

The Curta, a Technical Marvel

The development of mechanical calculating machines began in the 17th century with Wilhelm Schickard (Germany), Blaise Pascal (France) and Gottfried Wilhelm Leibniz (Germany). It reached its peak after more than 300 years with the Austrian engineer Curt Herzstark, the inventor of the Curta. This technical marvel was manufactured in large numbers in Liechtenstein. In the 1970s, however, digital mechanical calculators and analog logarithmic slide rules were replaced by electronics. The mathematical devices, which were very popular and widely used at the time, are now largely forgotten. Thanks to new discoveries of patent documents and design drawings, there are new insights into the Multiple Curta, the world's smallest mechanical parallel calculator.

BY HERBERT BRUDERER

The highly gifted Austrian engineer Curt Herzstark ^{1,3,4,9} created the Curta, the tiniest mechanical calculating machine in the world. The round-shaped calculator, which reminds one of a pepper mill, was manufactured in high numbers in Liechtenstein from 1948 to 1971. However, the inventor was cheated out of his life's work. Only recently, high-quality design drawings for the Multiple Curta, the world's smallest mechanical parallel calculator, came to light. The University of Birmingham constructed a twelve-fold Curta in 1953.

The Curta was the most successful mechanical four-function pocket calculating machine ^{2, 7, 8, 15, 16, 18}. It was even capable of extracting square roots. The Curta is considered the crowning achievement of the 350 year history of mechanical calculating machines. The stepped drum devices remain completely functional to this day. The precision mechanical marvel is the forerunner of today's electronic pocket calculators, which appeared on the market in the 1970s. The early providers included Canon, Hewlett-Packard, Sanyo, Sharp, Olivetti, and Texas Instruments.

Curt Herzstark

The life of the Austrian inventor Curt Herzstark (1902–1988) (see Figure 1) was overshadowed by tragic events ^{5, 6, 11, 12, 17}: prevention from taking over his parents's calculating machine factory because of the "annexation" of Austria, prisoner in the Buchenwald concentration camp, escape from Soviet persecutors in Thuringia, defrauding with the buildup of mass production for the Curta by the Prince of Liechtenstein, and the resistance of certain Swiss competitors.



Figure 1. Curt Herzstark, the inventor of the world's smallest mechanical pocket calculating machine. Although he was Austrian, the Curta was manufactured in Liechtenstein (Credit: Liechtensteinisches Landesmuseum, picture: Sven Beham).

Curt Herzstark's life^{5,6}

January 26 th 1902	Born in Vienna
August 19 th 1938	Granting of the main patent (DRP no. 747 073) for the complementation gear-work (complementation stepped drum)
April 13 th 1939	Granting of the main patent (DRP no. 747 074) for the reduction
October 27 th 1988	Death in Nendeln, Liechtenstein

The Curta is a stepped drum machine^{3,4}

Primarily stepped drums and pinwheels were used with mechanical calculating machines. These two devices for mechanical numerical notation were invented by Gottfried Wilhelm Leibniz. The pinwheel was also (probably independently) designed by Giovanni Poleni (Italy). A stepped drum (see Figure 2) is a (broad metal) drum with teeth of different length. The teeth, with staggered length and parallel to the axis of the drum, represent the numerical values 1 to 9. No tooth has the value zero, and all teeth correspond to the number 9. The numeral 1, for example, is represented by one (the longest) tooth and the number 2 by two (the longest and the second longest) teeth. 3 is composed of the longest, the second longest, and the third longest teeth. The stepped drum is also described as a stepped wheel or a Leibniz wheel.

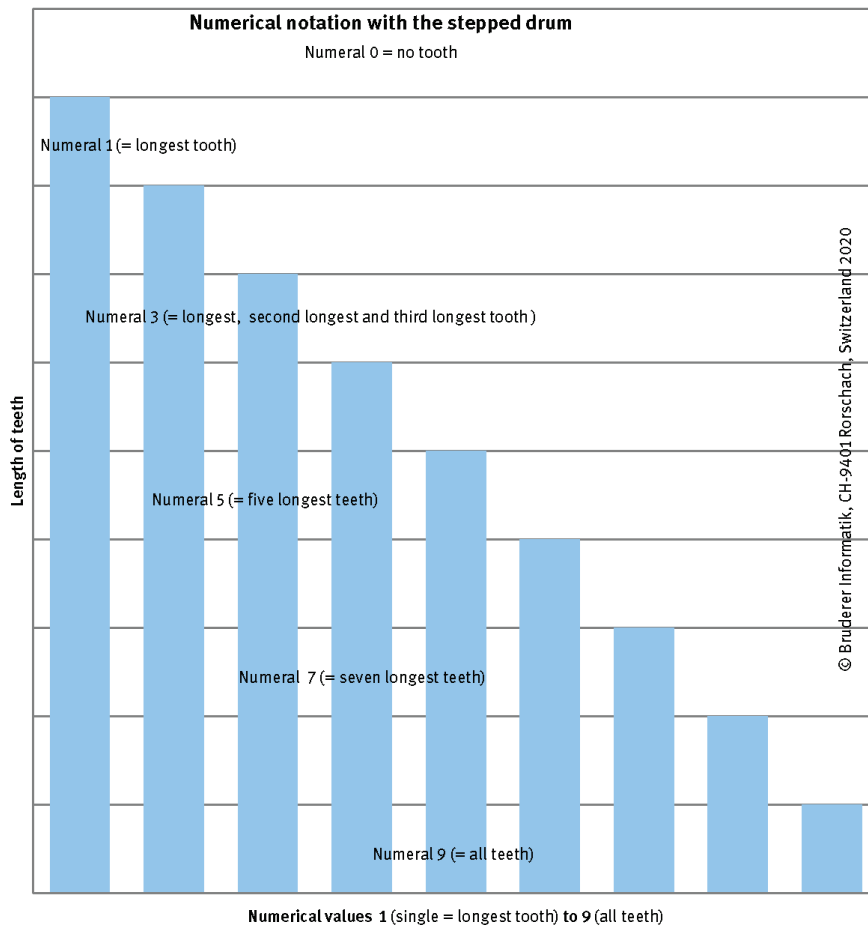


Figure 2. Stepped drum. A complete revolution of Gottfried Wilhelm Leibniz’s stepped drum drives a gear wheel of the calculating unit further according to its position, e.g., at zero (top line in the drawing) or at nine teeth (lowest line). (Source: Albert Rohrberg: Theorie und Praxis der Rechenmaschinen).

The Curta is a cylindrical calculating machine^{3, 4}

Most calculating machines are rectangular. However, there were also numerous cylindrical devices (see Table 1). Mass production of stepped drum machines did not begin until around 1850 with the French Thomas Arithmometer.

Table 1: Early circular (cylindrical) four-function machines that have been preserved

Inventor	Year built	Design
Braun, Anton	1727	Pinwheel machine
Hahn, Philipp Matthäus	1774	Stepped drum machine
Hahn, Philipp Matthäus	1776	Stepped drum machine
Leupold, Jacob; Braun, Anton; Vayringe, Philippe	1735	Toothed segment machine
Müller, Johann Helfrich	1784	Stepped drum machine
Roth, Didier	1841	Pinwheel machine
Sauter, Johann Jacob	1796	Pinwheel machine
Schuster, Johann Christoph	1792	Stepped drum machine
Schuster, Johann Christoph	1820	Stepped drum machine
Schuster, Johann Christoph	1822	Stepped drum machine

A pinwheel is a (narrow disc-shaped) gear wheel with nine movable and adjustable pins. The teeth, arranged perpendicular to the shell, can be individually extended or retracted or folded inward and

outward. If no pins extend from the wheel rim, this represents the number 0. Nine extended teeth correspond to the value 9. Five extended pins give the value 5.

The magnificent circular calculating machines (see Figure 3) are usually one-of-a-kind devices.

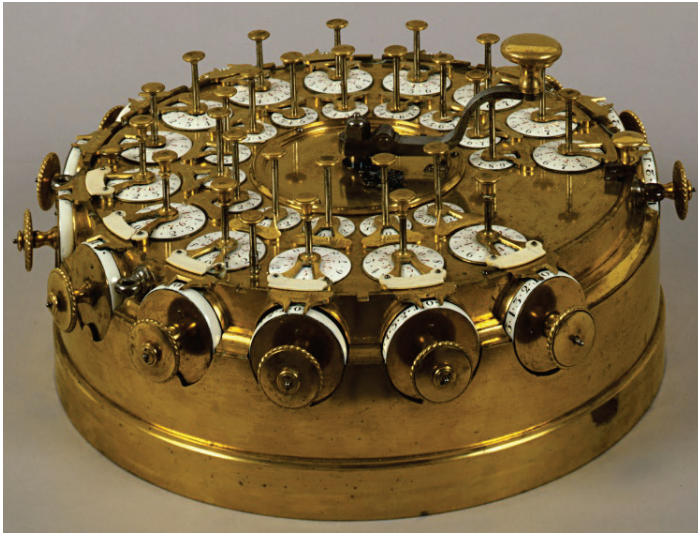


Figure 3. Müller's stepped drum machine (1784). This cylindrical 14-place four-function machine of Johann Helfrich Müller (Germany) enables calculations in different number systems (base-2 to base-12 number system) by changing the numeral discs (Credit: Hessisches Landesmuseum, Darmstadt).

The development of the Curta

For a long time there were only heavy, inaccurate or unsuitable calculating aids. Today electronic pocket calculators are commonplace. However, until the 1970s there were practically only:

- Portable bead frames, which in fact enabled all four basic arithmetic operations but had no automatic tens carry
- Light-weight, easy to use (logarithmic) slide rules, which were incapable of addition and subtraction and inaccurate
- Mechanical pocket calculators, such as the sliding bar calculator, which was incapable of multiplication and division and exhibited only semi-automatic tens carry
- Heavy mechanical desktop calculating machines, which were capable of all four basic arithmetic operations and had automatic tens carry, but could not be easily transported.

Features of the two models

The Curta (see Figure 4) is a cylindrical digital calculating machine capable of all four basic arithmetic operations. Contina manufactured two models, a smaller and a larger version:



Figure 4. The Curta (Model 2). The Curta pocket calculator is a full-fledged four-function calculating machine (Credit: Liechtensteinisches Landesmuseum, Vaduz, picture: Sven Beham).

Curta 1

- 8 places in the setting mechanism, 6 places in the revolution counter, and 11 places in the result mechanism, i.e. $8 \times 6 \times 11$
- 53 mm diameter, 85 mm high, 230 g weight without sleeve, 330 g with sleeve
- The manufacture and assembly of a Curta 1 took 9–10 hours.

Curta 2

- 11 places in the setting mechanism, 8 places in the revolution counter, and 15 places in the result mechanism, i.e. $11 \times 8 \times 15$
- 65 mm diameter, 90 mm high, 360 g weight.

Design drawings

The large-format design drawings for the Curta are extremely complex. Since they would no longer be readable following reduction in size it is unfortunately not possible to reproduce them here. The following illustration (see Figure 5) serves only to convey an initial impression.^{3, 4, 12}

Mass production of the Curta in Liechtenstein

The first devices were manufactured in 1948. The two diagrams below (see Figures 6–7) illustrate the development of mass production.

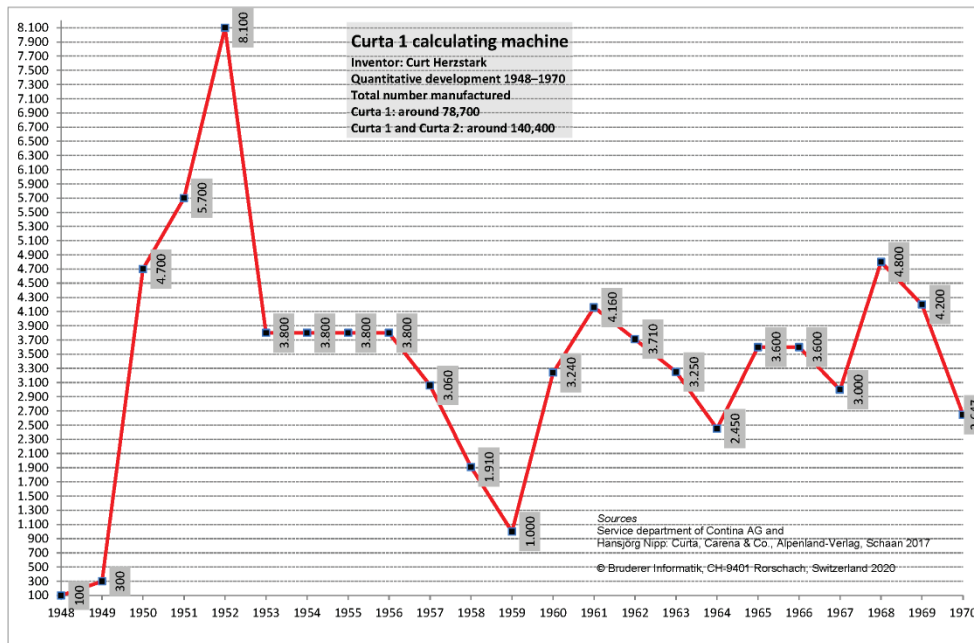


Figure 6. Manufacture of the Curta 1 from 1948 to 1970. A pronounced drop production occurred in 1953 (Credit: Bruderer Informatik, CH-9401 Rorschach, Switzerland).

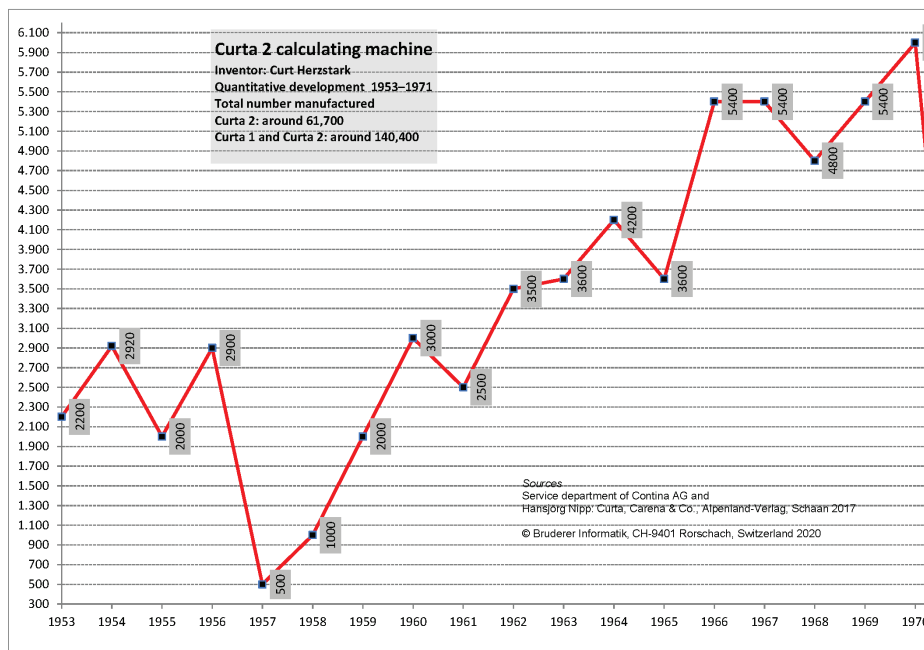


Figure 7. Manufacture of the Curta 2 from 1953 to 1971. The number built dropped dramatically in 1957 and especially in 1971 (Credit: Bruderer Informatik, CH-9401 Rorschach, Switzerland).

A mechanical parallel calculator from Liechtenstein

On November 14th 2015 the investigation of Curt Herzstark's estate brought to light exceptionally interesting original drawings and patent documents at the Schreibmaschinenmuseum Beck in Pfäff-

ikon ZH (see Figures 8–9) for a previously unknown multiple calculating machine, the world's smallest mechanical parallel calculator.

According to the newly discovered patent documents, any number of circular machines can be coupled. In particular, Herzstark describes the following configurations:

- Two Curtas standing next to each other
- Three Curtas stacked over each other
- Four Curtas standing next to each other
- Five Curtas in a circular arrangement.

Features of the multiple calculating machine

The parallel calculator is distinguished by the following features:

- All machines are driven simultaneously by a single hand crank.
- All devices can be (by axially shifting the drive shafts) changed jointly or individually to another basic arithmetic operation. This is possible even when the individual calculating machines are set to different arithmetic operations.
- All counting mechanisms can be simultaneously or individually advanced with the correct number of places (decade-wise) in both directions of rotation.
- All result mechanisms and/or all revolution counters can be reset to zero jointly or individually.

Curt Herzstark adds: "In addition, the multiple calculating machine can also be operated with an electric drive" (see patent specification no. 195 147, page 5).

Double, quadruple and quintuple Curtas

The entirely surprising findings show that the Viennese inventor designed not only individual devices, but also Multiple Curtas. Calculating machines with several counting mechanisms were known from earlier times, for example the double or triple Brunsviga, Marchant, Millionaire, Monroe, Thales, and Triumphator machines. They accelerate the calculation process and were used for surveying and liquidation calculations. The following illustrations are concerned with the Curta 1.

In order to simplify operation, Herzstark designed a further form of the Double Curta with a base plate (additional patent).

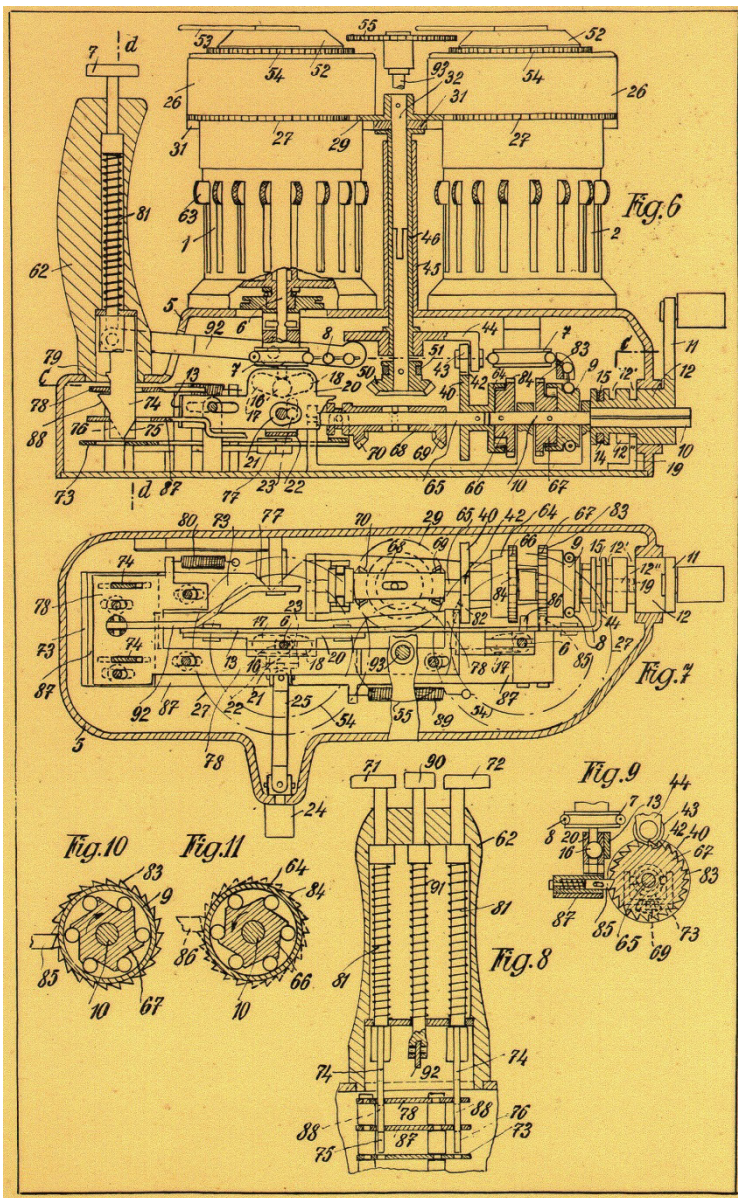


Figure 8. The Double Curta. The original drawing shows two mechanical pocket calculating machines arranged next to each other. The drive crank activates the main drive shafts via bevel gears and spur gears. A chain drive is also possible (Source: Schreibmaschinenmuseum Beck, Pfäffikon ZH).

The following variant with four cylindrical machines is missing from the patent application:

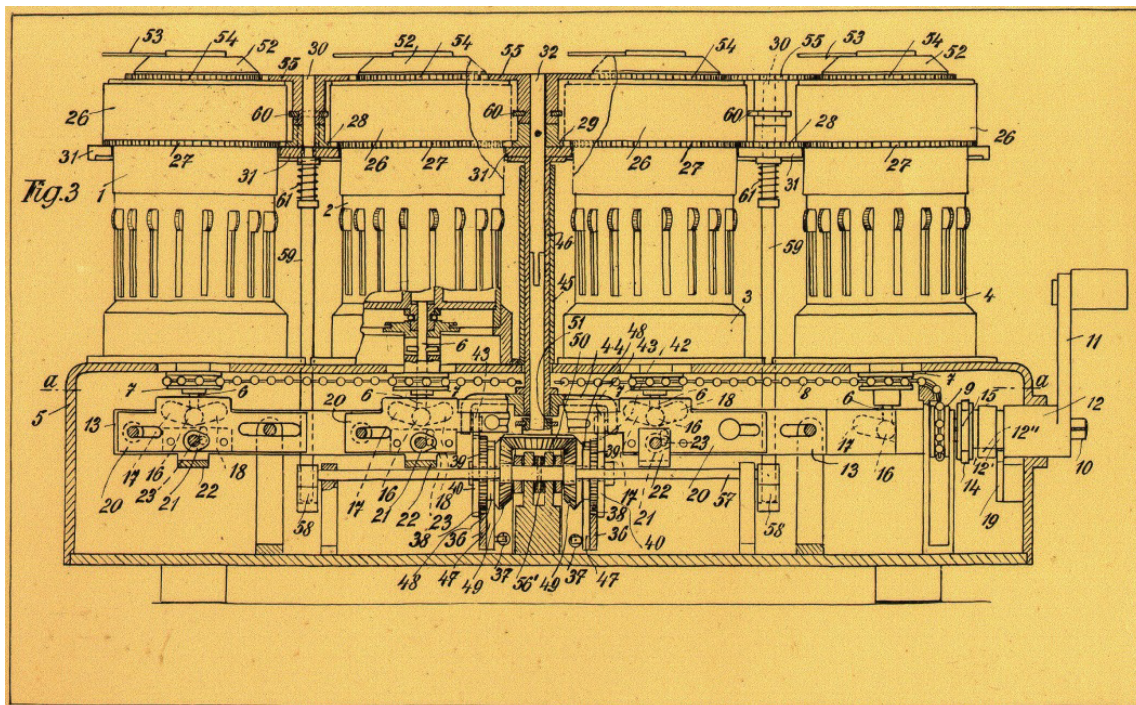


Figure 9. The Quadruple Curta. This original drawing shows four Curtas removably attached to a socket, which is equipped with coupling, drive and control elements. The joint drive crank is connected to the stepped drum shafts by a chain drive (Source: Schreibmaschinenmuseum Beck, Pfäffikon ZH).

Acceleration of the arithmetic operation

The high-precision Curta is capable of all four basic arithmetic operations. The coupling of several devices accelerates arithmetic operations considerably. For example, with a Quadruple Curta one enters the values (multiplicands) 137, 263, 389 and 491 and multiplies these by the number 7 (multiplier). The four multiplications are then performed simultaneously (in this case with seven rotations of the crank). One can simultaneously divide the numbers 623, 511, 301 and 259 (dividends) by 7 (divisor).

Possible applications were, for example, the simultaneous conversion of a price list to several currencies, the simultaneous calculation of piece prices for goods, or the simultaneous determination of the x and y coordinates in surveying.

Patent specifications for the multiple calculating machine

The following Austrian patents are known for the multiple calculating machine of Curt Herzstark:

Patent specification no. 195 147 of January 25th 1958 (basic patent):

Submitted: October 19th 1954

Granted: May 15th 1957.

Patent specification no. 205 775 of October 10th 1959 (additional patent):

Submitted: December 15th 1954

Granted: March 15th 1959.

The first application for a multiple calculating machine patent in Austria was already submitted on December 20th 1949. Efforts were also made to patent the device in America. Earlier Austrian patents for the customary Curta bear the numbers 747 073/192, 747 074/191, and 166 581, 163 380.

The British Twelve-fold Curta for matrix calculations

In the 1940s and 1950s the periodical *Mathematical Tables and other Aids to Computation*, founded in 1943, was the leading international journal for computer technology. Since 1960 it has the title *Mathematics of Computation*. In the issue of July 1954 (see Figure 10) A. Opler¹³ called attention to the Twelve-fold Curta in the section "Other aids to computation":

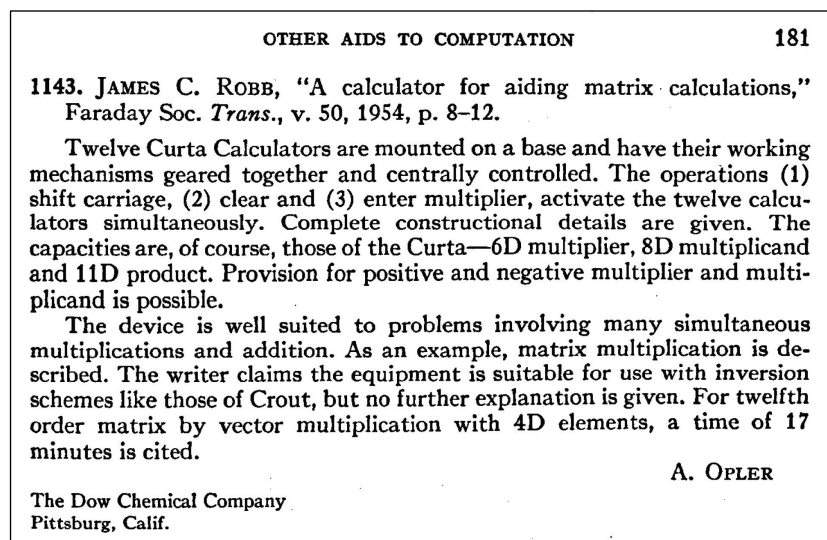


Figure 10. The mechanical parallel calculator. Review of the article of James Robb in the journal *Mathematical Tables and other Aids to Computation* (1954) (Credit: MTAC).

James Christie Robb (1924–1999)¹⁰, of the Chemistry Department of the University of Birmingham, had submitted an article¹⁴ about a Twelve-fold Curta to the *Transactions of the Faraday Society* (see Figure 11) that was received on July 20th 1953. The journal was published from 1905 to 1971.

Robb was active at the University of Birmingham from 1948. In 1956 he was appointed Professor for Physical Chemistry and in 1983 became the Head of the Department of Chemistry. The parallel calculator designed by Robb was built by S. Traver, with the support J. Harcourt.

The twelve Curtas (Model 1) are mounted in a circle on a Dural aluminum alloy octagonal base provided with two handles. Each cylindrical calculator has 8 places in the setting mechanism, 6 in the revolution counter, and 11 in the result mechanism. The base plate has three levers, (from left to right) one for shifting the carriage (6 different decimal places), one for resetting to zero, and one for multiplication. The lever at the left raises the carriage and rotates it to one of the six positions (ones, tens, hundreds, thousands, etc.). According to the description, there is in principle no limit to the number of Curtas that can be combined.

In this contribution the Curta and the Contina are mentioned, but not Curt Herzstark. The Liechtenstein Contina AG donated the twelve Curtas. The device simplified the solution of linear simultaneous equations. It served for the calculation of inverse matrices. One could multiply twelve arbitrary (1- to 8-place) values by the same (positive or negative) factor simultaneously.

The article refers to a patent application no. 10993/53 with the British patent office. However, whether a patent was granted is not known. There is no corresponding entry in the European patent database. Herzstark already submitted the first patent application for the multiple calculating machine to the Austrian patent office in Vienna on December 20th 1949, and in 1953 he had already left the manufacturer Contina.

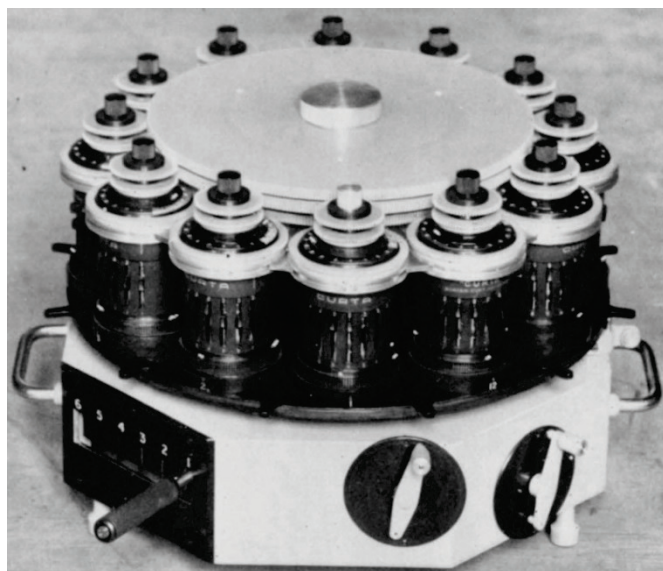


Figure 11. The Twelve-fold Curta. The world's smallest mechanical parallel calculator was built at the University of Birmingham in 1953 and comprises twelve Curtas (Model 1) (Credit: Royal Society of Chemistry, London).

Acknowledgments

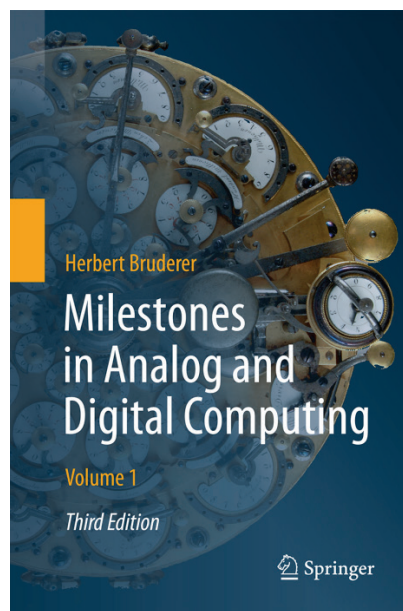
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