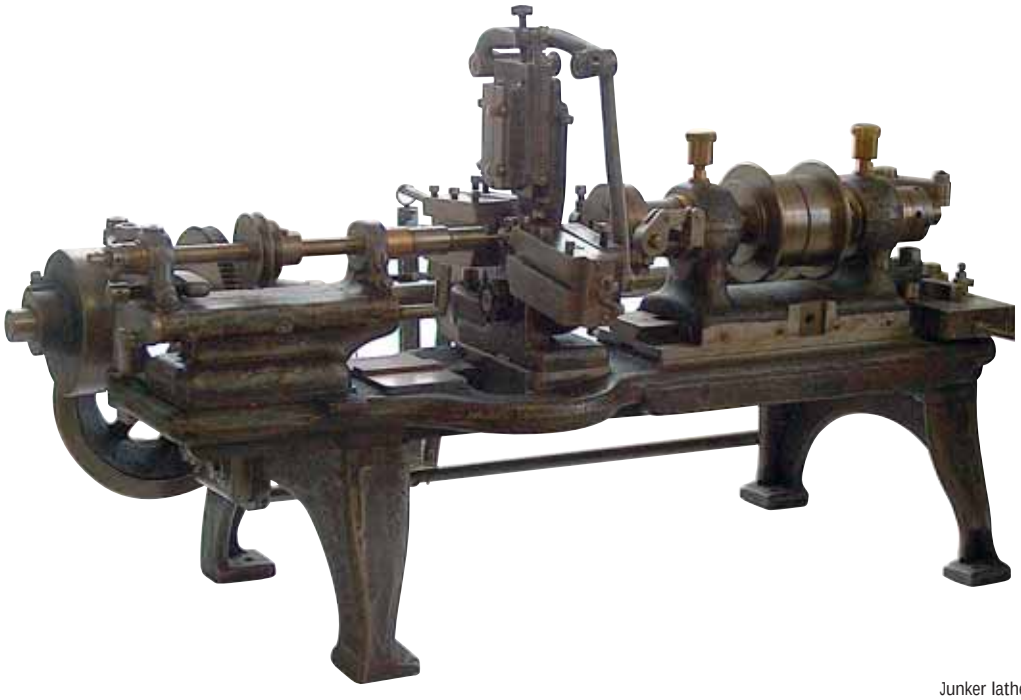
MACHINE TOOLS IN SWITZERLAND: HISTORY AND OUTLOOK

The majority of Swiss machine-tool producers were formed at the beginning of the 20th century to meet an urgent requirement for high-precision equipment for the production of components for the watchmaking industry. Indeed, the early part of the century saw the appearance of Swiss machine-tool producers, operating first in the Swiss market, then increasingly on an international scale, for the production of high-precision mechanical parts.

Edouard Huguelet, editor of MSM – Le Mensuel de l'Industrie (The industry's monthly review)



Junker lathe - 1900

The preferred locations of the machine manufacturing companies in the Suisse romande were generally dictated to by the presence or not of a flourishing watchmaking industry in the area. Logically, where there was a strong concentration of watchmakers: in the Jura, in the upper regions of the Neuchâtel canton (Le Locle in particular), in Bienne and in Geneva.

The machine-tool industry originated in Great Britain, Germany, France and the USA. It's only relatively recently (end of the 19th and beginning of the 20th century) that it came to French-speaking Switzerland (Suisse romande) and mainly driven by a watchmaking industry in expansion at the time moving from a craft to an industrial scale.

Surprisingly, the vast majority of these companies were able to "hold on" during the difficult years of unemployment, between 1929 and 1940. It should be noted that from the end of the thirties and even during the Second World War, the arms industry (components for shell fuses – mechanisms similar to those found in watchmaking) literally exploded. Numerous small-scale industrialists in the Moutier region made their fortune in quick time during this short period (and in certain cases squandered just as

Petermann factory - 1918

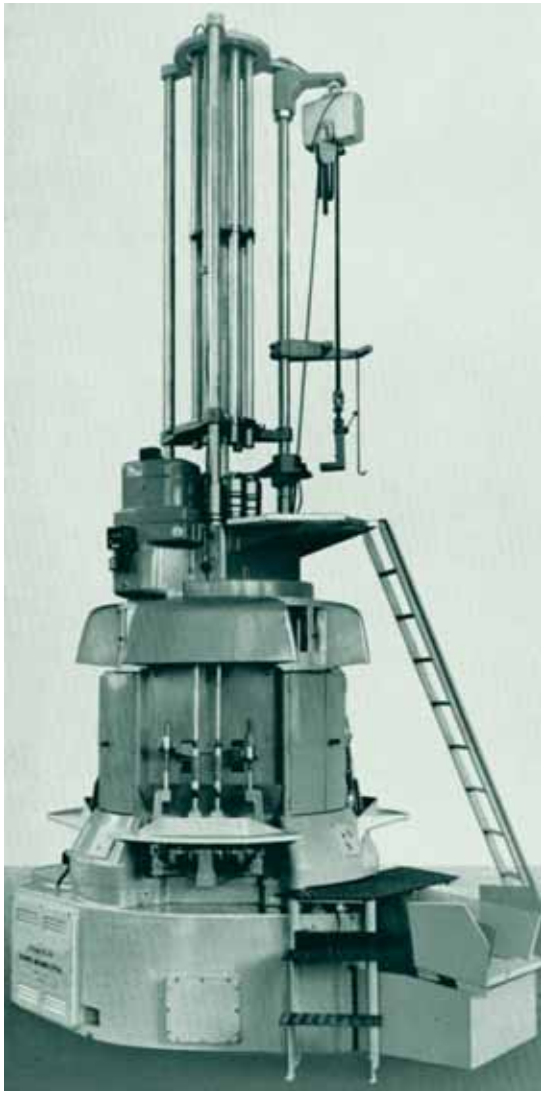
rapidly), selling their production to the future wagers of war, more concerned by quantities and delivery times than price. Some will tell you that the meticulous Allied bombing of the Moutier and Renens railway stations at the end of the war was a "premeditated mistake", wagons full of turned parts waiting to be taken to Germany (and safe to say not destined for the production of toys), was the real target.

The "first wave" of machine manufacturing companies

In this way, the automatic turning machine with sliding headstock industry saw the light of day in Moutier (see separate section entitled "The Swiss Automatic Lathe" [automatic turning machines]), with machines manufactured by three competing companies. Still in Moutier, another machine manufacturing company, previously involved in the manufacture of die stamps, munitions, bench-mounted drills, stand-mounted drills, vertical drilling-boring machines, slide turning machines and console milling machines. Two other companies, one making drilling and milling machines, the other boring-punching machines, also started producing at Le Locle, the latter facing competition from a company in Geneva. In Tavannes there was a company producing vertical automatic multi-spindle turning machines (for the manufacture of watch cases and components for the arms industry) and sliding headstock machines for long parts. A milling machine factory was founded in Bienne. In Bévilard, a company manufactured automatic machines for cutting pinion teeth for the watchmaking industry. In Chaux-de-Fonds, there was a constructor of cylindrical grinding machines and in Geneva, a company making electro-erosion machines. The dense industrial landscape of the Jurassic arc region was now in place: not merely the watchmaking industry with its dependent sectors (bar turning, manufacture of gears and pinions, cutting, rough and final finishing) and machine-tools, but also manufacturers of tooling, dimensional measuring equipment and metrology. Alongside these developments, diverse industrial companies involved with the manufacture of tools and machine accessories were also created.

Rather strangely, the industrial specialisations are distributed geographically bar turning is mainly located in Court and Moutier, pinions and watch gears in Malleray and Bévilard, watchmakers in the Vallée de la Suze in Moutier, Tavannes, Reconvilier, the Vallée

Petermann automatic lathe - P16



Vertical multispindle lathe

de Joux and Tramelan, in Geneva and Bienne; pendulum mechanisms in Moutier, in the Béroche area around Neuchâtel and in Le Locle. Musical mechanisms are manufactured in Sainte-Croix and the surrounding area, machine-tool producers in the Vallée de la Birse (Moutier, Bévilard, Tavannes), in Bienne, in Geneva and in the Neuchâtel mountains, manufacturers of watch casings in the Vallée de la Sorne and in Bienne, polishing workshops and precious stone craftsmen in Ajoie.

The "second wave" and CNC control

The first CNC controlled machines appeared in the early seventies. In the turning sector, Schaublin (Bévilard) designed the world's first CNC controlled turning machine, equipped with a "home" command with an integrated micro-computer: the Data General Nova-II. (the author of this article having actually been involved in this project). In the past, SIP was considered a pioneer, having developed a boring-puncher machine with a "home" numerical command in Geneva – a project that would prove so costly it almost brought bankruptcy upon the company.

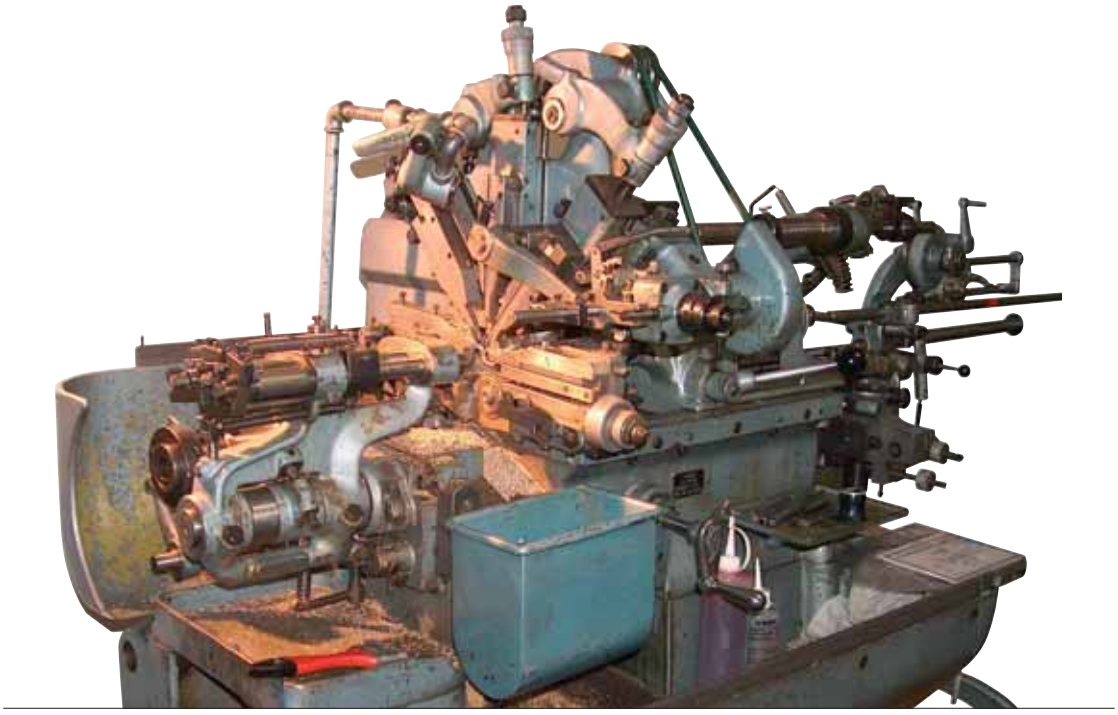
Some constructors, however, did not grasp the determining factors revolutionising the design of machine-tools quickly enough. They disappeared one after the other, some having tried in vain to convert at the last minute. Those able to adapt did however survive and evolve. In the automatic turning machine sector, it at first seemed outrageous to replace cam-driven systems with numerical control. André Bechler, in particular, saw no advantage to be gained from producing automatic turning machines at a cost two or three times higher that would require training operators in techniques that still remained a mystery.

At Tornos-Bechler, new families of automatic turning machines came out, ENC, then TOP-100 and TOP-200 ranges. It was indeed a great success, but these machines were actually more CNC machines than turning machines in the real sense of the word. Customers hesitated to buy for their production in long production runs. This period also saw the launch of automatic multi-spindle turning machines with barrels of 6 or 8 spindles, mainly designed for the manufacture of parts in long production runs for equipment and the automotive industry. Tornos and especially several specialist companies in the Moutier and Grand-Val valleys bought old Tornos, Bechler et Petermann turning machines up to date, fitting electronic variators for the programmed rotational speed control of the spindle and cam shaft. The aim of this was to enhance the productivity of traditional machines by reducing the amount of non-productive time.

At this time, whereas the majority of the machine manufacturing companies in Suisse romande had to close shop, some new machine manufacturing companies were starting up, mainly in areas close to the manufacture of components for the watchmaking industry, in the Vallée de la Sorne, Val de Ruz, Le Locle and Chaux-de-Fonds in particular. Esco in Genevez-sur-Coffrane, for example, manufactured fixed-spindle automatic turning machines with rotary tools, initially for relatively straightforward parts machined from profiled bars, which means material bars do not have to be rotated, at the same time reducing the machine floor space.

CNC-controlled machines are notable for their simplified kinematics: gear systems, transmission shafts, transmission systems, gear boxes and pulleys disappeared. If the machines are fundamentally more straightforward from a mechanical point of view, their CNC controls and programs have become faster and more powerful, especially as a result of progress made in cutting tools. Spindle speeds, cutting forces and speeds therefore increased, requiring machine manufacturing companies to manufacture more rigid components. In certain cases, the motor/spindle partnership using pulleys and drive belts disappeared in favour of the powered spindle, a compact and direct solution. Notions such as elasticity, vibrations, resonance, harmonics, distortion levels, strength… took on a new meaning. The LMO (machine-tools institute of the EPFL), under the guidance of Professor François Pruvot, established the rules of the scientific design of machine-tools towards the end of the eighties. The MSM review – Le Mensuel de l'Industrie [The industry's monthly review] published a full series of papers at the time on the transfer of techniques on the subject entitled "The future of machines-Machines of the future".

In the area of bar turning, towards the end of the nineties, Tornos designed the DECO 2000 concept. The idea was to transfer the bar-turner's expertise to CNC control, rather than force the bar-turner towards technologies he does not want or know how to use. In partnership with GE-Fanuc, a solution named TB-DECO was created. It was suited to single spindle as well as multi-spindle machines. Moving away from the tried and tested, a line of new machines called DECO, were now ready to replace the cam-type machines. The sliding headstock system, decidedly irreplaceable, was preserved. The bar-turner is on familiar ground with numerical control, which incorporates "spreadsheets" and genuine "virtual cams". The cost of the machine remains reasonable. In addition, it has a modular fitting system depending on the complexity of the machining operations to be carried out. It was a success. More ranges followed and new CNC machines gradually replaced cam-type machines in the impressive Bechler-Tornos-Petermann machine park (and competitors, for that matter) in place all over the world.



Bechler lathe - 1950

Tornos in 2007 before the construction of its new building.

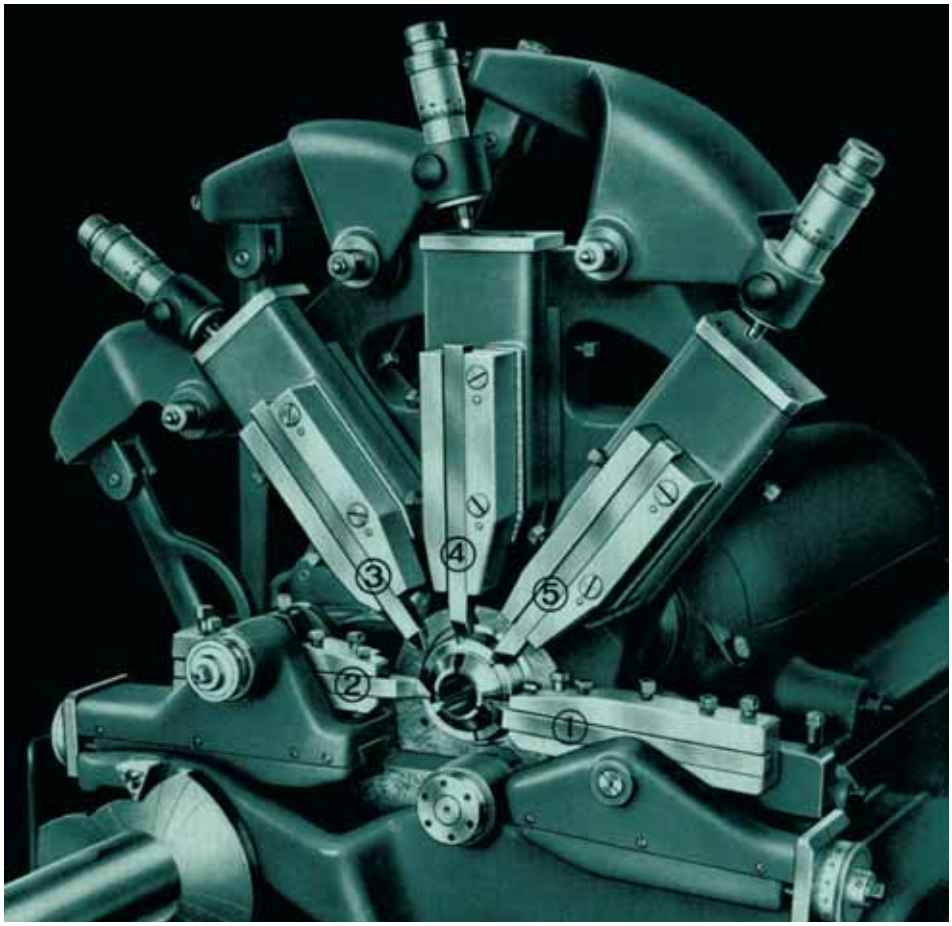
In the field of 3D machining, this period saw the appearance of "machining centers" and "machine-transfers". The latter carry out complete machining of high-precision mechanical parts or watchmaking components. They incorporate an ever-increasing number of numerical axes and are fitted with various features such as magazines, tool changers, measuring systems and palletization for flexible machining. The "home" CNC controls are being replaced by equipment developed mainly by GE-Fanuc, Siemens, Heidenhain and NUM. With the increasing levels of complexity and continual evolution of CNC controlled systems, the development of this equipment is no longer within the machine manufacturing companies' fields of expertise. Machine-tools are becoming ever-more rigid, to be able to withstand machining demands such as high speed machining technologies. Besides, the Swiss are not alone on the market. Besides the traditional competitors (Germany, Italy) new competitors from the USA, Japan, Taiwan, South Korea and in the future continental China are appearing. They are producing quality products which export well to Europe and Switzerland.

Outlooks and prospective

The outlook for the machine-tool in Switzerland is a favourable one, provided this industry does not rest on its laurels. We have witnessed the appearance of numerical technologies which has led to the disappearance of nearly half of Switzerland's machine-tool constructors, over a short period of 10 years. Technology is rapidly changing.

The current trend is to produce machines totally adapted to production, which means a modular design. The era of universal machine-tools made in large volumes is gone because the user does not want to pay for functions that he is not going to use. An important factor is the services that come with the product. All this actually requires the need for a PLM approach. This acronym stands for "Product Lifecycle Management". It is a strategy that helps companies share their product data to apply common procedures and to compile company information for product development, from the design phase to the disposal process.

A well-trained machine-tool operating and maintenance staff is also key. Decentralised courses, if possible on DVD with interactive exercises need to be available. Programming systems (CAM) need to be intuitive, object based: machine programming is to be done by mechanical staff and operators, and not by mathematicians or IT people. Special attention should be paid to element libraries, especially for tooling and clamping units and flanging. Reference documents (service instructions) need to be user-



Tool system "in a star shape"

friendly and realistic. We must not forget that services are an integral part of the product and are often even the decisive sales argument.

There is also a need for the notion of "product manager" to become more widespread, i.e. giving managers the level of responsibility they need to perform the role of "integrated entrepreneurs". The machine constructor in his overalls in his ivory tower in the research and development department is also to be put away in the antediluvian fossils drawer. The constructor of the future will spend a third of his time with the customer (with sale engineers or exterior sales technician for example), another third in production and assembly workshops and only a third of his time at his CAD work station, it will be an improvement for his eyes as well as his productivity!

Current trends in machine-tools can be projected into the future with confidence: ever faster and precise machines, more rigid, more user-friendly CNC interfaces, reduced cost of machines, purely through new manufacturing technologies and component assembly. A decade ago, we were predicting a general breakthrough in linear motor drives. Nothing came of this attractive solution in principle (involving circular movement giving way to linear movement – the key to simplifying the kinematic chain and eliminating inertia from rotating elements) except in a few special cases, to which the new principle was eventually applied.

This reminds us of the mitigated success of Wankel engines (which, at the time, seemed to be heralding the end of the traditional engine). It just proves that great ideas do not necessary succeed in the face of market restrictions. The hydrogen-fuelled cars of the future seem to be a way into the future. This idea may well lead to new generations of engine components, in particular in the injection area, which would mean new and possibly challenging applications for machine-tools. In research departments, the solid CAD approach is the preferred one. As early as the machine component technical drawing stage, parts need to be designed taking into account the best production method from a cost point of view.

Besides, a well-organised production and assembly workshop will allow other, quite substantial savings to be made. This is something that has been taken

on board by a new American constructor producing machine-tools (milling machines, CNC turning machines and machining centres) at nearly a third of the cost, for the same quality of equivalent products from Europe and Asia, thanks to highly-efficient and well-organised production.

A wish for the future…

Machine-tools do, however, need to be designed in a scientific and rigourous manner, while at the same time maintaining the practical knowledge-based aspect. For this reason, it would be advisable to reopen the EPFL (Swiss Federal Institute of Technology in Lausanne), along with the LCSM (Laboratory of Mechanical Systems Conception) a Machine-tools laboratory (LMO) entirely dedicated to machine-tools operating on swarf removal, cutting tools and machining technology (including CAM), so as to train the elite constructors of the future, while at the same time carrying out fundamental and applied research, possibly in partnership with Swiss industry.

We know that the challenges of the future – at least as far as the machine-tool sector is concerned – do not allow us to throw all our energy into fundamental research in the engineering laboratories of the various industrial companies. However, if such a Laboratory was reopened at the EPFL, you can be sure that the large Swiss machine-tools constructors would assign the best young engineers, scientific collaborators or postgraduate students, with research subjects which would not only be fascinating, but also hope for future generations of machine-tools.

… and even a hope

Why, as in days gone by, should the Swiss machine-tool industry not once again take on the role of pioneer and innovator, as was the case at the start of the 20th century with automatic turning machines? And why not – turn an idea from the author of this article into reality, who used to be (in the Cretaceous or Jurassic period?) a constructor in the Tavannes Machines Co engineering department (a company which no longer exists), who used to produce vertical automatic multi-spindle turning machines called Gyromatic, able to operate with bars of 40 mm, or 60 mm? Personally, I feel this size of machine could be revised under the CNC format. Indeed, the material bars being vertical, they are lowered using gravity alone, and the friction in the bar loader is reduced due to the vertical positioning, swarf is removed simply by gravity and the required floor space is halved. Who is prepared to take up this challenge?