

# Optomechanix

Zimak Watch Factory  
Watchmaking Machines  
How to make a Wrist Watch  
Making the Case  
Making the Dial  
Watch and Clock Repair  
Tribute to Rostam Moharami  
Connecting to Grassroots

Oct-Dec 2021

The Art of Watchmaking



Technical journal of OMiD, Opto-Mechanical Institute of Design

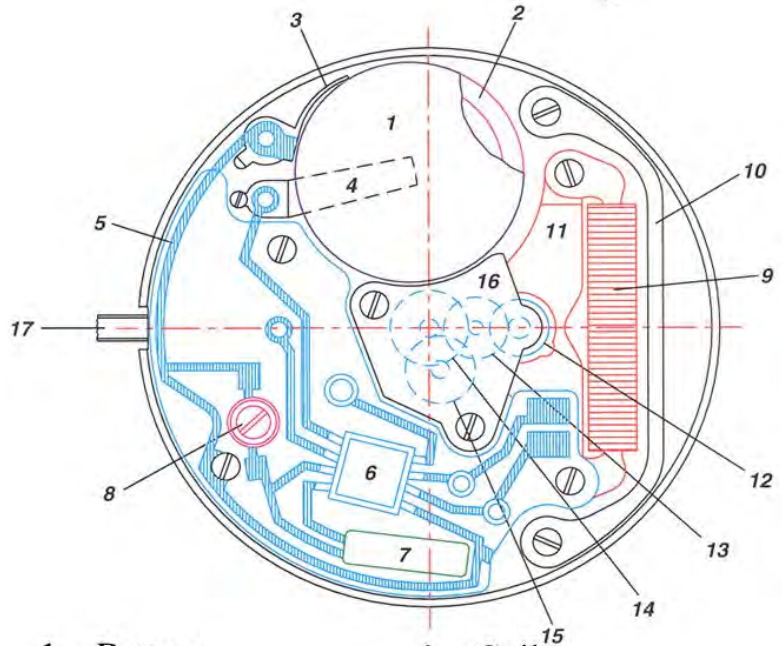
# How a watch works

I won't bore you with how a watch works. Just watch some YouTube videos, and you'd learn it in a few minutes, and will be far more entertained.

Just briefly, in a quartz watch (right), there is a quartz crystal that sends out signals to a down counter to reduce its frequency to 1 Hz. This signal is fed into a coil to rotate a small gear to drive the watch. You could tell if you own a quartz watch or not if it uses batteries or if it's dead silent, or if its second hand moves and stops in one second intervals.

If you own a mechanical watch its movement is most likely a modern balance wheel design (below) that operates by an oscillating balance wheel driven by a main spring that needs to be hand wound or is automatically wound when you move around your arm during your daily activities.

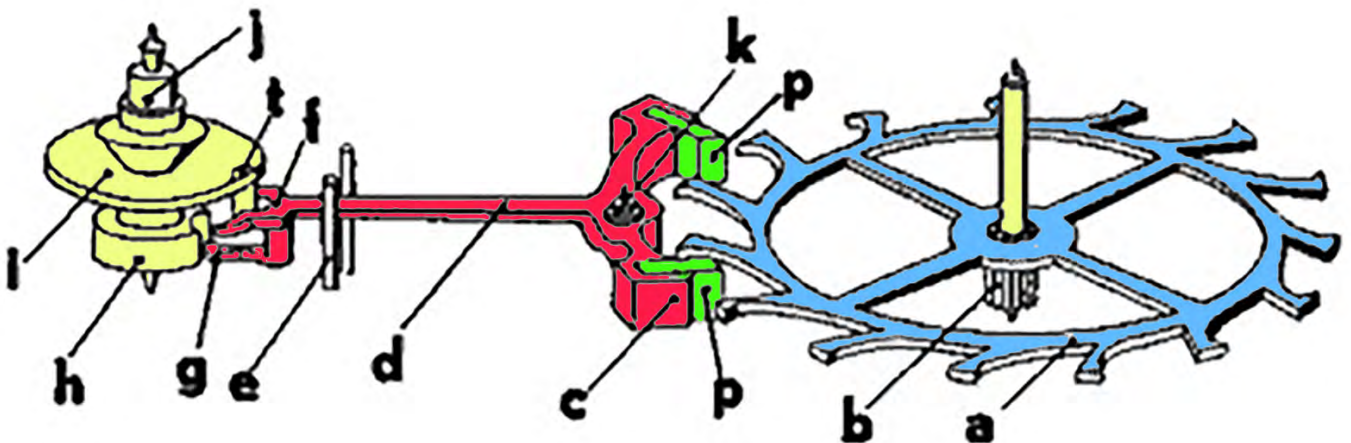
The mechanical watch is less accurate than the quartz watches but its second hand is far more interesting to watch because it has more emotion in it. It's the difference between a mechanical music box, and a tune from your mobile phone.



- |                       |                        |
|-----------------------|------------------------|
| 1. Battery            | 9. Coil                |
| 2. Insulator          | 10. Coil protector     |
| 3. Positive contact   | 11. Stator             |
| 4. Negative contact   | 12. Rotor              |
| 5. Printed circuit    | 13-15. Train wheel     |
| 6. Integrated circuit | 16. Train wheel bridge |
| 7. Quartz             | 17. Setting stem       |
| 8. Trimmer            |                        |

As a technician, I prefer quartz watches because they are so easier to repair, and they have less mechanical wear, and they are dead accurate. As a mechanical engineer, and someone who loves astronomy I love mechanical watches because they connect me with Galileo.

If you live in Southern California, go visit the 5-meter Palomar telescope, and watch it through its glass door. Those who have Caltec or JPL badges could even get a permit to get in. There is a tall clock you could watch near the front door with a long pendulum. You could feel the telescope micro-turning in the background with every click of that clock. Telescope now use servo drives but imagine several tons of glass, and steel being the second hand of a mechanical clock.



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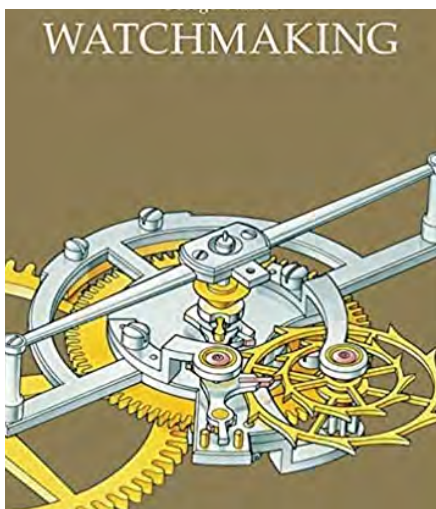


This issue Dedicated to:

George Daniels (1926-2011) was an inventor, watchmaker, car enthusiast, and illustrative author. He was considered by some to be one of the best in the world in the field of mechanical watches and timepieces during his lifetime. He was a watchmaker who built complete watches by hand (including the case and dial). During the quartz crisis, George Daniels accepted a commission from American industrialist and watch collector Seth G. Atwood to create a timepiece that would fundamentally improve the performance of mechanical watches. After much experimentation, Daniels had designed a new type of watch escapement by 1974. The mechanism, which was first unveiled in 1976 as the Atwood watch and patented in 1980, was called the coaxial escapement.

It was his creation of the coaxial escapement for which he is most remembered. The movement, which theoretically removed the need to add a lubricant, has been used by Omega in most of their collections since 1999 except of the Speedmaster Moonwatch (until the release of the Speedmaster Moonwatch Caliber 3861 in 2021).

A yellow gold chronograph pocket watch made by George Daniels, the Space Traveller's Watch I, ranks as one of the 20 most expensive watches ever sold at auction, fetching £ 3,615,000 in London on 2 July 2019. His apprentice watchmaker was Roger Smith whom he gave away his entire watchmaking shop to continue his legacy of watchmaking.



### George Daniels book on watchmaking

Daniels was particularly interested in the development of the escapement - many are described in his book, several of his own designs (left). The reader is encouraged to explore this aspect of watchmaking in even greater detail. This classic handbook still remains indispensable to generations of watchmakers and repairers, and also provides a fascinating insight to the enthusiast and watch-collector. George Daniels has another great illustrative book on the works of Breguet.

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Optomechanix is a quarterly journal of Opto-Mechanical Institute of Design (OMiD), with technical articles for practical, hands-on opto-mechanical engineers. This magazine is privately founded.

**Cover page photo:** Three of the current employees at Zimak factory

**Front back:** Watch movement comparison between mechanical and Quartz.

# Introduction

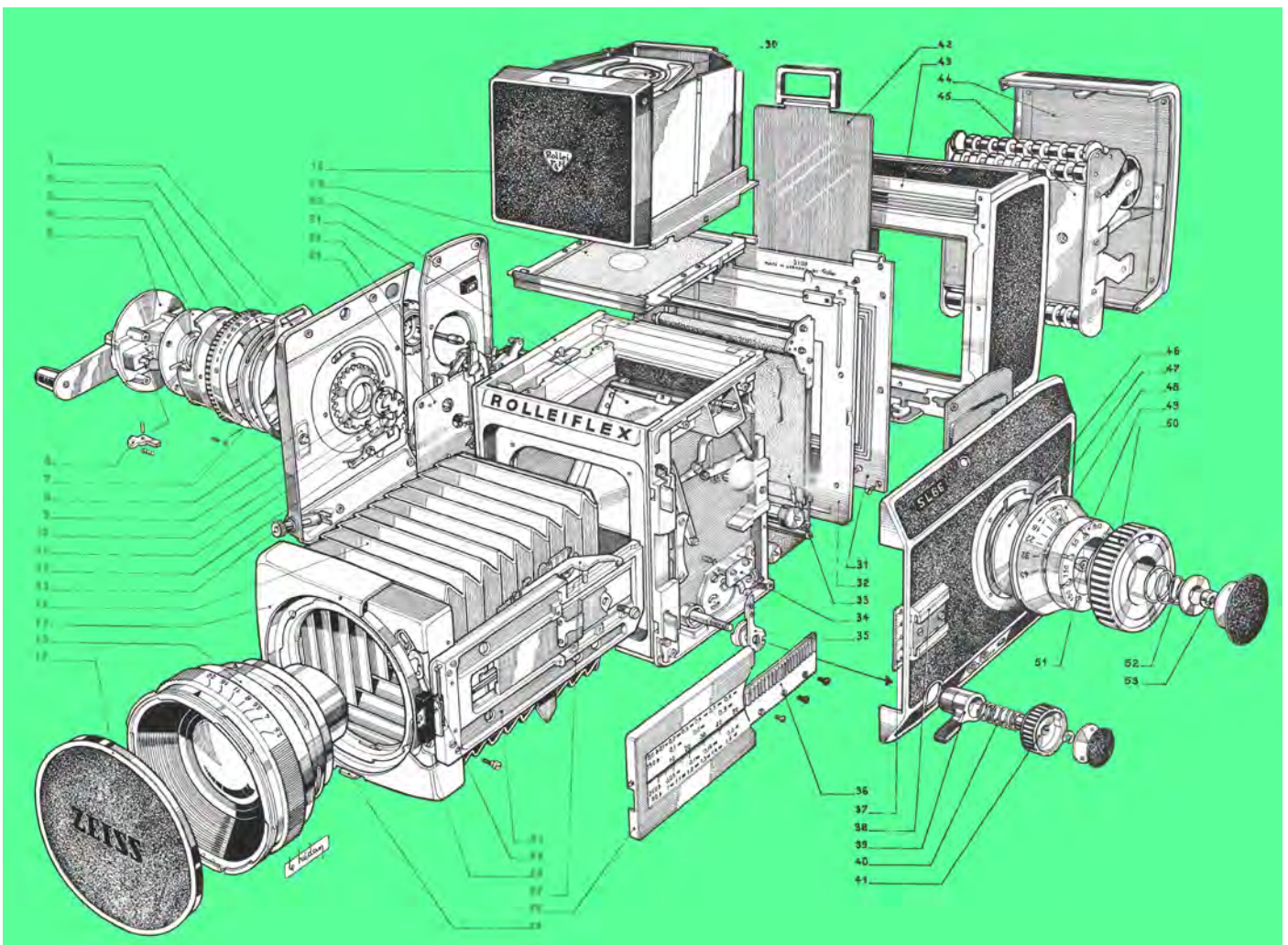
Somewhere along the path of Optical engineering, you'll end up crossing the art of watch making. These two trades give hand in hand to gain the skills of their mother ship called micromechanics. Optical engineering is really an scaled up micromechanics, and in so many cases meets it at the same level of precision, and craftsmanship. If you consider the requirements to construct the opto-mechanics of today's mobile phone, it's much closer to watchmaking than ever.

We'll dedicate this issue of Optomechanix to the art of watchmaking: What are its tools, and what skills are required to implement its marvel of mechanical engineering. Watchmaking is the learning platform for every nation that wishes to produce precision products, otherwise the eyes of its engineers would miss so many details in their own trade. To give you an example, the employees of the world renown Hasselblad cameras used to manufacture clocks. It was through their skills learned in clockmaking that enabled them to produce the camera that was taken to the moon.

Those who used film cameras before the digital age, enjoyed the wonderful "Bzzz" sound out of their cameras at slow speeds. The miniature Minox camera was entirely at the level of the craftsmanship of a wrist watch, and so were all the shutter mechanisms in cameras, and the shutter mechanism in Voyager, and its filter wheel, and almost every mechanism in the wide field camera in Hubble Space Telescope that I worked on for a few years. Optical instruments gained so many of their precision know how from watchmaking.

The first machine we'll discuss is the Eboza machine. This machine is famous for making the lens barrel components for photographic cameras as well as manufacturing watch cases. We'll look at this machine to see how it does both.

Ali Afshari  
Editor in Chief, Opto-Mechanical Institute of Design

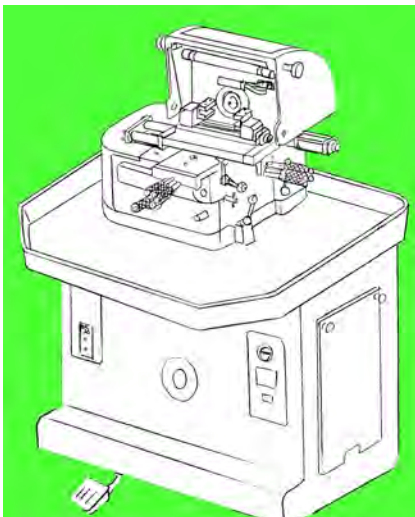
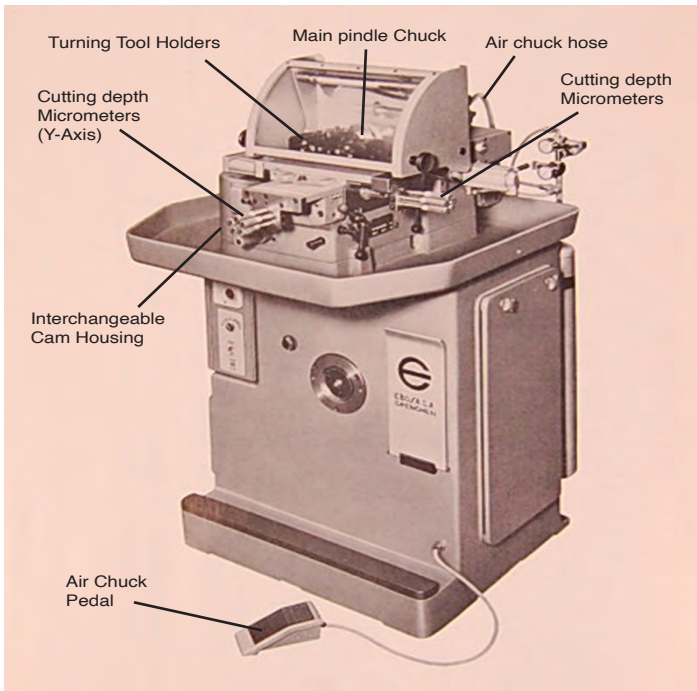


Photographic cameras are a vivid example of micromechanical engineering that contains parts that are inherited from watchmaking. The sequential operation of cameras is so much like the sequential operation in watches, and clocks. The balance wheel in watches, and the pendulum in clocks, resemble so much the mirror movement in SLR cameras. The balance wheel rotates the second hand in watches while the charged spring in mechanical cameras is utilized to take photos.

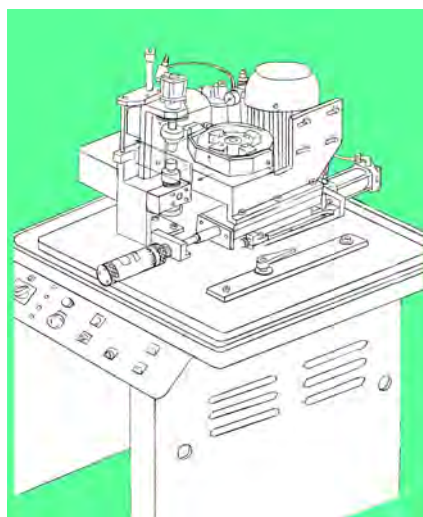
## The Machines

The Ebosa turning machine (left) is really an automated lathe with its main chuck facing towards the operator instead of the usual left position of the chuck on the lathe. If you have experience using lathes, imagine standing at the left side of this machine, and the chuck would fall at your normal left, and the cutting tools would be on your right. This is a six-cycle automatic lathe ideal in machining lens barrels, and watch cases.

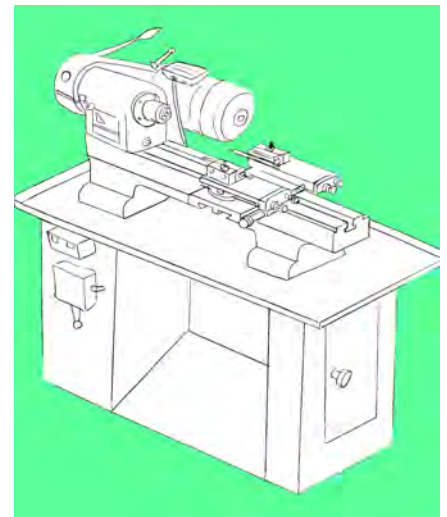
Ebosa works like a cam machine. To start with, a pedal operated air chuck secures the part to be machined. As the machine starts its cutting cycle on the part, a rotating cam pushes the X, and Y axis to their starting points. Translation of X, and Y axis are air operated, and their finish points are set by the six micrometers that are preadjusted for each X-Y cut. Up to six operations can be performed in preprogrammed sequence at a relatively high speed. There are other machines that we'll be visiting throughout this issue.



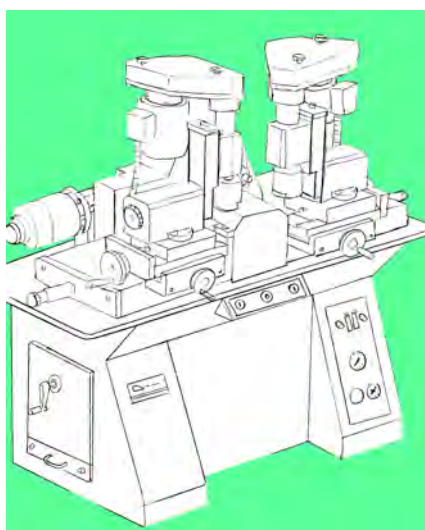
Eposa Lathe used in both watch-making, and producing lens barrels.



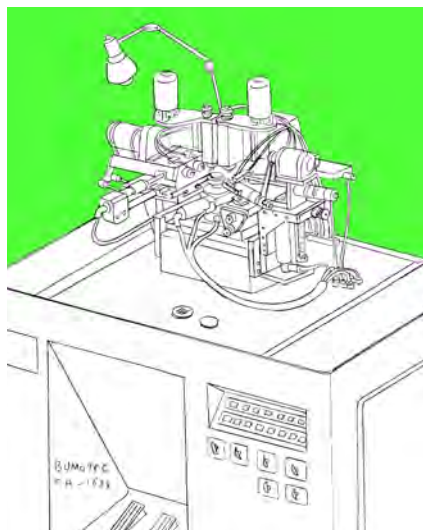
Bosha diamond wheel dial diameter cutting, and shaping machine: P 12



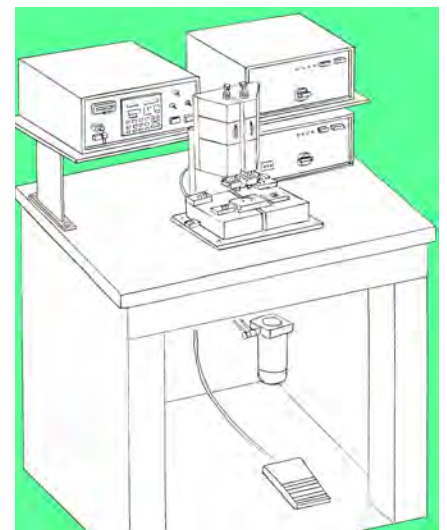
Schaubline Watchmaking Lathe for cutting watch cases: Page 38



Bumotec S32 Replicating Machine produces watch cases from a sample Page 24



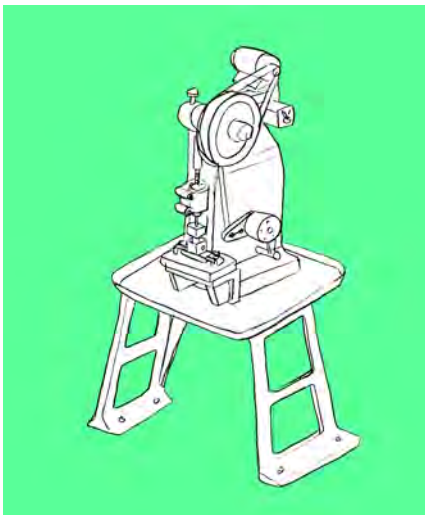
Jolia machine drilling the side holes on the watch case: Page 9, 38



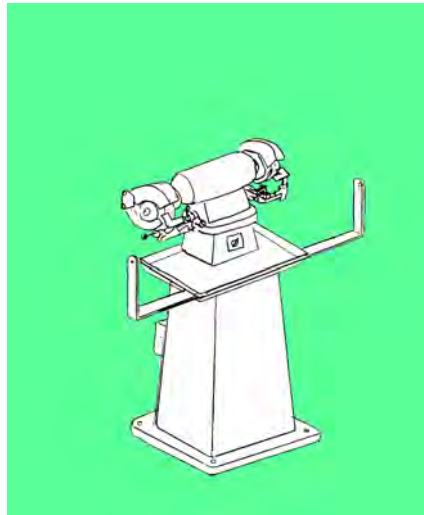
Covatec machine welds dial support pins on the back of dials: P 12, 33



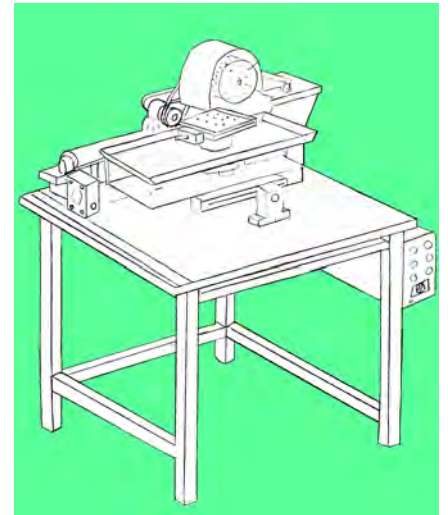
Levin 10 mm precision lathe, Bolova microscope, Bergeon drill, Bergeon tapping and boring stand, and precision press.



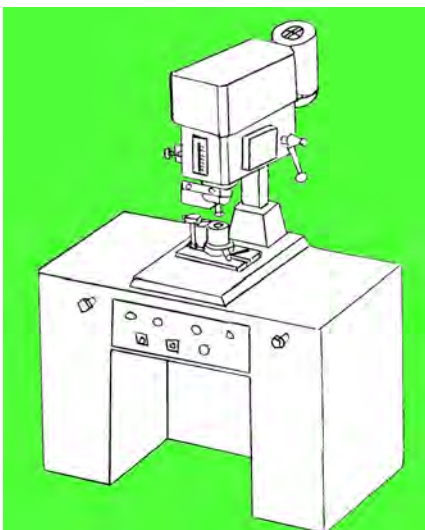
Wire punching machine to cut dial support legs from a roll of brass wire



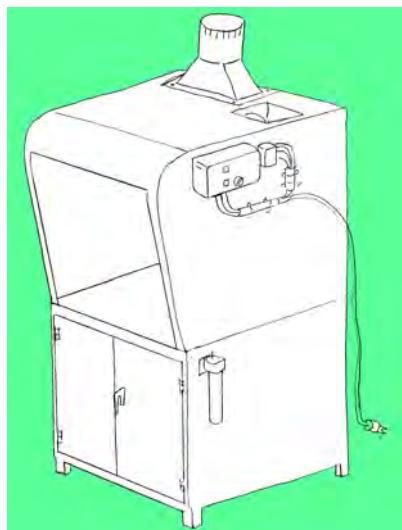
Tool grinder with precision tool guide stage, and angular adjustment: P 38



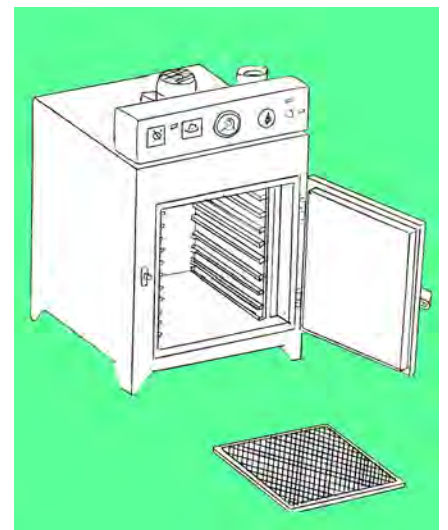
Firex dial polisher lays down parallel texture on the dial face: P12



Bumotec S25 Back Cover Cutting Mill: Page 23, 24



Painting Chamfer with Spray Gun, and convection fan: P 13

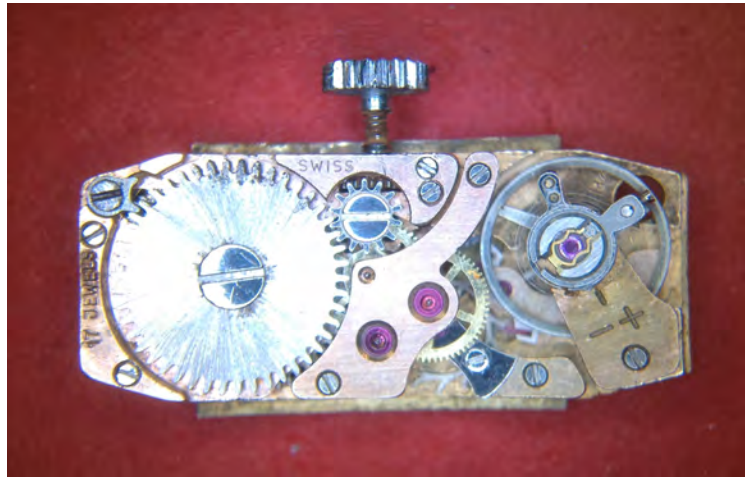


Dial paint drying oven with watch dial, and case trays: Page 13

## How a wristwatch is made

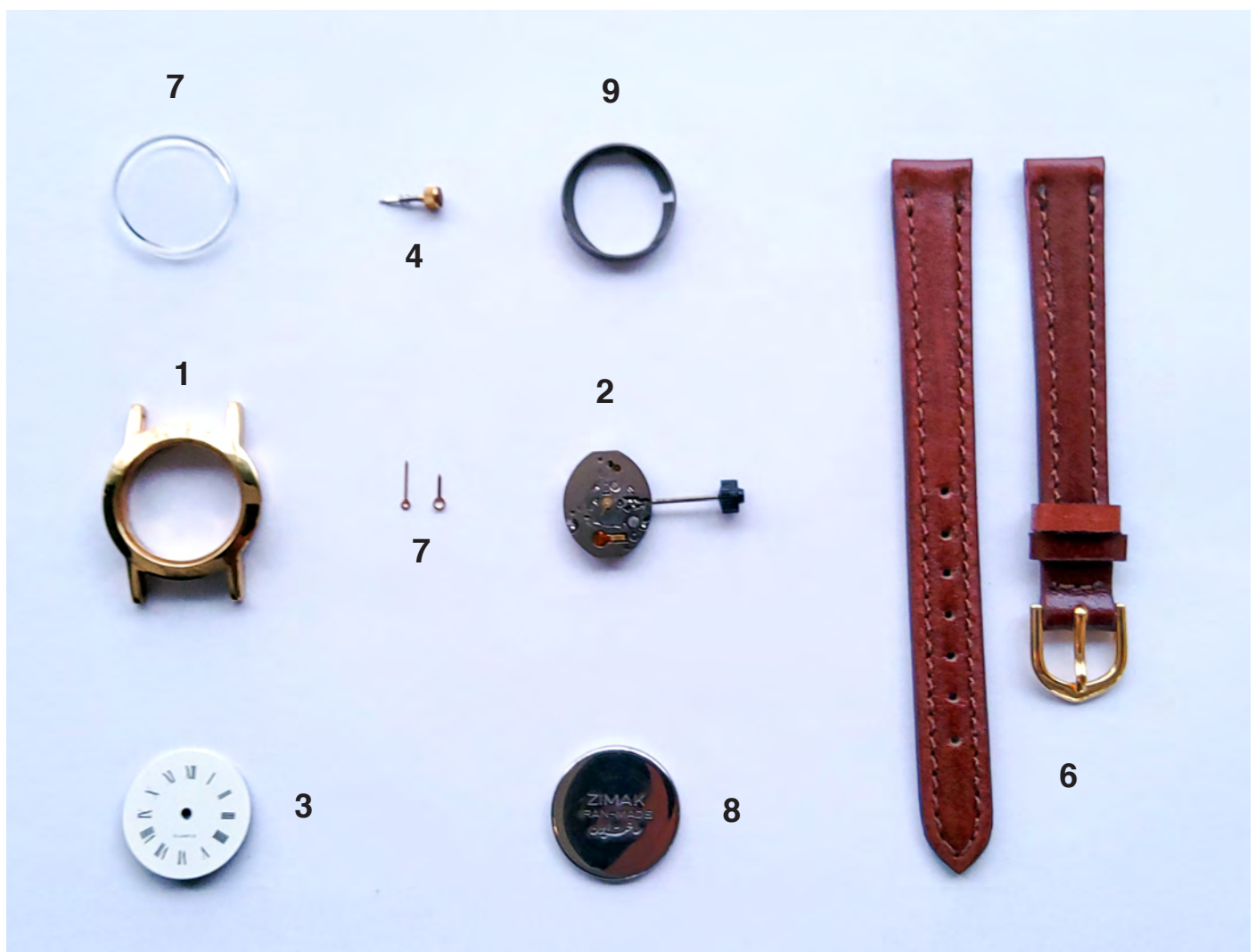
A wristwatch is made by assembling a number of parts together:

- 1) Watch Case
- 2) Movement (Quartz or Mechanical)
- 3) Watch Dial
- 4) The Crown
- 5) The Hands
- 6) Wrist Strap
- 7) Front Crystal Cover
- 8) Back Cover
- 9) Movement Centering Shell



We'll learn how to build a watch by visiting a small watchmaking factory. Some parts like the watch dial are created from scratch, where as other parts such as the movement are bought from other suppliers. One has to be passionate about the art of watchmaking, and have a great deal of devotion to build good quality watches.

The wrist watch is part of what is generally known as micro-mechanics. Watchmaking is engineering at its best because it deals with general public as much as the mobile Phone. While It is engineered for perfection, it also has fashion in it, as well as many of the arts. One could get lost inside a watch as one would get lost in a recreation park or carnival. You don't need a guide while wondering inside a watch. The mechanical watch will teach you on its own how to treat it with respect. You'd learn how to be gentle with it once you see the delicacy of its making. Poets show their love through poetry, while watch makers show their love with micromechanics. If you are a watch expert, you'd pay for the love that is put into making it. This installment is just an entry level display of the art, and the precision tools it uses to achieve it.



Basic elements of a Quartz ladies watch



## Zimak Watchmaking Facility

Watchmakers possess some of the most comprehensive collection of tools. They would put most tool collecting auto mechanics behind with their special gadgets: For every job, for every spring, for every screw, and for every bridge, or lever, there is a special tool. Watchmaking shops have to have an elaborate toolmaking shop side by side just to keep up with what they need to make quality watches. Zimak watchmaking facility is such a place in a beautiful garden in north east of Tehran, Iran. Its goal is to bring traditional Iranian craftsmanship into the world of watchmaking.



# 1 The Case

Watches are picked for their outer appearance, namely, their casing. Watch cases usually range from 7 to 9 mm in thickness.



You could produce watches today without owning a factory: Pick parts from catalogs, containing a full range of pre-made cases, movements, dial faces, watch hands, crowns, wrist straps, all the 10 pieces. There are companies all over Europe who do nothing but making them. They are so specialized in what they do that almost every famous brand relies on them, including Rolex, Omega, and many luxury watch companies like Cartier. So why build your own parts?

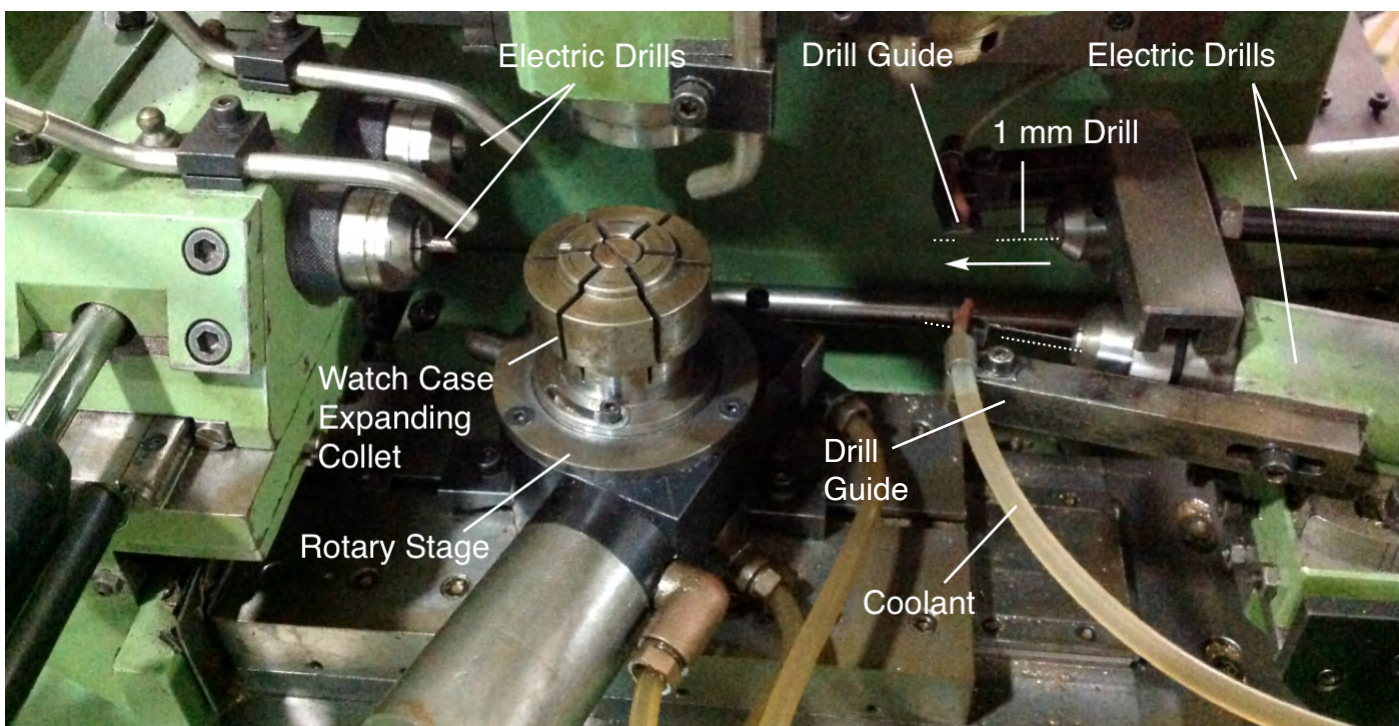
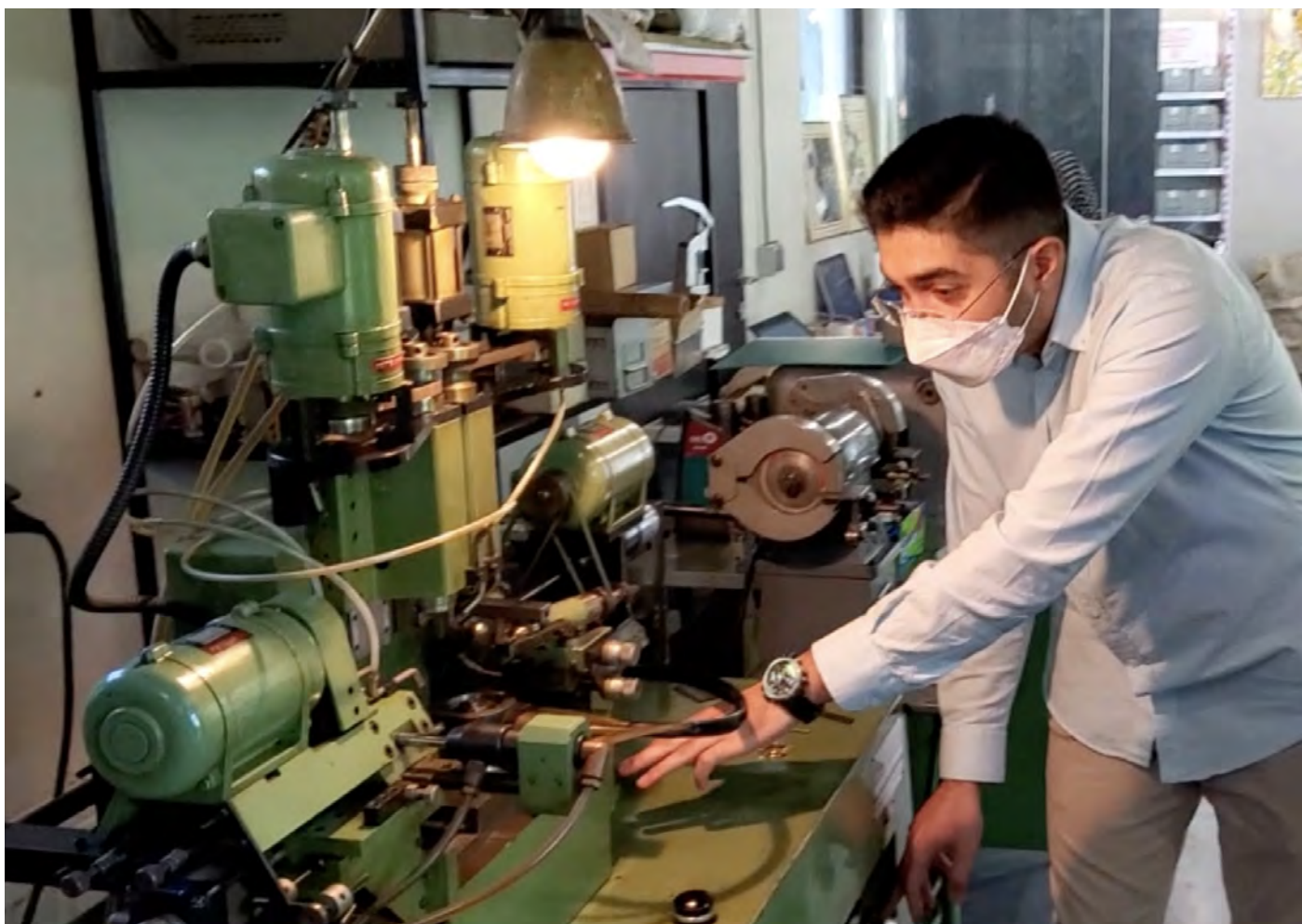
For starters, this might be an appealing option but not for people with taste. You can't have your own unique look if you keep building your brand from off the shelf parts. Most watch manufacturers won't make their own movements but, in most part, many parts are built in house. As we follow the process of watchmaking in this small shop, we'll see how this shop cares about details of their watches.

Designing the watch case is not that trivial either. There are several types of watch case styles, and the most creative watch designs are not fully water resistant. Water proofing a watch puts so much constraint on its design. The 100 m waterproof Rolexes look more like a submarine! It's still beautiful because so much thought has been put into designing it. In its components, Rolex design is like a Hasselblad. It has design accents that are picked to give it its unique look. The bevel in Rolex is like the shutter speed dial on Hasselblad. It's definitely not a Dieter Rams (less is more) design.

Going back to case design, the simplest watch cases rely on the dial to hold the movement, especially when it comes to Quartz movement that only weighs less than as six times the weight of its battery. The crown that sets the watch is drilled just beneath dial's seating plane as shown in this side view illustration. There is one detail in watch case manufacturing that only a few notices: How is the wrist strap securing bores are drilled from the inside, not outside of its lugs? This is a specialized operation that is performed by Julia drilling machine. It's among the most complex machines that was distributed by a Swiss firm named Bumotec.

Julia is a pneumatic drilling machine (opposite page) that fabricates all the side bores on a watch case before it goes to polishing. It could perform up to six drilling operations on the watch case; Two from above, and four on the sides. The machine could be programmed to work automatically. The inner bores on the lugs are drilled by a combination of two side drills, and four rotation angles.

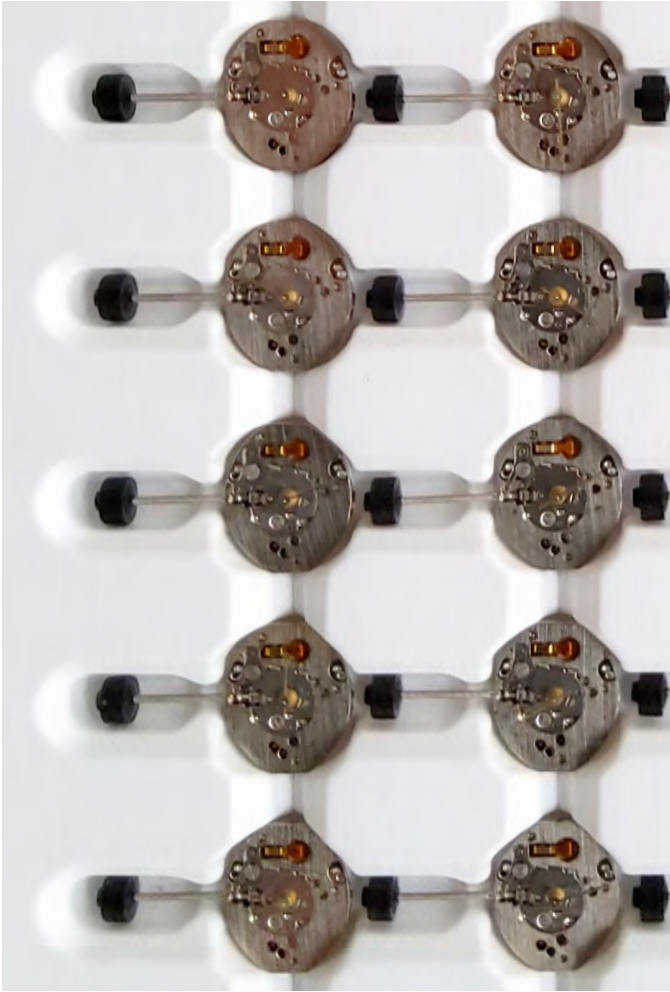
The next step is polishing the case, and metal plating to make the watch case more sweat resistant, and also scratch resistant. For Gold coating, the watch case also receives a thin plastic coating to protect the gold from hand sweat. With proper coating a watch case could maintain its finish for 5-10 years (refer to page 30).



Mass producing watch cases requires precision side drilling done mostly by Julia drilling machine (above). This pneumatic multi drill Swiss machine makes all the side bores in watch cases. The 1 mm blind holes are made from inside the strap lugs. This takes place at a slant angle with super long drills for clearance. Swiss ingenuity uses L shaped drill guides close to the drill tip for precise drilling. The drill guide drops in between the logs to perform the drilling operation, and is lifted up to allow the watch case to rotate to its next side or top drilling position. Winding stem bore is drilled by larger drill heads on the left. All drilling angles are fine adjusted by graduated micrometers, and fine screw dials.

## 2 The Movement

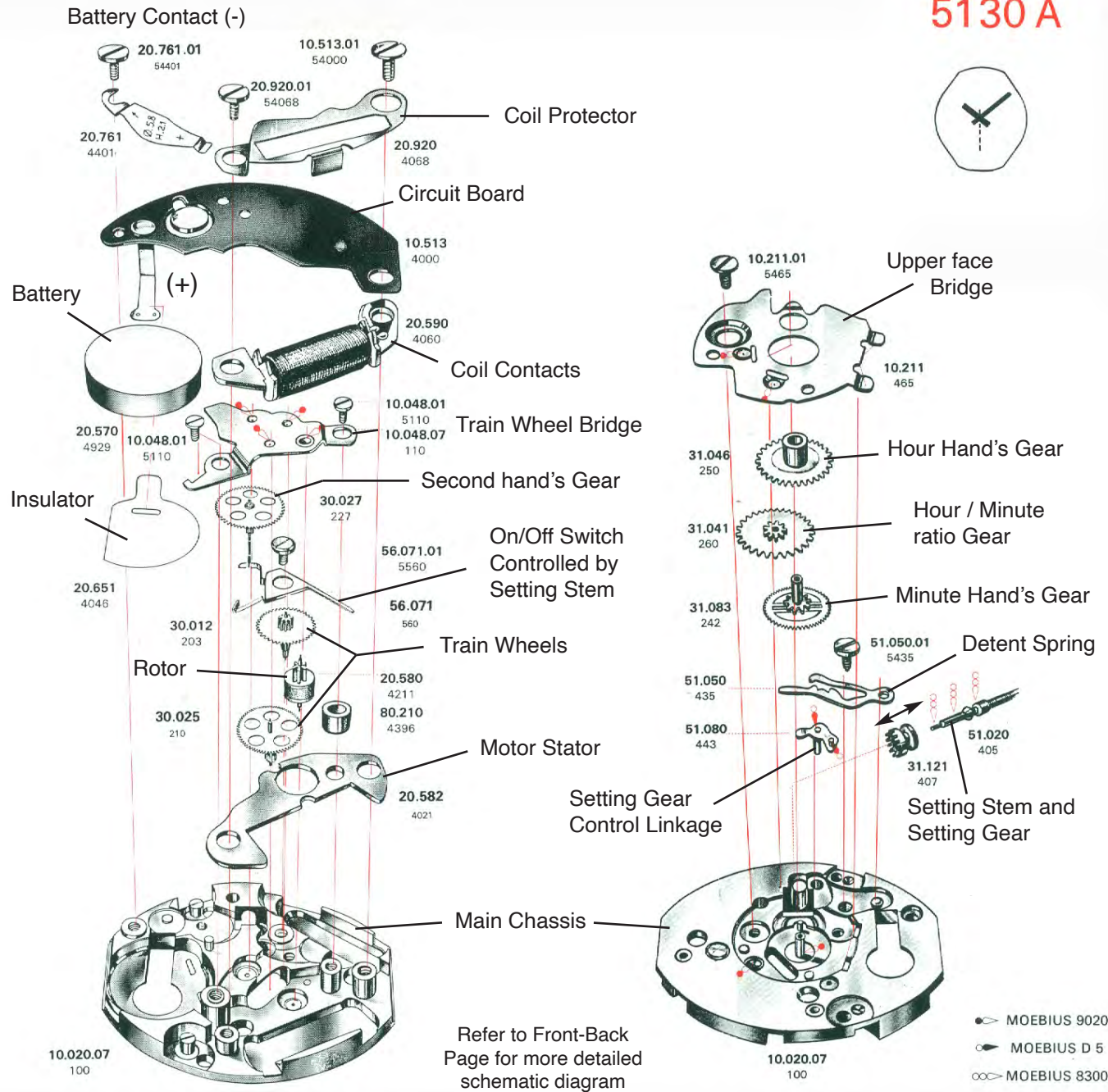
The movement is the most outsourced part of the watch, yet it's always considered to be uniquely manufactured in house.



Quartz versus mechanical: Although I personally like mechanical movement (right), quartz is so easy to assemble, and maintain. The mechanical watch drifts with temperature, and by its angular orientation. If you watch the mechanical escapement under an electron microscope, you'll see the friction reality facing micro-mechanics. As the angle changes, so does the friction. Breguet, developed the Tourbillion watch to average the friction to some extent. In most part, we'll follow the quartz watch in this small factory. A section at the end will cover maintenance of mechanical watches.



A ladies watch, product of Zimak watch factory (left). The back cover is removed for battery replacement (right).



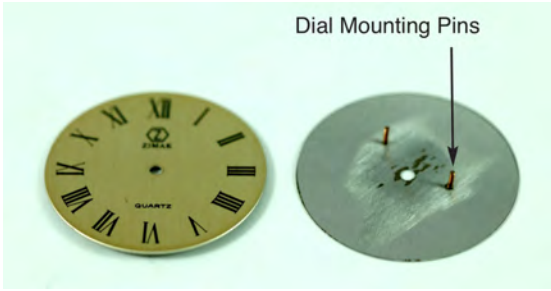
Exploded view of Caliber 5130A Quartz movement (above) revealing its main motor coil, electronics board, and its drive gears.

Right, troubleshooting, and testing the 5130A Quartz movement could be fully performed using an oscilloscope, and a standard voltmeter. The condition of the coil (above) is verified using an ohmmeter by touching the probes on its contacts.



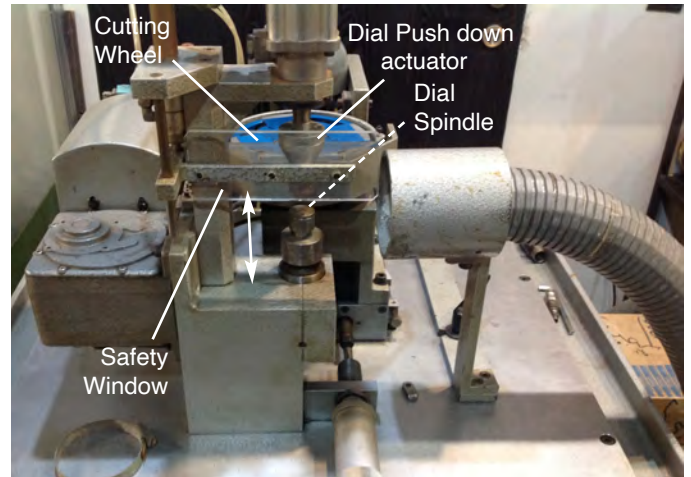
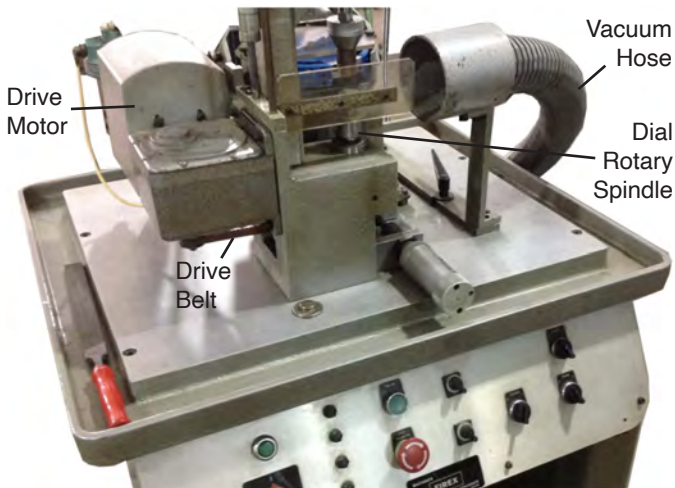
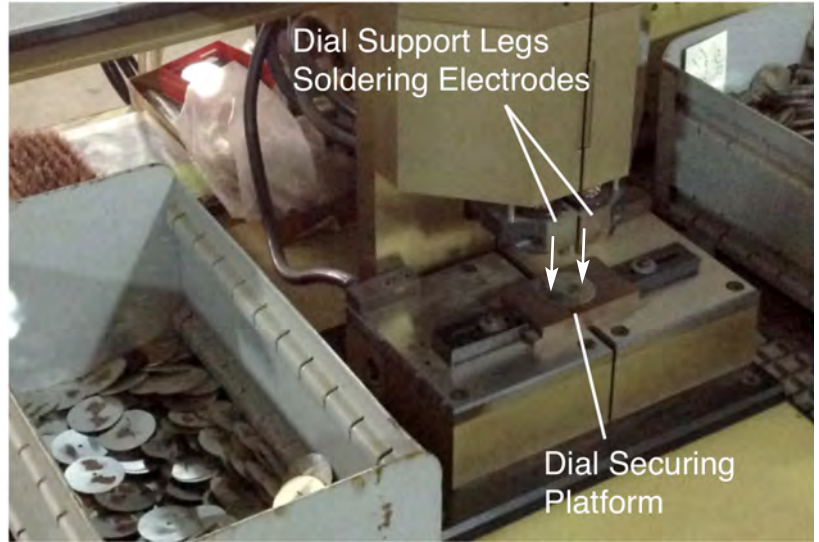
# 3 The Dial

The watch dial is the most invested piece of the watch. It is decorated to shine bearing the name of the watch.

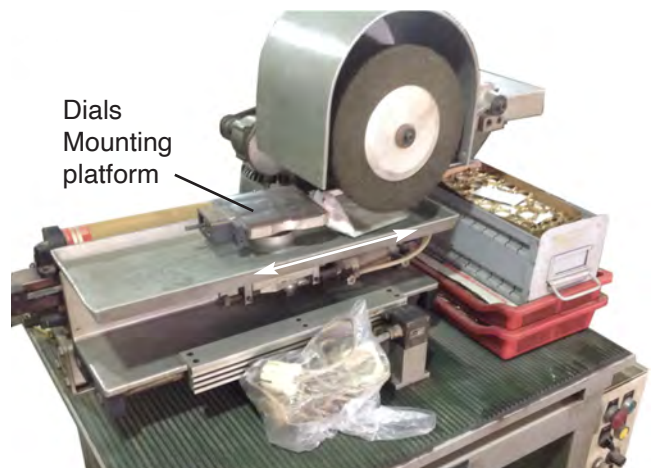
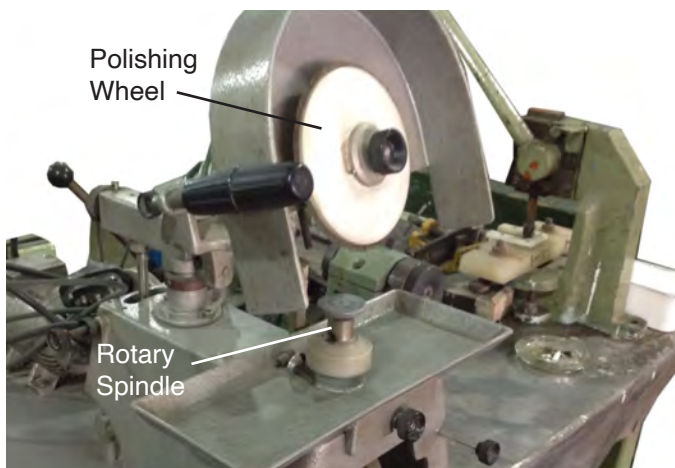


Everything is mechanically mounted inside a watch. Nothing is glued. Using high amperes, Covatec welding machine (right) welds these tiny brass legs behind each dial.

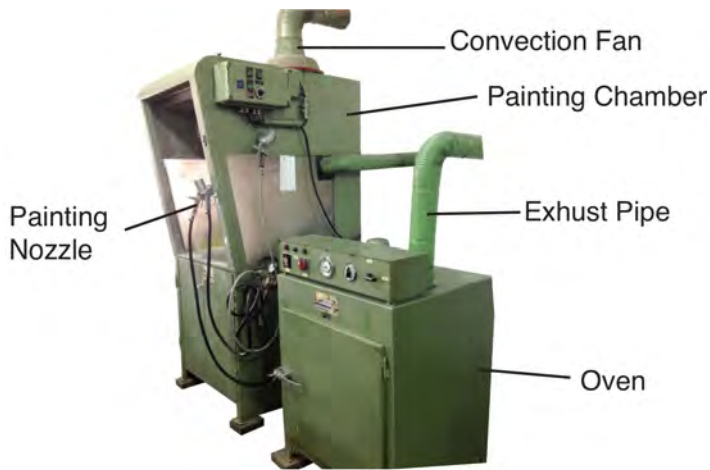
Dial mounting pins that are welded behind the watch dial are inserted in two openings around the watch movement and secured in place by set screws.



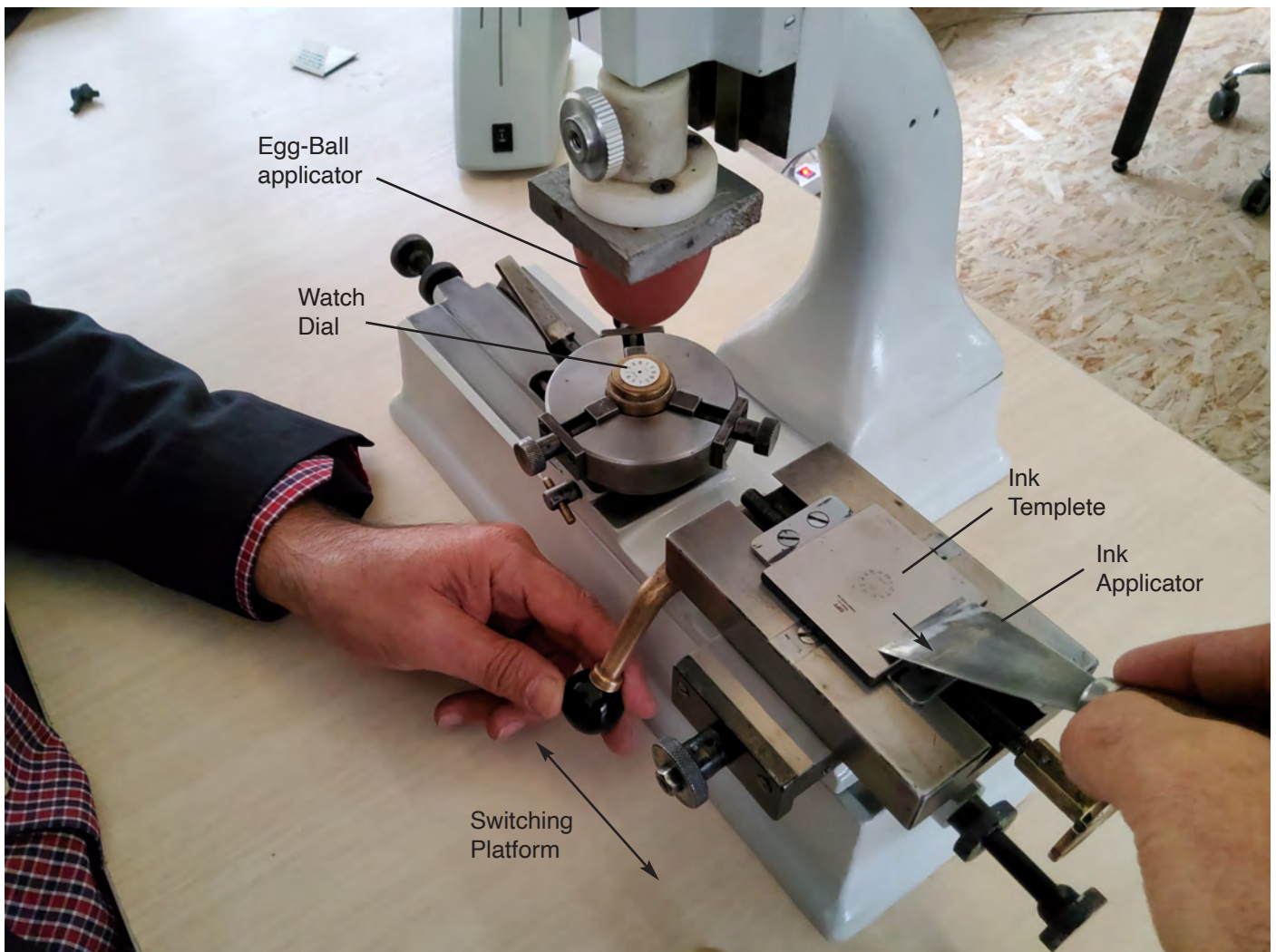
The watch dial diameter, and inner diameter of the case have a close fit. The watch dial cutting machine by Firex cuts it to size plus generating various shape dials from a template mounted below its spindle. The cutting operation is done automatically by rotating the dial 360°. The vacuum hose on the right guides the micro cut particles to a waste chamber. The huge micrometer in front adjusts the cutting diameter of the dial. The spinning wheel has diamond blades.



Two Firex dial polishers lay down parallel texture (right) or sun-like rays extending from the center of the dial (left).



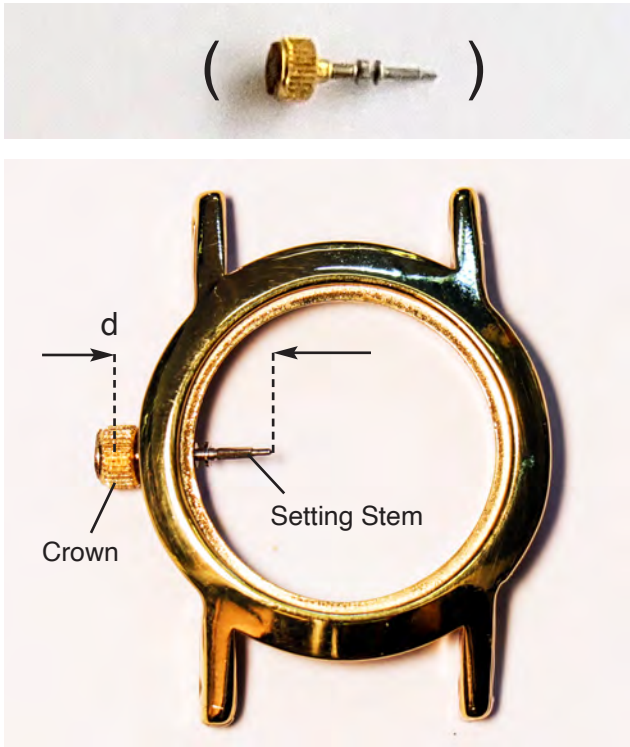
The spray paint chamber for dial face (left), and the baking chamber (right) coats the brass dials to desired colors. The Baking process produces a hard paint that won't be wiped off with alcohol cleaning. This is a compact / precision painting chamber that provides precise control of face dial painting. After the first layers of primer, and the cover paint, and baking process, the dial is ready to receive its precise graduations applied by a stamping machine (below). The dial is returned to the baking chamber for its final hardening.



Roger Ferner dial stamping machine uses templates (right) to imprint precise marks on the dial face (left). Applying the ink on the template (right), leaves off the dial marking ink on the etched template. The ink pattern is lifted off with the soft egg ball applicator, and imprinted on the dial face. The angle of watch dial in the stamping machine (above), and the position of support legs welded behind each dial by Covatec machine (opposite page) must be in perfect alignment. This becomes so crucial when stamping watch dials with a calendar window.

# 4 The Crown

The crown is the user interface from outer diameter to the inner watch movement to set the time.



Attaching the setting stem to a watch seems to be trivial but it's not. Watch movements are supplied with a default length setting stem (page 10), and a plastic crown that needs to be cut to length depending which case size you are going to use. The watchmaker buys the crown separately to replace the dummy plastic piece. Shortening the supplied stem, for its insertion into the watch requires specialized tooling. This operation requires exact cutting length (d), and the screw tip needs to be deburred, and epoxied inside the crown.

The Seiler machine (below) is designed to do just that. It utilizes a diamond powder cut off wheel to cut the stem to length while it is precisely held in place by an 8 mm collet. The shortened stem's tip also gets conically deburred by a step built into the cut off wheel as the push-in arm is further moved in to its stop (opposite page). There is a crown securing collet on its opposite side (below) that drives the crown onto the shortened stem after the cut-off operation, and stops automatically by a micro switch as soon as the screw reaches the end of crown's blind hole.

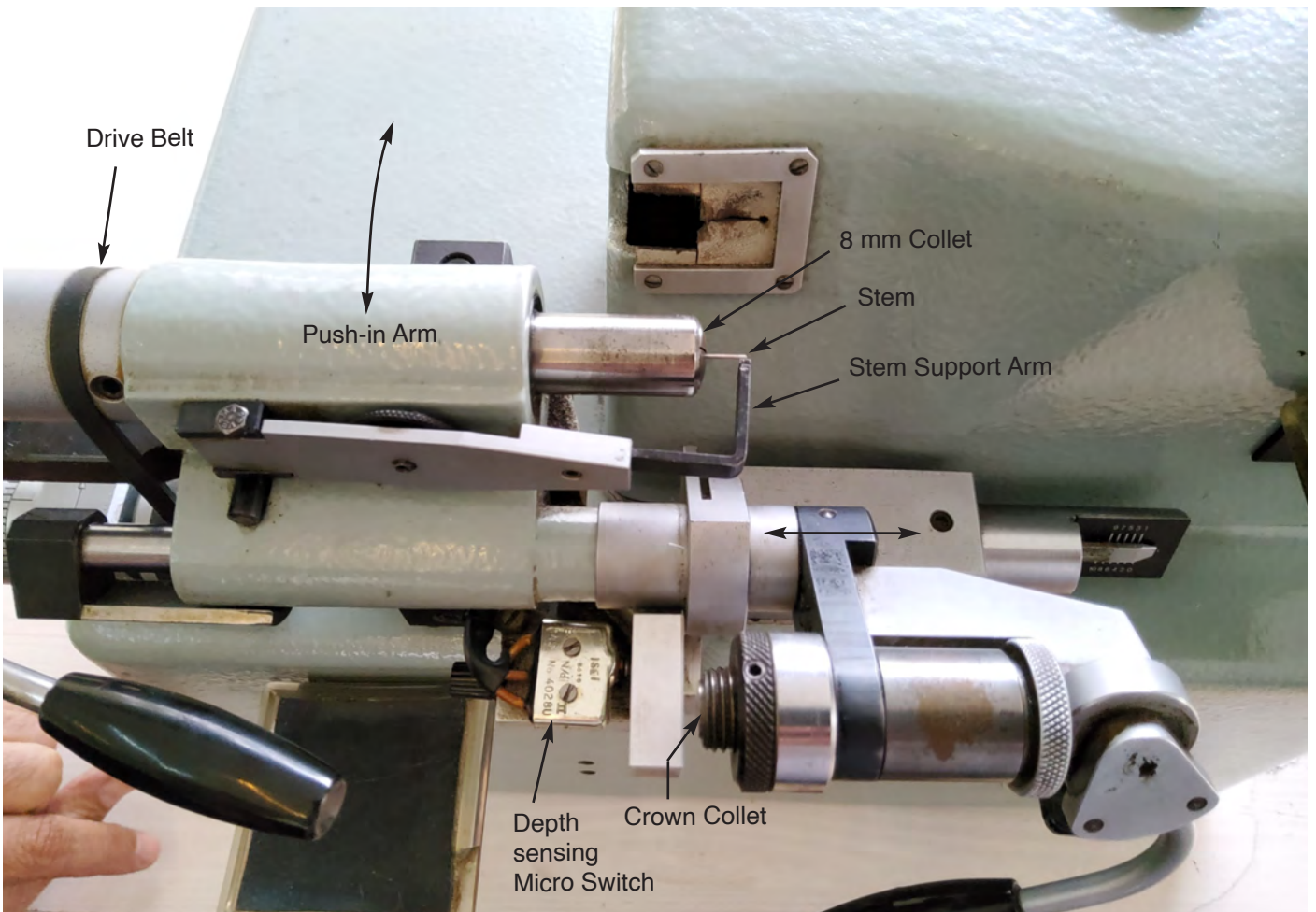
To really appreciate this, try using Dremel to cut the setting stem. You'll be spending an hour to fit each pin.



Seiler stem cutting machine



Cutting off the setting stem to length, and installing the crown is done precisely with this machine.



# 5

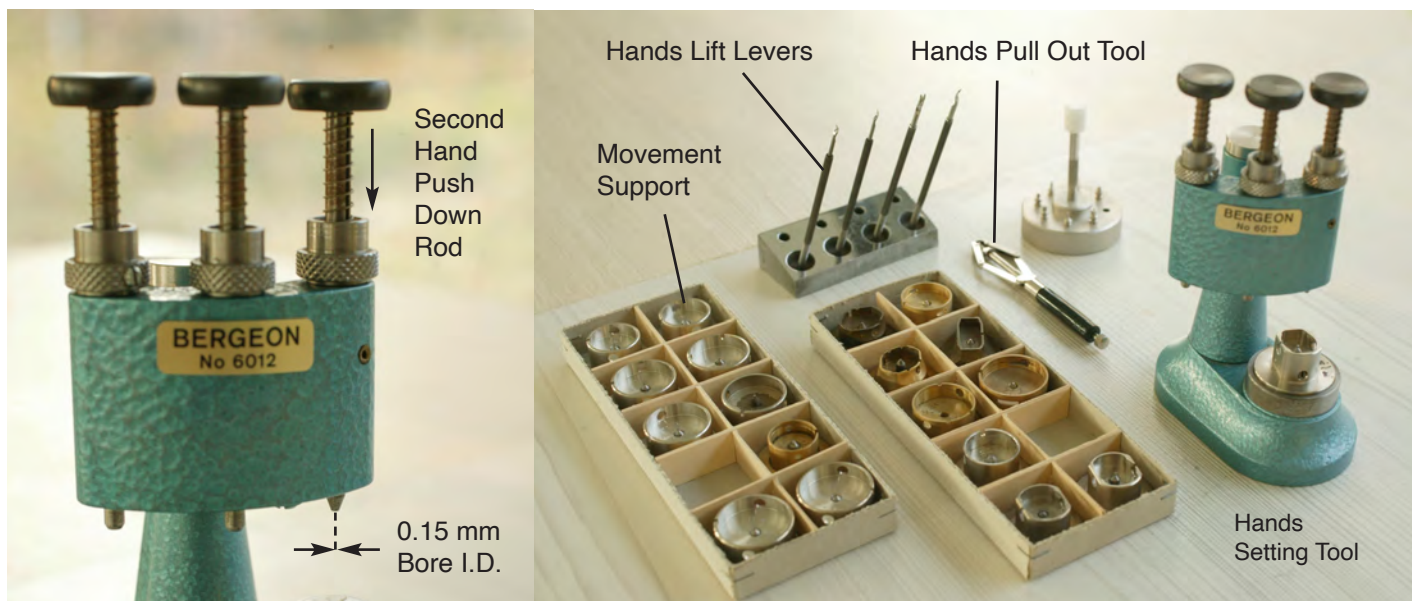
## The Hands

The hands are the main means to tell time but also if designed properly, the least noticed part of the watch.



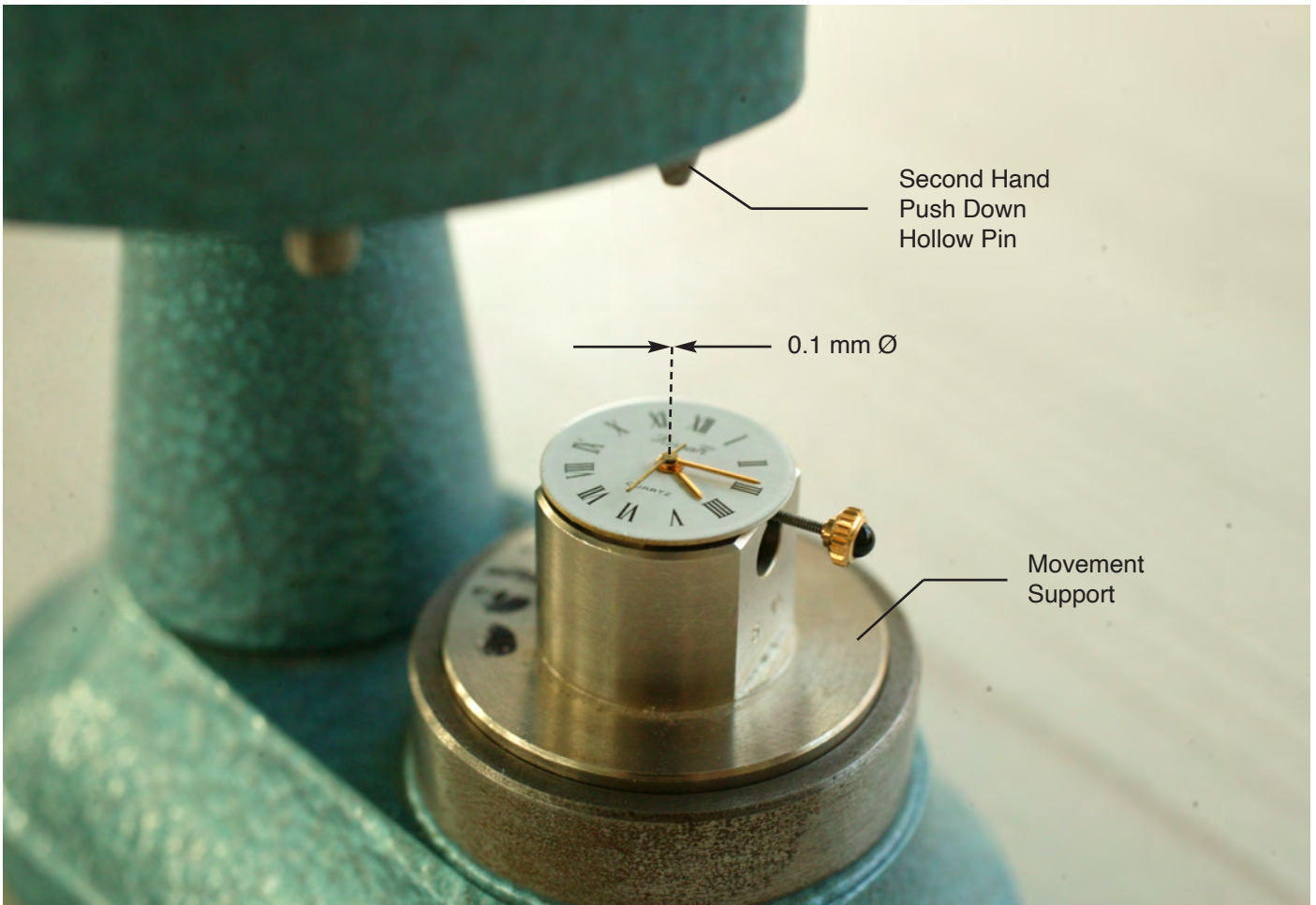
Hands fitting tool is the standard way for installing watch hands on a movement. This tool utilizes centering supports to center a variety of movement calibers on its mounting platform. Most of these centering supports are available by watch tool suppliers like Bergeon, but it is also the most common fixtures produced in the tooling department.

Movement supports (below), cannot be so tightly designed to fit onto the hands setting tool. The technician has to be able to use the hands fitting tool with moderate comfort, and not be irritated with its constant lockdown. So there has to be acceptable mechanical play into this device. At Lange Sohne, I have seen experienced watchmakers using a flat mounting platform (with no centering) for fitting hands on their chronometer watch movements. For that, they could only look and feel the centration of the push-down rods with their hands. In either case, fitting the second hands are really challenging on a movement, considering the center pin to hold the second hand measures only 0.1 mm (opposite page). This is the most vulnerable part of the watch, second to the balance wheel, and the pallet.



Hands fitting tool for installing watch hands

Specific mounting supports to fit each and every movement



Fitting the watch hands in their 1.5 mm space above the watch dial (below) is an intricate task performed with specialized tools under a magnifier or microscope. Never attempt to install the second hand without proper tooling.



In hands setting, it is necessary to set the time so both the hour, and minute hands will line up at 12 o'clock. If the dial print is exact, the rest of the hours, and minutes will fall right into place. Calendar watch hand setting is more involved.

## 6 Wrist Strap

The wrist strap is the every day means to put on and off the watch. It is the most pronounced visible part of the watch.

In watches, the rotary path of watch hands would tend to make the watch case circular, and the band going around the wrist would tend to make it rectangular. In watch design, these two forms have been combined to reach the accepted wrist watch form (below, A). I personally prefer the rectangular case (B) because it brings harmony between the two forms. In mechanical watches, the rectangular movement is also my favorite design compared to the standard circular mechanisms.

Wristbands are more difficult to implement than they are taken by consumers. It involves both the case size, and the wrist size of the person wearing it. In watch design, the strap size is usually half the diameter of the case. The watch would look out of proportion when the strap size is too large or too small (A, C). When you order watches, you'd also have to specify your wrist size.

If your wrist size is 6 to 7 inches, a 38 to 42 mm case size is recommended. If your wrist circumference is between 7 to 8 inches, a 44 to 46 mm case is recommended. The length of the wrist bands for each case size would differ accordingly. I am not so much in favor of metal watch bands but in general, the length of wrist bands ranges from small (< 34 mm) to standard (39-42 mm), to large (43-46 mm).

Inserting the wrist band into the lugs have to be done professionally, leaving no marks inside the lugs. Metal straps are more difficult to put on the lugs, sometimes leaving unnoticed scratches.





Men's watch with mechanical movement, and Farsi numerals with Zimak's logo, stainless back, and leather straps. Below, the polishing department uses polishing tools such as Lorch to polish various watch components before plating.



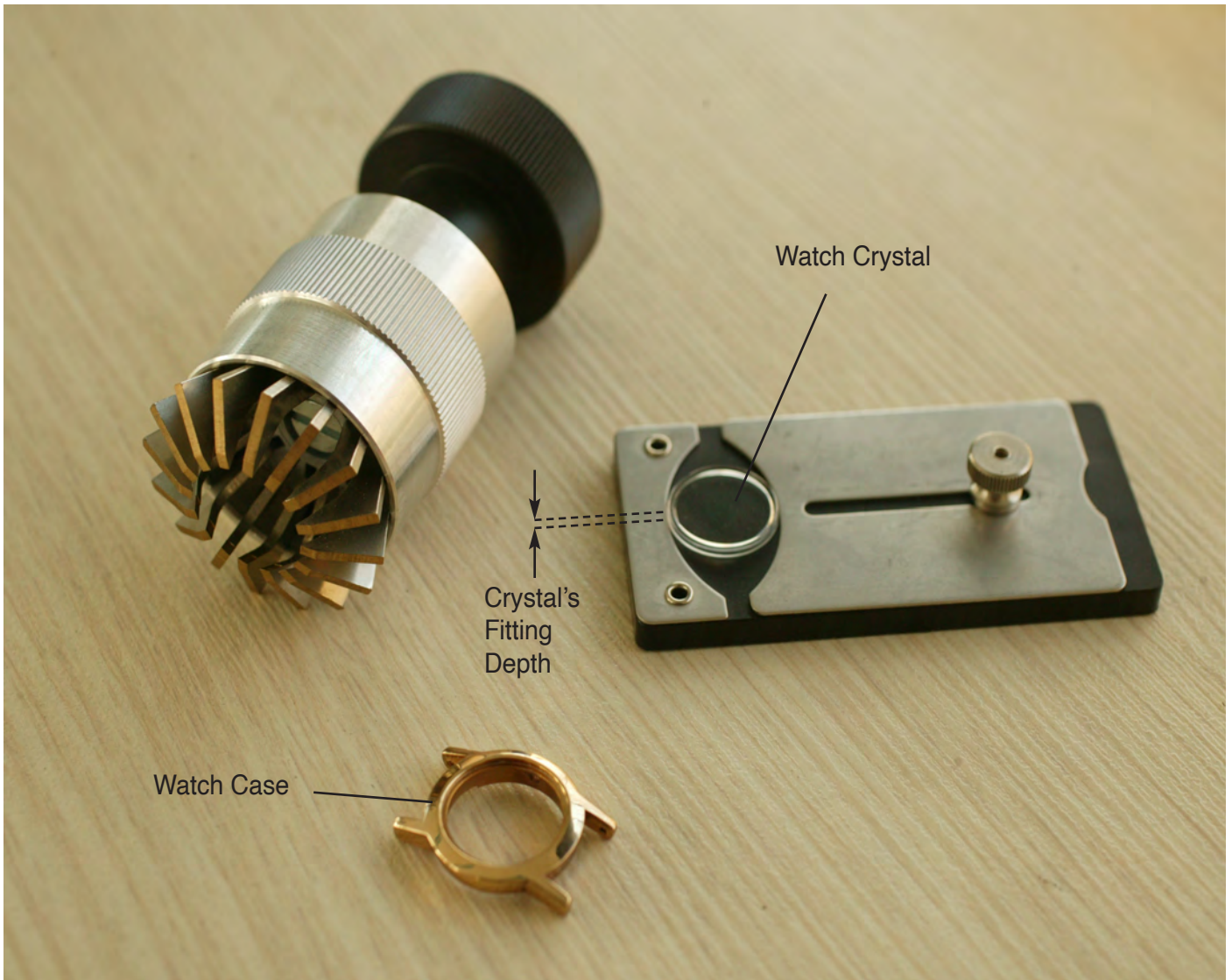
## 7 Cover Crystal

The cover crystal protects the watch dial, and its the main window to see time.

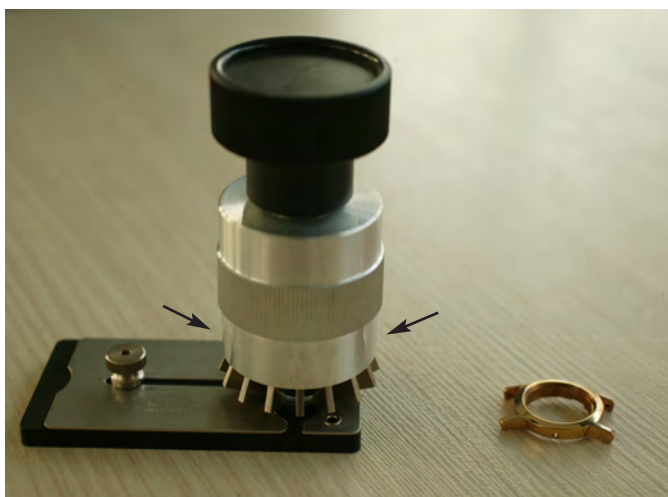


Watch crystals with designation 178 stand for 17.5 mm diameter



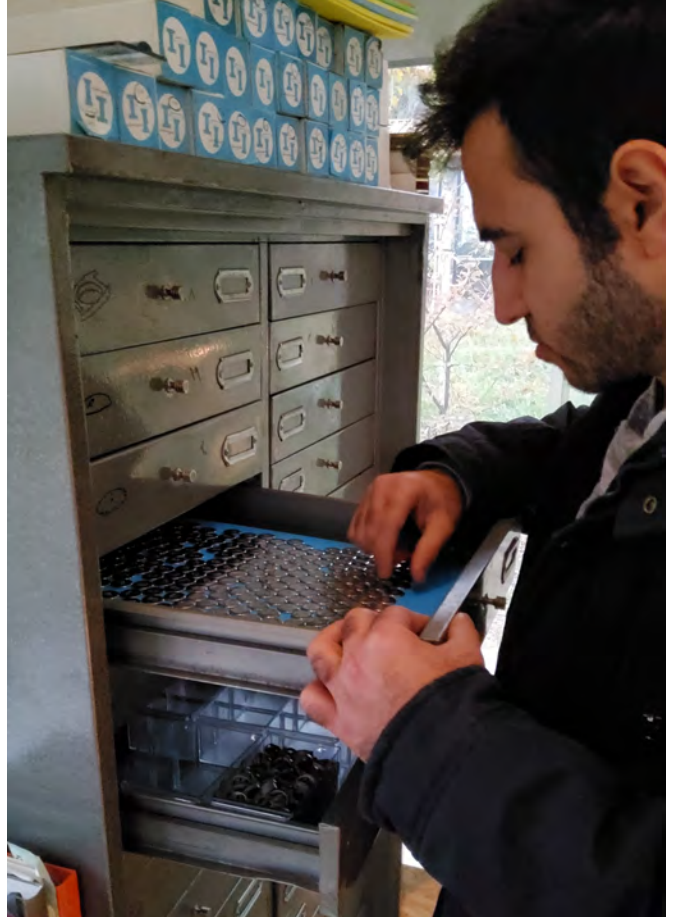


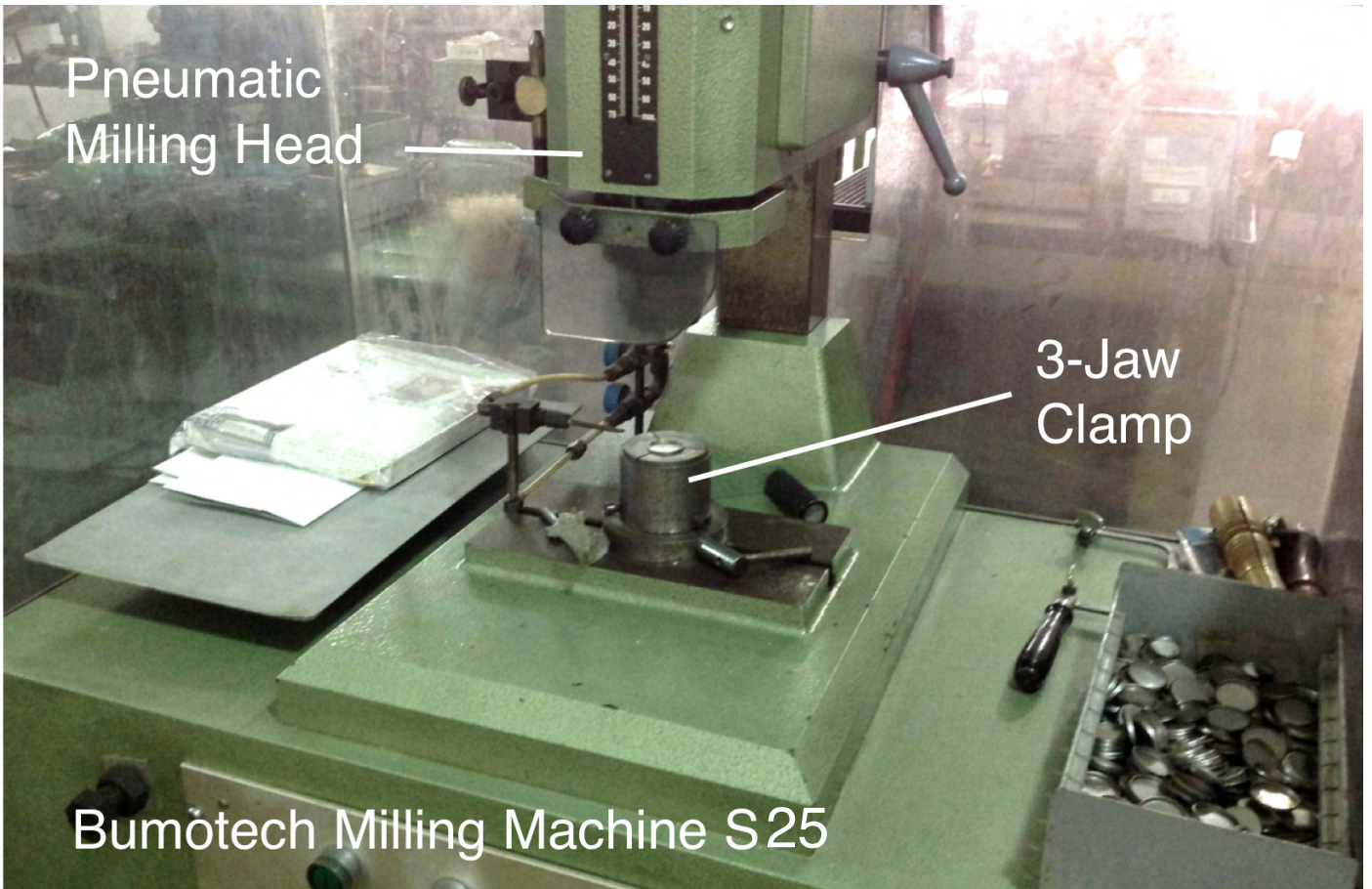
Watch cover crystals (above) are closely matched with their seating diameter on the case (below). The numeral 178 on each box stands for 1.78 mm (opposite page). This is the outer diameter of the crystal that would mount on front face of the watch, closely above the dial. For larger diameter watches, the crystal is slightly squeezed (less than 0.1 mm) for its insertion. For ladies' watches, the crystal has less tolerance to fit in its place. To install the crystal, it is grabbed from a stand-off plate (below left), then transferred to the watch case (right), and the squeeze pressure is released.



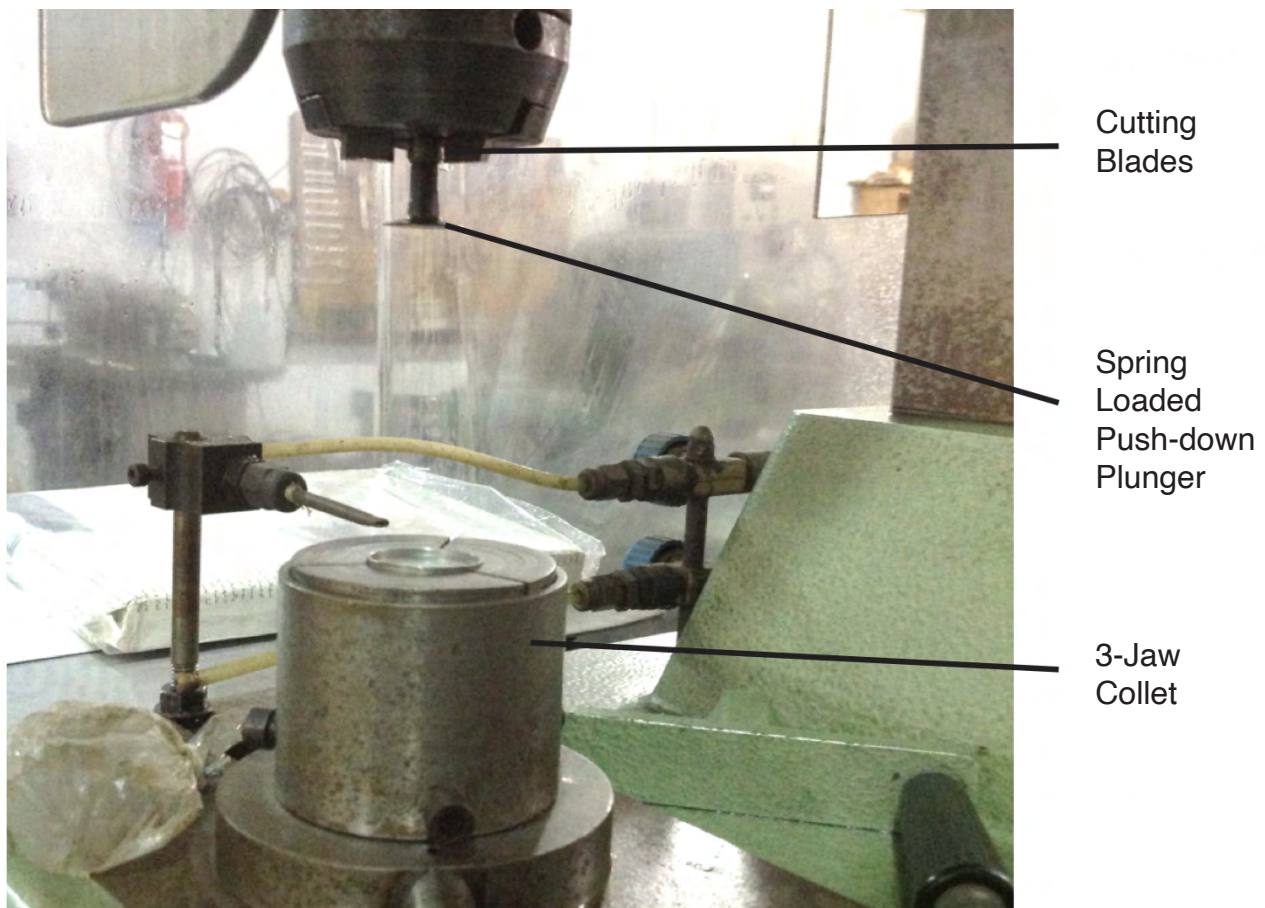
# 8 The Back Cover

Back cover is the user interface for minor repairs, and its battery replacement. It protects the watch against moisture.





Bumotec S25 performing back cover milling to fit on back of the wrist watch. The 3-jaw clamp, and spring loaded plunger prevent the back cover from flying off during machining.



## 9 From start to end

Zimak factory could produce 100% of its needs in house, using its wide range of watchmaking machines.



Various swiss machines brought in by Mr. Moharami (see page 33) reside in the tooling department, and along the main manufacturing facility (above) to make watch parts.



This watchmaking facility is spread into four closely spaced facilities: One for precision dust free assembly, the main parts production shop, the machine shop tooling department to produce special fixtures, and the painting department.



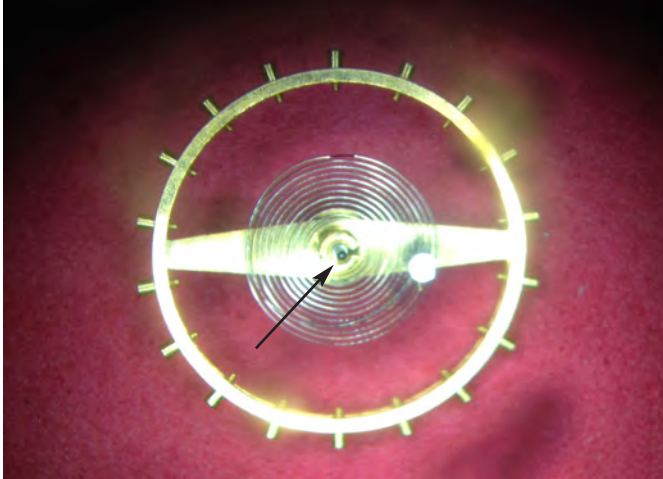
Main manufacturing facility producing watch case parts is surrounded by nearby trees, with full height windows. High tech products are made in high tech environments but in case of watchmaking, it creates more harmony to see more trees.

# Watch and Clock Repair

It's not possible to be a watchmaker without enjoying classic art, and not to participate in its maintenance, and repairs.

An important part of mechanical watches and clocks is its hand polish, requiring good understanding of metals, various protective coatings, and sufficient experience with polishing materials. The most ordinary mission in classical watchmaking is making replacement parts, using specialized tooling. When pocket watches without Inca Block (a shock absorbing washer) are dropped, they are prone to bending of balance wheel pivot, or its breakage (below, left). A pivot polisher (next page) is ideal for such tasks. Main spring replacement (below, right) is also a common repair.

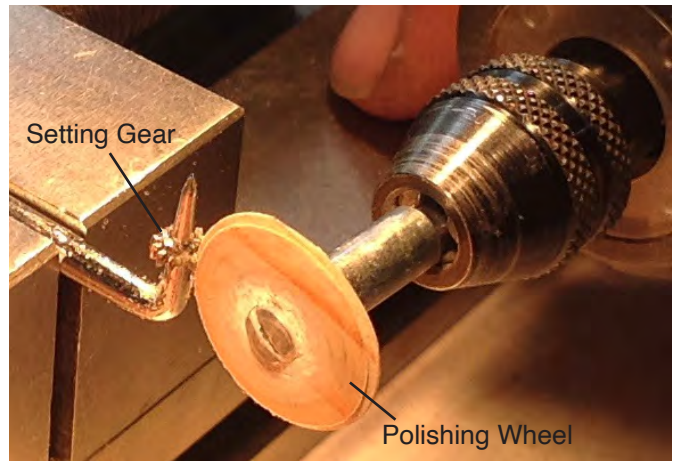
We will follow a routine clock repair on the next pages (28-29), and making a replacement pin for its pin escapement.



Center pivot of balance wheels (left) may easily break during a drop specially in pocket watches without an Inca Block.



Hand polishing the case of a pocket watch



Polishing a tiny gear by grinding wheel made of cider wood



Woslon & Powel Pendulum (P 28, 29) before polishing



Hand polishing the Woslon & Powel Pendulum



Small parts machining for desktop, and antique clocks.



Watch case modifications on Levine lathe



Jewel setting the mech plate of a wrist watch



Tightening the mounting bore of a watch hand by punching



Elina Parts Washer

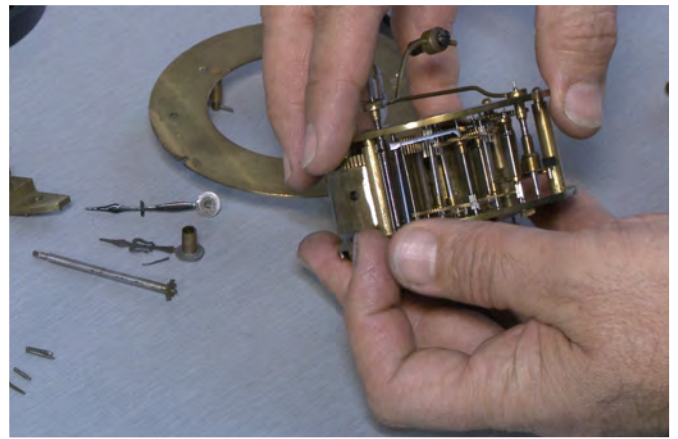


Pivot polishing the balance wheel of a pocket watch

Watchmaking takes so many special tools, and it would take discipline to actually use them. Some watchmakers unfortunately get the habit of using the tools that are nearby their workstation. It takes a good floor manager to establish professional habits among his staff to be using the right tool for the right task. Some tools are avoidable to use from time to time, such as the pivot polisher above, and specially the precision Levin lathe.



Repairing a French made Woslon & Powel clock



Dismantling the clock for complete overhaul and repair



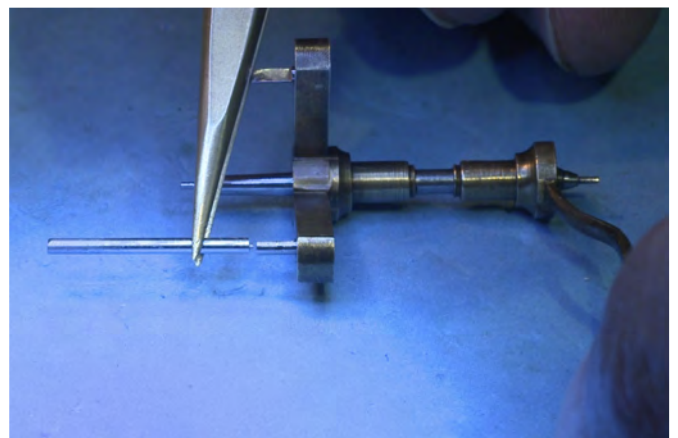
Removing the spring box for cleaning and lubrication



Remake of one of the broken spring hooks



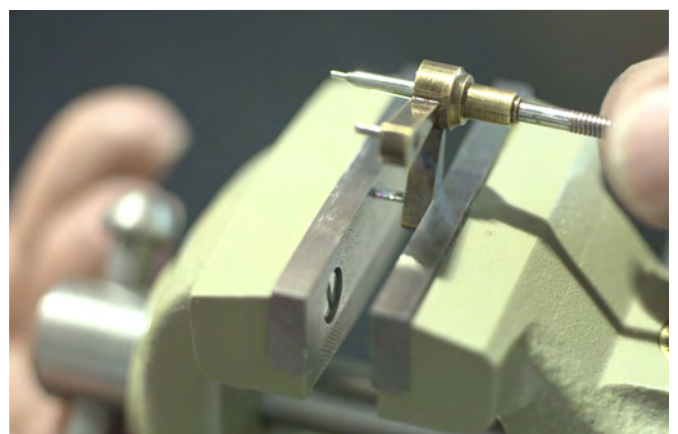
One of the pallet pins needed replacement



Pallet pin was matched with stock steel for fabrication



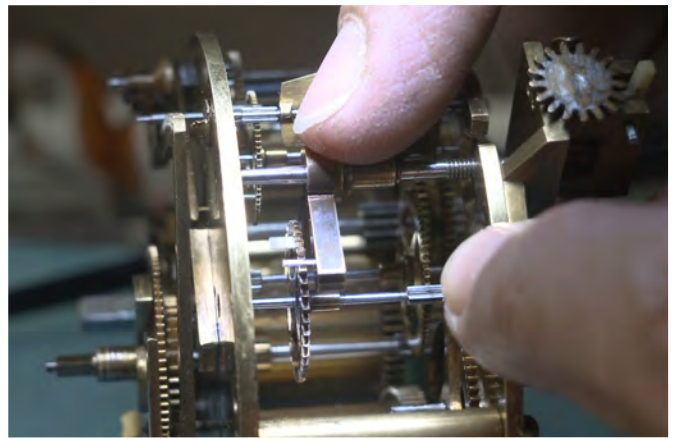
The rod was machined using Levin lathe, and mill



New pallet pin was replaced after hardenning, and anealing



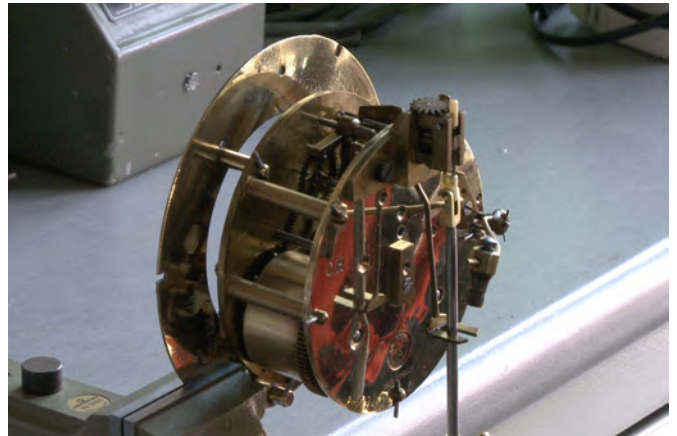
Fine polishing the pallet wheel with a sapphire file



Installing the refurbished pallet, and pallet wheel



Appropriate lubes are applied to all moving parts



Testing the clock by letting it to run for a few days



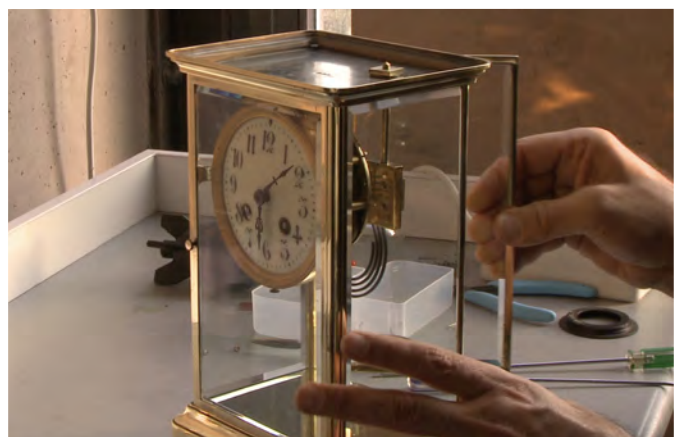
Reassembly of the dial, and the hands



Reinstalling the movement on the main housing

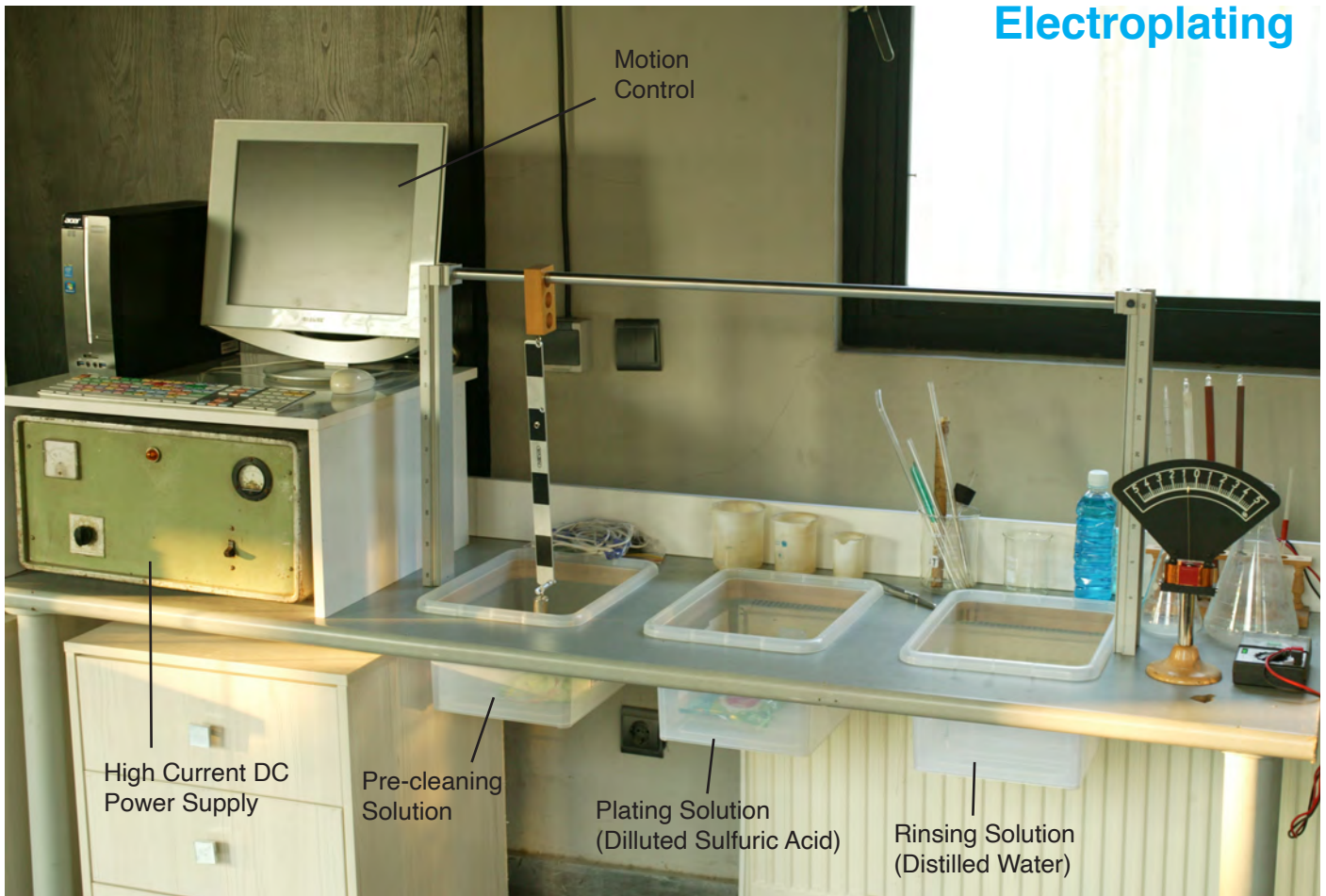


Installing the polished pendulum, and the helical chime

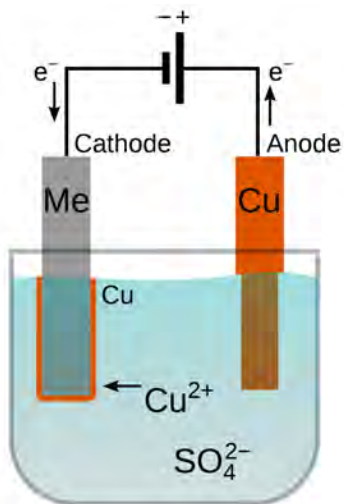


Woston & Powel clock after polishing, and full maintenance

# Electroplating

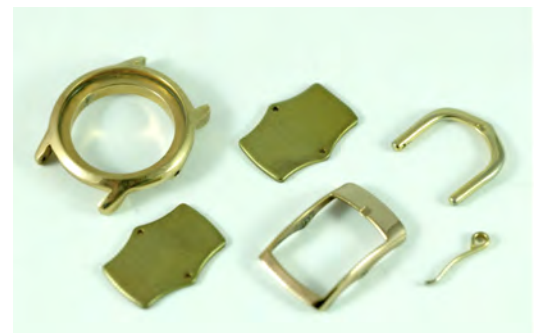


Watch cases, and all fabricated parts that are non-stainless receive a 5 micron thick coating inside plating tanks with Gold, Nickel, and other metals. Gold plated parts are further plastic coated to prolong their life against normal sweat on the wrists.



## How it works

Plating is the process which electrically conductive surfaces are coated with metals. Parts are immersed into a metal salt such as diluted Sulfuric acid, and a high current DC power supply establishes an electric current between an anode (in this case Copper, Cu), and the immersed parts (Me), hanging on a rack (Cathode). The anode is the material that is consumed during the coating. During the electro plating process, positively charged Copper ions are migrated from the surface of the Copper plates to the cathode, hence coating the parts. The longer this process takes, and higher the current, the thicker the coating. The surface area of the Anode must be higher than the total surface of the parts being coated.



## A tribute to Rostam Moharami: Handing off the Torch By Ali Afshari

Iran has had many watchmakers in its history, but very few has had the opportunity to be educated in Swiss academia. This story is about a passionate watchmaker who emerged from a small town in Iran to enter one of the most prestigious watchmaking institutions in Switzerland, and working at factories like Omega, etc.

Rostam Moharami had spent most of his youth in small city of Kashan, and he fell in love with watchmaking at an early age. He realized he first had to learn to speak French, and then he had to move to Switzerland to learn this trade. His mother was a native of Kashan, and his father was from City of Tabriz, serving the government during the Shah. After his father was sent to Tabriz on a long assignment, Rostam, and his mother moved to Tehran so he could continue his schooling there. "The first thing I did was to visit Swiss consulate to see if they would grant me a visa. There was a nice young lady working there, and she said she'll help me if I would only speak French when I visited her, and I agreed. During that time, I had found work at a small watch repair shop, and was taking night classes to learn French. It was in that school, that I started meeting some very influential people like Rouhollah Khaleghi, the most famous musician of the time, and Ali Tehrani the famous Tunbak (tabla) master. I told Mr. Khaleghi that I wasn't interested in music but he still offered to teach me French". With his beginner French, and little watch repair experience, Moharami began writing letters to Swiss watch companies to see if they would recruit him. One of them eventually offered him an entry position.

"The lady working at the Swiss embassy wrote a hand note which I couldn't read so well, and asked me to go visit somebody at Swiss air, who could help me get a discounted ticket. He read the hand note, and said he had won two free tickets, and could give me one at half price. What he eventually did was he said: "Pay me back later after you finish your school, and return." She had also told me there was a watchmaking school in city of Biel Bienne, Switzerland that I could start attending." Biel Bienne was actually headquarters to Rolex, and Omega, and Moharami had no idea he would even-



Rostam Moharami, now retired, recalls his watchmaking career from going to Switzerland to working at Omega.



Shokufeh Tavakoli, Moharami's wife, was the technical support at Zimak factory throughout its operation.

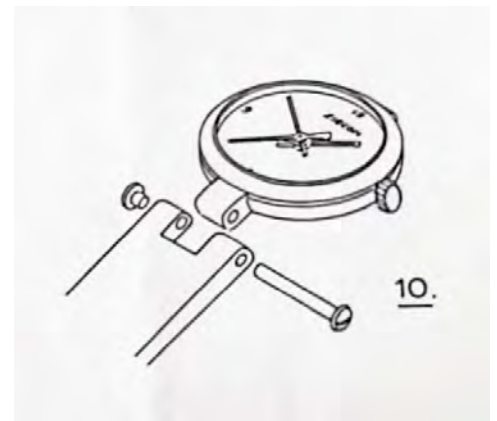
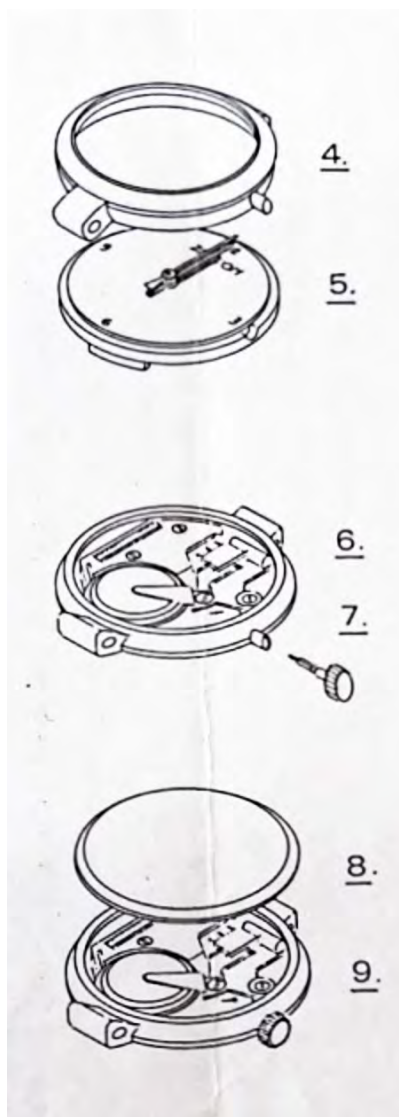
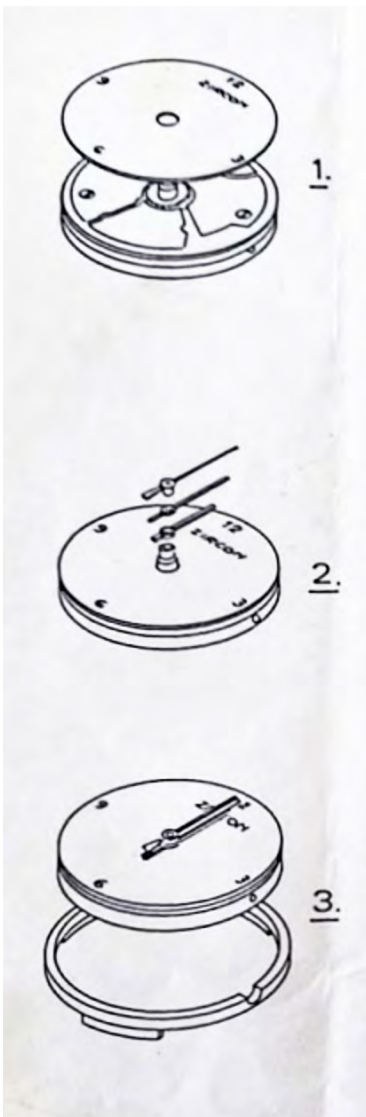


Hotel Elite in Biel Bienne, Switzerland

usually work there. "So I got a free ticket from Swiss air, and the money I had saved by selling three small rugs my mother had weaved for my trip, but I still had no place to stay. The lady at the Swiss embassy suggested that I go talk to a fellow who was the hotel manager at Elite hotel in Biel Bienne. When I arrived there, the manager asked me what my plans were, and I explained I was a student, and I was there to learn French, and to learn watchmaking. He



Rostam Moharami was a graduate of Ecole Holoragy School in city of Biel Bienne. His most influential professor was Emil Golay who taught him everything he needed to know about watchmaking. Emile Golay later came to Iran to visit his factory, and was amazed of what he had accomplished. Then he asked what do you do for fun around here other than working? Then they all went sight seeing together.



## The Design

Elements of watch design has been through many years to reach its current form. The watch case itself has the circular shape dictated by the 360° rotation of its hands.

The wrist strap, on the other hand, has the very common simple form always being a long rectangle. Many designers has tried to change this form but have always gone back to it.

So the wrist watch is simply a combination of a long recatangle intersecting a circle. The quartz watch has followed the same form. It would take someone from outside the industry, a new comer to charge its widely accepted form.

said that's great. Then I'll give you the room upstairs below the cellar, and we won't charge you anything! He asked me if I had money for food, and I said yes I did. Months passed, and I was so overwhelmed with what I was learning that I felt no sense of time while attending the watchmaking school. The girls at their cafe were giving me free breakfasts. I asked them why they weren't charging me, and they said they were just sharing their own food with me."

Moharmi eventually finished his schooling in 1975, and began working at several watch companies like Omega, and started saving all his money. Like everyone at that time who had left his homeland, he kept visiting back home, and wondered if he could open his own factory there. He eventually did return, selling everything he owned in Swiss Franks to raise money to purchase the machines he needed. He then loaded them on trucks to transport them to Iran.

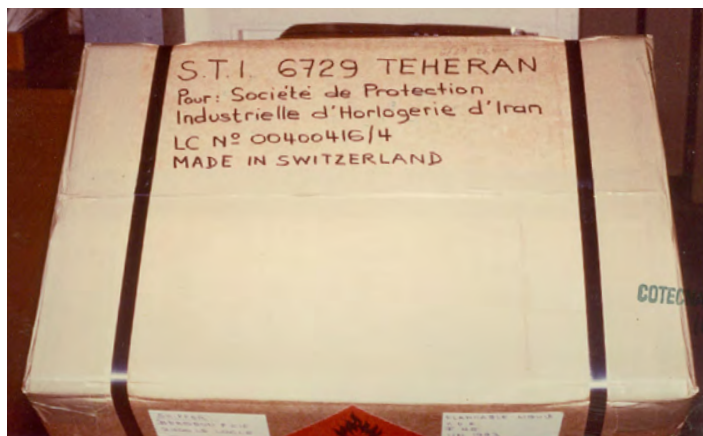
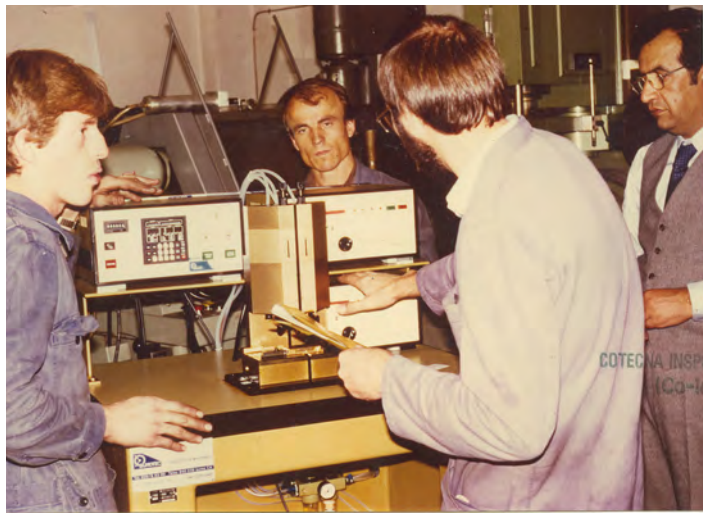
## Transporting the Machines

Back 35 years ago, it was much easier to import machinery to Iran because many less sanctions were imposed (I think toothpicks are still ok!). Mr. Moharami's trucks were stopped at the European border, but all he had to do was to go back to the head of his school, to get a letter stating those machines were for watchmaking. He actually had more problems getting them inside Iran than getting them out of Switzerland. At Iranian customs, he was asked why watchmaking? Why not just buy them! He eventually managed to pay off customs, and arrived at an industrial park in the city of Ghazvin, 140 kilometers west of Tehran. It had taken him two and a half months to transport the machines, and took him another year to start using them.

## Zimak Factory

The factory was officially opened by minister of Industry Mr. Nematzadeh, who spent two hours at the factory watching the entire process of watchmaking. It started with 25 female employees trained to run the 50 machines with a capacity to produce 2000 watches per day. He named his brand "Zimak". This is the Persian abbreviation for: "Elegant Wrist ware of Ancient Persia".

Shokufeh Tavakoli (Moharami's wife), started working at the factory in 1992. She was the operations manager at Zimak, and was the technical back up to keep the machines running. She recalls their main customers were large companies, and banks who gave watches with their own logo to their employees. "The orders ranged from 3000 to 30,000 watches that kept us busy, increasing our staff to 35 people. The orders gradually dropped with illegal imports from China, causing the prices to drop, and Moharami's persistence to manufacture watches in the factory instead of relabeling them from China for a cheaper price."



“We coated watches with Gold, Nickel, and Silver with a 5 micron coating. In case of Gold we also coated them with a plastic coating called Satine. This coating protected the Gold from harmful sweat, and helped it last more than 5 years.

I married Mr. Moharami after 8 years of working there. The working atmosphere was so friendly, and it was such fun, and innovative environment. We developed strong family bonds, and still are in contact, and visit each other after the factory's shot down.”

## Zimak Factory Today

It's a classic conclusion similar to George Daniel's story in Britan, who donated his shop to his apprentice Roger Smith, to continue his work. Mr Moharami donated his entire factory to a group of students to carry the torch. Watchmaking is a long-term commitment, and requires a huge tooling capital. Giving it all away to an apprentice is like giving birth to a newly born child with all those toys around him or her to play with, and I'm not joking.

I've never heard of opticians giving away their factory to a group of students so they would contribute to the cause. Watchmakers do. Watchmaking is just a small part of micro-mechanics, but they have had the kind of teachers that the rest of us seem to have dropped out. If you just recall what happened during the 80's, with the emergence of the Quartz watch, and how mechanical watches still managed to survive; The camera industry with all its glory, with its Hasselblad left on the moon, gave it all up as soon as digital age came along. Even Leica fans saw their great guru taking a nap.

We'd really miss out in life by lacking genuinely influential teachers. When a student keeps quoting: “My teacher said so and so...”, what he/she's really saying is: “I didn't really get it. My teacher knew, but he/she failed to teach me.” We don't empower students to think for their own. Teaching how to think can begin with a humble padding on the student's shoulder, and saying: “You really could understand this better than I do”. The student wouldn't really learn if they feel you are lying to them.

The secret of giving, and receiving such teachings is so vulnerable in its nature. In “Les Misérables”, the candle sticks the priest gives to Jean Valjean is with the hopes that he will understand it. For that, he chooses the most vulnerable being he could find. “Charlie and the chocolate factory” touches on the same exact point. Only someone who doesn't want to sell off his watchmaking factory understands what it's for.

Not everyone who opens a genuine watch for the first time, would see the art form to touch their lives. Only someone like my friend Coung Dang, who spent the rest of his life learning how to gently touch it without harm, would become a watchmaker. The watch itself teaches those who know how to receive it. It's like a mother putting her baby in a basket, and letting go of it in the Nile river, and you'd be the one receiving it. Watchmakers don't find any place else they could feel that way.



Moharami overlooking his watchmaking factory in 1990



Zimak company managers, Moharami seated in white coat



Zimak factory received cover page on this 1998 issue of Skill magazine. At the time, 25 women worked at the factory.

## Connecting to Grassroots

I have always wondered why the eastern world has fallen behind in technology. Even to create their traditional handcrafts, people of middle east have been competing in an uneven playing field with the rest of the world. This is why people like Mr. Moharami who studied in Europe, and decided to bring back their tools with them, have done far more than they could imagine.

Khalil Gibran, Ighbal Lahori (right), Fereydoun Moshiri, and many others weren't engineers but they formed the modern intellect towards scientific advancement better than those in the field. Being raised in Middle East's deficiency in science labs, and having seen the rest of the world in my life, it couldn't be better expressed than this poem by Ighbal Lahori:

So blessed is a bird who has not seen a cage,  
more pleasant if she has escaped one with rage.  
They cut off my wings, unlocked the doors,  
how free is a bird without her wings?

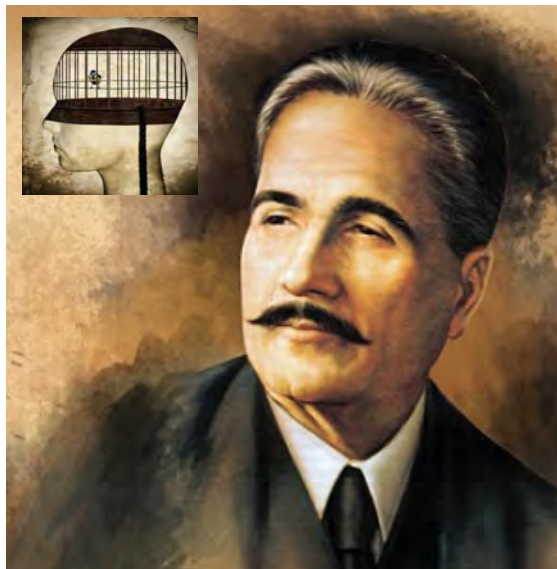
Ighbal studied philosophy in Cambridge, and in Munich. His doctorate thesis in 1907 was Development of Metaphysics in Persia. He had never set a foot on Iran but he devoted a huge collection of his poems to Farsi literature. He noted while the western world was advancing in sciences, the eastern world had been seeking secrets of the spiritual path, and love. "Scientific knowledge would lose its way without love, and love alone could not sustain itself without knowledge". He believed: "If the east caught up with the sciences, it would sculpture a new world". Ighbal's best known work is Reconstruction of Islamic Thought, published in 1930. Like Gandhi, he was a practicing lawyer, and author. He fought the colonial rule to liberate India from the British. Gandhi's last wish was to reunite India, and Pakistan. He said: "The only enemy whom we have to fight is within us".

Here's the translation of the "Wolf" poem By Fereydoun Moshiri

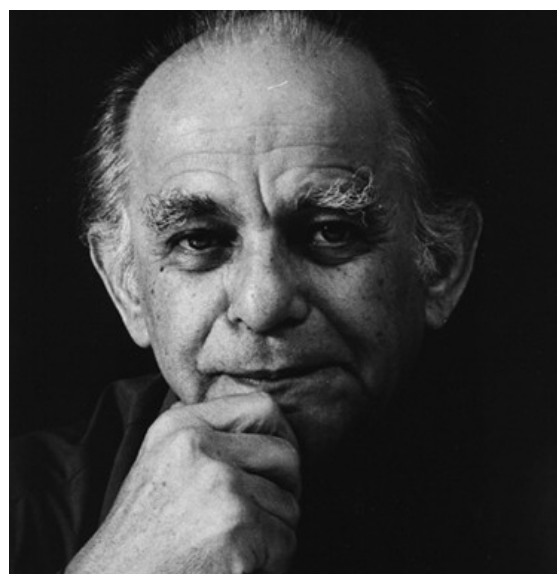
A tenacious wolf, said a wise man once,  
Is hidden deep within each of us.  
Hence, an immense daily struggle is ongoing,  
Between the wolf and the human being.  
Might alone will not this wolf subdue,  
One with intellect would know what to do.  
Many a man, weak and grieved,  
Have their wolves by the throat seized.

And, many a man, courageous and strong,  
Have been trapped in their wolves' claws for long.  
Whoever defeats his wolf, gradually,  
Becomes a wholesome man, eventually.  
And, one who's always defeated by his wolf,  
May appear to be a human, but he's a wolf!  
And, one with whose wolf he will conspire,  
Wolf-like nature he will acquire.

When you're young, your wolf's life you must take,  
To let him grow old with you is a grave mistake.  
Even a lion of a man when he's old,  
Is no match for a wolf who's grown old.  
Whenever people tear each other apart,  
The wolves are their guide and steward.  
Why humans are in so much pain?



Ighbal Lahori, India 1877-1938



Fereydoun Moshiri, Iran 1926-2000



Persian Calligraphy for watch dial, and the case

Because it's their wolves who have the reign.  
 And, tyrants who keep one another in confidence,  
 Their wolves are each other's acquaintance.  
 Alliance of the wolves, estrangement of the men,  
 Of this strange state, to whom may one complain?

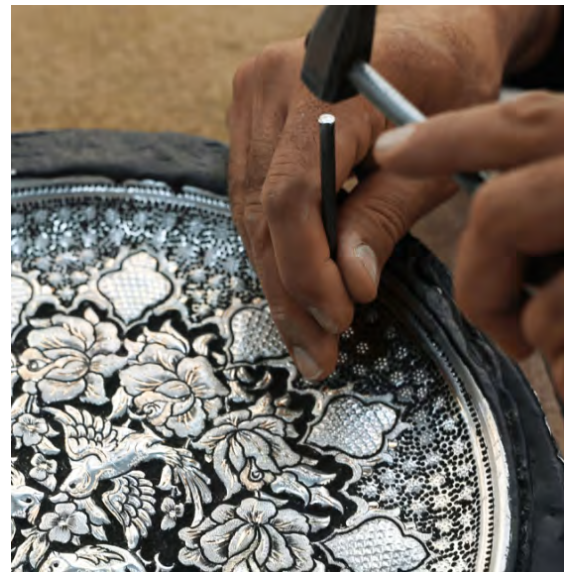
In his "Master's Touch" poem, Moshiri gives an old musician's story who lived in despair. I found no translation for this poem so I'll give it a shot myself, just because a weak translation is better than nothing at all. Persian Tar is a traditional musical instrument that is entirely handmade. "Yahya's Tar" gained legendary fame for its maker broke it to pieces if it didn't sound right. Here's "Master's Touch":

An old musician in deprivation,  
 had concealed himself in isolation.  
 He had no worthy possessions,  
 to exchange for food, and sustenance.  
 Nothing but his old instrument,  
 to sell in market for his nourishment.  
 It had collected dust for ages,  
 hanging alone on empty hedges.  
 Its strings were loose, untouched,  
 drawn into deep silence in fear of night watch.

A seller put the old instrument for auction,  
 starting off at 2 dinars for motivation  
 As he pushed to get higher bids,  
 the bids hardly went up to 3 dinars.  
 The instrument had lost its appeal,  
 nobody offered to make a deal.  
 The musician fell into deep sadness,  
 heartbroken for their indifference.  
 He picked it up with trembling hands,  
 cleaned off the dust with his hands.

For too long its strings were left alone,  
 but he managed to bring them to tone.  
 While he united with his old friend,  
 the doors of heavens began to bend.  
 Two old friends raised in poverty,  
 joined hands with unexpected novelty.  
 They broke their long silence,  
 cried out their painful experience.  
 So beautiful, so swift, so soon,  
 all passers stopped to hear their tune.  
 Embracing their reunified treasure,  
 hearts were filled with pleasure.

Music so pleasing to the ears,  
 it brought some listeners to tears.  
 Wanting to seize the moment,  
 hands reached to buy his instrument.  
 A thousand cried the seller twill be sold,  
 the price reached much higher, three-fold.  
 Remarkably the impoverished musician,  
 would not depart from his companion.  
 He didn't sell his talent as commodity,  
 his worth high-ranked in humanity.  
 He prevailed his triumph with confidence  
 his defiance made all the difference.  
 When effort joins hands with aptitude,  
 the whole world is yours in magnitude



"Ghalam Zani" (metal engraving) for watch case



"Khatam" wood covering for watch boxes



"Mina Kari" (baked ceramic) for watch dials

Inside the heartbeat of middle east, one could look beyond the violence, and politics to see people's struggle for self-determination to break out from their cage. This is what all their intellectual thinkers, philosophers, lawyers, and poets have been saying for at least a century. Poetry has been the most progressive way for middle east to put these into words. Watchmaking is perhaps one of the ways the middle east could regain its forgotten heritage.

In Iran, there used to be finely crafted metal engravings, finely weaved silk carpets, and beautifully hand carved musical instruments. Today, they are all becoming abandoned because of the so-called china imports but it's much deeper than that. Talented artists no longer find good pay for their work. Watchmaking, being so small in size, could draw, and employ those declining skills. High quality handmade watches would start trade relationships between countries, and genuine trade would bring back dialog between nations. Genuine dialog then brings about lasting world peace. That's what those thinkers have been saying all along. As Bertrand Russell once said: "Love is wise, and hatred is foolish in this world".

I watched a movie on the plane that resonated so much with me: "The distinguished Citizen" or "El Ciudadano Ilustre" in Spanish, which Oscar Martinez won the best actor for in Venice film Festival. The plot is about the recipient of the Nobel Prize for Literature, who has been living in Europe for decades, accepts an invitation from his hometown in Argentina to receive a prize. In his country, the protagonist finds both similarities and irreconcilable differences with the people of his hometown. A local TV invites him for an interview but they constantly interrupted him to sell a certain brand of shampoo!

People who return to their homeland in middle east don't get any type of reception at all, and this is mostly cultural, not political. That's why those who go back find no easy route to reconnect with their people at grassroots level. The East, and West keep moving forward in their separate ways, watching each other through TV sets. It's ironic that nations could readily find the solution to their own dark side by just interacting with one another, but politicians obscure it to do so. As Mark Twain said: "If you don't read the newspaper, you are uniformed. If you do read the newspaper, then you are misinformed".

In spite of all these harsh realities, here's an example of someone making that connection with his own people, and in return, many of the traditional arts, and handcrafts that were diminishing in Iran are now articulating themselves through the art of watchmaking. This is one way that Iranians could claim the world would be lacking something without them. Maybe it wouldn't be a bad idea to engrave watches with Persian poems, to recall a rich history the world seems to forget.

One of my classmates at Ohlone college said to me: "Why do you say you couldn't move a piece of your antique furniture to Iran? My teacher, and his wife just shipped all their household belongings, and furniture there". I asked him to look into it. He came back two days later, and said: "Oh, it's Abu Dhabi, isn't it the same?!"



Persian rug design for watch dial, and the case



"Moaragh' art (wood carving) for the watch box



Persian "Minature" painting for watch dials

