Wilhelm Schickard

Born April 22, 1592, Herrenberg, Wüttemberg, died October 23, 1635, Tübingen; created an adding machine preceding that of Pascal, and using logarithms of Napier, it could perform multiplication and division.

Wilhelm Schickard was professor of Hebrew, professor of Oriental languages, professor of mathematics, professor of astronomy, professor of geography, and, in his spare time, a Protestant minister in the German town of Tübingen during the early 1600s. He has been compared to Leonardo da Vinci in that both had far-ranging interests and inquiring minds. Besides being an excellent mathematician who developed some methods that were still in use well into the nineteenth century, he was a good painter, a good enough mechanic to construct his own astronomical instruments, and an engraver skilled enough to provide some of the copper plates used to illustrate Kepler's great work *Harmonices Mundi.*

It is known that Schickard and Kepler not only knew each other well but also collaborated on several occasions. It was one of these joint efforts that resulted in Schickard's producing the first really workable mechanical adding machine. Kepler and Schickard were both born in the same town; they shared an interest in mathematics and astronomy, and both had associations with Tübingen University. It was only natural that they saw each other whenever possible, and wrote back and forth discussing the problems each was attempting to solve. When Kepler's mother was accused of being a witch and thrown into jail, Kepler returned to Tübingen to help in her defense and, while there, was known to have associated with Schickard. Kepler and Schickard were known to have discussed John Napier's various inventions as early as 1617. During Kepler's stay in Tübingen he shared with Schickard some results he had obtained using Napier's "bones" and logarithms. This seems to have inspired Schickard to consider the design of a machine that would incorporate both a set of Napier's "bones" and a mechanism to add up the partial products they produced in order to completely automate the multiplication process. On September 20, 1623, Schickard wrote to Kepler saying (in translation):

> What you have done in a logistical way (i.e., by calculation), I have just tried to do by mechanics. I have constructed a machine consisting of eleven complete and six incomplete (actually "mutilated") sprocket wheels which can calculate. You would burst out laughing if you were present to see how it carries by itself from one column of tens to the next or borrows from them during subtraction.

Kepler must have written back asking for a copy of the machine for himself because, on February 25, 1624, Schickard again wrote to Kepler giving a careful description of the use of the machine, together with several drawings showing its construction. He also told Kepler that a second machine, which was being made for his use, had been accidentally destroyed when a fire leveled the house of a workman Schickard had hired to do the final construction.

These two letters, both of which were found in Kepler's papers, give evidence that Schickard actually constructed such a machine. However, the drawings of the machine had been lost and no one had the slightest idea of what the machine looked like or how it performed its arithmetic. Then some scholars who were attempting to put together a complete collection of Kepler's works were led to investigate the library of the Pulkovo Observatory near Leningrad. While searching through a copy of Kepler's *Rudolphine Tables,* they found a slip of paper which had seemingly been used as a bookmark. It was this slip of paper which contained Schickard's original drawings of the machine.

Little detail can be seen, but with the hints given in the letters it became possible to reconstruct the machine. The reconstruction was done by Professor Bruno Baron von Freytag Loringhoff, now retired from the post of professor of philosophy at the University of Tübingen. The baron was able to figure out the details of the machine because, among other things, he is an expert on the techniques used by seventeenth-century clockmakers. This reconstruction was featured on a stamp issued by West Germany in 1971 to honor the 350th year of its invention.

In the stamp illustration, the upper part of the machine is set to show the number 100722 being multiplied by 4. The result of this multiplication would be added to the accumulator, using the lower portion of the machine. The upper part is simply a set of Napier's "bones" (multiplication tables) drawn on cylinders in such a way that any particular "bone" may be selected by turning the small dials in Schickard's drawing. Moving the horizontal slides would expose different sections of the "bones" to show any single-digit multiple of the selected number; the fourth multiple is shown exposed in the stamp illustration. The very bottom of the machine contains a simple *aide-memoire.* By turning the small knobs it was possible to make any number appear through the little windows, eliminating the need to have pen, ink, and paper handy to note down any intermediate results in the computation.

The mechanism used to effect a carry from one digit to the next was very simple and reliable in operation. Every time an accumulator wheel rotated through a complete turn, a single tooth would catch in an intermediate wheel and cause the next highest digit in the accumulator to be increased by one. This simple-looking device actually presents a host of problems to anyone attempting to construct an adding machine based on this principle. The major problem is caused by the fact that the single tooth must enter into the teeth of the intermediate wheel, rotate it 36 degrees (one tenth of a revolution), and exit from the teeth, all while only rotating 36 degrees itself. The most elementary solution to this problem consists of the intermediate wheel being, in effect, two different gears, one with long and one with short teeth, together with a spring-loaded detente (much like the pointer used on the big wheel of the gambling game generally known as crown and anchor) which would allow the gears to stop only in specific locations. It is not known if Schickard used this exact mechanism, but it certainly works well on the reproductions constructed by von Freytag Loringhoff.

The major drawback of this type of carry mechanism is the fact that the force used to effect the carry must come from the single tooth meshing with the teeth of the intermediate wheel. If the user ever wished to do the addition 999,999 + 1, it would result in a carry being propagated right through each digit of the accumulator. This operation would require enough force that it might well do damage to the gears on the units digit. It appears that Schickard was aware of this weakness, because he constructed machines with only six-digit accumulators even though he knew that Kepler undoubtedly needed more figures in his astronomical work. If the numbers became larger than six digits, he provided a set of brass rings that could be slipped over the fingers of the operator's hand in order to remember how many times a carry had been propagated off the end of the accumulator. A small bell was rung each time such an "overflow" occurred to remind the operator to slip another ring on his finger.

Although we know that the machine being made for Kepler was destroyed in a fire, there is some mystery as to what happened to Schickard's own copy of the device. No trace of it can be found in European museums. It may well turn up one day in some dusty forgotten corner of an old building, but the more likely situation is that it has simply been lost. This is particularly likely in that Schickard and all his family died during one of the great

plagues that swept Europe. As he left no living heirs, the machine was probably taken by someone who could not understand its workings and found its last use as firewood in some family kitchen. [1]

BIBLIOGRAPHY

Biographical

Möhring, Manfred, "Wilhelm Schickard: Erfinder der Ersten Mechanischen Rechenmaschine (1623), " J *Wissenschaft und Fortschritt,* GDR Academy of Sciences, Vol. 38, No. 10, 1988.

Williams, Michael R., "From Napier to Lucas: The Use of Napier's Bones in Calculating Instruments," *Ann. Hist. Comp.,* Vol. 5, No. 3, July 1983, pp. 279-296.

Williams, Michael R., *A History of Computing Technology,* Prentice-Hall, Englewood Cliffs, NJ., 1985, pp. 123-128.

UPDATES

Portrait added (MRW, 2013).

Spelling of "Schickard" corrected from the original (MRW, 2013)

---

[1] Reproduced with permission from Williams 1985.