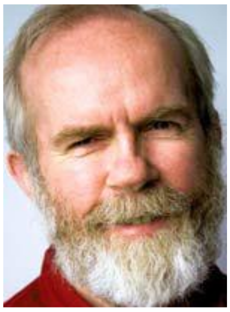
Discovering the Millionaire

Dirk Rietveld



Introduction

I will take you on an adventurous journey, at least for anyone interested in mechanical calculators. It is my own journey in finding out more and more about millionaires, not the human ones, but the calculators. Although, if you want to own one, it helps if you are a millionaire.

I am used to the fact that when I want to multiply numbers on a mechanical calculator, it is by repeated additions. That is, until I began to find out about the Millionaire. The Millionaire is not the first machine that does direct multiplication, but it is the first that became a commercial success.

Meeting the Millionaire

The first time I saw a Millionaire, I could only see the controls, as you can see on this photo (Fig. 1). It shows a basic Millionaire, with the standard controls in neutral positions.

In the centre, you may set the number to be multiplied. In this case up to eight digits. Millionaires with six, ten or twelve digits have also been made, not unlike the human millionaires. Just a bit to the right you'll find a lever to be set to Addition, Multiplication, Division or Subtraction, the four functions this machine can perform.

Again to the right, you see a crank, the actual driving mechanism of the Millionaire. Back to the left of the machine, you see a lever that may be set to a number from zero to nine. This lever lets you form the multiplier, one digit at a time.

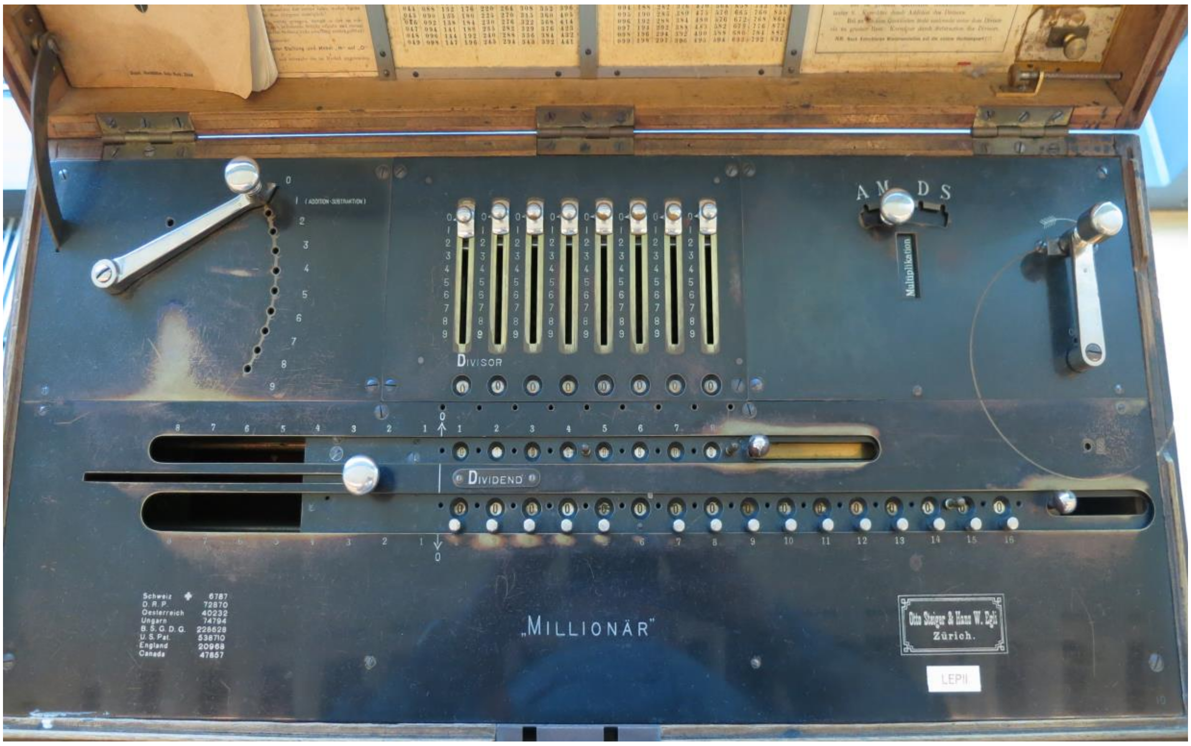


Figure 1. Basic Millionaire at the Arithmeum, Bonn

Finding a Millionaire for discovery

If I had turned to the internet after I met my first Millionaire, my adventure would not have been nearly as wondrous as it has been, and I'm happy I didn't. Instead, I went a lot further than the internet, all the way to Bonn in Germany.

In Bonn, not far from the railway station, there is a unique museum, dedicated to the art of calculating. This museum, the Arithmeum, is part of Bonn University, and houses a collection, ranging from ancient and far away ways of depicting numbers and doing calculations, to the modern day computer. Yet, the main part of the collection is a huge number of mechanical calculators, which, to my knowledge, must be the largest and most complete collection to be found anywhere. At least, for a collection in a museum that can be seen and for a part also touched.

This collection houses several Millionaires of various types, with three on display and the others stored in the very full depots.

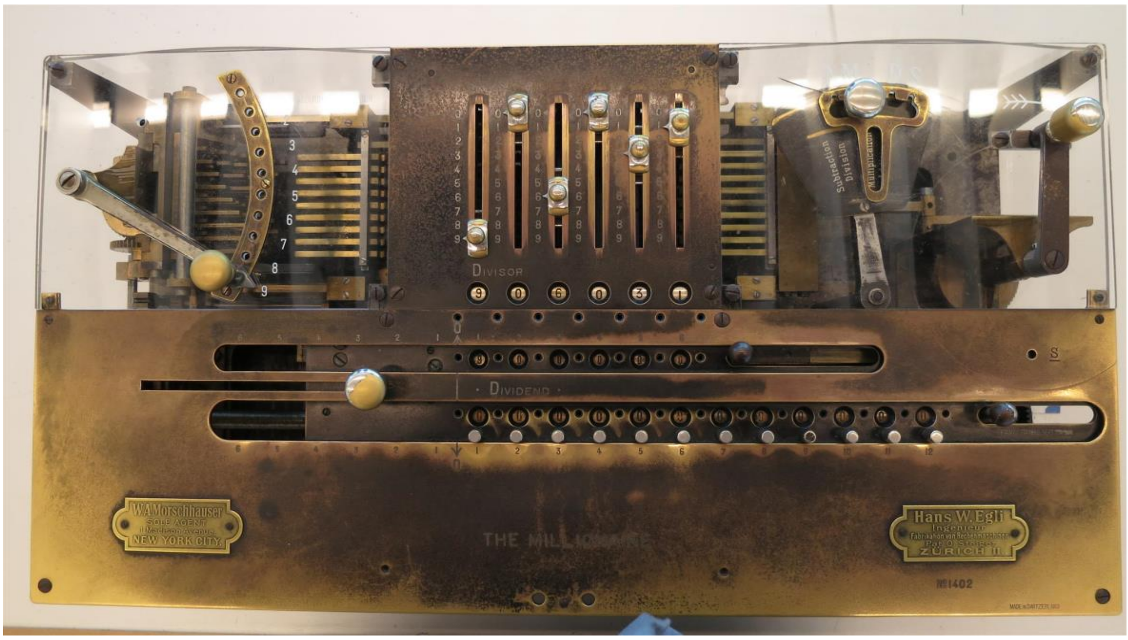


Figure 2. See-through and hands-on Millionaire at the Arithmeum, Bonn

One of the Millionaires has been made transparent by exchanging several metal plates with perspex ones (Fig. 2). It is this Millionaire that I have visited five times in the past twelve months, and which has given me insight into its inner workings. It also gave me the opportunity to make the photos for my story.

From miracle to reality

Let's go back to my first moment of amazement with a Millionaire. Mind you, this was not a see-through machine. Once I got the hang of multiplying on it, I had absolutely no clue as to what mechanism could do what I saw happening. It really seems to do a direct multiplication, one digit at a time for every turn of the driving crank. When you don't know what is happening inside, it feels like seeing a miracle.

The first time I went to Bonn, it had to do with the exposition of the Schuitema collection of slide rules. Yet, I soon found the see-through Millionaire and started to try it out. At first, that was no success, but after I opened the manual, all four functions were more or less quickly mastered. But still I had no idea of the way it operated.

Then I saw this strange piece of metal next to the Millionaire (Fig. 3). In the description I found that it is called an ein-mal-eins. In English that would be a one-times-one. And that is the first line in the tables of multiplication as all of us have most probably learnt in elementary school. On the ein-mal-eins you see the tables from one on the left to nine on the right, and the number of times from one at the bottom up to nine at the top. The tables are made up of two vertical rows, the left one with the units, and the right one with the tens. For instance, on the left side, the table of one has only units, in a neatly ascending order from one to nine. The next one, the table of two, on the left you see two, four, six, eight, zero, two, four, six and eight. On the right you see four times zero and five times one. Together they make 2, 4, 6, 8, 10, 12, etcetera. On the far right, the table of nine, the left row neatly descending from nine to one, and the right one, ascending from zero to eight.

To me, after understanding just this, most of the mystery was now gone from the Millionaire. Of course, some things still have to be done, but with those tables firmly implanted in the machine, as a read-only-memory, it seems clear that direct multiplication is now a possibility.

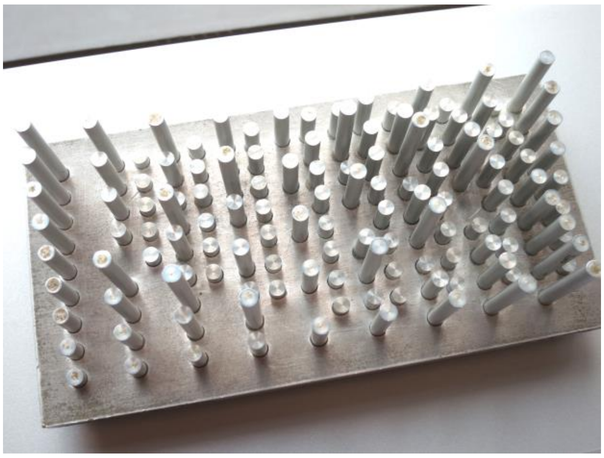


Figure 3. Modell of an ein-mal-eins

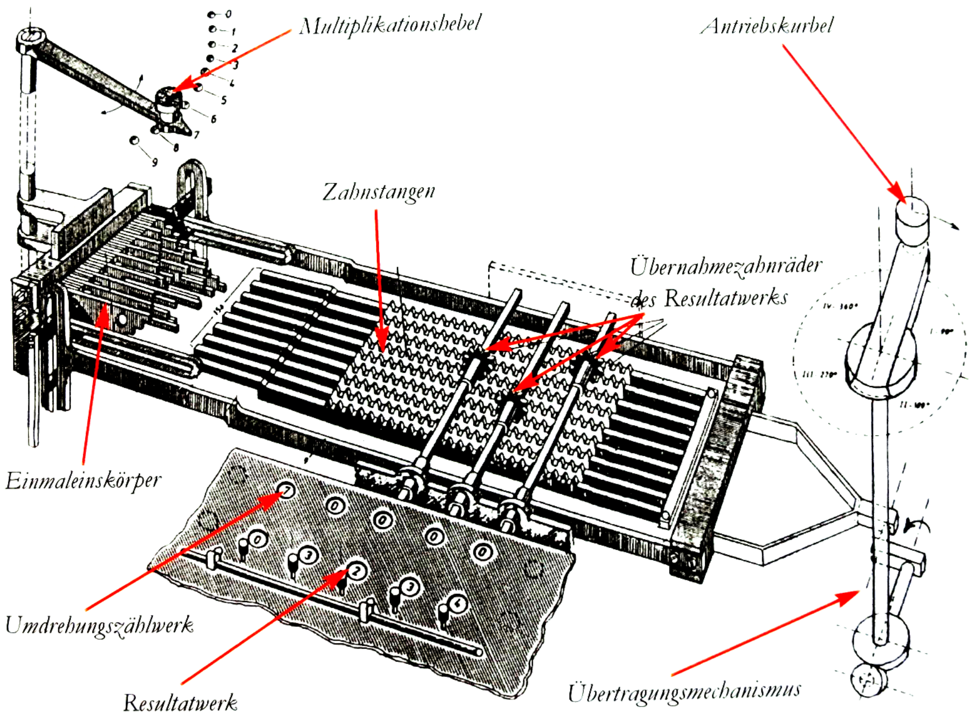


Figure 4. Schematic inside of a Millionaire

A quick look at the mechanics

In this diagram (Fig. 4), copyright the Arithmeum, Uni/Bonn, the basics of the inner workings are depicted. When you move the left lever from zero to nine, the ein-mal-eins moves from down to up, aligning the line of corresponding steps in the tables with the line of toothed rods that by moving will turn the perpendicular axles that drive the result counter. And by setting the numbers of the multiplicand, you choose the rod that will be used for that number.

By now it could be clear that this machine is not really multiplying, but is doing additions based on the tables of multiplication, much like we all have learnt to do in school. I was a bit disappointed when I thought of this, it does take away some of the magic. There is also a difference with the way we have learnt to do multiplications in school. The Millionaire works the multiplier from left to right instead of from right to left. I think this is to avoid having to change the direction of the automatic movement of the carriage when switching between multiplication and division.

Figure 5. Setting a digit of the multiplicand

Digging deeper

Now, let us look closer at the inner workings of this machine. A proper starting point is to set all levers and counters to zero, move the carriage all the way to the right, and set the machine to multiplication. Also have the driving crank in the neutral position, which is pointing upwards. Use the sliders from left to right to set the number to be multiplied. On this photo (Fig. 5) you see what is happening inside.

Moving one of the sliders moves a cogwheel across a square axle, and aligns it with the desired step in the tables of multiplication. This leads to the correct number being added to the counter in the carriage when the rods are moved by the ein-mal-eins.

With the left crank we set the first digit of the multiplier. When you do this, the ein-mal-eins moves up so that the proper line in the tables aligns with the rods, as you can see here (Fig. 6). In this photo, taken from the back of the machine, the ein-mal-eins is in position seven.

Figure 6. The ein-mal-eins in position for the table of seven

Multiplication in four quarter turns

First we set the machine for the multiplication 906031 times 9 (look back at Fig. 2). Now we can rotate the crank to see the multiplication with the chosen number. We will stop between the four distinct parts of the turn, where different things happen.

In the first quarter of the turn (Fig. 7 above), the ein-mal-eins is moved a bit to the side, as to align the tens of the tables with the rods. Then the ein-mal-eins moves forward and pushes the toothed rods away. The toothed rods turn the cogwheels and the square axels, thus counting the tens into the result counter on the carriage, leaving the number 805020.

In the second quarter turn (Fig. 8 above), the ein-mal-eins is pulled back, the rods are pushed back, the carries are performed (none in this case), and the carriage is moved one step to the left, ready to receive the units.

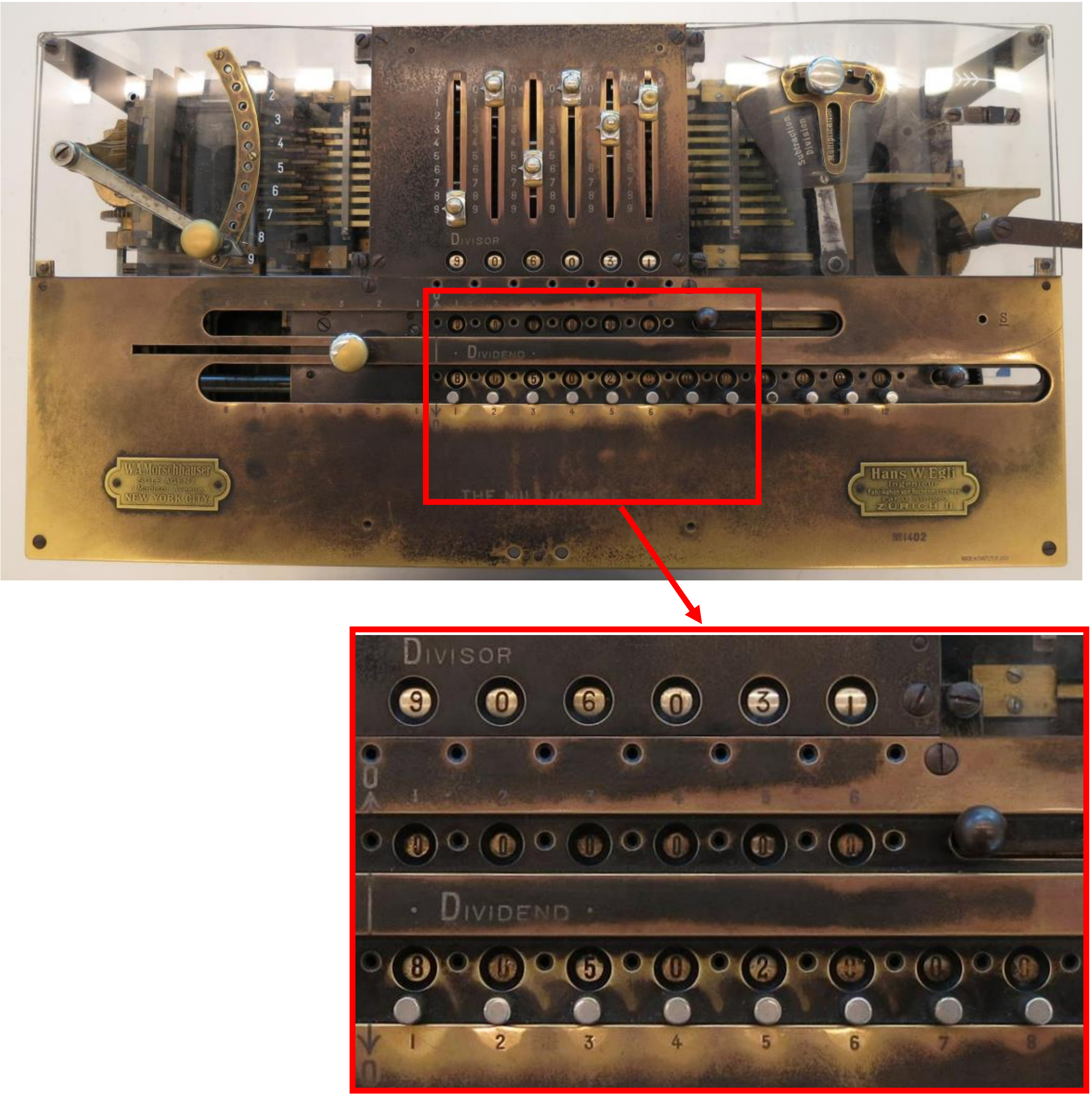


Figure 7. After the first quarter turn of the crank

During the third quarter turn (Fig. 9), the ein-mal-eins is moved a bit to the other side, to allow the units to do the work. With the same sequence the units are brought to the counters, which, as you remember, had moved one step to the left, and the units are counted into the result one position to the right of where the tens were counted, leaving 8154279 in the counter. At the same time, the multiplier 9 is counted into the multiplier counter, just above the result counter.

The last quarter turn (Fig. 10) moves the ein-mal-eins and the rods back, and performs the carries, resulting in the completion of the multiplication with the first digit. Of course, in our simple example there are no carries to be performed.

After the last quarter turn the machine is ready for the next digit of the multiplier. This shows that multiplying with the Millionaire is very quick, alternating between setting the digit and turning the crank. If the next digit is the same, turning the crank a second time is all that has to be done. For example, 99 times 99 only requires setting the lever to 9 and turning the crank twice.

Addition and Subtraction

Now that we have seen how the multiplication is performed by the machine, the addition is a no-brainer. The moving mechanism of the carriage is now disconnected, and you have to set the multiplier lever to one. So, addition is now a multiplication by one, and the result is added into the total counter. Subtraction is just as simple, with the counters working in reverse.

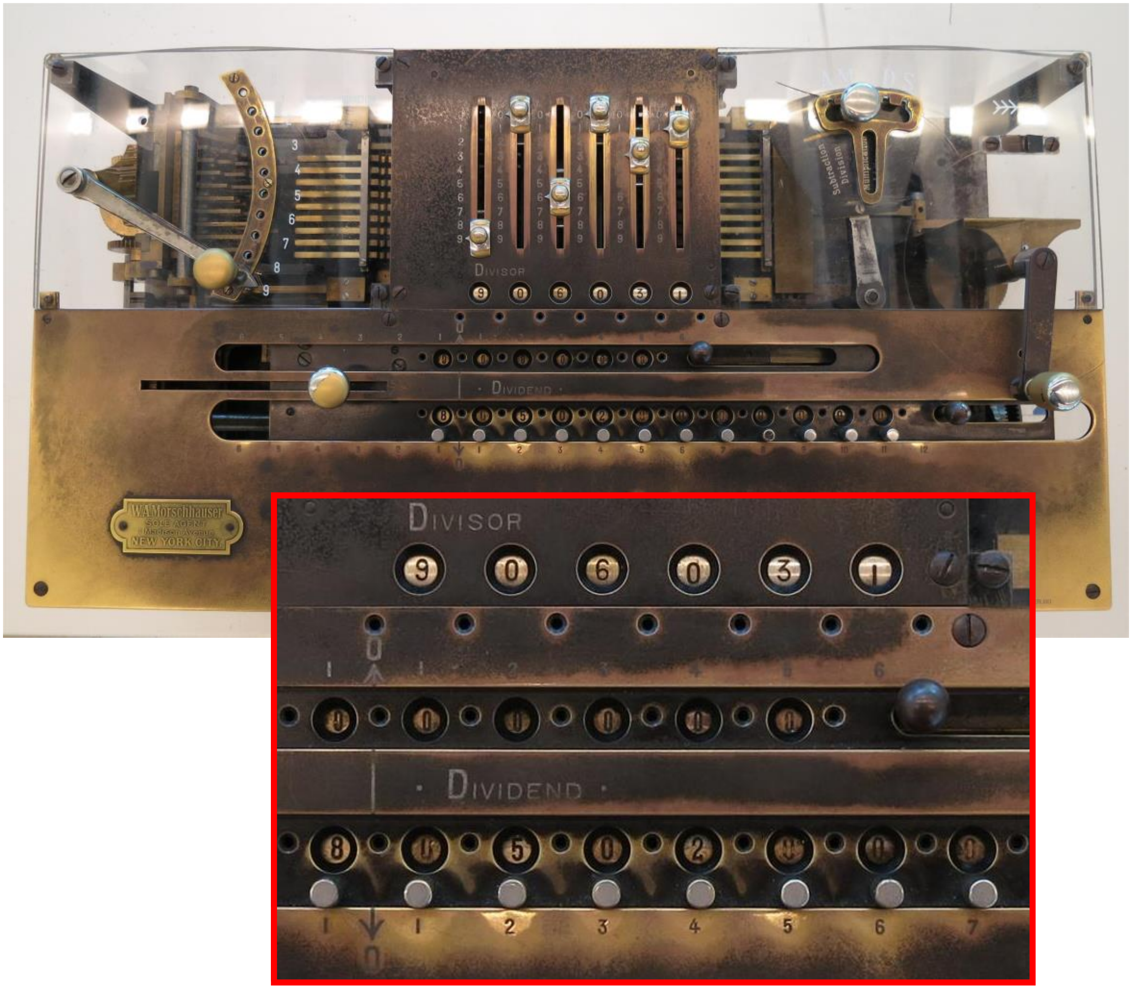


Figure 8. After the second quarter turn

Division needs a lot of thinking

The last function, division, is not as simple. Essentially it is quite the same as how we learnt to divide in elementary school. First you set the divisor using the sliders, then set the number to be divided into the total counter, using the small turning knobs.

Take care that you start with a zero if the divisor fits at least one time in the first part of the number to be divided. Reason for this is that subtraction starts at the second position of the total counter. Alternatively, you may always start with a zero in setting the number to be divided, at a possible loss of one digit in the precision of the result. Now you have to estimate the number of times, from zero to nine, the divisor fits into the first part of the number to be divided, set that number with the multiplier lever, and turn the crank. Proceed with estimating the next number and continue until the carriage has reached its final position, announced by the sound of a bell. The result of the division is now visible in the upper counter on the carriage.

This procedure may seem fairly simple, but if you make a mistake with the first position zero, or in estimating the number of times the divisor will fit, then you are in a bit of trouble. Correcting your mistake is not complicated, but you have to stick to the manual, or you will get lost.

To help in estimating the number of times the divisor fits, a table on paper (Fig. 11) is delivered with the Millionaire, on the inside of the top cover.

Essentially, this table shows the tables of multiplication from 1 to 99. Yet, when in doubt, the use of a slide rule might be the answer.

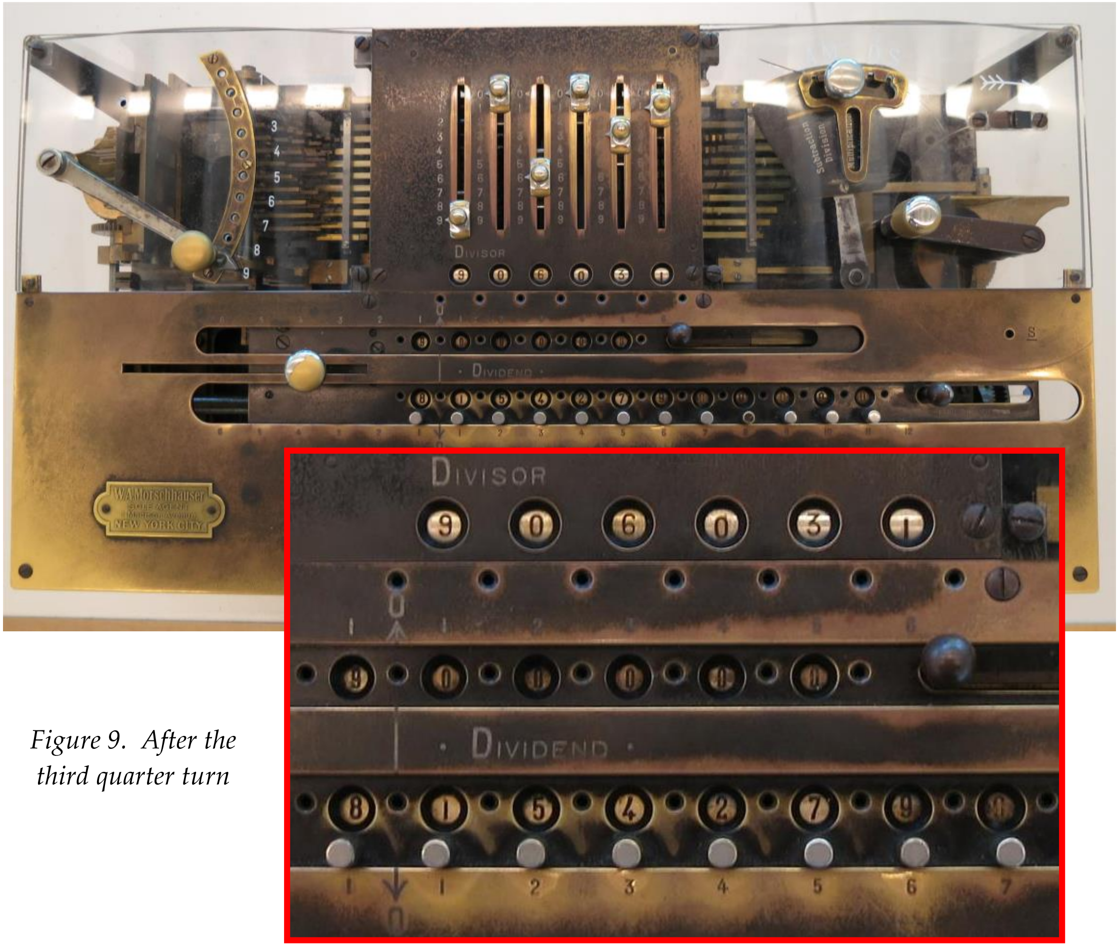


Figure 9. After the third quarter turn

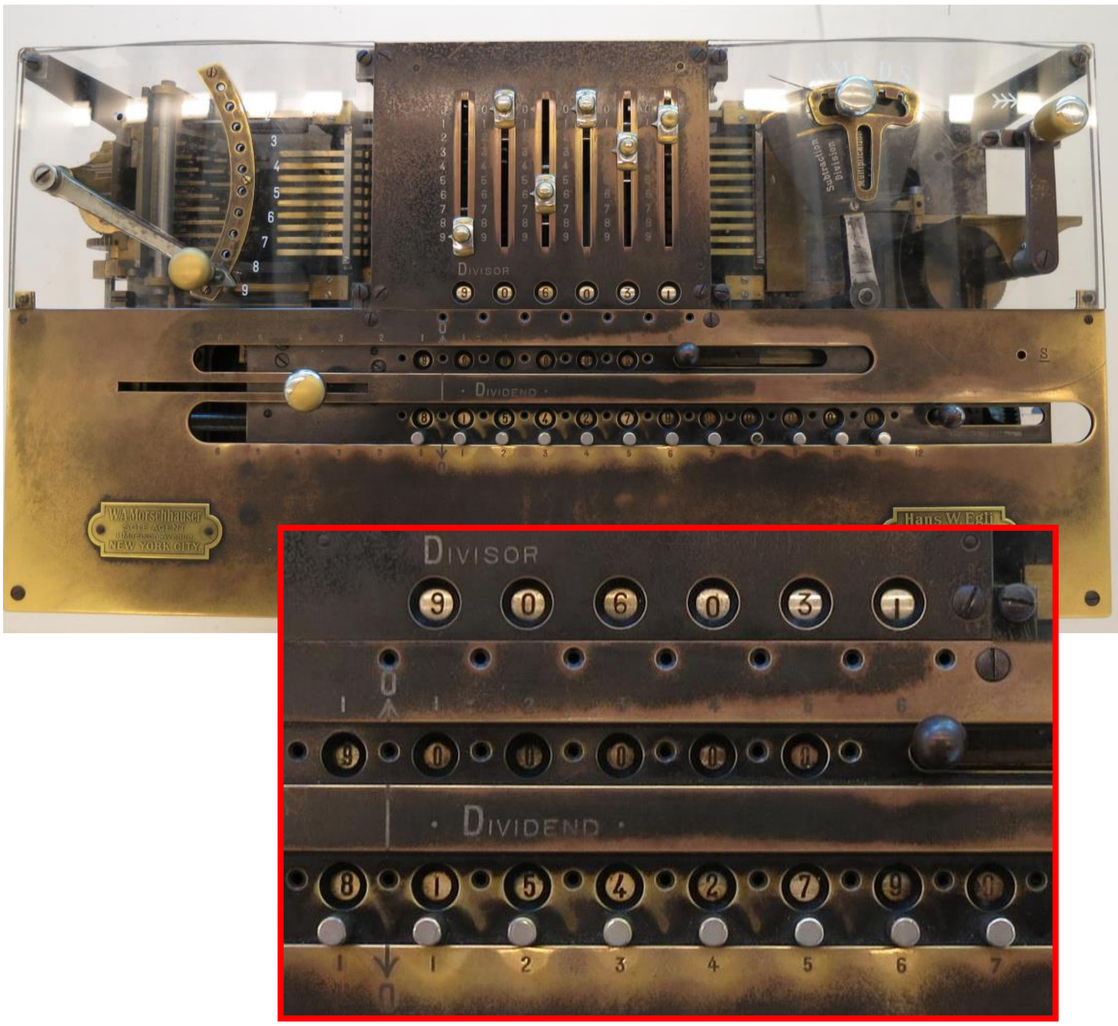


Figure 10. After the last quarter turn

The carry mechanism

As Millionaires have total counters ranging from twelve to twenty digits, a carry that goes all the way, may lead to a very heavy job. To avoid this, the Millionaires perform the carries separate from the counting.

To get this done, another complicated mechanism was designed. The logic behind this is as follows. During addition, when a digit reaches the zero from nine, a carry needs to be prepared. During subtraction, reaching nine from zero, also a carry needs to be set aside.

The mechanics of these actions may be seen from the front of the machine (Fig. 12). Under the total counter, a cylinder is connected to the carriage. Above this cylinder, small pointed rods are pointing downwards. When a carry is needed, the pointed rod is pushed in the direction of the next digit. This may also happen when a carry gets needed by a carry that is performed just before it.

During the second and fourth quarter turns, the carries are performed by small objects on the upwards turning cylinder that interact with the downwards pointing rods. To let the carries follow each other from right to left, the objects on the cylinder to the left of the previous one are placed a little bit downwards from the previous one. Just after performing the carries, the rods are pushed back to their original position by another set of small objects (see fig. 13).

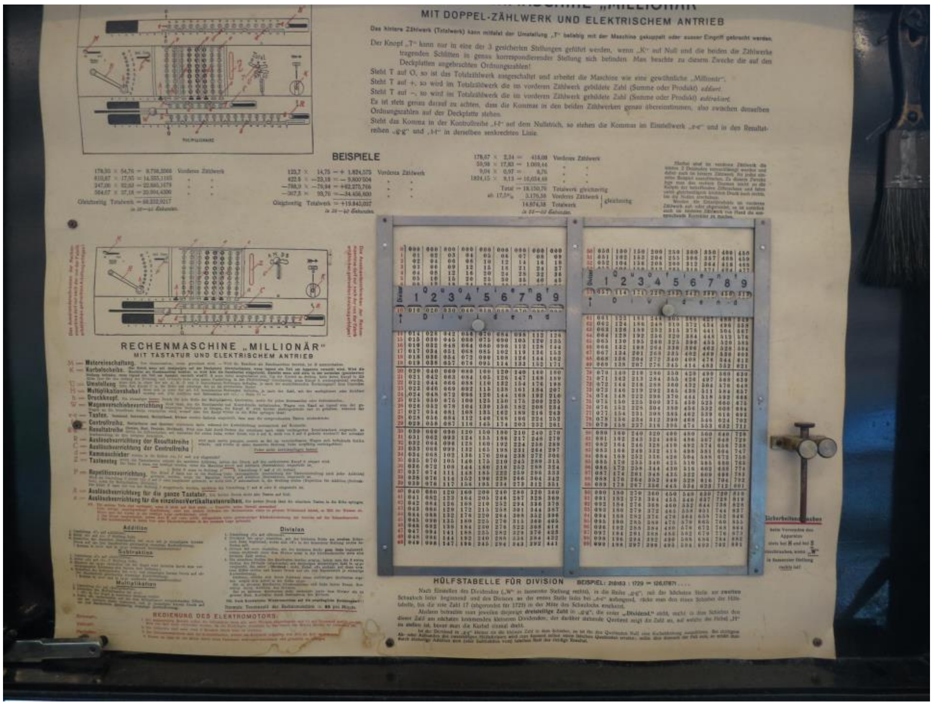


Figure 11. Paper table with the tables of multiplication from 1 to 99

Figure 12. Cylinder with objects for performing carries

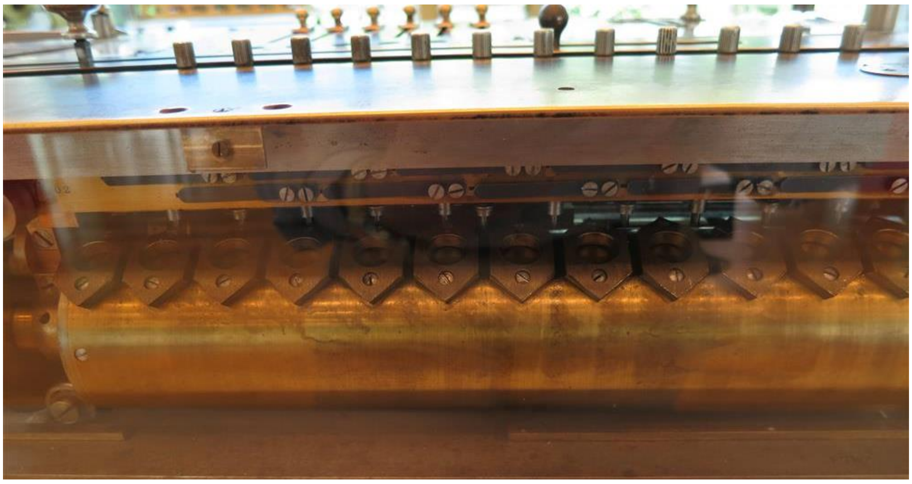


Figure 13. Cylinder with objects for resetting rods

Variations in Millionaires

The Millionaire was patented by engineer Otto Steiger in 1892/1893. Production started in 1899 by the firm of Hans Egli in Zurich, Switzerland. The last one of the 4655 Millionaires that were produced, was sold in 1935.

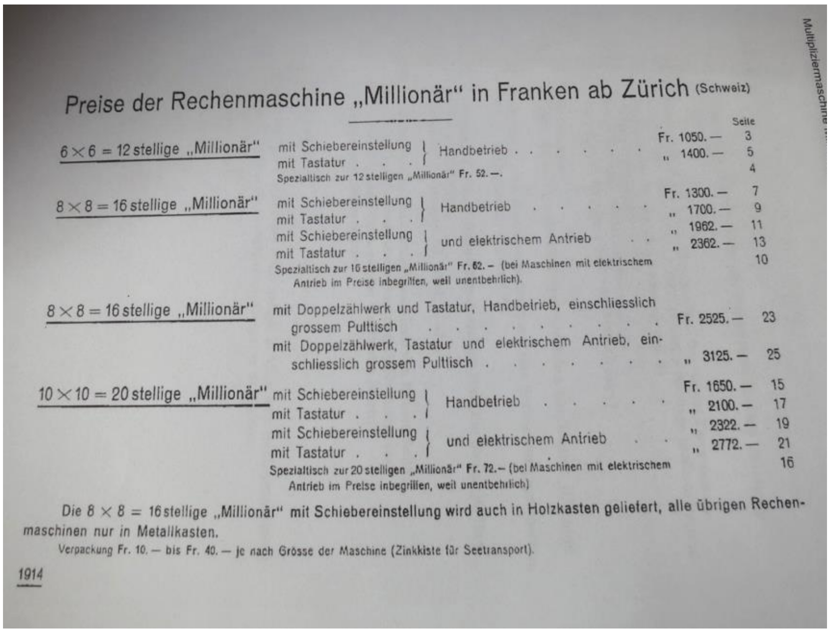
Some Millionaires had six by six by twelve digits, most had eight by eight by sixteen digits, some had ten by ten by twenty digits, and some had twelve by eight by twenty digits.

Figure 14. Motorized Millionaire with keyboard, constant mechanism and second total counter, on a custom made table

At some point in time the sliders could be replaced by a keyboard.
On the keyboard version an extra mechanism could be added for setting one of two constant values by pushing it down onto the keys.

The driving mechanism could be motorized. In that case the starter knob was on the left lever, so setting the multiplier lever and starting the mechanism was a one-handed operation.

Some Millionaires have been made with a second total counter above the setting mechanism. This counter could be switched between idle, adding and subtracting. This made it possible to get a grand total of a number of multiplications, or to subtract a percentage at the end of a calculation.



Preise der Rechenmaschine „Millionär" in Franken ab Zürich (Schweiz)

			Seite
6 × 6 = 12 stellige „Millionär"	mit Schiebereinstellung / Handbetrieb	Fr. 1050.—	3
	mit Tastatur / Handbetrieb	„ 1400.—	5
	Spezialtisch zur 12 stelligen „Millionär" Fr. 52.—.		4
8 × 8 = 16 stellige „Millionär"	mit Schiebereinstellung / Handbetrieb	Fr. 1300.—	7
	mit Tastatur / Handbetrieb	„ 1700.—	9
	mit Schiebereinstellung / und elektrischem Antrieb	„ 1962.—	11
	mit Tastatur / und elektrischem Antrieb	„ 2362.—	13
	Spezialtisch zur 16 stelligen „Millionär" Fr. 62.— (bei Maschinen mit elektrischem Antrieb im Preise inbegriffen, weil unentbehrlich).		10
8 × 8 = 16 stellige „Millionär"	mit Doppelzählwerk und Tastatur, Handbetrieb, einschliesslich grossem Pulttisch	Fr. 2525.—	23
	mit Doppelzählwerk, Tastatur und elektrischem Antrieb, einschliesslich grossem Pulttisch	„ 3125.—	25
10 × 10 = 20 stellige „Millionär"	mit Schiebereinstellung / Handbetrieb	Fr. 1650.—	15
	mit Tastatur / Handbetrieb	„ 2100.—	17
	mit Schiebereinstellung / und elektrischem Antrieb	„ 2322.—	19
	mit Tastatur / und elektrischem Antrieb	„ 2772.—	21
	Spezialtisch zur 20 stelligen „Millionär" Fr. 72.— (bei Maschinen mit elektrischem Antrieb im Preise inbegriffen, weil unentbehrlich)		16

Die 8 × 8 = 16 stellige „Millionär" mit Schiebereinstellung wird auch in Holzkasten geliefert, alle übrigen Rechenmaschinen nur in Metallkasten.

Verpackung Fr. 10.— bis Fr. 40.— je nach Grösse der Maschine (Zinkkiste für Seetransport).

1914

Multipliziermaschine ...

Figure 15. Millionaire variations and prices from a 1914 catalogue

All these extras put together make for an impressive Millionaire (Fig. 14, on display at the Arithmeum, Bonn). From 1927, also the left lever could be replaced by a keyboard. As the Millionaires are quite large and heavy, the more so with extras, custom tables were made for Millionaires. And in tune with the customs of the period, the tables were made in different heights, for use by both sitting and standing operators.

The next item I will show is a page from a 1914 catalogue which gives an idea of the variations and pricing (Fig. 15).

Preventing mechanical disasters

As with any mechanical device, moving any sliders or levers when the driving crank is partly rotated, will probably result in a disaster of having a machine that is very stuck. Luckily, preventing this type of disaster has played a major part in the design of the Millionaire. Many parts, and a lot of extra weight, have been added to block the movement of any other slide or lever as soon as the crank has moved from its neutral position. No doubt, this fact has had a major positive influence on the commercial success of the Millionaire calculator.

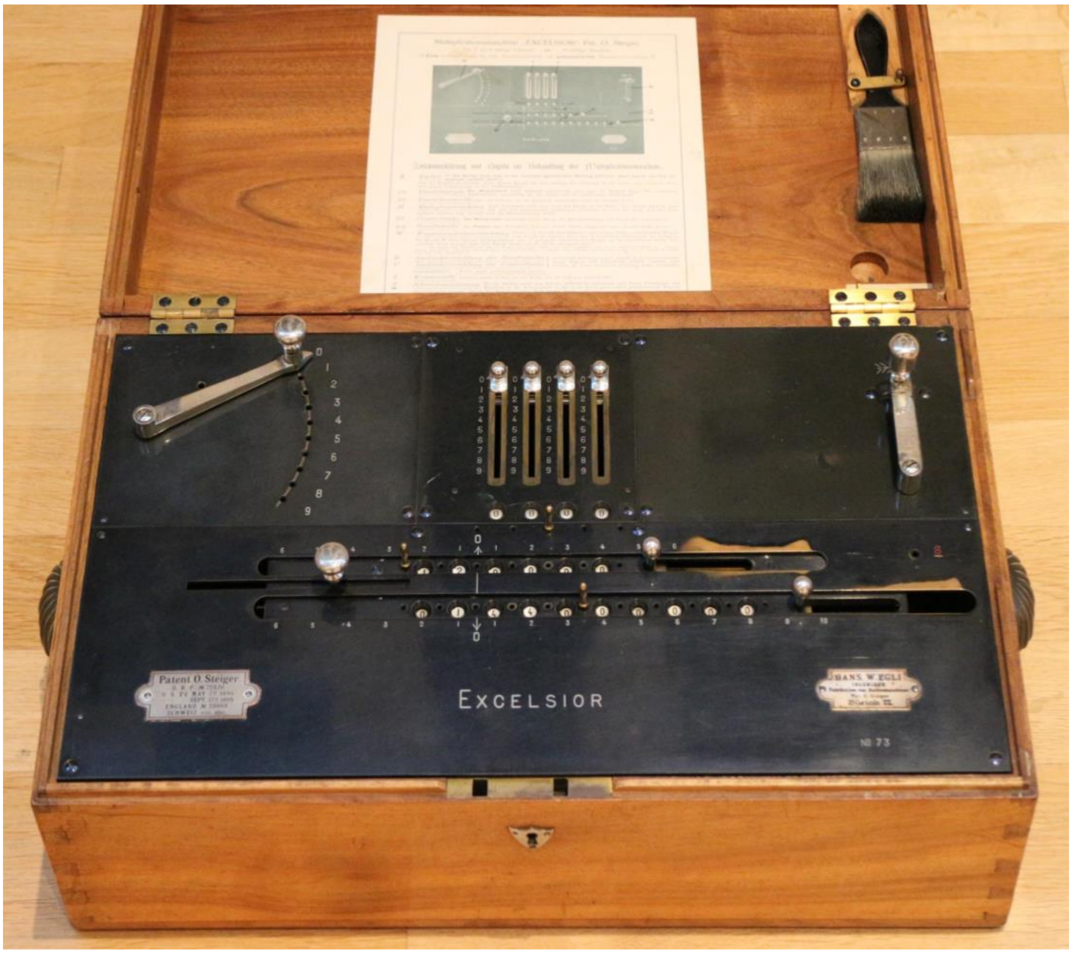
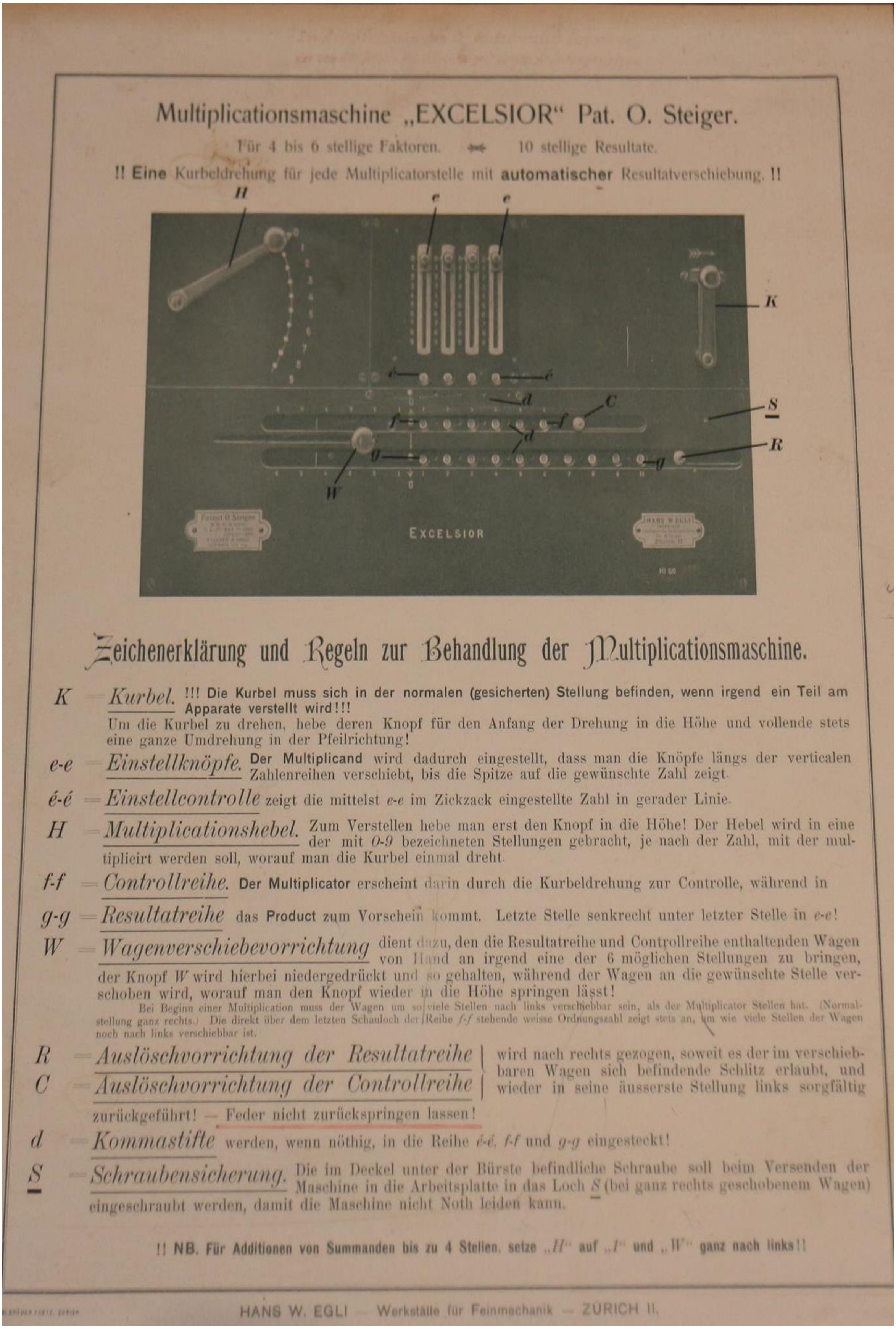


Figure 16. Simplified Millionaire, the Excelsior

Some odd Millionaires

As may be expected from building a complicated machine like a Millionaire, getting from a first design and patent to a properly functioning machine is not an easy step. It required the building of prototypes, followed by changes in the design and patents, to get to a point where the real production of the Millionaire could be started up. The same goes for changes like the addition of a keyboard. At least three prototypes still exist and are to be found in the Arithmeum in Bonn, although not on permanent display.

A simplified Millionaire was built that can only multiply and has four by six by ten digits. It was meant to be a cheaper version and got the name Excelsior (fig. 16). Only one is known to have been built, and is in the possession of the Arithmeum in Bonn. The inside of the cover of the Excelsior shows a simplified manual (Fig. 17, next page).



Multiplicationsmaschine „EXCELSIOR“ Pat. O. Steiger.

Für 4 bis 6 stellige Faktoren. 10 stellige Resultate.

!! Eine Kurbeldrehung für jede Multiplicatorstelle mit automatischer Resultatverschiebung. !!

Zeichenerklärung und Regeln zur Behandlung der Multiplicationsmaschine.

K = *Kurbel.* !!! Die Kurbel muss sich in der normalen (gesicherten) Stellung befinden, wenn irgend ein Teil am Apparate verstellt wird!!!
Um die Kurbel zu drehen, hebe deren Knopf für den Anfang der Drehung in die Höhe und vollende stets eine ganze Umdrehung in der Pfeilrichtung!

e-e = *Einstellknöpfe.* Der Multiplicand wird dadurch eingestellt, dass man die Knöpfe längs der verticalen Zahlenreihen verschiebt, bis die Spitze auf die gewünschte Zahl zeigt.

é-é = *Einstellcontrolle* zeigt die mittelst *e-e* im Zickzack eingestellte Zahl in gerader Linie.

H = *Multiplicationshebel.* Zum Verstellen hebe man erst den Knopf in die Höhe! Der Hebel wird in eine der mit *0-9* bezeichneten Stellungen gebracht, je nach der Zahl, mit der multiplicirt werden soll, worauf man die Kurbel einmal dreht.

f-f = *Controllreihe.* Der Multiplicator erscheint darin durch die Kurbeldrehung zur Controlle, während in

g-g = *Resultatreihe* das Product zum Vorschein kommt. Letzte Stelle senkrecht unter letzter Stelle in *e-e*!

W = *Wagenverschiebevorrichtung* dient dazu, den die Resultatreihe und Controllreihe enthaltenden Wagen von Hand an irgend eine der 6 möglichen Stellungen zu bringen, der Knopf *W* wird hierbei niedergedrückt und so gehalten, während der Wagen an die gewünschte Stelle verschoben wird, worauf man den Knopf wieder in die Höhe springen lässt!
Bei Beginn einer Multiplication muss der Wagen um so viele Stellen nach links verschiebbar sein, als der Multiplicator Stellen hat. (Normalstellung ganz rechts.) Die direkt über dem letzten Schauloch der Reihe *f-f* stehende weisse Ordnungszahl zeigt stets an, um wie viele Stellen der Wagen noch nach links verschiebbar ist.

R = *Auslöschvorrichtung der Resultatreihe*
C = *Auslöschvorrichtung der Controllreihe*
wird nach rechts gezogen, soweit es der im verschiebbaren Wagen sich befindende Schlitz erlaubt, und wieder in seine äusserste Stellung links sorgfältig zurückgeführt! — Feder nicht zurückspringen lassen!

d = *Kommastifte* werden, wenn nöthig, in die Reihe *é-é*, *f-f* und *g-g* eingesteckt!

S = *Schraubensicherung.* Die im Deckel unter der Bürste befindliche Schraube soll beim Versenden der Maschine in die Arbeitsplatte in das Loch *S* (bei ganz rechts geschobenem Wagen) eingeschraubt werden, damit die Maschine nicht Noth leiden kann.

!! NB. Für Additionen von Summanden bis zu 4 Stellen, setze „*H*“ auf „*1*“ und „*W*“ ganz nach links!!

HANS W. EGLI — Werkstätte für Feinmechanik — ZÜRICH II.

Figure 17. Simplified manual of the Excelsior

The Deutches Museum in München has a demonstration model with an open and simplified mechanism that has two by two by four digits. It can perform only two functions, multiplication and division (Fig 18).

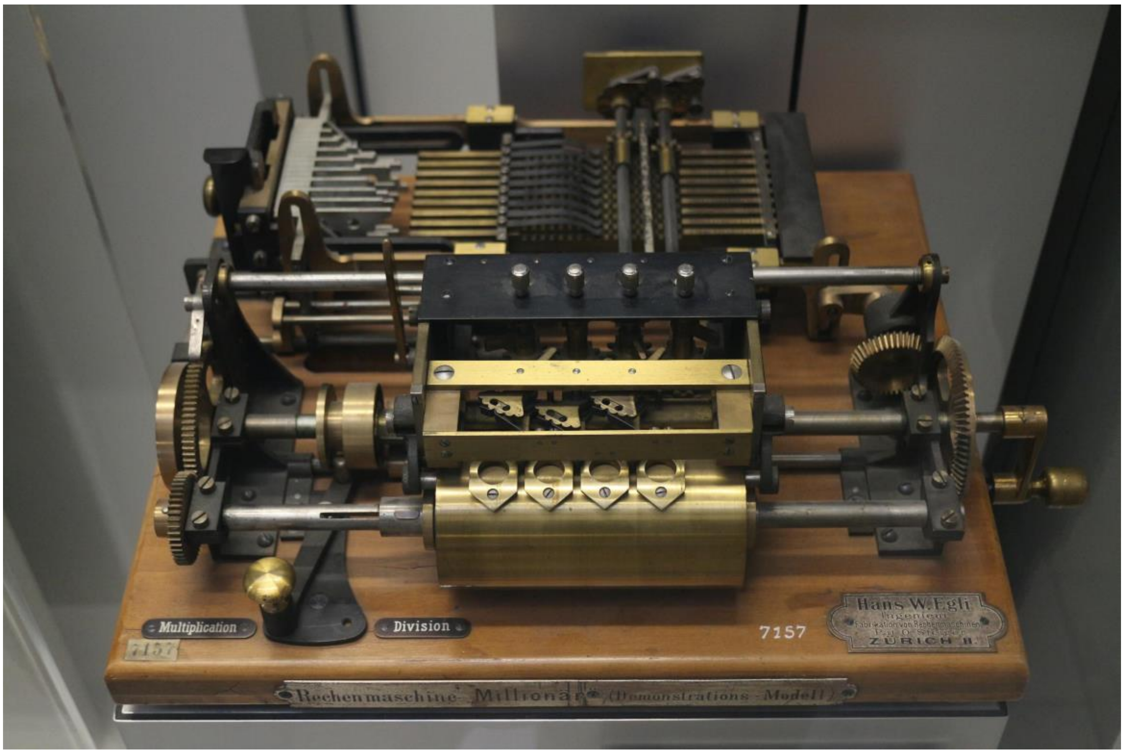


Figure 18. Demonstration model of the Millionaire

Just a few years ago, two brave men with special skills have built a fully working replica (or maybe even a first version) of a Millionaire from an early patent. In this case the ein-mal-eins is not rectangular but has the form of a cylinder and is turned to get to the desired multiplication table.

Where to find more (about) Millionaires

If you want to get hands on with a Millionaire, one way is to travel to Bonn in Germany and visit the Arithmeum. Yet there is a way closer to home, using the internet.

On the website www.mechrech.de a fully functional simulation of the Millionaire is to be found. Search for ‘modell millionaer’ and choose the same name. Then click on ‘Funktionsmodell’, and you will get to a fully functional simulation of a Millionaire of five by five by ten digits, and featuring original sounds. This one is an absolute treat.

An even more absolute treat is to be found on the Australian website of John Wolff, www.johnwolff.id.au, John Wolff’s Web Museum. In the technical section you will find a very detailed description of the Millionaire, with an abundance of beautiful photographs of all major parts of the machine. Just looking at the contents will probably make your mouth water. And choosing number 19 ‘Register of Millionaire calculators’ will certainly do the trick. You will find a list of more than a hundred still existing Millionaires with short descriptions, where they may be found (if in a museum), and many with a photograph when clicking the production number.

Having shown you to these two websites, it is time for me to end my story about these wonderful Millionaires.