified version of Pascal's machine.

Leupold (1727)

In the *Theatrum Arithmetico-Geometricum*,[24] Jacob Leupold published the drawing of a calculating machine shown in figure 21. but it was never constructed.

24. Leupold, Jacob. 1727. *Theatrum Arithmetico-Geometricum*. Leipzig.

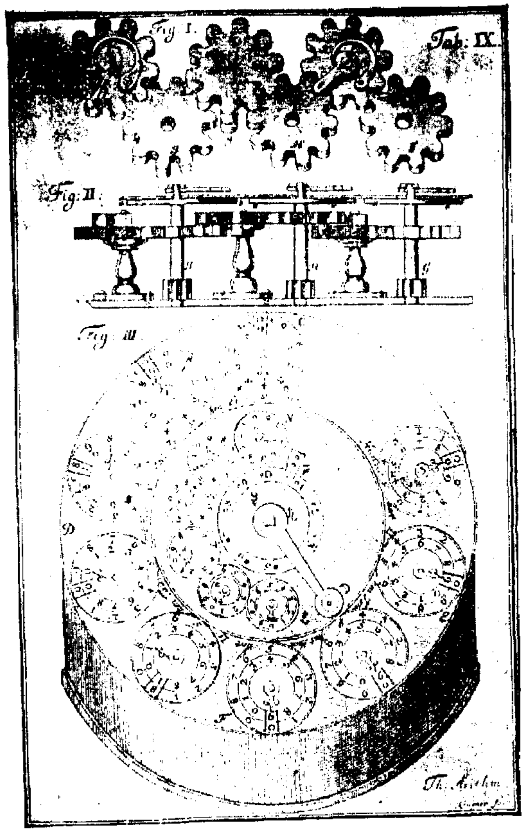


Figure 21
Machine of Leupold. (Source: Engelmann, Pfarrer Phil. Matthäus-Hahn)

Poetius (1728)

In his *Anleitung zur Arithmetischen Wissenschaft,*[25] published in 1728, Johann Michael Poetius provided ideas for a calculating machine, but it seems they were never acted upon to produce a working example.

25. Martin does not give the title of the main work; it is usually cataloged under Poeli. *Introduction to the Science of Arithmetic.* J. Mich. 1728. *Anl. z.b. arithmet. Bissensch.* Halle, Fritsch.

Hillerin de Boistissandau (1730)

This is an adding machine, without key setting, similar in type to that produced by Pascal. The friction generated during the use of this machine was so great that it could not be used in practice. The inventor attempted to improve it twice, but without success.

Gersten (1735)

In 1735, C. L. Gersten, mathematics professor in Giessen, submitted to the Royal Society in London an adding and subtracting machine with setting slides that had six places in the setting mechanism and seven places in the result mechanism and that also had a tens-carry mechanism. A model of the machine can be found in the Calculating Machine Museum of the firm Grimme, Natalis and Company in Braunschweig.[26,27]

Pereire (1750)

Jacob Isaac Pereire constructed a machine having a number of small boxwood drums, all of which rotated around a common shaft. Each drum had the digits 0 to 9 written around the circumference three times. This small machine was housed in a box, the surface of which had slots for each of its numeral wheels. The wheels could be set into motion by manipulating them through the slots with the aid of a pointer or stylus.

Hahn (1774)

The Parson Phillip Matthaeus Hahn was born on 25 November 1739, at Scharnhausen. He was not only a parson but an eminent clockmaker and maker of astronomical instruments as well. He also undertook, from 1770 in Kornwestheim and from 1781 in Echterdingen, the manufacture of calculating machines. According to the present status of research in calculating machines, he was the first to design a truly usable calculating machine for all four arithmetic operations and to manufacture a number of models, several of which have been preserved and are still in usable condition. Although he knew that

26. We believe that, in this case, *model* should be interpreted as *replica*.
27. Now in the Braunschweigisches Landesmuseum, Braunschweig, Germany.

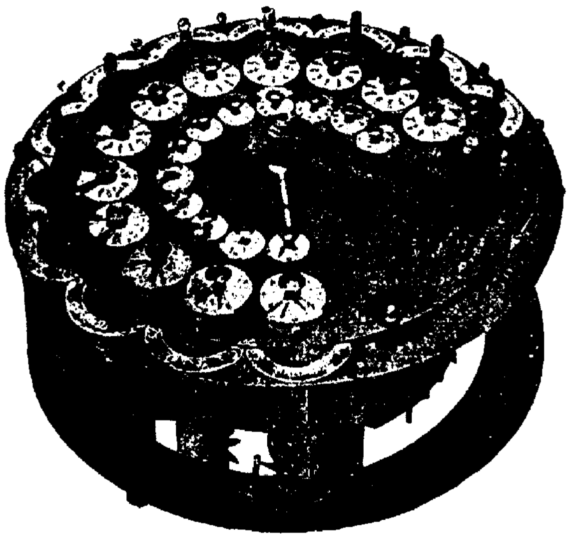


Figure 22

Leibniz had occupied himself with the problem for forty years and had sacrificed a fortune for it without producing a machine capable of solving large problems, Hahn was not deterred from considering the matter in detail.

In his experiments he used the stepped drum, which Leibniz had used before. It is not known whether Hahn reinvented the stepped drum or simply borrowed the concept from Leibniz. He arranged the stepped drums in a circle so that on the outside his machine is similar to the one designed by Leupold.

Max Engelman's book ***Leben und Wirten des württembergischen Pfarrers und Feinmechanikers Phillipp Matthäus Hahn*** gives, on page **4,** detailed information on the history of the development of his machine.[28] The first machine was demonstrated in **1774**, but it is possible that a usable model existed as early as **1773.**

The machine illustrated in figure **22** is the property of the Duke of Urach. In 1882 it was repaired by Arthur Burkhardt, who is well known as the founder of the German calculating machine industry. Figure **22** shows the complete machine out of its case. Figure **23** shows the frame, the stepped drums, and the drive gears. Figure **24** shows the movable carriage and the indicator mechanism with the crank.

28. *The Life and Activities of the fine Mechanic Phillip Matthaus Hahn of Wurtemberg.* This volume appears to be extremely rare.

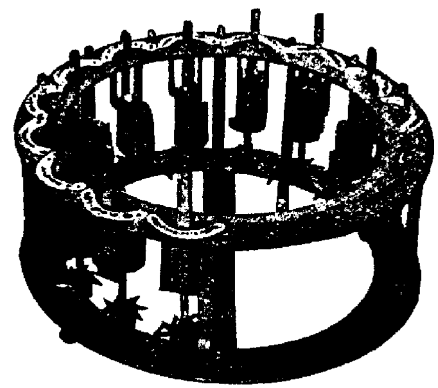


Figure 23

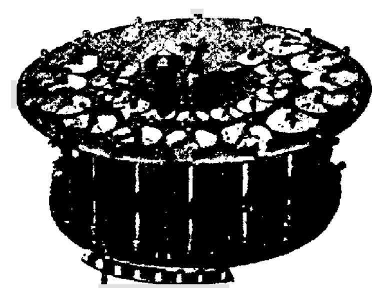


Figure 24

The method of operation of the machine is explained in detail in Hahn's ***Beschreibung*** des ***rechten Gebrauchs der Rechenmaschine,***[29] (Cod. Math. **4** No. 55, State Library in Stuttgart).[30]

The calculating machine has twelve numeral rods inserted around its outer rim. and inward has twelve large enamel plates. on each of which there is a row of black and a row of red digits. Further toward the center are twelve small enamel plates on which the digits 1 to 0 are written. To begin adding, one sets the indicators on the black numbers on the large numeral plates. Each indicator has a window or opening so that the digits may he seen through it. Since adding and multiplying are done with the black numbers on the enamel plates, just above the indicator and the engraved numbers

29. *A Description of the Proper Use of the Calculating Machine.*
30. The following is a translation of a quaint German text of 200 years ago. and frequently the sentences seem mutilated or in the wrong order. The editors have made only minor attempts to correct the worst of these problems.

the letters *A* and *M* are indicated. In the same way, the letters *S* and *D* are above the remaining numbers.

For addition the intermediate, larger, numeral plates are all set at zero if I wish only to add with units or tens. because here the sum is to appear." The digits will appear below the openings of the numeral plates. In connection herewith it should be noted that addition and multiplication take place with the aid of the black digits, and subtraction and division take place with the aid of the red digits. In order to give an easy example. let us assume that I wish to add **12, 8,** and **15.** For this purpose I withdraw the numeral rods so that the unit rod shows **2** at the bottom near the rim and the tens rod shows 1. Then I turn the crank around once, and 12 appears in the windows of the intermediate numeral disks which formerly showed zero. Now I set the unit rod to 8, turn around once. and **20** will appear in the openings; then I set the unit rod to 5, the tens rod to 1, turn around, and *35* will appear in those windows, and so on. No matter how large the number and how long the column of digits to be added, all will add into one sum. When adding larger numbers the procedure is:

1. One row, for instance **34,562. is** set into the larger numeral plates in black digits below the openings.

2. The other number given, for instance 23,541, is set up at the outermost rim by withdrawing the numeral rods. **so** that on the unit rod the lowest digit is 1, on the rod of the tens the lowest digit is **4,** on the rod of hundreds it is 5, and *so* on until the second number given is completely expressed.

3. Then the crank is lifted a little, until its point of rest is passed, and is turned around until it strikes against a stop; then the sum 58,103 appears in the openings.

Subtracting occurs in the same way. The larger number given, for instance **58,103,** is set in red digits underneath the openings of the larger numeral plates; the smaller value, for instance 34,562, is set below in the numeral rods. **As** in addition, units are always to be beneath units, tens are to be beneath tens; then the crank is released and is turned once around, and as a result **23.541** will appear in red digits below the openings.

Multiplication is carried out in the following manner:

1. One of the given values. for instance 3,235, is set below on the numeral rods.[32]

2. The larger and smaller numeral plates are set at black zeros below the openings.

3. The crank is turned around as often as the first digit of the other given number, that is. if the multiplier be **432,** until the digit 2 appears in the first upper opening of the small numeral disks.

4. Now I move the multiplier one place ahead. This happens if I release the steel latch on the outer rim and advance the inner disk with the numeral plates by one gap as provided on the outer rim of the disk until the latch engages again or until the indicator in the center of the surface points to the second small upper numeral plate; (then I turn the crank) until the second digit **of** the multiplier, which in the present case is 3, appears in the opening. Since in the present case the multiplier consists of three digits, I once more move the inner disk by one gap in the exterior rim until the indicator in the center points to the third numeral plate, then I turn around the crank until (in this case) the digit **4** appears in the third opening of the third numeral plate. Now the numbers have been multiplied and the product **1,397,520** appears in the lower windows of the larger numeral plates in black digits.

31. Hahn appears to he describing the larger numeral plates as intermediate between the numeral rods and the smaller plates closer to the center.

32. Hahn refers to setting numbers on the stepped drums with his rods as *setting below.*

Division occurs as follows:

1. The dividend. for instance 1,397,520, is set in the red digits upon the larger lower numeral plates beneath the windows, that is, in the present case 0 appears upon the units tablet. 2 appears upon the tens tablet, and so on, in red digits.

2. Zeros are set below the small numeral plates.

3. The divisor is set below with the numeral rods, for example, **3235.**

4. Now the inner disk with the plates is moved **just** like in multiplication in such a manner that the value **3235** is positioned below the value **13975,** and because **1397** is smaller than **3235,** I had **to** move the divisor one place further in order that the dividend be larger than the divisor, in the same manner in which it is customary to position the values in ordinary division.

5. Now I turn the crank until the value positioned above the divisor becomes, for the first time, smaller than the divisor, for which reason it is necessary to check every time that the crank has been turned around whether the upper value is not yet smaller than the value placed underneath—which in the present instance will be the case during the fourth turn of the crank. Now **1035** will appear above the divisor instead of 13975.

6. Therefore I shift the disk with the dividend by one place with the result that my divisor now appears below the value **10352.** Now again I turn the crank until this value becomes smaller, which will be the case during the third time, and **647** will remain as the diminished value from which the divisor **3235** can no longer be subtracted. For this reason, I again move one place ahead so that the divisor will be positioned below the value **6470.** If I now turn the crank until this value is smaller than the divisor, this will occur during the second time. Then there will be only red zeros in the windows as a sign that there is no remainder, unless a fraction has remained, which would show. Now the openings of the upper numeral tablets will show the values sought, namely the quotient **432.** If something had been left over and the divisor had not gone into the dividend without remainder, then the remaining value would have been the upper part of the fraction above the line and the divisor would have been the lower part of the fraction below the line.

The rule of three and other calculations, such as calculation of fractions, and square root. and cubic root extractions, may all be performed on the calculating machine because they may all be carried out through multiplication and division; all one has to know is how to position properly. If the correctness of the result is doubted, the problem should be attempted in the opposite form of calculation. For instance, if one has multiplied, then divide this number so one has proof of the correctness of the calculation.

It is strange that the published literature has not mentioned the similarity of the main parts of the Thomas machine with Hahn's machine much earlier than this, We conceded to the Frenchman the invention of the calculating machine, although Thomas merely produced Hahn's machine in a partly modified form and exploited it commercially, whereas the manufacture of Hahn's machine was discontinued soon after the death of Hahn (2 May 1790) and his collaborators. At the occasion of the Exhibition of Scientific Apparatus in South Kensington Museum in 1876,[33] the original machine. illustrated in figure 22, was demonstrated and the exhibition catalogue contained the following statement on the subject:"

The model on display shows all the details of arrangement of the Thomas calculating machine which is now in use. with the difference that in the Thomas machine the digits are arranged in a straight line, whereas they are arranged in a circle in Hahn's machine. Most likely a model was the pattern for the Thomas calculating machine. The machine operates perfectly well up to values having twelve digits.

In his rather interesting publication, ***Die Sogenannte Thomassche Rechenmaschine***,[35] Professor F. Reuleaux criticized this opinion as inaccurate and going too far. However, the Thomas machine has several main characteristics in common with the older machine: the stepped drums already used by Leibniz, although with twice the number of teeth as Hahn's, an automatically operating tens-carry mechanism that acts through all places, a shiftable carriage. and finally the employment of black additive and red subtractive digits on circular numeral disks. Since Engelmann's book tells us that Hahn was continuously in contact with the city of Colmar, by maintaining correspondence and business relations with a parson Günther who lived in Colmar. it is entirely possible that this connection drew Thomas' attention to Hahn's machine and Thomas used Hahn's machine as prototype and created his well-known arithmometer by using it as the basic model.

Whether Thomas used Hahn's machine as a pattern or not is of lesser importance. It is more important that the view, originally prevalent, that Hahn's machine was not operative has been thoroughly disproved

33. See *Handbook of Scientific Apparatus*, London: HMSO, 1876.
34. This is a translation from Ernst Martin's German and not a quotation from the original English version.
35. *The So-Called Thomas Calculating Machine*, published in Leipzig by A. Felix. 1892

1. by the detailed description of the operation of the machine as reprinted above,
2. by the above mentioned opinion of the London Exhibition, and
3. by the fact that there are still machines in existence, which can demonstrate at any moment that Hahn's machine was capable of performing the four basic operations of arithmetic in a thoroughly reliable manner.

Hence, Thomas was by no means the builder of the first usable calculating machine that permitted performance of not only addition and subtraction but also of multiplication and division; it is Phillip Matthaeus Hahn who deserves the credit.

It has not been established how many copies of this machine were produced. According to Engelmann there are four in Stuttgart, there is one in the Deutsches Museum in Munich (which also has two copies by his brother-in-law, Johann Christopher Schuster), one is owned by the Duke of Urach, one is in the Technische Hochschule in Charlottenburg (likewise by Schuster). Since Hahn's two sons in Stuttgart and his brother-in-law Schuster in Uffenheim and Ansbach manufactured calculating machines after Hahn's death (Schuster, in fact, up to 1820), it is likely that an appreciable quantity were produced having various numbers of decimal places.

Mahon (1775)

Lord Mahon, Earl of Stanhope, designed two machines, one for addition and subtraction and the other one for multiplication and division. His constructions are also reported to exhibit the drums with teeth of uneven length (stepped drums), which were employed by Leibniz and Hahn.

Miiller (1783)

Johan Helfreich Muller, a captain in the engineers and county surveyor, designed a calculating machine, which he had built by a clockmaker from Giessen. It is very similar to Hahn's machine, but Hahn's setting rods, which were adjustable in height and had to be handled very carefully, were replaced by rotatable disks that bore the digits 0 to 9. The machine also had a signal bell. In later years Hahn's brother-in-law Schuster manufactured calculating machines embodying Müller's improvements. One of them may be found in the Deutsches Museum in Munich, and a Muller machine may be found in the museum in Darmstadt.

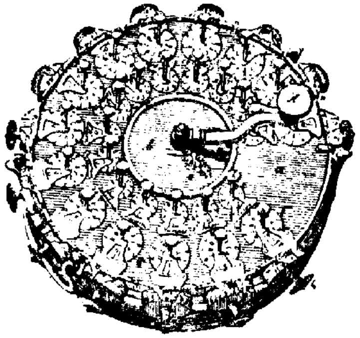


Figure 25
Müller's machine.

Auch (1790)

Jacob Auch, one of Hahn's coliaborators, constructed a machine that can be seen in the Physical Institute of the Technische Hochschule in Karlsruhe. It was rectangular in form and is reported to have been suitable for adding, multiplying, subtracting, and dividing (figure *26).*

Steffens (1790)

This is another German calculating machine which is unknown in practice.[36]

Reichold (1792)

The parson Reichold of Dottenheim in Aischgrund engaged, just like his colleague Hahn of Kornwestheim, in the manufacture of wooden clocks. He also made, among other things, a calculating machine for addition, subtraction, multiplication, and division. However, this machine did not offer any particular advantage over earlier machines. If Parson Reichold had not died early, he would undoubtedly have made a significant contribution to the development of calculating machines.

36. Martin often uses the phrase unknown *in practice.* The editors are unsure if this implies *not* known *to be extant* or simply *never became of any practical importance*, however the editors know of extant machines that Martin referred to in this way. and thus the latter phrase may be the best translation.

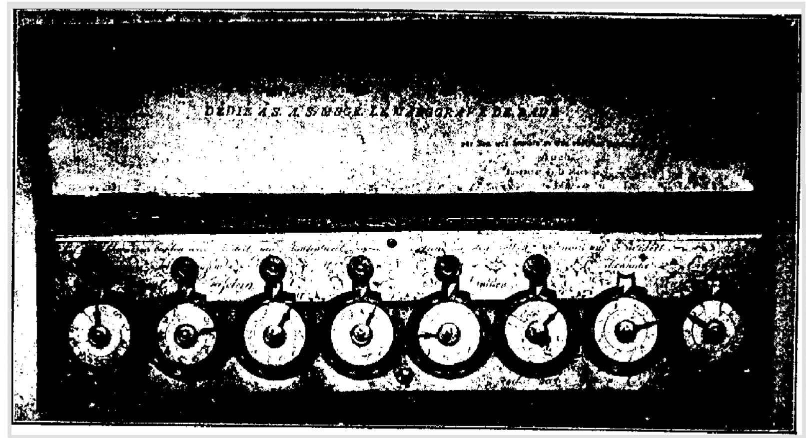


Figure 26
(Source: Engelmann, Phil. Matthäus Hahn)

Stern (1814)

The clockmaker Abraham Stern of Warsaw constructed a machine in which it was only necessary to set up the amount to be manipulated and then to start a clockwork mechanism. In 1817 he made a second machine that served mainly for extracting square roots. Later he consolidated the two machines into one, but it never had any real influence on further developments.

Thomas (1820)

In 1821 Charles Xavier Thomas of Colmar (1785–1870) (founder and manager of the Compagnie d'Assurance Le Phénix, 33, rue de l'Echiquier, and the Compagnie d'Assurance Le Soleil, 13, rue du Helder, both in Paris) submitted, to the Société d'Encouragement pour L'Industrie Nationale in Paris a calculating machine he had constructed, which he called an arithmometer. Thomas is usually thought of as the founder of the calculating machine industry because Parson Hahn's efforts probably did not yet amount to an industry since he and his collaborators manufactured only a relatively limited number of their calculating machines. Thomas devoted himself to this branch of industry up to the time of his death, and he raised this industry, over a period of several decades, to a rather high level. In fact, up to the time when

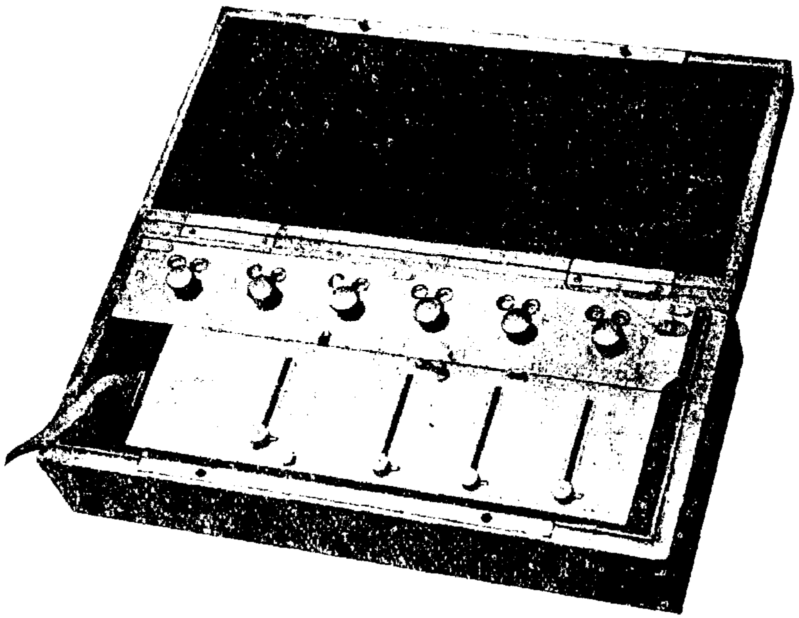


Figure 27
The oldest Thomas machine.

the calculating machine industry was introduced into Germany by Arthur Burkhardt (1878), the Thomas workshop was the only firm in this line and supplied the whole world with its products. We know, for instance, that the Thomas workshop completed five hundred machines from 1821 to 1865, three hundred machines from 1865 to 1870, four hundred machines from 1871 to 1875, and three hundred machines from 1876 to 1878. Approximately 30 percent of these machines were six-place machines, 60 percent were eight-place machines, and 10 percent were ten-place machines. Out of one hundred completed machines, sixty went abroad and only forty remained in France. The cost of a sixteen-place machine was five hundred francs, which at the time was generally regarded as too expensive to permit a larger turnover.[37]

The Machine of 1820 This machine, Thomas' first model, had only three setting slides and consequently it had only three stepped drums, but it had six places in the result mechanism. A fourth setting slot is provided to the left of

37. The *sixteen-place machine* presumably is one that showed sixteen places in the result. These machines allowed eight-place entries.

the other three, which is likewise provided with the scale 1 to 9 and with a slide bearing the inscription *multiplicateur.* Below this slide, in the interior of the machine, is a drum with a silk ribbon attached to and wrapped around it. The other end of the ribbon sticks out of the machine on the left hand side. To the left of the ribbon drum, also in the interior of the machine, there is another drum with nine steps and a spring attached between the drum and the machine casing. The two drums are connected by gears. The spring causes the ribbon drum to rewind; that is to say, the force of the spring automatically wraps the ribbon back on the ribbon drum after it has been pulled out during calculation. The three stepped drums are connected with one another and with the ribbon shaft by means of gears. When the ribbon is pulled, the ribbon shaft rotates, which, in turn, causes rotation of the three stepped drums. When a value has previously been set on the stepped drums by means of the slides (and if the slide of the multiplier device has been set to 1 on the scale), rotation of the drum will transmit that value into the result mechanism. Thus the pull on the ribbon takes the place of the turn of the crank employed in today's machines.

How does multiplication occur on such a machine? Recall that there is a multiplication slide that may be shifted along a scale marked 1 to 9. This slide acts upon the previously mentioned drum with nine steps in such a manner that if the slide has been set to 3 and the ribbon is then pulled. the ribbon drum can make exactly three revolutions. This rotates the three stepped drums exactly three times around their axes since the ribbon drum is connected with the stepped drums through gears, and thus the amount registered on the respective three places is transmitted three times in succession onto the result mechanism. Since the carriage may, if lifted, be moved horizontally, the machine permits multiplication of multidigit values.

The carriage possesses six double windows. A numeral disk, situated below two associated windows, contains two sets of digits—a black set on the outer edge of the disk and a red set on the inner edge. The black digits appear in the left window and the red ones in the right window; the black ones show the results of addition and multiplication and the red ones the results of subtraction and division. In order to avoid confusion, a perforated draw band is provided that exposes the left windows during addition and multiplication and the right ones during subtraction and division.

Subtraction occurs in the same way as addition except that the larger item may be set up directly with the aid of rotating knobs placed below the windows. The subtraction windows are opened, the amount to be subtracted is

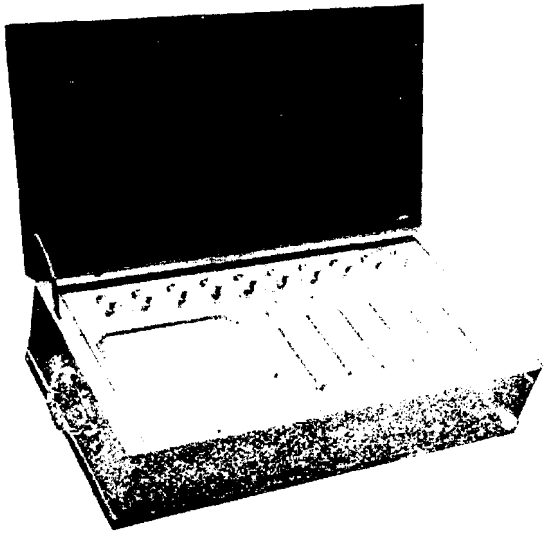


Figure 28
The machine of 1848

set on the setting slides, the multiplication knob is set to 1, then the draw ribbon is pulled out. Division occurs in the same manner except that the carriage is displaced from place to place in the same way as with multiplication.

The Machine of 1848 This machine has five slide slots and the previously mentioned multiplication slide. It has ten places in the result mechanism with only one window each because transition from addition-multiplication to subtraction-division is affected by a lever. In place of the complicated ribbon mechanism, a crank is provided in the front part of the machine. The individual stepped drums have only nine teeth instead of eighteen.

The Machine of 1858 The main improvement **in** this version **of** the Thomas machine is the second counting mechanism without a tens-carry (revolution counting mechanism). The uses to which this can be put have been described in the general description of stepped drum machines in the Introduction. The machine was also provided with one zero-setting device that acted on all the windows of the result mechanism and another for all the windows of the revolution-counting mechanism. Previously, all the numeral disks had to be set *to* zero individually **by** turning knobs placed below the individual windows. The zero-setting device is in the form of a rotating knob that is turned to the right until all the windows of the respective numeral mechanisms show zero. The zero-setting device of the result mechanism is mounted **on** the right side **of** the upper surface of the carriage, whereas the zero-setting mechanism of the revolution-counting register is arranged at the left.

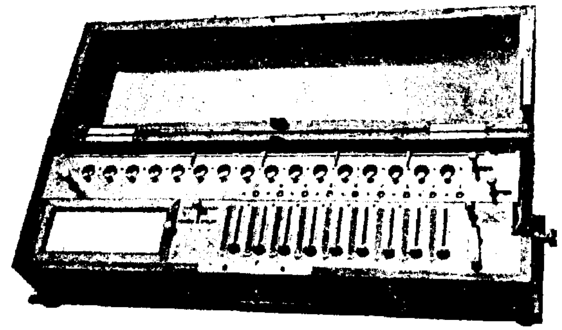


Figure ***29***
Present day model

The Machine of 1878 In this model the setting slides were provided with small springs, which, when the slide has been set to a certain digit, cause the slide to slip into a notch opposite that digit so that an accidental movement of the setting knob during operation of the crank **is** avoided. The tens-carry mechanism was materially improved. Means were provided to prevent overthrow.'' Of course, Thomas never manufactured the machines himself, rather he contracted out this aspect **of** the business. In the 1870s, **A.** M. Hoart was engaged in their manufacture in the house of the Insurance Company Soleil, 13 rue du Helder. Later the manufacture was transferred to L. Payen, then to L. Payen's successors, 16 rue de La Tour des Dames. Today Aph. Darras, 123 Blvd. St. Michel, Paris manufactures the arithmometer in France with 12, **16,** and 20 places in the result mechanism. Figure 29 shows a machine of the present manufacturer. One of the older original Thomas machines can be found in the Deutsches Museum in Munich.

38. Overthrow is the result of turning the crank with enough force that the momentum applied to the mechanism causes it to rotate past its normal stopping point and, *as* a consequence, produce incorrect results.

Tyrell (1830)

In many instances the literature contains only meager information about many of the details of the construction of different machines. These machines were of no influence in the further development of the calculating machine art, but we would like to mention them nevertheless for the sake of completeness. To this class of little-known instruments belongs the adding machine patented to the Englishman John Tyrell on 13 November 1830, which F. M. Feldhaus mentions in his *Technik der Vorzeit*.[39]

Samuel Downing (1833)

In 1829, after new imperial weights and measures were introduced in England, Downing constructed new slide rules as calculating aids for the new system. In the production of these instruments he used a composite plane for preparing the edges and the slides. He later invented a calculating machine about which there is some meager information in the English technical periodicals of his time. His calculating machine, which was intended to be competitive with the calculating machine designed by Babbage, was patented in England in 1833 and has been described in several places. No drawings are in existence.

Daniel Kohler (1835)

With regard to this inventor's adding machine, a contemporary report states that it (like all the other calculating machines that had been produced to this time) might, at best, find a place in the model collection of scientific societies.

J. S. Holland (1835)

According to a patent application. J. S. Holland of Three-Colt Street in Limehouse, London, invented a calculating machine capable of addition, subtraction, multiplication, and division, and also of solving problems of the rule of three, of powers, roots, and additional calculating problems. His machine was reported to have been so simple that it was not nearly as liable to malfunction

39. *Technical Science of the Past*, published in Leipzig and Berlin by W. Engelman, 1914.

as other models and would not cost any more than an ordinary clock. It was stated that any skilled mechanic would be capable of making it. Yet nothing was ever heard about this calculating machine again.

Barnet (1842)

The next English patent taken out for a calculating machine was that of Barnet. No further information is available.

Roth (1841)

Dr. Didier Roth. 21, boulevard des Capucines, Paris, designed an adding and subtracting machine with a stylus setting mechanism—similar to Pascal's machine but materially improved. Unlike Pascal's machine, Roth's is almost entirely flat. Here the result digits (0 to 9) appear twice on horizontal gears and are covered by a plate with semicircular slots so that one can see only the individual teeth of the gears. The addition digits are marked on the cover plate just above the setting slots. Setting of a value occurs by inserting the stylus next to the digit to be set up and pulling the setting gear to the left until the stylus reaches the end of the slot, whereupon the respective number appears in the window below. Unlike Pascal's tens-carry, the tens-carry in the Roth machine is a gradual one and consequently carries through to the last place. This is especially important in Roth's machine because of the zero-setting mechanism. Resetting is done by pulling a knob at the left of the machine that sets all gears to 9. In order to obtain zero setting, which is necessary for a new setting of the next value, 1 is added in the first place from the right, which sets all windows to 0. The individual digit gears are provided with locks so that no overthrow can occur. Later the machine was somewhat improved by providing red subtraction digits within the setting slots, whose setting result was shown in separate red subtraction windows so that the machine could be conveniently employed for subtraction as well. The machine was supplied with eight digit places, but neither in France nor in other countries did it gain any importance. Manufacture was discontinued a long time ago. An example of Dr. Roth's machine may be found in the Calculating Machine Museum of the firm Grimme, Natalis and Company of Braunschweig.[40]

40. Now in the Braunschweigisches Landesmuseum, Braunschweig, Germany

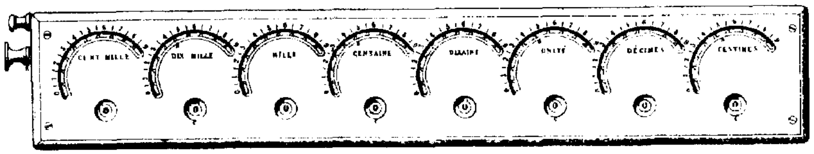


Figure 30

Dr. Roth also designed a machine that externally resembles Hahn's machine and possesses gears with a variable number of teeth. Setting up an amount upon the external numeral dials of the machine releases the corresponding teeth that carry out multiplication when the crank is rotated. The result may be read from the window of the inner circle. This machine, like his simpler adding machine. was of no importance, but two models of it may be found in the Conservatoire des Arts at Métiers in Paris.

Marston (1842)

No details are known about this machine that was patented in England.

Wertheimber (1845)

This English patent represents another attempt in calculating machine design to employ the pinwheel, which is the gear with a variable number of teeth. However, the idea was not actually implemented at the time. Baldwin was the first to revive this invention, and he actually used it in a machine for the first time (see Baldwin, 1875).

Staffel (1845)

This is a seven-place adding machine made by J. A. Staffel, a Pole. The machine is flat and has setting slides and windows below the slide slots. A zero-setting device is provided at the right side of the machine. Like Roth's earlier adding machine. it never gained any importance. An example may be found in the Calculating Machine Museum of the firm Grimme, Natalis and Company in Braunschweig.[41]

41. Now in the Braunschweigisches Landesmuseum. Braunschweig, Germany

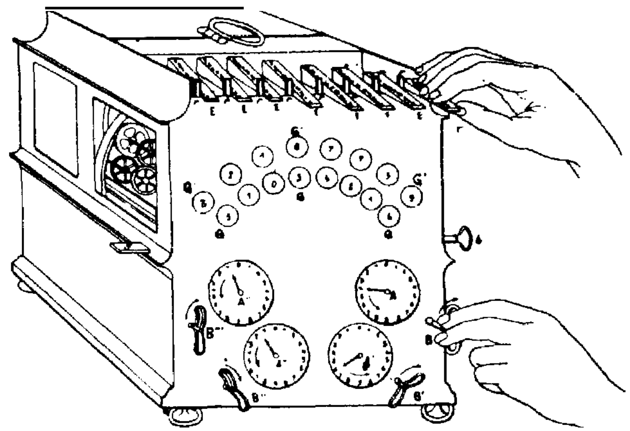


Figure 31

Arithmaurel (1849)

This device was made by Maurel and Jayet. The machine is especially well suited for multiplication and division but is also capable of performing additions and subtractions. The operation is very simple. The whole setting mechanism and the result windows are shown in figure 31.

For multiplication the larger amount is set up with the aid of the eight setting bars, which can be seen on the top edge of the machine. These are pulled out (forward) as required until the digit to be set up is positioned next to an indicator. Multiplication is carried out by means of the four keys shown on the front face of the machine. Each key has an indicator dial associated with it. There is no carriage shift. The first dial at the right performs unit multiplication, the one positioned below performs tens multiplication, the one situated at the lower left performs hundreds multiplication. and the last one performs thousands multiplication. As soon as one of the key-driven dials has been shifted to a certain number, the result may be read from the lowest set of windows. The machine allows multiplication of eight-digit values by four-digit values. The upper row of result windows serves to maintain a sum during continued multiplication. This is undoubtedly a rather interesting machine, yet it did not find introduction into practice because it is fairly complicated and may easily get out of adjustment. An example of the machine may be

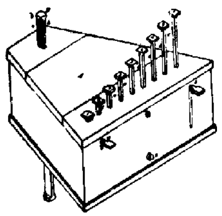


Figure 32
Parmelee.

found in the Conservatoire des Arts et Métiers, Paris. Two more examples are in the hands of private French owners.

Parmelee (1850)

The Parmelee machine is the first adding machine with keyboard (key-driven) setting. It must be admitted, however, that it was rather primitive and never went beyond the experimental stage.[42] It has nine keys, 1 to 9, which are mounted upon a progressively ascending key lever. At the other end of the machine there is a graduated bar marked with successive digits, and the front side is provided with teeth. Upon depression of a key, a lever (mounted on a shaft) with a pawl at the end engages the teeth of the bar and lifts it by as many units as are represented by the marking of the key. Another pawl is arranged to maintain the raised bar in its set position until subsequent depressions of a key raise it further. It is evident from this description that only as many digits could be added with this machine as were provided on the bar—to accumulate a sum of up to one hundred, the bar would have to be almost a meter long.

Schilt (1851)

This adding machine, with keyboard setting, was displayed in London in 1851. Details are lacking.[43]

42. The editors believe that it never even reached the experimental stage. All illustrations of Parmelee's machine appear to be simple copies of the illustration used in his patent application.
43. The Schilt machine is now in the National Museum of American History. Smithsonian Institution, Washington D.C.

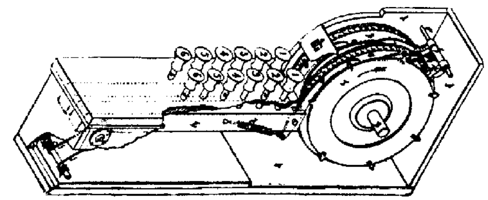


Figure 33

Hill (1857)

Hill's machine, as illustrated in figure 33, shows considerably more similarity with our modern keyboard adding machines than either Parmelee's or Schilt's device, yet it never advanced beyond the experimental stage. The model illustrated may be found in the National Museum in Washington.[44] The individual digit wheels have the digits 0 to 9 inscribed around them seven times. These digit wheels are moved by a gear which, in turn, is driven around by the action of depressing a key on the keyboard. There are no overthrow locks. The tens-carry mechanism is similar to that of Pascal's machine.

Arzberger (1866)

This is an adding machine with only two keys for the digits 1 and 3. This machine was only intended for the addition of individual columns.

Samostchoty (1867)

This machine was designed by Bouniakovsky. It is an adding machine of the same type as Pascal's.

Webb (1868)

Designed by C. H. Webb, it consists of two rotatable circular disks, one for the numbers up to a hundred, the other one for thousands. The apparatus has automatic tens-carry.

44. Now the National Museum of American History. Smithsonian Institution. Washington D.C.

Chapin (1870)

A nine-key machine for adding single columns of numbers. The machine never went beyond the experimental stage.

Robjohn (1872)

A nine-key adding machine with three result windows. On the exterior it resembles the Gab-Ka machine, and likewise. serves for the addition of columns of single-digit numbers.

Barbour (1872)

This machine deserves attention because it represents the first attempt to design a calculating machine that prints. It was an eight-place machine. The setting of a value occurred by withdrawing a slide, whose interior portion was provided with sets of one to nine teeth. The exterior portion of the slide was inscribed with digits corresponding to the number of teeth that were engaged inside the machine. In a way, these sets of one to nine teeth form a kind of multiplication mechanism such as we will find much later in Boilee's machine, in the Millionaire machine, and similar devices. To the right of the setting slides there is a scale inscribed with the digits 0 to 9, above which a lever may be moved.

If a number or amount has been set up with the aid of the slides and one wishes to multiply, the lever is moved to that digit of the scale which is to be the multiplier. This establishes a connection between the calculating mechanisms and the teeth on the slides and turns the result wheels an amount pro-

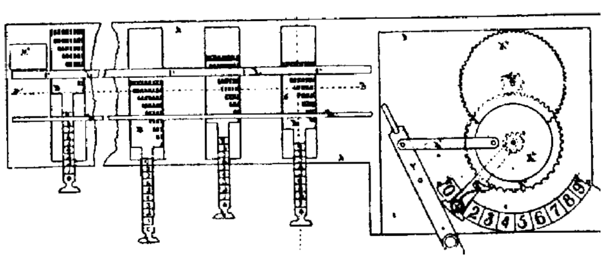


Figure 34

portional to the number of teeth currently engaged. Each place requires two result wheels, each of which contains an additive and subtractive circle of digits, one for viewing through the result window and the other for the printing mechanism. Only sums and subtotals can be printed. A piece of paper is placed upon a lid, the lid is hinged so that it may be raised, the printing wheels inked, and the lid is pressed down to provide the impression. The design of the machine was later improved by Ramon Verea, but only a few examples were built. In the United States it is regarded as the first complete machine of this type. It could perhaps be regarded as a forerunner of Bollée's design.

Beiringer and Hebatanz (1873)

This is a keyboard adding machine with clock mechanism drive. Details are lacking.

The Original Odhner (1874)

There is a difference between the Original Odhner and the Odhner machine. The ***Original Odhner*** was made by Willgodt T. Odhner of St. Petersburg, or his present legal successor. The term Odhner machine covers all those machines that have the same design as the Original Odhner; in other words, which are imitations of the same although they were originally manufactured on the basis of purchased patents. Several years ago the factory in St. Petersburg wrote the following about Odhner himself:

> Swedish by birth, and related to his great countryman John Ericson—the famous builder of the first modern steamboat—he left his home in Varmland at the age of twelve and went to Stockholm. originally with the intention of becoming a merchant. Even at that time his mind was set on technical matters and soon he recognized his true calling. He thus left the counter and entered a machine factory where he worked for several years gaining practical experience. He also prepared himself, by diligent study, for entry into the technical college. Having completed a three-year course, he obtained employment in the St. Petersburg plant of the Swedish industrial tycoon Nobel (the founder of the well-known Nobel prize),[45] but was later appointed to manage the Imperial Russian Workshops. Here he distinguished himself by the invention of a series of important improvements in such a way that, after only three years of service, he was honored by bestowal of the great golden medal.

45. In fact. the factory was owned by Ludvig Nobel, Alfred's brother. Ernst Martin obviously misunderstood the original reference to "the Nobel family."

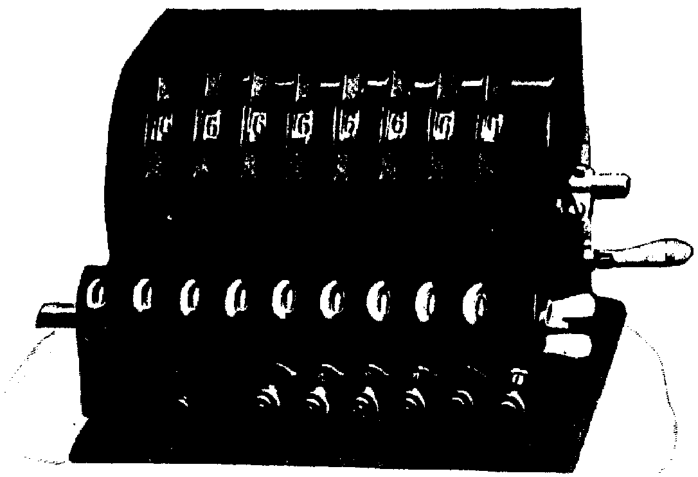


Figure 35
The model of 1874. handmade by the inventor himself

Odhner died on 15 September 1905. The invention of his calculating machine dates back to the year 1874. and our figure 35 shows the machine as it appeared at that time (which was already rather similar to the later Original Odhner machine). The setting wheels were shifted by small setting levers. which are scarcely visible in figure 35, in such a way that the digits to be set appeared in the upper row of windows. The lower row of windows belongs to the result mechanism of the carriage that was cleared, that is, was set to zero, by means of the winged screw. In this model the revolution counter mechanism has the form of six small cylindrical buttons with window openings on their surfaces. Zero setting of these revolution cylinders occurs by turning them to the right. Figure 36, which represents an 1876 model, shows the two characteristic arrows (which we find in all Odhner machines) near the crank that indicate the rotational directions for addition/multiplication and subtractionldivision. This model is of better workmanship and the German patent specification 7393, of 1878, is based on these two models (the German Patent Office did not commence functioning until 1877). The patent specification was not issued in the name of Odhner but in the name of Koenigsberger and *Co.* of St. Petersburg. because Odhner himself engaged in the manufacture of the machine in Petersburg and for this reason ceded the German manufacturing rights to the above mentioned company. This company, however, did not go into production and later sold their rights to Grimme, Natalis and

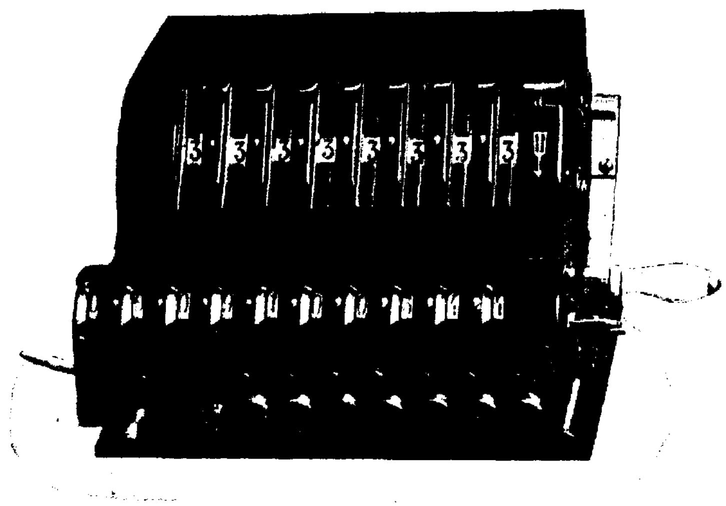


Figure 36

Co. of Braunschweig. who have very successfully distributed the machine, under the name of Brunsviga, all over the globe. The large-scale manufacture of the Original Odhner did not commence until 1886 when the W. T. Odhner factory, St. Petersburg. Tarakanoffski Per. No. 4, was specially built for this purpose. The machine had some distribution in Russia and sold well in the Nordic countries. At different times the firm kept representatives in England. the Netherlands. Belgium, France, and Italy, whereas the Original Odhner could not be marketed in Germany for a long time on account of the patents that had been sold. After these patents had expired, however, the Odhner firm took up selling the machine in Germany and Austria, .but was not able to compete, with any considerable success, with the well-established Brunsviga.

The machine illustrated in figure 36 became best known in Germany. It is the same in both exterior appearance and interior mechanism as the Odhner machine described in the Introduction under the heading The Pinwheel Machine. lt was manufactured in three sizes; namely, (1) thirteen places in the result mechanism, (2) fifteen places in the result mechanism, and (3) eighteen places in the result mechanism.

Machines (1) and (2) have eight places and (3) has ten places in the revolution counter mechanism. Several models appeared on the market under names such as VKD, G. HK, or VK. with almost no differences from one model to the next. For instance. the **VK** model possessed two extra keys, the

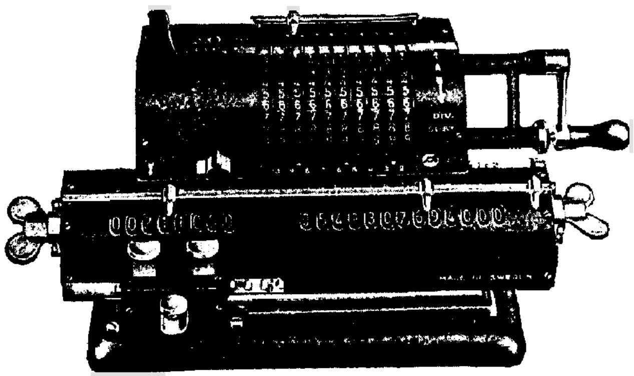


Figure 37
Model 8.

right one moving the carriage stepwise to the right, and the left one moving the carriage stepwisc to the left, with a lever mounted beneath the keys permitting one **to** move the carriage in both directions.

During the late revolution the factory in St. Petersburg became the property of the state, the equipment was moved **to** Moscow, and soon the manufacture was entirely discontinued. However, Odhner's legal successors, namely his two sons Alexander and George Odhner and his nephew, Valentine Odhner, went to Sweden where they founded the Aktiebolaget Original Odhner in Göteborg and resumed the manufacture **of** the Original Odhner machine. Today they manufacture the following models:

Model 7: 20 by 15 cm. weight 4.5 kg, ten setting levers, thirteen places in the result mechanism, eight places in the revolution counter.

Model 6: identical with model 7 but possesses an improved zero-setting device.

Model **8:** has the same size and capacity **of** model 7, but possesses tens-carry in the revolution counter register, hence operates without red digits. The tens-carry neither increases weight nor volume of the machines.

Model 14: shows special setting control windows.

Model 19: has ten setting levers. nineteen places in the result mechanism, ten places in the revolution counter. It weighs 5.5 kg, and its dimensions arc 25 by 15 cm. It is especially suited for banks, insurance companies, and the like.

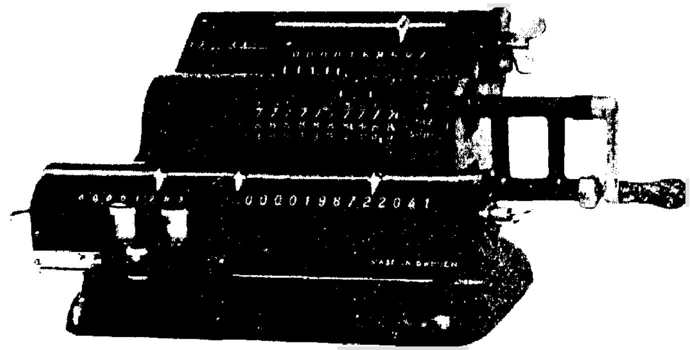


Figure 38
Model 14.

Model **9:** a small machine with only five setting levers, nine places in the result mechanism, and five places in the revolution counter. **It** weighs 3.8 kg, and its dimensions are only 18 by 13 cm. This **small** model is adequate for a large number of small calculating problems that were previously computed with paper and pencil because of the relatively high cost of calculating machines. In order to render the machine as cheap as possible, the automatic carriage shift and various locking devices were omitted.

All of the newer machines possess a lever that permits automatic resetting of the input levers to zero. Recently the Odhner factory paid particular attention to the production of machines for the complicated English currency and brought out no fewer than six models for this purpose:

Model A: a machine for multiplication or division **of** amounts in English currency **by** an amount in decimal currency (for instance f16.1 1.7 × 36.5 = £605.2.9½). This model has ten setting levers, seven places in the pound column **of** the result mechanism, and five places in the pound column of the revolution counter.

Model B: a machine for converting an amount in pounds at a particular rate into decimal currency and vice versa (for instance £945,126.19.11½ at a rate of $3.7675 equals $3,572,065.46). It has ten setting levers, ten places in the result mechanism, six places for pounds in the revolution counter.

Model C: a multiplication machine for English currency in cases in which the price is expressed in pounds or shillings or pence, but not in **two** or three of these units.

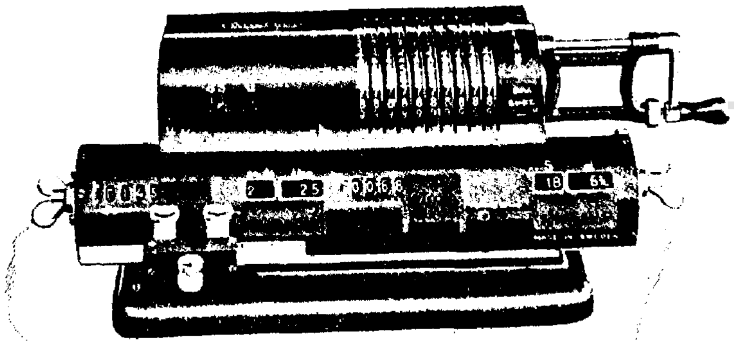


Figure 39
Model G.

Model F: a machine in which the revolution counter and also the result mechanism may be used for pounds. shillings, and pence or for decimal currency as desired. Therefore, this machine is a combination of the regular decimal machine and of models A and B. It is provided with movable decimal indicators for the setting levers and for the revolution counter and is therefore more suitable for a plurality of different calculation problems and is especially suited for calculating problems of different types and sizes. The machine has ten setting levers. the same number of windows in the result mechanism, and eleven windows in the revolution counter. It can, for instance, perform operations such as £6,217,293.12.5 at a rate of \$3.899375 = £24,243,559.31.[46]

Model *G:* a machine that combines the advantages of the regular decimal machine with those of machine model C and is also suitable for carrying out multiplications in which the quantity is given in tons, hundred weights, and pounds and the price in pounds, shillings, or in pence. It has ten places in the setting mechanism. four places for pounds in the result mechanism, and four places for tons, etc. in the revolution counter (for instance, 145 tons, 2 hundred weight, 25 pounds at 9½ shillings = £68.18.6¼).

Model H: is a special machine for computing the interest in English currency. It has the advantages of a regular decimal machine and. with a few small exceptions, also of models A and B. This machine is particularly intended for banks and insurance companies; it has ten setting levers. four pound places

46. Sic—the result should obviously have been expressed in dollars

in the result mechanism, and seven pound places in the revolution counter mechanism. The type of problem it does best is, for instance, £365,806 at 4% for 21 days (84) yields an interest of £841.17.1¼.

The Original Odhner is also sold under the name Arithmos, and in England it is sometimes sold with the label "Lusid," which was meant to represent "£ u s i d" or "f, sh. d".

Manufacturer: Aktiebolaget Original Odhner, Goteborg.

Baldwin (1875)

As previously mentioned, the wheel with a variable number of teeth seems *to* have been known to Leibniz. Later we find such a wheel in the model of Poleni's machine and also in the device by **Dr. Roth** that may be found in the Conservatoire des Arts et Métiers in Paris. However, these were all experimental machines. Baldwin was the first to employ this device in practice. We are indebted to L. Leland Locke, a well-known American calculating machine expert, for the photograph of a document according to which Frank Stephen Baldwin and William E. Harvey swore on 28 September 1872, before a notary public in St. Louis, that they believed to the best of their knowledge and conscience to be jointly the first inventors of the "improved calculating machine according to the following specification."

The specification is a patent application received at the patent office in Washington on 5 October 1872, which contains exact details and drawings of Baldwin's machine, specifically of the model that appeared on the market in 1875 that included the gear with the variable number of teeth. Under the date of 8 September 1873, an improvement on the first model was added to the patent.

Since Odhner's efforts date back only to 1874, the year he made his first model, it seems now definitely proved that Baldwin was the first to employ, in practice, the gear with the variable number of teeth in a calculating machine. It may be assumed that Odhner reinvented this device at a later date. In any case we have no proof whatsoever that Odhner imitated the Baldwin machine, which, as is widely known, the Americans often claim. Figure 43 shows Baldwin's setting wheel (Odhner's setting wheel, for comparison, was illustrated earlier in figure 6).

Apparently Harvey played only a subordinate part. Baldwin being the actual inventor. He was born on 10 April 1838 in New Hartford. During his

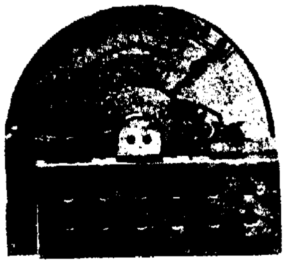


Figure 40

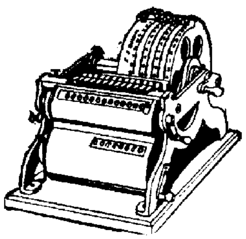


Figure 41

youth he created various inventions that, however, had nothing to do with the calculating machine industry; thus they will not be described here. About 1870 he saw the first stepped drum machine and it caught his interest. He decided to build a machine with only one cylinder instead of nine drums. The resulting model may be found in the patent office in Washington (figure 41).[47] In order to build this model, he employed William Seward Burroughs, later to be the designer of the adding machine capable of printing the result and which bears his name. It is known that Burroughs did not start working on his own machine until 1880. Baldwin had meanwhile moved to Philadelphia where he made a small machine that performed additions only (figure 40), which he called an arithmometer. This arithmometer was patented by him on 2X July 1874. Meanwhile, the first ten copies of the initial Baldwin calculator had been completed, so that Baldwin was in a position to enter into an agreement with the Reliance Machine Works in Philadelphia, according to which this firm was to undertake the manufacture while Baldwin was to take over the sales. The connection with this company, however, did not prove profit-

47. The model is now in the National Museum of American History. Smithsonian Institution. Washington D.C.

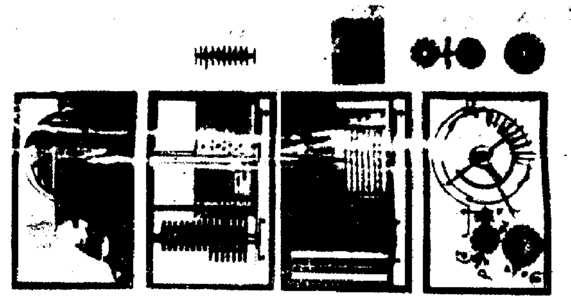


Figure 42

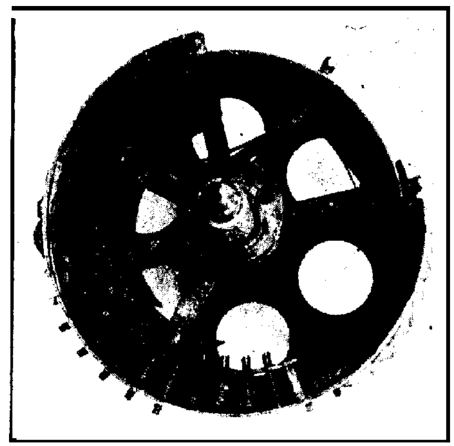


Figure 43

able. and Baldwin therefore returned to St. Louis in 1876 and manufactured the machines himself. As may be seen from figure 41, Baldwin's invention had a great similarity with the Odhner machine, quite apart from the pinwheel mechanism: setting slots, setting levers, the result mechanism disposed underneath, the revolution counting mechanism at the very bottom, the crank at the right side that rotated forward and backward, the zero-setting cranks for the two counting mechanisms — all these are details found in the Odhner as well. It should be mentioned that Baldwin manufactured the machine shown in figure 41 with a printing device, but this model remained unknown in practice.

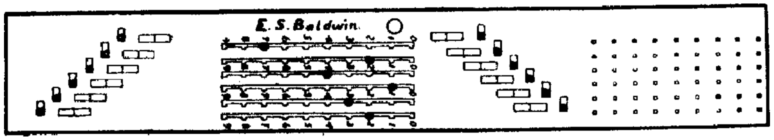


Figure 44

Figure 45

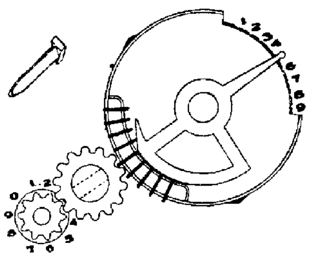


Figure 46

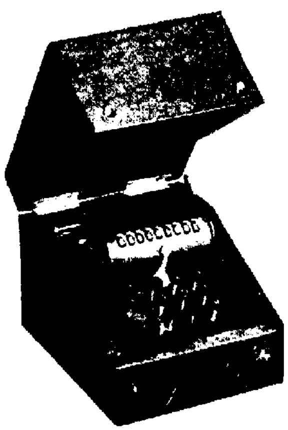


Figure 47

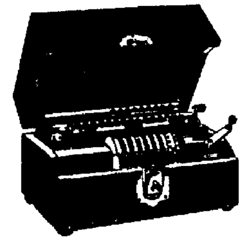


Figure 48

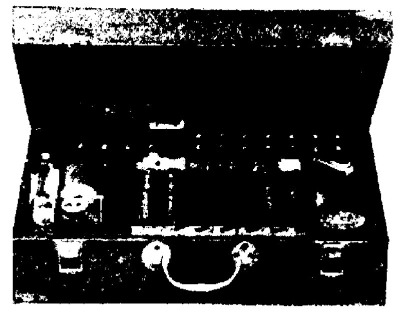


Figure 49

In 1900 a calculating machine was patented by Baldwin with which multiplication and division could be carried out by a single lever pull per digit place. However, the machine remained unknown.

In 1902 there appeared an improved model of the Calculator (figure 48) and a number of these machines are still in use today. In 1905 a ten-key adding machine appeared (figure 47), and in 1908 the Baldwin Recording Calculator, which is illustrated in figure 49. This machine is the forerunner of the Monroe machine of today (see the Monroe reference in this volume).

Figure **42** shows details from the patent application of 1872; figures 44, 45, and 46 are construction drawings of the same model. These **four** figures originate from **Mr.** Leland Locke in Brooklyn.

Carroll (1876)

This is a single-row adding machine with key setting.

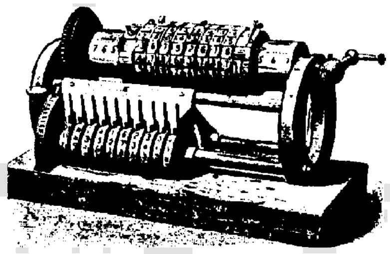


Figure 50

Grant (1877)

This machine was constructed by George B. Grant as early as 1870, but was not publicized until 1877. Additional publications concerning this machine are likely to appear in Brooklyn in the near future.

An upper cylinder is turned by means of a crank and drives a small shaft mounted underneath. A slide on the cylinder, which may be set in eight different positions, carries eight digit rings that may be set for eight or fewer decimal places. With each turn of the crank, the numbers set up in the rings are added to the value set in the ten numeral wheels of the lower shaft.

The multiplication process is best explained with the aid of an example. In order to multiply 347 by 492, the upper rings are set to 3, 4, and 7. The cylinder is turned twice in order to multiply by the units digit (2) of the multiplier; the slide is shifted by one notch so that each ring now moves to the next higher numeral wheel and nine rotations are made, which multiplies 347 by 90 and simultaneously adds the product to the previously computed product. An additional shift of the slide and four revolutions complete the operation and show the result $170{,}724 = 347 \times 2 + 347 \times 90 + 347 \times 400$ in the numeral wheels. Half a reverse revolution of the crank clears the result and sets all rings to zero. thus readying them for the next calculation.

Division is carried out in the opposite way from multiplication. The dividend is set on the wheels, the divisor on the rings, and the quotient appears on the upper numeral wheels. The machine illustrated in figure 50 operates with eight place values or less and shows the result in full, unless it yields more than ten places. The size of the machine is 33 cm by 12 cm by 18 cm. It has only eighty operating mechanical parts, and none of them is either small or fragile. It seems that the machine was never put into mass production. Until recently it was unknown even to the American experts. The description originates from Scientific *American*.

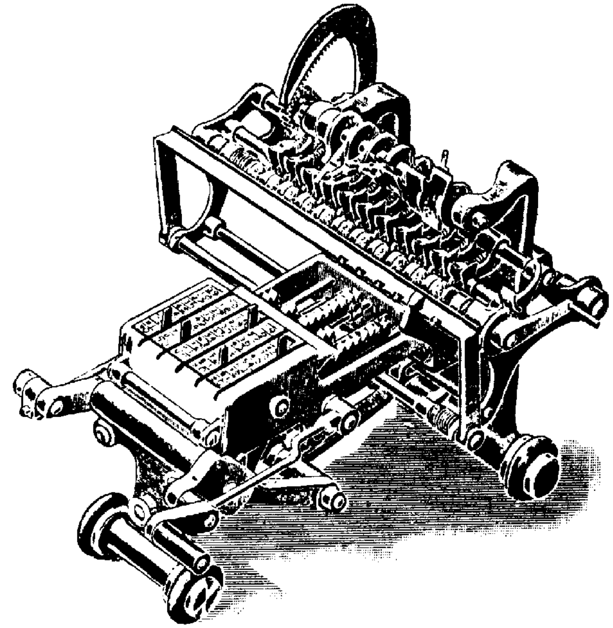


Figure 51

The machine illustrated in figure 51 also originates from the same inventor, In front there arc five setting slots with setting levers protruding from them; each slot has two rows of additive and subtractive setting numbers printed adjacent to it. Movement of the setting lever forward or backward moves the racks visible in the drawing. When the crank is turned, the whole carriage is moved forward, and the setting racks mesh with the gears and move them, together with the appropriate numeral wheels. When the carriage is returned, the connection between racks and gears is broken and a successive tens-carry takes place. Zero setting also occurs by rotation of the crank. The machine was suited for all four types of calculation and was later designed to print as well, but it never gained any importance in practice.

Burkhardt's Arithmometer (1878)

In 1876 C. Dietzschold. an engineer in the town of Glashutte, set out to build a multiplication machine. He encountered difficulties, however, and asked for help from one of his schoolmates, Arthur Burkhardt, another engineer who was then serving his time in the army. Burkhardt came to Glashutte in 1878, shortly after Dietzschold had supplied one of his machines to the Royal Prussian Statistical Office. The statistical office found that the machine did not operate to their full satisfaction. A year later Burkhardt replaced this machine with two others constructed according to the stepped drum system (Thomas-Colmar) and thus laid the foundation for the calculating machine industry in Germany. Soon afterward Professor Dr. Reuleaux confirmed that Burkhardt's product excelled the French one in many ways. A number of machines were produced for government authorities, insurance companies, and the like, but the demand for such machines was still so insignificant that Burkhardt had to turn to the manufacture of other articles and, in fact, had to leave Glashutte for Braunschweig (during which time he was active in an entirely different line). He later returned to Glashutte and again devoted his time to the manufacture of calculating machines, which were becoming popular in commercial firms, manufacturing enterprises, and banks. Burkhardt is generally regarded as the founder of the calculating machine industry in Germany, and in the course of years he managed to keep improving his product so that, even today, it is still very popular and meets with increasing sales. Burkhardt died on 21 July 1918.

The following four models are no longer produced but will be mentioned so that the record will be complete:

Model H: It came in a wooden chest, had six setting rows, twelve places in the result mechanism, and seven places in the revolution counter (it was also available with 10 × 20 × 11 places). In this model the setting slides could be returned to their initial position by means of handle E. In order to facilitate reading the values that have been entered, the slides are provided with small cover plates that show the entered digit but cover the preceding and succeeding digits. *S* marks the lever for reversing from addition to subtraction. The two rows of windows are cleared by clearing-levers A and B. The machine is provided with decimal point indicators.

Model D (of 1909): A machine having two result mechanisms (the use of these was described in the Stepped Drum Machine section of the Introduc-

Figure 52
Burkhardt's original machine

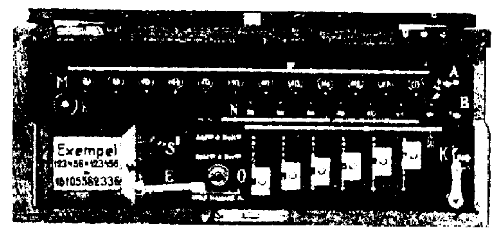


Figure 53
Model H.

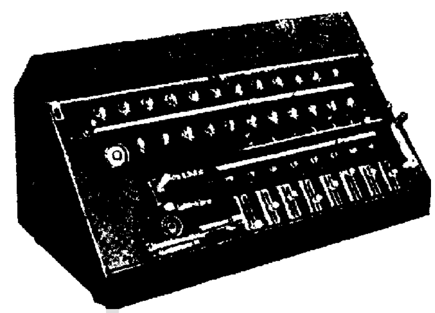


Figure 54
Model D.

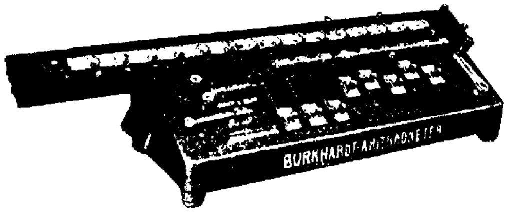
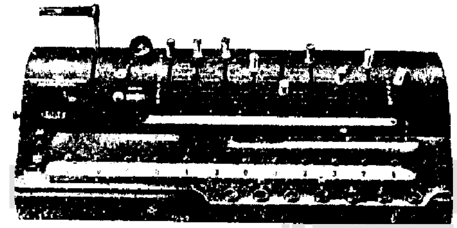


Figure 55
Model *G*.

tion). The three rows of windows have instantaneous resetting devices, as do the setting slides. The reversing mechanism is a double one because of the two result areas: the upper result mechanism can be disconnected. The machine comes in an enameled aluminum casing with a protective wooden chest. It was furnished with eight setting rows, twelve places in the result mechanism. and seven places in the revolution counter.

Model G: This was supplied in a black enameled casting with handles and a protective wooden chest. The two rows of numerals had uniformly colored backgrounds tor the figures, which allowed more convenient reading. Resilient setting slides were employed, as in model D, and also slide cover plates as in model **H.** Two keys took the place of the reversing lever, and a device for locking the crank in the normal position was provided. Smooth tens-carry was achieved in this model. Model ***G*** had eight setting rows, sixteen places in the result mechanism, and nine places in the revolution counter. This model was provided with a decimal point indicator and, in fact, all models so far described were equipped with setting knobs below the windows for entering the dividend or for correcting (rounding off) the results.

Model K (1913): **A** design by Max Klaczko of Riga (who now resides at Goethe **Str.** 76 in Charlottenburg). who became famous because of his earlier typewriter designs. This model combines the convenient setting device and the Comprehensive view **of** the pinwheel machine. with the dependable smooth mechanism of the stepped drum system. The machine also possesses a number of advantages **of** its own. **All** operational digits are positioned in front and above one another, offering a comprehensive view. The rows of digits possess uniformly colored backgrounds and thus permit convenient reading. The setting levers. whose handles are arranged into colored groups, engage easily and securely at the desired figures and thus make the machine especially suitable for addition. To facilitate checking, the entered digits ap-



g *56*
›del K

pear in a straight line. An easily operable, and reliable, clearing device is provided for the setting mechanism. The drive mechanism acts through a conveniently arranged traction lever that, for the purpose of addition, is equipped with an item counter that has a complete tens-carry and zero-setting mechanism. Reversing occurs by means of two keys that indicate in a window, for checking purposes, the type of calculation for which the machine is set. A hand bar with seven key buttons is provided for moving the carriage, which permits automatic movement of the carriage so that the hand may remain at a fixed location. The machine has nine setting places, twelve places in the result mechanism, and seven in the revolution counter. This model is also built into a casting and is furnished with a protective wooden chest.

Model C: Essentially identical to model G, but the setting plate is provided with resilient setting slides and checking digits arranged in a straight line so that they can easily be read. This model was furnished in the following sizes:

Setting mechanism	Result mechanism	Revolution counter	Weight
8 places	13 places	7 places	*6.5* kg
8 places	16 places	9 places	7.2 kg
10 places	20 places	11 places	7.65 **kg**

Model E: At the present time it is mainly model E that is being supplied. The characteristic feature **of** this model is the setting mechanism. Numbers are entered in a convenient manner by levers that are movable in a straight line and may be set quickly and quietly with utmost reliability. Above the setting levers is the setting control mechanism. This offers a fully comprehensive view because it cannot be covered up during operation of the machine. The setting mechanism is sealed in a way that prevents dust from entering the

Figure 57
Model E.

machine, Another innovation is the instantaneous zero-setting of the setting mechanism by depression of a key. A quick, light pressure upon the key is sufficient to return all digits of the setting mechanism to zero. The machine is built into a black-enameled aluminum casing. It has convenient handles at both sides, and a protective metal casing is furnished with each machine. The instantaneous clearing device for the two calculating mechanisms may be found at the right side of the carriage. The instantaneous clearing of the result mechanism may be operated to simultaneously deal with two different calculation operations, so that a double result mechanism is not necessary. Reversing occurs through the setting of two keys, and a lock is provided for the crank in its normal position. The tens-carry in the result mechanism is designed to act smoothly and automatically. Model E is supplied in the following sizes:

Setting mechanism	Result mechanism	Revolution counter	Weight
10 places	13 places	7 places	7.2 kg
10 places	16 places	9 places	8.5 kg
10 places	20 places	11 places	9.9 kg

Arthur Burkhardt's Erste Glashiitter Rechenmaschinenfabrik in Glashutte merged, in 1920, with the Glashutter Rechenmaschinenfabrik, Saxonia, also in Glashutte, so that nowadays the Saxonia machine is manufactured by the same firm. The name of the new firm is Vereinigte Glashiitter Rechenmaschinenfabriken Tachometer und feinmechanische Werkstatt, Glashiitte i. Sa. The abbreviated mailing address is Vereinigte Werke, Glashutte, Sachsen.

Borland and Hoffman (1878)

A single-row adding machine with key setting.

Leiner (1878)

An adding machine with rack drive.

Smith (1881)

A single-place adding machine with key setting.

Berndt (1881)

An adding machine with eleven keys, ten of which serve for setting up the digits, For addition the machine is first set to zero, which lowers the eleventh key to the bottom.[48] The first digit from the right is pushed (to enter the units digit), and this action raises the eleventh key by a small increment; then the second (tens) digit is set, which again raises the eleventh key, and so on. The eleventh key is raised ever higher as more digits are entered. After the total value has been set, the eleventh key is pressed down to add the set value to the result mechanism. The second and subsequent amounts are added in the same manner. The machine is not provided with zero setting, and the individual numeral drums must be successively adjusted to zero by depression of the corresponding digits. The designer is O. Berndt of Nienburg. The machine never acquired any importance.

Tschebicheff (1882)

This is a combined adding, subtracting, multiplying, and dividing machine designed by the Russian mathematician Tschebicheff.[49] Only one example of the machine was built, in Paris, and it may be found in the Conservatoire des Arts et Métiers. The machine does not use any springs.

The Adding Machine: A shaft carries ten drums, each of which have three sets of the digits 0 to 9 printed on their circumferences. Each drum is provided with a drive gear, whose teeth project beyond the circumference of the drum.

48. The original German said "Key I," which we presume was a misprint for "Key II."
49. A different description. together with several more photographs. can be found in an appendix to *Le Calcul Simplifié: Graphical and Mechanical Methods for Simplifying Calculation*, Volume II in this Charles Babhage Institute Reprint Series for the History of Computing.

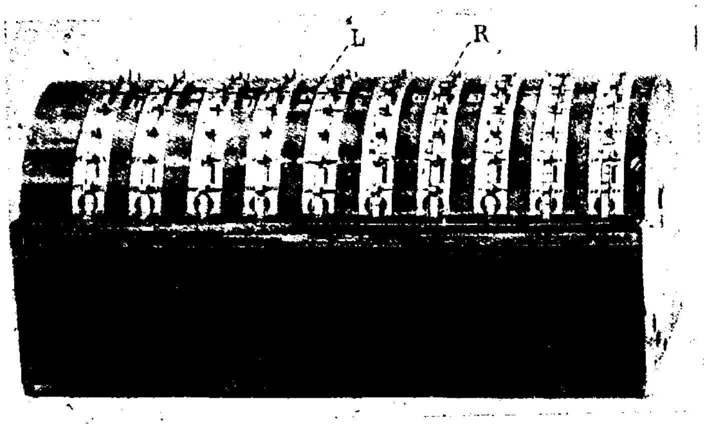


Figure 58
Tschebicheff's machine.

The gear and drum are mounted on the same shaft. The characteristic feature of this machine is a gradual tens-carry, a part of which is placed between each of the individual digits on the drum circumference, as can be seen from figure 59.

The windows are rather large because not only must they show their respective digits but also up to nine-tenths of the preceding or succeeding digits. The shaft, together with drive gears and numeral drums, is arranged within a housing (figure 58) with slots along its carefully made surface. The teeth of the drive gears may move in these slots. The setting digits 0 to 9 are adjacent to, and between, the slots. The windows are approximately midway along each slot. Adding occurs by taking the tooth of the setting wheel (which is next to the digit to be added) and moving it down until it reaches a stop, whereupon the number entered will show in the window. Subtracting occurs by shifting the tooth from zero up opposite the digit to be subtracted.

Zero Setting: A button on the left side of the machine is depressed. then the first of the adding gears is turned until it engages with a stop, then the second from the right. and so on.

Multiplication: If the machine is to be used for multiplication. it must he partly shifted into a separate multiplication mechanism. The multiplication machine, with the adding machine inserted, is shown in figure 60. The multiplicand is set with the aid of small slides, not visible in figure 60, in the longitudinal slots at the right side of the machine. These slots are provided with notches on their lower edges. Every place. that is. units, tens. hundreds.

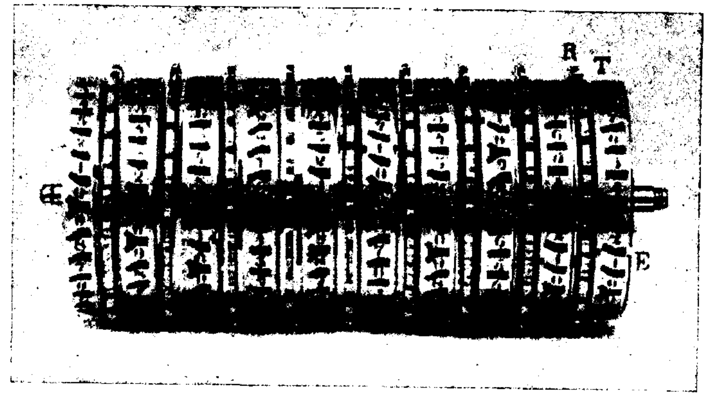


Figure 59

and so on. requires one such slot. The multiplier is entered into the counting mechanism with the aid of the eight levers farther to the left. These may be moved back and forth in the slots adjacent to the marked digits after a lever. mounted below these setting slots. has been shifted completely to the right. Alter setting up the niultiplicr. the lever must be moved back completely to the left. The crank of the machine is then turned until all the setting buttons on the right setting mechanism have returned to their initial positions.

Division: This occurs in a similar manner to multiplication, but the complement of the dividend has to be set into the adding machine, and then the adding machine is connected with the multiplying machine. The divisor is set in the right setting mechanism, the setting ievers of the counting mechanism are set to 9. and the lever mounted underneath is shifted to the left, after which rotation of the crank may commence.

Hammenstede (1882)

In 1882 Edward Hammenstede of Cologne received German patent number 20443 on a Schnelladdicrmaschine[50] with two rows of keys arranged in the following way:

6 7 8 9
1 2 3 4 5

A numeral drum was at the heart of the mechanism for doing the arithmetic.

50. Speed-Adding Machine.

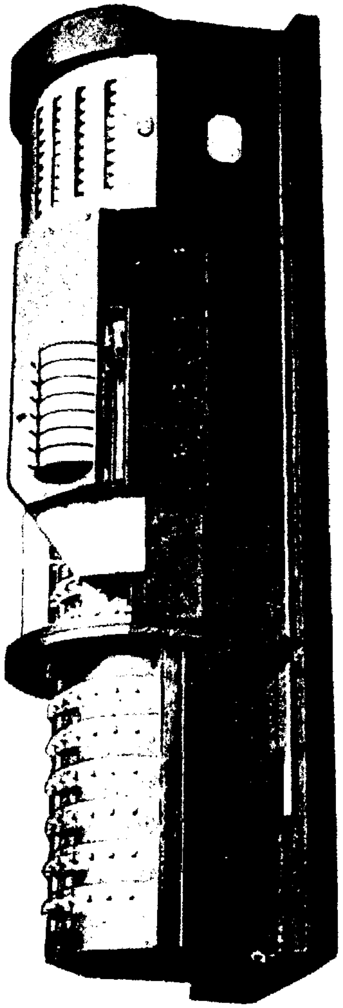


Fig re 60

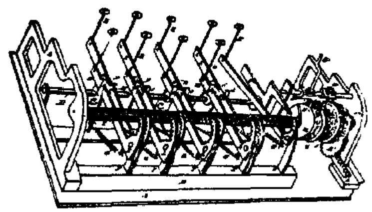


Figure 61
Bouchet.

Layton (1883)

From 1883 to 1886 Layton's Arithmometer was manufactured and sold by Charles and Edwin Layton on Farrington Road in London. This was the first English stepped drum machine. Later Tate, a sales agent for the machine, improved it. It was sold under the name Tate from 1907 until 1914. At the present time manufacture has been discontinued.

Bouchet (1883)

The machine, illustrated in figure **61,** was made and sold in America but never gained importance. It is a nine-key adding machine for single-column calculations: the keys are arranged in two rows: 1 to 6 and 6 to 9. The ends of the key levers are bent upward and carry from one to nine teeth, depending **on** their values. Upon depression of a key, these teeth engage a grooved rod. extending over the total length of the machine, and turn the rod an amount proportional to the number of teeth on the end of the key being pressed. The same action also turns a counting wheel mounted on the rod. A tens-carry mechanism carries the tens to a second and third counting wheel so that columns of figures may be added up to a total of 999.

Spalding (1884)

This is a single-column adding machine with nine slides, situated in one row, for setting up the individual digits. Instead of the customary counting gears, this machine has mounted on its surface two numeral dials, each with a pointer. The large dial on the left (figure 62) is for the numbers 1 to 99; the

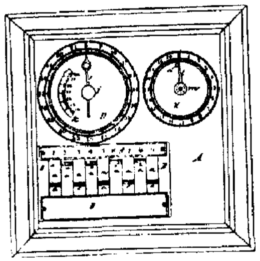


Figure 62

right and smaller one for the hundreds. of which it may register up to 19. The individual setting slides therefore act upon the large dial moving its pointer an amount depending on the value entered. When the sum exceeds 99, a hundred is automatically transferred to the smaller dial on the right. The machine was never put into production and remained unknown in practice.

Stark (1884)

This is a single-column adding machine with keys 1 to 9 in a row. As far as we know, it was never put into production.

Azevedo (1884)

This machine—a nine-key. single-column adding machine with ten places in the result mechanism was designed hy Ant Jul. Rodrigo D'Azevedo. Coutinho. in Povoa de Lanhoso.

Bagge (1884)

This was only a primitive device. of the type called addition control machine. created by O. J. Bagge of Christianssund. It never went beyond the experimental stage.

Pottin (1885)

This construction actually was part of a cash register, but it is mentioned here because for the first time we find a key-setting mechanism in which addition

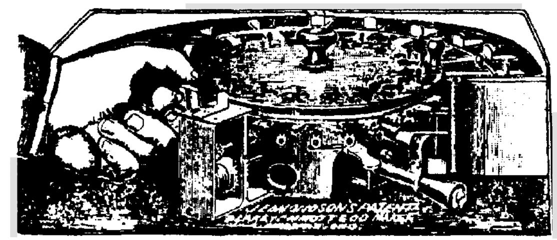


Figure 63
Edmondson.

and printing are not accomplished directly by the setting mechanism but by a special lever pull.[51] as will later be seen in many of the full-keyboard and ten-key adding machines capable of printing.

Swem (1885)

A single-column key adding machine that remained unknown in practice

Edmondson (1885)

In this machine the multiplicand and divisor are set with the aid of the slides shown in figure 63. The result mechanism and revolution counter are situated upon a circular disc in the center. This arrangement has the advantage that a division that does not end without remainder may be continued for any selected number of places. whereas the stepped drum machine or the pinwheel machine only permit division to be carried on over a limited number of places. The machine is provided with a zero-setting device with which some, or all. of the windows may be set to zero. The machine was manufactured by Blakey, Emmot. and Company in Halifax, but has long since disappeared.

Comptometer (1885)

Dorr E. Felt was employed as a mechanic in Chicago in 1884 when he was twenty-two years old. He spent his free time on experiments making a calculating machine. In 1885 his first machine, which admittedly was rather

51. That is to say. the machine has keys. but is not key driven

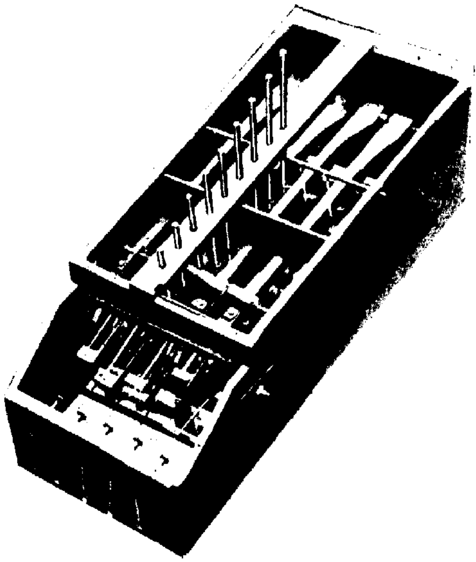


Figure 64

primitive, was completed. It is illustrated in figure 64, and since it was built into an old macaroni box. it received the name *macaroni box model.* This model is still in existence today.[52]

This wooden model was improved, and in the fall of 1886 the first machine with a metal mechanism in a wooden housing was completed. By September 1887 the first eight machines were completed, and one of them (figure 65) went to Washington where it was employed in a government office until 1909. Today it may be found in the National Museum in Washington.[53] The other seven machines were also placed and gave full satisfaction.[54] In November 1887 the firm Felt and Tarrant was founded. It was registered in January 1889. and since that time the firm has been manufacturing Cornptometer calculating machines under the personal management of the inventor.

Although the machine of today follows the principles of the original machine, many major and minor improvements have been provided in the decades this machine has been in use. The first important improvement was the

52. It is currently in the National Museum of American History. Smithsonian Institution, Washington D.C.
53. Now the National Museum of American History, Smithsonian Institution, Washington D.C.
54. It is not entirely clear if Felt sold his first machines or gave them away in exchange for recommendations.

Figure 65

introduction of the so-called multiplex keys, which permit simultaneous depression of keys in several different columns—the earlier models permitted only successive depression of the keys. This innovation is based upon a device that does not perform the tens-carry from a lower to a higher order immediately but delays it until such time as the movement of the higher place result wheel is finished.

After the multiple-key mechanism came the so-called controlled keys. This mechanism prevents entry of a wrong number if the key has not been fully dcprcssed. It is a known fact that most of the errors occurring during mechanical calculation are not due to the machine but to improper operation. It is readily understandable that a machine operator may make errors if we stop to think that he carries out between 50,000 and 200,000 keystrokes daily.

Another important improvement in the latest model is the triple-clear signal. which eliminates the danger of the machine not being set to zero before a new operation is begun. Since two or three thousand zero settings are needed a day, such a safety device is certainly indicated. If an operator should forget to perform the zero setting before a new operation is commenced, three different signals will remind him of this fact. As soon as a new calculation operation commences, a bell sounds. If only half-zeros appear in the windows, and if during the first depression the finger feels a certain resistance, it means that the machine has previously been set to zero.

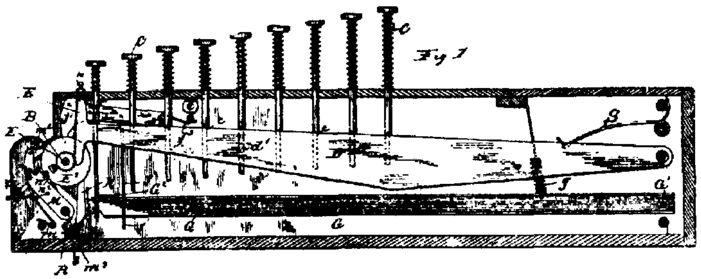


Figure 66

The Comptometer belongs to the class of true calculating machines because not only addition and subtraction but also multiplication and division may conveniently be carried out (the actual keyboard adding machines are less suited for multiplication and division, as is well known). The Comptometer excels adding machines proper as regards speed. After a value has been depressed in an adding machine, a crank must be pulled or a motor key depressed; then the amount entered is transmitted to the calculating mechanism and the keys are released for setting up the next amount. In the Comptometer. however, the operator merely has to depress the key (or, if possible, several of them at the same time), and the result may be read from the windows below the keyboard. The crank. which can be seen at the right side of the machine, serves merely for zero setting of the counting mechanism. The right hand remains above the keys and the left one serves for checking and for turning over pages.

Multiplication: For example. to multiply 1364 x 57, the index finger of the left hand is placed over the 50 key and the index finger of the right hand is placed over the 7 key and both are pressed down as often as the rightmost place of the multiplicand requires (4). Now both fingers are moved one column to the left and are depressed as often as the second place of the multiplicand requires (6). The procedure is continued, the index fingers are moved to the next columns to the left, the respective two keys are depressed three times and finally, after an additional lateral displacement, once. The result of the problem may now he read in the windows. In this manner four-digit values may be multiplied (two keys for each hand). In the case of larger values it is advantageous to break the numbers apart and to carry out the multiplication in two stages.

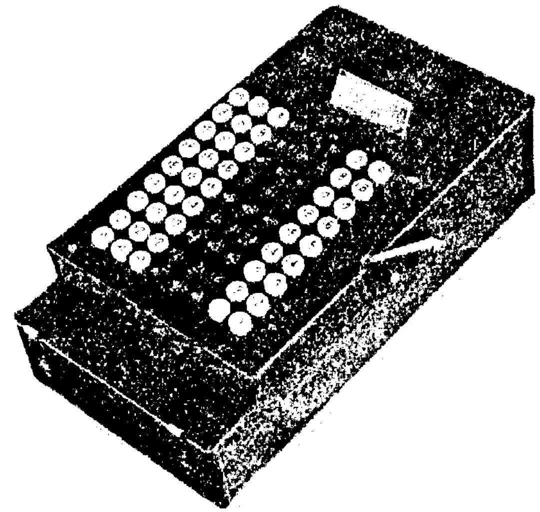


Figure 67
Model A—the first machine with a metal case

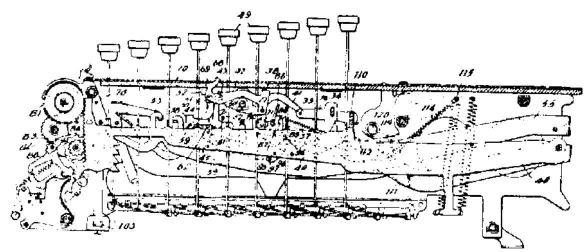


Figure 68
Cross section of the present model

Division: **For** example, to divide 63542 / 77, the dividend is entered by depressing the appropriate keys on the left side of the keyboard. The divisor cannot be deducted from the first two digits of the dividend. Therefore, the comma is placed above the respective first three digits **of** the result mechanism, then the two first fingers of the right hand are placed above the keys 76(77 – 1) ending with the comma at the right, and the keys are pressed down while keeping the eye on the respective three result windows. The two keys are to be depressed as often as the dividend allows. When 77 can no longer

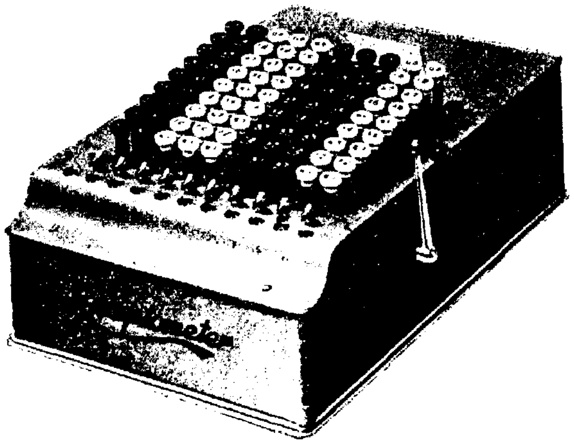


Figure 69
Model H, presently on the market.

be deducted from the amount appearing in the result window, the two fingers are moved one place to the right, and the respective keys are depressed as often as the dividend allows, and so on. Eventually the result appears in the windows at the left, and at the right side is the undivided remainder.

The Comptometer has always been available with eight, ten, and twelve places. Every one of these models has one additional place in the result mechanism. From 1887 to 1903 the machine was supplied in a wooden case. Spiral springs surrounded the shafts of the keys. In the following three years the Comptometer was provided with key coverings of a composite substance.” In these machines it was already possible to depress several keys at the same time. Since 1913, longer keys have been employed. The machine was equipped with a release key situated at the top right, to be depressed if one of the keys had not been completely depressed; such a partial depression is an error and locks the other columns of the keyboard. The present model has been on the market since 1920 and is equipped with the previously mentioned triple-clear signal.

55. Martin indicates that, from 1904 to 1906, Comptometers were sold with *gläsernem* key covers. This adjective means glassy or crystalline. In fact. chemical analysis indicates that the keys from this period are neither glass nor ceramic but a composite of a resin and a filler. We thank Nikki Horton of the National Museum of American History, Smithsonian Institution, for this information.

Number of decimal places	Weight	Dimensions	Price
8	8 kg	37 × 20 × 14½ cm	$300.00
10	9 kg	37 × 24 × 14% cm	350.00
12	11 kg	37 × 28 × 14½ cm	400.00

Machines for fractions and for English currency are also available. The Comptometer is well established in all European countries that are of any importance for the calculating machine trade. Approximately 10,000 Comptometer operators are trained annually in special Comptometer schools. The Comptometer is manufactured by Felt and Tarrant Manufacturing Company, 1713 to 1735 North Paulina Street, Chicago.

Duschanek (1886)

Duschanek’s device is a stepped drum machine with three rows of windows. One row is for the setting mechanism, one for the result mechanism, and the last for the revolution counter. All three window rows are arranged in a straight line, and they are set to zero by a single rotation of a crank. Subtraction occurs by rotation of the crank in the opposite direction. The machine did not develop beyond the experimental stage. The designer was Carl Duschanek of Freiburg in Baden. An example of the machine can be found in the calculating machine museum of the firm Grimme, Natalis and Company in Braunschweig.[56]

Summa (1886)

Designer: Max Mayer of Munich. Manufacturer: M. Barthelmes of Munich.

The first patent for this machine was filed as early as 1881. The Summa is

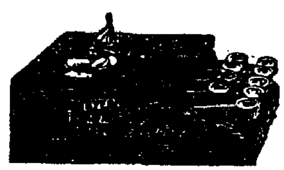


Figure 70

56. Now in the Braunschweigisches Landesmuseum, Braunschweig, Germany

a single-column adding machine in which the keys are arranged in two rows. Like all nine-key adding machines, it had only a very small distribution.

Lindholm (1886)

This is a single-column adding machine of American origin. It remained without any importance.

Selling (1886)

Professor Dr. E. Selling of Wurzburg designed a calculating machine in which the tiresome turning of the crank, and also the jerky tens-carry. was successfully avoided by employment of the device known as the Nuremberg shears (also known as a stork bill).

The machine consists of two separate mechanisms that are brought into joint action during the operation. The two parts are:

1. The Nuremberg shears with toothed racks and keyboard for setting the multiplicand.
2. The gears and numeral wheels. all mounted upon a common shaft and adapted to receive the longitudinal movement of the racks and convert it into a rotating movement. The numeral wheels are connected with one another by so-called planetary gears for the purpose of tens-carry. Thus a malfunction due to spring obstructions is rendered impossible.

The actual calculating occurs by opening and closing the Nuremberg shears by means

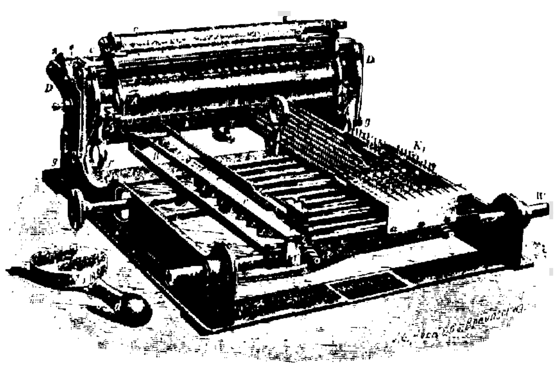


Figure 71

of a hand ring, the magnitude of such movement being determined by the multiplier. (This quotation is from a communication from the former designer Max Ott of Würzburg.)

Dr. Selling later constructed a larger machine that was electrically driven and was equipped with a printing mechanism. It was made by H. Wetzer in Pfonten. One sample of each of the two machines can be found in the Deutsches Museum in Munich. Neither of these machines assumed much importance and their manufacture has been discontinued.

Mahn (1887)

An adding machine with keys was patented to Rudolf Mahn in Leipzig-Reudnitz under German patent 41,725 of 1887. In the finished model, the adding of either single-digit or multidigit items occurred by depression of individual keys marked with the required digits. These keys were arranged in rows, side by side and beneath one another. Racks, connected with the keys, turned the numeral dials in such a way that the total amount appeared directly in the windows. In carryovers from one decimal place to another, the next higher dial was turned by one-tenth of its calibration with the aid of intermediate gears.

Büttner (1888)

Designer: Otto Buttner, Kaulbachstr. 18, Dresden, Sales agency: Wilhelm Brückner, Dresden.

In appearance the machine resembles the contemporary stepped drum machines. The *Unweisung zum Gebrauch der Biittnerschen Rechenmaschine* mention the following advantages over other stepped drum machines:[57] "The carriage is tilted slightly forward affording the operator a better view; the digits in the setting mechanism appear side by side in a straight line so that any setup value may be read directly from them; the crank can be turned backwards."

The notched wheels protruding from the slots at the left of the setting windows may be turned in both directions over an arc of about a quarter revolution. If a setting window reads 0, one turns the wheel upward until the desired figure appears in the window. Similarly, values may also be set directly into

57. *Instructions for the use of Büttner's Calculating Machine*

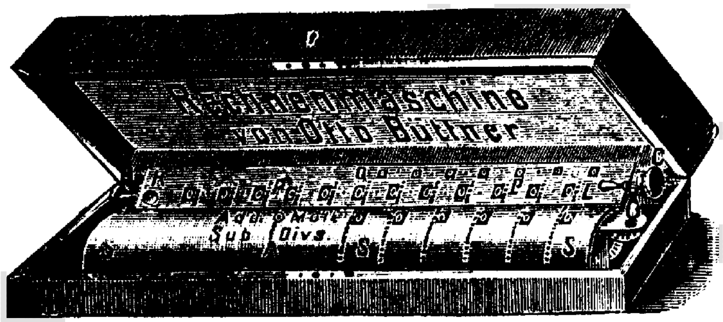


Figure 72

the result mechanism but not in the revolution counter. The latter has a tens-carry and exhibits red and white numerals.

Mounted between the marks ***Add*** - Mult there is the reversing button. Button ***K*** serves for lifting and moving the carriage from side to side. *B* and *C* are zero-setting buttons for the two counting mechanisms. The machine was supplied with six, eight, and ten places in the setting mechanism, with twelve, sixteen, and twenty places in the result mechanism, and seven, nine, and eleven places in the revolution counter. The manufacture has long since been discontinued,

Bahmann (1888)

A key adding machine in which the result is indicated by a pointer in a manner similar to gas meters.

Ludlum (1888)

Ludlum's design, shown in the drawing in figure 73, is the first ten-key adding machine capable of printing. The keys are arranged in one row. The design exhibited a number of defects **so** that the machine never appeared on the market.

Bollee (1888)

All calculating machines described so far have implemented multiplication by continued addition and division by continued subtraction. Leon Bollée, born

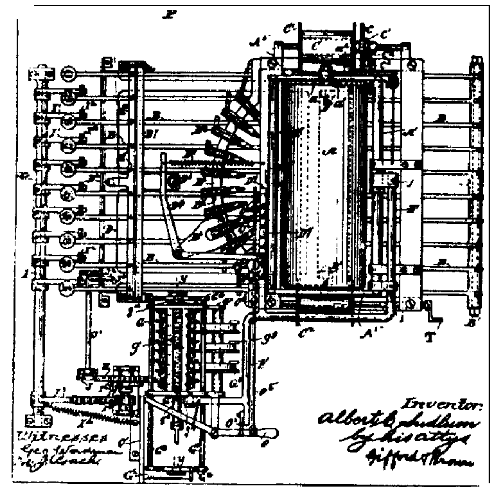


Figure 73

I April 1870, constructed in the course of three months (from February until April 1888) a calculating machine in which the multiplication table was mechanically represented for the first time. In other words, he created the multiplication body that we find today in the Millionaire machine, in the Moon-Hopkins machine, and in the Kuhrt machine, although the various manufacturers designed it in slightly different forms. Bollée's father had a factory for constructing steam tramways and later turned to the manufacture of automobiles. At the age of thirteen his son obtained a patent on an unsinkable water bicycle that was used by the Englishman Rigby to cross the channel. Before starting with the large calculating machine described here, he had made several smaller ones that were also capable of practical use but were never put into manufactured production. There are only three examples in existence of the large machine: the first one has only three places and does not work satisfactorily, while the two others of 1889 and 1892 each have twenty places in the result mechanism and in the revolution counter." One of these latter machines is owned by the widow; the other and older one may be found in the Conservatoire des Arts et Métiers in Paris. Bollee did not exploit his invention. He gave his main attention to the automobile industry to which he made considerable contributions. Later, after the Wright brothers in Amer-

58. Another example. which Martin seemingly did not know about, is in the National Museum of American History, Smithsonian Institution. It is larger than those he describes, being 12 × 22 × 22 rather than 10 × 20 × 20. It is made to the design of 1892.

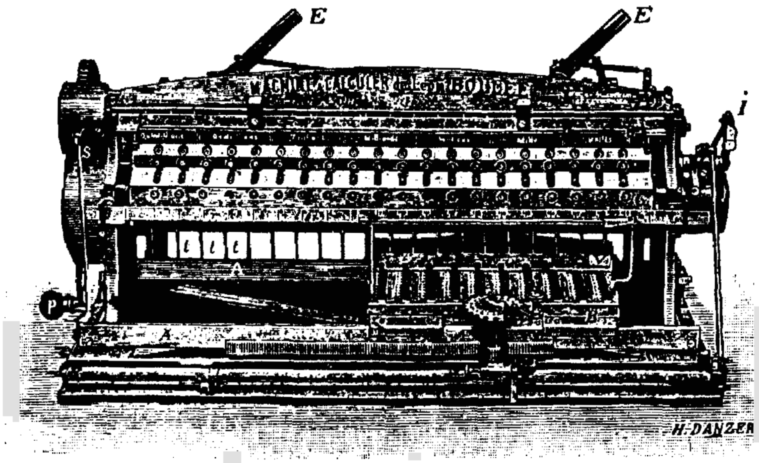


Figure 74

ica had started their attempts to fly, he invited the inventors to France and placed his two large factories in Le Mans at the disposal of Wilbur Wright in 1908 and supported him to a very considerable extent. As a result of his other interests, the plan to manufacture calculating machines fell completely into oblivion. Bollée died on 16 December 1913. His machine is especially remarkable because the designer was not yet eighteen years old when he built the machine and knew no details of other calculating machines except his own earlier constructions.

Figure 74 shows a full front view of the machine. Figure 75 shows the same machine from the back. Figure 76 shows the machine resting on its back. Figure 77 shows the setting mechanism with the multiplication crank. a multiplication, or times table, body, and an upper and lower numeral wheel placed in front of it. It also shows the ten multiplication bodies side by side in the rear of the setting mechanism.

The machine has ten setting rows with setting slides that may be shifted along the digits 0 to 9. Displacement of a setting slide moves the multiplication body connected to it. The multiplication body may best be compared with a brush. In the multiplication body the individual digits are represented by little pegs that vary in length according to the individual digit values. Thus. for instance, the digit 1 is expressed by a peg of unit length, the digit 2 by another of length two. and so on. Multiplication of single-digit numbers sometimes gives two-digit results, for example 2 × 6 is represented by two

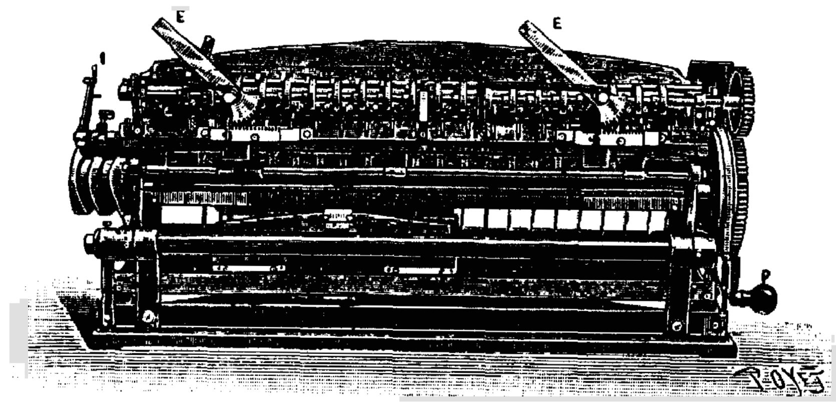


Figure 75

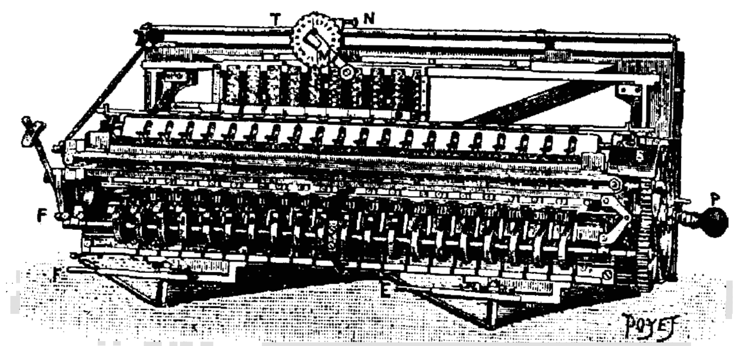


Figure 76

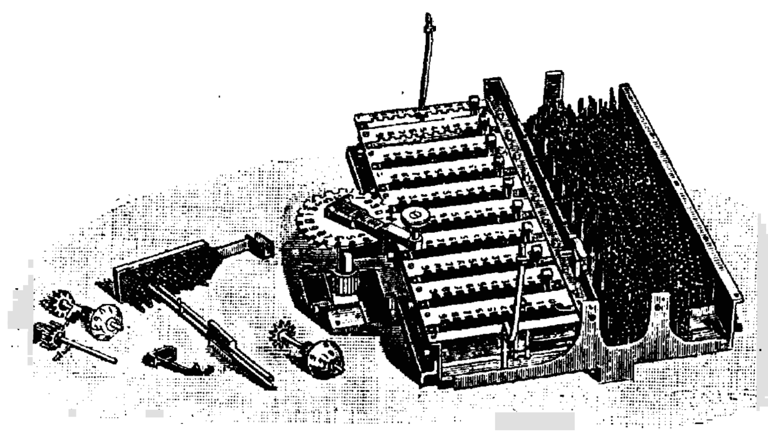


Figure 77

pegs, one of length two, the other of length one; **7** × **7** by one peg of length nine, and the other of length four; **9** × 9 by one peg of length one, and the other of length eight; etc.

The whole setting mechanism, together with the multiplication bodies, may be moved along the whole machine by means of the multiplication crank. This crank revolves around a circular scale with the digits 0 to 9 engraved twice around the circumference. The main crank is positioned on the left side of the machine and is denoted by P. The lever *I* on the right side is used for setting the machine to plus and minus; the two levers E set the two counting mechanisms to zero. The result appears in the upper windows, and the revolution counter numbers appear in the lower windows. The machine is primarily intended as a multiplication machine, but it may also be used for addition, division, and subtraction.

The little bars, *t*, form the connection between the multiplication bodies and the two numeral mechanisms. As may be seen from the illustration, each digit place of the machine has such a bar, but behind each of them are two similar bars that cannot be seen in the illustrations. **1** will now briefly describe the function of these 20 × 3 connection bars.

Let us assume 3 is to be multiplied by 27. We enter the amount **27** by means of the setting slides, as has been explained before, and turn the multiplication crank to 3. As a result of this action, a multiplication mechanism is moved so that the number seven is set on the calculating slide. a peg of length one is below the middle bar, and a peg of the length two is below the back bar—corresponding to the two digits of the product 21 resulting from 3 × 7. On the second setting slide, a peg of length six is below the middle bar corresponding to the product of 3 × 2. Movement of the main crank P lifts the setting mechanism and pushes it against the multiplication bodies. thus transferring the product to the result mechanism. It is not my intention to delve further into the mechanical details in this book.

If, for instance, a larger value is entered with the setting slides (the setting mechanism of the machine has ten places) and is to be multiplied by a multidigit value, for instance **429,** the multiplication crank is set to 4, then the main crank *P* is rotated: thereafter, the multiplication crank is set to 2, the main crank is again turned once, then the multiplication crank is shifted to **9,** and the main crank P is again turned. The upper windows show the result and the lower windows show the multiplier.

So far we have described the function of the middle and back connection bars. The front one transmits the number of revolutions to the lower counting mechanism by means of a tab stop *V,* which is positioned above the setting slide in notches provided for that purpose. This tab stop has steps corresponding to the digits I to 9. For instance, if the multiplication crank was set **to** 3, that is, multiplication was performed with 3 as the multiplier, then step 3 of the tab stop acts upon the front connection bar during upward movement of the whole setting mechanism and also acts on the multiplication bodies because of the rotation of main crank P. This lifts the front bar three places, which in turn advances the respective revolution counter wheel by three digits.

Addition: Addition occurs in the same way as multiplication. The first amount is entered with the aid of the setup slides, the multiplication crank is turned to 1, the main crank P is turned once. and the amount set appears in the upper counting mechanism. Any number of additional items may be added in the same manner.

Subtraction: The larger amount is entered. The multiplication crank is turned to 1, the main crank *P* is turned, and the minuend appears in the result mechanism. Then the machine is set to minus, the subtrahend is entered by means of the setting slides, the multiplication crank is turned to 1, the main crank *P* is turned once, and the remainder may be read from the result mechanism.

Division: Division is carried out in a similar manner.

It would, of course, require going into too many mechanical movements to describe the machine in detail. Here, it is only intended to give an idea of its method of operation, which is certainly not simple. To demonstrate this, it might be mentioned that a single rotation of the main crank *P* performs no fewer than nine different operations in very quick succession, only one of which is the lateral displacement of the setting mechanism. Moreover, the machine consists of more than three thousand parts.

Our description is based upon the machine of 1892, which is the one shown in the illustrations. The earlier machine (1889) differs only very slightly from the machine described here.

Although Bollée's machine was never put into mass production, the model shows an entirely new way of carrying out multiplication and division. It is faster than the methods used in the stepped drum and pinwheel machines. The imitations of Bollée's multiplication body are proof of its practicability.

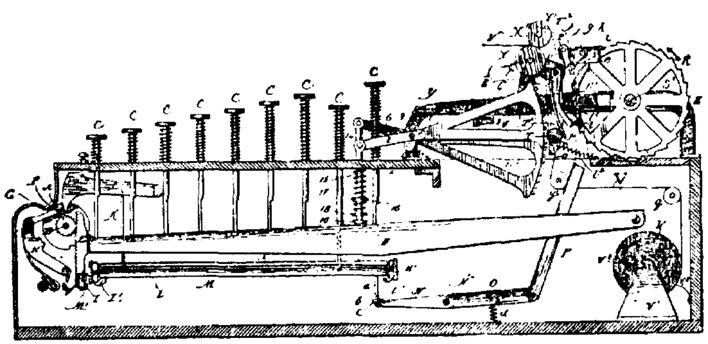


Figure 78

Comptograph (1889)

The Comptograph followed the Comptometer described earlier in this volume. It is essentially the same machine equipped with a printing device. It originated from Dorr E. Felt, who was the first to bring out a large printing adding machine. He could be described as the most successful and most versatile builder of adding machines, and both his method of setting up the type bars and his single type hammers were later adopted by Burroughs and others. His first model (patent applied for on 19 January 1888, granted 11 June 1889, partially illustrated in figure 78) was not, however, usable. For one thing. the spring that produced the printing motion had to be wound up. and the machine did not print zeros.

Even before the patent was granted. Felt brought out a new model. Felt and Tarrant built twenty-five of these new machines. These were sold to various hanks—the first in December 1889. This is the oldest printing adding machine known and was in use until 1889.[59] It can be found in the National Museum in Washington (figure 79).[60]

The paper was fed out by a hand lever attached to the right of the machine. This machine printed zeros automatically. Each row of keys not only had one typing sector but also a typing hammer that struck from behind the paper. The typing hammers were returned to their rest position by a lever, the use of which also caused the paper to be pushed up. The printing was always in full view.

59. Ernst Martin has obviously made an error in his dates. The error persisted in the 1928 edition. No attempt has been made to change either the dates or the sentence.
60. Now in the National Museum of American History, Smithsonian Institution.

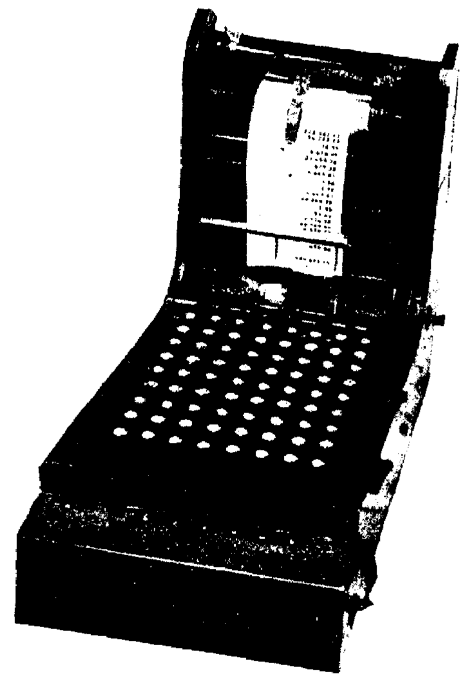


Figure 79

Felt's next improvement was the wide carriage. This enabled several columns to be printed next to one another. Other firms such as Burroughs, Wales. etc., were only allowed to make wide carriage machines after paying license fees to Felt. With this machine the digits had to be entered from right to left. In order to print the result, it had to be taken from the figures appearing in the result windows. The first hundred machines, which were produced in 1890, had a key on the left side of the keyboard that caused this printing to occur automatically. In entering numbers, keys could be pressed either from the left or right or in any order (figure 81). In all the models described here so far. addition and printing were carried out solely by pressing keys.[61]

The Comptograph described above was not introduced into Germany but rather a much-improved machine, briefly described here and shown in figures 82 and 83. This is a visible printing, full-keyboard adding machine with self-

61. On the 1890 machine. numbers entered were printed. The total accumulated on numeral dials. as on a comptometer. When this total was to be printed. one pushed a large key to the left of the keyboard.

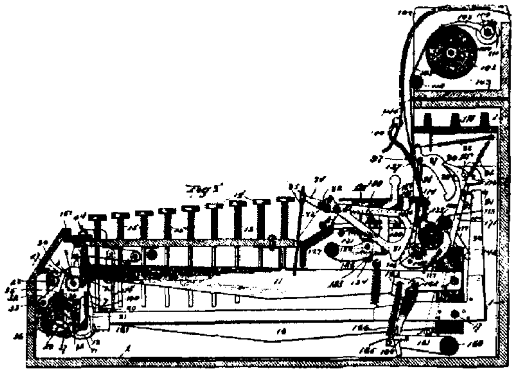


Figure 80
Cross section of the above machine.

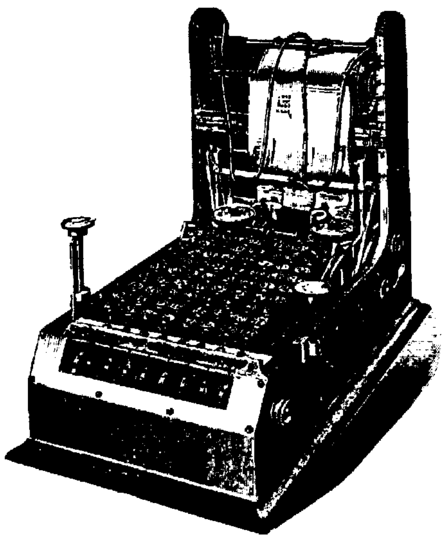


Figure 81
Later model.

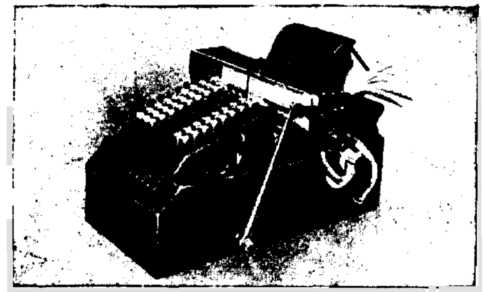


Figure 82
Improved machine

correcting keys and complementary figures for subtraction, wide carriage and, if desired, with paper rolls in whatever width is required. The Comptograph automatically indicates when the bottom margin of the paper has almost been reached. In this case it prevents the crank from being turned. It is thus impossible to print near the lower edge of the sheet, or to have the paper fall out. The paper lock operates in the same way with rolls of paper. This locking device allows one more number or sum to be printed, but only by pressing a lever. In order to bring the paper back to the beginning for the start of a new column, it is not necessary to roll the paper back by hand, as it is with typewriters. All that is needed is to press the paper return lever. This causes the paper to roll back automatically and at the same.time shifts the carriage one place over to the next column.

Devices for switching off the printing mechanism, for cutting out the last two columns, for dividing the machine into two or three separate printing and adding columns (for example. for dates and amounts, etc.) are all to be found, together with the repeat key, on the right side of the machine. The left hand is, therefore, always free to remain on the manuscript. Total addition is also carried out manually with one movement, so that the left hand is never needed for operating the machine. Row cancellation keys are found underneath the keyboard. The strike of a hammer can be made stronger in order to make a number of carbon copies. It is also possible to do cross addition with this machine. It is available with nine to sixteen places and with either manual or electric drive. The price is $275 to $350 without electric drive, depending on the number of digits. Production has been established for a number of years and spare parts can be obtained through the Comptometer manufacturers.

Manufacturer: The Comptograph Co., Chicago.

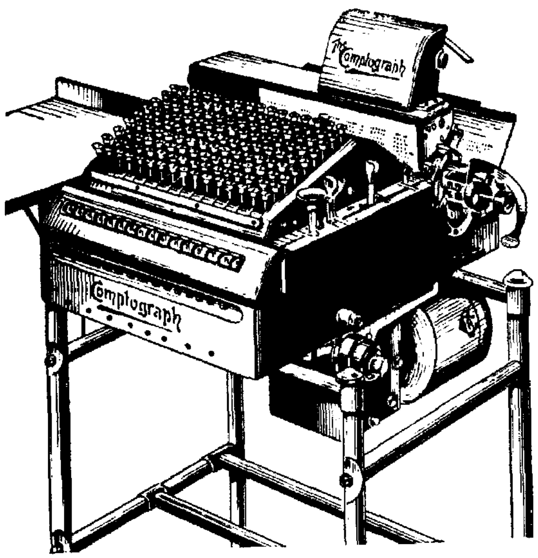


Figure 83

Cuhel (1890)

The designer was Dr. Franz Cuhel of Prague. The machine has eight places in the result mechanism and four places in the setting mechanism. It has thirty-six keys (nine keys repeated four times) in two long rows. It had no importance in the development of calculating machine technology.

Orlin (1892)

An automatic-screw adding and subtracting machine without keys. which never advanced beyond the experimental stage.

Esser (1892)

Setting occurs by using gears with a variable number of teeth. The designer was Heinrich Esser of Aachen. An example may be found in the Calculating Machine Museum of Grimme, Natalis and Company of Braunschweig.[62]

62. Now located in the Braunschweigisches Landesmuseum, Braunschweig

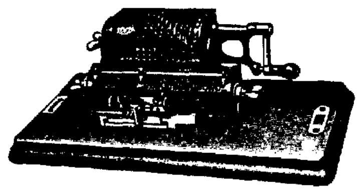


Figure 84
Model M.

Brunsviga (1892)

In 1892 the firm Grimme, Natalis and Company **A.G.** of Braunschweig acquired the current patents of the original Odhner pinwheel machine, which it manufactured in an improved form and sold under the name Brunsviga until about 1900. Since then the company has placed a number of new models on the market that embody basic improvements. The engineer S. Trinks is regarded as the originator of these improvements, and because of his calculating machine inventions he was appointed Doctor-Engineer Honoris Causa by the Technische Hochschule of Braunschweig. At the present time the following models of the Brunsviga (Trinks System) may be found on the market.

Model B: This machine is the oldest type and, in external appearance, approaches the original Odhner type closer than any of the other models. However, there are basic differences that make it superior to the Odhner machine. This model has nine places in the setting mechanism, thirteen places in the result mechanism, and eight places in the revolution counter. It is provided with white and red figures in the revolution counter mechanism and possesses all safeguards against misoperation.

Model M: This machine has all the features of model B, but it has the advantage of being extraordinarily small. Its leather case included, its dimensions are 26 × 15 × 12 cm and thus it may be taken along on trips. Like all models of the Brunsviga (Trinks System), it is furnished with an automatic carriage, which is an arrangement that makes it possible to shift the carriage to the left or right by pushing a bar. Apart from this device, the carriage may be shifted by any number of places without any special manipulations.

Model MD: This is similar to model M. It has twelve setting levers and twenty places in the result mechanism, with a tens-carry that goes right through to the last place. It has twelve places in the revolution counter.

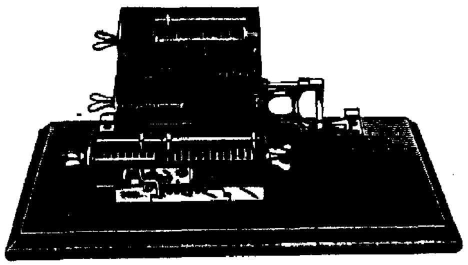


Figure 85
Model MH

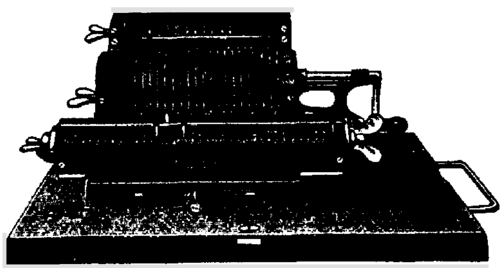


Figure 86
Model MJR

Model MH: The features of this machine resemble those of model M, but it has, in addition, a second revolution counter with a tens-carry mechanism to the last place. This machine allows one to very simply perform continuous multiplication calculations and simultaneous addition of the individual factors.

Model MJR: This machine has nine setting levers, fifteen places in the result mechanism, and ten places in the revolution counter. This model differs from the other types insofar as the entered value may. at any time during the whole calculating operation, be clearly and conveniently read from special windows. The revolution counter has tens-carry through to the last place. The addition and subtraction results appear in the revolution counter in white or red figures, respectively, without any reversing being necessary. The setting levers are longer than usual and remain stationary during calculation. This affords the operator an additional opportunity for continuous control.

Trinks Triplex R: This model has twenty setting levers, twenty places in the

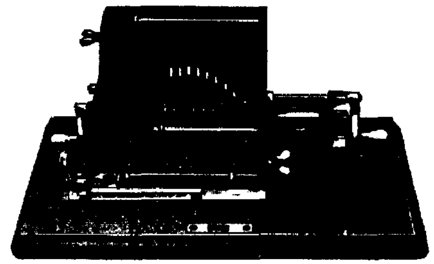


Figure 86a
Trinks—Triplex.

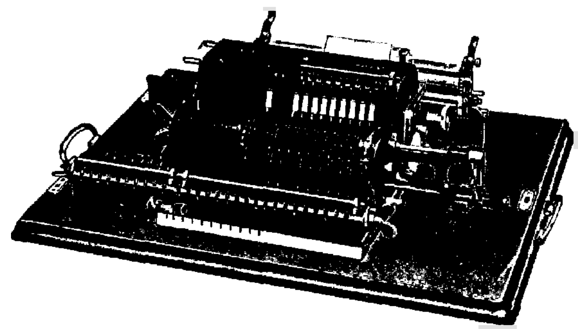


Figure 87
Trinks Arithmotype.

result mechanism, and twelve places in each of the two revolution counters. The Triplex R model has the efficiency of three calculating machines. Just as in model MH, the second revolution counter has a tens-carry that continues through to the last place; the other revolution counter acts in the usual manner. Red and white figures appear in the revolution counter without any reversing operation, just as in all R-type models, the reversing mechanisms being protected by patents. The advantages of this machine are enhanced by an arrangement that enables the result mechanism to be used as one unit or as two separate parts—each being capable of having a self-sufficient tens-carry and clearance. The Triplex R is popular wherever large numbers are involved in calculations; it is practically indispensable for scientific computations.

Trinks-Arithmotype: This machine possesses all the features and devices described further in connection with models J and N. In addition, the machine has a printing mechanism that allows it to perform all four kinds of calculations and simultaneously print the result of the operation. The printing mechanism may be connected or disconnected as desired, so it may be used without the printing mechanism just like a machine model J or N. The Trinks-Arithmotype is the first machine that prints for all types of calculation.

The following models are no longer in production:

Model A: The model A has all the features of model **B,** but it possesses eighteen places in the result mechanism. It is provided with either nine or twelve setting levers and has ten or twelve places in the revolution counter.

Model MA: The model MA has the same features as the model A but. like the model M, it is reduced to the smallest possible dimensions.

Model J: Instead of short setting levers, this machine is provided with long setting levers with convenient handles that may be grasped by two fingers and adjusted in an extremely convenient manner. The entered value appears in the special windows. All digit rows are arranged below one another, so that the operator may survey and check all functions of the machine at a glance. The setting levers are locked as long as the crank is released for. or in the process of, rotation; thus. the setting levers do not participate in the rotation.

Model MJ: This model has the same features as the model J, but it has been reduced to the minimum dimensions.

Model N: In its features this machine **is** almost identical with model J, but it has a particular feature that enables it to simultaneously and automatically transmit, by operation **of** the clearing device, the value from the result mechanism into the setting mechanism. **As** a byproduct of this arrangement, values also may be introduced directly into the result mechanism by the setting levers without operation of the crank. In this model the revolution counter is not located above the setting levers, as in model J, but on the left side of the carriage. The revolution counter has red and white digits, and the digits are smaller than those of the result mechanism, which avoids errors and confusion in reading. This model was provided with eighteen places in the result mechanism.

Model MDII: This is also called the Trinks-Triplex. This machine **is** no larger than model MD, yet it has twenty setting levers—that is, it has two groups of setting levers, one with twelve levers and the other with eight levers. Additionally the machine has twenty places in the result mechanism and twelve places in the revolution counter. The result mechanism has tens-carry to the twentieth place. The tens-carry mechanism is capable of interruption: thus, the twenty setting levers and the twenty places in the result mechanism may be used jointly as an undivided unit or as **two** separate mechanisms. Two multiplications may be performed simultaneously on the machine or the machine may show individual products and, at the same time, the sum **of** the products. Moreover the machine may be used **for** multiplication and simultaneous division of large numbers. The numbers in the result mechanism may all be set to **zero** by a single turn of the winged clearing handle, or they may be set to zero separately if desired—that is, the whole row of numbers may be cleared all at once, or only either the left or right half of the numbers in the result mechanism may be cleared.

In France the Brunsviga was originally sold under the name Rapide, and the miniature models at one time bore the name Brunsvigula.

Burroughs (1892)

William Seward Burroughs was the designer of **this** machine, likely the most important of all the printing full-keyboard adding machines. He was born 28 January 1857, the son of a mechanic, in Rochester. He attended primary school in Auburn and was then employed in a branch of a bank there. In 1882 he moved to St. Louis where he found a position in a machine shop. There he became familiar with the Baldwin Calculating Machine and, from 1880 **on,** occupied himself with the idea of building an adding machine. Later he worked on his model of an adding machine in the workshop of Joseph Boyer in St. Louis. **He** completed the model in **1884,** and his first patent was granted on **21** August 1888. This was a machine that printed only the final sums, not the individual items. Nonetheless, in principle it otherwise already resembled the machines of the present day. On the same day, however, he was also granted a patent on a later application, according to which individual items could also be printed. The first fully functional Burroughs model is based on a patent granted on **5** May 1892, and it was during that year that the first large-scale production was undertaken. The inventor's health had suffered badly during the many long years of failure. His money often ran out, and he had to interrupt his work to earn money in other ways. He died prematurely on 14 September **1898** without ever having seen the great success **of** his invention.

In **1888,** the American Arithmometer Company was founded in St. Louis. They were to take care of sales, while the manufacturing of the machines was carried out by the Boyer Machine Company. Later, however, the first firm took over production as well. In 1904 the factory shifted to Detroit, and in 1905 the name was changed to the Burroughs Adding Machine Company. This company still manufactures the machine today and has branches in Windsor (Ontario) and Nottingham (England). It is the largest firm in the world for the production of printing adding machines.

Today, the Burroughs is manufactured in three designs:

Class I machines with one calculating mechanism (1892).

Class 2 machines with two calculating mechanisms (1910).

Class 6 machines with one calculating mechanism and direct subtraction.

Other classes carry the Burroughs name but were not designed by William Seward Burroughs:

Class 3 is the earlier Pike machine.

Class 4 is also a visible typing machine with special multiplication device.

Class 5 is the nontyping Burroughs Calculator (very similar to the Comptometer).

Class 7, the Moon-Hopkins, is a calculating typewriter manufactured previously by the Moon-Hopkins Company.

The last two machines will be described in detail later.

Class I, 2, and 6 machines are known as the blind printing type because the operator cannot see the printed results without checking behind the machine. The interior mechanism has already been explained in the introduction. In these models, the carriage is attached behind the machine. It is designed to be folded back so that the printed work can be examined. Figure 10 shows this sort of machine with a hand crank. Class 2 machines have two calculating mechanisms. If the crank on the left of the keyboard is pushed up, then the items in the upper calculating mechanism are added and printed. On the other hand, if it is set on the lower calculating mechanism, then the items in the lower calculating mechanism are added and printed.

Class 3 machines are equipped with the following auxiliary keys:

Total key: all sums are indicated with a star, and at the same time the calculating mechanism is set on zero.

Subtotal key: all subtotals are indicated by an S.

Nonadd key: all amounts not added are specially marked

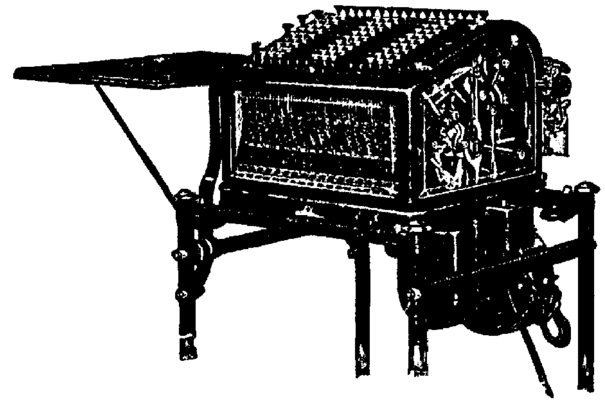


Figure 88

Keys for correcting single columns on the keyboard:

Correction key: when this is pressed, all the keys that have been pressed down return to their normal position,

Repeat key: this is particularly useful for multiplication and division.

The following devices can be attached on request; in certain models they are part of the machine:

Dividing devices: mechanisms that can divide the machine at any row of keys.

Movable paper carriage: this is for 31-cm or 45-cm wide paper.

Semiautomatic jump carriage: for 31-cm wide paper with adjustable tabulator stops.

Automatic jump carriage: for 31-cm wide paper.

Electrically driven carriage return: for setting up the carnage at the point of printing of the first item.

Platen dividing device: Enables the 31-cm wide carriage to be divided into two sections 9 and 22 cm wide so that it can then type two forms next to one another. The platen can also be used undivided.

Date printing and numbering device: The last two or three rows of keys can be separated and used as an item counter or for writing the date. There is a special lever on the keyboard for controlling this area. If this is put on the mark labeled item counter, then the items are continuously numbered, the sum typed, and the number of items simultaneously printed. If the lever is shifted to date, then the machine prints the dates, which are not, however, added when the sums are printed.

Fractions: (eighths, twelfths, or sixteenths).

Form feeder and ejector.

Electric drive.

Carry-over key (only on Class *2* machines): when this key **is** pressed, it transfers an amount from the second to the first calculating mechanism and also sets the second calculating mechanism to zero.

Printing device: Special rows of keys with symbols for months, days of the month, as well as the designations debit, credit. and balance.

If you consider that the Burroughs **is** available today with nine, eleven, and seventeen places, then you can imagine how many different models can be created and how versatile the machine is. At one time the machine was also available with nine, eleven, thirteen, fifteen, and seventeen places.

An Example of the Use of the Machine in a Business Office

The account sheet is fed into the automatic jump carriage, and a special device quickly brings it up to the required height for typing. The old balance is typed. When the electric key is pressed, the carriage, together with the account sheet, jumps into the column for the date and receipt number. The date **is** automatically typed and can be repeated **as** often as is necessary. The entry symbol (corresponding to that used in the account or journal) is typed in abbreviated form. When the receipt number has been typed, the carriage moves into the debit column, where the debit is automatically subtracted. The machine is automatically set on addition when the carriage moves into the credit column. There the credit is automatically added, and the machine then moves on to the new balance column. Here the new balance is automatically calculated and typed without any effort on the part of the bookkeeper. The account sheet is ejected just as quickly as it was fed in. At the end of the workday, the machine supplies a check of the entries that have been made by demonstrating that the difference between the old and new balances is the same as the difference between the net total of debits and credits. Except for the fact that the amounts that are to be entered must be typed, and the electric key must be pressed. the machine operates automatically throughout.

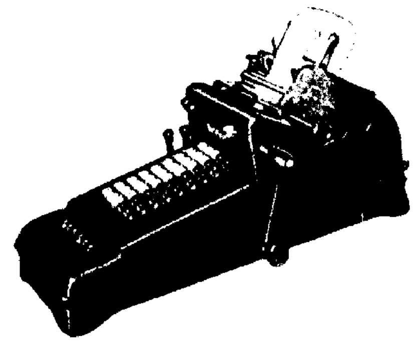


Figure 89

Such a mechanical entry of accounts offers a number of advantages over the old handwritten method. The main ones are:

1. A quick check of all entries made during the day. This assures that the old balance was brought forward correctly, that not only were all the items entered but they were entered correctly, and, finally, that the credits and debits of the individual items have been done on the right account.
2. Automatic daily raw balance.
3. Automatic calculation and typing of the new balance on each account.
4. Automatic warning signal that shows when an account has been overdrawn; the overdrawn account is automatically calculated, typed, and specially marked—all simultaneously.
5. All balanced accounts are specially marked.
6. The date of each entry is automatically typed and repeated.
7. The statements of accounts are typed and checked daily, which means that the counter account books do not have to be brought into line each month.

Some class 1 and *2* machines are supplied with hand or electric drive and some only with electric drive and either eight, eleven, **or** seventeen decimal places. Prices for these range between $325 and $910.

Class *3* machines were manufactured to meet the demand for cheaper, visible typing, full-keyboard machines (see figure **89).** The total, subtotal, and nonaddition keys print the same symbols as do the class 1, **2,** and *6* machines. These machines also have repeat and nonadd keys, while the total key serves at the same time as a correction key. Some of the models of this class are supplied with a two-colored ribbon and can be divided so that it is possible to add and print two columns at once. They are also available with a date printing device. Those machines that use only roll paper have a fixed carriage. On the other hand, they can also have a movable carriage for monthly statements as well as a wide carriage that is also movable. The movable carriages are equipped with tabulator stops, although they must be manually raised each time; that is, the machines have no automatic or only semiautomatic carriages, and it is not possible to attach an electrically driven carriage return as it is in the machines of the major classes. The amount stored each time in the calculating mechanism can be read from the viewing windows underneath the keyboard. Most machines of this class have self-correcting keys. Certain models can be supplied with electric drive, others with forms feeder and ejector. There are machines available with fractions (eighths and twelfths) and they are made with five, seven, nine, or ten columns of keys. Prices range from $125 to $375. Electric drive, like any other special extra, results in an additional charge.

Class 4 machines resemble those of class 3. They also print visibly and have result viewing windows under the keyboard, the same auxiliary keys. and a two-colored ribbon. They are available with both electric and manual drive and also have a device with which it is possible to move the multiplicand from right to left or from left to right, which certainly makes the multiplication easier. This machine is only made with ten digit places and costs $425 (at one time it was also available with nine places).

Shohe Tanaka (1893)

A single-column adding machine with only five keys. Values above five were set by depressing three and three, three and four, four and four, or four and five. Shortly afterward the same designer made a similar single-column adding machine with nine keys. It seems that none of them was ever put into production. The designer was Dr. Shohe Tanaka from Awadji, Japan, who was staying in Berlin at the time.

Rapid Computer Adding Machine (1893)

The manufacturers were the Rapid Computer Adding Machine Company in Benton Harbor, Michigan, which was a branch of the Baker-Vawter Company. This machine will be described in detail under the name Comptator.

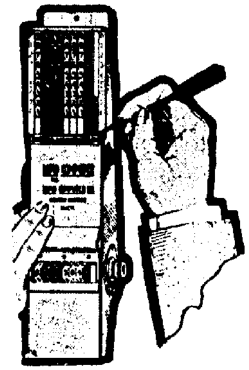


Figure *90*
Rapid Computer.

Millionaire (1893)

This machine is intended for the performance of all simple and composite problems of calculation that can be solved by the application of the four operations: addition, subtraction, multiplication, and division. The main advantage of the Millionaire calculating machine, as against all other types of calculating machines, is the astounding speed with which it operates, especially while doing multiplication and division.

Each place of the multiplier or quotient requires only a single turn of the crank, during which the necessary displacement of the result occurs automatically. From the outside the machine possesses the following parts (figure 91): the reversing lever *U*, by means of which the machine may be set for the different types of calculation; the hand crank ***K;*** the multiplication lever ***H;*** the setting board with the setting slides e-e; and the corresponding row e'-e'; for checking. The register mechanism has the following parts: the row of numeral dials *g-g* for the results; the row of numeral dials *f-f* for checking the positions of lever H; the mechanisms ***R*** and *C* for returning these numeral dials to their zero positions; and the knob *W*, by means of which the register mechanism may be shifted.

The Millionaire machine is to be regarded as a proper multiplication machine in that it solves problems of multiplication directly on the basis of the multiplication table, whereas other types of calculating machines are only adding machines and, as such, carry out multiplication by a continued series of additions (exceptions are the machine by Bollée, of which only a very few

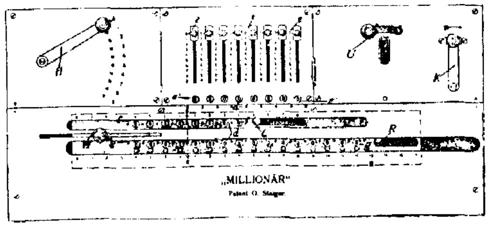


Figure 91

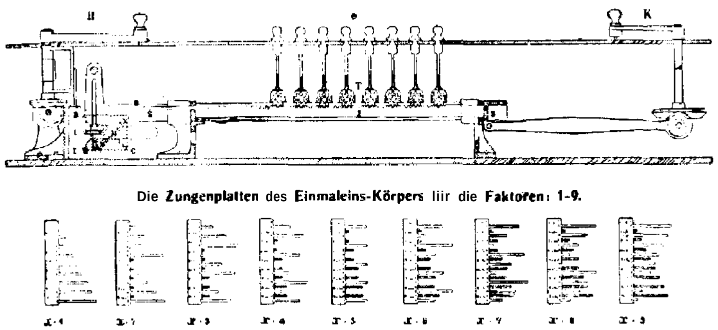


Figure 92/93

were ever produced, the Moon-Hopkins machine, and the Kuhrt U.S. machine). (Subtractions and divisions may be regarded as additions and multiplications in a negative sense; therefore, we shall not make any special mention of them from this point on.)

It is obvious that a multiplication machine that only employs the multiplier digit 1 corresponds to a pure adding machine.

Three main mechanisms may be distinguished in the Millionaire (figures 92, 93, and 94): (1) the multiplication mechanism, (2) the transmission mechanism, and *(3)* the register mechanism, which in turn is divided into two sections, one of which (*g-g*) is essential and registers the product, whereas the second one (*f-f*) is in fact only a matter of convenience in that it registers the multiplier and is not absolutely necessary in the actual multiplication machine.

The multiplication mechanism consists of the so-called multiplication table body[63] and its setting device that permits it to move **(1)** in vertical direction,

63. There does not appear to be any generally accepted English phrase for this device. Martin originally used *Einmaleinskörper* so we have simply accepted a close translation.

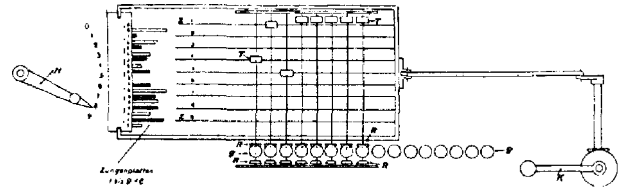


Figure 94

(2) in horizontal-longitudinal direction, and (3) in horizontal-transverse direction. The multiplication body, which is the essence **of** the multiplication machine, consists of nine toothed plates (figure 93), the first of which contains the product of 1–9 times the digit 1, the second contains the product of 1–9 times the digit 2, and so on; the ninth plate contains the product 1–9 times the digit 9 so that the entire multiplication table is represented. Every one of these products is expressed by two elements (teeth) each, one of which represents the tens value (cross-hatched) and the other represents the units value of the product in question. The length of the tooth corresponds to the value it represents. All the tens values of a toothed plate form a group and so do all units values, and these groups act successively upon the transmission and register mechanisms. **A** review of figure 93 shows every individual product; thus, for the factor **6** we have on plate 7 four tens and two units, which is the product $7 \times 6 = 42$.

The transfer mechanism consists of (a) nine parallel racks **Z**, and (b) the shafts positioned transversely across these racks. Along these shafts the setting wheels *T*, may be shifted in the customary manner by means of the knobs on the setting board and may thus be brought into mesh with any one of the nine racks, depending upon the value of the respective place of the multiplicand.

On each of these shafts is also mounted a pair of bevel gears *R*, which are shiftable in their axial direction. The bevel gears transmit the rotation **of** the drive gears *T*, which corresponds to the longitudinal movement of the racks onto the register mechanism in a positive sense in case of multiplication and in a negative sense in case of division. Appropriate shifting mechanisms move these bevel gears periodically into and out of mesh with the register mechanism so that only the forward movement of the racks is transmitted while the return movement of the racks has no effect upon the register mechanism. The ends of the racks are either opposite the tens **group** or the units group of the teeth of a multiplication plate. The alternation **of** the groups is effected by a small, horizontal, transverse shift of the multiplication body, whereas the set-

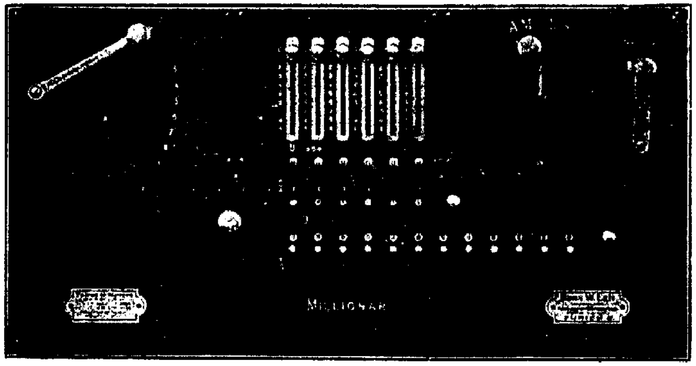


Figure 95
Millionaire with slide setting

ting of the various plates occurs by shifting the lever H along a scale. For each rotation of the hand crank ***K***, that is, when multiplying with any single-digit factor, the racks are first advanced according to the tens values and are advanced a second time according to the units values. Since the tens and units values in the multiplication body are made up of the same length units, it is necessary that, after transmission of the tens value, the register mechanism be shifted one place to the left, which occurs automatically so that the units values are registered one place to the right next to their respective tens.

This explains the essence of the calculating machine. To facilitate understanding, the method of operation will be explained with the aid of an example. Let us, for instance, multiply 516 by 8. For this purpose the first setting slide *e* (counted from the left) is shifted on the cover plate to position drive gear *T* above rack **5**, the second setting slide *e* is shifted to position drive gear *T* above rack 1, and the third setting slide *e* is shifted to position drive gear T above rack 6. The multiplier is entered by shifting the lever *H* to the respective digit of the scale, with the result that the multiplication plate ***X*** x 8 is placed opposite the ends of the racks. During a revolution of the hand crank K, the multiplication body is pushed twice against the racks Z, and these racks are pushed forward an amount corresponding to the tens and units values of the products of 1–9 × 8. Transmission to the register mechanism occurs, of course, only from those racks above which drive gears T have been set. In the present case, therefore, the racks 5, 1, and 6 transmit the products **5** × 8 = 40, **1** × 8 = 08, **6** x 8 = 48 in such a manner that

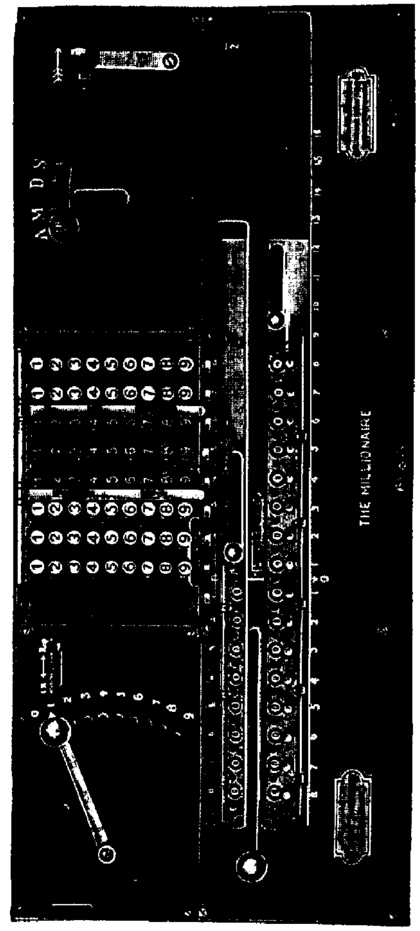


Figure 96
Key-set Millionaire.

the apparatus registers first the tens 4, **0,** and 4; after displacement of the tens by one place to the left, the units 0, **8,** and 8 are added on to obtain the product **4,128** as in:

4	0	4	
	0	8	8
4	1	2	8

Transfer of a ten resulting from the addition **of** the individual products is taken care of by the register mechanism during the idle return movement of the racks. For each rotation of a dial of the main register mechanism beyond 0 or 10 respectively. whether in a positive or a negative sense, **+1** is to be added *to* the next digit to the left. Such rotation pushes a so-called tens transporter out of its normal position (preparation) and engages it, by corresponding motive mechanisms, with the next dial to the left at the proper moment so as to carry over the ten in question.

The following synopsis shows the sequence of the various functions of the calculating machine during one rotation of the hand crank:

Rotation of Crank K from 0° to 360°

0°–90°: Coupling of the bevel gears **of** the transmission mechanism with the register mechanism. Transfer of the tens values and preparation for carrying tens resulting from the addition of the new item to the previously registered amount.

90°–100°: Uncoupling of the bevel gears from the register mechanism. Idle return **of** the **racks,** displacement of the register mechanism to the left. Transfer of the tens carried from the previous addition.

180°–270°: Coupling of the bevel gears with the register mechanism. Transverse displacement of the multiplication body. Transmission of the unit values and preparation for carrying tens resulting from the addition.

270°–360°: Uncoupling of the bevel gears from the register mechanism. Idle return of the racks and transfer of the tens carried from the previous addition. Transverse displacement of the multiplication body into its initial position.

Models

6 x 6 x 12 places with slide setting and hand operation

6 x 6 x 12 places with keyboard and hand operation

8 x 8 x 16 places with slide setting and hand operation

8 x 8 x 16 places with keyboard and hand operation

8 x 8 x 16 places with slide setting and electrical drive

8 x 8 × 16 places with keyboard and electrical drive

8 x 8 x 16 places with double counting mechanism, keyboard, hand operation, and, stand

8 x 8 × 16 places with double counting mechanism, keyboard, electrical drive, and stand

10 x 10 × 20 places with slide setting and hand operation

10 × 10 × 20 places with keyboard and hand operation

10 × 10 × 20 places with slide setting and electrical drive

10 x 10 × **20** places with keyboard and electrical drive

12 × 8 × **20** places with keyboard and electrical drive

Designer: Otto Steiger (deceased) of St. Gallen, manufacturer: H. W. Egli, A. G., Zurich 2.

Monopol-Duplex (1894)

This machine developed from a construction by W. Kuttner in Burgk. Later the production passed into the hands of Woldemar Heinitz of Dresden and still later to the Dresden Control Cash and Calculating Machine Factory, **A.** G. in Dresden. In 1904 the production passed to the Bicycle Works Salzer and Company, G.m.b.H., the present name of this firm being Schubert and Salzer **A.** G. of Chemnitz.

The Monopol-Duplex machine was the first pinwheel machine that possessed tens-carry in the revolution counter, thus for the first time ensuring appearance of the correct value in the revolution counter not only in ordinary but also in shortcut multiplications and divisions.

In this machine the carriage is located above the setting mechanism, and the crank is positioned on the left side. Originally it was manufactured with 8 x 16 x 8 places and later with 6 × 12 × 7 places. The price **of** the machine was 460 marks. Production has been discontinued since 1914.

At some time Woldemar Heinitz produced an adding machine that printed the items and the totals. Depression **of** the keys sets the amount, but transmission into the counting mechanism and printing occurred by movement of the crank or by pressure upon the motor key. The machine appeared in different models, but production has long been discontinued.

Saxonia (1895)

This machine emerged indirectly from the Burkhardt Arithmometer; the owners of the Saxonia firm, Schumann and Company (Zeibig and Strassberger), had fonnerly been employed by Burkhardt for many years. It is therefore understandable that their product was rather similar to Burkhardt's. Figure I shows the machine in its original form having six setting slides, twelve places in the result machanism, and seven places in the revolution counter; it also has the customary setting screws below the windows. ***R*** designates a somewhat complicated and time-consuming wheel clearance that was customary at the time and had previously been employed in other stepped drum machines. Since 1901 it has been replaced by the instantaneous clearance that is now generally in use.

Figure 97 shows a later model of the machine with venetian-blind locks and collapsible side walls. This model generally agrees with the other stepped drum machines. but instead of the customary setting slides we find small levers, movable in circular arcs with easily read checking digits arranged in a straight line positioned above the levers. The setting mechanism is dust proof. Two instantaneous clearing devices are provided on the right end of the carriage, and the setting levers may also be returned to zero by an instantaneous clearance device.

Figure 98 shows another model that appeared somewhat later. This model was available in the following four sizes:

Setting mechanism	Result mechanism	Revolution counter	Weight
8 places	13 places	7 places	7.1 kg
8 places	16 places	9 places	7.5 kg
10 places	16 places	9 places	8.4 kg
10 places	20 places	11 places	9.0 kg

Production of this model has been discontinued.

Today's product is illustrated in figure 99. The early slide or rotatable lever-setting mechanism has been replaced by a keyboard. The machine comes in a black enameled aluminum casing with handles, and protective sheet metal box is supplied. Carriage and clearance devices remain the same as in the earlier model. The machine has eight columns of keys. **A** large, easily readable checking digit may be found above each column of keys, All keys may

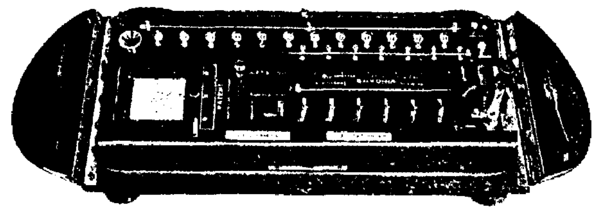


Figure 97
Saxonia.

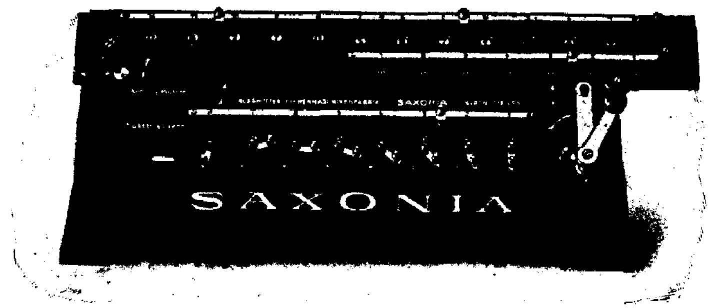


Figure 98

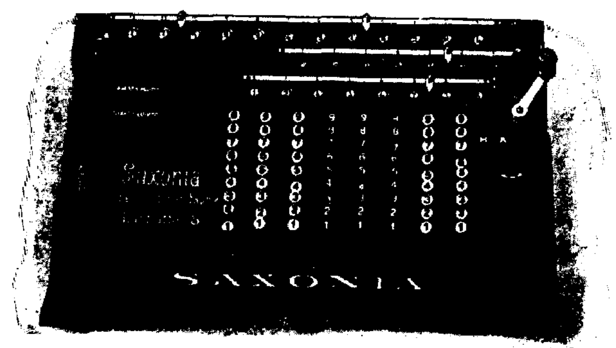


Figure 99

be set to zero by a single key on the right side of the keyboard. Every column of keys may be individually set to zero by a key located at the bottom of the keyboard. Columns of keys are colored in groups, which matenally facilitates operation. Key reversing is secured by a positive locking mechanism and the same is true for the tens-carry mechanism. This keyboard machine excels all stepped drum machines having setting slides, particularly in cases in which relatively large additions are to be carried out, because the keys may be automatically cleared by means of a lever positioned at the right side of the keyboard. At the present time this model is furnished in the following four sizes:

Setting mechanism	Result mechanism	Revolution counter	Weight
9 places	13 places	7 places	10.4 kg
9 places	16 places	9 places	10.7 kg
10 places	16 places	9 places	10.5 kg
10 places	20 places	11 places	11.5 kg

It has an improved tens-carry warning device through to the last position of the carriage. In 1920 the Saxonia factory was merged with that of the Burkhardt Arithniometer. The firm that produces the machine at the present time is Vereinigte Glashutter Rechenmaschinen-Fabriken, Tachometer and Fenmechanische Werke, Glashutte Saxony.

Runge (1896)

This is an adding machine with only two rows of keys. The numbers to be entered could be classified according to their value by means of an indicator device, that is, as units, tens, hundreds, and so on up to nine decimal places. The designer was Ed. Runge of Berlin; the machine did not advance beyond the experimental stage although it permitted the entering of totals.

A. T. Ashwell (1897)

This keyed printing adding machine is based on German patents 102935 and 103099. It has (after Mehmke) obviously made use of a design from typewriters that allows one piece of paper to be printed with parallel rows of

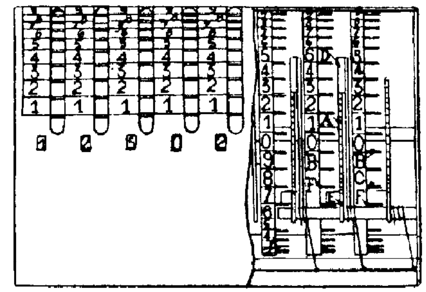


Figure 100

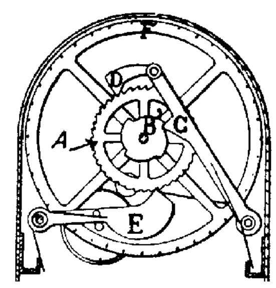


Figure 101

numerical columns without being removed from the machine. When a preset number of rows have been printed, a bell sounds.

Fossa-Mancini (1900)

This is an eight-place adding machine with stylus setting. The individual numeral wheels are printed with four groups of the digits 0 to 9. Entering of the individual values occurs in the usual way by pulling down the respective numeral wheels of the number to be added until encountering a positive stop. The respective sums of the entered values appear in windows in front of the machine. The last numeral wheel to the left causes a bell to sound with every quarter revolution as a sign that the capacity of the machine has been exceeded.

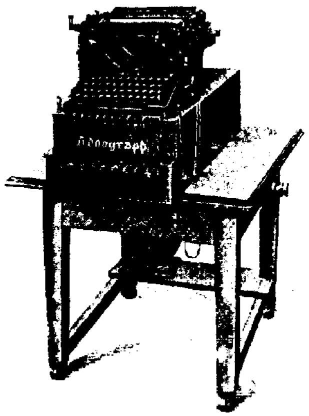


Figure 102

Addograph (1900)

A machine was brought out under this name that can transform every typewriter into a writing adding machine or an adding typewriter. It is only necessary to place the machine under the typewriter and, as soon as the numerical keys of the typewriter are used, place the adding mechanism in action. At any time the Addograph is capable of showing the result of the addition of the series of numbers entered on the typewriter. The device can also be used independently of the typewriter and, for this purpose, is easily separated from it. Of course, once separated, the entered numbers will no longer print. The apparatus cost $100 and was produced by the Addograph Co., 71 Broadway, New York. The inventor is B. M. des Jardins of Hartford, Connecticut. The Addograph was also sold out of Berlin in 1908. It never attained great significance either with us or in America, and production has long been discontinued.

Mechanical Accountant (1900)

This is an adding and subtracting machine that resembles, in appearance, the Mercantile machine but has a result mechanism and checking windows located above it. Both counting mechanisms may successively be set to zero by means of a crank. A bar. located below the lowest row of keys, and extending transversely over the whole width of the machine. serves for clearing the

lower counting mechanism, which is used as the result mechanism. The machine calculates directly, thus it is not necessary to transmit the entered amount into the result mechanism by rotation of a crank. The original model (Simplex Model) was arranged only for operation with columns, that is, several keys could be depressed simultaneously only if none of the key depressions had to accomplish a tens-carry, otherwise the tens-carry would have been lost. The Simplex model was made in two forms: one with only five keys per column, and one with nine keys per column. Machines having only five keys were based on the theory, which was tested in Germany, that it is easier to depress two keys having a small descent than one key having a large descent. Later the so-called Duplex machines appeared on the market; on these it was possible to depress several keys at the same time because the tens-carry took place sequentially. This Duplex model is made with five and nine keys per column, but it has no setting checking windows. Clearance of the result takes place by a small crank. Today the five-key design is supplied in the following models: 6 × 6 places, $125.00; 8 × 9 places, $150.00; 10 × 11 places, $175.00; and 12 × 13 places, $200.00. The nine-key design is supplied in the following models: 9 × 10 places, $175.00; 11 × 12 places, $200.00; and 13 × 14 places. $250.00.

The designer is J. A. V. Turck; manufacturers are the Mechanical Accounting Company in Providence, Rhode Island. A few machines reached Europe.

Berolina (1901)

The Berolina is one of the oldest pinwheel machines, and its main parts have been described in the introduction. Originally it was manufactured by Ernst Schuster of Berlin, SW. 68, 87 Charlotte Street. In 1923 the manufacture transferred to the German-American Metalware Manufacturing and Trading Company in Berlin, S. 42,51 Oranien Street, which marketed the machine, under Schuster's management, under the name of Damhag. After dissolution of this company, in 1924 Ernst Schuster again took over production and sales, and today his office is in Berlin, W. 57.3 Bülow Street.

The machine has nine setting levers, thirteen places in the result mechanism, and eight places in the revolution counter. The many confusing digits on the cover plate have been omitted. Carriage shift from place to place occurs by rotation of the crank. Distinctiveness and comprehensive view of the digits are the distinguishing features of the machine. The digits of the two counting mechanisms are positioned directly on the surface. A double zero-

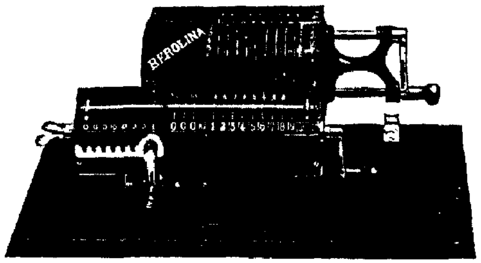


Figure 103

setting device enables the two counting mechanisms to be returned to zero by a single rotation of the crank. A locking device for the setting levers makes it impossible for the entered values to be accidentally changed, however fast a calculation is performed. A double-acting locking device prevents overthrow of the digits even during fast revolution. The tens-carry is effective to the thirteenth place. Dimensions: 7 × 23 × 40 cm, weight 11.5 kg, price approximately 400 gold marks. This firm also produces the Duplikator machine. This is the Rcrolina machinc with two result mcchanisms and two revolution counters. In this machine two opposite calculations may be simultaneously carried out in the two counting mechanisms; one may add or subtract in both mechanisms or may operate one while disconnecting the other. Thus the machine is especially suited for integral calculus computations. The dimensions of the Duplikator are: 23 × 23 × 40 cm, weight is 14 kg, and the price is approximately 950 gold marks.

Calcumeter (1901)

This machine is very similar to the adding and subtracting machine known as Patent Michel Baum, however it has several disadvantages as compared with Michel Baum's machine. When entering digits larger than five, it is necessary to move the stylus in an arc of over 180 degrees; there are no means for checking whether the item to be added has been correctly entered; the machine does not have automatic clearance of all the windows, thus every dial must be individually set to zero; and the windows of the machine are positioned at the left of the digit circles between the digits 7 and 8. The machine was available with six, seven, eight, and nine places. It was manufactured in America and was imported into Germany via Hamburg in I9 12 where it sold for about 100 marks. The number of sales was very small.

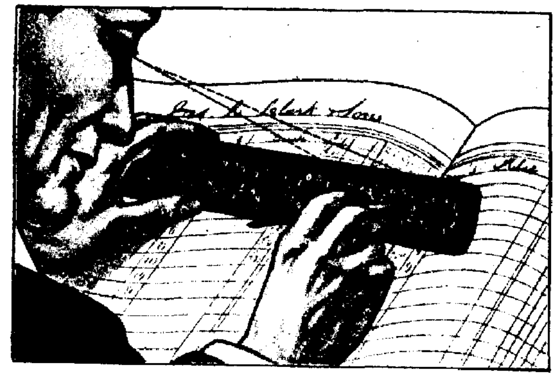


Figure 104

Dalton (1902)

Designer: Hubert Hopkins. Manufacturer: Dalton Adding Machine Company (located at first in Poplar Bluff, Missouri, now in Cincinnati, Ohio).

This is the most important of the printing, ten-key adding machines. By the end of 1906 only six machines had been manufactured, but from January 1907 they were manufactured on a large scale and, since then, have been retailed with ever growing success. From the beginning, the machine has been supplied with a double-row keyboard with 2, 4, 5, 7, and 9 in the upper row and 1, 3, 0, 6, and 8 in the bottom row. The machine is designed so that it is possible to operate it without having to look at the keyboard. Originally. the ribbon had to be moved by means of a lever on the keyboard, but later an automatic ribbon system was installed. On the first machines the side walls were made of glass and only later of metal casing. The older models were equipped with a 10-, 25-, 33-, or 46-cm-wide carriage or sliding carriage with a two-color ribbon, combined total and subtotal key, nonaddition, correction, and nonprinting keys, and dividing devices (so that this machine could print two columns and add simultaneously or else one column could be printed, added, and combined with dates, etc.)

The present so-called super model has been manufactured since the beginning of 1921 in more than 150 designs. This number is even larger if you consider that all models can be equipped with either manual or electric drive and can be completely fitted out according to the wishes of the customer. Generally, they are supplied with nine, eleven, or thirteen places; in the Little

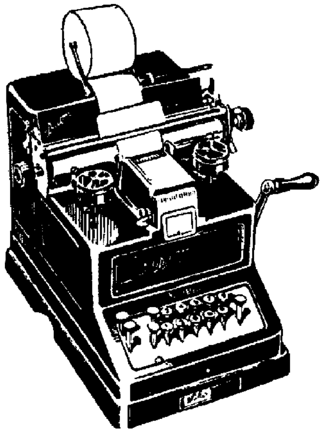


Figure 105

Giant series they are also available with six or seven places. Base, side sections, and casing weigh approximately 4 kg in this model. a considerable reduction from the 13.5kg in the older model. On the other hand, the interior mechanism is more durable since it is made of steel and is protected against rust. To specify all the models here is pointless, for they are mostly tailored for American standards. Nonetheless, the following points should be noted: the nonaddition, return, subtraction, multiplication, and repeat keys are all on the keyboard; the correction key is on the upper left; the nonprinting key is next to the right ribbon spool; the total and subtotal keys are in the front section on the right. Electrically driven machines have an activation key that looks like the spacing key of a typewriter and is also found below the keyboard. The machines are equipped with a sliding carriage for 15-, 25-, 33-, 46-, 61-, or 76-cm-wide paper and can also accommodate rolls of paper of between 5 and 25 cm. Printing is fully visible, in two colors, with automatic ribbon movement. Totals are clearly indicated by an asterisk, nonadded quantities by a ◇, subtotals by *S*, and subtraction items by –. In order to set up subtractions, it is only necessary to use the red complementary digits when entering a number and then press the subtraction key. Subtraction values are not printed. Printing such a value can only be done with the aid of the nonaddition key. All Dalton machines, except for the Little Giant, can be used for addition in two columns; that is, the printing of dates, etc. in the first column and addition in the second.

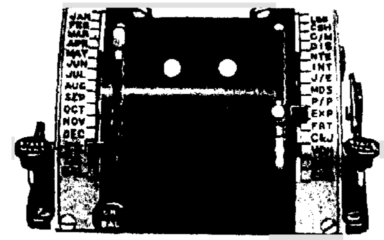


Figure 106
Double printing device

In many work situations, the printing of statements is important. A special printing device attached to the regular printing mechanism is used in this operation. There are single and double printing devices. The single device specifies the months, as well as the credit, debit, and balance of accounts. The double has the same symbols but, according to the wishes of the customer, can be fitted with an additional fifteen symbols—for example, symbols for interest, rebate, weight, currencies, etc. Printing these symbols is done by shifting the setting slide to the appropriate symbol, just like slide setting in the calculating machines, and pressing the printing key. Entering the value to be added is carried out in the usual way.

The basic model, although lacking a word-printing device, has in addition to the devices already mentioned adjustable column tabulators, an injector and ejector, a paper release lever, an item counter with a bell instead of a left hand platen button (so that the bottom of the paper is signaled at the right time), an adjustable paper guide, a carriage release key, a lever for spacing between the lines, and a device that makes it possible to print OR previously drawn lines.

Some of these mechanisms are superfluous for certain purposes and can be omitted. On other occasions, wider carriages are required. Thus a large number of different models are manufactured. The average machine costs $350, has nine-piace capacity, and has a 25-cm carriage.

The motor drive creates a certain uniformity among all the machines. Every Dalton can be driven electrically. All that is required is to switch to the electric motor, connect the electrical circuit, and set the machine up. If electric drive is no longer required, then it is always possible to use the machine manually. This is true of all models. Power on and off takes place automatically. This prevents the possibility of having the motor running **all** night if the operator has forgotten to switch it off in the evening.

The eleven- and thirteen-place machines are equipped with two special additions: general release of all auxiliary keys, which may sometimes be pressed incorrectly (keys on the left of the subtotal key), and a motor release lever on the right side **of** the keyboard. With the aid of this lever, the motor can be disengaged so that the machine can be used with the crank and vice versa. The price of this model (thirteen place, 25-cm carriage) is **$450.** For an extra charge the following can be added: a device for continual multiplication, which prevents changes being made to the set multiplicand, and a duplex device. which allows the machine to register and add two columns next to one another.

The next model is a bookkeeping machine. It has, in addition to the devices just mentioned. the word-printing device described earlier, an adjustable paper facility (which means that if the same form is used a second time, in order to record further postings, the new digits can be brought directly under the previous ones). The machine also has an automatically advancing carriage. Tne price for a nine-place. 25-cm carriage machine is **$600**.

Another design is also for use in bookkeeping, primarily in the calculation of the daily balance of all customer accounts. The price for a nine-place, 25-cm carriage machine is **$650.**

There is a special model for monthly statements, which lists and adds up credit items with dates. subtracts debit totals from credit totals, and prints the balance. This machine is fitted with a printing device so that the items can be marked for debit, credit, and balance. Such a machine with nine places and a 25-cm carriage costs **$475.**

The Little Giant is the same Dalton but has no dividing device, no word-printing device, no automatic carriage, and is equipped on request with a two-colored ribbon, a nonprinting key, subtraction key, and nonaddition key. This model is also made with eight and seven places. The price is **$125** and up, depending on the model, i.e., according to carriage width and any specially requested features.

Finally, there is the Dalton combined with a cash register. This model obviously requires the word-printing device to specify the individual items in more detail.

All special machines can also be used as normal adding, subtracting. multiplying. and dividing machines so that they can be in daily use for every sort of activity.

In **1924** the Dalton Multiplex came onto the market. This was different from the rest of the Dalton models in that it subtracted directly and therefore did not need complementary digits. The direct subtracting machine **is,** for the present, supplied in four different designs: the normal manual model, a machine with automatic carriage return, a ledger entry model, and a bank ledger entry model. The machine not only adds and subtracts simultaneously but also adds and multiplies simultaneously.

Adix (1903)

The Adix, manufactured by the Adix Company (Pallweber and Bordt, later Adolf Bordt of Mannheim), is an adding machine with only nine keys. **It** was always supplied in a case. It is constructed **of** steel, aluminum, and brass and is composed of only **122** parts. **Its** weight, including the case, is **250** grams. Its length is 15 cm, its width is **8** cm, and its height is **2** cm, thus it may conveniently be carried in the pocket. The whole mechanism lies exposed so that the operator may clearly see the manner in which the key depression is transmitted to the counting mechanism. Addition occurs by key depression, but the machine does not permit addition **of** whole amounts, it merely permits additions of columns of individual digits to the extent to which they do not exceed a total sum of **999.** If calculation in one column has been completed, the operator makes a note of the last digit and registers the carryover by means of the keys. The machine sold originally for eighteen marks and the later model, which was somewhat improved, for thirty marks (figure 107).

In **1906** the Diera emerged from the Adix. **The** seven shiftable levers, positioned at the right side **of** the keyboard, serve merely for recording the final digits of every added column so that paper and pencil are not required in operating the Diera. Zero setting occurs automatically by depression of a lever. Dimensions: 13 × **26** cm. Weight: **1250** grams. Price: **40** marks.

The Kuli **is** a later improvement (1909). It is sturdier than its predecessors and has large keys such as may be found on typewriters. **It** too serves for adding columns, but after addition of a column it is only necessary to depress a special key to start with the next column **of** digits. The total remains in the machine up to a twelve decimal place result. Depression of a particular key shifts the module with the counting mechanism into the desired higher decimal place. The Kuli may even be used for multiplication, in fact five-digit numbers may be multiplied by six-digit numbers. Multiplication, too, occurs merely by depression of keys. Size: 23-cm wide, 10-cm deep, and 8-cm high.

Figure 107

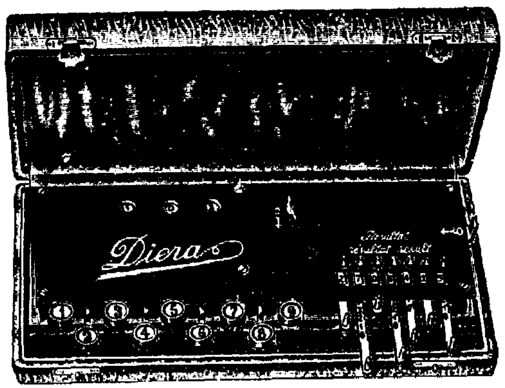


Figure 108

Weight: without case 1300 grams. Price: originally 60 marks, later 75 marks.

The production of the Adix, Diera. and Kuli has long been discontinued. The Bordt adding machine of later date emerged from these machines, and the **Bordt** machine in turn may be termed the predecessor of the Adma machine,

Wales (1903)

From the beginning the Wales was a strong rival of the Burroughs. From the outside it resembles the earlier Universal but has the advantage of visible

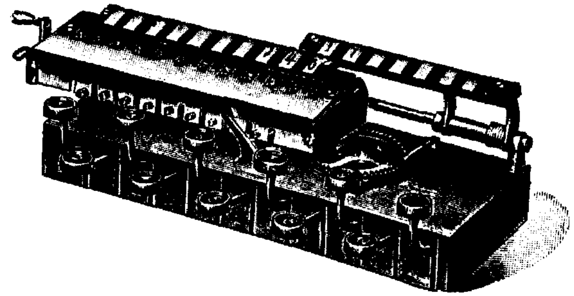


Figure 109
Kuli.

print, something not thought about much with respect to adding machines until lately. In the Wales the results are visible above the keyboard, the value entered is printed by means of the crank, and the keys then spring back to their normal position. Formerly, the Wales was produced in more than forty different models that varied according to carriage width, number of places, and auxiliary keys. Since the end of 1923 only two main types are still being made—large machines and small portable ones. Both types are made with one or two calculating mechanisms. The large machines are supplied with a fixed carriage for paper reels or with a wide, movable carriage for use in bookkeeping (the portable machines only have reels). Generally, both types are supplied with seven and nine places, but large machines are also available with more digits.

The Large Machines

These have a full keyboard with self-correcting keys grouped by color. There are also complementary digits for subtraction. The repeat, subtotal, and total keys are on the left of the keyboard; the correction, nonaddition, and non-printing keys are above the keyboard. The machine is provided with **a** two-colored ribbon. The entire ribbon mechanism can be removed. Zero setting of the calculating mechanism is done by pulling the lever; at the same time the symbol *T* is printed, which is a sign that the machine is reset to zero. The first new item following this one is identified by means of a circle with a dot in the middle, a sign that can only be printed if the machine was initially set at zero. If requested, the machine can be supplied with a carriage for 33-cm or 46-cm-wide paper. The carriage moves sideways **by** pressing on the lever attached to the right side of the platen. The paper reel can be turned up to

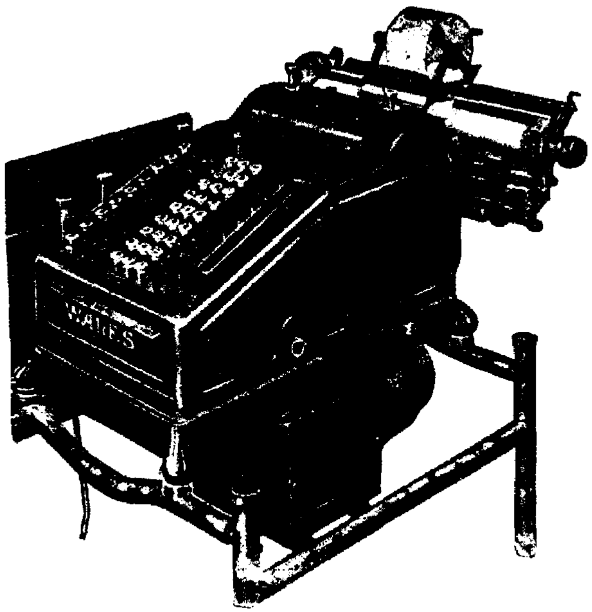


Figure 110

print on wide paper. An automatic item counter is connected to the left platen knob.

Model 20:	**9** places	33-cm-wide paper	$300.00
Model 208:	**9** places	paper rolls	$250.00
Model 25:	**7** places	33-cm-wide paper	$225.00
Model **25B:**	7 places	paper rolls	$175.00
Model 401:	11 places	33-cm-wide paper (with dividing device)	$360.00

For an extra charge. special requirement:, can be met.

The bookkeeping machine largely conforms to the model so far described except that it has two calculating mechanisms that work independently of one another and two corresponding rows of windows. One can be used for debit, the other for credit items; the items of one appear in black, the other in red. To the right **of** both rows of windows **is** a lever for turning the lower or upper calculating mechanism on **or off.** Debit and credit items can be combined and entered into the machine. then both kinds of values are added up respectively.

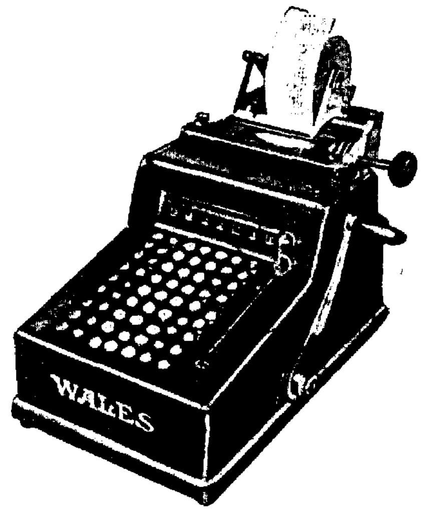


Figure 11I

If the balance is to be made, then the lever on the left **of** the windows is pressed, and at the same time the crank is moved twice; this action prints the balance. **If** the left lever is pulled down, then the debit item is reduced by the credit item. If it is moved up, then the debit value is subtracted from the credit value. Keyboard and calculating mechanisms can be optionally divided between the fifth and the eleventh decimal place ***so*** that two columns can be simultaneously printed side by side. In addition, up to twelve symbol keys can be attached. irrespective **of** the number of places. These symbols are all composed of three letters and are used ***to*** provide annotation to the particular bookkeeping items. The bookkeeping machine has either nine or eleven places and is equipped only with electric drive. For example, an eleven-place machine with dividing device and carriage for 33-cm-wide paper costs $700. **Also** the bookkeeping machines can be adapted according to any individual requirements. Machines are also available for monthly statements, with six or seven places. injector and ejector, dividing device, date and repeat key, letter-printing device, etc. The price for such machines with a hand crank varies from $375 to $510.

Portable Machines

These have been available since 1921. They largely resemble the big machines but weigh less than 14 kg. They are only supplied with a paper roll and a hand crank. Auxiliary keys are on the right side so that the left hand is always free. All portable machines are equipped with two calculating mechanisms, but they do not function the same way as in the big bookkeeping machines. When both calculating mechanisms work simultaneously, items transferred into the first calculating mechanism also appear in the second. If the total of the first calculating mechanism is printed, then the total in the second calculating mechanism is not disturbed.

Model 103:	seven places, one calculating mechanism	$185
Model 105:	seven places, two calculating mechanisms	$235

(There are also six-place machines)

Those machines with two calculating mechanisms have only one row of windows. The portable machines are also supplied with a connecting cash till and are available in both models, i.e., with one or two calculating mechanisms. In these machines, the recording rolls of paper are wound up in the interior of the machine. Nine keys can be attached to the left side of the machine to signify who registered each individual item. The total can only be made by an authorized person. Machines with two calculating devices print on two paper strips, one with particulars on purchases, the other with the total of purchases. The first paper strip, to be given to the customer, can be supplied with whatever specifications one chooses. Items that have been paid for are, with the aid of the nonaddition key, prevented from being carried over into the calculating mechanism. Such machines cost $235 with one calculating mechanism and $285 with two.

Finally, machines are also available with devices for pay envelopes. These print on the pay envelopes while they automatically fill them; at the same time they give out duplicate copies, on a counterfoil, of all work carried out.

Manufacturer: Wales Adding Machine Company, Wilkes-Barre, PA.

Graeber's Arithmometer (1903)

Designer and manufacturer: Joseph Graeber of Vienna, XVIII, Martin Street. Production was discontinued in 1905. It was a stepped drum machine in a wooden case according to the general description given in the introduction. It was available with six, eight, twelve, sixteen, and twenty places in the result mechanism. It had no unusual features.

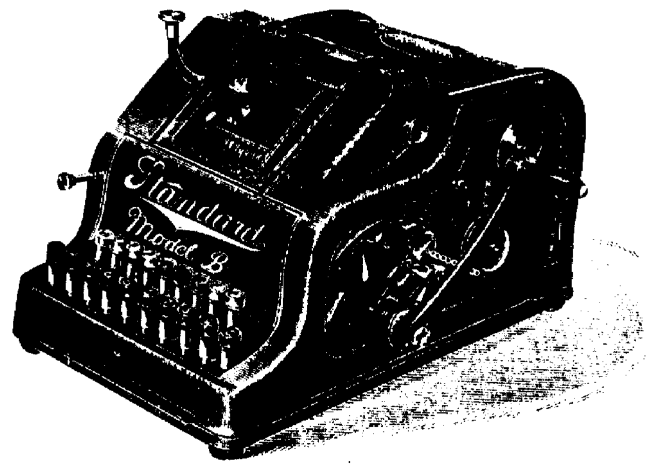


Figure 112

Standard (1903)

This is the first ten-key, visible printing adding machine to achieve wide distribution. The ten keys are in one row, underneath which are the nine tabulator keys. In order to enter a number, the corresponding tabulator key must first be pressed. If the amount to be added has five places, then first the tabulator key marked 5 is pressed; the amount is entered from left to right—for example. if the amount is 125.30, then the digits 1, 2, 5, 3, 0 are typed one after another exactly as they would be typed on a typewriter.

Originally, the machine was available in four designs:

Model B: the most frequently used adding machine.

Model B 1: with an automatic position key for adding columns of numbers with an equal number of decimal places.

Model B 2: for adding items of figures with fractions.

Model B 3: for adding figures with fractions and with automatic position key.

These models were built until 1913. There was also a model E, the details of which are lacking, and finally a model K, which was available from 1914 until only recently. The manufacturer was originally the Standard Adding Machine Company, Spring Avenue, St. Louis. This later became the New Standard Adding Machine Company, 1827 Pine St., St. Louis. The machine is no longer being built, although it can still be obtained through the Adding Machine Inspection and Sales Company, 61 Fulton Street, New York.

Originally, the machine was only supplied with narrow paper rolls. These were inside the machine and were pressed from behind against the digits as they were set up. From 1904 on, the machine was also supplied with a carriage for 30-cm-wide paper. To attach the carriage, the typewriter ribbon guide (which is automatically changed over) has to be fixed on the outside of the casing. The machine has an item counter, to prevent one from typing too far down the bottom of the page, which makes it impossible to enter more items after the counter has reached its limit (the limit being set by a pin on a small indicator). A bell rings to indicate the total should be entered. Then the indicator automatically springs back to zero so that one can start again from the beginning. This model can also be equipped with narrow paper rolls that are fixed on a holder behind the carriage and fed through the typing cylinder platen exactly as a whole sheet of paper would be. The machine always had nine places in the **setup** mechanism and ten places in the result mechanism. The price is $150 for machines with paper roll.

Triumphator (1904)

The Triumphator plant in Leipzig-Molkau provided the pinwheel machine from the very beginning with two pioneering improvements, namely:

1. A row of windows showing the amount registered by the setting levers in a straight line so that it may be conveniently checked **for** accuracy.

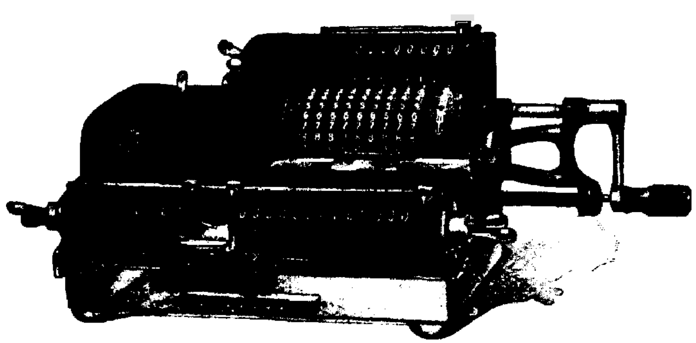


Figure 113
Triumphator, model C

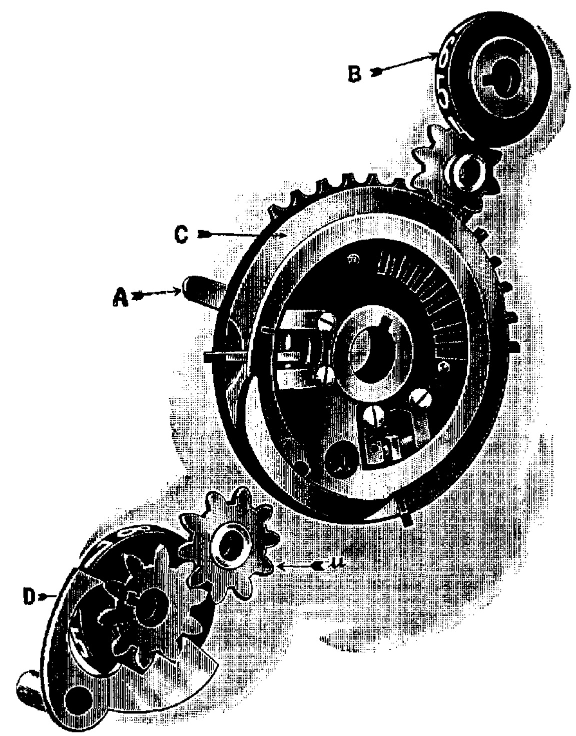


Figure 114
***Cross* section of the Triumphator**

2. The tens-carry in the revolution counter, superseding the red digits that were previously employed in competitive machines, which substantially facilitates shortcut multiplication. The machines were provided with much larger and very distinct white digits. The entered digits were locked before rotation of the crank, and movement **of** the carriage occurred by depression of a tabulator key. The Triumphator machines of more recent date possess a device by means of which all setting levers may simultaneously be returned to zero position. In these machines, the carriage **is** located perpendicularly to the setting levers; thus, the lifting of the carriage will effect a zero setting.

The most important Triumphator models produced today are:

Model ***C:*** nine places in the setting mechanism, eight places in the revolution counter, thirteen places in the result mechanism, weight **8** kg, dimensions **36** × 16 × 11 cm.

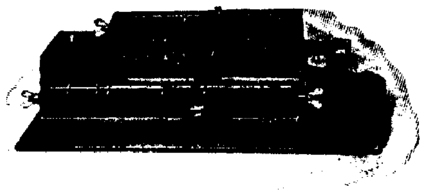


Figure 115
Duplex model

Model D: twelve places in the setting mechanism and in the revolution counter, twenty places in the result mechanism, weight 11.5 kg, dimensions 36 × 16 × 14.5 cm.

Model P: ten places in the setting mechanism and revolution counter, eighteen places in the result mechanism, but tens-carry only to the thirteenth place from the right, weight 8.5 kg, dimensions 38 × 12.5 × 12.5 cm.

Duplex Model: This model has two setting mechanisms, each for nine places; two result mechanisms, each for thirteen places; and one revolution counter with eight places. Its weight is 23 kg, dimensions 60 × 19 × 15 cm. The two counting mechanisms may operate in the same or in the opposite sense. A reversing lever controls the two setting mechanisms. Thus, this machine is capable of calculating problems such as (12,875 × 7,849)/486 = 207,933.89 with eighteen crank revolutions in one single operation.

Machines with red complement digits in the left counting mechanism, instead of tens-carry, can be made cheaper and are frequently in demand because of price considerations. For this reason the Triumphator plant furnishes a model H with an upper straight setting and a model K without such a setting. Before the war the products of the Triumphator plant were supplied in a much larger and heavier finish, which may be still obtained if especially required. In general, however, only the previously mentioned models are in demand. The prices of the Triumphator calculating machines range from 400 to 1,000 gold marks (figures 113, 114, 115).

Golden Gem (1904)

This machine is also known under the name Gancher Adding Machine but so far has not been imported into Europe. Designer: Abraham J. Gancher; manufacturer: The Automatic Adding Machine Company, 148/152 Duane Street, New York. The factory mainly sells directly to the consumer.

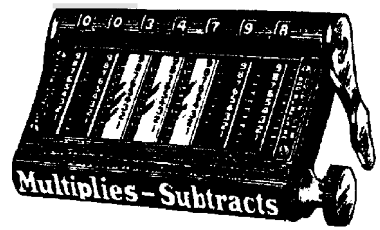


Figure 116

The links of an endless chain may be seen in each of the setting slots. Adding occurs in the customary manner by inserting a calculating stylus into the chain link of the digit to be added and pulling it down until the chain stops. This transfers the digit into the window of the respective decimal place or adds it to the digit already there. Tens-carry occurs automatically. The machine may be used for subtraction as well, but there are no complementary digits in the cheaper models. Zero setting occurs by turning the knob on the right side.

Models:

seven places, $15.00

nine places, $20.00

eight places (Model 16), $20.00, with red subtraction digits

eight places (Model 15), $20.00, without subtraction digits

seven places, $20.00, with ⅛ to ⅞

nine places, $25.00, as above

seven places, $25.00, adds feet and inches.

Model for English currency, $30.00.

The weight of the machine is about 750 grams. It is provided with a stand and its dimensions are approximately 17 × 80 × 100 mm. It is supplied with a leather case and may easily be carried around in the pocket. Previously the seven-place model was sold for $10.00.

Figure 117

Universal (1904)

This was a full-keyboard adding machine manufactured by Universal Adding Machine Company, 3823 Laclede Avenue, St. Louis. It was available as both seven and nine-place versions with the result windows above the keyboard. The printing, on the other hand, could only be seen after the carriage had been raised, just as with a covered typewriter. A pointer indicated the exact point of printing. From the beginning, the Universal had steel-type slugs so that it was strong enough to make carbon copies. The machine was the first to be supplied with a two-colored ribbon. The addition items were printed either in black or violet, and the total values in red, without any special assistance by the operator. If a wrong key was pressed in any column, it could be cancelled by pressing the red cancellation key under the respective column of keys. The electric drive could be replaced by a hand crank. In Germany, models 4 and 5 were, until recently, available for $300, and an extra $75 was charged for an electric drive.

In 1908 the production rights were transferred to the Burroughs Adding Machine Company in Detroit, but they did not continue production. It appears they wanted only to get rid of a disagreeable competitor. The Universal was the first printing-adding machine with an electric drive.

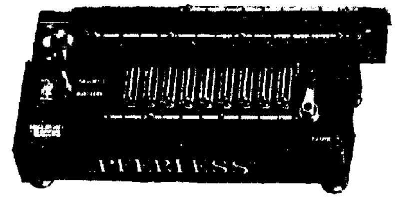


Figure 118

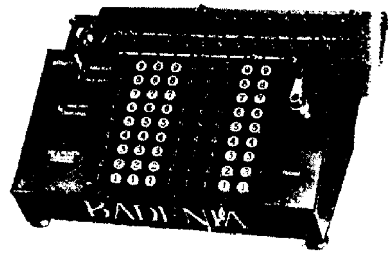


Figure 119

Peerless (1904)

The manufacturer of this stepped drum machine is Math. Bäuerle in St. Georgen in the Black Forest. Originally it was supplied in the customary wooden case, later mounted on a solid cast iron base, and more recently in a metal sheet casing. The construction has remained substantially the same since the beginning.

The amount registered by the setting slides may be read in a straight line from the setting checking mechanism located below the slots. All setting levers may be shifted to their zero position by a lever provided on the left side of the cover plate. The Badenia is a Peerless machine with a keyboard in which a mechanism provides automatic key release after every revolution during addition and subtraction. In spite of their small size, both machines have clearly readable digits. The Badenia also shows the entered amount in straight line.

Recently the factory placed the Rapid on the market. This machine is also a keyboard calculating machine with all the advantages of the Badenia, in addition, it has a new transmission device that makes it possible to accomplish multiple multiplications in every place of a quotient by a single revolution.

For small numbers a quarter revolution is sufficient, for medium ones a full revolution will suffice, and for the highest capacities one and a half revolutions are sufficient. In the case of addition and subtraction, a short depression of the crank produces the result of the operation and automatically releases the keys.

Until about 1912 the factory provided the Peerless machine (which had either motor drive or manual drive) with a special setting mechanism, located below the setting slots, for a multiplier. At that time the value corresponding to the multiplicand had to be entered by a setting crank; today a similar device is located in a straight line to the right of, and adjacent to, the key body. A special design of the exterior frame positions the three rows of windows, in every machine, at a very convenient angle of vision for the operator.

Details of the various models:

Model	Number of places	Weight	External dimensions
Badenia			
I	9 × 8 × 13	9 kg	34 × 25 × 16 cm
II	9 × 9 × 16	9½ kg	39½ × 25 × 16 cm
IIa	12 × 9 × 16	10% kg	40 × 25 × 16 cm
III	12 × 11 × 20	11½ kg	47% × 25 × 16 cm
IV	12 × 12 × 24	12½ kg	55½ × 25 × 16 cm
Badenia-Rapid			
I	9 × 8 × 13	10 kg	38½ × 25 × 19 cm
II	9 × 9 × 16	10½ kg	39½ × 25 × 19 cm
Peerless			
I	9 × 8 × 13	6 kg	34 × 18 × 12 cm
II	9 × 9 × 16	6% kg	39½ × 18 × 12 cm
IIa	12 × 9 × 16	7½ kg	40 × 18 × 12 cm
III	12 × 11 × 20	7½ kg	47% × 18 × 12 cm
IV	12 × 12 × 24	8 kg	55% × 18 x 12 cm
Baby Peerless			
	9 × 8 × 12	5 kg	30½ × 15 × 12 cm

The Baby Peerless is a machine, fitted into a wooden frame, with setting slides; it is so small that it may justly be called the smallest stepped drum machine. Like all Bauerle's calculating machines, this machine possesses three rows of windows and is otherwise designed in the same way as the other Peerless calculating machines. The crank may be folded to permit convenient closing of the wooden lid. This may easily be carried around in a briefcase.

Previously the machine was supplied with 6 × 7 × 12 places, 8 × 9 × 16 places, and 10 × 11 × 20 places. In France it was sold under the name Calculographe.

National (1904)

The National is an adding machine that can either be connected to a typewriter or used alone. The connecting of the two machines is carried out by means of a simple lever system. At any time the machines can be separated from one another by means of a knee lever; each machine can then be used independently. The capacity of the machine is ten billion. It prints totals and subtotals in red ink. and each value is immediately visible to the eye. The machine adds not only horizontally but also vertically. It is founded upon the most essential patents of the earlier Bankers' Adding Machine, but both the National and the Bankers' did not seem to make it out of the trial period. They have never been shipped to Europe and even in America they remained relatively unknown. Production was, however, soon to be resumed.

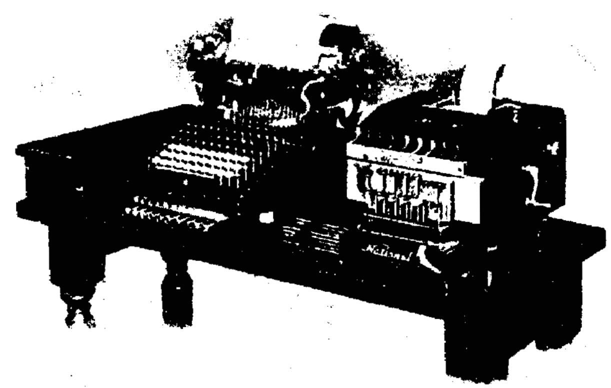


Figure 120

Figure 121

Pike (1904)

The original manufacturers were Pike Adding Machine Co., Orange, N.J. In 1909, production was transferred to the Burroughs Company. which still builds the mode1 today. In Europe the Pike attracted much attention, especially in England, Germany, and France.

The visible printing, full-keyboard adding machine is supplied with a carriage for paper 30-cm wide but can also accommodate a narrow paper roll. On the left side, above the keyboard, can be found: the repeat, nonaddition, total. and subtotal keys. The result windows are visible, and the machine has a keyboard release in columns. It is manufactured with seven, eight, nine, and ten places (see also the entry on Burroughs).

Arithmograph (1904)

An invention of John T. Howieson in New York, this is an adding and subtracting device for typewriters. The Fay-Sholes Typewriter Co. in Chicago

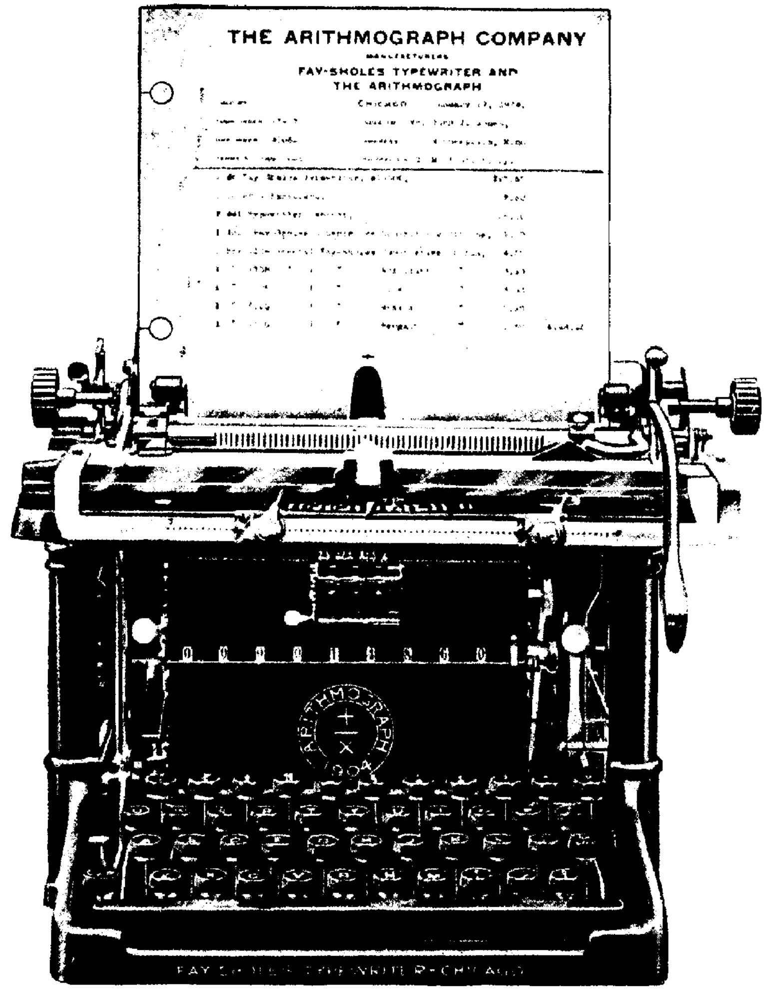


Figure 122

amalgamated with the Arithmograph Co. and introduced to the market, both in America and in **Europe,** their typewriters combined with the arithmetic device belonging to the Arithmograph Co. In Germany, for example, the calculating Fay-Sholes was sold for a price of 800 marks. But the machine was not engineered thoroughly, and there also arose a number of difficulties in the administration of both companies, with the result that the production of the Arithmograph, in conjunction with the Fay-Sholes typewriters, was given up in **1907.** The adding device was situated above the typing keys, and the digit keys of the typewriter were connected to the adding device. The typewriter could, of course, also be used without the adding device.

Mallmann (1904)

Manufacture was carried out by the Mallmann Addograph Mfg. Co., Chicago. The machine is no longer manufactured and has not been for a number of years. In fact, it has never reached Europe at all. It is a full-keyboard adding machine in the same style as the Wales except that the printing **is not** visible. It is a nine-place machine and has **a** 25-cm-wide carriage. The price is $250.

Adder (1904)

This machine was built by the Adder Machine Company in Detroit. It could be employed in combination with a typewriter. It never appeared in Europe and it remained almost unknown in America. After a few years production was discontinued.

Figurator (1905)

This machine was also known under the name Ray and was manufactured and sold by the Ray Adding Machine Company, **465** Washington Street, New York. The present address of this firm is unknown, This machine was similar to the Lightning Calculator and its price was $25.00 for a seven-place device.

Twentieth-Century Computator (1905)

The Campbell Manufacturing Company of Hackensack. New Jersey, has been

mentioned as the manufacturer of this machine. It has not been possible to determine any details of the device.

Matador (1905)

This is a single-column adding machine with setting levers from the well-known calculating machine factory Grimme, Natalis and Company, A. G. in Braunschweig. **As** compared with their other products, this machine has the following advantages: the result of individual columns of digits need not be written on paper, nor the counting mechanism set to zero, nor is it necessary to reenter the carryover because the calculating mechanism may be shifted laterally place for place (which occurs every time after a column has been added up). whereas the carryover remains in its place with the additional digits being added thereto. The weight of the machine was 9 kg and its price 150 marks, but it has not been manufactured for many years because the time **of** the single-column machines has long passed and many improved machines are available at reasonable cost.

Gauss (1905)

Designer: Christian Hamann of Berlin-Friedenau. The first model of the machine was exhibited at the Paris Exhibition in 1900, but its construction was not entirely the same as the model to be briefly described here. Plant production commenced in 1905, and the sales were handled by the mail-order house R. Raiss in Liebenwerda in Saxony.

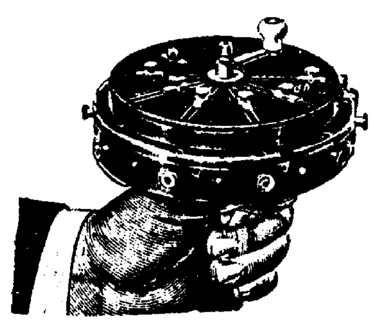


Figure 123

This machine has no stepped drums but possesses only a single actuating element in the form of a developed stepped drum that, by rotation of the crank. is moved past, or brought into mesh with, numeral gears positioned in a radial direction around the shaft of the crank. The entering of the value occurs with the aid of setting slides that move in six slots. with white and red digits. and are likewise radially located relative to the shaft of the crank. The machine may be lifted from its base. In a later version it was secured to a solid iron base so that it could not be displaced from its position during the turning of the crank. The weight of the machine, without its iron base, is only 850 grams; it has a diameter of 12.5 cm and is 10 cm high. The price was, at first. 175 marks and later rose to 200 marks. The cover plate may easily be lifted by means of a lever at the bottom of the machine (or when held on a handle, it is lifted directly with the right hand) to such an extent that the digit 1 on the edge of the cover can be positioned opposite the stationary indicator. When properly positioned. several cuts in the edge of the lid fit over corresponding projections of the lower part, and the gears of the two parts engage. Manufacture of this machine has been discontinued.

Mercedes-Euklid (1905)

Designer: Christian Hamann of Berlin. Manufacturer: Mercedes Office Machine Works of Charlottenburg 2. Berlin Street 153.

The principle upon which all Euklid models have been based differs entirely from the calculating machine systems so far described. The actuating mechanism consists of ten parallel racks that are proportionally displaced by a lever connected to the racks. The particular advantages of this machine show that the Euklid has not only overcome the defects of other machines but possesses a multitude of innovations and improvements, for instance:

Automatic Carriage Movement: The cumbersome lifting and shifting of the carriage by the operator has been eliminated. Movement occurs automatically by depression of a key or reversing lever.

Instantaneous Clearance: Clearing of one or both counting mechanisms is effected by a single. short manipulation without lifting the carriage, without operating winged handles, and may take place in any position of the carriage. The machine has complete tens-carry in the result mechanism. up to the highest place. and the same is true for the revolution counter, in a positive as well as in a negative direction. The negative tens-carry arrangement is important

because it enables dependable performance of shortcut multiplication with a correct multiplier indicated. Therefore, several multiplications with constant multiplicands may conveniently be carried out, without clearing or new settings. merely by changing the multiplier. Furthermore, it permits direct adding of multipliers and quotients. This tens-carry frees the operator from the red digits, which are so liable to cause errors. Direct setting of the dividend into the result mechanism occurs by setting knobs without the need for lifting the carriage and without previous setting in the selection mechanism. Since the divisor may be retained, several divisions with constant divisor may be carried out consecutively.

Automatic Division: Contrary to the usual method of division, the Euklid machine has completely automatic division, which is carried out entirely mechanically by rotation of the crank and manipulation of the reversing buttons, without requiring any attention or consideration on the part of the operator. It is bound to yield correct results even if the carriage has been placed incorrectly. An automatic lock of the crank takes the place of the bell signal, which may easily be missed by the operator. The entered digits may be read in a straight line. The machine offers a convenient and comprehensive view because the result mechanism, which is the most important part of a calculating machine, is positioned directly before the operator. The closely adjacent digit drums exhibit large white digits on a black field; they are clear and easily readable.

Figure 124 shows model I—a manual machine with slide settings. The machine has nine places in the setting mechanism, sixteen places in the result

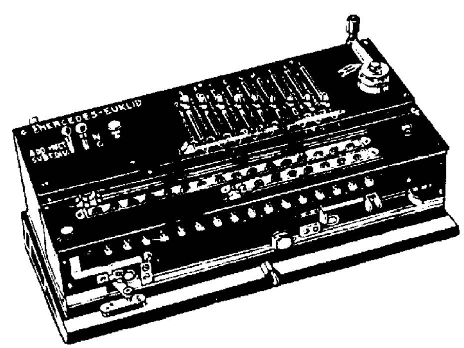


Figure 124
Model I.

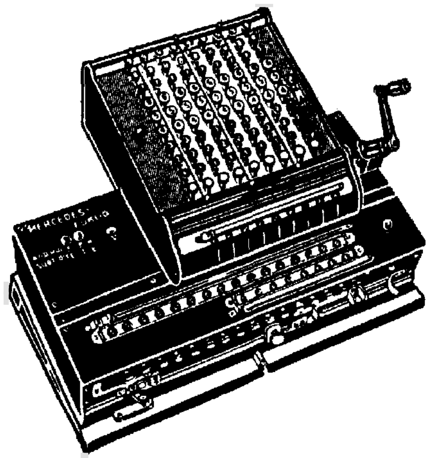


Figure 125
Model 4.

mechanism, and eight places in the revolution counter. The setting mechanism may be increased by four places, i.e., to thirteen setting slides.

Model 4 (figure 125) is a manual machine with keyboard setting; it has nine places in the setting mechanism, sixteen places in the result mechanism, and eight places in the revolution counter. Like model 1, the setting mechanism may be extended to thirteen places. Keys are the preferred setting means. They increase the reliability. speed. and convenience of entering data. Consequently this model is primarily suited for employment as an adding machine.

Apart from those already mentioned, the keyboard Euklid machine exhibits additional advantages. A small keyboard field, and therefore fast and dependable operation, facilitates the setting of multidigit values by simultaneous depression of keys. Simultaneous depression of two or more keys in the same longitudinal key row is impossible; the key touch is extremely light and of equal depth for all digits. The great clarity of the keyboard is increased by a checking row, positioned below the keys, in which the entered values appear in a straight tine; thus. the operator may immediately survey even the largest values. Every addition is followed by an automatic key release, which may be disabled for other types of calculation. Clearance of the whole keyboard, in multiplication and division, is done by a lever. The keys in any column release one another when depressed. Individual key columns may be released by themselves.

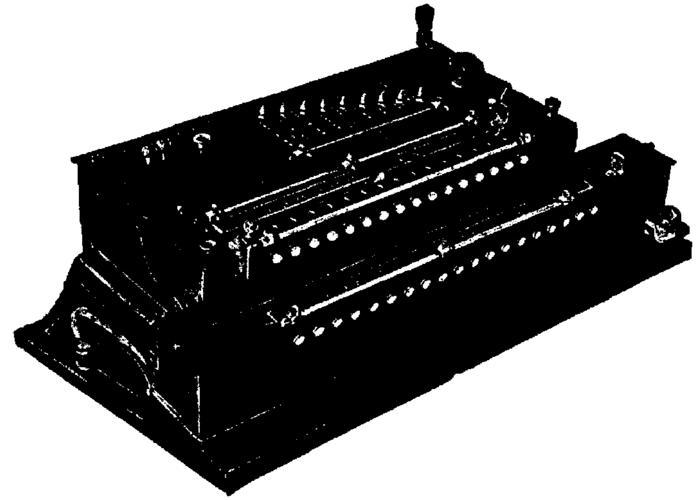


Figure 126
Model 5.

Key interlocks—when the crank is not in its basic position, depression or release of depressed digits is impossible.

Separation of the columns is accomplished by readily movable decimal point slides positioned before the key columns. The slides permit the key columns to be divided to the left or to the right as desired. The operator may survey at a glance which columns are occupied by the individual groups of numbers.

Figure 126 shows model 5. This is a manual machine with slide-setting and totaling mechanisms: it has nine places in the setting, sixteen places in the result, eight places in the revolution counter, and seventeen places in the totaling mechanism. When compared to model 1, this machine has the advantage of a totaling mechanism that serves for adding the individual products or for subtracting them from one another. The advantage of this arrangement is that a complicated calculation may be accomplished with only one result mechanism, rather than by the method used in other machines in which it is necessary to operate two result mechanisms simultaneously. After a problem has been solved, the product is easily transferred to the totaling mechanism by simply operating the clearing mechanism. Thus, in calculating invoices for instance. the individual items may be found in the result mechanism after the multiplication, and after each clearance their total sum may be found in the totaling mechanism. This eliminates the separate addition of the items that is otherwise necessary. The manipulation of this machine is not tiring because only one mechanism is being operated at a time, and its handling does not differ from that of Euklid model I. Hence, the expenditure of strength required for the operation of the second result mechanism is saved; only one counting mechanism has to be displaced from place to place, and as this is done without lifting the carriage it requires no effort. Rounding of decimal places prior to totaling may be arranged so that the correct total is obtained. Direct setting up of small items for addition is possible without operation of the crank. The results of intermediate calculations, which are not to be added to the totals, can be cleared without being transferred. The subtraction of intermediate results can be accomplished in the simplest manner in a special counting mechanism, with the machine showing at the same time the positive and the negative values. Separate item counters enable the operator to check at once the number of positive and negative items that make up a total sum.

Model 6 is illustrated in figure 127. It is a manual machine with keyboard setting and totaling mechanism; it has nine places in the setting mechanism. sixteen places in the result mechanism, eight places in the revolution counter, and seventeen places in the totaling mechanism. Model 6 is an amalgamation of models 4 and 5 and possesses all the advantages of each.

Model 7 is illustrated in figure 128. It has slide setting and an electric drive; it has nine places in the setting mechanism, sixteen places in the result mechanism, eight places in the revolution counter, and eight places in the setting mechanism of the multiplier. The setting mechanism may be extended by four places to thirteen setting slides. This machine corresponds to the Euklid model I with the difference that it is driven by an electric motor. This drive operates so efficiently that the machine calculates entirely automatically. The operator is only required to enter the two values necessary for multiplication or division problems, even clearing occurs automatically. In fact, it is unnecessary to watch the place number of the multiplier. The automatic calculating machine forms the long-desired ideal of calculators since it relieves the operator almost completely from any mental or manual work. It is not possible in this place to recite all the advantages of model 7 individually. Suffice it to mention that the electric Mercedes-Euklid has not yet been excelled by any other calculating machine in speed and reliability. It carries out the calculations with a steady speed of approximately 240 to 260 revolutions per minute. The electric Mercedes-Euklid no longer tires the operator because it requires

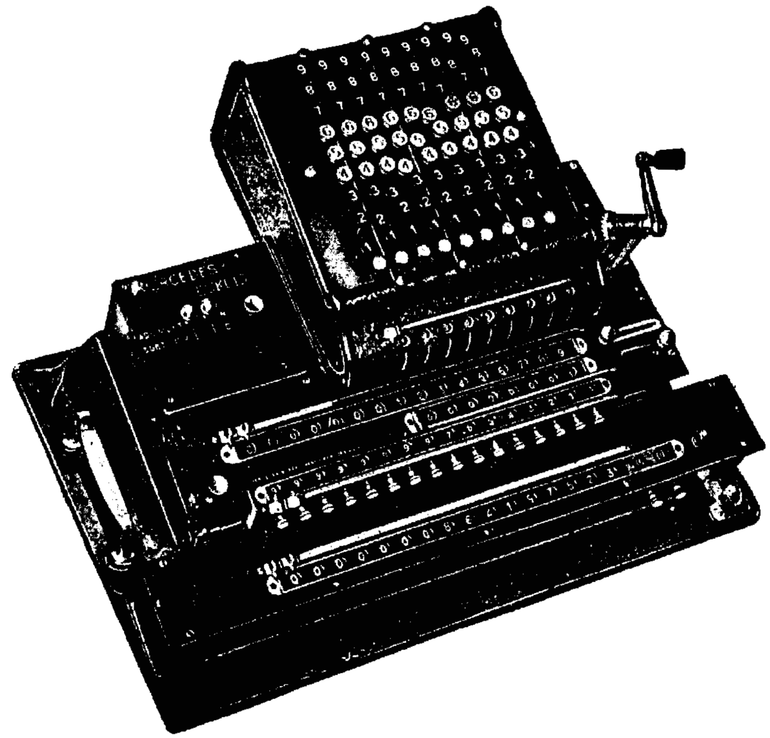


Figure 127
Model 6.

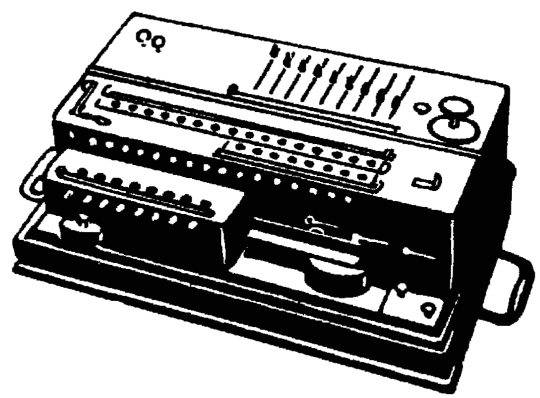


Figure 128
Model 7.

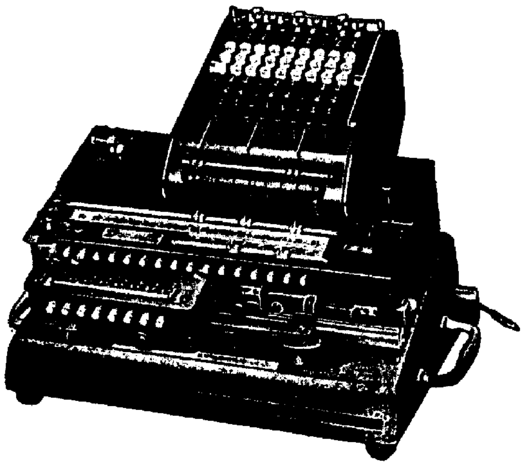


Figure 129
Model 8.

neither rotation of the crank nor displacement of the calculating mechanism, and apart from the setting of the problem, not the least amount of attention is required by the operator. The cost of operation is very small because the motor employed to drive the machine has a strength of only 1/40 horsepower and may be connected to any electric light system. When the calculating operation is begun, the motor is automatically connected and it is automatically disconnected upon termination. This saves electricity but most of all it avoids any unnecessary noise and any overloading of the motor. If, in a large business enterprise, model 7 should be required in several places where different kinds of current are available, the motor may be exchanged for another one in a few moments. The electric drive ensures an extremely uniform, speedy, and reliable operation. This smooth operation of the drive preserves the mechanism of the Euklid and hence extends the life of the machine.

Figure 129 shows model 8, which is the same as model 7 as regards the drive and number of places but is provided with key setting. The keys give it the distinct character of an electric adding machine. The clearly arranged and easily operable keyboard field corresponds with that of model 4. An addition bar, adjacent to the keyboard, enables convenient operation. This increases still further the applicability of this machine over that of model 7. This type of machine constitutes in every respect a perfect and entirely automatically operating universal calculating machine whose performance excels all others

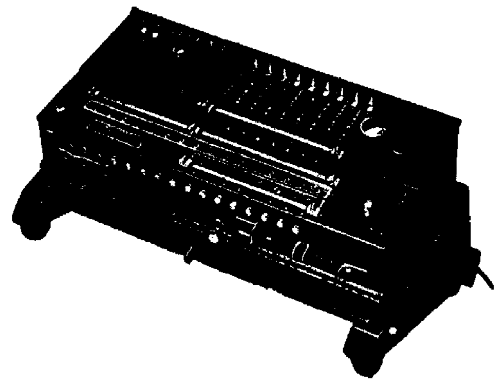


Figure 130
Model 11.

known. All that is necessary is to enter the problem, the machine calculates it automatically, and all the operator has to do is to mark down the result.

Figure 130 shows the semiautomatic model 11.[64] In construction and dimensions it corresponds entirely with the manual model 1, but it has an electric drive by a motor of 1/40 horsepower built into the base of the machine. This motor may be connected to any electric light system. The mode of operation is exactly the same as in model 1, the difference being that the hand crank has been eliminated and the revolutions are carried out by the motor, which may be started by depression of a button. The machine has slide settings; it has nine places in the setting mechanism. sixteen places in the result mechanism, and eight places in the revolution counter. The setting mechanism may be extended up to thirteen places.

The semiautomatic model 12, whose overall construction is the same as model 4, possesses an electric drive by a motor of a 1/40 horsepower, as described in connection with model 11. This model has not been illustrated. What has been said about model 11 as compared with model 1 logically applies to model 12 as compared with the manual model 4, model 12 is especially suited for use as an adding machine because of its keyboard setting and electric motor drive.

64. At this point Martin switches hack and forth between Roman numerals and Hindu-Arabic numerals for various model numbers. We have transcribed everything into Hindu-Arabic numerals.

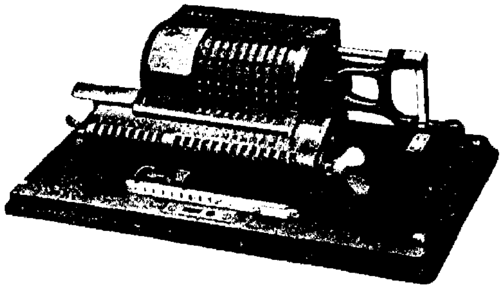


Figure 131
Chateau.

Chateau (1905?)

This pinwheel machine is manufactured in Foncine-le-Haunt (Jura); the owners of the factory are the Chateau Brothers, 125 Boulevard de Grenelle, in Paris. It became better known under the name Dactyle, which it received from the selling agent. It differs very little from the Original Odhner. It has nine setting rows, thirteen places in the result mechanism, and eight in the revolution counter. Its price, before the war, was 475 francs and afterward 425 francs. It was offered for sale at various places outside of France, but its distribution is rather insignificant, even in France. Its length is 40 cm and its width is 20 cm.

Goldberg (1905)

The Goldberg was an adding device for typewriters of all systems. To our knowledge a number of machines were sold, but only in connection with the blind-typing Remington. The machine did not gain any importance.

Bri-Cal (1905?)

This is a product of British Calculators Limited of Belfast Road, Stoke Newington, London N. This firm, as is generally known, produced and sold the Cosmos, but apparently no longer exists. The Bri-Cal is a small adding machine with automatic tens-carry. To add, the adding stylus is inserted into the opening next to the number to be entered and is pulled to the right until it hits a stop. whereupon the added digit appears in the respective result window.

Figure 132

The two outer slots represent the pennies, and the following ones represent the units, tens, hundreds, and so on. Zero setting does not occur automatically on the machine. The adding stylus must be inserted into the outermost slot behind the red tooth and the calculating wheel moved to the end; the procedure is then repeated in the next slot, and so on. Naturally the machine is also furnished for English currency. Prices: five places £4.4.0; six places £5.10.0; seven places £7.00.0.

Outside of the British Empire only a few models of the machine were sold. In England the sales were also not large.

XxX (1906)

A stepped drum machine of A, G. vorm. Seidel and Naumann of Dresden. Since 1919 the manufacturing rights have been the property of the Presto Bureaumaschinenbau Ges.m.b.H, Rabenerstr. 6, Dresden 24.

The machine is manufactured in two main models: with setting slides and with keyboard setting. Both models are available with 8 × 8 × 13 places, 9 × 9 × 16 places, or 11 × 11 × 20 places. Both models have complete tens-carry in the revolution counter with red and white digits.

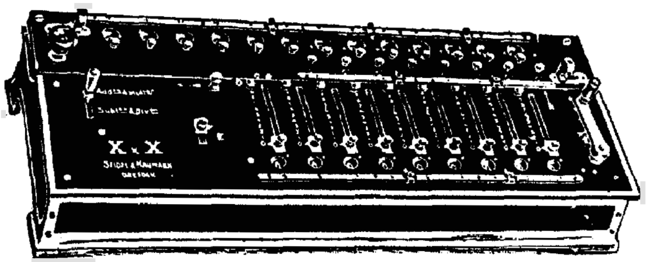


Figure 133

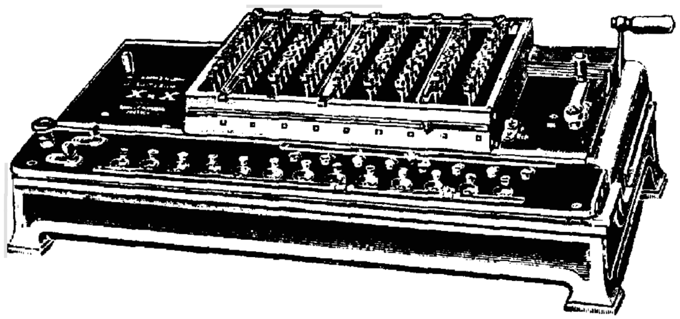


Figure 134

In the machine with slide setting, the carriage is arranged on the top. The setting checking windows are located below the slide slots. A total clearance device is provided for the setting slides.

Aside from the setting keys, the machine with key setting has an additional key at the top of each column with which an inadvertently depressed key may be released. A repeat key is also provided. Clearance of set up amounts occurs by means of a lever. and at the same time the numeral wheels of the setting checking mechanism are set to zero. In these machines the carriage is located below the keyboard. The keys are self-correcting. A printing model was built for a short time.

Gab-Ka (1906)

This small, inexpensive machine was manufactured by the Zephir Company in Paris but remained of no importance. It merely serves for adding columns

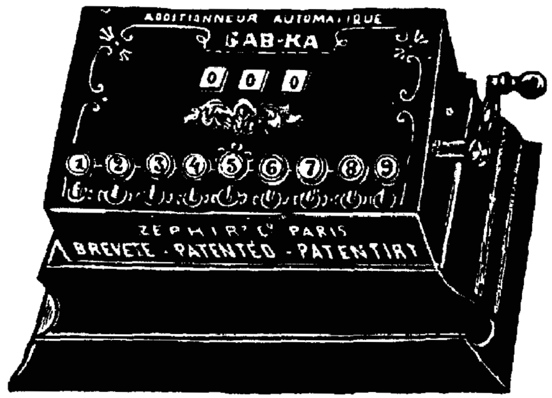


Figure 135

of digits, limited to a total of 999 per column. The unit digit of the result was noted down, and the remainder carried over to the new column, and so on, until all the columns had been added. The crank serves for resetting to zero.

Cram Writing Machine (1906)

This is not a typewriter, as you might think from the name, but rather an adding machine, In fact it is a Burroughs connected to a printing device attached above the machine and is similar to the Edelmann typewriter.

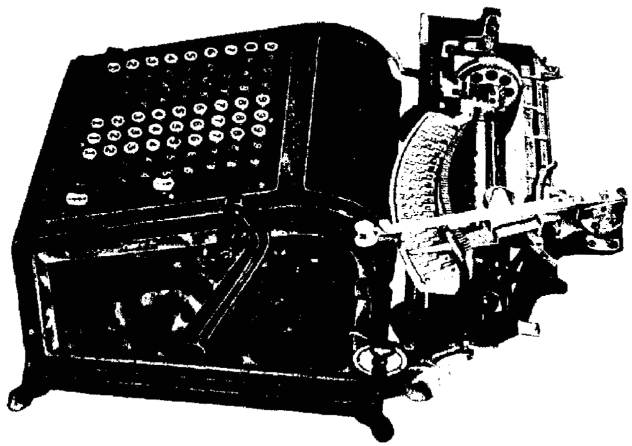


Figure 136

One drawback of the ordinary printing-adding machine is that the digits, but not the text belonging to them, can be printed. At times this has been overcome by attaching certain letters or special symbols to the keyboard, thereby enabling the machine to print specific notations like *C* for credit, *D* for debit, *S* for sum, and the like, but this was only a makeshift measure. With the Cram you can write any text you wish in capital letters, as well as not-added digits and various symbols, which can be used to explain in more detail the relevant item. A company was established in St. Louis for manufacturing these machines, but no business worth mentioning was carried out. The designer was B. Cram in St. Louis.

Goldschmidt (1906)

J. Goldschmidt of Rue de Chabrol 12, Paris, manufactured a stepped drum machine under this name. The manufacturer has moved away, and no other details regarding the machine could be ascertained. Presumably his machine is identical with the Multaddiv that was sold, before the war, by a well-known office machine dealer on the large boulevards of Paris.

Ellis (1906)

The inventor of this machine was Halmcolrn Ellis in East Orange, **N.J.** The Ellis is a full-keyboard adding machine connected to a typewriter. It is, however, different from the Burroughs machine. Not only does it print number columns, results, and. if necessary, a few symbols or words like debit, credit, balance, etc., but, just as the Remington, Monarch, Smith Premier, or Yost typewriters are supplemented by adding devices, so the Ellis **is** an adding machine that is supplemented by a typewriter. In considering this machine, it must be remembered that what is being dealt with here are two different groups of mechanisms. The number key mechanism, two adding mechanisms, and the number printing mechanism belong to the one **group,** while the other group contains the system for the typewriting mechanism.

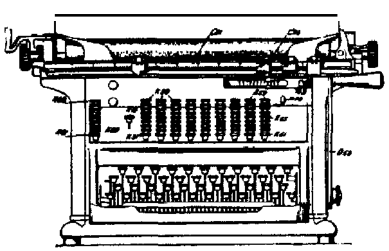


Figure 137

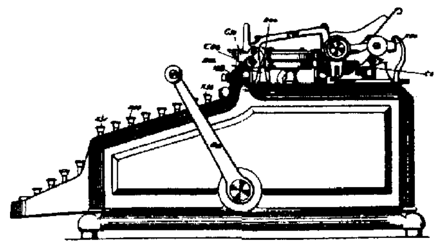


Figure 138

The **Original Ellis:** In front of the machine there is the typing keyboard consisting of four rows (the universal keyboard with forty-two keys). Then there is the adding machine keyboard with nine rows—nine columns of numeral keys and nine operating keys, Behind this **is** the type lever mechanism and the carriage. The calculating keys are clearly shown in figure 138.

The Typewriter: The typewriter has a simple shifting device with shift keys on both sides of the keyboard. It is equipped with one tabulator whose setting key found in the uppermost row of keys on the right. There is also a release for the tabulator stop. In construction, these machines resemble the Underwood. The type levers **are,** of course, very long because they transverse the underbody of the adding mechanism. There is a carriage release key on the left side of the carriage where the adjustable setting device for spacing (three different spacings) is also found together with the carriage return and new-line levers. Diagonally across the machine runs a toothed bar on which sit both the margin setters and the stops of the typewriter tabulator as well as the stop blocks of the adding machine tabulator; therefore, the typewriter and adding machine each have a separate tabulator. To the left, on the front part of the machine above the operation keys, is the ribbon key used to change from one color to another. The type hammers meet at the printing point in a central type control, and on both sides of this are the other stop blocks. To the right, on the carriage, is a lever that loosens the paper feed drums and another carriage release key. The ribbon **spools** are attached in the usual way. Both paper feeders are adjustable at the side.

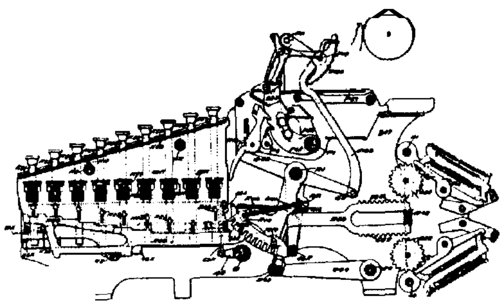


Figure 139

The Adding Mechanism: The eighty-one calculating keys are part of the setup mechanism for entering the numbers that are part of the calculation. When these keys are pressed down, both the setting of the corresponding digit-type head and the addition of the corresponding number is prepared. The lever (visible in figure 138), on the right side of the machine, operates the devices for printing numbers, adding numbers, and printing totals. In addition to the eighty-one calculating keys and nine operating keys, the adding machine has a tabulator key, which is between the row of operating keys and the first row of calculating keys. Nine operating keys are to the left of the calculating keys.

Release key: releases all the depressed keys (number keys and operating keys)

Repeat key: prevents the release of the number keys while using the lever

Total printing key: for the upper set of adding gears

Subtotal printing key: for the same set of gears

Line addition key: for the upper set of adding gears

Total printing key: for the lower set of adding gears

Subtotal printing key: for the lower set of adding gears

Line addition key: for the lower set of adding gears

Key for switching off addition

Calculation Possibilities

The following examples have to do with monetary values and their decimal places.

Example 1: There are several digits under each other in a single column, and the total is to be printed at the bottom.

543.25
23.76
40.00
0.37
1.00
608.38

Keys in columns K55, K52, K53, K54, and K55 are pressed from right to left[65] (the sequence of the entries is of no consequence). Then the sliding carriage is brought into the position of one of the two tabulators; for example, in concurrence with the left stop block, and the lever, which at this stage has been released. is pulled. This prints the number in the first row of the example. When the lever is shifted back, the adding of the number into the upper mechanism is performed, while at the same time the digit keys spring back to rest position. The other four items of the total are printed and added in the same way. Where there is a zero, naturally no key in the corresponding column is pressed. It is important to maintain the tabulator setting under all circumstances. Finally, the upper total printing key K63 is pressed and the lever pulled. This returns the adding mechanism to zero, and the total is printed. The lever, which automatically moves back, causes the total printing key K63 to return to its rest position.

Example 2: Once again there are columns of numbers to add, but this time the total must be carried over to a new column.

325.48	391.93
21.35	3.45
6.40	50.00
38.00	0.75
0.70	20.50
391.93	466.63

65. Although these columns are marked in figures 137 and 138. they are very difficult to read. Essentially Martin is saying you enter the first number in from right to left.

The five items in the left column are printed and added in exactly the same way as described by means of the upper adding mechanism. Then, instead of the total printing key K63, the subtotal printing key K64 is pressed. If the lever is now pulled, the total—namely, 391.93—is printed. The adding mechanism then returns to zero, as in the previous example, but, by the return of the lever, is reset to the earlier number. Meanwhile, the subtotal printing key K64 has been released and comes back up again. The sliding carriage is shifted to the left until the right stop block comes into effect. The upper total printing key K63 is pressed. If the lever is now pulled, the upper adding mechanism returns to zero, and the value 391.93 is printed as the first item in the new column. When the lever has moved forward, the lower adding mechanism is thrown into gear with the rungs (according to the position set up in the upper calculating mechanism). When the lever begins to return. the upper calculating device is disengaged and in the end remains on zero while the lower adding mechanism is set on the items. The total printing key of the upper adding mechanism is automatically released again. The addition is carried out as already described, until finally the end total 466.63 is obtained with the help of the lower total printing key K66.

Example 3: In adding a column of numbers, it is occasionally necessary to print a number that should not be part of the final total. In such a case, all that is required is to press down the nonaddition key K69 before pulling the lever to print the respective value.

654.60
45.04
11.11 x
130.50
830.14

The item in the third position marked with an x is not a part of the addition. Before printing this, the nonaddition key K69 must be pressed; with the return of the lever, it springs back to its normal position again. The symbol is itself not printed automatically but is put there by means of the typewriter. This number can easily be printed in a special color by changing the colored ribbon. This is done by means of one of the small buttons (which can be seen in figure 137) on the right, next to the row of operating keys, on the front part of the machine.

Example 4: When a balance sheet is to be set up, or an entry to be made where numbers in successive rows are to be entered alternately in two columns to be added independently, both tabulating stop blocks are set accordingly. By alternating operation of both stops, each number is printed and added up in their respective columns.

204.05	50.04
45.56	6.50
12.60	0.56
0.15	657.08
262.36	714.18

Here the first number in the left column, then the first number in the right column, then the second in the left column, etc. is printed. The totals are obtained in the usual way—that is, on the left by means of the upper total printing key K63, and on the right by means of the lower total printing key K66.

Example 5: When two columns of numbers have been added up on both adding mechanisms, it is, of course, possible to combine their totals.

54.30	76.00
4.07	45.05
300.66	0.46
3.03	600.05
40.10	5.70
1.32	3.02
403.48	730.28
	403.48
	1133.76

The total under the left column is obtained, as in the second example, by means of the subtotal printing key K64; it is then stored in the upper adding mechanism. Then, independent of this, the right column is printed and the total obtained similarly with the aid of the lower subtotal printing key K67. As in the second example, the upper total printing key K63 is pressed and the left total carried over into the right column again as a term of the total. With the aid of the lower total printing key K66, the total of both columns finally appears in the right column.

Example 6: It is also possible to add only a part of a number in a column of digits to be printed, then to print this subtotal beside it on the right and, after printing the rest of the numbers in the column, to then print the equivalent subtotal next to it on the right, underneath the first subtotal, and finally compute the grand total.

45.67	
406.00	
2.40	
67.06	
50.06	
20.04	
200.00	791.23
550.00	
5.60	
40.06	
5.03	
22.02	
14.08	
2.35	639.14
	1430.37

The particular subtotals (there can, of course, be more than two) are obtained in this case by means of the upper total printing key K63, and then. as in examples 2 and 5, are transferred as terms of the totals to the right. Then, with the help of the lower total printing key K66, the grand total is calculated.

Example 7: In all the previous examples, the printing and adding has taken place in columns. If, on the other hand, individual numbers in a row are to be printed and added up, then one (or both) of the two line-adding keys K65 and K68 must be pressed down. Both adding mechanisms then remain engaged during the operation (as long as this is not stopped by means of the

release key) independent of the position of the carriage, and however many numbers, in however many lines, can be printed and added in succession, and the total obtained.

12.35	40.70	33.65	6.50	5.00
1.70	50.00	8.70	25.00	5.01
2.77	0.66	9.00	30.44	120.00
3.33	0.55	= 355.36		

The nonaddition key K69 can, of course, be used exactly as it was in adding up columns, and the subtotal printing key can be used in place of the total printing key.

Example 8:

1.25	4.30	2.20	0.67	4.50	7.55	= 20.47
3.40	5.40	6.60	2.67	0.11	5.05	= 23.32
5.40	6.66	3.50	7.37	1.11	7.10	= 31.14
						74.93

In this case, the items that have been printed in each line are added by pressing down the upper line, adding key K65 on the upper adding mechanism. Each time the total is obtained (when the upper total printing key K63 has been pressed at the same time as the carriage is in gear with the right stop block, for the lower adding mechanism, and after measures have been taken to print it at the end of the right, it is stored as a subtotal in the lower summing mechanism. After this, the grand total is obtained with the aid of the lower total printing key K66.

Example 9:

34.51 × 32 = 1104.32

Multiplication is carried out with this machine as repeated addition. The small button 10B (on the right in figure 137) is positioned so that the small indicator points completely to the left at the end of its sweep. This disengages the machine's printing action without stopping any of the other functions of the adding machine, with the exception of the paper feeder, which is automatically disconnected.

34.51
34.51
345.10
345.10
345.10
1104.32

This illustrates how the result is arrived at, except that printing does not take place. The arrangement of the items into columns should indicate that the carriage has been brought into tabulator position (pressing a line-adding key would do just as well). Next, the multiplicand. 34.51, is set up in the usual way by means of the digit keys, and at the same time the repeat key K62 is pressed down. The number 34.51 is added by pulling the lever as many times as indicated by the digit in the units position of the multiplier. By pressing the release key K61, the repeat key K62 is released, and this causes the digit keys that have been pressed down to return to rest position. The multiplicand is entered again with the aid of the digit keys in such a way that its individual digits have shifted one place to the left (that is, the 1 is entered in the second column of digits from the right, the 5 in the third column, etc.) When the repeat key has been pressed, and the lever has been repeatedly pulled, it then follows that the multiplicand (which has been multiplied by 10) is successively added up as many times as the digit in the tens position of the multiplicand—that is, in this example, three times. These operations are carried out repeatedly until the multiplication has finished. Finally, with the help of the corresponding total printing key, the total is obtained, and this represents the product. When the total printing key is pressed, the repeat key is released.

Example 10:

12 boxes at	1.45	. . .	17.4
18 chests at	2.35	. . .	42.30
			59.70

If calculations of the above form are to be written down, then the multiplication is carried out with the help of one summing mechanism (say the upper one), and the total is printed each time while the machine works together with the stop block of the other summing mechanism (say the lower one). The total sum is obtained as in example 8.

Example 11:

5 bales silk 51, 49, 47, 50, 53, = 250 m at 1.13 . . .	282.50
7 bales satin 48, 51, 53, 49, 49, 47, 52 = 349 m at 1.46 . . .	509.54
	792.04

This example is to some extent a combination of examples 7 and 10. In the first group, the numbers 51, 49, etc. are added and the total 250 is multiplied by 1.13.

Example 12:

36 572.81
– 14 975.36
21 597.45

On this machine, subtraction is carried out in the usual way for this type of calculation; that is. the number that complements the subtrahend is added to that which complements the capacity of the machine (plus 1).

· 36 572.81
14 975.36 *x*
9 985 024.64
21 597.45

The subtrahend is appropriately printed underneath the minuend after the nonaddition key has been pressed down (indicated by the symbol *x*), and when the printing operation has been switched off, the complement, which has been entered on the keys, is added to 10 000 000.00 in the tabulator setting.

Example 3:

705.00	767.50
340.50	440.00
4 400.00	6.00
160.04	4 354.87
5 605.54	7 746.00
	13 312.37
	5 605.54
	7 706.83

In order to get the difference between the totals of two columns of figures, first, as was done in example **5,** the totals of both columns must be obtained by means of the upper and lower subtotal printing keys. The left total is then carried as an item over to the right side by pressing the upper total printing key.

705.00	767.50
340.50	440.00
4 400.00	6.00
160.04	4 354.87
5 605.54	7 746.00
	13 312.37
	5 605.54
	9 994 394.46
	9 994 394.46
	7 706.83

Since the nonaddition key could not be pressed this time, the complement of the subtrahend, **5605.54,** must then be added twice, as is indicated here by the double printing (which is of course switched off).

It is easy to see by these few examples that the uses of the calculating Ellis are more varied than those of the calculating models of other systems so far described.

The Ellis Today: During the ten or more years that it has been on the market, the Ellis has. of course, been much improved. For example, on both sides of the paper support there are paper guide rails that can be moved sideways. Machines with three different carriage widths are available. In both the typewriter and adding machine, it is possible to print over the entire surface of the paper (with the exception of the small margin on both sides). As was mentioned at the beginning. the Ellis was originally supplied with a simple case shift; however, now it is usually supplied only with uppercase letters, just as the Remington. Smith Premier, and Underwood typewriters were only equipped for uppercase letters when they were designed for use in bookkeeping. Machines with a case shift are now supplied by the Ellis factory only on request. In this new model, the tabulator key for the calculating machine tabulator is attached to the right of the calculating keys.

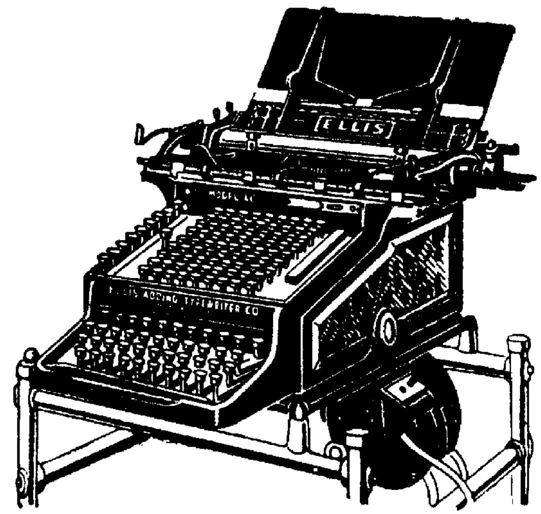


Figure 140
The newer Ellis

The greatest advantage this new model has over the old one is that the manual lever has been replaced by electric drive. The machine now stands on a massive frame made from hollow iron tubes. Underneath this is the electric motor. By simply pressing a key, the same work can be carried out that before would have involved a lot of tedious arm and hand movements. The motor contact key can be found on the right of the digit keys.

What are the advantages of the Ellis as opposed to the other typewriter systems with adding and subtracting devices?

1. With the Ellis it is possible to repeatedly use and print (or repeatedly print but only once use) the keys that have been struck on the keyboard.

2. It is possible to repeatedly print the end totals and carry the results over into the second adding mechanism as one prints them.

3. If necessary, it is possible to add a number that has been entered only once on the keyboard simultaneously in both adding mechanisms.

4. Transferring the totals from the calculating mechanism to paper is not done by copying them down (as with the Remington, Smith Premier, etc.) but follows automatically when the lever is pressed (and in electric models when

the contact key is pressed). Copying errors are therefore not possible with the Ellis.

5. The combination of the calculating machine with the typewriter is such that full annotation can be provided for items and this can be in any position desired—in front of, behind, above, or below the amounts. It is nevertheless impossible to mix up those amounts written by the typewriter with those written by the calculating mechanism because both mechanisms work fully independently of each other.

6. The Ellis is not only a bookkeeping machine; it can be used purely as an adding. subtracting. and multiplying machine for control operations, etc.

7. At the end of the line an adjustable stop causes the automatic carriage movement, with or without line feed, to move to the left margin. By pulling the lever mentioned earlier, the automatic paper feeder (which is otherwise present when digits are written vertically) is switched off. There are two other keys, one right next to the adding keyboard and the other right next to the typewriter keys. These can cause the automatic carriage movement at all times, even in the middle of lines.

This machine is also manufactured in a second model that, unlike the model just described, has only one calculating mechanism. On request, the machine is also supplied with a divided platen, so that it is possible to use one half of it for writing particulars on the page and the other for filling out monthly statements.

The Ellis is also supplied without a printing device, so that it then resembles other full-keyboard adding machines. This model is also made with either one or two calculating mechanisms, and both are equipped with a double-column writing device, just like the machine with typewriter described above.

The prices of Ellis machines are as follows:

Adding machine with one calculating mechanism	$450
Adding machine with two calculating mechanisms	$550
Typewriter and adding machine with one calculating mechanism	$850
Typewriter and adding machine with two calculating mechanisms	$950
Special machine for direct subtraction	$1275

All prices are for machines with 53-cm-wide, nonautomatic carriage but with electric drive and, in the case of the typewriter machines, without case shift. Machines with 45-cm and 60-cm-wide carriage and with case shift (that is, upper and lowercase letters) cost more.

Manufacturer: Ellis Adding Typewriter Company, East Orange, N.J.

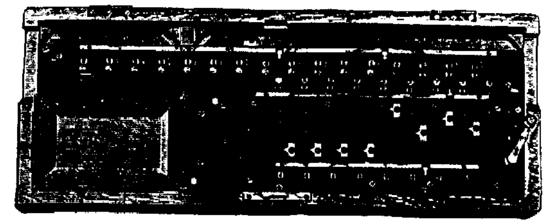


Figure 141
Model A.

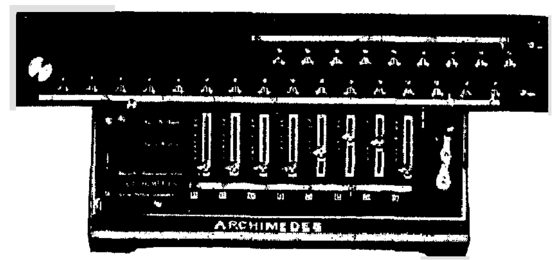


Figure 142
Model B.

Archimedes (1906)

This is a stepped drum machine similar to that described in the introduction. Both models A and B have the well-known slide-setting mechanism. Model A did not have tens-carry in the revolution; model B, however, was the first stepped drum machine to incorporate this feature. The two models do not differ materially from the remaining Glashiitter products with regard to size and weight.

Model C (1913) has slide setting, like model B, but was considerably smaller, so that the main disadvantage of the older stepped drum machines (widely spaced result windows) was considerably reduced. A setting check mechanism is provided that shows the digits of the entered value in a straight line. In the early model C machines the setting check mechanism was located below the setting slides. In a later version of this model it was located above the setting slides. Decimal point indicators are provided in all three window rows. Above the individual windows of the result mechanism are located knobs for setting the dividend or for correcting (rounding off) the result. They can only be turned either to the right or to the left when the carriage has been lifted.

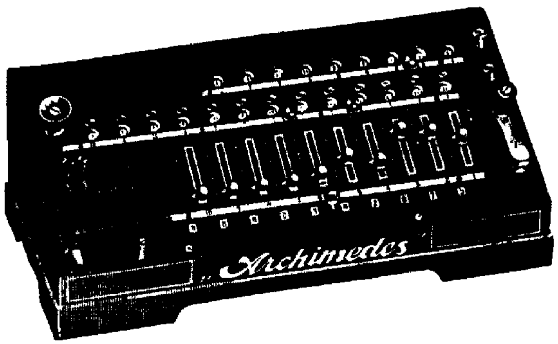


Figure 143
Model C (older version)

Model D (1915) is generally the same as model C, but it has key setting instead of setting slides. A lever is provided at the right of the keyboard that. when set to *AS,* results in automatic clearing of the depressed digits at the end of every crank revolution during addition and subtraction. This device enables stepped drum machines to add with the same speed as the full-keyboard adding machines. Shifting this lever to point to *MD* sets the machine for multiplication and division, or addition and subtraction, if an identical amount occurs repeatedly in a column—the amount need only be entered once and the crank is turned a corresponding number of times.

Below this lever a zero-setting key that clears all depressed keys. Individual keys may be cleared by slight displacement of the zero-setting buttons located below each key column. In this model the crank is arranged on the right side but, if desired, it may be provided on the left side so that people whose right arms are missing may operate the machine. The keys are only depressed to a depth of seven millimeters.

Models C and D may be equipped with an electric drive, which involves an additional cost of 900 marks. Machines with two calculating mechanisms are in preparation.

Model E is also a keyboard calculating machine. In multiplication and division the decimal shift of the counting mechanism occurs automatically in both directions by electrically driven actuating gears. The machine may be operated from any electrical power source. The motor operates only during calculation and requires approximately 16 to 20 watts—in other words, scarcely as much as a light bulb. If the electric current should fail, shifting a lever adapts the machine for operation by a hand crank; movement of the carriage also occurs automatically in this manual mode.

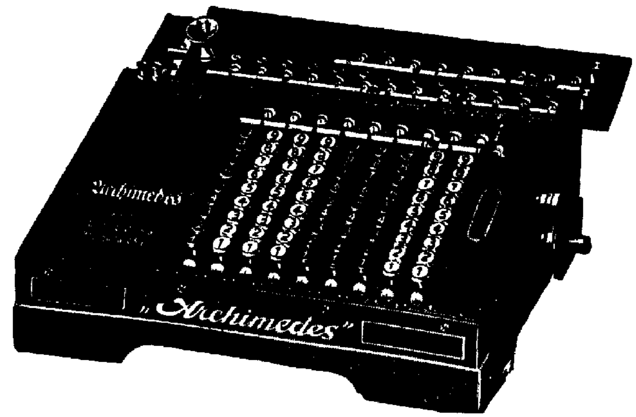


Figure 144
Model D.

The last model is the Archimedes Junior (1925), which meets the demands for a small, light, cheap, and yet entirely reliable calculating machine. It has all the advantages and features of the other Archimedes models.

Models:

Model	Places in the result mechanism	Places in the setting mechanism	Places in the revolution mechanism	Weight in kilograms	Price in marks
C 13	13	10	8	6.5	875
C 16	16	10	9	7.0	970
C 20	20	10	11	7.5	1100
C 12/24	24	12	12	9.0	1470
D 13	13	9	8	11.0	1260
D 16	16	9	9	12.0	1420
D 20	20	10	11	13.0	1630
D 12/16	16	12	9	12.5	1630
D 12/20	20	12	11	12.8	1800
D 12/24	24	12	13	13.0	2100
D 14/24	24	14	13	15.5	2300

Details regarding models E and Junior are still lacking.

Figure 145

Manufacturer: originally Fisher and Pöthig of Glashütte, and since 1912 Glashütter Rechenmaschinenfabrik Reinhold Pothig of Glashutte, Saxony.

Contostyle (1906)

Designer: Henry Goldman of Chicago. The machine was also called Arith-style and was manufactured by Gesellschaft fur Maschinenbau und elektrische Neuheiten G.m.b.H., Hafenplatz, 5, Berlin, and sold by Henry Goldman of Berlin. The factory is no longer in existence, and production of the machine has been discontinued. It is a nine-place miniature adding machine, with chain setting, without check windows, but with a decimal point indicator. Zero-setting of the calculating mechanism occurs by forward rotation of the small gear that can be seen on the right side. Subtraction takes place by means of complementary figures; provision is made in the machine for the correction of the units place in subtraction; all other places are to be read according to the left complementary digit row.

Austria (1906?)

This is a stepped drum machine similar *to* that described in the introduction. Manufacturers: Rechenmaschinenwerk, "Austria" Herzstark and Company, of Vienna, originally V/2 Morizgasse 2c and now XIII, linke Wienzeile 274.

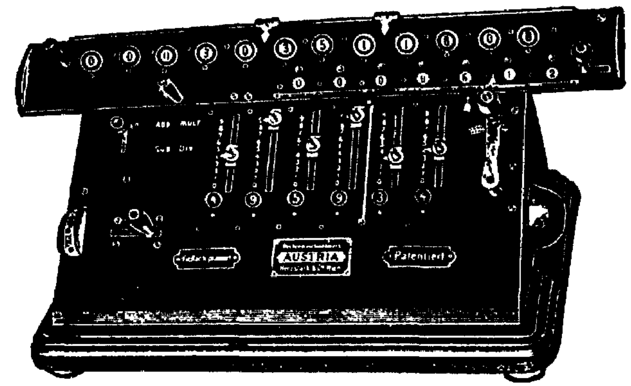


Figure 146
Model 3.

Model III: six places in the setting mechanism, twelve places in the result mechanism. and seven places in the revolution counter.

Model IV: seven places in the setting mechanism, twelve places in the result mechanism, and seven places in the revolution counter. The machine is provided with a crank lock against erroneous operation and also possesses a device for moving the carriage one place at a time by the push of a key. The machine may also be equipped with a double carriage or with a double-carriage electric drive, and a mechanism for setting the multiplier by multiplication keys provided on the right side of the machine, each of which, when depressed, carries out a multiplication by a single-digit amount. The maker calls this model Elektromens.

Model V: this model has seven places in the setting mechanism, fourteen places in the result mechanism, and seven places in the revolution counter. It has a device that, in division, locks the crank in place if a larger value is being deducted from a smaller value.

Model VI: has nine places in the setting mechanism, eighteen places in the result mechanism, and nine places in the revolution counter. It has a keyboard setting capable of automatic release during addition. This model may be supplied with electric drive.

All models have setting check windows.

In former years the machine was available in Germany. At one time it was sold there under the name of Austro-Germania.

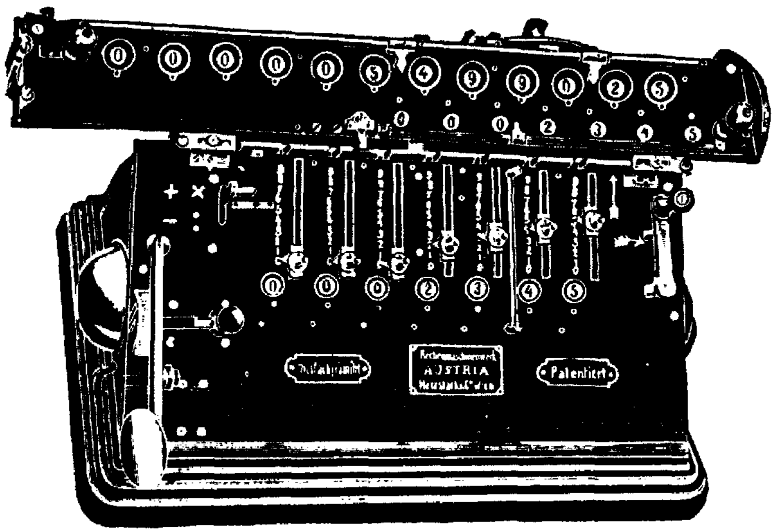


Figure 147
Model 4 (Austria)

Adsumudi (1907)

Designer: Alois Salcher of Innsbruck. Manufacturer: Uhrenfabrik C. Werner of Villingen in Baden. The factory is no longer in existence, and production of the machine was discontinued about 1908.

It is an adding and subtracting machine that is also capable of multiplication and division when multiplication slides (as shown in figure 148) are attached. The machine has a second row of result windows so that the result of the main calculation may be stored for possible later use. Entry of numbers is done with the aid of the slides held under the pressure of springs. The even numbers may be found at the right side and the odd ones at the left of the slides, which are just above the setting check windows. These windows, in which every entered amount becomes visible, are driven by a double rack (which forms an extension of the setting slide in the interior of the machine) that serves to convert the motion of the slide to a corresponding rotation of a gear located between the two racks, which turns a numeral dial located above the gear to the right or to the left. The right rack acts in an additive, the left in a subtractive sense.

If one intends to add with the machine, the first amount is entered by means

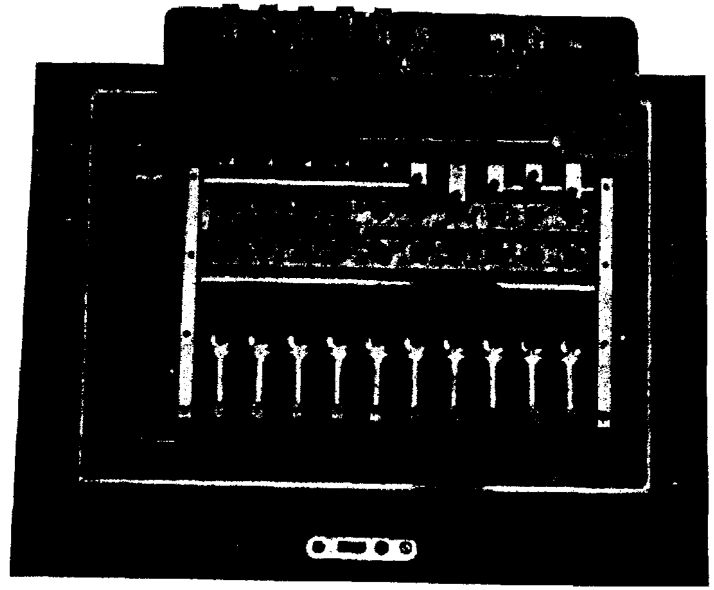


Figure 148

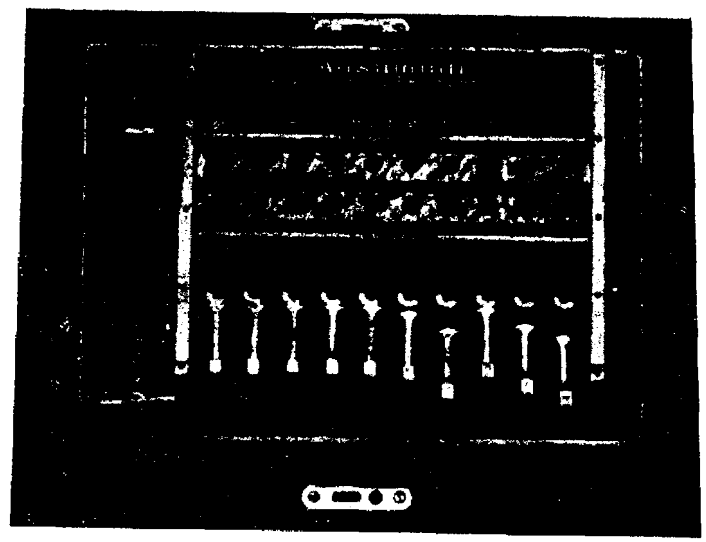


Figure 149

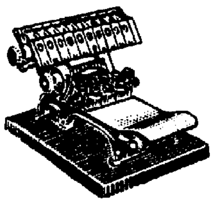


Figure 150

of the setting slides, then the machine is adjusted for addition, and the lever situated at the left of the machine is raised. This allows springs to return all setting slides their initial positions. The racks mesh with the gears of the adding disks and turn them so that the amount set may be read in the result windows. Additional items may be added in the same way.

In division the larger amount is first introduced into the result windows, then the smaller amount is entered by means of the slides.[66] The machine is adjusted for subtraction and the previously mentioned lever is raised, which effects release of the slides causing them to snap back into their initial position and thus turning the numeral disks in a substractive direction. As previously mentioned, multiplication and division occur by applying a special multiplication slide. The machine was available with ten places, but it never gained any importance.

Heureka (1907)

This is an adding machine with only nine keys but ten places in the result mechanism. It was manufactured and sold by the A.G. for the technical industry in Zurich. A small number of these machines were, in their time, sold in Switzerland and France and individual machines may be found in Germany and London. Production has long since been discontinued, and the firm that manufactured the machine has long ago ceased to exist.

Soll and Haben (1907)

The inventor of this machine is the bank accountant Karl Kettlitz of Breslau IX, Adalberstrasse 9. Models of this machine have been prepared, but up to now the machine has not been put into production.

66. Martin clearly has the word *division* at this point, but the editors believe that *subtraction* would be more to the point.

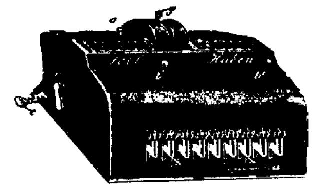


Figure 151

It is a nine-key adding machine with which columns of digits, and even multidigit values, may be added. It is intended for current account calculations and thus has two separate counting mechanisms, one for debit items and the other for credit items. Both types of numbers may be entered at random. If both columns have been added up and the balance is to be computed, the mechanism exhibiting the smaller sum is set to zero, which leaves the balance in the other calculating mechanism. The machine is said to perform multiplications and divisions as well.

Ensign (1907)

This is a highly developed, electrically driven adding and subtracting machine particularly suited for multiplication, and in this respect it exceeds many other American machines.

On the exterior of the machine is a keyboard containing complementary digits for subtraction and division. At the right of the keyboard there is a long

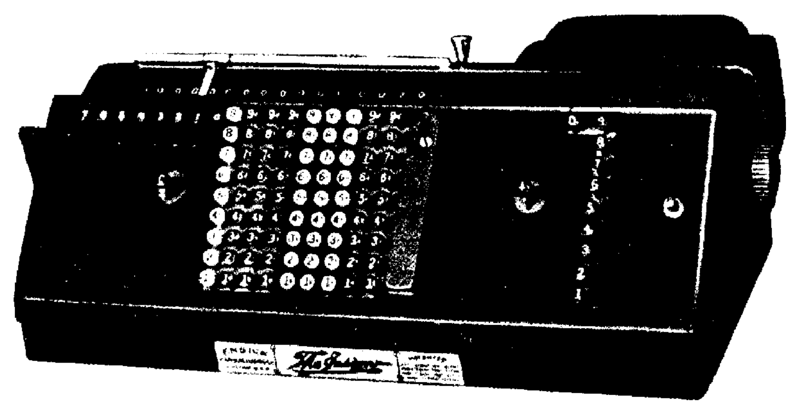


Figure 152

adding key, further to the right is the division key, and finally the multiplication keys marked 0 to 9. To the left of the keyboard is a key that allows the value entered on the keyboard to be locked in place. At the top left is the revolution counter, and above this, within the carriage, is the result mechanism with sliding decimal marker and the carriage handle. The keys are self-correcting.

Addition: The **first** amount is entered in the customary way; the long adding key is depressed, and this transmits the amount to the result mechanism. Any number of additional items may be added in this way. The added items are counted in the revolution counter. In order to set the machine to zero, the carriage must be placed to the extreme left. Then the small lever (to the left of the revolution counting mechanism) is quickly depressed into the machine, and both counting mechanisms are cleared. The keyboard may be divided so that two rows of items may be simultaneously added by the machine (for instance, debit and credit items).

Subtraction: This operation takes place in the same manner as addition, but the amount must be entered by using the small complementary digits.

Multiplication: The multiplicand is entered in the usual manner. If it is intended to multiply it by 205, the digit 5 of the multiplier keys is first pressed, then 0, and finally 2; the result may be read in the result mechanism. The multiplier may be read in the revolution counter and the multiplicand in the keyboard, which provides a check on the operation.

Division: First the division key is pressed, then the zero of the multiplication keys is kept depressed until the carriage is positioned to the extreme right of the machine. Now the dividend is entered, and the long adding key is pushed, which transmits this amount into the result mechanism. The digit 1, which appears in the revolution counter because of the above action, is cleared, and the divisor minus 1 is set into the keyboard, by using the complementary digits, in such a way that the left-hand digits of the values are aligned. All the keys to the left of the divisor must be set to nines. An estimate is then made as to how often the divisor is contained in the dividend: if, for example, the estimate is two, then the 2 key of the multiplication row is depressed, the machine commences operation, and the digit 2 appears in the revolution counter. The carriage is now shifted by one place to the left. and the division is continued in the manner explained. The result may be found in the revolution counter, a repetition of this quotient in the left of the result

mechanism, and the undivided remainder, if any, in the right portion of the result mechanism (separated from the other numbers by zeros).

The machine is available in two models:

Model 75	7 × 5 × 12 places	$450.00
Model 90	9 × 7 × 16 places	$500.00

Manufacturer: The Ensign Company, Brighton District, Boston, Massachusetts. This machine has not, up to now, been introduced into Europe. The designer is Emory A. Ensign of Boston.

Tim (1907)

The Tim is a stepped drum machine (Thomas system), similar to the general description given the introduction. Manufacturer: Ludwig Spitz and Co. of Berlin-Tempelhof, Eresburgstr.

Originally the machine was supplied built into a wooden case. In 1909 the machine was improved by the engineer Robert Rein. The particular characteristics of the improvement will be described. A cast iron housing with a tight-fitting central bearing plate took the place of the wooden case and of the brass bearing plates. The bearing plate at the back, which serves as support for the result mechanism and for the locking disk shafts,[67] and the bearing plate at the front, which serves as support for the locking disk shafts, the stepped drum shafts, the drive shaft, the crank shaft, and the setting slides, are screwed to the housing. Thus all the movable parts of the machine are supported by three cast pieces.

The Tim machine differs materially from the other stepped drum machines with regard to the performance of the counter mechanism. To be sure, in the Tim machine the movement of the entire mechanism originates from the counter mechanism and the tip (3) of the actuating arm (2) is pressed down, the actuating arm (2) operates the lever *(5)* by means of a pin (6) that slides in the center of the bearing plate (1). In other words, in this machine the lever is located on the other side of the central bearing plate (1). Now comes the great simplification of design: the guide rod, with the spring and fork, has been dispensed with. The lever engages directly, without any intermediate mechanism, the annular groove (7) of the hub of the actuating tooth (8) for the tens wheel. Another improvement is the separation of this hub from the

67. **The editors freely admit that they have no idea what a "locking disk shaft" is.**

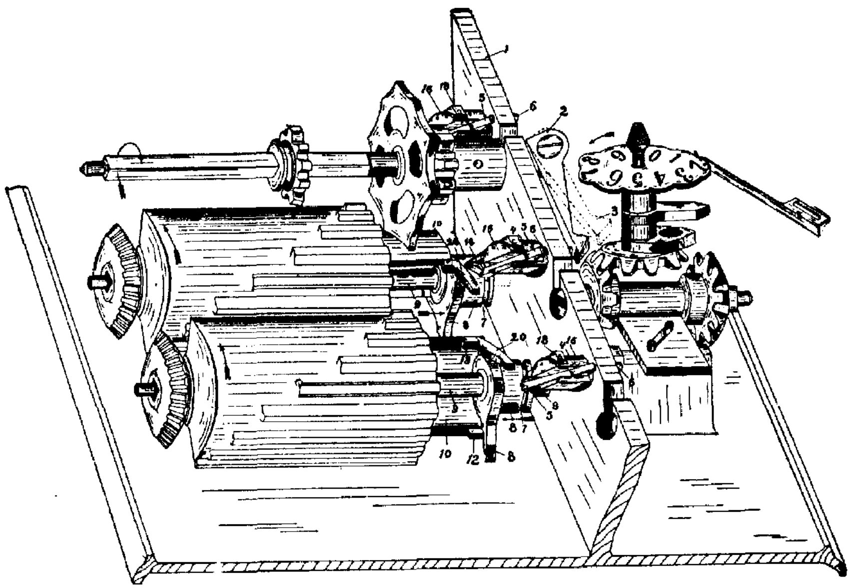


Figure 153

locking cylinder (10), thus this heavy part no longer partakes in the movement. Additionally the whole arrangement **is** made positive by the fact that lever (5), when actuated, is locked by steel piece (18), and is again unlocked at the appropriate time by cam (20). Thus, the number and mass of movable parts has been reduced. The number has been reduced by elimination of the guide rod (12) and spring and fork, and the mass has been reduced by the fact that the actuating knob is no longer integral with the locking cylinder, and hence this heavy part need no longer be moved. When in use, these improvements demonstrate themselves primarily by the quietness of operation, the easy rotation of the crank, and last, but not least, by correct results no matter how hastily the crank is turned.

It will be seen from the figures that the values entered are indicated in a special row of windows. The levers that can be seen below the setting slides serve as general or group clearing devices. They permit any desired number of setting slides, on the left or on the right, to be set to zero. If a lever in the middle is raised, then all slides to the right move to zero, and if it is depressed, all slides to the left move to zero. When either the rightmost lever is depressed or the extreme left lever is raised, **all** of the setting levers snap back

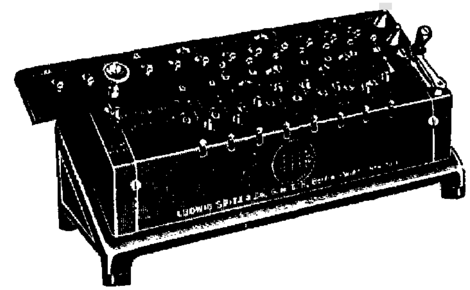


Figure 154
Slide setting, manual drive

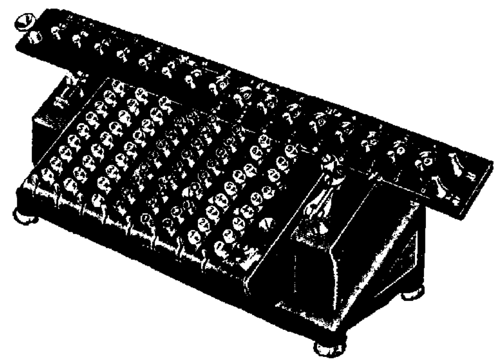


Figure 155
Key setting. manual drive.

to zero. This arrangement is an appreciable timesaving device. The front plate and the carriage are arranged in such a manner that they may be conveniently detached in order that the machine may be opened for cleaning and lubrication without using a tool. Multicolored decimal point markers are provided for all rows of windows.

Setting knobs are provided below the windows of the result mechanism ***so*** that digits may be entered directly.

The Tim machine also has a version with key setting. These keys allow one to set up eight- to ten-place numbers by a single depression of the corresponding keys. During addition the zero setting of the keys occurs automatically, in the usual way, during each turn of the crank. **All** advantages of the machine with slide setting have been fully retained.

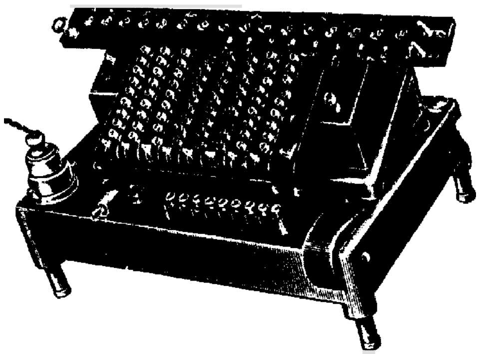


Figure 156
Key setting. electric drive

Both of the models described may be equipped with an electric drive usable with any kind of current; it may also be fitted to previously supplied machines, except those in wooden cases, by simply returning it to the factory for a few days. In a machine having electric drive, the turning of the crank is completely eliminated. It is only necessary to depress one of the multiplication keys and the machine immediately begins to calculate automatically; the entered amount and the desired value appear automatically in the result and revolution counter mechanisms respectively. Thus, in the Tim machine, both factors may be entered by means of keys.

All three models of the Tim machine and the Unitas machine are manufactured in the following sizes:

Size	Digits in the setting mechanism	Digits in the result mechanism	Digits in the revolution counter
II	8	12	7
III	8	16	9
IV	10	16	9
V	10	20	11

Unitas (1907)

Unitas is a trade name for the Tim equipped with a double counting mechanism, designed by the engineer Robert Rein, who passed away on 8 January

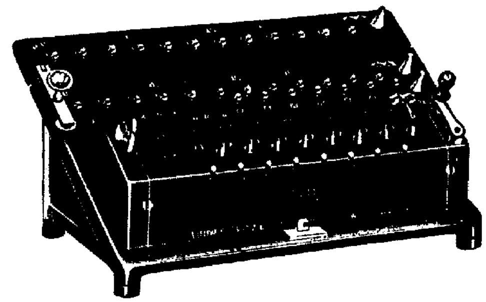


Figure 157
Slide setting. manual drive

1921. The Unitas was originally supplied in a wooden chest, but since 1909 it has been furnished in the form illustrated in figure 157.

The reversing levers, positioned to the left of the setting slides, are capable of setting both counting mechanisms to addition or subtraction, or of setting either one to add while the other subtracts. This considerably increases the applicability of the machine. It is possible to simultaneously subtract a result, computed in the first result mechanism by multiplication, from a given value in the second calculating mechanism. For instance:

63 meters @ 4.25 =	267.75
57 meters @ 3.75 =	213.75
7X meters @ 5.27 =	411.05
	892.56
Less 7¾% discount	69.17
	823.39

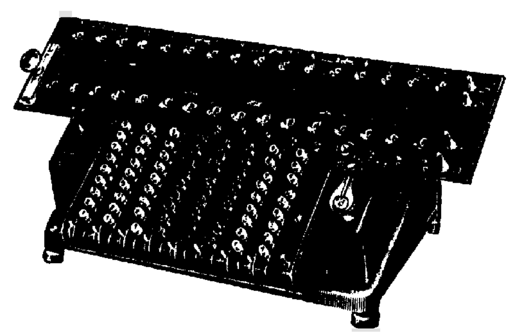


Figure 158
Key setting. manual drive.

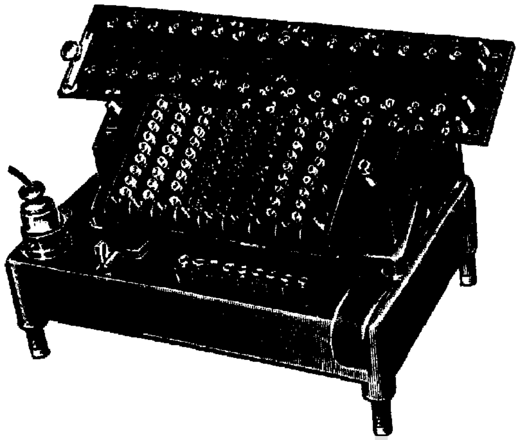


Figure 159
Key setting. electric drive

The Unitas may therefore be regarded as a machine unsurpassed in its efficiency.

The Unitas is also supplied with keyboard settings. and both models are available with electrical drive. Like the Tim, it is manufactured in four sizes, with identical numbers of places.

Manufacturer: Ludwig Spitz and Company, Ltd., Berlin-Tempelholf, Eresburperstr.

Madas (1908)

The word Madas is composed of the initial letters of the words Multiplication, Automatic Division, Addition, and Subtraction. The machine belongs to the class of stepped drum machines but has automatic division. In all other calculating machines, division requires great attention on the part of the operator because a relatively large number of different kinds of manipulations. and even corrections, are necessary for every individual place of the quotient. The Madas divides entirely automatically. All that is necessary is to enter the dividend and the divisor and then to turn the crank until the bell sounds, which indicates that the division has come to an end. The computation of the quotient, the shifting of the carriage, and the indication of the remainder are automatically taken care of by the machine.

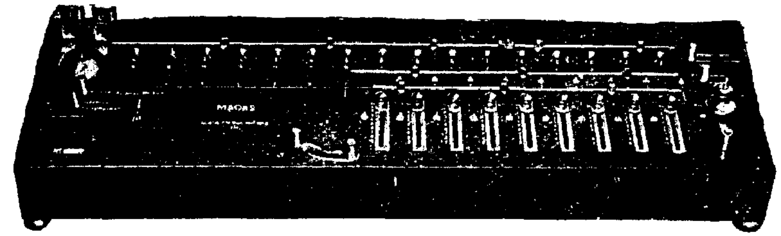


Figure 160
Madas with slide setting. hand drive.

Aside from automatic division, the Madas exhibits several additional advantages compared to other stepped drum machines. The lifting of the carriage has been eliminated, thus displacement of the carriage from place to place or over its total path of travel, clearing of the two rows of windows, and setting up of digits in the result row, may all occur when the carriage is in its normal position. Moreover the Madas possesses devices intended to prevent errors in operation: most of the handles in the machine have ingenious interlocks so that none of them may be operated when another one has been incorrectly set.

On the exterior, the Madas differs from the general description of stepped drum machines as given in the introduction in several points. Located between the slide slots are windows from which the amounts set may be read in a straight line. A lever is provided to the left of the last setting slot by means of which all setting slides may be returned to their initial positions.

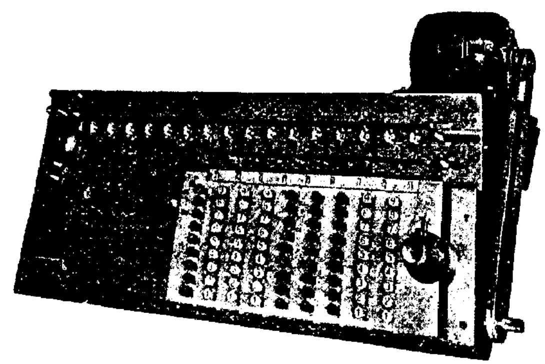


Figure 161
Madas with key setting and electric drive

The two levers located above the bell serve for moving the carrige from place to place and over its total path of travel. The knob for automatic division is located below the bell—this knob is to be pushed to the left. Upon termination of automatic division, the digit 0 must appear in the window below the automatic division button, otherwise it is necessary to make one or two additional turns of the crank.

Designer: Erwin Jahnz, Manufacturer: H.W. Egli, A.G. in Zurich, 2.

Models:

7 x 7 x 12 places, slide setting, manual operation or electric drive

7 x 7 x 12 places, with keyboard, manual operation or electric drive

9 x 7 x 12 places. with keyboard. manual operation or electric drive

9 × 9 x 16 places, slide setting, manual operation or electric drive

9 × 9 x 16 places, with keyboard, manual operation or electric drive

11 x 9 x 16 places, slide setting or keyboard, and a divided 0 setting, manual operation or electric drive

11 x 7 x 16 places (for English currency), slide setting, manual operation or electric drive; or keyboard, manual operation or electric drive

Bunzel-Delton (1908)

This is a stepped drum machine. The designer was Hugo Bunzel, a calligraphy teacher and former painter in Prague. The manufacturer was the Bunzel-Delton-Werk Fabrik automatischer Schreib- und Kechenmaschinen, Favoritenstrasse 194, Wien X.

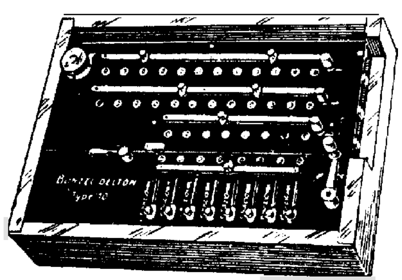


Figure 162

The machine was supplied with one and two result mechanisms, with and without tens-carry in the revolution counter, and with additional stepped drums. In some machines one could switch from addition-multiplication to subtraction-division by reversing the direction of the crank. A number of different sizes were available. Factories were set up in Austria, Germany, Italy, and France, although the number of units sold was never large. At the end of 1915. production was stopped because of the death of the factory owner. Since that time, a Bunzel-Delton calculating machine factory has been set up again (12 Klimschg., Vienna III/1), although there are no details available about their machine at this time.

Kosmos (1908?)

This is a full-keyboard machine. manufactured only for English currency, by the British Calculators Ltd.. Belfast Rd, Stoke Newington, London N. The firm is no longer in existence.

The machine has three columns for pounds, ten keys for shillings, eleven tor pence, and three for farthings. On the left of the keyboard is a zero-setting key; when this is pressed, while at the same time the crank is turned as far as it can go. all the viewing windows are simultaneously set to zero. Apparently there was also a model constructed with five columns for pounds.

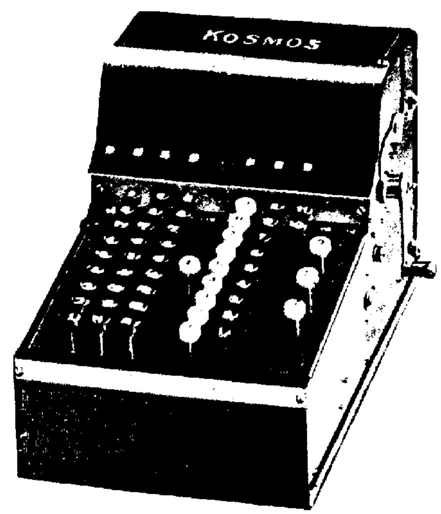


Figure 163

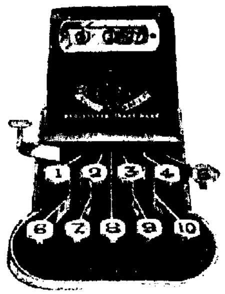


Figure 164

Adder (1908)

This is a ten-key adding machine intended only for the addition of single columns of digits. In operation it is similar to the Adix. It was manufactured in London and sold for two guineas, although production has been stopped for some time now.

Lightning Calculator (1908)

This is a seven-place adding machine, similar to the machine of Michel Baum, although it does not equal it in quality. For any digit over five, it is necessary to move the adding stylus quite a distance. It is not possible to check whether or **not** the correct amount has been entered, and all the calculating gears used have to be returned to zero individually. The viewing windows. visible above the setting gears, are used to read sums, while the results from subtraction appear in the setting windows of digit 9. Tens-carry is automatic. Dimensions: 30 × 8½ x 5 cm. Price $15. Manufacturer: Calculator Company. Grand Rapids, Mich.

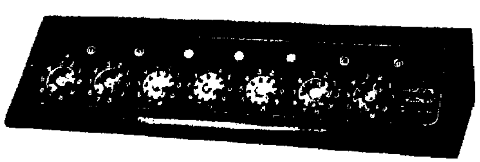


Figure 165

Figure 166

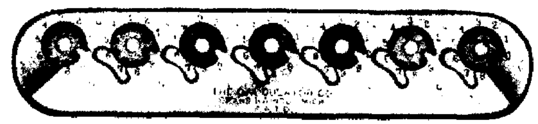


Figure 167
Calculator.

Pangborn Adding Machine (1908)

This machine comes from the same factory as the Lightning Calculator, but it docs not have any special viewing windows for sums. Results of addition appear as red figures and subtraction results as white figures in the setting gears. In **ail** other respects, the Pangborn is identical to the Lightning Calculator — including the price.

The same machine is also available without a stand and is **simply** called Calculator. The price of this machine is $7.50 (out of sheet steel) and $10.00 (out of plated steel), although these prices may no longer he valid. It can be assumed here that the Calculator is identical to the Calcumeter described earlier.[68]

Pebalia (1908)

This is the design of Vinzenz Edlen of Pebal. It has the same type of digit disks that were in the machine Michel Baum brought onto the market **as** a torcrunner to his machine. It has direct subtraction, which means that the digits to be subtracted arc entered by turning the gears backwards. This would

68. Examination of devices in the National Museum of American History Collections suggests that while the Lightning Calculator. the Calculator, and the Calcumeter are similar, they arc not identical.

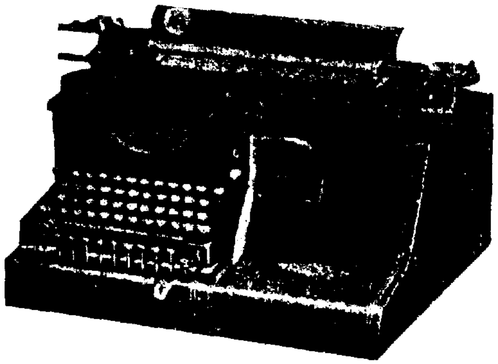


Figure 168

have been an ideal solution if the machine had not become too long, thereby slowing down the entry of numbers. There was also a five-place model of this machine (Triona) that was built into a case; this was used as a household money box with calculating device, however manufacture was soon halted.

Duntley (1908)

Figure **168** shows the Duntley adding and subtracting machine of the Duntley Adding Machine Company, 1010 Fisher Bldg., Chicago, in combination with a Monarch typewriter. For some time now the machine has not been manufactured and has remained essentially unknown, even in America.

Bordt (1908)

The Bordt is from the same designer as the Adix described earlier but is a printing, full-keyboard, adding machine. Digits to be added are simply entered into the keyboard according to their decimal place and value, the crank is moved up and then down again to carry out the addition, and the keys return once more to their rest position. The result can be seen through the viewing windows above the keyboard every time movement of the crank is complete. Before the beginning of any new addition, the machine must be cleared, i.e., set on zero. This is done by raising the zeroing lever and then turning the zero-position crank from left to right—all the viewing windows will then show zero.

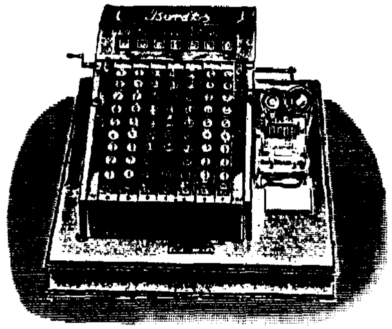


Figure 169

For each decimal place there is a correction key located below the 1 key. Each time an incorrect digit has been entered, the correction key, at the relevant decimal place, is pressed, and the incorrect key springs back to the rest position. In addition to these keys, there is also a correction lever on the left side of the machine used to erase a complete number, several digits long, that has been incorrectly entered. If this lever is pressed down, it raises all the keys in all decimal places. As soon as a key has been pressed, all those in the corresponding decimal place are locked to avoid accidental entry errors. The correction lever also saves having to press the same keys more than once—it can be pushed up, causing those digits that have been pressed once to remain in their position; all that is needed to add the same number several times is to move the crank up and down.

There is a printing device attached to the right side of the machine that may be used to check the numbers entered. During addition it is possible to check the digits entered and, if necessary, to add any notes by hand. Printing is visible immediately. The holder for the roll of paper is installed at the front right edge of the board upon which the machine is mounted. The roll is then fed to the paper transport feed reel, and the wing nut next to the reel is turned from left to right until the paper passes out about two centimeters above the rubber base. The paper strip will automatically move again as soon as the crank moves. The machine can add and print, or add without printing, depending on the position of the lever attached to the crank shaft. If it is pushed up so that it is in the same position as the crank shaft itself, then the machine is set for printing. If the lever is pulled down, then the printing device is switched off.

If zeros are not to be printed in front of the numbers, there is a zero-

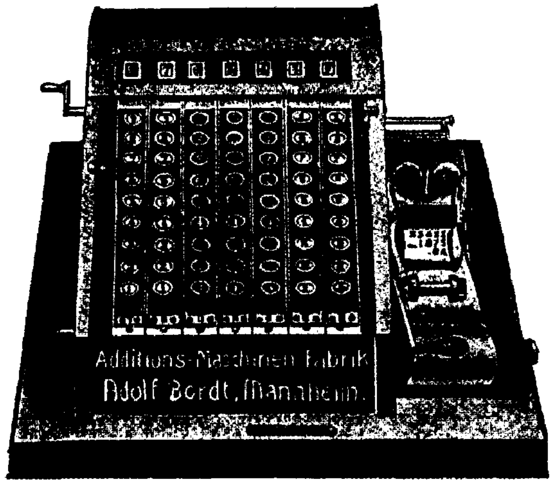


Figure 170

covering mechanism that automatically removes the zeros on the left side by means of a sturdy little plate. This plate has to be replaced from time to time, but this is easily done by simply taking out the old one and inserting a new one onto the shaft.

When a column has been added up, and the result is to be printed, the crank must first be moved: i.e., a dummy operation is carried out in order to make a gap on the paper strip. It is then necessary to enter the number appearing in the windows of the result mechanism. A key, standing alone on the left side next to the keyboard, is then pressed, after which the crank is moved, and the result appears on the checking paper strip. If this key is held down, then the printing repeats itself as long as the crank is operated. The digits are not printed by means of a colored ribbon but rather a colored pad, which from time to time must be resoaked with fresh stamping ink. This can be done using a small paintbrush.

In 1910 the Bordt was improved. The result mechanism now has an eighth digit place, so that the seventh column of keys may be used for addition. The printing mechanism has a colored ribbon that runs automatically and switches automatically from one side to the other. The machine is also available without a printing mechanism. Price: 450 marks.

Manufacture was later moved to Leipzig, and the name of the firm changed to Bordt and Behrens. The Adma, which has already been referred to in the discussion of the Adix, was later to develop out of the Bordt.

Greif (1908)

This is a small adding machine with chain drive, similar to the Argos. It was distributed in both Germany and France (Griffon-Duplex). Manufacturer: Gesellschaft Fur Maschinenbau und Elektrische Neuheiten, G.m.b.H., 2 Bach St., Berlin NW, and later 22 Karlsbader St., W. 35. The firm is no longer in existence, and the machine is no longer manufactured.

Dennis (1908)

This is an adding and subtracting machine that can be used with a typewriter. It is from the same designer as the National although it has never gotten past the trial period.

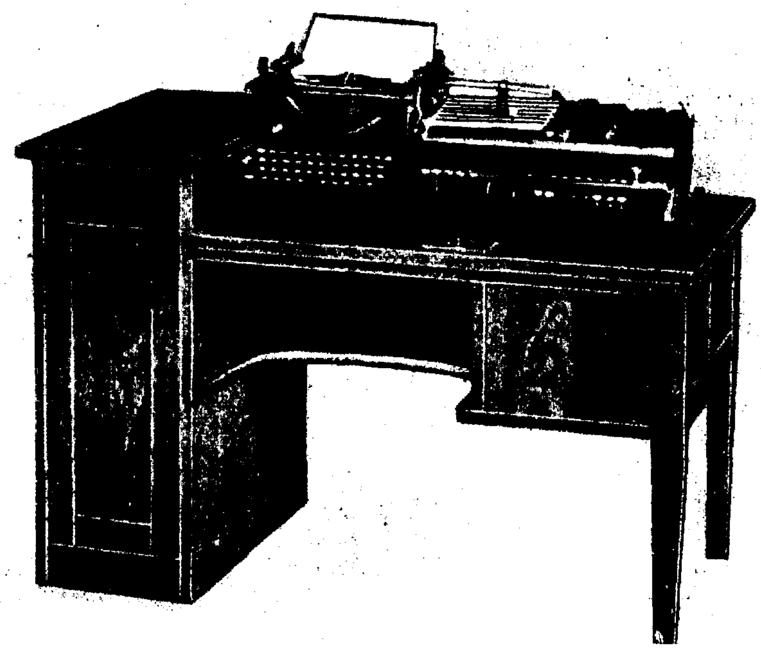


Figure 171
Dennis.

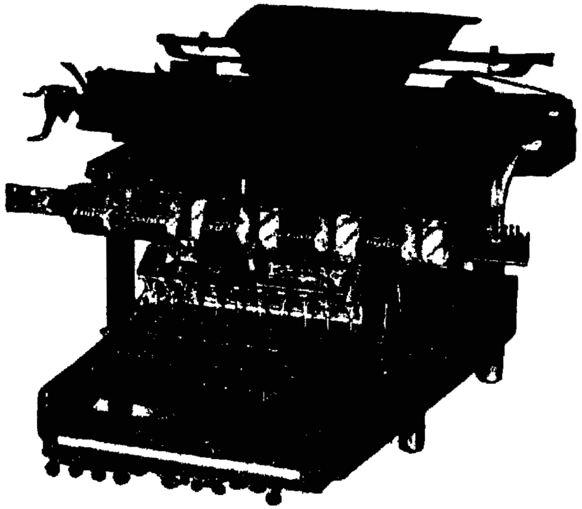


Figure 172

Wahl Adding and Subtracting Device (1908)

The Wahl adding and subtracting device can only be used when connected to a typewriter. Exclusive right of use was acquired by the Union Typewriter Company. the well-known manufacturer of the Remington, Smith Premier (with full keyboard), Monarch, and Yost. It is only with these four machines that the Wahl adding and subtracting device can be used. The Remington. whose printing was of the blind. or hidden, variety at this early date, was the first to be supplied with it. Shortly afterwards the company brought out a model with visible typing. This model was immediately equipped with the device and, somewhat later, so was the Monarch. Production of the Monarch machine stopped in 1921; that is, the product was renamed from this time onward the Smith Premier, although. as opposed to the Smith Premier (with full keyboard), it operated with only uppercase. It is illustrated in figure 178. Both the Smith Premier (with full keyboard) and the Yost (visible printing models of both these kinds only) were equipped with the Wahl device, white the earlier hidden printing models were not equipped for addition and subtraction. In **1923.** the typewriter firm discontinued both brands. Today only the Remington and the Smith Premier, both dual case, are available with the Wahl adding and subtracting device.

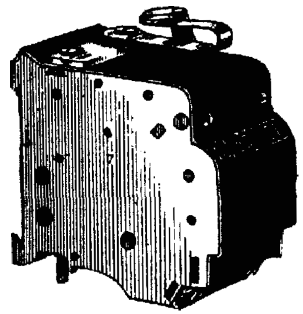


Figure 173

The device consists largely of an actuator and one or more calculating mechanisms. Above the typing keys is a boxlike device that belongs to the counting mechanism. This is the actuator from which rods lead down and connect. in turn. to the digit keys. The calculating mechanisms are placed on a rod running diagonally across the machine. One such calculating mechanism is shown in figure 173. This case is less than 4 cm high and 3 cm wide. On the inside there are small disks, indented on one side, printed with the digits 0 to 9; these are placed vertically next to one another. They are set in motion by pressing the two gear wheels attached to the typewriter. This is the same system, only on a smaller scale, as it used in the well-known large calculating machines. The two gears rotate around themselves simultaneously with the number disks. The typist will meet a certain resistance when typing the numbers, arid this causes a delay in the action of the machine. The bigger the value of the digit to be added, the longer the delay in action is. although it should be pointed out that this is really quite minimal and something one soon gets used to.

To attach the device to a rod, a small lever must be pressed. This automatically causes the lower groove of the calculating mechanism to lock into a lower disk. After it is attached, it is possible to shift the calculating mechanism to either side but with little or no clearance either above or below. When the place where the column should appear on the paper has been located, the calculating mechanism is shifted to this position and fixed there. If there are several columns in the calculation, then several calculating mechanisms will be needed. Up to thirty calculating mechanisms (Monarch **32)** can be attached depending on the width of the carriage. As the typewriter moves

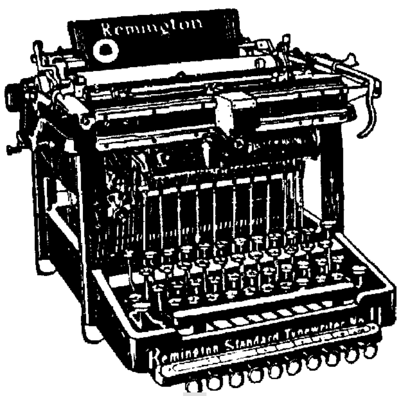


Figure 174
Remington with one calculating mechanism

sideways, the calculating mechanisms move along with it. The actuator. however. does not move, as it **is** fixed to the body **of** the machine.

In order to add **or** subtract, the typewriter must first be connected to the adding and subtracting machine. This is done by shifting a lever on the left side of the actuator. In order to add, the actuator must be set on addition. When this is done. and the digit key (say 3) is pressed, then the calculating mechanisms mesh in the row of digits that is in gear with the actuator. The number 3 appears in the result window. If the carriage of the typewriter is shifted back the space of one letter and the digit 4 is pressed. the corresponding calculating mechanism will show 7. In order to subtract 2 from this sum, the actuator must be set **on** subtraction **and the carriage** shifted back one letter space; when the digit **2** is pressed. the calculating mechanism will move to show 5. The gears rotate forward **or** backward according to whether they are performing addition or subtraction. The machine only begins to add if the actuator. itself stationary, comes into gear with the calculating mechanism which moves along with the carriage.

How does such a machine operate in practice'! In order to produce a statement of account, all the debit items are entered in the first column and, by so doing. are automatically added up. The calculating mechanism **is** then shifted to the second column where all credit items are entered. The entering of the credit items must only be done after the calculating mechanism has already been set on subtraction—this ensures that each individual credit item, as it is typed. is subtracted from the sum of debit items without the typist having to

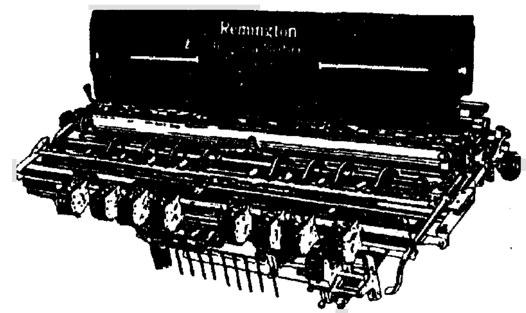


Figure 175
Carriage of a Remington with eight calculating mechanisms and cross footer.

do anything extra. When all the credit items have been entered, the amount remaining in the calculating mechanism represents the balance that must be typed into the credit column (in red if necessary). If the calculation is correct, that **is,** if the typist has not made a mistake in reading or typing, the calculating mechanism will show **a** result of zero. To finish **off** the account, there **is** nothing to do except enter the sum of the debits underneath the calculation. This example shows that it is possible to use one calculating mechanism for two columns.

Let us assume, for example, that there are accounts to be written, the amounts of which have already been entered into the account book and totaled. The individual entries are added up while being typed in and, as soon as the last item has been typed, the result of all the written totals appears in the calculating mechanism. If this total agrees with that already added up in the book, then this **is** proof that not only is the addition in the book correct but also that the individual amounts have been correctly entered. For this sort of work a single calculating mechanism is sufficient. For other operations. two calculating mechanisms are necessary. and in certain cases as many as thirty can be attached and used. **All** of these work independently **of** each other, and each gives the total for its column as soon as the typing has been finished. When transferring to another task. the calculating mechanisms must be reset to zero. This is done by setting the machine on subtraction; the amount in each calculating mechanism is entered, and this will cause the mechanism to return to zero.

In addition to those calculating mechanisms already mentioned, which can be provided in whatever number is convenient, the machine can also be

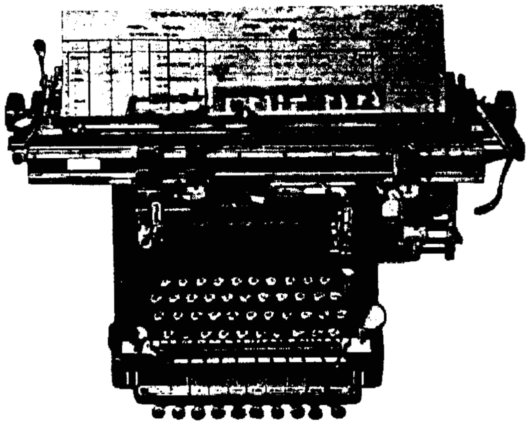


Figure 176

equipped with another adding and subtracting device. This does not move when the typewriter carriage shifts sideways but is situated to the right of the actuator and is used to add or subtract the amounts in calculating mechanisms, for vertical columns of numbers, in order to work out the balance. This second machine is called, in the United States. *cross-footer*—a name we have adopted; more correctly. however, we should say transverse adder.

How does such a machine operate? Let us assume, for example, that the following four columns are to be filled out:

old balance debit credit new balance

First the blank form is put into the machine. The four calculating mechanisms necessary for the task are attached in such a way that each comes over one of the four columns. All calculating mechanisms must be checked to make sure they are registering zero. Then the typewriter carriage is shifted (with the help of the proper tabulator) to the first column. The first amount, 200 marks, is entered and at the same time it is transferred into the respective calculating mechanism; it also appears in the viewing window of the cross footer. The carriage is shifted into the debit column and the amount of 50 marks is typed in; this is added in the second calculating mechanism, while the amount in the viewing window of the cross footer increases to *250* marks. The next amount, 10 marks, is typed into the credit column after the adding device has been set on subtraction; it immediately appears in that column's calculating mechanism but is subtracted from 250 marks—the amount which

is in the viewing window of the cross footer. If this amount is then entered into the column for "new balance" so that it appears in the calculating mechanism for that column, then, at the same time, the amount disappears from the result mechanism of the cross footer. If, however, a mistake has been made so that the cross footer does not go to zero, the machine becomes locked. The rest of the items are added in the same way. The calculating mechanisms above the individual headings indicate the sum of all

old balances debit carryovers credit carryovers new balances

At the end of a day's work, it is possible to make a check; namely, the sum of the old balances, plus the sum of the debit items, minus the sum of the credit items should give the sum of the new balances. The cross footer mechanism can also be switched off so that, if necessary, amounts only appear in the respective calculating mechanisms without effecting the result in the cross footer.

The description so far concerns not only the Wahl device in combination with the nonvisible and visible typing Remington but also the Monarch, Yost, and Smith Premier with shift key. The Monarch and blind Remington were in fact available only with actuator and calculating mechanisms but not with cross footer. The next few lines will be given to the description of Remington-

Figure 177
Monarch with two calculating mechanisms

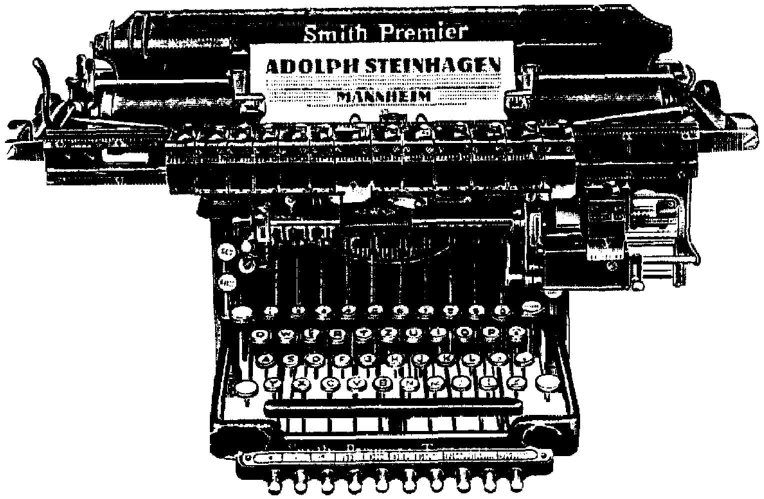


Figure 178
Smith Premier with provision for vertical and horizontal addition and subtraction

Wahl, since their factory made an especially large number of units for use in billing, or rather bookkeeping.

As is well known. the Reniington is also supplied with a divided (or divisible) platen cylinder. In this model, the right half responds to the right platen roll control knob. the left half to the left knob, although both halves can be connected so that they work as a whole, like the paper cylinder of a normal typewriter. With this machine it is possible to insert two forms next to one another and enter information into each of them. An example would be to take the account form on the left half and on the right half the book page containing only the total, not the details of the account. Making out the account and transferring the items to the book can be done simultaneously on the same machine. This method has three advantages. First, the work is carried out by one clerk. There is no longer any need for the clerk to wait for the account to be made out before he makes the transfer. Second, carbon paper is not needed to transfer to the book, as is standard practice in other billing methods, and, as everyone knows, carbon copies easily become indistinct when the book is frequently used. But the greatest advantage of all is that the columns are added simultaneously as the typing is being done.

For other reasons. it may well be desirable to have a machine available not only with a decimal place tabulator but also a column tabulator. Whereas the first is used. as is well known. to print columns of figures aligned according

to their decimal place, the second is to stop the carriage at the column positions of a form, allowing one to move from the first directly to the fourth, tenth, or fifteenth column by simply pressing a key and using the decimal place tabulator to align the value in use. Of course such a machine is only required when there are forms to be filled out with a great many columns. The column tabulator keys are attached above the calculating mechanisms of the respective columns. The label for each column can be attached to the key. Such a machine is illustrated in figure 175.

There is another special machine that, on payday, makes out the check at the same time as it fills out the statement of payment or the respective ledger page. The check forms used are simplified so that the name of the recipient and the amount in words and figures are all on one line, and the date is printed or is put in by means of a stamp. Since this machine is equipped with the standard calculating mechanisms and billing device, it permits the use of a ledger page and, independently, another form. Hence the booking entry and check may be typed in one operation. For example, if the ledger page has fifteen lines. and can therefore take fifteen entries, it is possible to insert fifteen different check forms. one check for each line of the ledger. The machine is equipped with type heads that perforate the paper so that it is not possible to increase the amount or write in another payee (with intent to defraud). There is also the added security that the value of the check should correspond to the amount in the ledger and furthermore the possibility of automatically adding the individual amounts in the columns of the ledger at the same time as the values of the checks. With this machine up to 800 ledger entries, and just as many checks, can be made in an eight-hour working day. A machine like this is illustrated in figure 176. It is usually only supplied with capital letters, therefore it comes without shift keys.

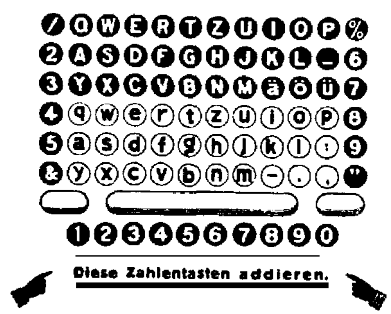


Figure 179

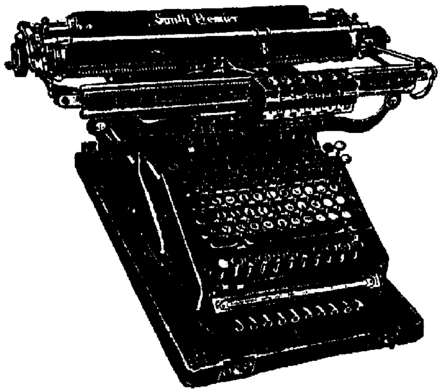


Figure 180

These are only a few examples of both the capability and versatility of the Remington in combination with the Wahl adding and subtracting device. It is the responsibility of the retailer to tailor the machine to the individual needs of the buyer. The fact that no less than ninety-six different totaling mechanisms are available for different currencies; apothecary's weights; tons and hundredweights; hours, minutes, and seconds; dozens and fractions; yards, feet, and inches, etc.. shows how the machine has developed in versatility, to the extent that there is hardly a business in existence for which the Remington with an adding device would not be of use.

The prices for the Remington Typewriter with actuator, but without calculating mechanisms. range between **$210.00** and **$277.50,** depending on the width of the carriage. With actuator and cross footer, they range from **$397.50** to $480.00, again depending on carriage width. Calculating mechanisms cost, for example, $55.00 for a four-place one, and units up to ten-places can be obtained at a cost of $5.00 for each extra place. Prices for the Smith Premier with shift are similar, as are those of the Smith Premier with full keyboard as well as the Monarch and Yost.

In **1924** there appeared a new model of the Remington with the Wahl adding and subtracting device. This has a lever on the left side, in the front of the keyboard, that is used to shift the carnage from column to column. There is also a special key for calculating the balance, a correction key, and a cross footer. The actuator is built into the machine and the digit keys are not in the uppermost row but underneath the space key. The machine only types capital letters and is therefore used less for correspondence than for bookkeeping. It

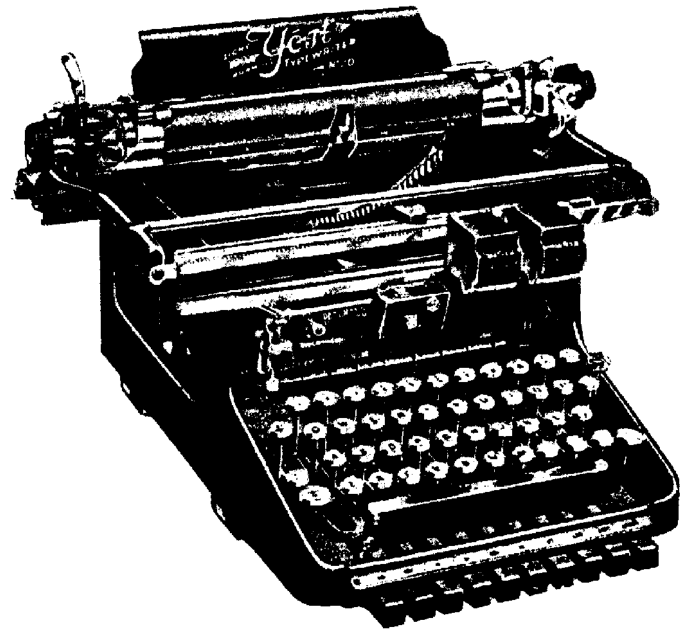


Figure 181

is available with or without electrically driven carriage return. This machine, shown in figure **182,** is known as the Remington 23.

At the same time the Remington 21 also appeared. This does not have a cross footer mechanism but is only equipped for column addition and subtraction. It has the standard four rows of keys of the older Remington **and** operates with a shift key. In this model, as in the previous one, the keys of the tabulator are on the front edge.

The device for the Smith Premier with full keyboard is different from those machines mentioned with shift keys (with the exception of the Remington 23), insofar as the digit keys of the typing keyboard do not operate on the calculating mechanisms. Rather. underneath the space key (see figures **I79** and 180) are another ten digit keys that are only used if the values entered are also to be added and subtracted. The decimal place tabulator is attached on the front edge. Whereas with the shift machines it is necessary to switch on the digit keys before beginning to add or subtract (that is, to connect the typewriter to the calculating device), this is not necessary with the Smith Premier with full keyboard. The digit keys of the typing keyboard have the same light typing action as for typing letters. Only the special calculating keys

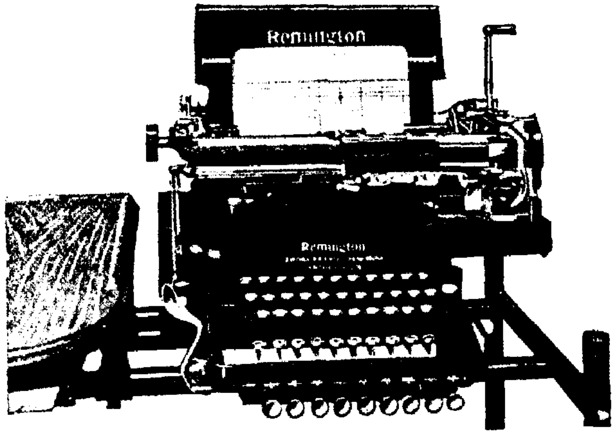


Figure 182

arc a little harder to press. These can never be confused with the usual digit keys since they are set quite apart from them. These calculating keys are much closer to the decimal place tabulator and, when operating the tabulator, one's hands do not have to go far to reach them. In machines with a larger and therefore heavier carriage, there is the added advantage that this carriage does not have to be raised for capital letters as with the familiar shift machines. The Smith Premier. if requested, is also supplied with only fifty-eight typing keys, so that they only type capital letters (this is sufficient for bookkeeping purposes).

Each of the calculating keys operates

1. the typing hammer, throwing it against the platen where the printing then takes place

2. the driving wheel in the actuator (by means of a special lever underneath the type hammer), moving it the required number of teeth forward in addition, and backward in subtraction.

Manufacturer: Remington Typewriter Company Inc., Ilion, Smith Premier Typing Company, Syracuse.

Comptator (1909)

This is the same design, although somewhat improved, as the Rapid Computor Adding Machine mentioned earlier. The manufacturer was originally

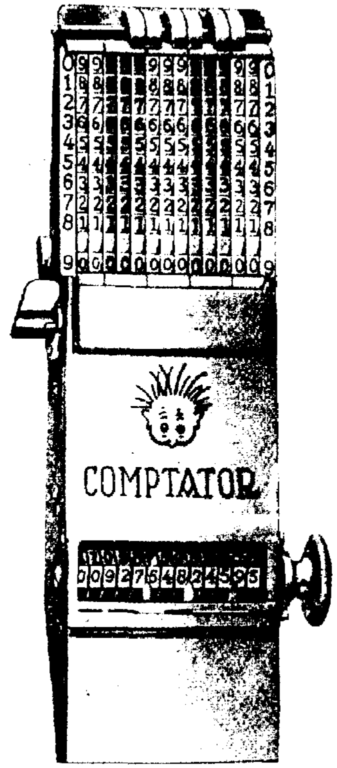


Figure 183

Schubert & Salzer, Maschinenfabrik, A. G. Chemnitz, Sa. but, since 1922, it has been Hans Sabielny, 1a Bismarkpl., Dresden, A. 24. This is a small adding machine with rack drive. It is available with nine or thirteen places, an adjustable decimal point indicator in both the entry and result mechanisms, steel margins with complementary figures for subtraction, setting control mechanism, and release key controlling the return of the setup racks to their normal position. The release key can be locked, which is a distinct advantage in addition from dictation and in multiplication. To set the result mechanism to zero, the knob on the right side is pulled out and then turned to the left until it can go no further; it must then be turned to the right again until it has clicked back into its normal position. If the whole reset operation is not completed, the setup mechanism is locked.

The thirteen-place machines allow amounts to be entered in two columns next to one another (debit and credit, for example) and the smaller sums to be subtracted from the larger ones.

Price:

9-place	105 marks
13-place	150 marks
for English currency:	
9-place	125 marks
13-place	175 marks

Adam Riese (1909)

This machine. shown in figure 184, has a control mechanism for adding individual items, automatic deletion in the control mechanism as soon as a number is added, and continual tens-carry in the summing mechanism. It works quickly and reliably. An error in entry is corrected by pressing the small knob mounted on the hand lever. Whereas the sum is visible in the upper row of viewing windows, the individual entries can be seen in the lower row. The machine is operated as follows: the sliding knob in the slot (position indicator) is shifted far enough to the left to show the position of the leftmost digit of the item to be added; the hand lever on the right is moved along a scale until it is opposite the digit to be added and then pulled all the way

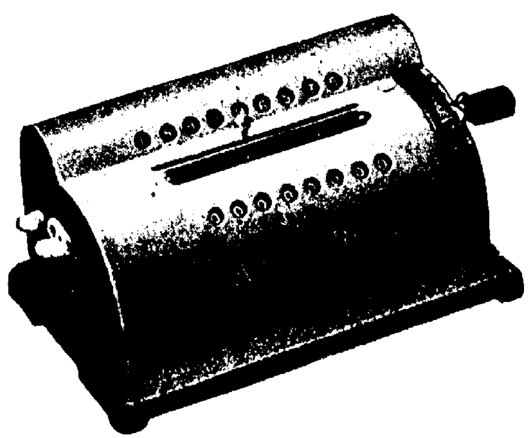


Figure 184

down. This action moves the position indicator one place to the right, where the operation is then repeated. When the position indicator has reached the far right. the upper and lower rows of viewing windows will show the same number; however, this automatically disappears in the lower row as soon as the position indicator is again moved to the left. The wing knob on the left is turned to reset the upper row of viewing windows to zero, although this can, and should, only happen when the position indicator is on the far right. Designer: Chr. Hamann. Manufacturer: Chr. Hamann, Math.-Mech. Institut. G.m.b.H., 19 Charlotten Street Berlin SW 68. Price: 175 marks. This machine was manufactured and distributed for only a short period, and the firm has been out of existence for some time.

Morse (1909?)

This is a ten-key adding machine. The printing is hidden and can only be read if the carriage is raised. It has visible result viewing windows for nine digits and viewing windows below these from which it is possible to check the amount entered. It is supplied with a single-color ribbon. Ribbon direction change is automatic. Total, subtotal, repeat, and correction keys all lie above the numeral keys. Dimensions: 20 cm × 20 cm × 15 cm. Price: $125. The machine has never reached Europe and is no longer manufactured. Manufacturer: Morse Adding Machine Company, Chicago.

Mercantile (1909)

The Mercantile is a nonprinting, full-keyboard adding machine with complementary numbers for subtraction. It has eight places in the setting and nine places in the result mechanism. The result mechanism is above the keyboard; the addition mechanism is powered by the crank. The machine weighs only 5 kg and is therefore extremely light to carry. Manufacturer: Mercantile Adding Machine Company, Norwalk, Conn. The machine has never reached Europe and apparently is no longer being made.

Elliott-Fisher (1910)

The Elliott-Fisher is well known as the only typewriter with typebars that has, instead of the usual typewriter cylinder, a flat typing surface. It is, as a con-

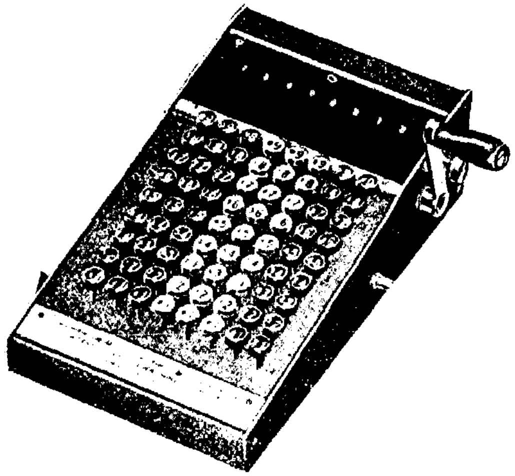


Figure 185
Mercantile

sequence, the only machine with which one can write in bound books. All other so-called bookkeeping machines can write only on loose sheets of paper, which are later collected in books with the help of well-known permanent accounting procedures. It is self-evident that the machine is provided with adding and subtracting calculating mechanisms. so that with it one automatically adds the columns of numbers as they are typed, and eventually can obtain the balance without special effort by the typist.

The keys for calculations are found above the keyboard, and the separate calculating mechanisms are behind the machine. Each column to be added requires a special calculating mechanism; from 1 to 29 of these mechanisms can be attached. These do not share in the sideways motion of the typewriter but rather remain sitting over the columns upon which they have been set by the machine operator. Thus addition or subtraction can be carried out if the typewriter is first at the point of typing the corresponding column. The calculating mechanisms only add or subtract; the operations cannot both be carried out at will.

The machine is produccd in two models, namely as the Simplex and the Universal bookkeeping machines. The Simplex has only calculating mechanisms, the number of which are specified by the purchaser of the machine. These mechanisms are so placed that the typist has the viewing windows just in front of his eyes without having to change his position in front of

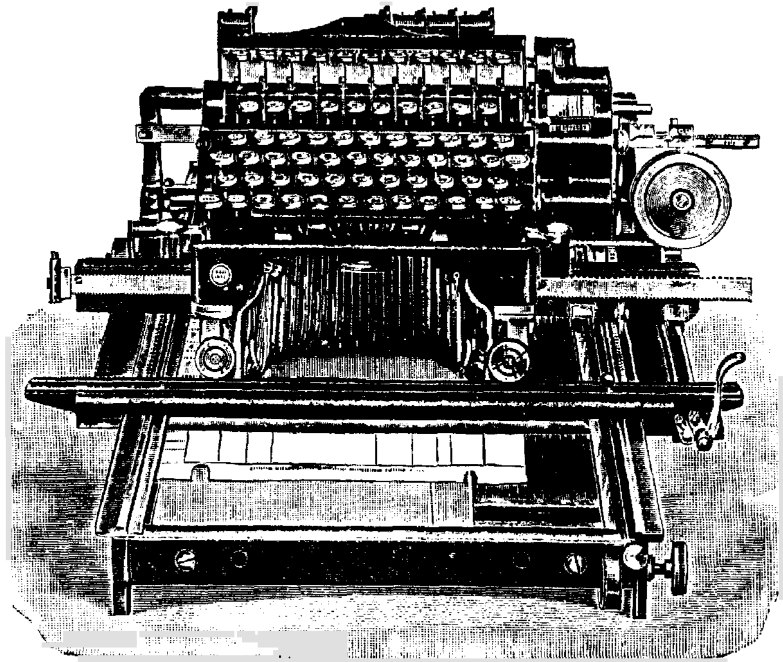


Figure 186

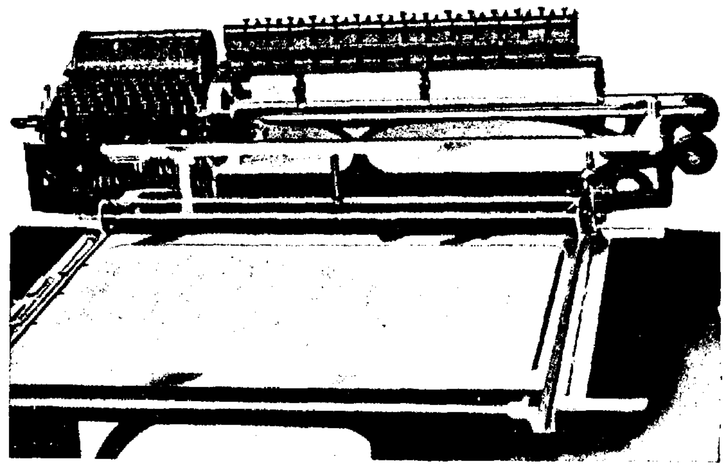


Figure 187

the machine. The calculating mechanisms are set to zero by subtracting the amount in them. This occurs with the help of complementary digits in the usual way. There are also calculating mechanisms that can be set to zero by hand; these cost $5 more. If desired, subtractions can be printed in red so that they stand out. The Simplex is mainly used for bookkeeping, statistical accounts, numerical statements, check statements, and in general for simpler tasks. For example, with one calculating mechanism the individual postings may be added, with the second subtotals, and with the third amounts in the daybook, etc. The daybook can be kept in short or detailed form. In the latter case, the separate quantities can be divided into their respective coiumns and then added.

The Universal generally resembles the Simplex. However, it also has (next to the calculating mechanisms mentioned, to the right of the typewriter) a further mechanism for addition and subtraction. This shares in the sideways motion of the typewriter during typing and, moreover, serves to add or to subtract all quantities in the calculating mechanisms for the vertical columns

Figure 188

and to ascertain the balance. This second mechanism is the cross footer, known here from the description of the Whal Adding and Subtracting Device.

How does such a machine work? Suppose that it is necessary to supply the following four columns:

old balance   debit   credit   new balance

One brings a calculating mechanism over each of these four columns, then shifts the typewriter to cover the first column and types in the quantity, say 200 marks. At the same time, this number is transferred into the corresponding calculating mechanism and also appears in the viewing windows of the cross footer. The machine is then shifted to the debit column, and the quantity 50 marks is keyed in. This number is, at the same time, transferred into the corresponding calculating mechanism and counted on the cross footer. so that in the windows of the latter the quantity 250 marks is visible. The credit of 10 marks is typed into the credit column and at the same time transferred to the corresponding calculating mechanisms and also subtracted from the total in the cross footer, so that there remains in its calculating mechanism only 240 marks. One now enters this quantity in the new balance column so that it appears in the corresponding calculating mechanism. This cancels the amount registered in the calculating mechanism of the cross footer, and, assuming that the whole calculation contains no typing errors, the viewing windows of the cross footer show zeros in all places. The subsequent postings are done in the same way. The calculating mechanisms over the individual columns therefore give:

1. all old balances
2. all debits transferred
3. all credits transferred
4. all new balances.

At the end of the day's work a check can be made, namely, the sum of the debits posted minus the sum of the credits posted gives the sum of the new balances. This is, naturally. only one example of the applications of the Universal. How easily it can be applied to a variety of problems is evident from the fact, already mentioned, that no fewer than twenty-nine such calculating mechanisms can be set on one Elliott-Fisher.

The Elliot-Fisher is available in three writing lengths (for machines with cylindrical platens, one would say carriage widths), and the machine can be

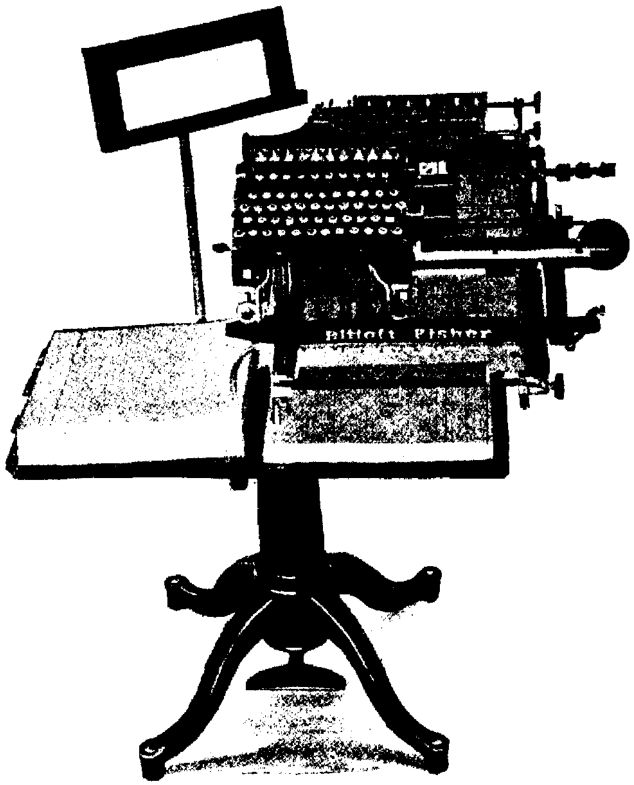


Figure 189

provided for just typing or bookkeeping, purposes—thus, with or without calculating mechanisms, and with or without cross footer, with a massive stand that adjusts in height, etc. In general, when supplying a machine, the factory will adjust it to suit the requirements of the buyer. However, in order to give an idea of the relative prices, the cheapest version of the smallest model. without tabulator, without calculating mechanism, without stand. etc. costs $156. The same machine with tabulator and cross footer but without calculating mechanisms costs $572. The cost of individual calculating mechanisms ranges from $42 for five places to $67 for ten places. In Europe, higher prices must be expected.

Manufacturer: Elliott-Fisher Co., Harrisburg, Pa.

Triumph (1910)

The Triumph is a small adding machine. It has four movable parts: the knob above the last two viewing windows on the left, the crank, the release-rail, and the operation chains.

The knob can be shifted up and down. When up, it separates the two left viewing windows from the rest and records the number of items added or subtracted; when down, it reestablishes the connection with the other place positions.

The crank is used to reset the machine to zero. It is turned until red zeros appear in all the viewing windows. The crank may not be turned backwards.

The release-rail stretches out underneath the calculating chains for the entire width of the machine. It must be pressed down before entering each new item in order to release the locking device of the machine. If not pressed, the chains only move with difficulty, and if force is used it can damage the machine. It is the action of pressing the release-rail that causes the items to be counted and the number registered.

Addition is carried out in the usual way. The finger is placed on the digit to be added, and the chain link is pulled down as far as it can go, thereby transferring the respective digit into the calculating mechanism, or rather adding it to the amount already there. Digits are always entered from left to right, although it is possible to move several chains at once. Subtraction is done with the help of complementary digits. Multiplication can be done according to the multiplication table method, or the repeated addition method, although here the machine does not offer any extra advantages. The machine is not suitable for division.

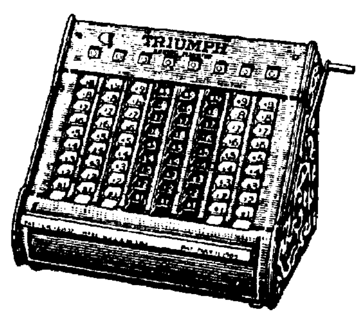


Figure 190

Model **A**	eight places, for decimal currency	$50.00
Model B	ten places, for decimal currency	$60.00
Model C	twelve places, for decimal currency	$70.00
Model D	eight places, for inches, fractions, or English currency	$60.00
Model E	ten places, for inches, fractions, or English currency	$70.00
Model F	twelve places, for inches, fractions, or English currency	$80.00

Manufacturer: Triumph Precision Machine Co., 74 Wall St., New York.

Teetor (1910)

This is a nine-place, full-keyboard adding machine without complementary digits and with wide carriage. The amount printed is hidden, as in the Burroughs, although the result is visible in windows above the keyboard. The machine is equipped for electric drive. Repeat, nonprinting, subtotal, total, addition, and subtraction keys are all on the right side of the keyboard *so* that the left hand always remains free. The machine has only a single-color ribbon. It was originally made by the Teetor Adding Machine Company in Des Moines, and later in Pomona, California. Production has stopped for the time being.

International (1910)

This is a nine-place, full-keyboard adding machine that was supplied with a narrow and a 30-cm-wide carriage. It had self-correcting keys and visible addition and printing. Repeat, correction, total. subtotal, nonaddition, and nonprinting keys were on the right side. It was available with manual and electric drive. The price was $225.00 for roll paper, $250.00 with 30-cm-wide carriage.

This machine was also supplied connected to a payment machine. It was possible with this combination to write wage sheets at the same time as pay envelopes, to count up the necessary coins, and finally to put them in the envelopes. The manufacturer was the International Money Machine Company, Reading, Penn., but the factory is no longer in existence.

Addall (1910)

This is a single-row adding machine from the Addall Company, Temple Courts, Temple Row, Birmingham. This machine disappeared from the market a number of years ago.

Kollektor (1910)

This small machine was brought out by the Wurttemburgische Uhrenfabrik Bürk Sohne in Schwenningen on the Neckar. It never gained a really wide distribution and today is no longer being manufactured.

Only the left hand is needed to operate this machine. The setting of numbers is carried out by so-called control areas instead of keys. There are four of these control areas, one for each of the numbers 1, 3. 4, and 5. Of these, 1 is controlled by the small finger. 3 by the ring finger, 4 by the middle finger, and 5 by the index finger. The other digits are done by double movements in rapid succession: 2 = 1 and 1; 6 = 3 and 3; 7 = 3 and 4; 9 = 4 and 5.

Addition of Columns: The calculating mechanism must be set up on the viewing window corresponding to the column by being raised, shifted sideways, and let down again so that the stationary indicator points to the correct viewing window. The single digits are then added one after another by the fingers lightly pressing and pulling on the control surfaces. At the end of entering a column of digits, the control mechanism is simply moved to the next digit place and the process is repeated.

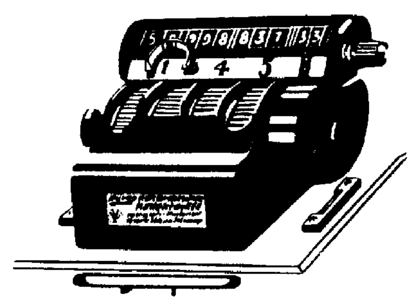


Figure 191

Addition of Single Coupons, Etc.: After entering each digit, the calculating mechanism must be moved over to the next digit place; otherwise the procedure is the same as addition, Since with this mode of operation the right hand does not have to follow the numbers, it can be used to move the mechanism very quickly.

subtraction: In order to use the apparatus for subtraction, all that is required is to pull out the knob on the left side (which prevents it from turning), which causes the machine to operate in the opposite direction. The procedure is then exactly the same as addition. For resetting to zero, the calculating mechanism must be raised by means of the knob protruding on the right. This is pressed in and very slowly and gently turned forward until it snaps into place again. To change any number. for example in making a correction, the knob on the left side is used as in subtraction. It is turned forward or backward but may not be moved axially.

The Zeitschrift fur Vermessungswesen (1910, vol. 31) described the machine as follows:[69]

This is surely the first adding machine one can operate without having to look at the machine. As figure 1 shows, only four fingers of the left hand are used. and this is in a comfortable and fixed position—the little finger for the key (or rather cylinder) 1, the ring finger for 3. the middle finger for 4, and the index finger (which can be moved further and more easily than the little finger) for 5. There are not nine elements but rather only the four that have been named. The four fingers are only required to gently press and pull in order to add each of the respective numbers 1. 3, 4. and 5. On the other hand, 2 is done by two pulls of the little finger. 6 by two pulls of the ring finger, 7 by the ring and index fingers, and 9 by the middle and index fingers. There is of course no objection in attaching nine instead of only four elements, and at first sight it may even seem strange that with this machine a part of the addition has to be calculated in the head. even if it is only a small part. But it is, in fact, much simpler to design the machine as compactly as this inventor has done; that is, by equipping it with only four elements, since one then has the advantage that the calculating hand can remain at "rest position." As long as the correct position of each finger is clear in one's mind (that is. without having to think), the calculation is in fact carried out much more quickly. reliably. and smoothly than if one's hand had to move around to search for the right key among a great number of different keys. Because of the way the Kollektor is designed, one's eyes can remain on the written numbers to be added. Another advantage of this new machine is that these digits are transferred to the machine, not in groups that must he remembered, but rather digit by digit. The machine takes care of everything else with only a simple movement of the fingers needed. In addition. it is possible to relax one's attention somewhat, since one does not have to keep looking from the machine to what is written down.

69. *Journal for Surveying*

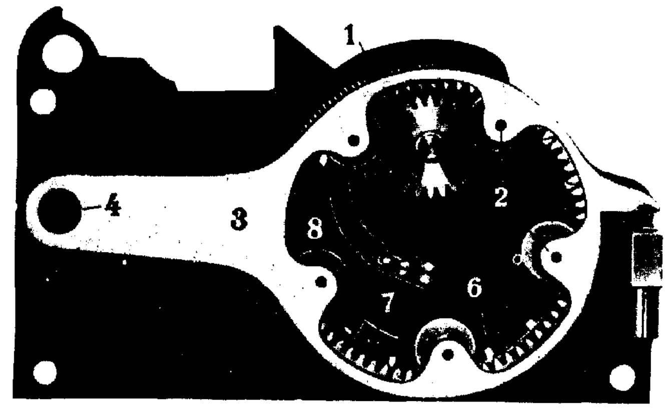


Figure 192

What the size of the four numbers 1, 3, 4, and 5 signifies is superfluous for the practical use of the machine in that one must know the number mechanism with the fingers without thinking and without looking at each number. The four "keys." which are each worked by one finger on the left hand, are corrugated cylindrical rollers that one's finger must lightly press and turn by pulling gently as far as the mechanism allows. Each of the rollers (marked 1 in figure 192) has two inner gearings and, with the help of five small rollers (2), is positioned on the arm (3), which can swing around the pivot point (4). The arm is moved by gentle pressure from the finger until it strikes against stop (5). With this action, the gearing belonging to (1) is meshed into wheel (9). and at the same time the locking teeth (6) are taken out of the stationary block (7), which had, until this time, prevented the roller from turning. The small wheel (9) is carried along with the rotation of the roller that is now possible. Each rotation is restricted by the stop lever (8); that is, whenever the next locking point position (6) is positioned exactly under block (7). Only in this position can the arm (3) return to its rest position, and roller (1) can only be turned exactly within that arch between the two locking points (6). The small wheel (9) (visible in figure 193 with roller (1) removed), which has been carried along with the rotation, now drives cog (11) positioned on the same axle (10), which by means of (12) carries the movement further over to wheels (13) and (14).

The calculating mechanism is positioned above these arms and wheels. It is shown in Figure 1931194, taken out of and placed next to the machine. By means of wheels (14), wheels (16) and the digit cylinders of the calculating

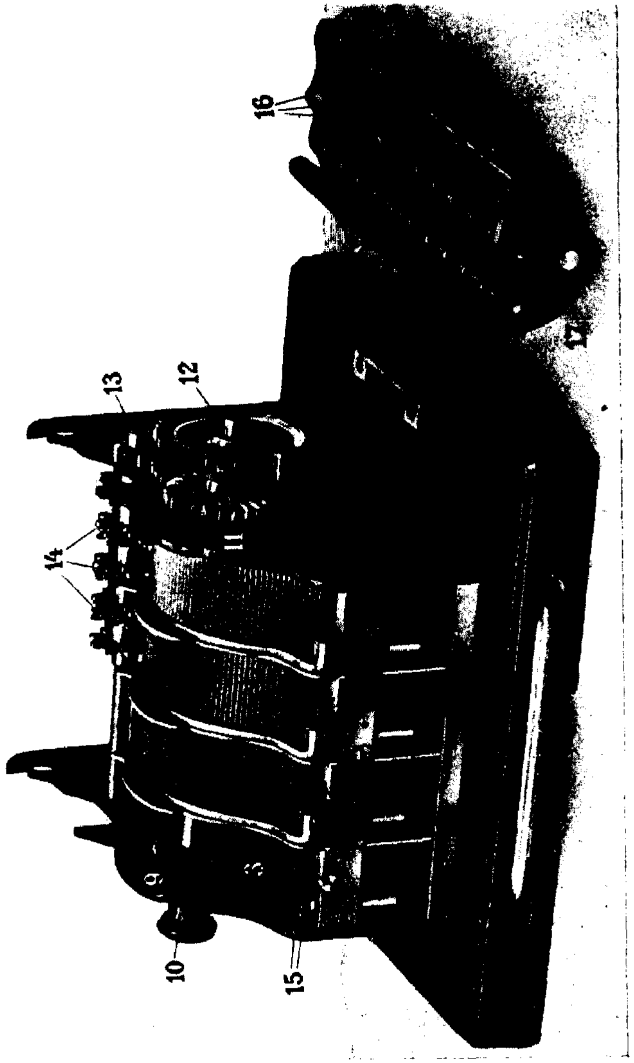


Figure 193/194

Figure 195

mechanism are moved. As is usual, it is possible to read from these digit cylinders in the viewing windows. The four mechanisms, which are placed together in the machine, operate differently only in the fact that the cogs within each of them are placed far away from each other. The first cylinder from the left transfers 1, the second 3, the third 4, and the fourth 5 units. Any error in the calculation caused by two keys (rollers) being pressed down at the same time is prevented since it is not possible to simultaneously move two rollers. As soon as a roller has been pressed down, all others are locked by a lever (15). After adding up a column, the calculating mechanism must, as usual, be shifted one position.

Figure 195 shows the resetting to zero of the calculating mechanism. The adding machine Kollektor subtracts in exactly the same way as it adds. All that is required is to pull out knob (10). Any changes to the total are as possible during subtraction as they were for addition. The whole machine is really one of the simplest imaginable, on account of the small number of movable parts. In spite of its handiness and the small size, the good materials which make up the machine guarantee unlimited durability.

The price of the machine is 150 marks.

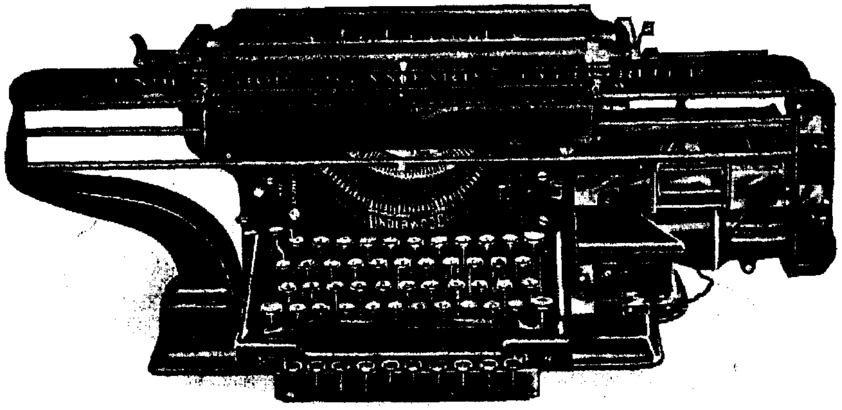


Figure 196
Model A.

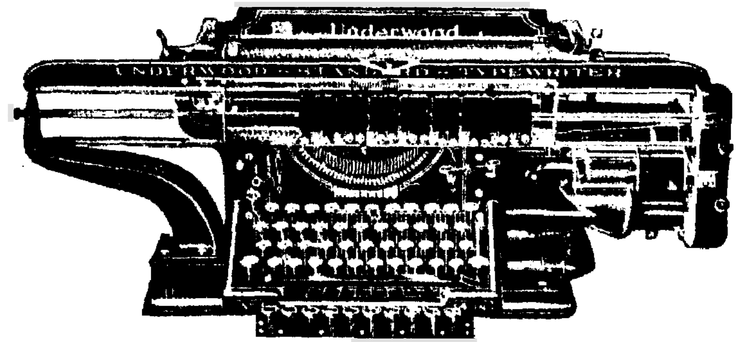
Underwood (1910)

Since 1910, the well-known Underwood Typewriter has been equipped with an adding and subtracting device. This was originally the design **of** John T. Howieson of New York, who earlier had designed a similar device for the Fay-Sholes Typewriter (see the 1904 entry for the Arithmograph). However even the Underwood Company never produced the machine on a large scale. Later there appeared almost the same adding and subtracting machine with the name Typewriter Calculating Attachment. Even with the new name it remained relatively unknown.

In 1911, the Underwood company brought out the Underwood Computing Machine illustrated in figure **196.** It has a number of small calculating mechanisms mounted on top, or attached to the side, of the Underwood Typewriter. Virtually the same work can be carried out with this machine as with the Wahl Adding and Subtracting Device but with the difference that with the Underwood addition and subtraction is done via an electric drive. This means that the keys are always struck evenly, whether it be a *2* or a 9 that is pressed. The following models are available:

Model A: with one 12-place calculating mechanism attached on the side, vertical and horizontal adding and subtracting.

Model B: with two 12-place calculating mechanisms attached on the side,



igure 197
lodel D.

vertical and horizontal adding and subtracting. In preparing statements **of** current accounts, this machine looks after not only the addition of individual columns but **also** always records the balance amount.

Model C: with any number of small calculating mechanisms attached. The calculating mechanisms can be **4, 5**, 6, **7, 8, 9, or 11** places for monetary values and **4, 5, 6,** 7,[70] **8, 9,** or 12 places **for** quantities.

Model D: with any number **of** small calculating mechanisms attached, in addition to a cross or control adding mechanism attached on the side. The uses of this machine are many and versatile. For example, a number of columns can be added vertically; simultaneously a number of columns can be added horizontally and the total subtracted from another column.

Apparently, the electric drive has not proven a success when a very large number of columns are involved, and for this reason production of the machine was given up once again in 1917.

In 1912 there emerged the Underwood adding or bookkeeping machine, as illustrated in figures **198** and 199. It can also be electrically driven although that model is constructed quite differently. Here the typewriter stands on a base, approximately 12 cm high, containing one or more calculating mechanisms. The machine is very simple to operate. It is only necessary to set up the tabulator stops in accordance with the work to **be** carried out (exactly the same as with the standard typewriter) and to attach either adding or subtract-

70. At this point Martin actually has "4" rather than "7"—we presume it is simply a typographic error.

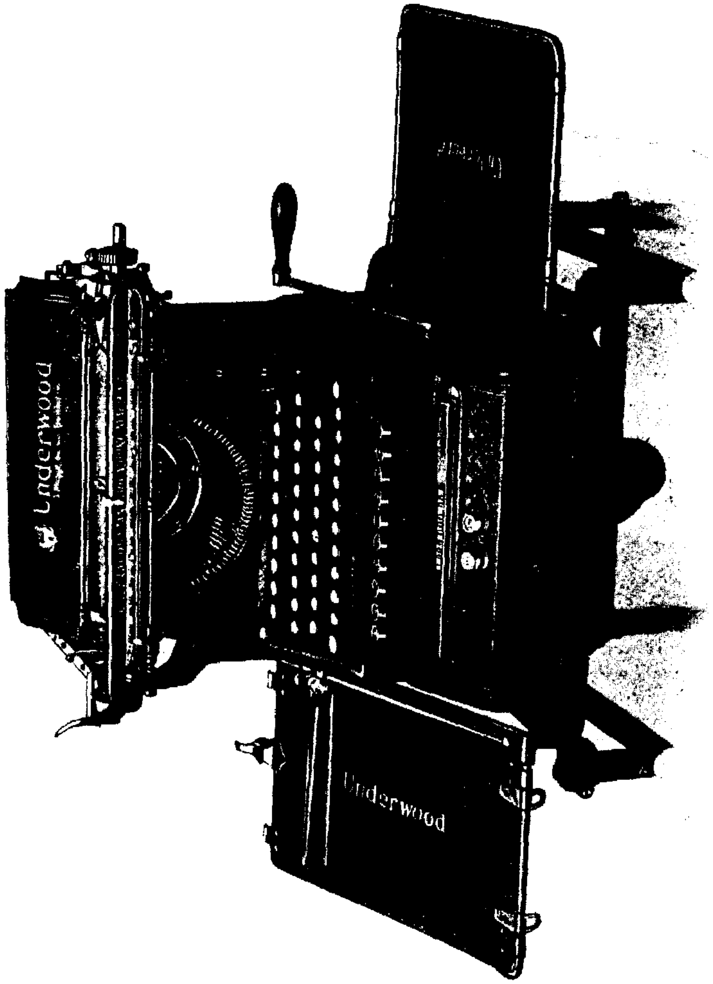


Figure 198
Machine with one calculating mechanism.

ing stops—the adding stops differ in shape from the subtracting stops. In order to add up a column with a calculating mechanism, it is necessary to use an adding stop behind it and in order to subtract in another calculating mechanism a subtracting stop must be used. The machine is now ready, and as long as the same column setting is used, it is not necessary to make any sort of changes to the setting in preparation for addition or subtraction.

The numbers are entered by means of the number keys of the typewriter. If an incorrect key has been struck, the error can be corrected by simply pressing the E key next to the respective calculating mechanism If a number has been skipped over or pressed too lightly so that it does not come out clearly in the print, then by pressing the backspace key, it may be struck again.

The amount typed can be automatically added (or subtracted) and registered in two ways: automatically by means of the stop already mentioned, which operates the motor after the last digit, or by lightly touching a key on the right side. If the electric motor is not used, then the hand crank, which is attached to the right side of the machine, is used instead. This simply requires a light, quick pull. In this way, one amount after the other is typed and added. If the typist forgets to pull the crank, a locking device, which falls across the number keys, automatically prevents typing further amounts before the previous amount has been added or subtracted. If one wants to know the sum totals, then one only has to copy down the last figure in the calculating mechanism. Before this is done, it is advisable to set the machine on subtraction—this is carried out by simply pushing in the subtraction key on the left side of the machine, or by setting up automatic subtraction. If the typing of this total is correct, it sets all calculating gears to zero, and the machine is then free for the next task. This also proves that the sum total has been correctly copied. Subtotals can be taken at any time by pushing the nonaddition key.

Next to the E key is another zeroing key. If this is pressed at the beginning of a new operation, it prints a star on the paper as proof that the respective calculating mechanism previously stood on zero. If the sum total has been typed during simultaneous subtraction, and if the star can be typed next to it, then this is further assurance that the sum ha5 been correctly copied. Subtraction is just as easy to do as addition. All that must be done is to push in the subtraction key or set up automatic subtraction. Once an amount has been subtracted, the machine automatically changes back to addition if one does not want to do several subtractions. Sums and subtractions automatically appear in red, or in another color different from that of the amounts to be added.

Moreover, there is always a signal at the front of the machine indicating addition or subtraction, so there can hardly be any confusion. It is possible to add or subtract rows of figures vertically and even horizontally in one or several calculating mechanisms simultaneously. If horizontal rows of figures are added up, the sum total of all end sums can be registered in a second calculating mechanism. For work involving invoices, etc., the machine can be used so that credit items are automatically subtracted from debit items and the balance always given.

With other adding typewriters (an exception being the Calculating Mercedes-Elektra), the gears must be turned by pressing keys. It is easy to understand (insofar as the digit keys run 1 to 9) that the striking action must be uneven. A one key will be easier to hit than a nine key since the latter does more work. Since all tasks such as turning the various gears (driving gear, transmission gears, number pears, etc.) as well as the movement of all other parts are done by finger pressure, it is only natural that such machines are more difficult to operate. Moreover it is necessary to make an apparatus

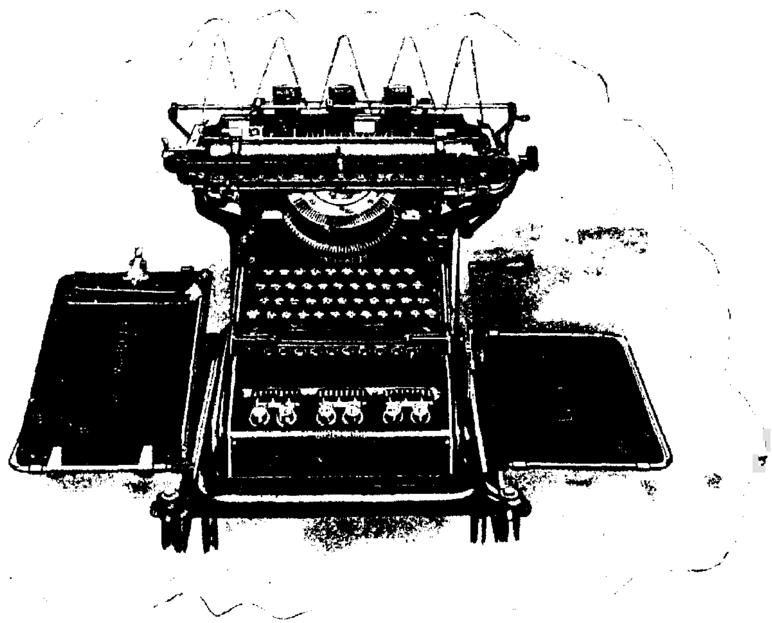


Figure 199
Machine with three calculating mechanisms.

such as this small and light. It is, therefore, often extremely difficult to read the numbers of the number gears, which, by necessity, must be kept small.

As was mentioned earlier, for their first models the Underwood Company followed the same principles but very soon changed them over to direct striking action. which will now be briefly described. In these machines, only one pin is set up when a key is struck, and only when the whote amount has been typed in will a common driving mechanism (itself either operated automatically by an electric motor or by a hand crank) perform the necessary rotations and movements in order to carry the figures over into the calculating mechanism. The digit keys of the typewriter therefore work just as easily and quickly as for a standard typewriter.

With such a machine there are many different kinds of tasks that can be performed. Each machine is equipped with automatic carriage return and line feed and. furthermore, bas all the modern supplements of the Underwood bookkeeping machines. The numbers on the base denote the number of calculating mechanisms as well as the width of the carriage in inches.

For example, figure 199 shows a machine with three calculating mechanisms and a 14-inch or 35-cm-wide carriage. Machines are available with 1, 2, 3, 4, and 5 calculating mechanisms, and each machine can be supplied with 30-, 35-, 40-, 45-, 50-, and 66-cm-wide carriages. Prices range between $575.00 and $1,225.00. There are also machines built without shift, which therefore print only capital letters.

Distribution is done through the Underwood Typewriter Company, New York.

Autarit (1910)

Designer: Alexander Rechnitzer. of Vienna. Manufacturer: the Autarit Company, Ltd., of Vienna I, Fuehrichgasse No. 10. Production has been discontinued since the beginning of the war; the firm is no longer in existence.

This is a stepped drum machine, with motor drive for completely automatic multiplication and division. The machine has two rows of setting slots: one on the lower part of the machine and a second one on the movable carriage underneath the result windows. For addition, the first item is entered in the lower slots in the customary manner, the machine is set to addition by means of the button located to left of the setting slots, the start key for the motor is pressed, and the amount is thus transferred into the result mechanism. For subtraction, the greater item is introduced into the result mechanism as in addition, the reversing button is set to subtraction, the motor is started, and the remainder may be taken from the result counting mechanism. in multiplication, the value to be multiplied is introduced into the result mechanism in the manner described in connection with addition, the machine is set to multiplication. the multiplier is entered by means of the upper setting slides, and the motor is started; whereupon the machine commences to multiply automatically. With each revolution of the shaft the setting slide, at the first place from the right, moves one digit toward zero; when it arrives at zero, the carriage is automatically shifted by one place, and now the slide set in this place commences to move automaticaiiy towards the zero position, and so on, until multiplication is complete and the result may be read in the result counting mechanism. Division, including ordinal displacement of the carriage, also occurs automatically. In **1913** the Autarit factory maintained a sales office in Frankfurt on the Main; it does not seem likely however, that anything other than experimental models were produced.

Midget (1910)

Manufacturer: Midget Sales Company, 60 Van Buren St., Brooklyn. The machine is only used for addition. The left hand holds the handle, and the small finger on the right hand holds the machine steady (as shown in figure 200).[71] The right hand also holds the calculating stylus. In setting up values, the digits on the right or the left edge plate are used. The tip of the adding stylus must be placed in the hollow of these digits (units, tens, hundreds, etc.), which are to be added and teft there while the handle is turned with the left hand until it hits the calculating stylus. The other numbers are entered or added in the same way. The sum can be read behind the stop rod J. Resetting the machine to zero is done by lifting the stop rod *J* and turning the handle until the small lug of the individual calculating gears presses against the stop rod.

Price: $10.00. It appears that the machine is no longer produced. It was never introduced into Europe.

S and N (1910)

This is a small adding machine with chain drive and stylus entry produced by Seidel and Naumann, Dresden. There are a number of models in production:

71. **Martin aclually had figures 200 and 201 reversed; we have corrected the error in this reprint.**

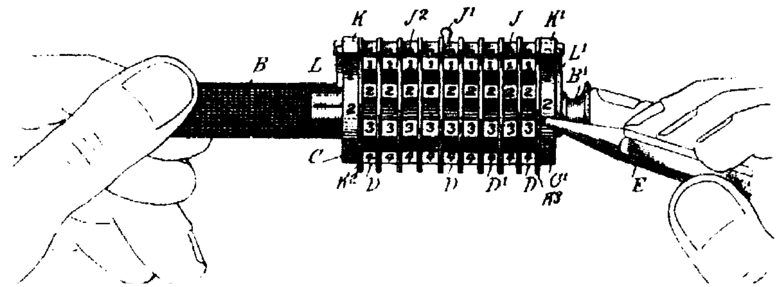


Figure 200
Midget.

nine and thirteen-place machines, a debit and credit machine (always with two six-place calculating mechanisms and seven-place result mechanisms), and three models for English currency.

The machine operates in the same way as described for Small Adding Machines in the introduction. Zero setting of the result mechanism (which is above the entry mechanism) is brought about by turning the crank on the right as far as it can go. The force of the spring will then turn the crank back to the rest position. On the right side there are two keys labeled ***A*** and *M*. The ***A*** key is used to return the chain links to their rest position after the value entered has been checked for accuracy. If, during multiplication and subtraction, the *M* key is pressed, the individual chains spring back to their starting position after the adding stylus has been removed. At the other end of the

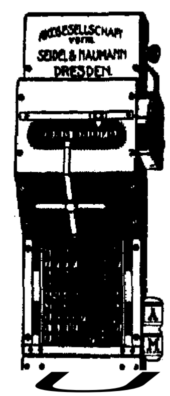


Figure 201

adding stylus there is a three-sided key that, with one turn to the left, operates the bolt attached to the right side panel. With this, the chains, the item cancellation, and the sum cancellation are locked, and the machine can, therefore, not be used by any unauthorized person. The connecting cross piece, as can be seen in figure 201, points from the digits of the chain columns to the digits of the result mechanism. The result mechanism also has a movable decimal point. Subtraction is carried out using scales with complementary digits, which are attached on both sides. To enter units in subtraction, one uses the scale on the right side. For other places (tens, hundreds, etc.), one uses the left scale.

Model	Weight	Price
nine-place	1.4 kg	100 gold marks
thirteen-place	1.8 kg	125 gold marks
for English currency		110 gold marks

Barrett (1910)

Designer: Glen G. Barrett. Manufacturer: originally the Barrett Adding Machine Company, 142 Court St., Grand Rapids; since January 1, 1922, Lanston Monotype Machine Company, Philadelphia.

This machine was introduced into Europe before the war, although up until now it has not been distributed on a large scale. It is a full-keyboard adding machine with visible printing in one color but only on narrow paper strips. The machine has self-correcting keys with complementary keys for subtraction and division. There are repeat, keyboard cancellation. total, and nonaddition keys on the right side of the keyboard so that the left hand is free to turn pages or point to figures. Carryover totals are added and carried forward with the aid of the total or sum and keyboard cancellation keys. By using the nonaddition keys, figures that have been entered can be excluded from addition, provided that this key is pressed before the crank has begun to move back. All values that have not been added are specially marked on the paper. Dimensions of the machine are 25 × 30 cm, and its weight is approximately 11 kg.

Models dating from before the war were supplied with the so-called mezzanine attachment, which is shown in figure 204. With this device, values that have been entered on the keyboard can, in multiplication, be shifted side-

Figure 202
Older. nonprinting machine.

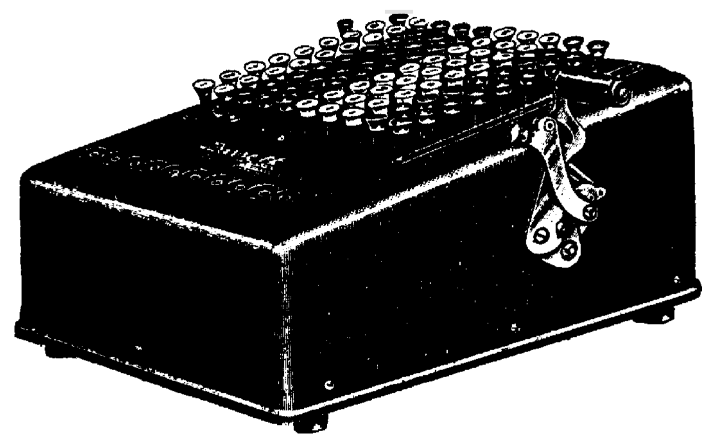


Figure 203
Later model

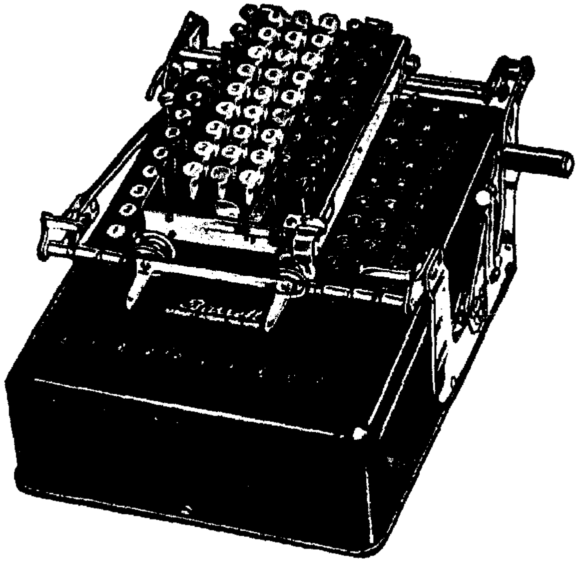


Figure 204

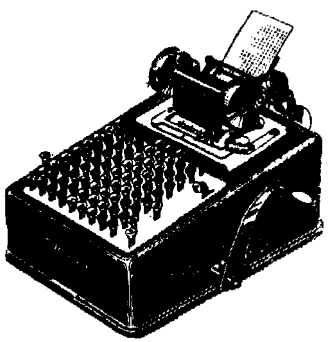


Figure 205

ways into the next column without having to be entered again. Model 12 has been equipped with another device for multiplication; this makes it unnecessary to set up the multiplicand again in transferring to the next multiplication. The adding gears are shifted back and forth by means of a lever, adjustable in notched positions, attached beside the right ribbon spool. This represents, of course, an important saving of time.

Model	Columns of keys	Number of digits in result	Price in $[72]
*7	7	7	175.00
*7¼	7	7	190.00 (Model 7 with ¼, ½, ¾)
9	9	9	225.00
9¼	9	9	240.00 (Model 9 with ¼, ½, ¾)
9⅛	9	9	250.00 (Model 9 with ¼–⅞)
9A	9	10	250.00
9B	9	11	275.00
9C	9	12	300.00
12	9	9	325.00 (with multiplication device)
*5	5	6	125.00
*7A	7	8	200.00
*6 *10	Models 6 and 10 were nonprinting models (figures 202, 203).		
*14	This was the same as model 12, but with a wider carriage.		

Note: Those with * beside the model number are no longer available.

Marchant (1911)

Manufacturer: Marchant Calculating Machine Company of Oakland. The Marchant is a pinwheel machine that operates like the one described in the introduction. Originally two models were manufactured, the Pony and the Standard, which differ from one another in size.

Until 1922 the two models had the small setting levers of the well-known German machines and resembled them in other respects as well. The revo-

72. Martin left the price of models 6, 10, and 14 blank.

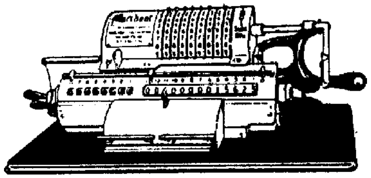


Figure 206

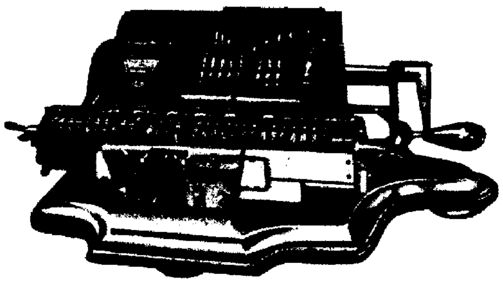


Figure 207

lution counter is equipped with tens-carry; instantaneous zero setting of the entry levers is provided by lifting a bar. Shifting of the carriage and zero setting of the two counting mechanisms occur in the usual way. Since 1915 the machine has been provided with electric drive. as shown in figure 208. in this model, when the motor lever is shifted to the digit 8, the motor will perform exactly eight revolutions. This is very useful in multiplication, etc.

Since 1922 the Pony model has also been provided with large, nonrotating levers. The keyboard model appeared in 1923 (figure 209). It possesses self-correcting keys, column clearing keys, a repeat key, a repeat disabling key, and a keyboard clearing key. The setting windows are at the very top left: a revolution counter is arranged to the right of the setting windows: the result mechanism is located underneath in the movable carriage. This model has no red numerals in the revolution counter—the American literature praises this as a novelty. but in reality this has simply been copied from German products. Aside from these models, they are still selling one with lever setting in which the movable result mechanism is located below the setting slots with the revolution counter located adjacent to it. The counter mechanisms of both models may be set to zero by rotation of a crank.

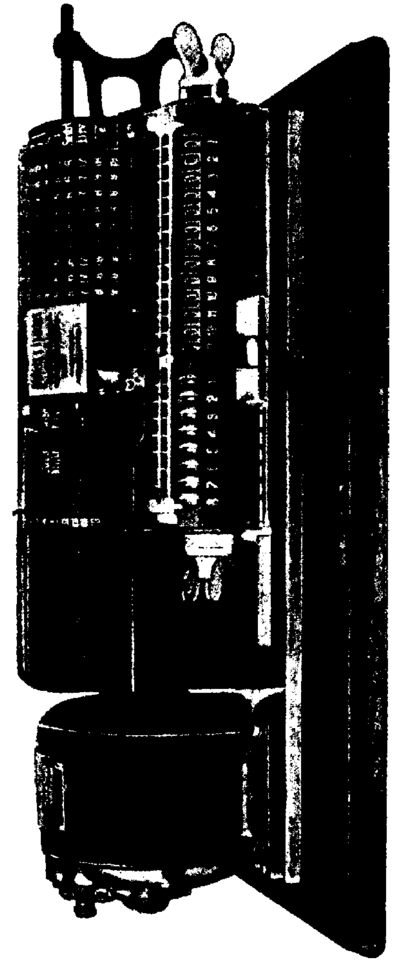


Figure 208
Lever set machine with electric drive.

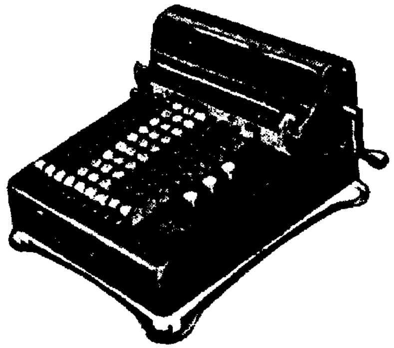


Figure *209*
Keyboard model.

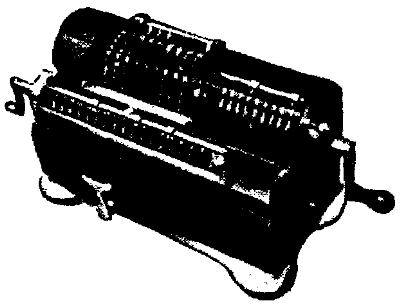


Figure 210
Model X-L.

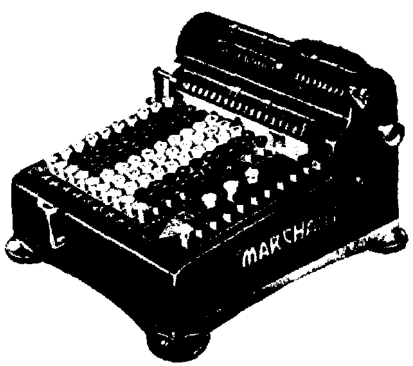


Figure 211

Models and Prices:

Pony A	9 × 6 × 13 places	$275.00
Pony B (1917)	9 × 10 × 18 places	$325.00
Standard A	9 × 8 × 13 places	$265.00
Standard B	9 × 10 × 18 places	$315.00
X-L Model with lever setting	9 × 9 × 18 places	$350.00
K-A Model with keyboard	6 × 6 × 12 places	$200.00
K-B Model with keyboard	9 × 8 x 16 places	$300.00
K-C Model with keyboard	9 x 9 x 18 places	$350.00

The K-C model may be supplied with electric drive if so desired (figure 211). To the right of the addition keys, and separated from them by two motor keys, are keys numbered 1 to 9. When a value is to be multiplied by 98, the 9 key is pressed, the carriage is shifted one place, then the 8 key is depressed, and the result may then be read from the machine. The additional charge for the electric drive is $150.00. The Marchant has been imported into several countries.

Monroe (1911)

The Monroe emerged, so to speak, from the Baldwin Calculator (see Baldwin 1875). The designer of both machines is Frank Stephen Baldwin who was in his late seventies when he set out on his new job. His work was instigated by J. R. Monroe from whom the machine derived its name and who actively participated in the making of the first machine.

When values are entered on a stepped drum or a pinwheel machine by means of the setting levers, the operating hand has to travel a relatively large distance. Moreover, the setting has to be carried out very accurately otherwise the result will be erroneous. Generally speaking, the pinwheel machines and the stepped drum machines with setting levers are not very well suited for addition of long columns of values because the accurate setting of the values takes a long time. Only one such machine having a keyboard was on the market when the Monroe appeared since this system was, at the time, still relatively unknown.

It was ***not*** a great leap to think of providing a machine that combined the advantages of the full-keyboard adding machine (speediest setting of the

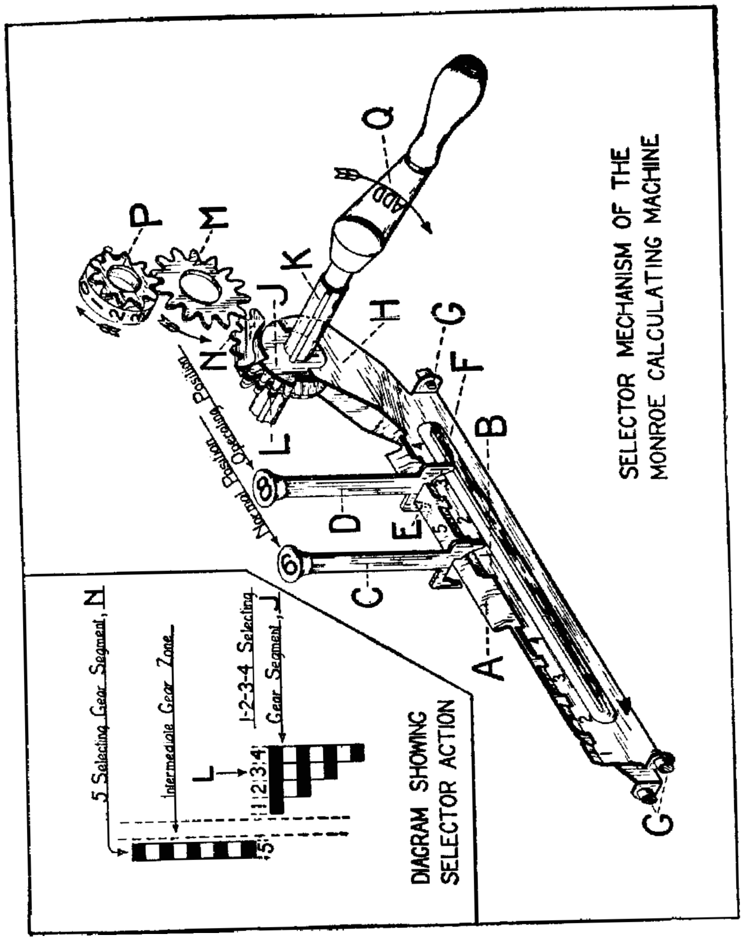


Figure 212

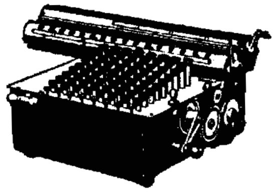


Figure 213

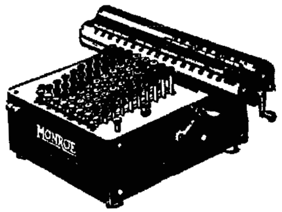


Figure 214

items) with those of the stepped drum and pinwheel machines (direct subtraction by turning the crank in the opposite direction or by special reversing setting, and in any case without the use of complementary digits; fast multiplication and division merely by turning the crank and appropriate ordinal displacement of the carriage). and this the designer succeeded in doing.

The key depression on such a machine must be short, of instantaneous effect, and light; no errors must occur by insufficient depression of the keys or by excessive speed in operating the machine. Because of this, Baldwin conceived the idea of subdividing the setting mechanism into two sections; the left half having five teeth and the right half having a first, second, third. and fourth tooth. One can now have five teeth activated at once and with them one or more of the first four teeth. The setting operation. the dimensions. and the weight of the machine are reduced. resulting in a short key travel no matter whether the first or the ninth key is used. Figure 212 shows the whole key and transfer mechanism of the present model.

The first model (as shown in figure 213) dates back to the year 1911, from which time these machines have been continuously on the market. Large-scale production was started in 1914. Figure 214 shows the model from 1915, which has a slightly altered design. At that time a banked (or stepped) keyboard was employed, whereas the present model **K** has an oblique keyboard

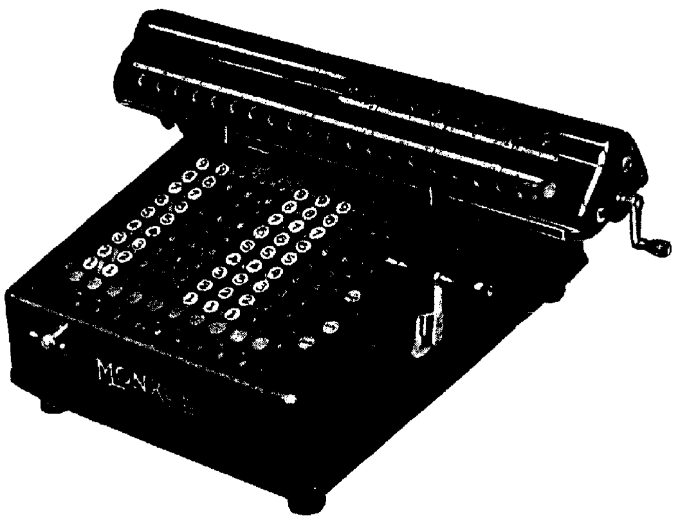


Figure 215
Model K. manual drive

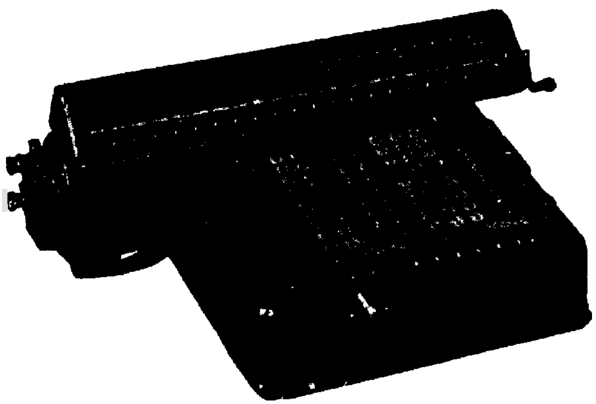


Figure 216
Machine with electric drive

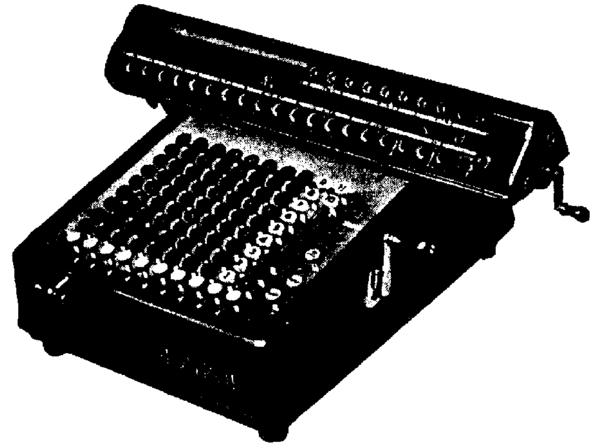


Figure 217
Machine for English currency.

with keys of approximately the same height in all key rows. The carriage is located above the keyboard. Rotation of a manual crank, which may be seen at the front of the machine, provides ordinal displacement of the carriage to the left or to the right, while a button on the right side of the carriage permits speedy shifting over its total path of travel. The keys for clearing of individual columns of the operational keys are located in the lowest row of the keyboard. The two counting mechanisms may be set to zero by a crank: the upper one by a forward movement of the crank and the lower one by a backward rotation of the same device. At the right side of the keyboard there is a repeat key, a repeat disabling key, and also a general clearance key for the keyboard. The keyboard is self-correcting. Addition, subtraction, multiplication, and division occur in the same manner as in the pinwheel machine, except the setting takes place by means of the keys.

No details are available with regard to the first three models, which were only manufactured in small numbers. Model D appeared in 1915, model E in 1916, model F in 1917, model G in 1919; then in 1921 the present model K appeared, which is manufactured in the following sizes:

6 × 6 × 12 places	10.5 kg	$200.00
8 × 3 × 16 places	11.5 kg	$200.00
10 × 10 × 20 places	13.5 kg	$400.00

The two larger models were also furnished with electric drive. The motor is located on the left side of the machine, while the plus and minus operating keys are at the right side of the keyboard. If the electric current should fail, which is known to happen, the hand crank may be slipped on and the machine may be operated manually. Machines for fractions and for English currency are also available.

Manufacturer: Monroe Calculating Machine Company of Orange, New Jersey. (The company took over the facilities and the equipment of the Pike Adding Machine Company in Orange.)

Tourtel (1911)

The Tourtel is a printing adding machine with setting levers just like the pinwheel machines. It is equipped only for English currency. The lever on the right side of the machine is marked F (farthings), followed by D (pence), I (shilling), and finally 10 (shillings). The remaining three levers are for pounds—the machine is thus capable of adding up to £999. The setting levers

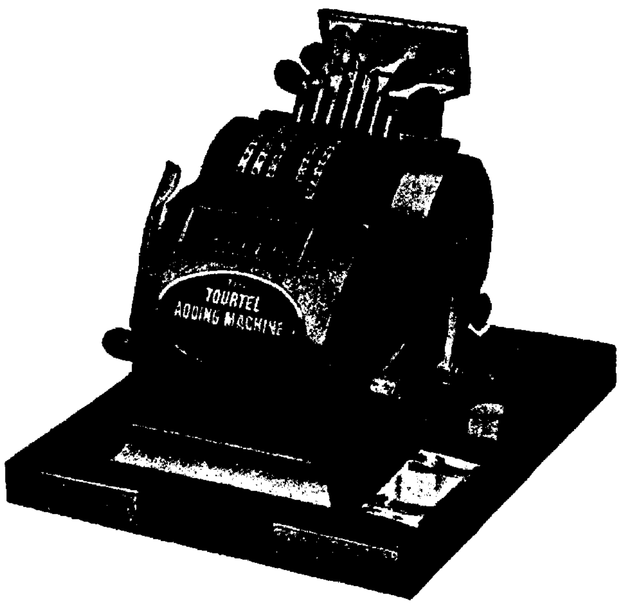


Figure 218

are, as usual, placed next to the setting slots, and the values are entered in the normal way. The result can be read from the wide window at the front of the machine, In order to print and add the value entered, the printing lever (on the left of the entry slots) must be pressed, which then forces the paper platen against the calculating gears. The crank on the right side of the machine must then be turned. This adds the value and brings the setting levers back to their rest position. On the front of the machine are two mirrors by which it is possible to check whether the correct value has been entered. To print the total, the lever next to the result window must be pressed and the zero setting crank on the left side of the machine must be turned—this causes the value in the result mechanism to be printed. To reset the machine to zero, the zero-setting crank must be turned without the total lever being pressed.

The weight of the machine is 5.5 kg. The designer is John Mesny Tourtel, London. and the manufacturer is The Tourtel Adding Machine Syndicate, Ltd.. 57 Chiswell Street, London E.C. In 1912, the German patent was tendered at £2000, although it was later sold by the designer for considerably less. Even in England the machine was not considered to be a significant one, and it has not been manufactured for some time.

Thales (1911)

The Thales is a well-established calculating machine with pinwheel gears (see the section in the introduction on pinwheel machines) that has been produced in four models.

Model A: nine places in the setting mechanism, thirteen in the result mechanism. eight in the revolution counter; weight: 4.5 kg.

Model B: nine places in the setting mechanism, eighteen in the result mechanism. ten in the revolution counter; weight: 5.5 kg.

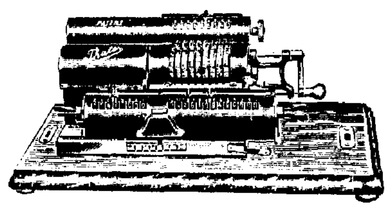


Figure 219

Model C: nine places in the setting mechanism, thirteen in the result mechanism, eight in the revolution counter. This model has tens-carry in the revolution counter and does not need any reversing lever; weight: 6 kg.

Model D: twelve places in the setting mechanisms, eighteen in the result mechanism, ten in the revolution counter. This model also has tens-carry in the revolution counter and does not require any reversing lever; weight: 9 kg.

The manufacturer is the Thaleswerk, Rechenmaschinen-Spezialfabrik G.m.b.H. in Rastatt (Baden), (formerly Landau in Pfalz). (See also Tasma.)

Hermes (1911)

The Hermes is similar to the stepped drum machines. However, the main feature of the former, namely the stepped drum, has been replaced by horizontally adjustable toothed rods. This means that the individual viewing windows are placed closer to one another, and values are therefore easier to read from them. The values are entered by means of the usual setting slides. A lever attached to the left of the machine can bring all of these back to the zero position in one movement. The change from addition-multiplication to subtraction-division is carried out by means of a lever.

The whole machine is cased in a metal box, which is suspended in a frame. A simple device allows the machine to be positioned at any desired angle.

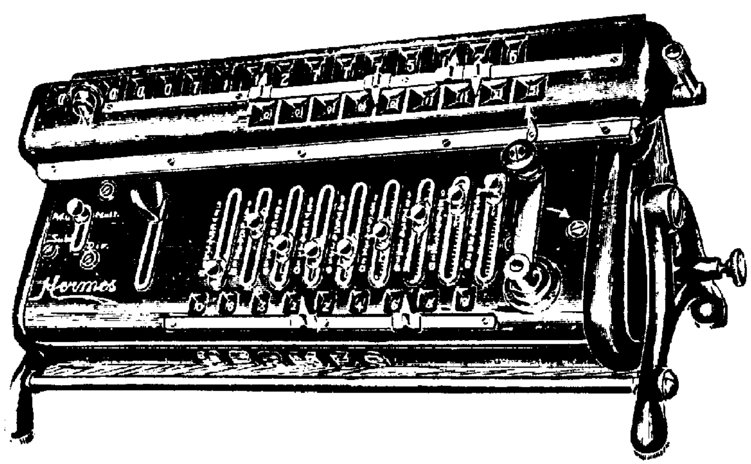


Figure 220

The machine is made with fifteen places in the result mechanism and nine places in the setting and revolution mechanisms. The entered values can be read off in a straight line from underneath the setting slots. There are also machines equipped with two calculating mechanisms, the second of which is placed underneath the setting slots. The manufacturer is Benno Knecht, Lüssow Strasse 105, Berlin W 35. Manufacture has ceased since the outbreak of the war.

Calculator (1911)

This pinwheel machine is manufactured by Joseph Kopfer und Sohne G.m.b.H. in Furtwangen (Baden) and is distributed without any special advertising. The locking device on the machine has been patented—it prevents the crank from being turned before it is in the correct position and also prevents the machine from being damaged by incorrect handling. There is also a locking device attached to the machine that makes it impossible for the crank to be turned back in the middle of a rotation—most errors result from this sort of incorrect handling. Production was stopped because it did not fall within the manufacturing scope of the factory involved. They had a shortage of precision mechanics and foremen. Furthermore, as far as their own specialty was concerned, the factory was already swamped with work, so that there was simply no space to extend production. The factory would also have come into difficulties with important clients at that time: namely, the calculating machine factories and clock factories (which also manufactured calculating machines) that they had, until then, supplied with their earlier specialties: cutting machines for gears, drives, worm gears, and racks.

In the autumn of 1912, the factory and a supply of complete machines and parts were offered for sale in London and Paris. At about the same time production of Calculator machines ceased. There is good reason to suppose that one of the large manufacturers of pinwheel machines purchased everything simply to get rid of new competition. The price of the machine was only 350 marks, and this was likely the main selling point.

Sirius (1912)

This machine was brought onto the market by Sirius-Werk, Wilhelm Keil in Nördlingen. It is shaped like a cash register with vertically positioned calculating gears. In place of the setting windows, the calculating gears have handles with knobs by means of which data entry can be carried out manually. The machine had nine places and cost 150 marks, but it has now disappeared from the market.

Moon Hopkins (1912)

The Moon Hopkins is not a new machine. As early as September **1902** it was completely ready for production and was on display in St. Louis in October nf that year. In January 1903 its patent was pending in America, although the patent was not granted until 24 September 1912 (in Germany it was granted in 1907), so that production could not be started any earlier.

The designer was Hubert Hopkins in St. Louis, and the financier was James L. Dalton in Poplar Bluff, who later became the adding machine manufacturer. In 1903 Hopkins sold his share to the American Arithmometer Company (today the Burroughs Company), from whom Dalton bought it back and founded the Adding Typewriter Company. Out of this arose the Dalton Adding Machine Company. In 1903 (after he had sold his share to the American Arithmometer Company), Hopkins interested John C. Moon in the manufacture of the machine. The latter provided him with the money and later brought the machine onto the market. After this, there ensued a rather lengthy patent dispute between the new Moon-Hopkins Company, which manufactured the machine on a large scale, and the Dalton Company, which held the patent.

Figure **221** shows the design of the machine as it appeared on the American market in **1912.** The description of the machine and all other illustrations refer, however, to the original model. The difference between the two is quite insignificant and relates principally to the drive mechanism. Whereas in the earlier machine the drive was provided by means of a hand crank, like several calculating machines it later came to be electrically powered. The carriage return is also automatic in the later model.

As should already be clear from what has preceded, the Moon Hopkins machine consists of a typewriter connected to a calculating machine. Whereas the Ellis, already described, has a front typing action and thus has visible printing. together with a calculating keyboard with nine rows of keys, the earlier Moon Hopkins has typing action underneath as did the original Remington, and furthermore has only a calculating keyboard with two **rows** of keys.

Figures 222 to *225* give some idea of the interior of the machine. especially the calculating mechanism.

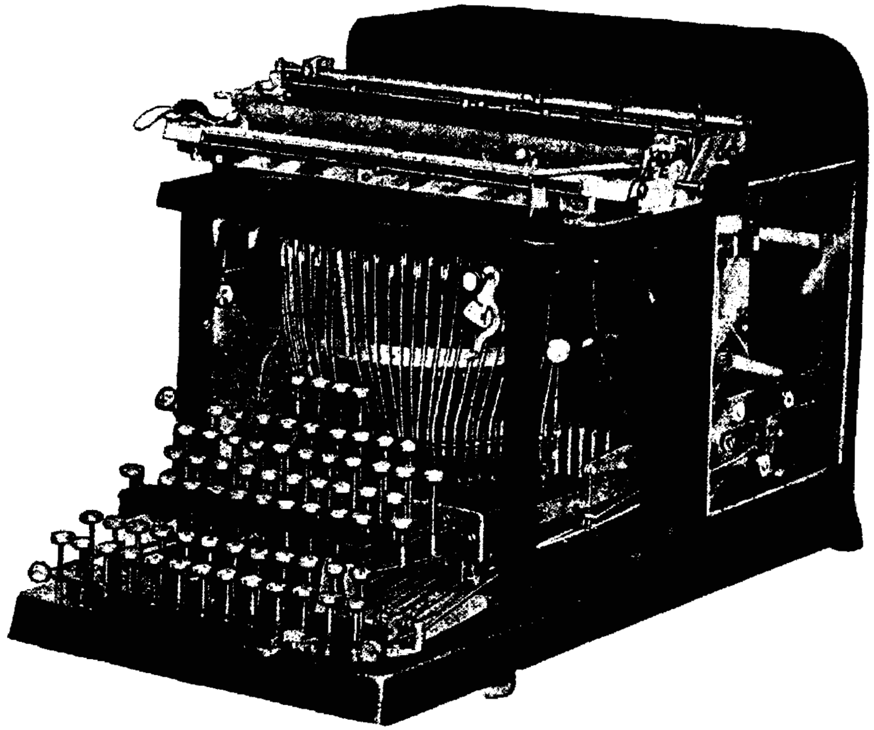


Figure 221

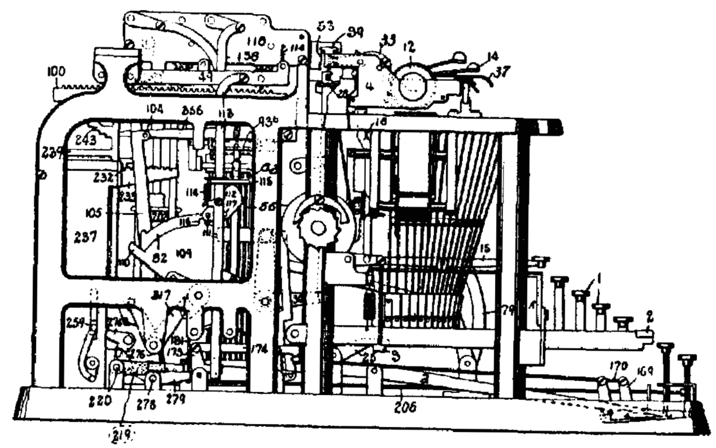


Figure 222

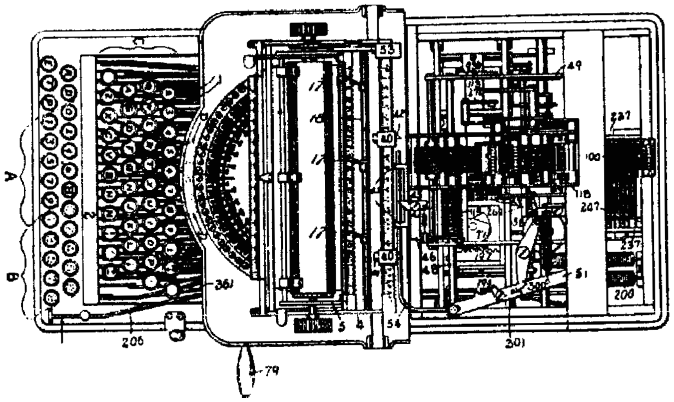


Figure 223

Apart from the letter, digit, and symbol keys, which are attached to a keyboard. the Moon Hopkins is equipped with two more rows of keys, including digit keys arranged into two groups. In addition to these digit keys, there are others, each of which is provided with a letter. By pressing these down, the adding mechanism of the machine is affected in different ways. The machine is designed *so* that, for example, figures can be printed in several adjacent columns and at the same time be registered in the sum gears **of** the adding mechanism, *so* that by pressing down the totalizer key, the **sum of** each column of figures is printed independently of the others at the foot of the column. The individual sums can be registered in other sums gears and can be combined into one total sum, which can then also be printed by pressing one **of** the letter keys. The figures registered in the sum gears and their sums can be retained in the sum gears by pressing one of the additional keys, even after printing has taken place, **so** that they can be printed at a later time.

As already mentioned, the typewriter resembles the Remington with its nonvisible typing action, although here the type levers are not attached in a circular fashion, but rather in a semicircle. That is, the machine does not print both upper and lowercase but only capital letters, a situation we have seen before in various other bookkeeping (or calculating typewriter) machines. The Moon Hopkins is **not** specially built for correspondence but rather for accounting. The lowercase letters are therefore totally dispensable. It has the universal keyboard with forty-one keys. The carriage runs on rollers. In order to read the typing, the carriage must be raised. It is pulled by the standard

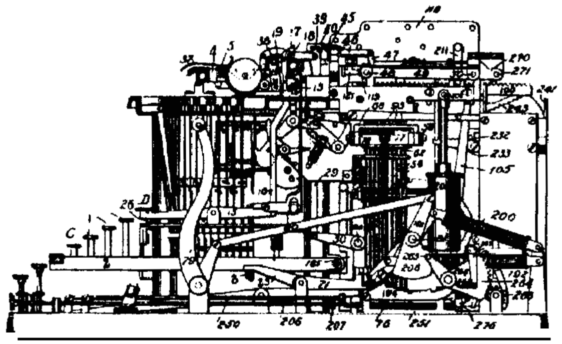


Figure 224

tension cord connected to a tension spring, while the release is handled by two small blades under the toothed rack. On the right side of the platen is the platen gear to which a cam lever is connected—this is used for setting the spacing **as** usual and at the same time for shifting the carriage to the right, back to the starting position. Next to it there is a lever connected to one of the disks in front **of** both blades. With the aid of this lever it **is** possible to remove the blades from the toothed rack, so that the carriage can be easily pulled against the tension spring as far as it is allowed to travel. Above the keyboard are four tab keys (marked ***D*** in figures **223** and **224)** that also operate both blades; that is, take them out of contact with the rack. The corresponding stops sit on a scale attached behind the platen. When the carriage is freed by one **of** the tab keys and is pulled to the left by means of the tension cord, the srop corresponding to this key halts the carriage at the place where the respective column should begin.

The calculating machine **is** built **on** the typewriter. It is protected from dust by a massive case made of metal with glass walls. On the right side there is a hand lever that moves the platen one line space.

It should be mentioned that the machine is equipped with three groups of sum gears, or totalizers. These are attached **to** a shaft that is free to be shifted across the machine frame. Each of these three groups **of sum** gears has ten such gears lying adjacent to one another. According to how it is set, either the left, middle, or right group is within range of the movable toothed racks (marked 100 in figures 223 and 224), on the front ends of which there are the type heads **of** the adding mechanism. The shaft is attached by means of connecting links to the paper carriage of the machine. As with standard type-

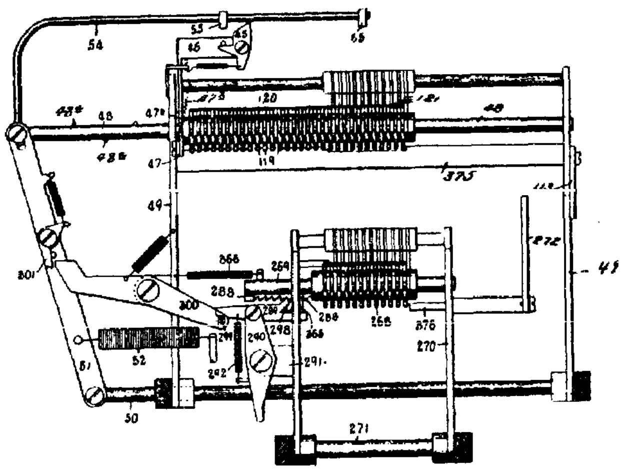


Figure 225
Partial view. calculating mechanism seen from behind

writers, this carriage is automatically shifted one space by pressing down a key and takes with it the above mentioned shaft. The connection between the paper carriage and the shaft bearing the sum gears can **also** be released. so that the sum gears do not shift simultaneously with the carriage.

Behind the three movable groups of sum gears is yet a fourth group. which at all times occupies a fixed position with respect to the toothed racks carrying the type heads and. together with these type heads. can be brought into gear with each of the front groups. When it is in gear. the number registered in the respective front group is also registered in the fourth back group. In the same way, the sum registered in each of the front groups can be registered in the fourth back group so that the sums that have been registered in the different front groups are all registered in the rearmost group, from which the total sum can then be printed.

Addition: Figures to be added are entered by means of the keys of the calculating machine keyboard (see group **A** on figure 223). These carry the figures into the first of the three front calculating mechanisms and, in this way, as many items **as** required can be added. The key T, in the lowest row of keys of the calculating machine keyboard, is used to print the result. Errors can be corrected by means of the correction key (206 in figure 223).

It **is** also possible to add up several parallel columns. With **two** such columns, the tabulator key is used to shift the carriage in such a way that the second calculating mechanism is brought into operation. The results are then recorded and printed in the way described above. In order to add columns together. keys *T* and *D* are pressed down and the hand lever **(79)** pulled forward; while the hand lever returns to starting position, the ***D*** key is held down. If the *T* key is held down, then the front sum gears remain in operation with their toothed racks, so that the total sum **is** recorded in the front sum gears. It is **also** possible to record the total sum in the back sum gears.

Horizontal addition is carried out in the same way as addition in columns. with the difference being that the tab keys are not used. The machine's spacing key is used to make the intervals between the numbers. The sum is printed in the same way as outlined above; namely, by pressing the *T* key and pulling the hand lever.

Multiplication: If the key marked ***R*** is pressed after keys from group **A** have been pressed down, the corresponding number is recorded **in** the front sum gears and at the same time is entered in the machine's multiplication device. If the number entered is to be multiplied by 9, then the key marked 9, in group B **of** the keyboard, must be pressed down. With two subsequent turns of the hand lever, (1) the back sum gears are connected to the toothed racks but not the front sums gears, as is normally the case, and (2) the printing of the number keys, which would otherwise result, fails to take place. The result then appears in the back calculating mechanism. In order to print the result, the *P* key is pressed down and the hand lever **(79)** is pulled toward the front. Through **this** action, the product is simultaneously recorded in the front sum gears, so that if more products are to be added. the total sum can be printed by pressing down the ***T*** key. If, in pressing down keys in group **A** and the ***R*** key, **a** figure is incorrectly recorded in the multiplication device, then it can be shifted back to its original position by pressing down the *P* key and pulling the hand lever. **If** the incorrect key in group B has been pressed down after a number has been recorded in the multiplication device, this error can be corrected by pressing down the so-called correction key.

This multiplication device, which has been mentioned several times, is nothing more than **a** multiplication table mechanism (see **also** Bollée, Millionaire).

If a number which has been recorded in the front sum gears is to be carried over into the multiplication device. then key ***E*** is used.

Addition in columns with multiplication:

123	×	12	1476
456	×	54	24624
789	×	35	27615
1368			53715

In this example, the number 123 is recorded and printed by pressing down the relevant keys in group A and by pulling the hand lever. However, before the hand lever is pulled, the R key is pressed down, which then records the number 123 in the multiplication device. As 123 is to be multiplied by 12, this number can be printed in line with 123 on the page by pressing down the respective keys in the machine's keyboard. But in order to retain the product of 123 × 12—namely, 1476—the following procedure must be carried out. To begin with, out of those keys in group B equipped with digits 0 to 9, the key marked 1 is pressed down and then the hand lever is pulled forward twice. The key in group B marked 2 is pressed down and the hand lever is again pulled twice more. This ensures that the product of 123 × 12 is recorded in the back sum gears. After the paper carriage has been shifted sideways, the product can be printed by pressing down the *P* key and pulling the hand lever. When the *P* key is pressed down, the product is recorded in those groups of front sum gears that at this point in time are situated opposite the toothed racks.

The paper carriage is then shifted to the right and, when the spacing has been set, the second number, 456, is recorded and printed in the manner already described. The multiplication of this number by 54 is carried out in the same way as the multiplication in the first row. When the number has been printed by the keys of the usual typing mechanism, both the key marked 5 and then the key marked 4 are pressed down and the hand lever is pulled twice. This records the product in the back sum gears.

After the paper carriage has been suitably positioned, the sum of the numbers can be printed in the first column by pressing down the T key and pulling the hand lever. In the same way, the sum of the products, which have all been recorded in the front sum gears, can be printed at the foot of the product column by pressing down the T key and pulling the hand lever (after prior setting of the paper carriage). If both sums are to be recorded in the front sum gears, the T key is held until the hand lever has returned to its original position.

Subtraction: The multiplication device will only store amounts and is therefore not a regular calculating machanism. It can also be used to store subtraction figures. Those sums from which subtractions are to be made are either transferred directly or by one of the three front calculating mechanisms into the back calculating mechanism. Then the subtraction key is pressed and, by pulling twice on the lever, the subtraction is carried out. The difference stays in the back calculating mechanism and can then be printed or carried over into one of the front calculating mechanisms.

The original Moon Hopkins, which is the machine that has been described so far, was manufactured by the Moon-Hopkins Billing Machine Company, 2235 O'Fallon St., St. Louis; however, they had to stop production. In 1923 it went over to the Burroughs Adding Machine Company, which only made machines with electric drive. Today they supply machines with one to five front calculating mechanisms and one back calculating mechanism. The machine is now equipped with a ribbon color change key so that, if necessary, it is possible to print amounts in red. There is also a special key available that sends the carnage back to the starting position and at the same time causes a line feed. The four column positioning keys can be found above the keyboard of the typewriter.

Price: Machine without multiplication device (therefore only for the addition of amounts without fractions with a front eight-place calculating mechanism ten-place result mechanism) and one nine-place back calculating mechanism (ten-place result mechanism), 25-cm-wide carriage with electric drive and motor, with automatic carriage return: $650.00.

The same machine, but with three front calculating mechanisms, subtraction, and multiplication device, 30-cm-wide carriage: $950.00.

Additional front calculating mechanisms: $50.00 each.

These machines can also be supplied with fractions (eighths and tenths).

Sanders (1912)

Designer: Roberto Taeggi Piscielli in Naples. Manufacturer: Société Industrielle des Téléphones, of Paris. Sales agency: S. A. des Anciennes Establisements Nico Sanders, 92 rue de Richelieu, Paris 2me.

Originally the machine bore the name L'Eclair. It has a remarkable pinwheel construction with electric drive.

On top are twelve long setting levers that may be moved in slots in the usual way; directly below are an equal number of checking windows (marked

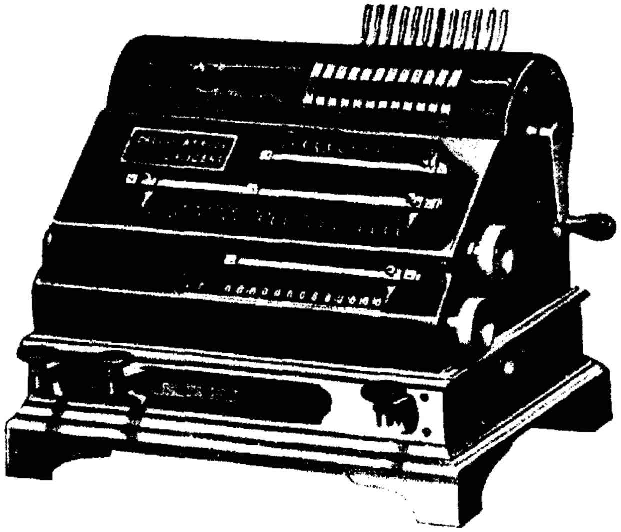


Figure 226

1 in figure 227) in which the entered value may be reexamined for accuracy. Below these is the result mechanism (2) with twelve windows, while to the left is a revolution counter (3) having seven decimal places. A little further down is an additionai result mechanism **(4)** having thirteen places, and to the left of this is a revolution counter (5) having two places. The switch for the electric current is on the right side of the base, and on the front are keys B. A, and C—the use of which will be explained.

Addition: The first item is entered in the usual way, it is checked for accuracy, and the lever **A** is shifted to position 1; it is then pressed, which connects the electric current, whereupon lever **A** is allowed to rise, the value having appeared in the windows of result mechanism 2. Further items may be added in the same manner.

Subtraction: The larger amount is entered and is transferred into result mechanism 2 in the same way as described under Addition, then the smaller item is entered, key B is pressed, key A is pressed into position 1, and the result is obtained from mechanism 2.

Multiplication: The multiplicand (e.g., 76) is entered by means of the setting levers, then, in order to multiply by 24, key A is pressed into the units

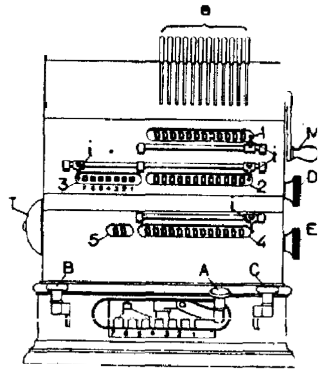


Figure 227

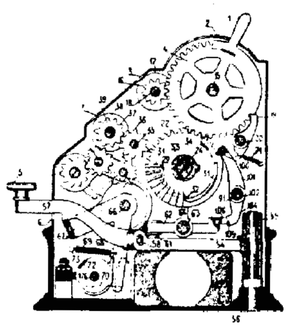


Figure 228

gap (1) until the electric motor has caused four revolutions; key A is then shifted into the tens gap (2) where it is left until the electric motor has caused two revolutions. The following values may then be read from the machine: the multiplicand from the checking windows (1), the multiplier from the revolution counter (3), and the result from the result mechanism (2).

Division: The dividend is entered in the result mechanism (2), and the divisor is then entered in the windows (1). Key B and key **A** are pressed in the appropriate positions until the signal bell (T) sounds, whereupon both keys are released. This operation is repeated with key A being pressed in each of the successive decimal places until the division is complete.

As previously explained, the machine is provided with a second result mechanism and a second revolution counter, the use of which is explained in the introduction. Key C serves for transferring an item from the first to the second result mechanism. Crank M is used for clearing the checking windows, while drum buttons D and E are for clearing the first and second result and revolution counter mechanisms. The machine has no externally visible carriage; the pinwheels and revolution counter, which are mounted upon one shaft, one moved to different digit positions by lever A, which fits into seven gaps shown in the lower part of figure 227. The price of the machine was originally 1250 francs and later 1500 francs (prewar prices).

Wrenn (1912?)

lust like the Triumph, described earlier, this machine has continuous loops of chain acting as the setting device. These are pulled down from the number to be added as far as they will go and then held there to stop them from springing back. It is then possible to immediately read off the number entered from the viewing window of the corresponding position; this value will be added to the number already stored in this position. The numbers must be entered in columns, otherwise the eventual tens-carry will go astray. Subtraction is done with the aid of complementary digits. Even the individual calculating gears have complementary digits, which is a great advantage in subtraction. Multiplication is carried out according to either the multiplication table method or the counting method. It is hardly worth considering the machine as far as division is concerned. Returning the machine to the zero position is done by turning a crank.

The machine is available in two sizes: eight-place at $47.50 and five-place at $30.00.

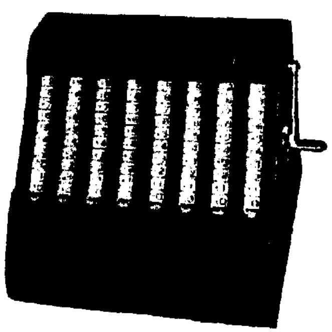


Figure 229

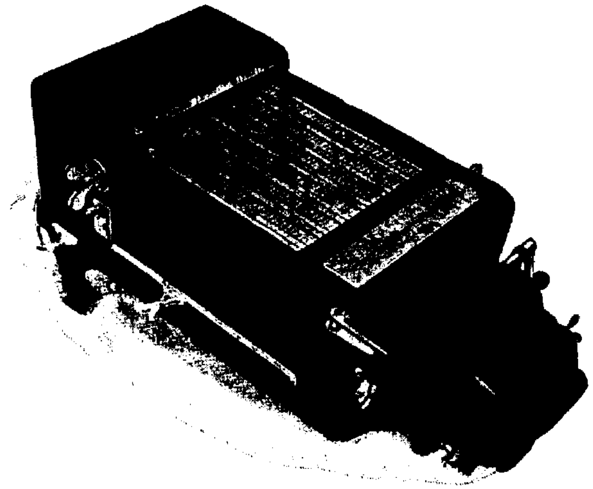


Figure 230

The dimensions of the machine are 20 × 25 cm and its weight is 5.5 kg. As yet, it has not been introduced into Europe. Manufacturer: Wrenn Adding Machine Company, 4th and Channing Streets NE, Washington.

Procento (1912)

The firm Procento, Ungarisohe Rechen-und Schreibmaschinenfabnk A-G in Kassa, used this name for both a stepped drum machine without any special features and a pinwheel machine as represented in figure 230. The latter was designed especially for calculating interest, but further details are unavailable. Today, the business carries the firm name Laplace Rechenmaschinenwerke und elektrische Uhrenfabrik, Inh. Victor Bernovits, Komenskeho ustav, Kosice, Czechoslovakia.

Austin (1912)

This is a nonprinting ten-key adding machine of the Austin Adding Machine Corporation, 927 Linden Avenue, Baltimore.

The amount entered can always be read from the lower adding mechanism; that is, it can be checked a second time before it is transferred into the larger calculating mechanism when the crank is pulled. There is a cancellation lever

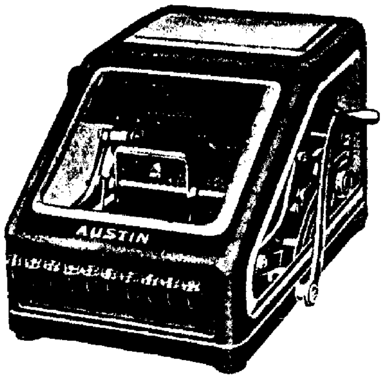


Figure 231

on the left side, as well as an item counter and correction key. The weight of this machine is 18 kg. It was offered **for** sale from Vienna at 600 marks, although the machine itself has never been of any great importance either in America or here. Production has now been discontinued.

Teetzmann (1912)

The Teetzmann machine is distinguished from other pinwheel machines largely by the fact that it has nine setting levers and control windows in front of the carriage. It is possible to operate the setting levers with the left hand only. while the right hand remains on the crank. Because of this arrangement, the interior mechanism is well protected from dust. The setting slide digits can easily be distinguished because they are kept in red and white sections. Digits of the result mechanism are red, while those of the revolution counter are white. The machine has fifteen places in the result mechanism and eight places in the revolution counter. The setting levers are brought into the zero position by pressing on the lever underneath the crank and moving the large knob next to the setting slots.

The machine is 20 cm long and 17 cm high. While there are only a few **of** these machines in Germany, a large number of them have been supplied from Manchester in England, and overseas. under the name of Colts Calculator. Manufacturer: Teetzmann and Company, G.m.b.H., Charlottenburg. Frauenhofer Strasse 18/19. In July 1915, this firm went into liquidation and the machine is no longer being manufactured.

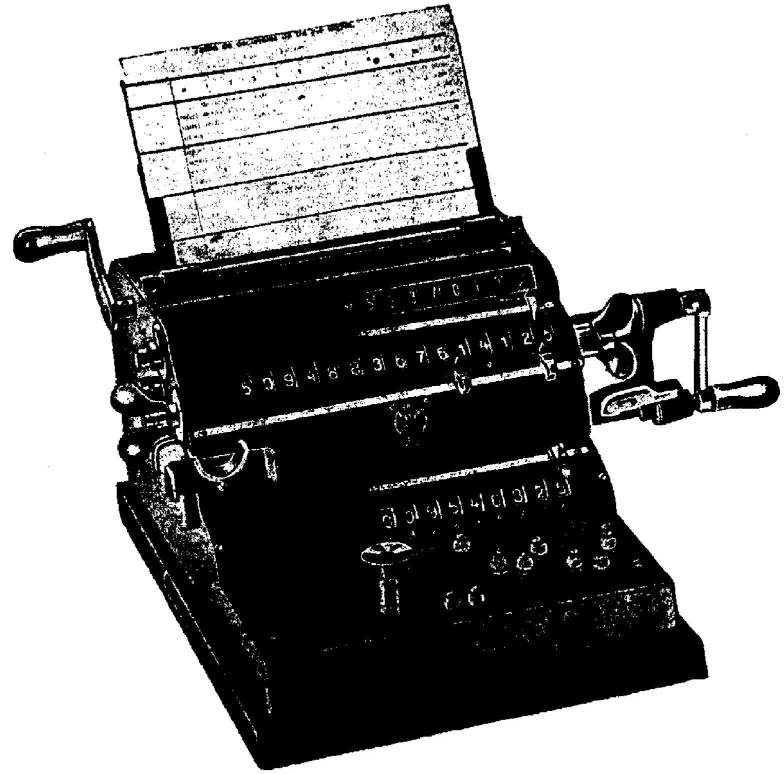


Figure 232

Burroughs Calculator (1912)

The Burroughs Calculator closely resembles the Comptometer described earlier. It is a calculating machine in which the keys directly operate the calculating mechanism, which is underneath the keyboard, so that neither crank nor electric drive is necessary. Several keys can be pressed at one time without causing the tens-carry to go astray, which is a real advantage in multiplication and division. It is impossible to press down several keys in the same column at one time; **as** soon as one key is pressed, all other keys of the same column are locked until the original key has come back up again. The machine is only available in seven-place or thirteen-place versions; both models have an **extra** place in the result mechanism. There are special models available for fractions and English currency.

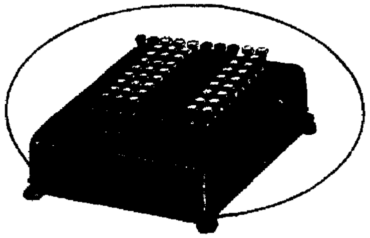


Figure 233

Price:

nine-place machine	$200.00
thirteen-place machine	$300.00

The machine does not need any more desk space than that required for a sheet of note paper. Manufacturer: Burroughs Adding Machine Company, Detroit.

Conto (1912)

Manufacturer: Carl Landolt, Thalwil near Zurich.

This is a cogged disk adding machine. On the cover plate are circular groups of digits placed very close together. In the middle of each circle is a rotating lever. or needle, which is moved by hand. Setting up a value is carried out by manually placing the needle on the digit to be entered for each position and clicking it into place. On the right, above the cover plate, is a thumb iever that must be operated after every setting. This causes the setting needles to spring back to their rest position while the result can be read from the viewing windows above the digit disks. There is a control available for every needle setting; by simply pressing it once, it brings all the viewing windows back to zero. Dimensions: 33 × 5 × 3.5 cm. Price: approximately 250 francs. This machine is available with six, eight, ten, or eleven places and for English currency with either nine or ten places. Apparently production has now ceased. Outside of Switzerland, the machine has never been well known.

Schooling (1912)

This is a special purpose machine for the calculation of net weights of railway cargo. especially coal, iron ore, etc. The gross weight is entered by shifting

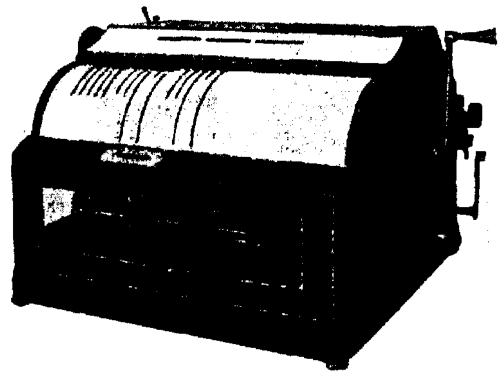


Figure 234

the setting levers in the setting slots. The tare weight is recorded in the same way beside it. Once the crank has been pulled and let loose again, the machine establishes the net weight, and the three weights are printed on a sheet of paper that is slipped into the machine from behind. It is also possible to add more weights in the same way, and in so doing the respective gross, tare, and net weights are added and printed. In order to print the total, the total lever is pressed and then the crank is pulled. The machine has only been made for English tons and hundredweights. There is also a version available for use in bookkeeping with English currency that both adds and prints debit and credit amounts as well as the balance. It is possible to add vertically and horizontally with this machine and, in fact, this can be done in three or more columns. Manufacturer: The Calculating Machine and Engineering Company Ltd., Welsbach House, 344/354 Grays Inn Rd., London WC. It seems, however, that the machine is no longer manufactured.

The Michel Baum Adding Machine (1913)

In appearance this machine resembles the Pebalia, but it is of a fundamentally new design and new patent. It was brought onto the market by Michel Baum, Hohenzollern Strasse 54, Munich.

In this machine the setting digits are crowded together into semicircles, which results in the machine being considerably shorter. It is, in fact, the flattest (rulerlike) machine in existence with a height of only 1 cm. It is a seven-place machine and costs 75 marks. Each digit position has a calculating gear and control gear on top of each other. These are simultaneously held by

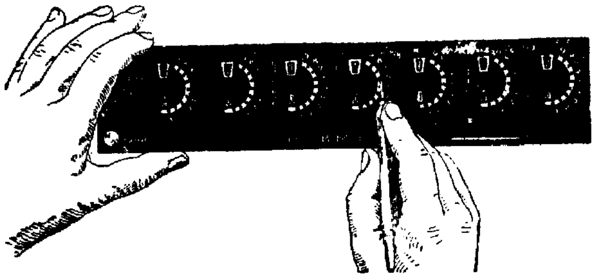


Figure 235

the calculating stylus, with which the machine is operated, and pulled down as far as they can go. Despite all this mechanism, it is only possible to see holes in the semicircular slots. During operation, the digits of the calculating gears show up as results in the upper viewing windows (these digits are on a red background), while the digits of the control gears show up in the lower viewing windows and are used to check the amount that has been entered. Both the result and control digits are visible at the same time.

Addition: The calculating stylus is inserted into the hole adjacent to the digit to be added, and the calculating and control gears are simultaneously pulled down as far as possible. For numbers of more than one decimal place, the other digits are entered, in the same way, in the semicircles to the left. When this operation is done, the amount entered is initially visible in both the upper and lower viewing windows. A quick glance at the control row is sufficient to check tor accuracy. It too little has been entered by mistake, it is possible to pull again on the relevant position, which will correct the result. If too much has been entered, it is possible to move back the corresponding calculating gear. This is a very practical means of correction in that it is not necessary to wait until entering the next number before taking into account the error that has been made. When the correct setting has been ensured, the knob on the left side of the cover plate must be pressed. This causes the control digits to automatically return to zero. If another item is then entered, the accumulated sum will appear in the upper viewing windows, while in the lower windows the last item entered is visible for checking. If the control item is not printed, then the addition automatically continues for the following settings, although the later items cannot be checked. It is therefore possible to calculate with or without checking, which is advantageous for those who

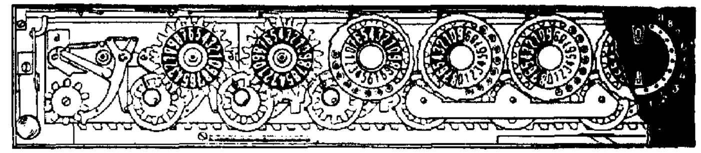


Figure 236

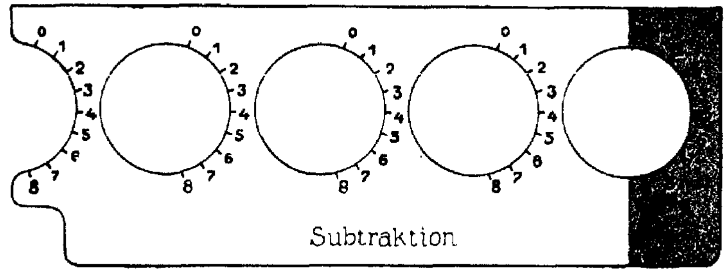


Figure 237

are experienced in the use of the machine. It is possible to add together as many items as required by repeating the process described.

Cancellation: In order to cancel the result, the setting stylus is inserted into the zero position slot situated on the right side of the machine and the slat visible there is pushed to the left until it stops. It must then be let loose and the action repeated a second time. Nothing but zeros should be visible in the upper viewing windows. As already mentioned, in order to cancel the control number, the knob must be pressed.

Subtraction: For this operation. it is necessary lo use a plate placed on the machine (see figure 237) that converts the addition digit disks to subtraction disks (these are arranged in the opposite order). The outermost position on the right has a red panel, and here the complementary digits are numbered from 1 to 9. For the other positions, however, the complementary digits are numbered from 0 to 9. Before subtracting there is. as a rule, already a number (the minuend) registered on the machine. The subtraction plate is placed on the machine in such a way that the red panel is put into the digit position where the subtraction begins. The number to be subtracted is then entered just as in addition, only beginning from the rightmost digit instead of the leftmost. All unused digits to the left of the number being entered are pulled down with the stylus in the uppermost holes. The resutt of the subtraction can be read at the top.

Multiplication: Multiplication can be carried out in three ways.

1. It is possible to enter the digits of the ones, tens, etc. quickly in succession. in the course of which the tens-shift is dealt with immediately by the machine.
2. As with the cogged rack and chain machines, it is possible to multiply by both the counting or the multiplication table method, where it is not necessary to aiiow the gears to jump back; quite tie contrary—in tact, they turn continuously forward.
3. With the multiplication table method, it is possible to do the carryover in one's head, therefore making the entering of numbers much quicker.

Record (1913)

Designer: Hugo Cordt, of Nordenham. The first machines were sold under the name Tasten-Universal-Rechenmaschine,[73] and manufactured, at that time. by the Nordenhammer Rechenmaschinen A.G. in Oldenburg. The original machine is shown in figure 238. In 1914 the production was taken over by the Rechenmaschinen-Fabrik, H. Ohlmann & Company of Oldenburg, which then moved it, in the same year, to Berlin SO 16 Kopenicker Strasse 72. At present the sole manufacturer, and owner of the patents, is Karl Lindstrom. A. G. of Berlin SO 33 Schlesische Strasse 26.

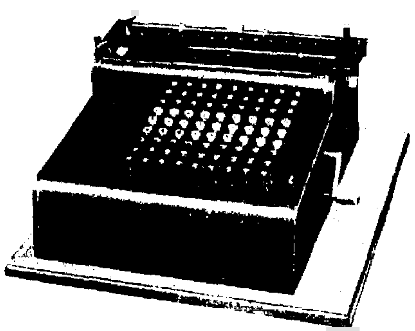


Figure 238

73. **Universal Key Calculating Machine**

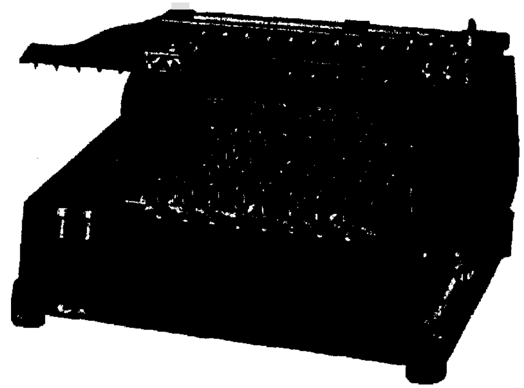


Figure 239
Current model,

The Record is a stepped drum machine, although this is not evident from the outside. In particular it is a stepped drum machine in which the drums are located in the back part of the machine, that is, in the carriage, where they arc positioned sloping slightly forward, arranged in a zigzaglike succession. This entirely novel arrangement permits using narrow upright digit wheels instead of the round counting disks employed in the older stepped drum machines, so that the individual windows of the two counting mechanisms and the setting check mechanism are positioned much closer together. Thus a disadvantage. if only a small one, of the older stepped drum machines is eliminated.

The crank is attached at an angle to the right side of the machine. It may be removed in order to prevent someone from playing around with the machine. Reversing from addition to subtraction occurs using a lever located on the left side of the carriage. which may be also used for raising the carriage to allow an ordinal shift. In more recent models ordinal shift of the carriage in both directions may be effected by means of two keys provided in front. The machine is available in two models for either manual or electric operation. The customary decimal point slides are provided; also the keyboard may be subdivided in any way to facilitate operation with large values. On the right side of the top surface is located a U-shaped slot in which a lever is mounted. This lever serves for clearing the values set up on the keyboard. When the lever is in the right slot, the keyboard is automatically cleared with every turn of the crank to allow for repeated addition of lists of numbers. For multiplication and division, the lever **is** positioned in the left slot. The keys are self-correcting.

A new model for a printing calculating machine along the lines of the proven system just described, combined with a new patented arrangement suitable for all types of calculations that automatically prints individual totals as well as intermediate products and final totals, is already in production and will shortly appear on the market. A new model with electric drive is also already in production.

Argos (1913)

This is a small adding machine with chain setting. The manufacturer was Gesellschaft fur Präzionstechnik G.m.b.H, Aite Jakob Strasse 20, Berlin **SW 68.** It was sold principally in Germany and, to a lesser extent, in France.

The result mechanism is to be found above the setting control mechanism below the setting surface. Zeroing the setup mechanism is brought about by pressing the thumb on a lever protruding from underneath the machine. By pressing it down and sliding it, the setting control mechanism can be changed for subtraction and multiplication. Subtraction is possible with the aid of complementary digits, which are to be found in red on both side panels **of** the machine. In setting up the units place, the otherwise standard correction procedure is not needed because the digits on the right side panel have been

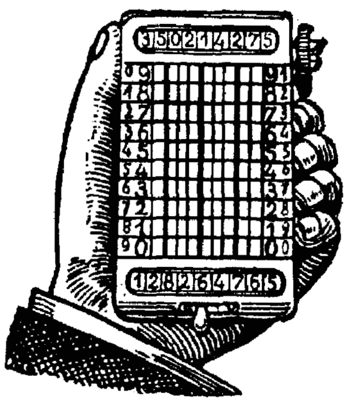


Figure 240

Figure 241

shifted one digit. On the other hand, the places that follow must always depend only on the remaining complementary digits.

Setting the result mechanism to zero: the small knob on the right side is pressed. and the wheel is turned until all the digit gears are on zero. The two rightmost columns show only red digits because it is clearer. The price is 125 marks. Production was started at the beginning of the war, but the firm no longer exists.

Klaczko (1913)

This is a small adding machine operated directly by hand without using a stylus. The result appears by simply setting the calculating digits, without turning a crank or carrying out any other operations. It is best to calculate with the index finger of the left hand so that the right hand is free to write, check. etc.

The most important thing about this machine is the fact that it can be **op**erated totally mechanically. Each of the nine calculating rods has two groups of teeth: the subtracting teeth, located on the upper section, and the adding teeth on the lower section. There is a plus sign printed on the lower section and a minus sign on the upper section of the machine. On the right is attached an adding disk and on the left a subtracting disk. The result windows are situated in the middle. This machine has no spiral springs, hinges, etc. It was an intentional design decision that the calculating rods were unable to operate the digit keys with or without a reversing gearbox, that there was no printing mechanism, nor is there a device for the carryover of tens. Somewhat later an improved model with tens-carny came out. Resetting to zero is done by a lever on the lower part of the machine. The decimal point slides are located on the upper section. On request, a small writing board can be attached above the decimal point slides. Multiplication is carried out with the aid of a table. The designer of this machine is Max Klaczko, Riga, 19 Scheunden St.

American (1913)

This machine was originally manufactured by the American Can Company in Chicago, which began production of the printing model on May 1, 1922. The nonprinting model is now distributed by the American Adding Company, 35 South Dearborn St., Chicago. This machine was introduced into all the most important European countries in **1914.**

It differs from all other adding machines in its setting mechanism. It has neither key nor slide setting, but instead has stepped finger supports upon which are printed the digits. To add, the tip of the index finger is placed on the digit to be added and the thumb of the same hand lifts up the corresponding lever, which is right underneath, until it strikes the index finger. It is possible to check the accuracy of the setting after all the digits to be added have been entered. If one or more digits have been incorrectly entered, the correction crank on the right side of the machine is needed: this returns the

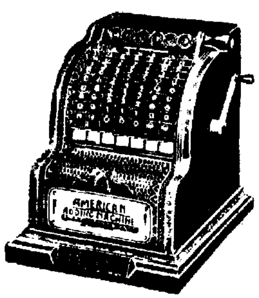


Figure 242

entire setting to the starting position without disturbing the result in the upper windows. The large lever next to the row of unit digits is used to transfer the entered value to the result mechanism; that is, to be added to the value that is already there. Another pull of this lever resets the entire calculating mechanism to zero. For subtraction and division, the small subtracting digits must be used.

After the value to be multiplied has been entered, the repeat lever on the left of the machine is pressed, then the larger lever next to the row of unit digits is pulled—as many times as the value of the number being multiplied. Before the last movement of the lever, the repeat lever must be raised. The number of movements of the lever is, at all times, shown through a small window on the front panel of the machine.

The dimensions of the machine are 19 × **23** × **24** cm and its weight is 7.8 kg.

Models:

- 0 nonprinting, 7 × **7** places, without repeat lever
- 00 nonprinting, 7 × 8 places, without repeat lever
- 1 printing, 7 × 8 places, release key, total and correction lever, double-colored ribbon with provision for 6-cm paper strips
- 3 the same as model 1
- 4 provision for 6-cm paper strips, double-colored ribbon, total and correction lever, visible printing (this model was also sold in combination with a till)
- 5 nonprinting, 7 × 8 places

Prices: Model **1,** $88.00; model 4, $150.00; model 5, $39.00.

Federal (1913)

This machine came on the market in **1913,** but at that time it was under the name White. Its designer was also the builder of the Wales machine of the time. The original manufacturer was the White Adding Machine Company in New Haven, Conn., but later the patent went to the Federal Adding Machine Company Inc., 33 East 21st Street, New York. They looked after the retail side themselves, but let the Colt's Patent Fire Arms Manufacturing Company in Hartford, Conn. manufacture the machine.

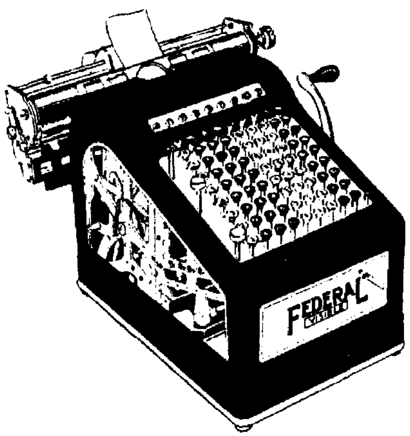


Figure 243

It is a full-keyboard adding and subtracting machine with self-correcting keys that are colored in groups. Subtraction and division are carried out with the aid of complementary digits, which are not, however, inscribed on the keys. Correcting, total. subtotal, nonaddition, and nonprinting keys are all found on the left and a repeat key is on the right of the keyboard. The subtotal key also serves as the correcting key. The machine is provided with a two-colored ribbon, and ribbon reversal is automatic. Totals, subtotals, and items not added are indicated by special symbols. Another symbol beside the first item printed indicates that the calculating mechanism was clear previously. Before it is turned, the crank lies parallel to the uppermost row of keys so that it has only a short way to travel. Returning the machine to the neutral state before printing the total is not necessary. The carriage accepts 33-cm-wide paper but must be shifted by hand—it is not automatic. The machine can be set for single and double spacing. It also adds across. On request, the machine can be equipped with electric drive: these models are produced with seven and nine places. The prices are $190.00 and $290.00 respectively.

Federal B (1913)

The designer was Fred. M. Carroll and the manufacturer was originally the White Adding Machine Company in New Haven, Conn., which distributed the machine under the name Commercial. It is now manufactured by Colt's

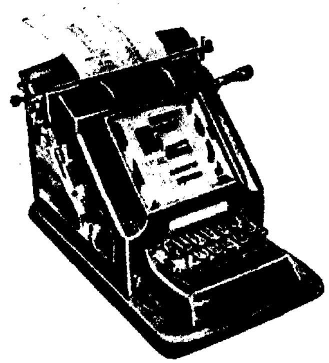


Figure 244

Patent Fire Arms Manufacturing Company in Hartford, Conn. and retailed by the Federal Adding Machine Company at 33 East 21st Street, New York. but up until now it has not had wide distribution.

The machine is used primarily for the preparation of statements of account, etc. The printing is immediately visible, and the machine prints in two colors so that the debit items can be written in black and the credit amounts in red. It is possible to see, through the large glass window on the front of the machine, the values that have been entered (before they are carried over into the result mechanism) as well as the total that is in the adding mechanism, the sign for whether the machine is set for addition or subtraction, and other possible specifications such as the date. Subtraction in this machine follows from pulling down a lever. The machine is not only equipped to print the date but also other designations such as debit, credit balance, etc. The total is printed after the total key has been pressed down. There is also a release lever and repeat key. The price is $300.00. If required, the machine can be supplied with electric drive.

Logarithmus (1914)

Logarithmus is a full-keyboard machine that, as compared to other similar machines, has the advantage that it multiplies directly and also prints the result. At this time the designer of the machine is unknown: in any case, it is not being manufactured. The following data has been taken from a preliminary description that appeared in *Bureau-fndustrie* in 1914. There it says:

The Logarithmus is not a multiplying adding machine but is a true multiplication machine that, however, adds as well as a true adding machine. The new machine has a full-keyboard so advantageously arranged that a depression of only **4** mm is all that is necessary to reliably operate the mechanism. In no other machine has it been possible to provide such a comparably short distance of descent, which has the particular advantage of enabling speedy operation. The machine possesses a double carriage and thus permits performance of additions and subtractions at the same time. The double carriage also offers an additional control as to whether the values were properly entered.

All result mechanisms, including the revolution counting mechanism, possess full capacity tens-carry. The printing of individual items is effected directly by the keys, whereas the final result is printed by the result mechanism of the carriage. The carriage shift is completely automatic. In designing the machine, care was taken to require a minimum number of different parts, but to employ those to the maximum possible extent in order to make the construction simple and advantageous for mass production. The machine combines the advantages of the best existing machines and has a number of novel features:

1. The machine has keyboard setting instead of lever setting.
2. The digits pressed are immediately visible.
3. Automatic clearance is provided for inaccurate settings
4. The double result mechanism enables simultaneous setting of two different columns of addition, simultaneous setting of two equal columns of addition, and simultaneous setting of two different operations.
5. The printing device enables printing of the individual values entered by the keys, printing of the total result from the result mechanism, i.e., without any need for again keying in the total result obtained, the setting and printing of any desired amounts without results. the setting and printing of the individual values and of the result, and the printing of the result without individual values.
6. The printing mechanism may be completely disconnected
7. The machine performs all four arithmetic operations directly without any different settings.
8. The machine may be used as a perfect adding machine. When the same values are being repeated, it is only necessary to operate the crank once for each item.
9. Simplified multiplication requires only the setting up of the two values to be multiplied, and then the machine produces the result by a single pull of the lever, where numerous turns of the crank were necessary on previous machines. The machine may also be provided with electric drive.

Lipsia (1914)

The Lipsia is a miniature calculating machine built according to the pinwheel machine system.

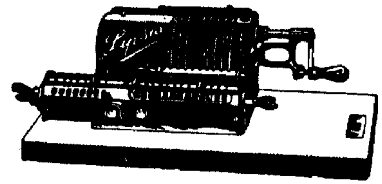


Figure 245
Machine without automatic carriage slide.

It is manufactured in six models:

Model 1: eight places in the revolution counter and thirteen places in the result mechanism; weight: approximately 3½ kg; external measurements: 33 × 15 × 14 cm; price: 500 marks

Model 2: ten places in the revolution counter and twenty places in the result mechanism; weight: approximately 5½ kg; external measurements: 40 × 20 × 15 cm; price: 920 marks

Model 3: corresponds to model 1, but has tens-carry in the revolution counter; weight: approximately 4% kg; external mesurements: 36 × 15 × 14 cm; price: 700 marks

Model 4: corresponds to model 2, but also has tens-carry in the revolution counter, and in the result mechanism the tens-carry goes through the 20th place; weight: 6% kg; external measurements: 45 × 20 × 15 cm; price: 1025 marks

Model 5: eight places in the revolution counter and seventeen places in the result mechanism; weight: approximately 4 kg; external measurements: 40 × 20 × 15 cm; price: 750 marks

Model 3D: has a double revolution counter with eight places and thirteen places in the result mechanism; weight: approximately 6 kg; external mea-

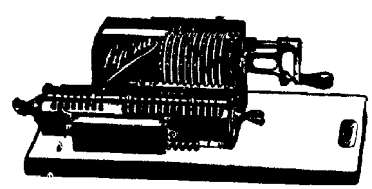


Figure 246
Machine with automatic carriage slide

surements: 45 × 20 x 15 cm; price: 800 marks; this machine has tens-carry in both revolution counters; by using the double revolution counter it saves each changeover in division.

All the models have a nine-place entry mechanism that, upon request, can be increased a few places in models 2, 4, and 5.

The carriage can be moved by manually operating a simple central lever lock or by means of an automatic lever attached to the front side of the machine that permits movement either one decimal place left or right at a time or else movement over all positions.

The numbers in the setup mechanism can be released automatically by a quick press on a locking bar together with a simultaneous half-turn of the crank.

The Lipsia is the product of thirty years of practical experience and theoretical knowledge in the building of calculating machines. It has been well established both in Germany and elsewhere since 1914 and has proved itself to be among the best.

Manufacturer: O. Holzapfel and Co. Leipzig, Dessauer Strasse 13.

Typewriter Calculating Attachment (1914)

This is an adding device that may be attached to several different makes of typewriter. Manufacturer: Typewriter Calculating Attachment Company, Bank of Commerce Building, St. Louis. Production has been under way for a long time.

The device consists of a square base, containing the adding mechanism, on which the typewriter is placed. There are nine noselike attachments sticking out from the surface of the machine. These are attached in such a way that, if necessary, they can be set in motion by the lever mechanism of the digit keys of the typewriter. The total can be read from the two calculating mechanisms at the front of the base. These are placed in front of, and underneath, the front edge of the frame. The addition device is activated by pressing a knob before any of the digit keys are pressed.

Phonix (1914)

This is an eight-place, nonprinting, full-keyboard adding machine. The values entered can be checked for accuracy in the windows under the keyboard be-

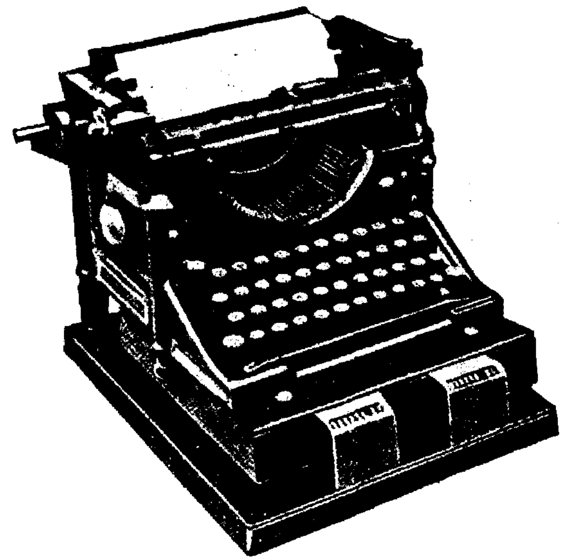


Figure 247

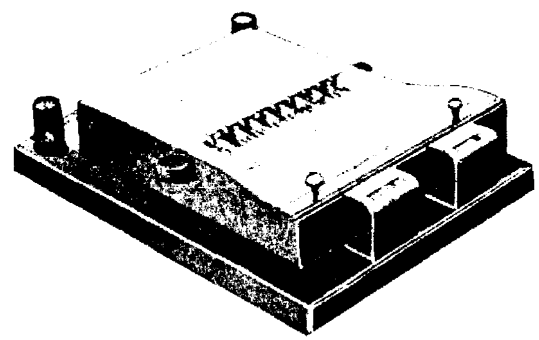


Figure 248

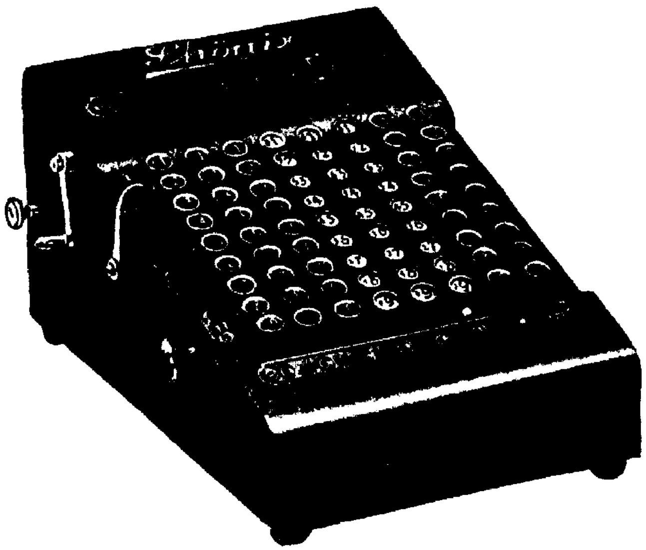


Figure 249

fore they are transferred into the result mechanism. If a correction is necessary, the knob on the left side of the machine is pulled out and the crank is turned once—the whole value is then cancelled. Subtraction and division are carried out with the aid of complementary digits. In order to save counting the number of turns of the crank during multiplication and division, the machine is equipped with a counter, on the left of the keyboard, that releases the pressed keys after the crank has been turned the required number of times. After this release the machine stops accumulating, even if the crank continues to be turned. Resetting the result mechanism to zero is carried out by one turn of the crank.

Manufacturer: Phonix Bureaumaschinenwerke, Robert Laupitz, Radebeul. This business is long defunct. Only a few samples of the machine have come onto the market.

Sundstrand (1914)

Designer: Oskar Sundstrand. Manufacturer: Sundstrand Adding Machine Company, Rockford, Ill.

This machine is a visible printing, ten-key adding machine and comes in

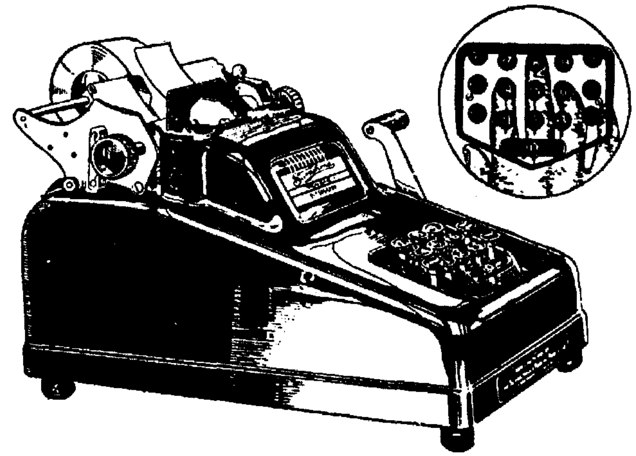


Figure 250

two principal models with either three or six auxiliary or supplementary keys. Models A, BS, and CS are equipped with three supplementary keys; namely, repeat, nonaddition, and total keys. Models B, C, and J have, in addition to these, three other keys; namely, nonprinting, error, and lock keys.

The subtotal is written in red by means of a dummy pull on the lever, while the end total is automatically indicated by a special sign. This same sign also serves as a check that the machine is set to zero at the beginning of a new calculation. If the lock key has been pressed down, then all other keys are stopped, so that the machine can no! be used by any unauthorized person. Nonaddition values are indicated by a black star. By pressing down the error key, or the backspace key, the last digit of a number already entered is cancelled. This removal is obvious because the position indicator jumps back one place. This device also serves as a correction key and is also used in multiplication from left to right and in division. Correction possibilities include the following:

1. To cancel an incorrect number that has already been entered, it is only necessary to gently pull on the lever and let it spring back again. This frees the machine,

2. If an incorrect number has been entered, and the lever has already been pulled forward, then it can still be canceled if the nonaddition and nonprint keys are pressed down before the lever springs back into place. If only the

nonaddition key is used, the number will be printed on the paper with a black star next to it, although it is not added.

3. In addition, a digit pressed incorrectly can be canceled from right to left with the aid of the error key. This is very advantageous if a larger number is to be corrected.

With the aid of the position indicator (situated above the keyboard), the operator can establish how many digits he has entered into the machine. As soon as he has pressed down a key, the corresponding indicator shifts one position to the right. If he has written a three-place number, for example, then the indicator points to the digit 3. The position indicator is also valuable in multiplication from left to right. If the error key is pressed to cancel one place, then the position indicator moves one place to the left. Pulling the lever immediately causes the indicator to spring back to zero. This is always the sign that no more of a number will be entered.

Addition: This is carried out in the usual way.

Subtraction (in the typical model): The minuend is entered in the usual way. If the machine in use has nine places, but the subtrahend is only five places, the procedure is that the key with the small zero is pressed four times, then the subtrahend is entered by using the small complementary digits. After this the crank may be turned and the result read.

Multiplication: The number to be multiplied is entered, and the repeat key is pressed. If the entered value is to be multiplied by 23, then the crank is pulled three times (units multiplication), then the zero key is pressed once and the crank pulled again twice (tens multiplication). During this time the repeat key must be canceled before the second turn of the crank. Then the crank is pulled once more and the multiplication is complete. This is multiplication from left to right. It is also possible to do multiplication from right to left.

Division (in the typical model): This is carried out by multiplication of the dividend by the reciprocal value of the divisor. A table of the decimal values of reciprocals is supplied.

Subtraction (in the subtraction model): This follows without the use of complementary digits. After the minuend has been entered, the subtraction key, which is attached in the place of the lock key, is pressed. The subtrahend is then entered and the crank is pulled. In the subtraction model the subtrahend is also printed and is indicated by a minus sign appearing next to the number. In the typical model the subtrahend is not automatically printed but must be specially printed with the help of the nonaddition key if it is to appear at all on the paper.

Machines with fractions are supplied upon request. The usual keys are used if fractions are to be printed—for example, for ⅝; key 5, then the fraction key next to the keyboard, after which the crank is pulled. Fractions greater than ⅞ are automatically changed into whole numbers. In electrically driven machines with fractions, the fraction key is connected to the motor. To enter a fractional amount it is sufficient to simply press the relevant digit key followed by the fraction key.

Since 1924 the machine has been supplied with wide, automatic carriage return. This model is used in bookkeeping. It is possible to use it, for example, to write the balance forward, credit value, debit value and balance, prepare payrolls, etc. The printing device has been expanded to such an extent that it is possible to print the names of months or other specifications. Finally, the machine may be obtained with two calculating mechanisms. The automatic movement of the carriage places the two calculating mechanisms alternatively in connection with the keyboard and the printing device. The choice of the designated calculating mechanism is also controlled by a key attached at the right end of the keyboard.

The models presently manufactured are:

With three auxiliary keys:

A	six-place, 12½-cm carriage
BS	seven place, 12½-, 25-, 33-, and 45-cm carriage
CS	nine place, 12½-, 25-, and 33-cm carriage

With six auxiliary keys:

B	seven-place. 12½-, 25-, and 33-cm carriage
C	nine-place, 12½-, 25-, and 33-cm carriage
J	nine-places in the calculating mechanism, ten-places in the result mechanism, with 12½-, 25-, and 33-cm carriage

Price: from $100.00 to $315.00, motor drive with stand $100.00

Rema (1915)

The Rema has nine setting levers, thirteen places in the result mechanism, and eight places in the revolution counter. It is only produced to these speci-

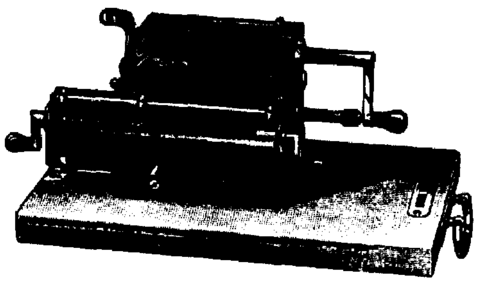


Figure 251

fications. The extraordinarily small size of this machine and its light weight (3.5 kg) allows it to be used on the smallest of writing desks. Its simple operation and safeguards, which rule out any calculating errors, make the Rema a first-class calculating machine.

Entering the numbers in the setting mechanism is done by means of a lever. The calculating mechanism is canceled by short turns of the crank. The Rema is equipped with a carriage return that automatically allows the carriage to glide from position to position or, if need be, over whatever width of the carriage is required. In the newer models of the Rema, the return of the setting levers to their zero position is carried out by a short pull of the left lever. This innovation, like many others, is protected by patent, The earliest model of the Rema had tens-carry in the revolution counter mechanism and was also equipped with windows in the setup mechanism. The firm also constructed a pinwheel machine with key setting; however, this was not produced on a large scale, and the manufacture of this model was soon halted.

Manufacturer: Braunschweiger Rechenmaschinen - Fabrik Rema, G.m.b.H., Braunschweig, Hoch Strasse 17/18.

Denominator (1915)

The Denominator is an adding machine for special uses. It is, in fact, simply a counting apparatus and, at least for the time being, it is produced only for American currency. It has eleven celluloid keys labelled 1, 3, 5, 10, 25, and 50 cents and 1, 2, 5, 10, and 20 dollars. Each of these keys operates a special calculating mechanism with three windows above the keys. The butterfly screw on the left side is used for setting all the windows to zero. The machine is primarily for setting up payrolls in calculating how many 1, 3, 5, 10, etc.

Figure 252

cent coins and 1, 2, 5, etc. dollar bills are needed so that the necessary change and bills are obtained from the bank. The machine does not add the amounts but functions only as an item counter. Each separate item must be specially pressed, and it is possible to press several keys down at the same time. The small machine is also supplied with special labels for keys, so that, with respect to restaurants for example, it is possible to establish automatically how many portions of soup, meat, or vegetables or how many selections from the menu were ordered from the kitchen. This is an effective control on the till that, over an evening. must show the equivalent of the items entered. For restaurants, an eleven-key machine scarcely suffices. In that situation it is necessary to purchase a number of machines and line them up beside one another.

The machine is made for the most part of steel. It sits on a felt pad, so as not to harm the finish of the desk. Price: **$45.00.** Dimensions: 8% **x** 25 cm. Manufacturer: Denominator Adding Machine Company, 315 Eighth Street, Brooklyn.

Commonwealth (1915)

Designer: Georg Browning. Manufacturer: Commonwealth Adding Machine Company, Muskegon, Mich.

This is a ten-key adding machine ***of*** special design. Each number entered appears in a calculating mechanism above the attached keys so that the entry can be checked. The result mechanism is above the control windows. The machine has seven places. Total printing and zero setting ***are*** both carried out in one operation——ne presses the total key and the zero setting lever is moved at the same time. All totals appear in red. Correction is carried out by pressing the correction key and shifting the correction lever. A nonprinting machine is also available. The keyboard shifts sideways whenever a key is pressed. Manufacture has been in progress for a long time, although the machine has not had wide distribution, even in America.

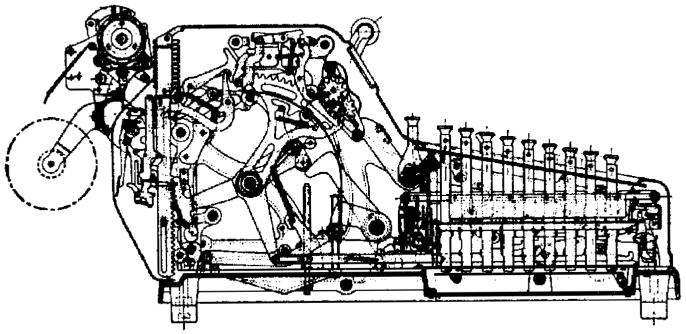


Figure 253
Cross section

Continental (1916)

This is a printing, full-keyboard, adding and subtracting machine produced by the Wanderer Werke, A.G. in Schonau b. Chemnitz.

The digit keys are in different colored groups and are self-correcting. The repeat key, nonaddition key, total, and subtotals lever are on the left; the correction, nonprinting, and switch lever for addition and subtraction is on the right side of the keyboard. The printing is fully visible at all times, as is the total calculating mechanism, which also indicates whether the machine is set on addition or subtraction. The machine works with a two-color ribbon, and ribbon reversal is carried out automatically. The machine has the facility for direct subtraction and therefore does not need any subtraction, or complementary, digits. The first item appears in red to show that the calculating mechanism was initially set to zero before the beginning of the calculation. If this is not the case, a zero setting must be generated by means of producing a total. With the exception of the first number, the items added appear in black without any sign after them. Items subtracted also appear in black, but with a minus sign after them. Subtotals (carryover totals) appear in red with the subtotal sign, and final totals are also in red and marked with an equal sign (=).

The carriage moves to the next column by pressing a tab key. It is equipped with a graduated paper locking bar with a disk that is used for setting up the tabs when working with the tabulator and for clear separation of the paper. A movable paper guide means that the paper can always be inserted at the same

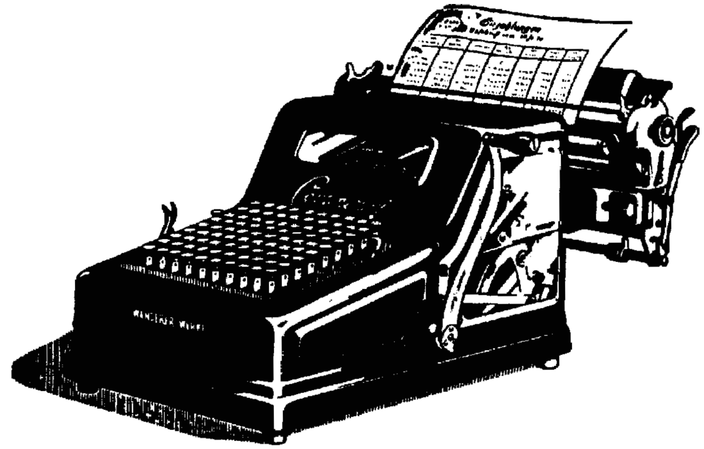


Figure 254
Manually operated machine.

place on the platen. There is a paper release lever behind the right platen knob. Setting the spacing at either *1* or 2 causes the machine to move the paper one or two lines respectively. By setting the spacing at *0*, the machine does not do a line feed and it is possible therefore to do cross additions. By turning the dividing knob (on the right side of the machine), the printing mechanism is divided so that it is possible to print numbers side by side in two columns. The carriage is stopped in fixed columns by the tabulator. There is an item counter on the left side of the carriage that causes a bell to ring after a certain number of items (decided on beforehand) have been printed and at the same time acts as the signal for the return of the paper to the first part of the computation.

The standard machine is equipped only for paper rolls. On request it is supplied with a carriage with a 38- or 60-cm-wide paper platen. It is constructed in such a way as to allow paper rolls of 4½- to 10-cm width to be installed, depending upon what the work requires. It is possible to guard against unauthorized use of the machine during a work break by removing the hand crank. Both models are equipped with electric drive if required.

As well as the ten-place machines, the Wanderer-Werke have also brought a fifteen-place adding and subtracting machine onto the market. In addition to the devices already described, it has individual correction keys for each row of figures, and an unrestricted possibility for dividing the carriage into a

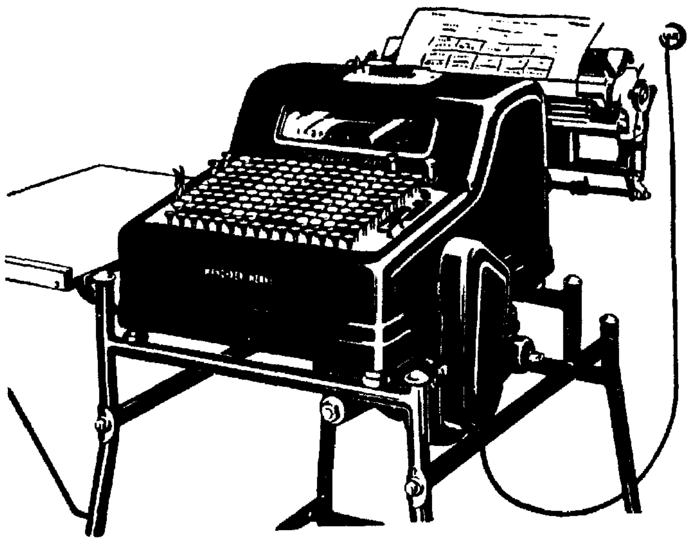


Figure 255
Machine with electric drive.

maximum of five columns. Moreover, if desired, the printing of totals can be switched off in particular columns. Designer: John E. Greve.[74]

Victor (1918)

Designer: O. D. Johantgen. Manufacturer: Victor Adding Machine Company, 3047 Carroll Avenue, Chicago. This is a full-keyboard adding machine. Originally it was supplied with only repeat and zeroing keys and was nonprinting but, at the beginning of 1921, it was replaced by a model equipped for printing. This came in two designs, one using narrow paper strips for printing and the second having a carriage for 30-cm-wide paper (although this carriage was not automatic). The machine was equipped with the usual typewriter keys; however, the model with a wide printing carriage, which appeared somewhat later, was provided with the improved celluloid keys.

Complementary digits were necessary for subtraction, although these do not figure on the keys of the newest models. To the left of the keyboard are

74. A correction. pasted in the back of the book, indicates that this sentence should read: "Designer of the first model John E. Greve, later models by the engineer Walter Hössler."

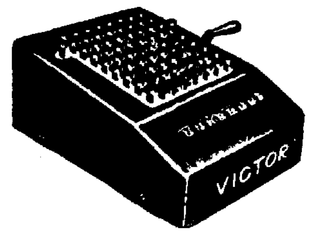


Figure 256

the nonaddition and combined total and subtotal key, and on the right is the repeat key. The calculating mechanism is under the keyboard. The printing is immediately visible, and the keys are self-correcting. The machine uses a two-color ribbon that reverses automatically. Totals, subtotals, and initial items are indicated by red signs. The calculating mechanism is reset to zero by printing the final value. The new model of the machine (which appeared on February 1, 1924), without the wide carriage, has separate total and subtotal keys as well as improved celluloid keys. An improved model with the wide carriage is also being prepared. From the very beginning the machine had eight places.

Price: early nonprinting model $85.00, current model without carriage $100.00, current model with carriage $125.00.

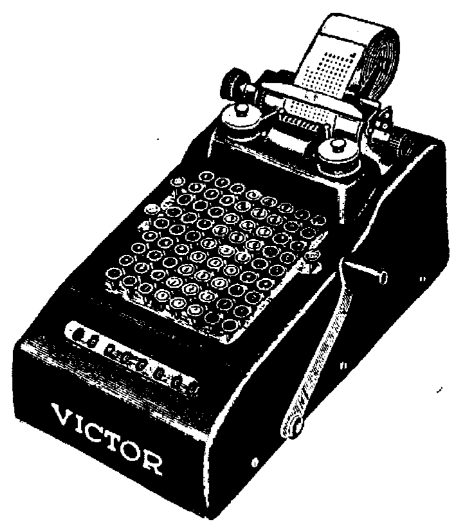


Figure 257

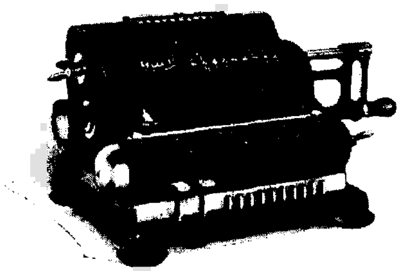


Figure 258

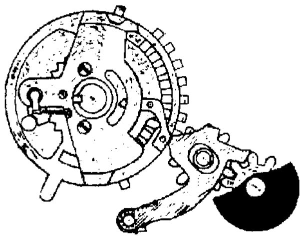


Figure 259

Facit (1918)

A pinwheel machine of the Aktiebolaget Facit in Atvidaberg, Sweden. The cross section, seen in figure 259, shows among other things how the designer eliminates overthrow of the gears without requiring the customary spring power. As is well known, the force of springs adds an extra load to the operation of the machine, so that parts normally subject to wear are worn out much faster.

A lever located to the left of the setting **slots** enables simultaneous return of all setting levers to their initial position. The result mechanism **is** located below the setting slots and the revolution counter is located above the setting slots. This arrangement permits the employment of a shorter carriage and of a greater number of decimal places in the counting mechanism. Both counting mechanisms may be smoothly set to zero by half a turn of the respective wing screws. The setting levers are relatively large and therefore are convenient to grasp. Ordinal displacement from one decimal place to the next is done by two keys; the button on the left **side** of the machine may be used **if** several decimal places are to be skipped. When the crank begins to turn, the setting

levers are locked and are kept in this condition until the crank has returned to its rest position. (As is well known, there are a number of products that do not have such locks at all, or in which the **lock** is released as soon as the crank approaches its home position, a situation that may cause erroneous results.) **If** the operator has commenced a wrong turn of the crank and wants to turn it in the opposite direction, a locking device will prevent such operation, provided the turn has advanced to a point where the accuracy of the result is in danger. When the crank is out of its rest position, the wing screws, the carriage, and the setting levers are locked. **If** the wing screws are not in their home position, the crank and the carriage cannot be moved. If the carriage is not in its proper position, the crank and wing screws are locked.

The machine has nine setting levers, ten decimal places in the revolution counter, and fifteen decimal places in the result mechanism.

The dimensions are 31½ × 18½ × 15½ cm, the weight is **7** kg, the price **is** 650 Swedish crowns.

Calculatrice Fournier-Mang (1919)

Designers: Louis Fournier and Gerald Mang. Manufacturers: same firm, at 19 rue Béranger in Paris.

This is a keyboard, stepped drum machine designed in such a way that a calculating operation is carried out by a single revolution of the crank, that is. wherein every one of the digits of a calculating factor requires only a single revolution. For instance, if the value 45,562 is to be multiplied by **7,** the result may be obtained by performing a single turn of the crank without any other preparatory or setting operations. This is a major difference compared to the other stepped drum machines in which the crank has to make seven revolutions or in which, prior to the turning of the crank, a device has to be brought into a position corresponding to the digit 7 (see, for example, the Peerless, 1904) whereupon a single revolution will suffice for the purpose.

The machine has eight decimal places in the setting mechanisms, fourteen decimal places in the result mechanism, and seven decimal places in the revolution counting mechanism. In order **to** reduce the exterior dimensions **of** the machine as much **as** possible, the keys are superimposed like fish scales. For instance, if the digit 3 is to be pressed in any one of **the** rows of keys, that key will also depress the 2 and 1 keys that lie underneath. This scalelike superimposition of the keys has previously been used in typewriters. The values entered appear below the keyboard in a straight line. The lever, marked

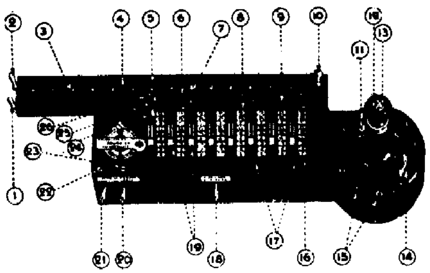


Figure 260

20 in figure 260, serves to adjust the carriage for automatic movement to the left or to the right; it also serves to completely eliminate movement of the carriage. Lever 21 sets the machine at plus or minus. An indication of the direction of the carriage travel and a plus or minus sign appear in small windows above these two levers. The result windows are provided with setting knobs. Zero-setting levers for the two counting mechanisms are located on the left end of the carriage. Lever 10 allows selective movement of the carriage, by hand, in either direction. Both rows of windows, as well as the keyboard, possess decimal point marker slides. Lever 18 clears a value entered in the keyboard.

The crank is mounted upon a drum attached to the right side of the machine. It is turned only once for every addition or subtraction and for every decimal place of the multiplier or divisor. During multiplication and division ordinal displacement of the carriage is produced automatically during operation of the crank.

The plate to which the crank is secured can be depressed into the drum. The edge of the drum exhibits the digits of the multipliers or divisors. Adjacent to each digit is a notch, which cannot be seen in our illustration. Just above the plate, the crank has a small arm, protruding beyond the edge of the drum, which is provided with a small traveling wheel at its end. When the crank is turned, this wheel travels along the edge of the drum. In stepped drum machines, the crank always has a certain distance of idle motion. Its actual operation commences only when the stepped drum has been turned far enough to reach the gear (of the setting or of the corresponding key) that it has to turn to effect the digit change in the window. The designers utilize this idle motion of the machine to compress a spring that is released as soon as the crank meets with a certain resistance and imparts its force to the rotating

crank, thus supporting the action of the crank and facilitating its manual operation.

Addition: If a value has been entered on the keyboard and is to be transferred to the result mechanism, lever 21 is set to plus. Lever 20 is set to make the carriage stand still. The crank with the traveling wheel is turned on the surface of the drum edge to the digit 1, and the wheel is allowed to drop into the notch located there, so that it will now travel within the drum, and the turn of the crank is completed. The total may be read from the result window. In this way any number of values may be added together.

Subtraction: This occurs in the same manner, the only difference being that after the larger item has been introduced into the result mechanism lever 21 is set to minus, the smaller item is entered in the keys, and the crank is rotated in the same manner as explained in connection with addition.

Multiplication: If a value in the result mechanism is to be multiplied by 63. lever 21 is set to plus, lever 20 is set for the appropriate direction of movement of the carriage, the crank is moved over notches 1 and 2, the traveling wheel is dropped into notch 3, and the turn of the crank is completed. Before the crank returns to its initial position, it automatically lifts the carriage and displaces it by one decimal place. The traveling wheel of the crank is then moved across notches 1 to 5, dropped into notch 6, and the turn is completed, whereupon multiplication is accomplished.

Division: This occurs in the same way except that, prior to the first subtraction, lever 21 is set to minus and lever 20 is set to the opposite direction for movement of the carriage.

Dimensions: 50 × 22 × 14 cm, weight: 11 kg.

The machine was given only a small distribution. At this moment production has been halted. Somewhat later, Fournier, together with the engineer Charpentier, designed the simplified Fournier Junior. It is not possible to predict, at this moment, whether this machine will ever appear on the market since Fournier died on 30 March 1925.

Adma (1919)

The Adma is a nonprinting, full-keyboard adding machine that developed from the Bordt (see the entry for 1908). Manufacturer: A.-G. fur feinmechanische Industrie in Leipzig, Heerstr. 4.

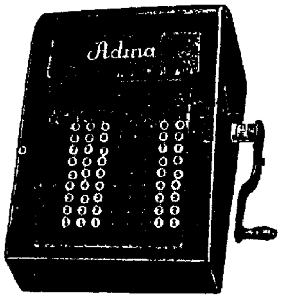


Figure 261

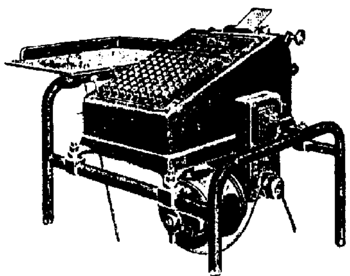


Figure 262

It has ten decimal places in both the result and the setting mechanism. The entered values may be checked for accuracy in the windows above the keyboard. The digits of the result mechanism are particularly large and distinct. Inaccurately set digit keys may be individually cleared by clearance keys located below the digit keys. If all depressed keys are to be cleared at once, the clearance key located to the left of the keyboard may be used. Transfer of the individual values into the result mechanism occurs by operation of a crank, which at the same time sets the digit wheels of the checking mechanism to zero and clears the keyboard. Resetting of the result mechanism to zero is done by a small crank located on the right side of the machine. Depression of a repeat key permits values that occur repeatedly in one addition to be totaled without need for entering the amount each time—the key is also very useful during multiplication. For smaller multiplications the Adma shows multiplier as well as multiplicand and product. Also subtractions and divisions may be carried out on the Adma with the aid of complementary digits.

Since 1921 the machine has been available with an electric motor (see figure 262).

Lehigh (1919)

The Lehigh. an imitation of the Triumphator, was first manufactured in Lehigh. It then was made in Newark from 1921 to 1923 but is no longer produced. In Europe the machine was imported from The Hague in Holland, but the number of machines sold was insignificant. The machine was manufactured in one model only with twelve decimal places in the setting mechanism, twenty decimal places in the result mechanism, and twelve decimal places in the revolution counting mechanism. Sales agency was the Lehigh Corporation, 25 West 43rd Street. New York.

Duco (1919)

In 1914 the Duco was ready to be put into production but, because of the war, it did not appear on the market until the autumn of 1919. Manufacturer is the Duco Adding Machine Company in St. Louis, Missouri. At the present time the machine is not being produced. It never was imported into Europe.

It has nine decimal places and, instead of setting levers or keys, it has indentations into which the fingers may conveniently be placed. The value to be entered is looked up, the finger is placed into the indentation, and the mechanism is pulled downward until it hits a stop. The set value may then be seen and checked in the checking window on the front panel of the machine. Corrections may readily be carried out by a reverse motion as long as the crank has not been moved, because that action transfers the amount set into the result mechanism. Printing of the result occurs by depression of the total key. Totals are printed in red ink. There is also a nonadd key. The weight of the machine is 17½ kg, the price is $150.00.

Addo (1920)

This is a miniature adding machine with rack setting. Manufacturer is A.B. Addo of Malmo. It is manufactured in three versions: model 2 is nonprinting, model 3 is for English currency and is nonprinting, and model 4 prints.

The amount set up may be checked for accuracy in the check mechanism

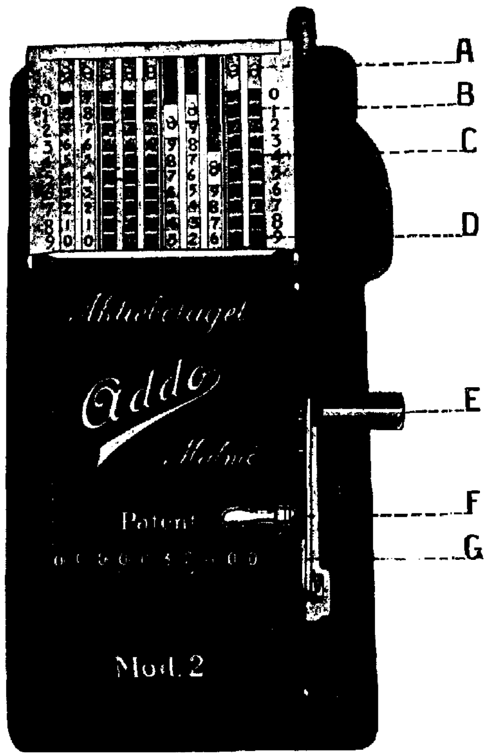


Figure 263

and is transferred into the result windows by operation of the crank E. The label A designates what are called resetting buttons with which corrections may be carried out, if necessary, before the result is transferred into the result mechanism. Zero setting of the result mechanism is performed by lever F. The machine has ten decimal places. The complementary digits, inscribed on the edge, serve for subtraction.

This description also applies to the printing Addo (1923) shown in figure 264. If the result is to be printed below, it must be set up with the aid of the racks. Then button M is pressed and lever I is moved. The roll of paper is located in the usual place behind the machine, the paper runs underneath a tear-off bar, and the paper advance occurs automatically. Inking occurs by means of a colored ribbon. The machine has visible printing. The price for the nonprinting machine is 160 crowns; for the printing machine it is 360 crowns.

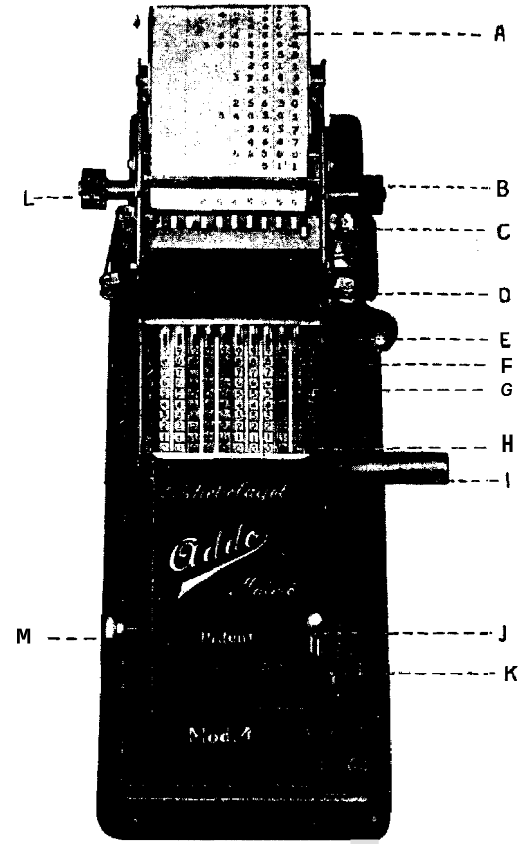


Figure 264
Addo with printing mechanism.

Urania-Vega (1920)

The Urania-Vega [named after Georg Freiherr von Vega—a famous Austrian military professor of mathematics (died 1802)] is the Urania typewriter with an attached adding and subtracting mechanism, like that of the Wahl Adding and Subtracting Device that has already been described in detail. With the Urania-Vega, as with the well-known American typewriters, several calculating mechanisms can be attached depending on the width of the carriage. Generally, one calculating mechanism is taken for one complete numerical field.

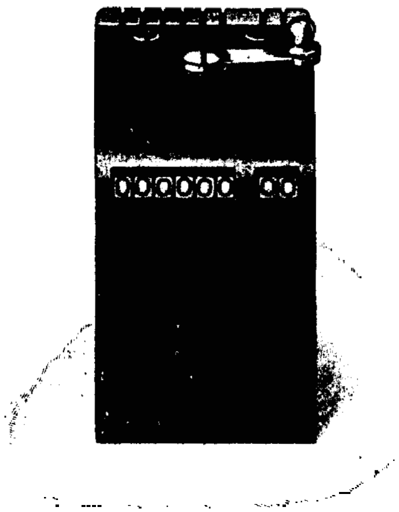


Figure 265
Nine-place calculating mechanism with separation.

But with the Urania-Vega there are also wider, compound calculating mechanisms for two and three columns of numbers.

The essential calculating drive mechanism is attached in the usual way above the uppermost row of keys and is connected to the digit keys of the keyboard. The calculating mechanisms sit on a toothed bar in front of the machine and can be moved to other places on the bar after turning the small crank sideways.

In order to add up values as they are typed, the button lever must be tightened—this connects the typewriter and the calculating machine together. Lever H must also be set on addition before the calculation can begin. The change from addition to subtraction is brought about by shifting lever H.[75]

As the respective digit keys are pressed, each value is added to the value already in the calculating mechanism. For the calculating mechanism to be brought to zero, the quantity found in it must be canceled. To do this, the machine is set for subtraction, and the quantity appearing in the windows is typed. Then zeros appear in all the windows.

The digit keys have two symbols, as is generally the case for every key on

75. The editors have been unable to locate a lever labeled H in any figure of the Urania-Vega.

Figure *266*

a typewriter with a simple shift mechanism. Thus each key has a digit and then another symbol, for example **M,** %, ¼, ½ (,), etc. It is therefore necessary to switch off the counting mechanism to type the nondigit symbols; otherwise the digit represented underneath the symbol is carried over into the calculating mechanism. This switching off of the calculating mechanism happens automatically in the Vega when the shift key is pressed.

When a calculation is being carried out, everything is much clearer if the end totals and subtraction items are marked in another color. The Urania-Vega is therefore always supplied with a double ribbon having both red and black sections. If the machine is adding, the numbers appear in black, and in red if it is subtracting. This change in ribbon occurs automatically when lever H is shifted from addition to subtraction, or vice versa (the typist not only is relieved of the attention and work of setting the ribbon color correctly by hand, but the machine shows him whether he actually added if he was supposed to add or whether he subtracted when subtraction was desired). It is also possible

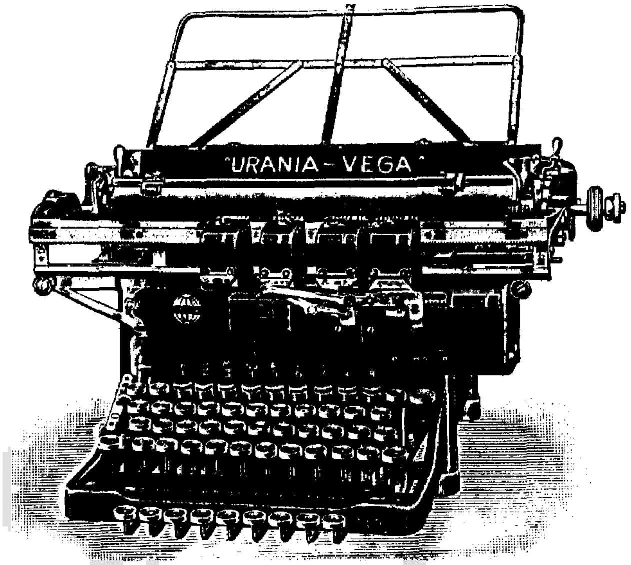


Figure 267
Machine with four calculating mechanisms and cross-adder

to change the ribbon color by hand. In this case, it is necessary to press both levers K and L together, before they are shifted. Separation of the levers is done by the small spiral spring placed between them.

With the calculating Urania, as with all key-set calculating machines, it is necessary to press down the individual keys as far as they can go during a calculation, so that their full value is transmitted into the calculating mechanism. This is also necessary because a key that has not been completely pressed down does not return back to rest position, but stays at the halfway point. This prevents errors that may come about by striking the keys too quickly. The design of the Urania-Vega offers a further insurance against errors of this sort by means of a digit key lock. If one of the digit keys is moving. then the other digit keys can not be struck but are locked in place. The digit keys are also locked if a calculating mechanism with separations (such as the comma or decimal point used in printing numbers) is located so that either the comma or decimal point is currently at the typing position. The digit keys are also locked before the first, and after the last, digit place. For example: if the number 1,842,763.95 were written with a nine-place calculating mechanism, then the digit keys would not be able to be struck before

and after the 1; and after the 2, 3, and 5. In this design, a series of warning symbols has been created for the typist to prevent errors that come about when digits are typed in the wrong place. If numbers, dates, and the like are to be typed in front of the calculation. the counting mechanism must be switched off.

Since 1925, the Urania-Vega has also been supplied with a device, which can be seen in figure 267, for cross addition. With this machine the entries can be printed and at the same time automatically included in other calculations, as was described during the discussion of the Wahl Adding and Subtracting Device. The Urania-Vega was the first German calculating machine of this type and, with justification, has created quite a sensation.

Manufacturer: Clemens Müller, A.G. Dresden N.

Arithmometre Electro-Mecanique Torres (1920)

The designer is Leonardo Torres y Quevedo of Madrid, a mathematician who became famous in Spain and France, and who also constructed the airship Astra-Torres. which the French used during the war. Another one of his inventions is the automatic chess player, which was shown in Paris in 1914. We are also indebted to him for various algebraic calculating instruments.

The Arithmometre Electro-Mecanique was first displayed by the inventor at the occasion of the Calculating Machine Exhibition of the Société d'Encouragement pour I'lndustrie Nationale in Paris (June 5–13, 1920) and it has been described in detail and illustrated by several drawings in the *Bulletin*, vol. 119, September and October issues of 1920.

The calculating machine proper is connected to any kind of typewriting machine by a number of electric wires. The two machines may be located in different places. They carry out the four basic calculations automatically.

For instance, if 345 is to be multiplied by 678, the problem is first typed on the typewriter, i.e., 3, 4, 5, then the spacebar, then the × sign, again the spacebar. then 6, 7, and 8. At this point the calculating machine, connected with the typewriter by the wires, calculates the problem whether the writer is present or not, then automatically writes an equal sign and the result on the typewriter and also leaves the necessary interline space for the next operation. It can, in a similar manner, carry out addition, subtraction, and division. In the latter case, remainders, if any, are automatically written beside the quotient without any action on the part of the operator, in other words, completely automatically.

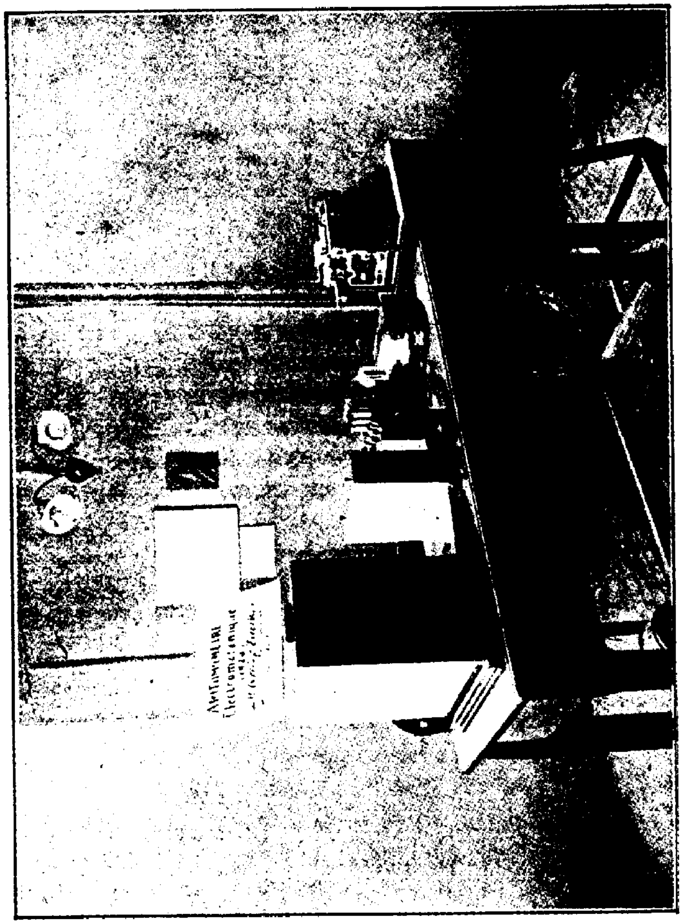


Figure 267a

This invention, if further developed, would enable the use of a single calculating machine by a larger number of participants whose typewriters may be connected with, or connectable to, the calculating machine. If a calculating problem is to be solved, the connection with the centrally located calculating machine may be established in the same way as we now have telephone connections established.

The machine illustrated in figure 267a has only six decimal places, but of course one could make them with a larger number of places. To our knowledge the manufacture of this entirely novel machine has not commenced.

Surot (1920)

The patent for this machine was issued to Oskar Rother and Karl Heindel of Dresden. Original Manufacturer: Schubert and Rother, Pillnitzer Strasse 62, Dresden A. As of 1921 it changed to Cosmos Buromaschinen, Berlin W.8, Leipzig Strasse 23 (at this time it was renamed the Addi-Cosmos). As of 1922 it passed to Bergmann Universal-Gesellschaft m.b.H, Berlin-Wilmersdorf, Landhaus Strasse 16. This firm named the machine B.U.G., although in 1924

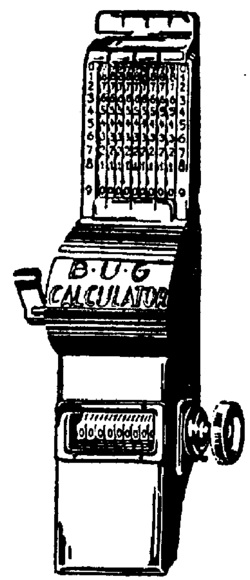


Figure 268

it stopped producing them, probably because they were also making another line of cheaper adding machines with hook tens-carry.

It is a small, nine-place adding machine with toothed rack setting. It is possible to check, in the setting control mechanism, if the amounts entered are accurate—only then are the toothed racks brought back to rest position by pressing a lever on the left side of the machine. This lever can be switched off when performing subtraction or multiplication. Resetting the result to zero is brought about by turning a knob on the right side of the machine. Subtraction requires the use of complementary digits.

Arithmograph (1920)

This is a product of the Rustringer Rechenmaschinenfabrik, Rustringer, Oldbg.. Göker Strasse 114. It is an adding and subtracting mechanism for all kinds of typewriters. Apparently, it has not yet reached the manufacturing stage.

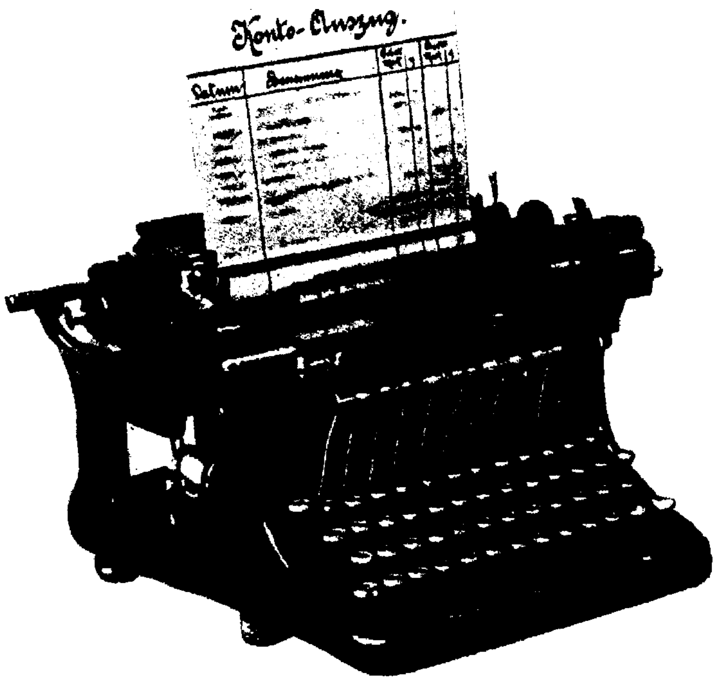


Figure ***269***
Arithmograph.

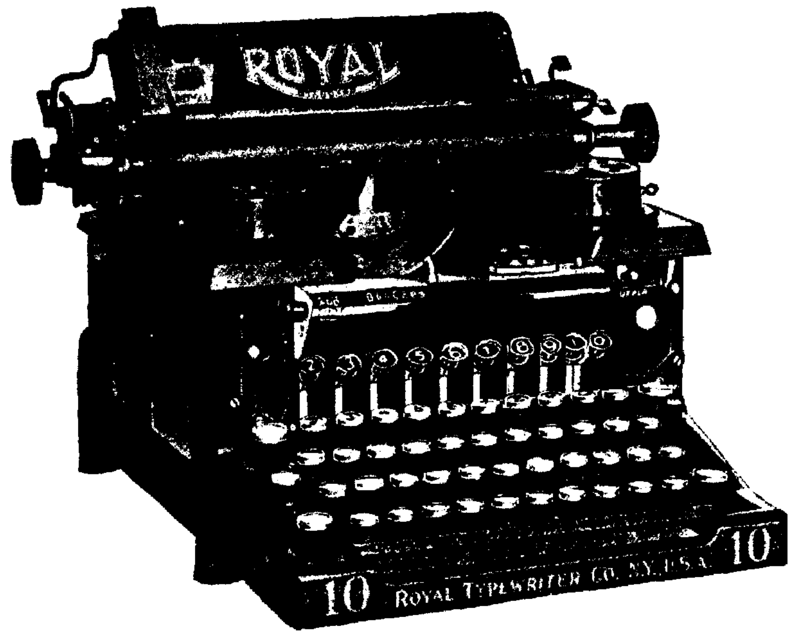


Figure 270

Type-Adder (1921)

The Type-Adder is an adding and subtracting machine that at first could only be attached to American typewriters. Designer: C. Hochman and Maurice Samburg, both in New York. Manufacturer: Type-Adder Corporation, Woolworth Building, New York. The Type-Adder can be fixed to any standard typewriter by means of a couple of clamps simply by removing two screws on the typewriter and using these same screw holes for mounting the machine. Any other changes to the typewriter need not be dealt with here.

The digit keys of the Type-Adder are used only if the digits typed are also to be added or subtracted. It is possible to type a series of items in a column, automatically adding them while typing, and then type the total in this or the next column, subtracting from this a credit item (provided the machine has already been set on subtraction, etc.). It is also possible to add and subtract numbers that have been printed horizontally. Resetting to zero is brought about by pressing a lever and subtracting. The machine has seven places. The result windows are to be found on the left side of the machine. In America it sells for $60.00. Its weight is approximately 0.5 kg. The firm W. Morgenroth,

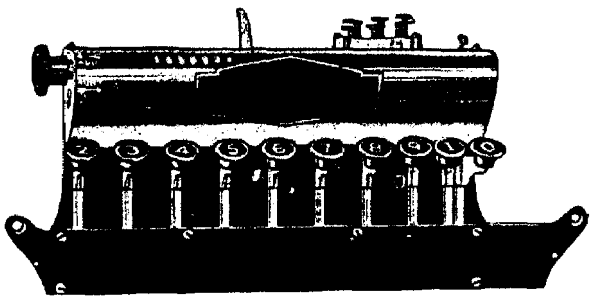


Figure 271

Arndt Strasse 30a, Berlin-Steglitz, is now manufacturing the device for German typewriters.

Arrow (1921)

This is a pinwheel machine manufactured and distributed by the Arrow Calculator Mfg. Company in New York. Production has now apparently ceased.

Summator (1921)

Manufacturer: Hans Sabielny, Dresden A 24, Bismarckpl. 1a.

This is a small, nine-place adding machine with toothed rack drive. It has an adjustable decimal point indicator on the result mechanism, a setting control mechanism, and a release key on the left side that allows the return of the setting racks to their normal position. The knob, which can be seen on the right side of the machine, is the zero-setting device. One short, even pull on it will return the result mechanism quickly to zero and it will then return automatically to its normal position. Subtraction is carried out with the aid of complementary digits and multiplication according to the multiplication table method. The price of the machine is 85 marks.

Calco (1921)

The Calco is the first Danish pinwheel machine. It is said to be no more expensive than the German Odhner machines. It has nine places in the setting

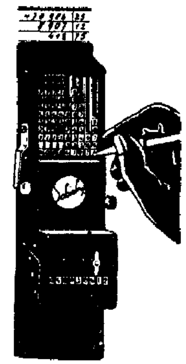


Figure 272

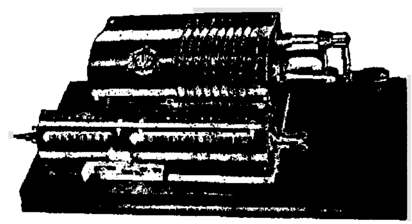


Figure 273

mechanism, thirteen places in the result mechanism, eight places in the revolution counter, and measures 30 cm × 16 cm with a weight of 4.5 kg.

The setting levers are rather long. They can be returned to their zero position by shifting the button to the left of the nine setting levers sideways and simultaneously turning the crank a quarter turn. Apparently there is also a model with continuous tens-carry in the revolution counter. Manufacturer: A. S. Nordisk Regnernaskinefabrik, Koldingg. 14, later St. Kongensg. 59 in Copenhagen. It seems that production has ceased for the moment.

Goerz (1921)

Designer: K Rauchwetter and Paul Riegel. Manufacturer: Optische Anstalt C. P. Goerz. A. G., Gerlin-Friedenau, Rhein Strasse 45/46.

This is a visible printing, full-keyboard adding machine with result win-

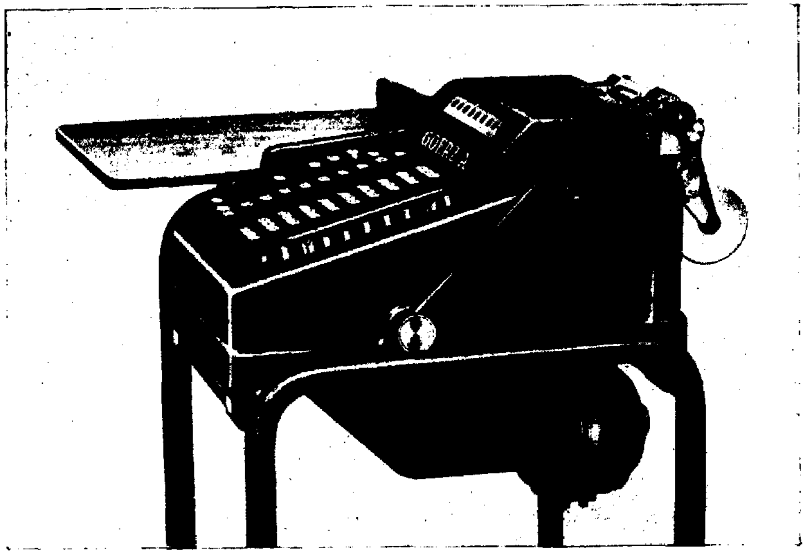


Figure 274

dows above the keyboard. It has nine places in the set up mechanism, ten places in the result mechanism, and the keys are colored in groups. It is self-correcting with red cancelation keys beneath the individual key columns. The auxiliary keys (total. subtotal, subtraction, subtraction release, repeat, non-addition. and general release key) are all on the left of the keyboard. The machine subtracts directly without the aid of any complementary digits. The slide on the left side of ihe keyboard is normally at position *E*, which results in the printing mechanism being switched on. If it is positioned at 1, the printing mechanism is switched on, but the first row of keys on the left is separated from the rest of the keyboard. If it is set to 2, it means the first and the second rows; on 3, the first, second. and third rows; on *4*, the first four rows. Thus one has two adding machines that have been joined together. of which one is attached to the first five places on the left of the keyboard, and the other deals with the five places on the right of the keyboard. By exclusively using the right part of the keyboard in the addition of numbers from 1 to 5 decimal places, the left part of the machine can be used in numbering the items to be added from 1 to 9999. If the slide is positioned at the mark *A*, the printing mechanism has been switched off, and, depending on whether the subtraction key has been pressed down or not, the machine adds or subtracts without printing.

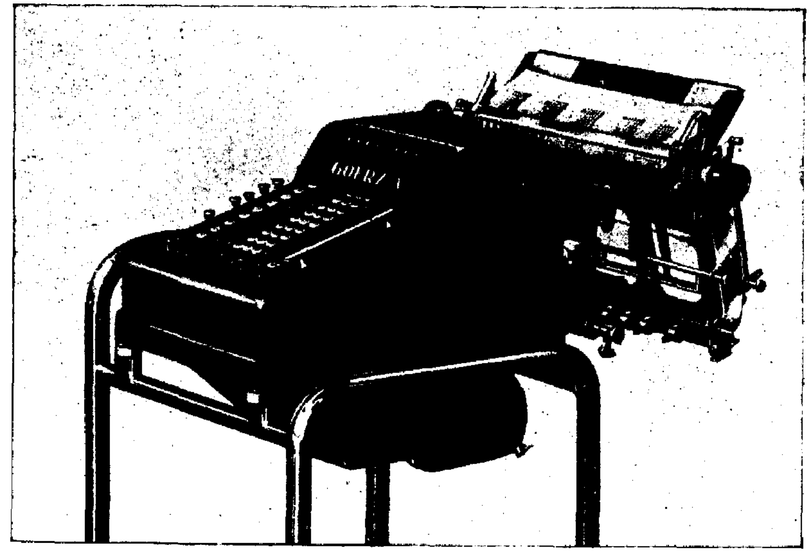


Figure 275

The Goerz A self-correcting adding and subtracting machine is manufactured today in only one model: model II. This is a machine with a subtracting mechanism, an additional device for printing without calculating and for calculating without printing, as well as potential division of the keyboard.

The machine can be supplied with three different carriages:

a-carriage: stationary, for rolls of paper up to 10 cm, with two line spacings.

c-carriage: with a printing width of 38 cm for printing forms and rolls of paper. If desired, it is possible to add a movable tabulator stop that adapts to each form, automatic carriage return with each pull on the crank, automatic item counter, line spacing release.[76]

d-carriage: like *c*, but 60 cm wide, with three different line spacings.

For the leather industry, a special model is available with fractions. On demand, the Goerz A can be fitted with an electric drive. External dimensions: 30 cm wide, 50 cm deep, 25 cm high. The price ranges from 1260 gold marks up to 2410 gold marks depending on the design.

76. This is the same device that. on typewriters. is usually called the "variable spacer" *or* the "platen variable."

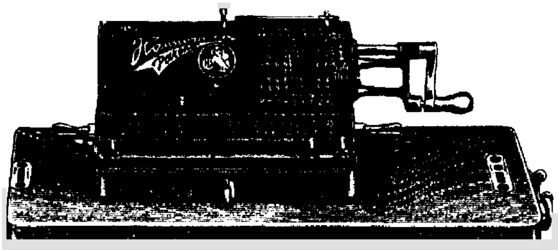


Figure 276
Model AK.

Hannovera (1921)

This is a pinwheel machine of the usual kind described in the introduction.

The Hannovera is at present manufactured in five designs:

Model AK: nine setting levers, thirteen-place result mechanism, eight-place revolution counter, automatic carriage movement. standard zeroing of the setting levers. This model has no tens-carry in the revolution counter.

Model **A:** the same number of places as in the model AK, automatic carriage movement, standard zeroing of the setting levers, device for easing addition. This model has tens-carry in the revolution counter and is equipped with a carry handle.

Model B: twenty setting levers, twenty-place result mechanism, twelve-place revolution counter, automatic carriage movement, standard zero position of the setting levers. This machine also has tens-carry in the revolution counter.

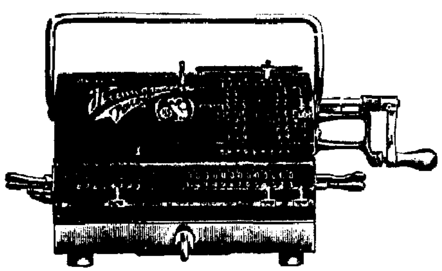


Figure 277
Model A.

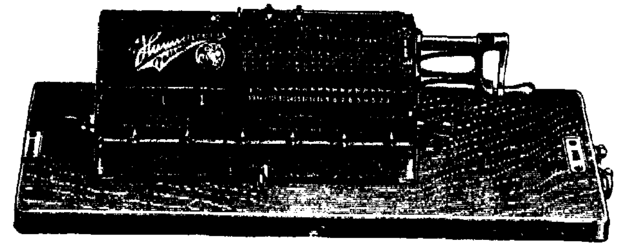


Figure 278
Model B.

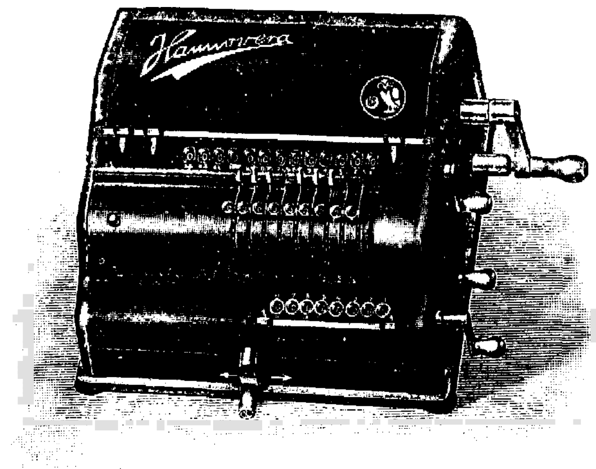


Figure 279
Model CK.

Model BK: Corresponds to model B, but without tens carry in the revolution counter.

Model CK: This model has its own system, which differs from the others in a number of respects. The thirteen-place result mechanism lies above the setup slots. The control windows are found between the individual setup slots. At the same time, the numbers inscribed next to the slots, which annoy so many operators, are missing. The eight-place revolution counter, without tens-carry, is attached underneath the setting levers. Both the result and rev-

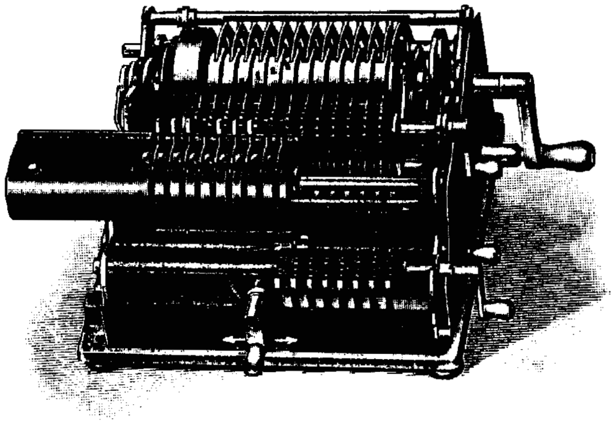


Figure 280
Interior view. Model CK.

olution counter mechanisms are stationary in this model; the calculating mechanism can be moved by turning the crank in either direction. Both calculating mechanisms are reset by turning the crank. The machine has large manual setting buttons that can be canceled automatically by means of a knob on the right side of the machine. The setup mechanism is cleared by turning the crank. All parts of the machine are replaceable. This newest model is considerably cheaper than calculating machines built according to the Odhner system.

Manutacturer: Hannovera Rechenmaschinenfabrik, Oventrop, Hcutclbcck und Co., Peine, Hannover.

Weiskopf (1921)

This is a ten-place, ten-key adding and subtracting machine measuring 25 × 12 x 9 cm. It consists of only 120 parts and weighs 1.5 kg. If, for example, 716.32 is to be entered, the decimal point slide must first be set at three on the scale below, as the number to be added is three places long (numbers after the decimal point do not count), The amount is then entered in the usual way from left to right. It is immediately transferred into the viewing windows, while the decimal point slide is simultaneously moved from place to place back to its starting position.

Since 1922 it has been possible to combine the machine with any typewriter

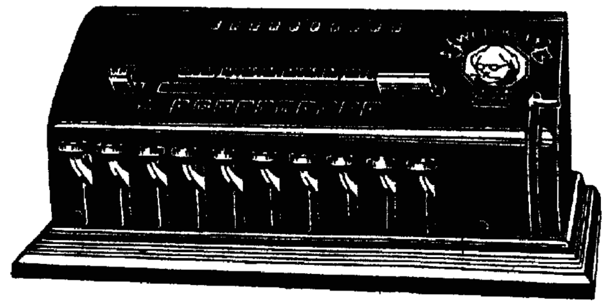


Figure 281

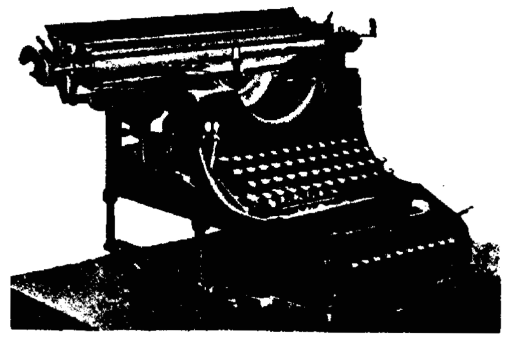


Figure 282

(with front striking action) by placing the typewriter on the base supplied with the adding machine and connecting the key levers of the typewriter digit keys with those of the adding machine. In printing calculations, the numbers to be added are typed with the aid of the keys of the adding machine. The total can be read from the viewing windows of the adding machine and entered with the help of the keys of the typewriter. Any numbers not to be added are typed with the keys of the typewriter. It is also possible to subtract amounts from the result. All that is required is to set the adding machine on subtraction and to type the amount to be subtracted with the keys of the adding machine. The adding machine can also be used without having *to* print the amounts that have been entered. Resetting to the zero position is achieved by pressing keys. The machine has been distributed overseas under the name of Addima.

Manufacturer: Weiskopf and Hetschko, Rechenmaschinenbau, A.G. Königswarter Strasse 44, Fiirth i Bayern.

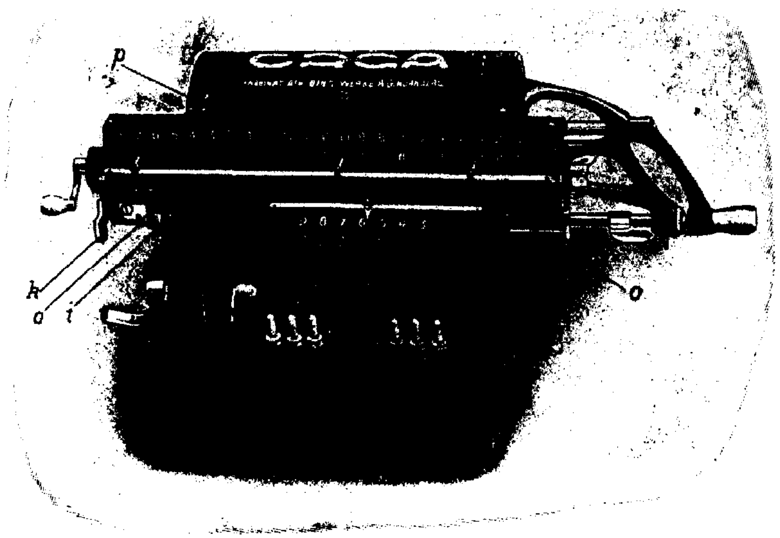


Figure 283

Orga-Constant (1921)

This machine was originally called Pythagoras and was manufactured and distributed by the firm Maschinenbau Koch, Berlin 0 17. Shortly afterward, the manufacturing rights were transferred to Bing-Werke A. G. in Nürnberg, which still builds them today. Sales are managed through their sales firm Orga A. G. in Berlin N. W., 7 Schadow Strasse 1a.

This is a pinwheel machine (see the Introduction) with a nine-place setting mechanism, thirteen-place result mechanism, and an eight-place revolution counter. It differs, however, from the otherwise standard design insofar as the setting levers of the machine. Unlike all systems described so far (with the exception of the Teetzmann, in which the levers are arranged on a drum), here they extend in front of the machine and are much larger and therefore easier to handle than those of most other pinwheel machines. A locking device, found inside the machine, means that the setup buttons can be moved only if the crank is precisely in the resting position and the crank handle *c* is clicked into the engaging axle *d*. To position the crank handle in this way is possible, on the other hand, only if key *b* has been pressed down completely. When a setting lever has been positioned halfway between numbers, a locking

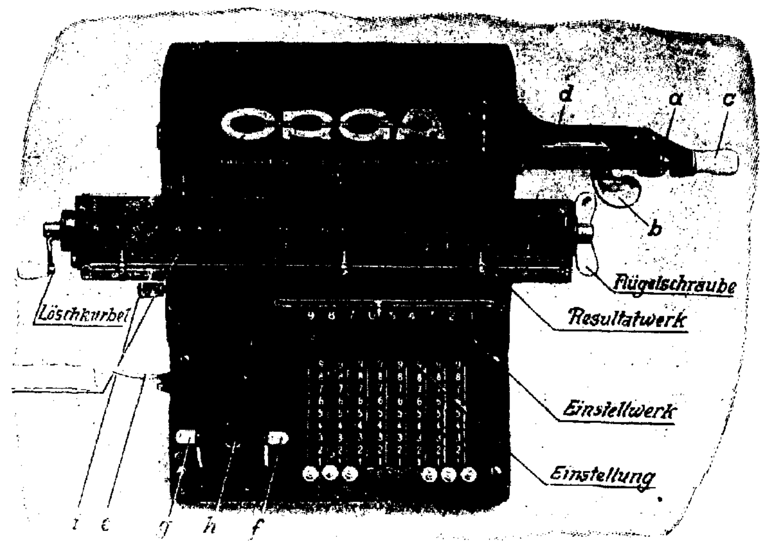


Figure 284

device prevents the crank from moving. This lock remains until the setting knob, which has been incorrectly positioned, jumps onto a whole number when the crank is lightly jolted. The operator may also manually shift the setting knob to the correct position. Only after pressing down key *b* is it possible to cancel the setup mechanism by moving the cancellation lever *e* forward. It is easy to read the entered numbers from the control mechanism situated above the sliding slots. The carriage lock, which consists of the three keys *f*, *g*, and *h*, is used for moving the carriage. By pressing down key *f*, on the right, the carriage moves to the right one place. In the same way key *g*, on the left, can be used to move the carriage one place to the left. Pressing down the middle key h allows the carriage to be moved manually in either direction, as many places as required. In this case it is up to the operator to take care that the carriage lock is clicked into the position he wants. It is possible to shift the carriage only when the crank is in the rest position. A wing screw is used to cancel values in the result mechanism, and zeroing of the revolution counter is achieved by means of a crank (wing screw and crank must always be brought into the designated rest position by inserting an attached detent into a notch). Dimensions of the machine are 31 × 23½ × 14 cm.

Another model of the Orga-Constant. which will have tens-carry in the revolution counter, is to appear in the near future. This model will also have the innovation that the total disconnection of the revolution counter can be done by means of a pin, so that in carrying over the dividend into the result mechanism, the marking of the rotation in the revolution counter does not take place.

There is also a key-set model in preparation.

Astra (1922)

This is one of the ten-key adding machines. It has, in addition to the usual digit keys, keys for 00 and 000, which speeds up any operation considerably.

Designer: John E. Greve. Manufacturer: Astrawerke. A.G. Chemitz, Sa.

The keyboard is visible in figure 285. The following auxiliary keys are available: nonaddition, repeat, total. and subtotal, as well as a lever for changing from addition-multiplication to subtraction-division and another for corrections. The latter is used to delete a number that has been incorrectly entered; in order to do this, the lever is pulled back as far as possible and then allowed to return. The incorrectly entered number is then canceled.

Addition: This operation is done in the usual way. First, the lever on the right side of the keyboard must be placed on addition. The first amount is entered and transferred to the calculating mechanism by turning the crank, etc. In order to print totals and subtotals, a dummy operation is necessary, the *S* or Z key must be pressed, and the crank turned again. Totals are characterized by ◇ and subtotals by +. Dates and other numeric items can be written, after they have been keyed in, by pressing the nonaddition key and then pulling the crank. These kinds of nonaddition items are also given a characteristic symbol to distinguish them.

Subtraction: The Astra subtracts directly. After the minuend has been entered, it is only necessary to set the lever on the right side of the keyboard on subtraction, after which the items entered are automatically subtracted; therefore, the machine works without complementary digits.

Multiplication: The amount to multiply is entered and the repeat key pressed. The lever is then pulled as many times as required by the units place of the multiplier. To change to the next digit position, the 0 key is pressed once, after which the lever is pulled as many times as the tens place of the multiplier requires, etc.

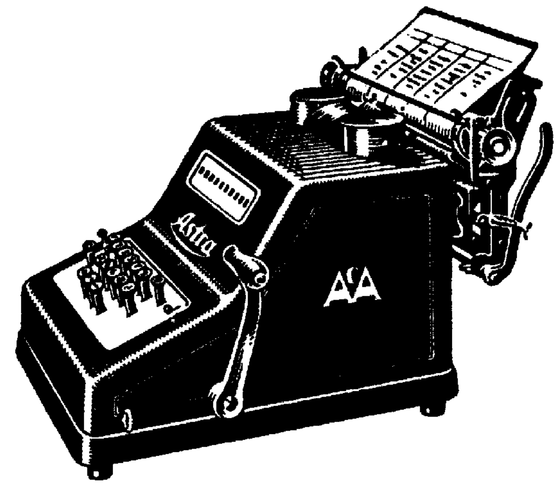


Figure 285

Division: The dividend is entered, and the divisor is entered underneath it. Zeros are then added so that the two numbers align with their most significant digits (provided that the dividend is larger, otherwise it would shift one place). The repeat key is then pressed, the lever placed on subtraction, and the entered divisor is deducted as often as possible by means of the crank. In order to proceed to the next position, the correction lever must be pulled forward. The procedure for division, from this point forward, is the familiar one that has already been described several times.

The Astra is able to take standard rolls and sheets of paper up to 25 cm wide. The carriage can, if necessary, be replaced by a wider one. The machine is the only ten-key adding machine with a fully visible calculating mechanism. The levers for freeing the platen and for spacing are on the left of the platen, and the carriage release lever is on the right of the carriage. It is possible to guard the machine against unauthorized use by means of a key.

Machines with electric drive are also available upon request. Coupling the machine to the stand containing the electric motor is automatic. All that is necessary is to switch on the current in order to be able to work with the machine.

Scribola (1922)

This is a small printing adding machine with chain drive. marginal scales for complementary digits used in subtraction, and a setup control mechanism. Addition and subtraction is carried out in the way described under the heading Small Adding Machines in the introduction. If the amount to be added has been entered, it can be checked by examining the setup control mechanism (lowest row of numbers). The printing key on the right side may then be pressed to cause the value to be printed on the strip of paper. After printing one item, the next item may be entered. If the result is to be printed, the calculating mechanism must be disengaged from the chains. This is achieved by pulling back the lever visible on the left side of the machine; if the chains are now moved, no addition will be carried out in the calculating mechanism. Now the result, which shows in the calculating mechanism, is entered and is printed by means of the printing key. By pulling the disengagement lever. the ribbon is automatically changed so that the total is printed in red and individual amounts in blue, It is also possible to print digits (for example, account numbers, dates. subtotals. etc.) in the same way as the result is printed and therefore not add them into the accumulating total (these are also printed in red).

In order to begin a new addition, the calculating mechanism must be reset to zero. To do this, the small arresting lever above the right marginal scale

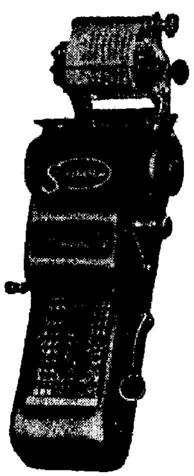


Figure 286

must be pressed down, and the zero position lever, outside the machine on the right, must be pulled forward until it can go no further, and the two levers must then be released. The clear sign (in this case a small circle with a dot in the middle) is automatically entered when the mechanism returns to zero. This symbol is printed on the right of the first item in the next summation. This machine also has a safety device to guard against unauthorized use.

As soon as one of the two ribbon spools has been completely used, the ribbon direction is changed by means of a control knob on the right side. It is very simple to change both ribbon and paper rolls. The width of the machine is 7 cm. the length, including paper carriage, is 31 cm, and its weight is 2.3 kg. Both ten-place and thirteen-place machines are available, costing *250* marks and 325 marks respectively.

Manufacturer: Ruthardt and Company G.m.b.H., Hack Strasse 77, Stuttgart.

Peters (1922)

This is a visible printing, full-keyboard adding machine. It has ten places in both the setup and result mechanisms. It has self-correcting keys arranged in

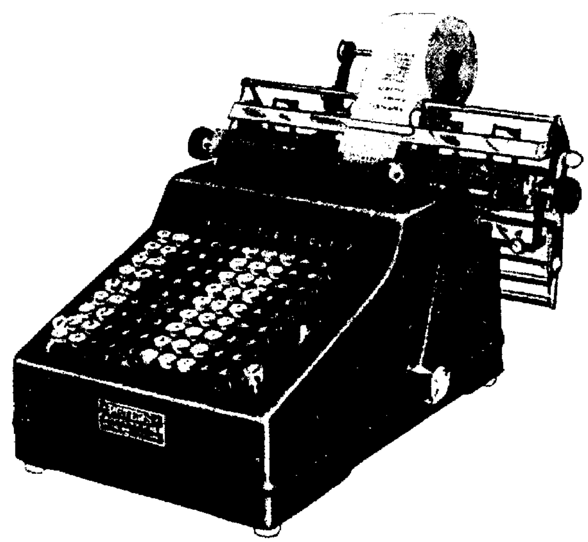


Figure 287

colored groups. The repeat, subtotal, key release, nonaddition, and total levers are all attached to the right side of the machine—so that the left hand is free for checking and to use the nonprinting lever. The paper carriage takes 30-cm-wide paper, and the carriage is shifted by hand. It is also equipped for rolls of paper. The machine has both single and double spacing and can also be used for cross addition.

The keyboard can be easily removed to provide access to the interior of the machine. There are special signs that mark totals, nonaddition items, subtotals, and zeroing of the calculating mechanism before the entry of the first item. The Peters is manufactured, for the time being, in only one model with dimensions 25 x 35 cm, and weight 16 kg. It can also be supplied with fraction keys (quarters and eighths) as well as a platen dividing device, which makes it possible to print with two columns next to one another, and with electric drive. The motor is fixed to the base, although at any time the machine can be detached and used on top of the desk with a hand crank.

Price: $250.00. Designer: H. C. Peters. Manufacturer: Peters-Morse Mfg. Company, Ithaca, New York. The designer was formerly with the Burroughs Company.

Britannic (1922)

This is a pinwheel machine.

Manufacturer: Guy's Calculating Machines L 1., Truro Works, Truro Rd., Wood Green, London N22.

The setting levers are locked as soon as the crank leaves the rest position and are freed again when it returns. The carriage shifts sideways when the keys are pressed. All setting levers can be brought back to their zero position by means of a single lever. The dimensions of the machine are 33 × 16 cm and its weight is 5 kg.

Star (1922)

This machine was previously called Amco and was manufactured and distributed by the Accounting Machine Company Inc. in New York. At the beginning of 1922 both manufacturing and sales rights were transferred to the Todd Protectograph Company, Rochester, which then named the machine the Star.

At first it sold for $42.50, although recently the retail price has gone down to $37.50. The original design had seven and nine places, although the pre-

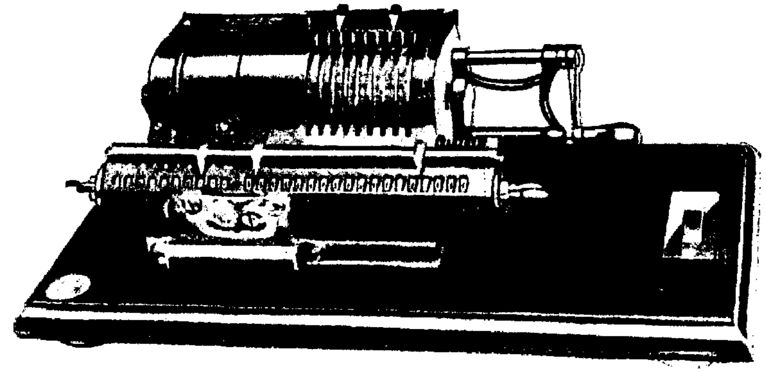


Figure 288

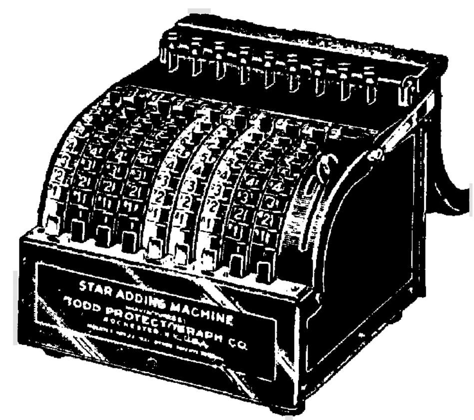


Figure 289

sent model is only available with nine places in both mechanisms. At the front of the machine are the adding and subtracting digits. In order to transfer a number into the result mechanism, which is above the setup surface, a finger must be placed on the stub next to the required digit and then pulled down until it goes no further. After this, the setup device automatically returns *to* its starting position. With this machine it is possible to enter several digits at one time, provided that a tens-carry does not occur, otherwise the digits must be entered one at a time. The zero reset key is on the right side.[77]

77. This is not exactly what Martin's original says, but the text is more than usually confusing at this point.

The nine keys visible on top of the machine are used for subtraction. After the minuend has been transferred into the calculating mechanism, the key in front of the most significant digit place and all other keys to its left are pressed down and kept there. The subtrahend is now entered with the aid of the complementary digits, after which it is possible to read off the result.

In multiplication, the multiplicand must be entered as often as each decimal place of the multiplier demands. If, for example, any amount is multiplied by 95, it must be entered five times, then nine times — altogether fourteen times.

The newer machines are equipped with a carrying handle. If the machine must be left before a calculation has been completed, the carrying handle should be placed in front, over the setup surface — the handle clearly shows the words "Machine is in use! Do not touch anything!"

Dimensions: 14 x 17 × 16. Weight: 3.6 kg.

Bird (1922)

Designer: H. L. Bird. Manufacturer: Illinois Bird Adding Machine Company, First National Bank Building, Chicago.

This is an adding machine consisting of fewer than 100 parts. It can be supplied in combination with a cash till. It is not yet available in Europe and is really only suitable for small shops. Its price is $30.00.

Naumann (1922)

This is a visible printing, full-keyhoard, adding and subtracting machine like those described in the introduction. It has nine places in the setup mechanism and ten places in the result mechanism. There is a lever for canceling individual columns of digits, found underneath the respective column of keys. There is a lever for changing from addition to subtraction, as well as a result lever and calculating mechanism shut off lever (for printing without calculation), which are all found on the left of the keyboard. Key release, as well as repeat levers (multiplication levers), are on the right of the keyboard. On the left side of the machine is a crank for resetting the mechanism to zero.

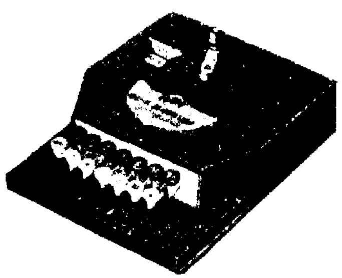


Figure 290

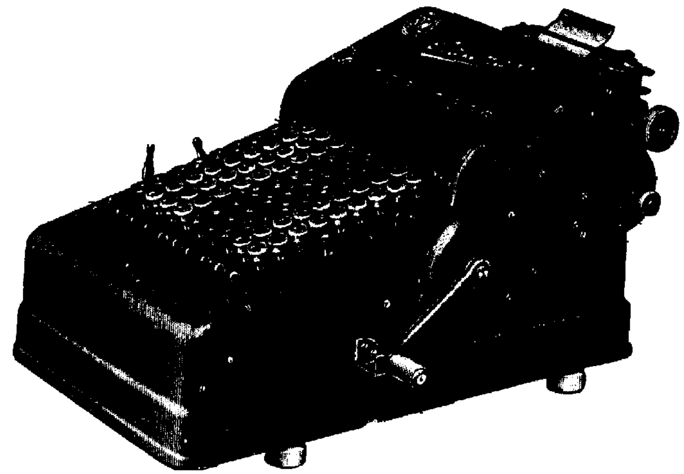


Figure 291
Manual drive.

At the beginning of each new calculation, an arrow appears to the left of the first value in order to show that the previous values are not part of the calculation now being carried out. The printing mechanism represents a completely self-contained subunit of the machine. It can be switched on and off completely arbitrarily. The machine therefore works with, or without, the printing mechanism. Ribbon reversal takes place automatically, provided that the particular ribbon designed for the machine is used. In other cases, it is possible *to* reverse the ribbon direction by hand. Subtraction items appear in red print, and final totals can be recognized by a star to the right of the value. The machine is supplied with a hand crank, pull lever, or electric drive.

Dimensions: 44 × 30 × 26 cm. Weight: The manual machines weigh approximately 15 kg and those with electric drive approximately 30 kg. The price varies from 1350 gold marks for electric drive to 1000 gold marks for manual machines.

Manufacturer: Aktiengesellschaft (formerly Seidel and Naumann), Dresden.

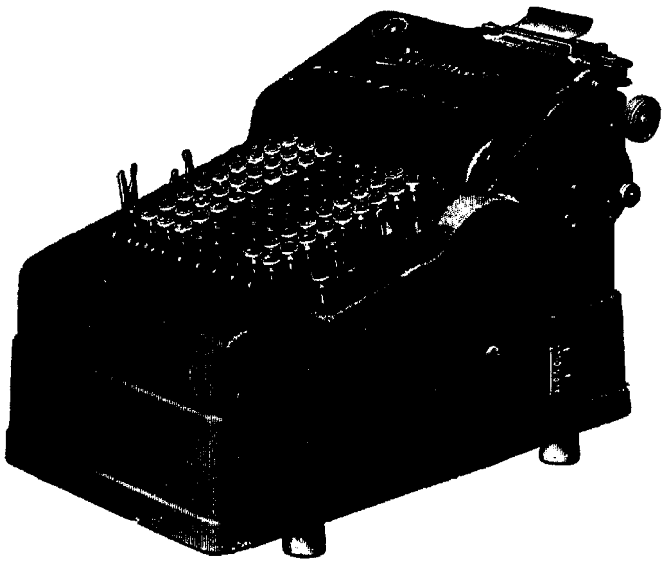


Figure 292
Electric drive.

Votam (1922)

This is a visible, full-keyboard adding machine from the firm Ehrich & Graetz, Berlin. It has ten places in both setup and result mechanisms and two viewing windows for numbers entered. The keys are colored in groups and are self-correcting. On the right of the keys is a zero reset lever. In order to print the total underneath a column of entries, the sum found in the viewing windows of the calculating mechanism must be reentered on the keys. The same procedure applies for subtotal printing as for totals: in this case the total, which has just been printed, is carried forward as the first item **of** the new calculation by setting it up again and pulling the lever. The strips of paper and the single-color ribbon move forward automatically. The machine can be used for the simultaneous addition of two columns.

This machine is smaller than most other makes. Only parts that have been stamped out are used in its construction; therefore, springs are hot to be found. Each of the ten columns of keys can be taken out by loosening two screws—this has the advantage that often-used columns of numbers (for example, the units digit column) that have suffered wear and tear can be ex-

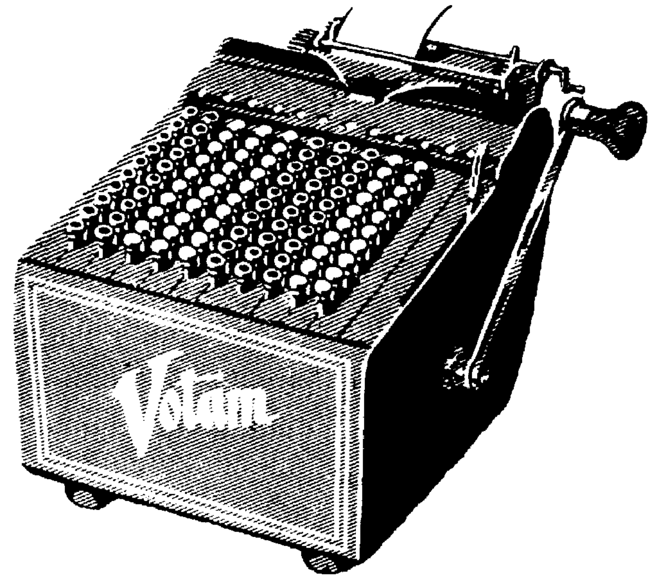


Figure 293

changed with columns used less often. The machine is also considerably cheaper than rival makes.

The model to emerge in 1923 shows several improvements. For one, the crank is returned by means **of** spring power. There are also a number of safety features attached. and the ribbon reversal is automatic.

Add-Index (1922)

This is a visible printing, full-keyboard adding machine. There are viewing windows above the columns of keys. The machine has self-correcting keys and complementary digits for subtraction and division. The total, carry-forward, repeat, and correction keys are found on the right side of the keyboard, so that the left hand does not need to leave the digit rows. Nonaddition and nonprint keys are found on the left side of the keyboard. The machine does not add until the crank has returned to its rest position. The colored ribbon reverses automatically. Under the repeat key is a viewing window that shows the number of times the crank turns. The machine has adding keys in two colors. and the auxiliary keys are red.

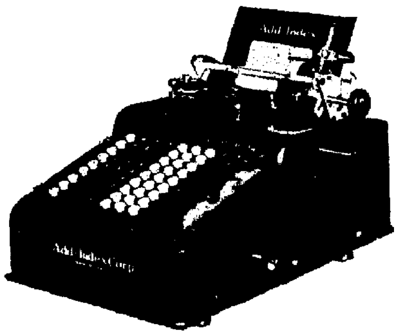


Figure 294

To reset to the zero position, the crank is pulled forward and is then left to return on its own. The total key is then pressed back with the thumb of the right hand while, at the same time, the crank is pulled up with the remaining fingers of the right hand—as soon as the crank finishes its travel the total key is released. This action prints the totals in red and resets the viewing windows of the result mechanism to zero. The first item in a list is always printed in red. This shows that the result mechanism previously contained zero. In addition, the totals and subtotals always appear automatically in red so as to be more distinct.

Even after the crank has begun to move, it is possible to correct mistakes by means of the nonaddition and nonprint keys. Amounts that are not to be added are automatically marked in some way on the list. This machine has not yet reached Germany.

Models:

671	seven places with a stationary 13-cm-wide carriage	$125.00
680	eight places with a stationary 13-cm-wide carriage	$150.00
690	nine places with a stationary 13-cm-wide carriage	$175.00
691	nine places with a 22-cm-movable carriage	$200.00

If specially ordered, each of the first three models can be provided with a movable carriage. The weight varies from 12 to 14 kg, and the surface area measures 25 × 35 cm.

Manufacturer: Add-Index Corporation, 120 Broadway, New York.

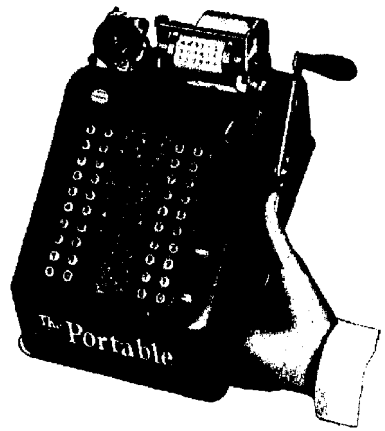


Figure 295

Portable (1923)

This machine has an area of only 18 × 28 cm and weighs 5.5 kg, hence the name Portable. it is a visible printing, full-keyboard adding machine with self-correcting keys. Printing is done by pulling a lever—the entire carriage is pressed against the raised, stamped calculating gears. There are no result viewing windows. Zeros are not automatically printed but like other digits must be individually entered. The machine is only equipped for rolls of paper and single-color ribbons. Ribbon reversal is automatic. The machine has a combined total and subtotal key, as well as nonprinting, correction, and repeat keys. It is only a seven-place machine and costs $65.00. As yet, it has not been introduced into Europe.

Designer: Glenn I. Barrett, who was also the designer of the machine by that name. Manufacturer: Corona Typewriter Company, Groton. Distributed by: Portable Adding Machine Sales Company, 208 S. La Salle St., Chicago.

Tim-Add (1923)

This is a full-keyboard adding machine with direct subtraction. The total, subtotal, nonaddition, and nonprinting keys are to be found on the left of the keyboard.

Figure *296*

On the right are the setting slides for addition and subtraction and also the general cancel and repeat keys. There are separate column cancel keys above the keyboard. The machines with a broad carriage are designed to add and print columns of numbers and, as a consequence, these machines have an item counter on the left side. The Tim-Add can also be fitted with a column device that makes it possible to print and add two separate columns simultaneously.

There are several other special advantages:

• The Tim-Add is completely built on a positive drive system, so even the letter types are gear driven. The Tim-Add does not, therefore, suddenly come to a halt, and any miscalculation caused by holding or pressing down the letter types, or by dirt getting in. is avoided.[78]

78. The editors believe this is correct. but freely admit that Martin's German is completely incomprehensible to them at this point.

• It is unnecessary to hold the subtotal and total keys for every dummy operation.

• It has self-correcting keys.

• The result and printing mechanisms are at eye level and visible at all times.

• There is an automatic ribbon reversal, and the ribbon is easily replaced.

• The Tim-Add is provided with an air brake, which overcomes the disadvantage of oil leaks that can occur with oil pumps.

Models:

1 nine places, with narrow carriage, total, subtotals, repeat, and general cancellation device
2 like model 1, but with large carriage and item counter
3 like model 2, but with nonprinting and nonaddition keys
4 like model 3, but with dividing device
5 like model 1, but with lever for direct subtraction
6 like model 2, but with lever for direct subtraction
7 like model 3, but with lever for direct subtraction
8 like model 4, but with lever for direct subtraction
13 thirteen places, otherwise like model 8.

All models are supplied with electric drive and are equipped for English currency.

Manufacturer: Gutschow and Company, G.m.b.H., Danzig, Weidengasse 35/38. General sales for Germany: Ludwig Spitz and Company, G.m.b.H., Berlin-Tempelhof, Cresburg Strasse.

Monos (1923)

This is a pinwheel machine, similar to the one described in the introduction, which at the moment appears in four models:

Model A: has tens-carry in the revolution counter.

Model B: does not.

Model A2: has tens-carry in the revolution counter and has an automatic adding device attached (this means that during the time when addition is tak-

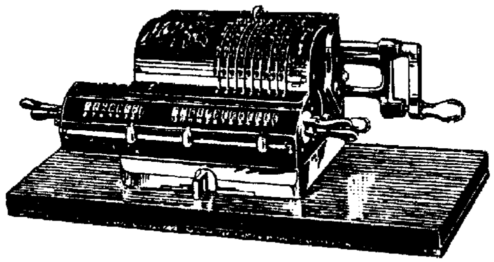


Figure ***297***

ing place in the result mechanism, the setting levers are automatically returned to their zero position without any action on the part of the operator).

Model D: does not have tens-carry in the revolution counter. although it does have twenty places in the setting mechanism.

Model	Setting mechanism	Result mechanism	Revolution counter	Weight kg.	Price gold marks
A	9 places	13 places	8 places	5.1	525.00
A2	9 places	13 places	8 places	5.1	550.00
B	9 places	13 places	8 places	3.8	400.00
D	20 places	20 places	12 places	9.5	700.00

Dimensions:

Model A and A2 18 x 11 × 12 cm
Model B 13 x 11 x 10.5 cm
Model D 22 × 1.5 x 13 cm

One special advantage of this machine is that the zero positioning of the setting levers is not controlled by wing nuts but by pressing a button on the right side of the machine. There are the usual decimal point slides. During multiplication or division, the carriage moves to the next digit by pressing the carriage lock on the side. Production has stopped for the moment.

Manufacturer: Monos A. G. Braunschweig, Cammann Strasse 7.

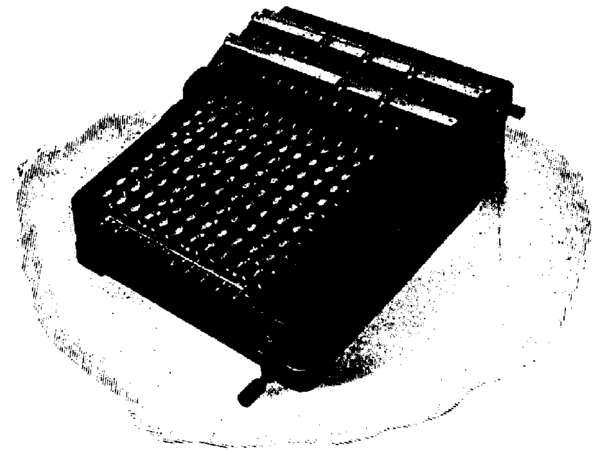


Figure ***298***

Kuhrt (1923)

There are two keyboard calculating machines in existence with this name; they are manufactured and sold by the firm Deutsche Rechenmaschinewerke A. G. in Leipzig.

Kuhrt A: Ten decimal places in the setting mechanism, ten decimal places in the revolution counter and thirteen decimal places in the result mechanism, Shifting of the counter mechanism over its whole length of travel, or from decimal place to decimal place, occurs by simple lateral pressure without any inconvenient lifting operation. Addition and multiplication occur by rotation of the crank to the right, and subtraction and division occur by rotation of the crank to the left. The machine has positive protection against overthrow. The numeral drums may also be set manually. Both counter mechanisms can be set to zero by a half turn of a crank. Setting check windows are located above the uppermost row of keys.

Model AB: is the same as described above but possesses two counter mechanisms for results and has an arrangement by means of which computed results may automatically be transferred from the result counter mechanism into the keyboard, *so* that one may carry out a second, third, or further multiplication without new settings in the keyboard. The purpose of the second result

Figure 299

mechanism has already been explained in the introduction. Width 32 cm, depth 35 cm, weight 14 kg.

Kuhrt US: is a printing, keyboard calculating machine with manual or motor drive, eighteen decimal places in both the setting and result mechanisms, and twelve decimal places in the revolution counter. It combines the advantages of multiplying and dividing machines with the efficiency of the printing, full-keyboard adding and subtracting machines. All numerical items in all four types of calculations are printed. Setting the machine for the desired type of operation occurs by pushing the appropriate key. Setting windows are located above the individual columns of keys. Width 41 cm, depth 48 cm height 22 cm, weight 50 kg.

Addition: It is possible, simultaneously, to both set up the items to be added and enter numbers with the counting mechanism disengaged. Consecutive items may remain in the quotient mechanism, from which they have been printed. There are partition bars on the keyboard. The printing mechanism may be divided into columns as desired. The machine has a clearance signal; broad, automatic, spring-driven carriage, convenient adjustment of the tabulator stops, and adjustable decimal point slides. It also has automatic reversing of the ribbon, continuously visible straight line printing, automatic printing of the results without a dummy operation, horizontal and vertical addition in the storage mechanism, automatic addition of final totals, automatic transfer of final totals into the setting mechanism for the purpose of using them in a different calculation, a repeat key, and a small switch for the motor drive.

Subtraction: The machine allows direct subtraction without the use of complementary digits. Subtracted items are printed in red. There is automatic conversion of negative (complement) values (996978) into positive values (003022) by a sensing device and automatic setting of the debit and credit signs.

Multiplication: Each multiplier decimal place requires one key depression only. Other characteristics are no noisy multiplication of the continuous addition type; multiplicand, multiplier, and product may be automatically printed for checking; adding up of the individual results by storage of the subtotals; automatic transfer of the product into the setting mechanism in compound calculating problems; rounding off of decimal places; automatic shifting of the counting mechanism; and register clearance by a half turn of the crank.

Division: Each quotient decimal place requires only one depression of the key. Other characteristics are simple correction in case the quotient is overestimated, without the necessity to switch over to multiplication; manual adjustment of the numeral display drums; large, single-colored digits in the quotient mechanism; and automatic printing of dividend, divisor, quotient, and remainder. The quotient may be automatically transferred to the setting mechanism for multiplication; several quotients may be added without need for a new setting. The quotient may be automatically transferred into the result mechanism as a dividend for the purpose of continued division.

The printing Kuhrt US is also a bookkeeping machine and serves for the preparation of interest tables, foreign currency calculations, balance sheets, discount calculations, statistics, and the like. It operates with multiplication bodies similar to the machines by Bollée, Steiger, and Moon Hopkins.

C. B. R. (1923)

Designer: Continentale Buero-Reform, Jean Bergmann, G.m.b.H., Kaiser-Allee 215, Berlin W. 15. This machine resembles the well-known adding machines with hook tens-carry, however, it has automatic tens-carry (although this runs through only one place). Thus if the number 9 is in one of

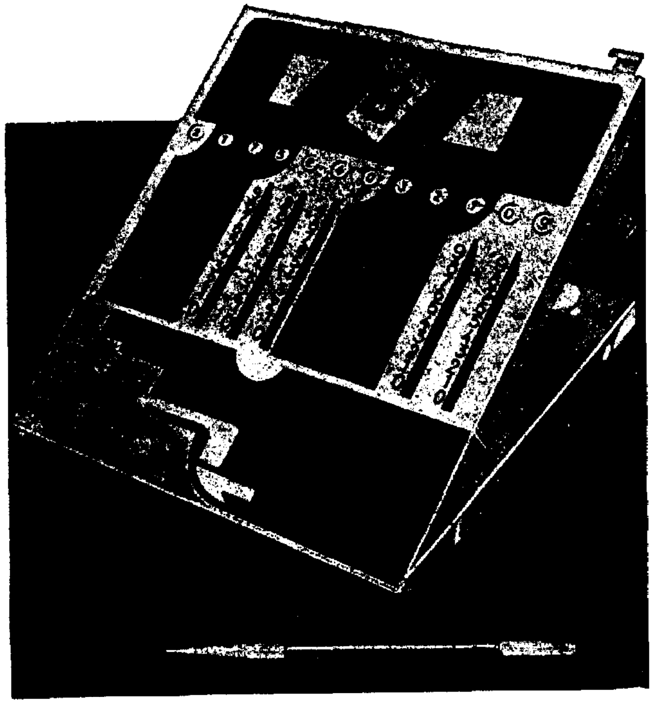


Figure *300*

the result windows and one adds 3 to it, the sum occurs in the usual way, that is, the tens-carry occurs automatically. If. however. 3 is added to 99, then the right window will show *2* while the left window shows a blank—this denotes 10. In this case the calculating stylus is set in the zero of the corresponding number slide and raised to the upper stop. If a blank result window appears, during addition, in the middle of a number, then the corresponding number slide is not to be raised, since the equivalent action occurs automatically in further calculations.

Subtraction: If the digit in the number to be subtracted is less than or equal to that in the result window of the corresponding column, then one places the stylus in the slot next to zero and raises it upward until it is next to the digit to be subtracted. If the digit being subtracted is larger, then the stylus is placed in the slot above the 9 and pulled down until it is next to this digit on the cover plate. One can perform additions and then subtractions or, if desired,

mix the operations. The machine has eleven places in the setting mechanism and twelve places in the **result** mechanism; therefore, it is most useful and can be divided. For example, one can enter debit posting on the left, enter credit items on the right, and subtract the smaller from the larger. Zeroing occurs when one pulls out the zeroing bar on the right of the machine.

The machine is 15 cm high, 15 cm wide. and less than 1 cm thick. It can be put in a pocket. It weighs about 1 pound and is provided with a stand that can be pushed down (for instance, if the machine should be put in a pocket) so that it is completely locked. Materials: strong sheet brass. Price: 25 marks.

Demos (1923)

The Demos (i.e., the people's calculating machine) is not one of the pinwheel machines. Its setup wheel (illustrated in figure **306)** is stamped out of a single piece of steel. It is therefore not subject, in the same way as the pinwheel, to wear and tear and, because of its simple design, is a fraction of the cost.

Figure **302** shows the wheel in its rest position. Lying opposite it is the Corresponding wheel of the result mechanism, also in zero position. Figure 303 shows the input wheel set on number 7. This is done by pulling down the attached lever. i.e., moving it forward seven teeth from its rest position. Figure 304 shows how both parts operate together after the crank has begun to turn. On contact, the totalisator moves forward, and the setup wheel rotates downward in the direction of the arrow and causes the corresponding wheel of the result mechanism to rotate 7/10 of a turn until it displays the number 7, Figure 305 shows the movement of the parts into their original position, which occurs when the crank has finished turning. With each turn of the crank. the entire setup mechanism (all the setup wheels together) makes only

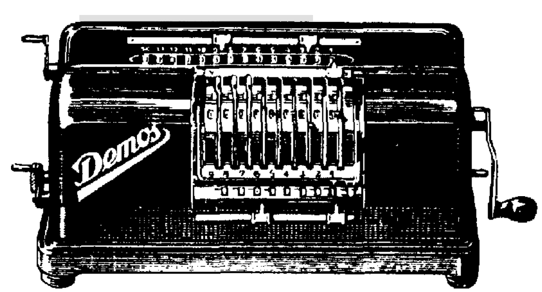


Figure 301

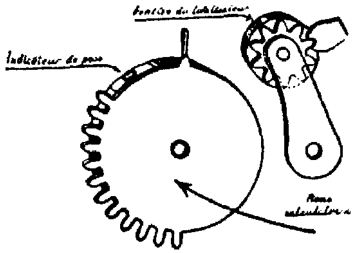


Figure 302

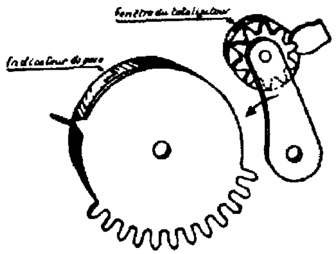


Figure 303

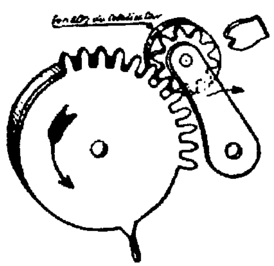


Figure 304

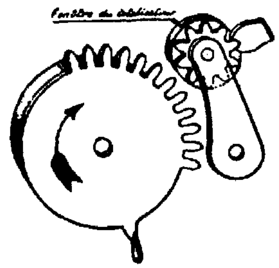


Figure 305

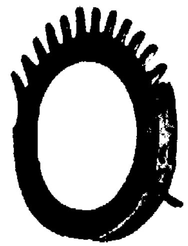


Figure 306

a slight movement to and fro, while the result mechanism makes a short swinging movement. Any sporadic or jerking action by the interlocking parts is therefore impossible, and consequently wear and tear is kept to a minimum. The tens-carry of the result mechanism is a positive one and can be considered an important safeguard against mistakes that can otherwise arise. There is also another safety device attached that, by blocking the setup wheels, makes any shifting movement during the calculation impossible. This safeguard comes into effect as soon as the crank begins to turn.

In the Demos, the setup mechanism can be moved. With the thumb and index finger of the left hand, one takes hold of the knob on the left of the carriage guide bar. When the knob is gently turned backward, the carriage becomes free and can be shifted at will by means of the bar. The two cranks on the left side of the machine are used to set the two calculating mechanisms to zero. Since the setup axle only has to make a quarter turn, it is possible to make the setup levers long and flat and therefore comfortable to hold. There are two rows of viewing windows between the slits for the setup levers—the adding numbers appear in black in the lower ones and the subtracting numbers in red in the upper ones. The setup levers are positioned on zero by raising the zero position bar underneath the setup slits. Both calculating mechanisms are equipped with the usual decimal point slides. The setup wheels are blocked as soon as the crank begins to turn. Because the crank is always turned in the same direction for addition and subtraction, it is possible to carry out combined operations (such as the rule of three. etc.) on the Demos. Its main advantage is uninterrupted multiplication without stopping the rotation of the crank.

The machine is supplied with nine places in the setup mechanism. fourteen places in the result mechanism, and eight places in the revolution counter. It weighs approximately 5 kg and costs only about half as much as similar calculating mechanisms. The distributor is Theo Muggli, 93 Bahnhoff Strasse, Zurich 1.

Quentell (1923)

The Quentell is a printing adding machine of new design especially notable for its low price. In other respects, however, it is the equal of more expensive machines. In America the price is $89.00. The machine requires a surface area of 25 x 27 cm, and weighs 9 kg. The machine is sold through Quentell Sales Corporation, 342 Madison Avenue, New York. Although it has been introduced into Holland, it is unknown in other European countries.

There are nine places in both the entry and result mechanisms. Numbers are entered in the following way: in each of the nine setting slides are nine setting levers leaning to the left—a slight pressure on the appropriate surface suffices to enter the corresponding digit. At the end of each setting slide is a

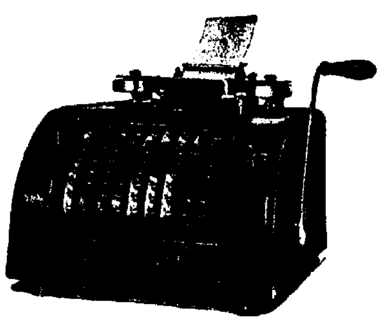


Figure 307

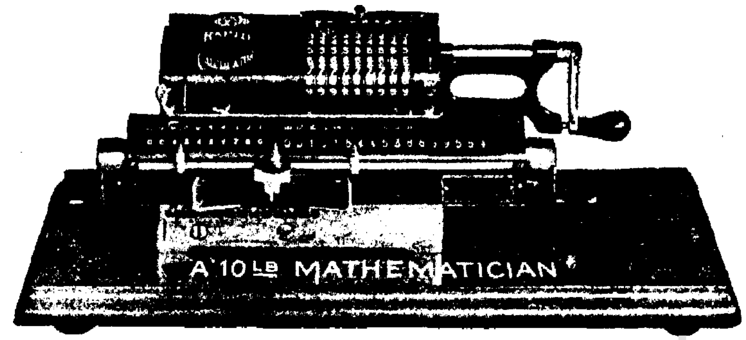


Figure 308

signal that is raised by the pressure on the setting surface, thus showing which digit has been entered. The signal remains in this position to allow checking of the entry before the crank is pulled. The crank action transfers the quantity into the result mechanism and causes the printing on a paper strip. Several digits can be entered at the same time. Total. subtotal, and correction levers are found on the right side of the setting slides. so that the machine can be operated entirely with the right hand, thus leaving the left hand free for making notes. A repeat key, found to the left of the entry mechanism, provides effective assistance in multiplication and division. The printing device uses a single-color ribbon, the pressure on the paper strips is light, and the printing is visible to the operator.

Rapid Calculator (1923)

Manufacturer: S. W. Allen Company, 20 South Eighteenth St., Philadelphia. The machine is said to have been manufactured since 1918. Reports of sales in larger numbers date from 1923. It is a pinwheel machine produced with either 8 × 9 × 13 places or 9 × 10 × 18 places. It weighs 4.5 kg.

Regina (1924)

The information obtained about the Regina is generally so useless to read that the design remains unclear (see the following), and one cannot gain an exact view of the way the machine works. Judging from the figure, it is a calculating machine with slide setting and a crank on the right side.

The numbers to be added are entered as in every(?) other machine, and the result immediately appears in the viewing windows without further work (for example, turning a crank)." A slide is easily changed for subtraction. The work proceeds as in addition. The number to be multiplied is entered in the multiplication mechanism(?), a slide placed on the multiplier, and the result read off. It should be mentioned here especially that the simplification of this mechanism places all existing systems in the shade, since one arithmetic number system entered on the cylinder saves every further mechanism and the assorted work('!). Division is the simplest imaginable, since it is the reverse of multiplication. Zeroing follows through pressure on a locking latch and one turn of the crank.

The price of the Regina is 140.00 marks. Designer: Hebecker & Taessel, Muhlhaused, Thuer.

Rheinmetall (1924)

The Rheinmetall is a stepped drum machine (see the introduction for a general description) that is now available only with keyboard setting. It has eleven decimal places in the setting mechanism, seventeen in the result mechanism, and eight in the revolution counter. Manufacturers are: Rheinische Metallwaren und Machinenfabrik in Soemmerda. The sales agency is the Rheinmetall-Handelsgesellschaft m.b.H. in Berlin W. 8, Friedrichstrasse 56/57.

The machine has double stepped drum drives, reliable gear meshing conditions, and a tens-carry throughout, even in the revolution counter (i.e., no red digits). so that the machine is particularly suited for shortcut multiplication. The setup values may be read, in a straight line, from the windows above the keyboard. The reversing lever is located to the left of the keyboard. Depression of key R causes the carriage to shift by one decimal place in the direction of the arrow. Lever 9 serves for shifting the carriage to the right—particular attention is drawn to the fact that lifting of the carriage, such as is required in other machines, is no longer necessary. Keeping correction key C depressed while the crank is being turned compensates for extra revolutions of the crank without the need to reverse the machine to the opposite type of calculation, which would be done by lever 6. When individual items are to be added, lever 3, located to the right of the keyboard, is set to A. This adjustment releases the values set in the keyboard after each turn of the crank

77. The question marks were part of Martin's original publication but were. presumably. not part of the original quotation. As Martin indicates, the original information was quite confusing. and we are sure that our translation into English does not help the situation.

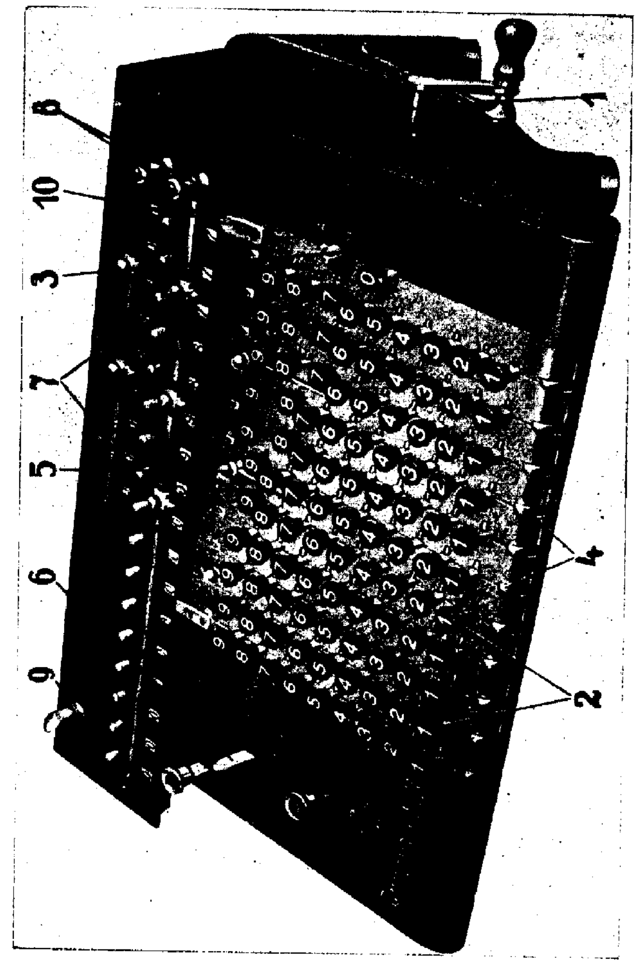


Figure 309

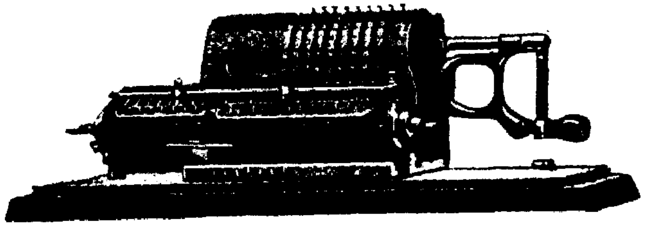


Figure 310

so that they do not need to be cleared by a separate operation. For multiplication and division, however, the lever is set to M so that the entered values may be maintained for the duration of these calculations. Depression of key **0,** which is also to the right of the keyboard, clears values entered in the keyboard. Any amount entered may also be cleared, in individual columns, by operation of lever **4.** The machine is also provided with the customary decimal point slides, with insertable decimal point plugs for grouping the keys, and with setting knobs located above the windows of the result mechanism—which can serve, as is well known, for setting up the dividend or for correcting (rounding off) the results. The sloping position of the keyboard and the large digits of the counting mechanisms permit very convenient reading of the results. The distance between the digits is only 18 mm.

Dimensions: 37 × 30 x 8½ cm. Weight: **13.7** kg net without baseboard or cover.

Muldovo (1924)

The Muldovo is a miniature pinwheel machine of French origin. The name of the manufacturer is unknown to us. Weight: 3.5 kg dimensions: **30** × 15 cm.

Gauss (1924)

The Gauss calculating machine factory was founded in Braunschweig in 1923 by E. Hengstmann, H. Scharff, and R. Ulbrich.

It is a pinwheel machine with fourteen places in the result mechanism, ten in the setup mechanism, and nine in the revolution counter. Zero position of the setting levers is brought about by pressing the zero position key on the

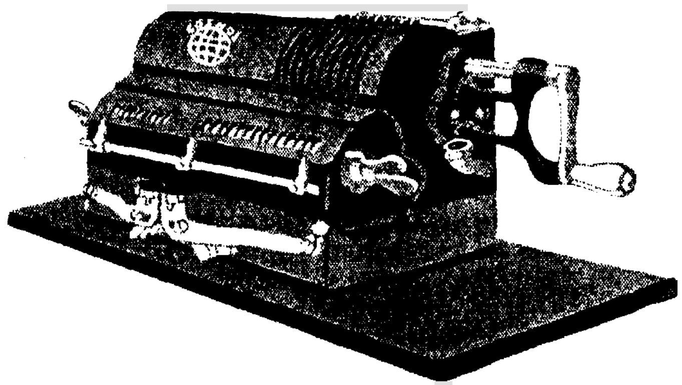


Figure 311

right side of the machine. The carriage is also shifted by means of keys. Only a few dozen machines were ever produced when, in October 1924, the production rights were transferred over to Hengstmann and Company. a factory for calculating machines situated at Mauernstrasse 41. Braunschweig. The machine is now called Cosmos. There is said to be a model under construction that has tens-carry in the revolution counter.

The Mercedes-Elektra Calculating Typewriter (1924)

This is a version of the well-known, electrically driven Mercedes typewriter, the Mercedes-Elektra. The calculating Mercedes-Elektra is provided with mechanisms for adding and subtracting digits. The numbers may be arranged under one another or next to one another in as many rows as are required; hence the machine is equipped for vertical as well as horizontal operations. The easily detached calculating mechanism, mounted at the front of the carriage, is used for the addition and subtraction of digits arranged underneath one another. The cross totaling mechanism, on the right side at the front, is used for horizontal addition and subtraction and also serves as the control calculating mechanism. The machine is provided with a decimal place tabulator, in front of which are ten keys for digits that can be used both for typing and calculating. For those numbers that need only to be typed, there are keys for that purpose in the fourth row of the actual typewriter keyboard. The use of these prevents numbers belonging to number statements, dates, and the like from entering the calculating mechanism.

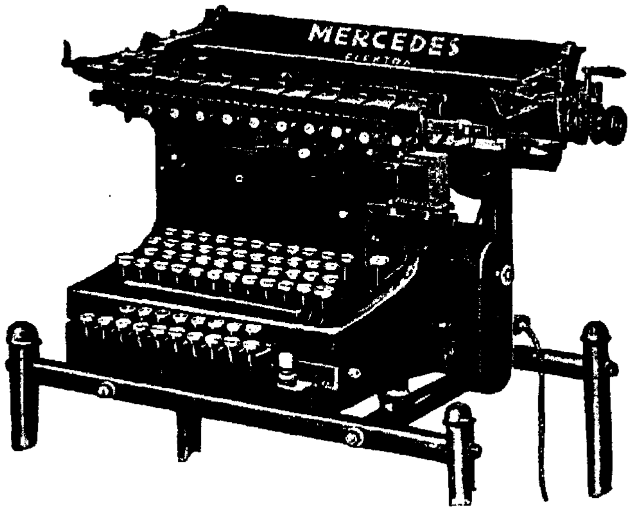


Figure 312

The machine is supplied with carriages of 30, 37, 47, and 60 cm in length. The calculating mechanism is available with four- to sixteen-place capacity. These are arranged as follows: with two or three places to the right of the decimal point. with or without decimal point; thereafter three figures are always combined in one group. The calculating Mercedes-Elektra is the only one of its kind that functions on electric drive. It is available in various models. The electric drive guarantees definite reliability and efficiency in calculations.

Manufacturer: Mercedes-Bureaumaschinenwerke, Berliner Strasse 153, Berlin-Charlottenburg 2.

Omiag (1924)

This is a production of the Optischen Maschinenbau-Industrie A. G. in Braunschweig-Gliesmarode. It is a pinwheel machine of the usual design (see the introduction), with nine places in the setup mechanism, thirteen places in the result mechanism, and eight in the revolution counter.

The machine has large setting levers that are easy to handle.. Below the levers are the setting control windows. The setting device can be returned to the zero position by means of a small lever attached to its left. The knob to

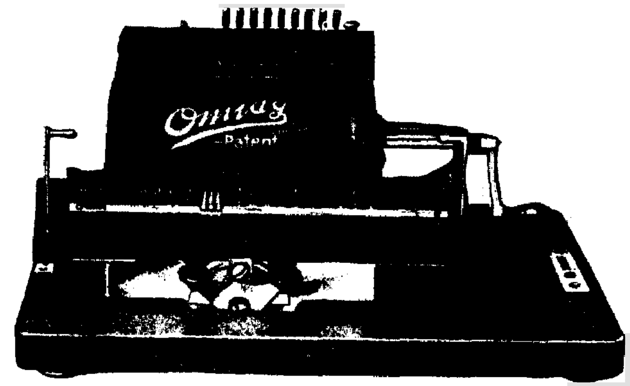


Figure 313

the right of the setting levers is used to turn off the setup mechanism after each setting has been carried out. The machine has no intermediate gears. The crank attaches directly to the axle of the main drum. The setup mechanism operates directly on the result mechanism. Zeroing of both calculating mechanisms is brought about by pressing down two levers. Two keys move the carriage sideways. Dimensions: 25 x 12 cm. Weight: 7 kg. Production has had to cease for the moment.

Mira (1924)

Manufacturer: Mira-Rechenmaschinen-Fabrik, Reichenberg, Bohmen. This is a pinwheel machine of the usual design (see the introduction). There are nine places in the setup mechanism, thirteen in the result mechanism, and eight in the revolution counter. Both calculating mechanisms and the setting levers are brought to their zero position by turning the small knobs. There are decimal point slides on both calculating mechanisms and on the setup mechanism. The carriage shift, to the left and right, is performed automatically when keys are pressed.

The mechanism is well supported, so that the machine has an extremely easy and smooth motion. Servicing this device is very simple since, by loosening only two screws, the setup mechanism can be pulled out without having

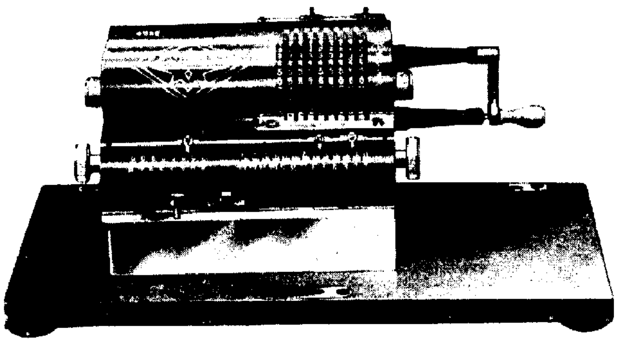


Figure314

to dismantle the entire machine. Standard machines are produced, some with tens-carry in the quotient, and with injector."

Dimensions: 17 × 12 × 12 cm. Weight: 6.5 kg.

Tasma (1924)

The Tasma is the smallest visible printing, full-keyboard adding machine. It measures only *28* x 14 × **20** cm, has ten places in the setup mechanism, and eleven places in the result mechanism. Although this machine has been kept very small, the following description **will** show that it can perform the same functions as a number of large, full-keyboard adding machines.

The complete key field has been reduced to 5 × 5 cm. One key cancels another in the same column. There is also a row **of** cancelation keys underneath the various columns of keys. As figure 315 shows, the keyboard is designed like a chessboard. The figures are entered by means of a light and easy to handle stylus. The depth **of** the keys is only about *3* mm, and the distance from one key **to** another is *5* mm. The total printing lever is on the left side of the machine, while the subtotals lever, the keyboard cancelation lever, and the repeat lever are on the right. The calculating mechanism lies underneath the keyboard. The machine prints on **rolls** of paper, and, as already mentioned, the printing is fully visible. Totals and subtotals are specially indicated on paper; they can be printed without a dummy operation. The machine uses a single-colored, 11-mm ribbon with automatic reversal.

80. The editors admit they have no idea what an "injector" is in the context of calculating

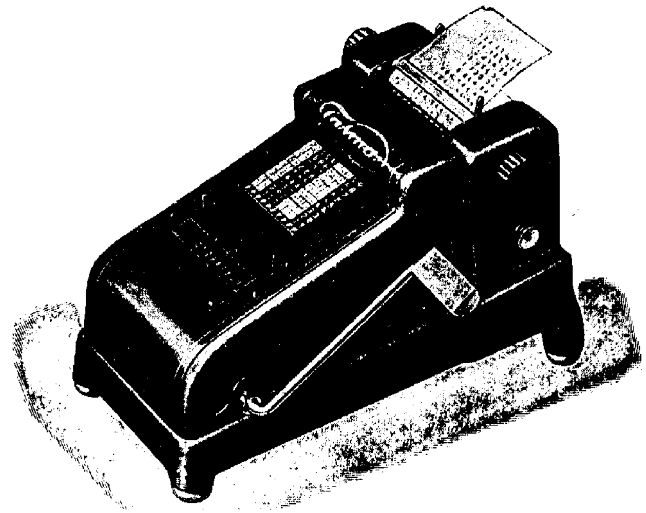


Figure 315

Paper feeding is also automatic. The printing mechanism is equipped with special digit rods. These are fixed in a solid fashion that ensures an accurate spacing of the printed numbers.

The addition lever is also quite new in its motion. It does not function as a pull lever but as a push lever. Immediately after setting a number, the hand can operate more easily by pushing rather than by pulling. The addition lever springs back to its rest position automatically.

Price: 600.00 R. marks

Manufacturer: Thaleswerk G.m.b.H., Rastatt (see the Thales (1911)).

Summograph (1924)

There are pinwheel machines with keyboard setting (Marchant, Rema) already in existence; furthermore, a printing pinwheel machine with lever setting (Trinks Arithmotype) is also available. The Summograph, illustrated in figure **316,** is a pinwheel machine equipped with a keyboard that prints simultaneously; hence it is the latest in this field.

The designer of the machine is Hans Behrens of Leipzig, Planitzstr. *22.*

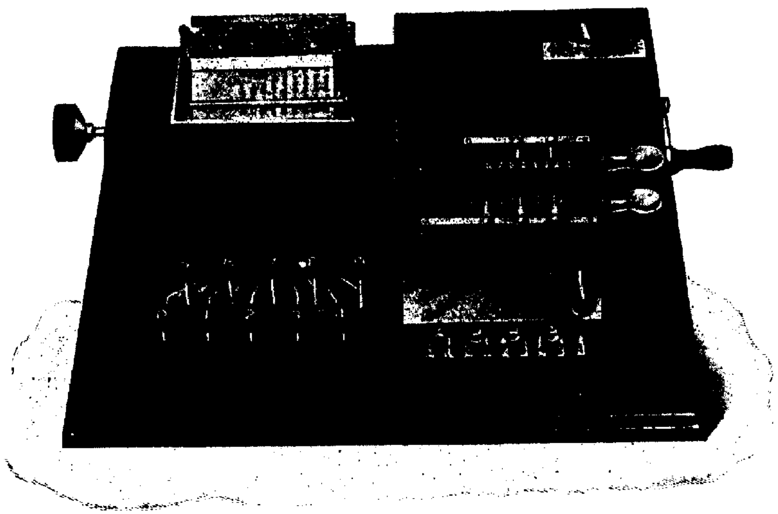


Figure 316

The machine is being produced by the A.G. fur feinmechanische Industrie in Leipzig, Heerstr. 4.[81]

The machine has thirteen decimal places in the setting and result mechanisms, and eight decimal places in the revolution counter. It operates exactly like all the other Odhner machines; however, the setting is not performed by levers but by ten setting keys located on the left side. The crank of the Summograph is always turned in the same direction—reversing from addition to subtraction takes place by shifting a lever. Numbers may be automatically aligned below one another by means of the decimal tabulator, located to the right and below the result mechanism. This machine not only adds, subtracts, multiplies, and divides, but it also prints the problem as well as the result so that the operation may be accurately checked. The paper, which has a width of 8 cm, may, if necessary, be retained as a record. The result may be retransferred as often as desired. Totals and subtotals are automatically printed in red. The printing is immediately visible. The weight of the machine is 9 kg, its dimensions are 15 x 30 × 20 cm.

81 . A correction pasted in the back of the book indicates "The designer of the machine is Obering. Fritz Maschiezeck."

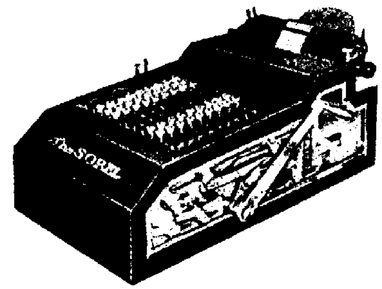


Figure 317

Gobel (1925?)

This full-keyboard adding machine is not yet on the market. It has nine places but has a special multiplication device that allows each multiplication to be done with only one pull of the lever per decimal place. The results are printed in red, provided that the total or subtotal key has been pressed beforehand. Manufacturer: Gobel Multiplying Bookkeeping Machine Company, Philadelphia.

Odhner Universal Calculator (1925)

The designer of this machine is, as far as we know, Valentine Odhner, the nephew of the famous inventor. The machine is a pinwheel machine with key setup. Further details are not available since the machine has not yet appeared. Manufacturer: Odhner Universal Calculator, A. B., Stockholm.

Amigo (1925)

In both size and shape, this machine closely resembles the Scribola, illustrated in figure 286 (32 x 9 × 7 cm, 2½ kg), but instead of a chain drive it has ten adding keys. It prints both individual items and totals on 58-mm wide paper. There is a lever, attached on the right, that is used to add and print the items that have been entered. The totals are printed when the left lever is moved—it is not necessary to enter them again. It has a single-color ribbon. Capacity: eleven-place setup mechanism, twelve-place result mechanism.

The price of the machine is 400 marks. Manufacturer: Amigo Addiermaschinen Gesellschaft, 11 Miiller Strasse, Stuttgart-Gaisburg.

Melitta (1925)

This is a miniature pinwheel machine with continuous tens-carry in the revolution counter. The shift from addition to subtraction occurs automatically when the crank is turned in the opposite direction. Manufacturer: Mercedes Bureaumaschinenwerke, Charlottenburg 2, I53 Berliner Strasse.

Hamann-Manus (1925)

The designer of this machine is Chr. Hamann, Berlin. Figure 318 shows the first model, which was driven manually. In both the interests of expediency, and to comply with what has proven popular with the machine operators. the designer has provided the machine with the same exterior design as that of the Odhner machines and also copied its dimensions. The interior design of the machine, however. is completely new and original and has nothing in common with the mechanical principles of the Odhner models. Its most important working part is not the pinwheel itself but a geared wheel with a thirty-six-part inner and outer gearing (see figure 319). The fully automatic silent movement prevents the possibility of otherthrow.

The Hamann-Manus has a capacity of 8 x 9 x 18 places. It has a linear setting control and longer and more manageable setting levers than the most important of the Odhner machines. During addition and subtraction the levers automatically reset themselves on zero after the crank has been turned. For

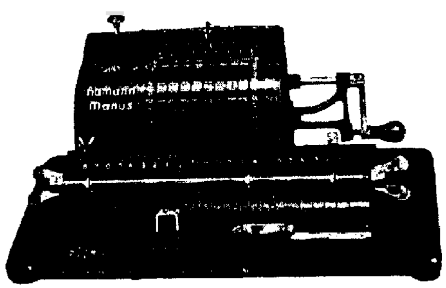


Figure 318

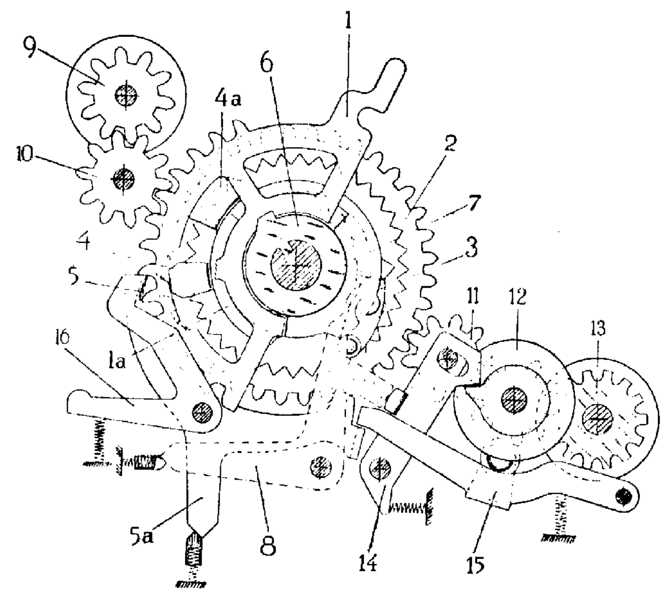


Figure 319

multiplication and division, there is a conveniently situated knob that must be pressed to cancel this automatic zeroing of the setup levers. Total reset of both calculating mechanisms is done by a 180-degree half turn of the right wing screw. In addition, the revolution counter can be zeroed in the same way by the left wing screw. The crank of the machine, which is designed the same as in the Odhner models, can only be turned in one direction. There is a conveniently placed lever that is used to change from addition to subtraction, from multiplication to division, and vice versa. Like the subtraction lever. the lever for carriage movement is also immediately below, or rather next to, the keyboard so that only the right hand is needed to shift the carriage in multiplication. Setting up the dividend in the result calculating mechanism is done directly by means of special devices and not by way of the setup mechanism—the subtraction of 1, which is usually done in setting up a dividend, does not take place. It should be stressed that the Hamann-Manus is the first and only small, manual calculating machine with completely automatic division. This sets it apart from all similar calculating machines.

The designer did not include continual tens-carry in the revolution counter since it is not necessary for automatic division. It can also be dispensed with in multiplication through the fortunate design of the carriage movement lever, which makes any use of the left hand superfluous. The second model of the machine is a so-called semiautomatic machine with electric drive. Here continuous tens-carry in the revolution counter is also unimportant because of the speed of the automatic calculation. This model, which, apart from the electric drive, is exactly the same design as the hand model, was shown to a small circle of interested people and experts. It aroused great interest and earned considerable recognition. Further models are supposed to be following. All of them are very compact machines, light in weight and small in size—they can be easily carried from one workplace to another and require neither a special table nor their own support frame.

The life span of these machines is the longest possible, since all working parts are manufactured out of first-class material in the most scrupulous and expedient of methods developed by modern mass production. The machine is also designed to allow the least possible wear and tear of material. For example, at each setup, the large, interior, geared working disks rotate only 90 degrees for every turn of the crank. The machine is manufactured by the Deutsche Telephonwerke und Kabelindustrie Aktiengesellschaft, Berlin SO. 33, 6/9 Zeughof Strasse.

Groesbeck

This is a small adding machine along the lines of Dr. Roth's machines (figure 30). It has six places in both adding and subtracting viewing windows. During the seventies, the machine was manufactured by Ziegler and McCudry and distributed in Philadelphia. However, it was never widely sold and production has long since ceased.

Frister and Rossmann

This is a nine-key adding machine contained in a wooden box. The machine itself was never of any great significance and production has long since stopped.

Mercedes

This is a nine-key adding machine that also has eight tabulating keys. Again, this machine was never widely distributed and has not been manufactured for a number of years. Manufacturer: Mercedes Bureaumaschinenwerke, Charlottenburg, 153 Berliner Strasse.

Mercur

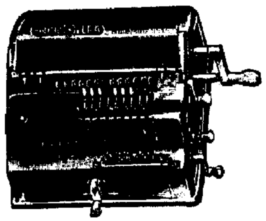
Manufactured by L. M. Ericson & Co.. Stockholm. Pinwheel machine with slide setting. The slides sit on the screw shaft. The carriage is above. The machine has sixteen places in the result mechanism and nine places in the revolution counter. It is no longer made,

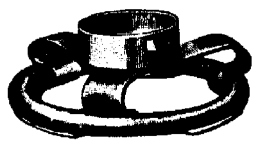
Index

,Hannovera chinen

werden in mehreren Modellen gelieferf:

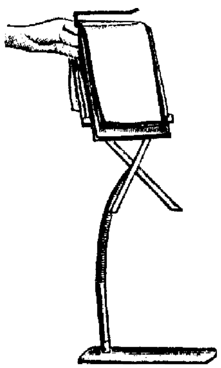
×8×13 und 20×12×20 mit und ohne Zehnerübertragung





Modell CK

mit langen Hebeln und Sichtbarkeit



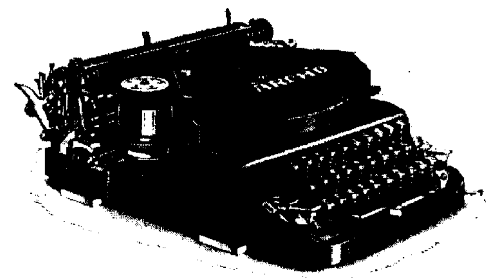
Schreibmaschinen-federungen fangen die schädlichen Stöße des Wagens auf

Stenogrammblockhalter nach jeder Richtung verstellbar

„Hannovera"-Rechenmaschinenfabrik

Oventrop, Heutelbeck & Co., Peine/Hann.

„Archo"



Schreibmaschine

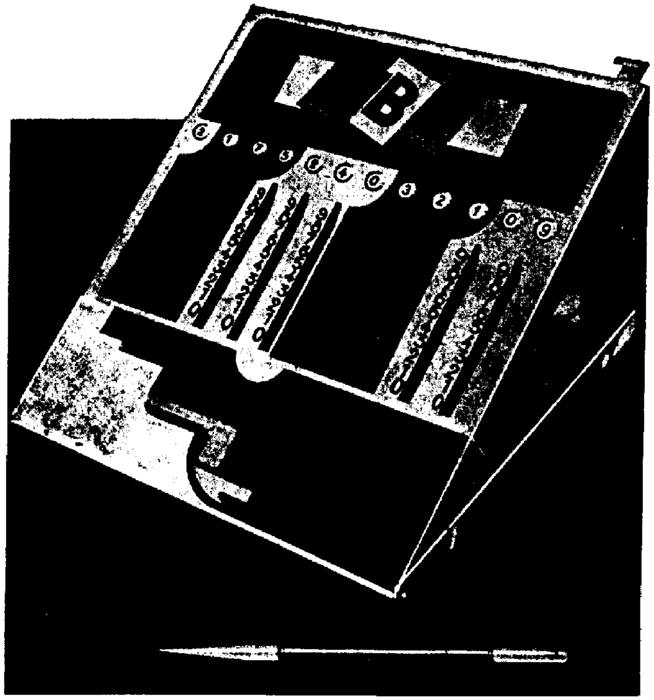
erstklassiges deutsches Fabrikat von vollendeter Gute und modernster Ausstattung

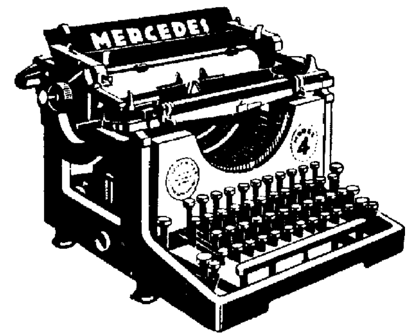
Archo Schreibmaschinen-Company

Winterling & Pfahl

Frankfurt a, M.

Vertretung
für einzelne Bezirke noch zu vergeben





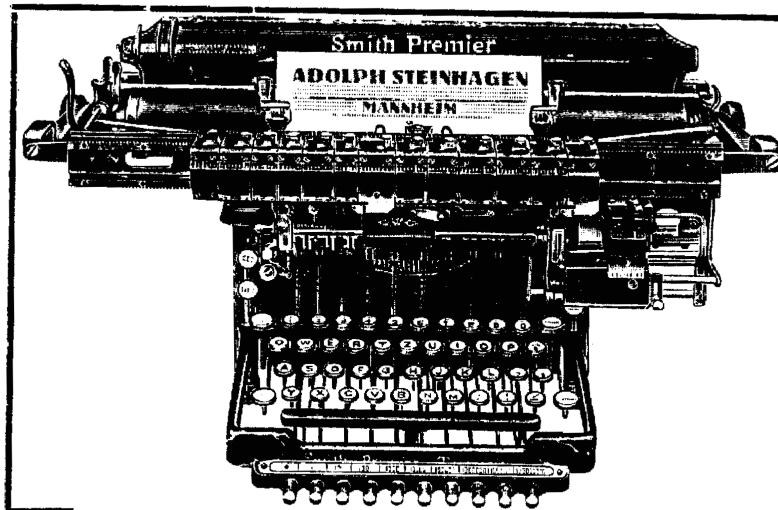
SIE SCHREIBT UND RECHNET GLEICHZEITIG!

DIE ZEITGEMÄSSE ORGANISATION BEDIENT SICH DER

URANIA-VEGA

(RECHNENDE SCHREIBMASCHINE)

CLEMENS MÜLLER AKTIENGESELLSCHAFT/DRESDEN-N.



Der zuverlässigste Rechner

addiert, subtrahiert automatisch längs und quer zugleich in beliebig vielen Spalten

Importeur:

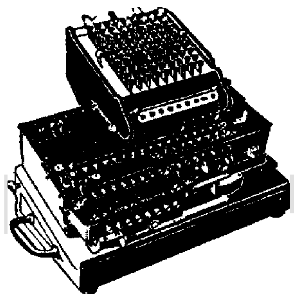
Adolph Steinhagen

Mannheim


Gegründet 1899
Alfred Ransmayer
Berlin SO 16
Köpenicker Straße 113
R
Schutzmarke
Typen u. Tasten
für
Rechenmaschinen
und
Schreibmaschinen
8

Mercedes-Euklid

die Universal-Rechenmaschine



Vertretungen in allen Weltteilen

Mercedes-Büromaschinen-Werke
Zella-Mehlis i. Thür. / Berlin