

# The Clock Book

The Mechanica M1

Precision Pendulum Clock

Construction and Technology

Build your own personal  
piece of history



Maple



Walnut



Black Lacquer



Cherry

Dear Fellow Clockmakers!

I congratulate you on obtaining this outstanding clock kit. I am confident that when you assemble your Mechanica M1 precision pendulum clock you will experience the fascination of a classic technology – clockmaking.

In today's hectic times, which are dominated by computers and electronic technology, more and more people love mechanical clocks. The steady tick and the calming swing of the pendulum give every room a relaxing atmosphere. The fascination of the visible mechanism made me think of the Latin name 'Mechanica'.

In recent times, more and more clocklovers have asked Erwin Sattler of Munich for gears, pendulums or cases from its range of clocks. The company has always had to refuse because it will never sell an Erwin Sattler clock as a kit.

But I couldn't get the idea of a 'doityourself' clock for enthusiasts out of my mind. The famous company Strasser and Rhode, which produced precision clocks at the end of the 19th century, made components available to individual clockmakers.

Erwin Sattler has more than 20 years experience in building precision clocks and in that time has manufactured more than 7000 clock-movements. The company wants to foster the skills and values of classic clockmaking. In addition, it wants to further develop traditional craftsmanship making use of the new technology available today.

Company 'know how', modern CNC machinery, totally new methodology,

and the use of up-to-date materials have made this project possible.

The movement of the M1 has 87 parts and although it has the same technical quality as a Sattler Precision clock, it is designed so that even inexperienced clock enthusiasts can assemble it without difficulty.

Those who want to read more about the principles of pendulum clocks may refer to the second chapter of this book.

Precious clocks can enhance any room and be the pride of every owner; especially, in this case, when he has assembled the clock by himself.

I wish you an enjoyable experience as you assemble and regulate the clock to perform with precision.

A clock of this quality will last hundreds of years and will be passed with pride from generation to generation.

Best regards

Richard Müller



## Acknowledgements

Many, many, thanks to all who made this project possible:

Production of the entire movement:  
Clockmakers, Master Clockmakers, Engineers and  
Mechanics of Erwin Sattler OHG

Production of the case:  
The company Josef Wochner at Heiligenzimmern

Graphics:  
Tanja Baufeld, TK Design

Photos:  
Atelier Schrader, Gräfelting

Text:  
Christian Schaffer, Erwin Sattler OHG

Illustration, Text:  
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Price: 25 Euro

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# Chapter I

INSTRUCTIONS FOR  
THE MECHANICA M1



## Important information before starting

Before you start assembling your Mechanica M1, please read the following information carefully.

Your M1 is a precision pendulum clock. All the parts were produced very accurately to extremely close tolerances. It is necessary therefore to be careful when unpacking, handling and assembling the components to avoid damage. Some of the parts are delicate.

Carrying out the procedures in the order described will save unnecessary work and ensure success.

We have tried to avoid using technical terms in this manual. When the use of special terms was unavoidable, we explain them in a glossary at the end of the book. They are marked in the text with an asterisk \*.

Let's start with the case. The versions which are to have a natural wood finish are first treated with woodcare oil. Make sure the room used has good ventilation. Between uses store the oil-soaked cloth firmly closed in the jar provided. This will prevent potential combustion due to the volatile gases. The treated case takes some time to dry, so you have plenty of time to continue with the next steps.

When assembling the case, handle the glass with care to avoid possible injury.

Choose and prepare your work place carefully before continuing with the assembly of the pendulum and movement. It must be clean at all times and should have good illumination.

We clean and pack the components carefully before despatch. To avoid contamination unpack parts just before assembly. Check for damage in transit.

The packing list includes a map of the compartments of the foam packaging. Most of the bags are labelled (in German) with contents. In the following instructions each part is referred to by its name followed by the compartment number as well as the German contents label on the bag to help you confidently identify parts.

The ball bearings\* are made of stainless steel\*. To ensure very low friction they are not sealed bearings and must be kept away from dust and dirt.

For maximum durability the arbors\* are made of hardened steel and can corrode. If held with the fingers, the gears, which are gold-plated, should be touched only at the ends of the teeth. Alternatively they can be held with tweezers. If you drop a wheel, check for damage using the loupe (magnifying glass). Even slight damage to a tooth could stop the gear train from running smoothly. A damaged part must be replaced. The needle of the oil syringe can cause injury. Keep away from children.

Note also that the sharp tip of the pendulum rod, protected in transport by a brass supply, could also cause injury. The dial and the pendulum scale can be scratched easily so please be particularly careful when handling these parts.

The dial is the face of your M1.

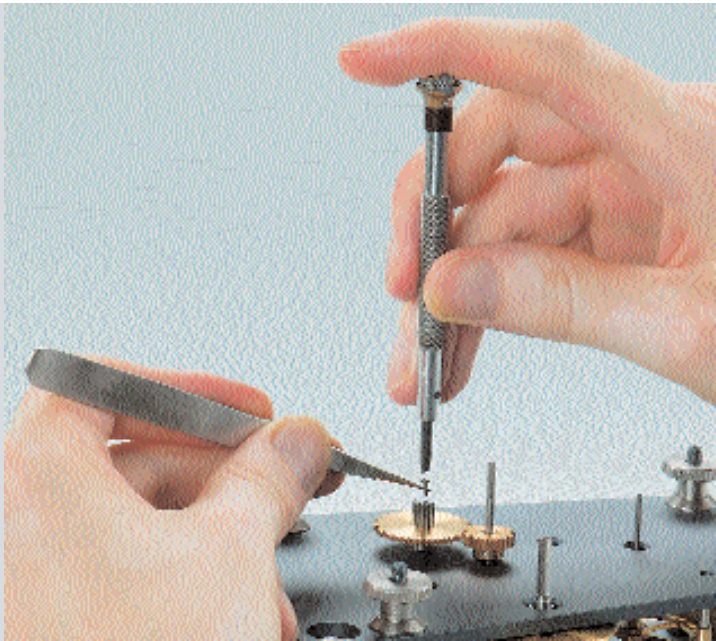


Should you have any problems regarding your precision clock M1 call us from 9am to 5pm (weekdays) at 0049-89-852090.



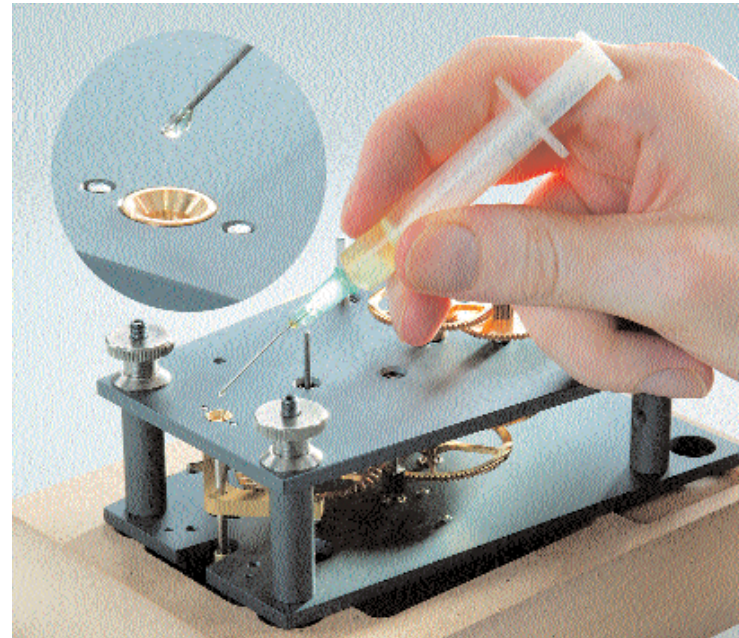
## Use of the tools

Only the simple tools provided are needed. You will gain confidence by learning to use the tools correctly and there will be less chance of damaging the components. Note how clockmakers use a screwdriver. The screw is held vertically with tweezers, the end of the screwdriver is placed in the slot or socket, held in position with the index finger and rotated with the thumb and second finger. Be very gentle. Pressure may cause the tool to slip, damaging the surface. Tighten firmly but remember that small screws require little force.



Clockmakers work like this.

The syringe is used to lubricate the pallets\*, the pulley and the pallet arbor pivots\*. Avoid over oiling. The gear train\* has ball bearings which do not need oil.



Enjoy the project and much  
success.

For correct lubrication, push the syringe piston carefully until a drop of oil appears at the tip of the needle. Now touch the drop on the place where the oil is required. You will find that there is no need for the needle itself to actually touch. Note that your hand can be rested on something to steady it.



# The Surface Finish of the Case

If you have chosen the black lacquer case you can begin the assembly immediately.

For the natural wood finishes, where surface treatment is required, the following equipment is provided:

## Tools:

- o Auro natural oil
- o polishing cloth
- o sand paper K600 or finer
- o screw driver

## Parts:

The case parts are in the bottom section of the pack. Locate the following parts for surface treatment:

- ☐ o case-back
- ☐ o bottom plate
- ☐ o cornice (upper) plate
- ☐ o two side pieces
- ☐ o top frieze
- ☐ o shelf cover with bottom frieze
- ☐ o door
- ☐ o block for the pendulum scale

Before treating the wood the door must be dismantled. The glass fits in a groove and is secured with a screwed fillet. Unlock both screws at the inner side of the upper door fillet and remove it. Pull the glass carefully from the groove and store it safely in the packaging provided. Take care when handling the glass.



The oil provided is a natural product but you should carry out the following steps in a room with good ventilation.

## PROVIDING THE NATURAL WOOD FINISH

The case of your Mechanica M1 is made from of solid wood, except the case back which is laminated and veneered for greater stability.

All cases except the black lacquer version must be treated with the wood care oil provided.

This method of surface treatment protects the wood from moisture, highlights the natural grain of the wood and enables any subsequent scratches to be repaired.

The Auro oil is linseed oil with the addition of tree resin and natural wax. It is not damaging to the environment.

Safety information: Oil your case in a well-ventilated room. Store the oil-soaked cloth in the jar provided and close it firmly to prevent the combustion of the gases produced by the linseed oil

### Let's start:

How to oil the case correctly:

Because spills or drips can be difficult to clear up after the oil has dried, protect your workplace with cardboard or paper. The parts are pre-sanded and ready to treat.

Apply the oil with the cloth provided. Treat all case parts with the oil. The wood will absorb the oil in about 20 minutes. Any oil which remains on the surface should be wiped off.

The treated parts should then be allowed to dry 12-24 hours. When the surface feels dry you should sand it very lightly because the treatment raises the wood grain a little.

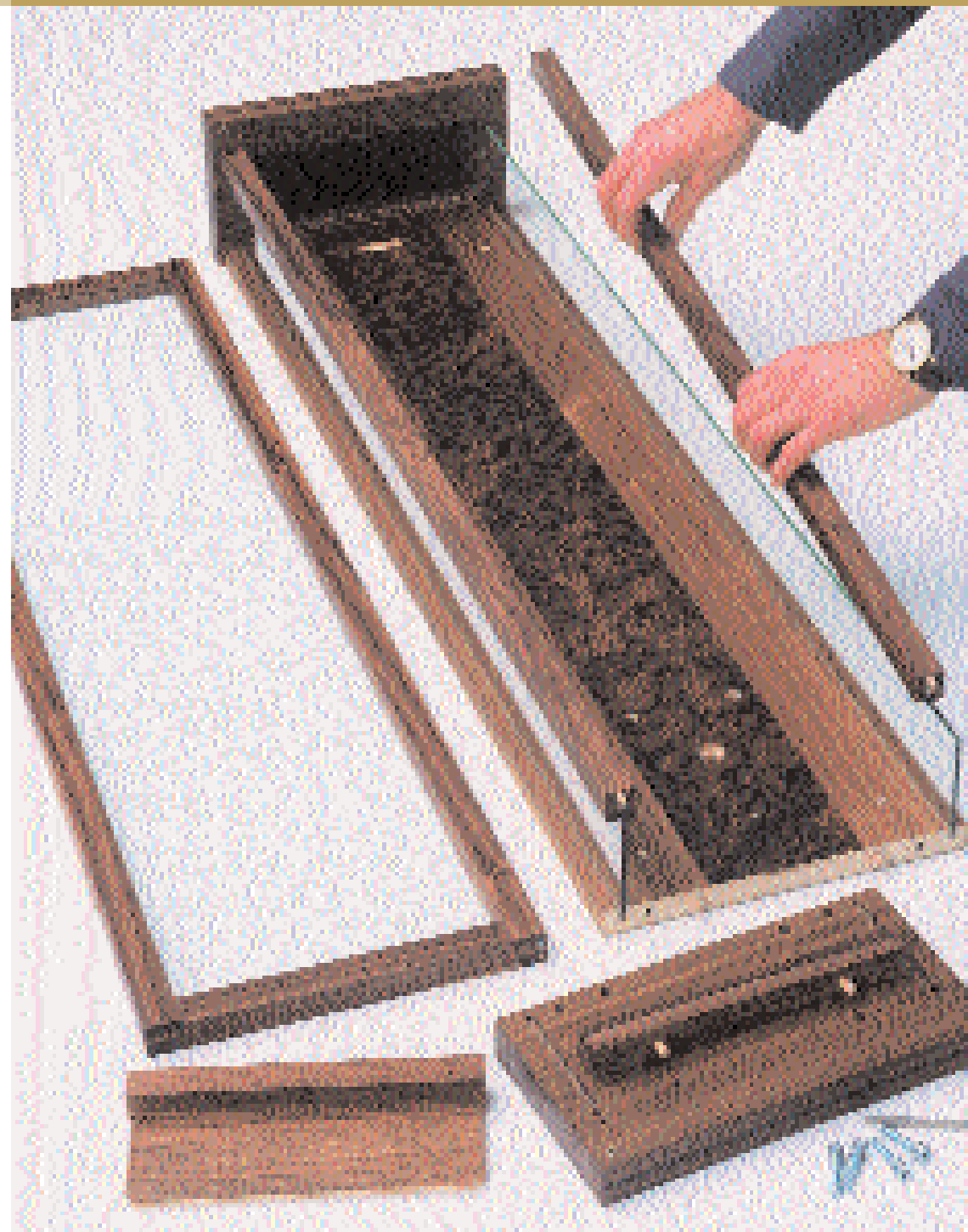
*The smoother the surface before the second oiling, the better the result.*

Note that in the second treatment less oil is required.

After this the case should dry at least 24 hours before assembling.

The surface should feel dry, not sticky. If you think the wood can absorb more oil, you may treat it a third time.

Give the case plenty of time to dry and keep it in a warm dry and ventilated place



# Assembling the Case

Assemble the case first so that you will have a safe place to put the movement when you have finished it.

## Tools:

Locate the following tools

- o screw driver
- o allen wrench 4mm
- o allen wrench 5mm
- o oil syringe

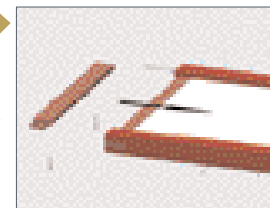
## Parts:

In addition to the oiled wooden parts the complete case consists of the following:

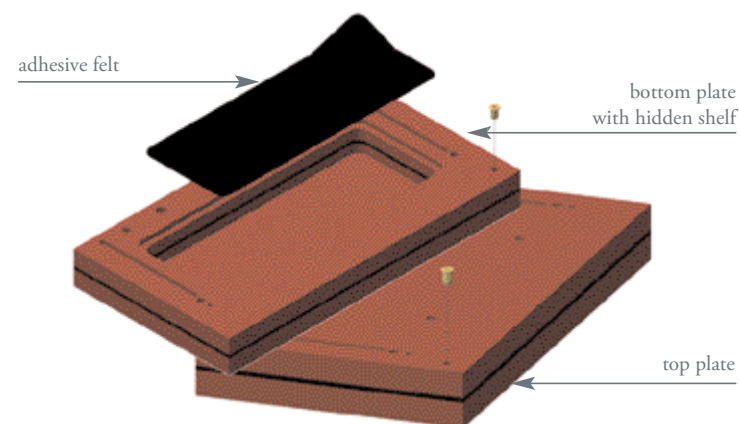
- ☐ o door glass (bottom section)
- ☐ o 2 counter sunk screws 2.5x20mm (bottom section)
- ☐ o felt inlay (bottom section)
- ☐ o 2 hinge pins (box 15)
- ☐ o 4 instrument screws 2x10mm (box 15)
- ☐ o 2 hooks (box 15)
- ☐ o 2 washers (box 15)
- ☐ o 2 hinge bushings (box 15)
- ☐ o 2 side glasses (bottom section)
- ☐ o sealing strip (box 2)
- ☐ o 8 corpus screws with washers M6x30mm (box 15)
- ☐ o pendulum scale (box 5)
- ☐ o 2 instrument screws 2x6mm (box 5)
- ☐ o 4 case adjusting screws (box 19,20)
- ☐ o pendulum cock (box 16)
- ☐ o allen screw M6x30mm (box 16)
- ☐ o washer (box 16)
- ☐ o 2 case pillars (box 12,13)
- ☐ o 2 allen screws M8x30mm (box 17)
- ☐ o 2 washers (box 17)
- ☐ o cable pillar (box 14)
- ☐ o allen screw M6x35mm (box 14)
- ☐ o washer (box 14)

Assemble the door first

Slide the door glass back into the groove it came from with the rubber damping strip in the bottom groove. Place the end fillet back into the notch. The top of the door should be aligned. Attach the fillet from behind using the two instrument screws 2.5x20mm. Push the hinge pins into the holes at the top and bottom of the door. On the opposite side of the door, screw in the two instrument screws 2x10mm until 3-4mm remain sticking out. These screws engage the hooks that will be added later so that the door can be fastened.



Prepare top and bottom plates



Push the hinge bushings into their holes in the top and bottom plate. Place a drop of oil in the bushings using the syringe. Recall the information about handling the syringe (page 15).

The adhesive felt is applied to the bottom of the hidden shelf.

Remove the protective backing, carefully position the felt, and press it down firmly.

# Assembling the Case

## Attaching the bottom plate

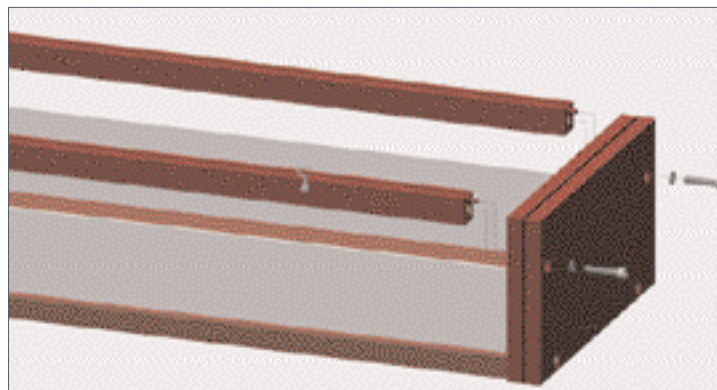
Lay the case back on your table; push the bottom plate onto the wooden plugs in the case back. Attach the bottom plate with the two allen head screws M6x30mm and the matching washers.

## Fitting the hooks

The hooks are attached to the left side piece. The holes are already predrilled. Put the spacers over the holes, then fix the hooks in place with the 2x10mm instrument screws. Do not over tighten the screws. The hooks should be free to move.

## Installing the side glasses

Place the side glasses into the grooves in the case back and bottom plate. Fit the side pieces, groove down, on the side glasses and push them along so that the wooden plugs fit into the holes in the bottom plate. Attach the side pieces and bottom plate using the socket head screws, M6x30mm, and washers.

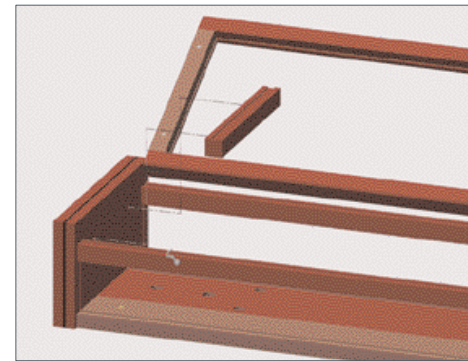


**Caution!**  
Pay attention that the side piece with the hooks is on the left side of the case

## Attaching the top plate

Put the door in position on the case. The lower hinge pin of the door must fit into the hinge bushing in the bottom plate. When positioning the top plate make sure that the upper hinge pin also fits into the bushing of the top plate. Attach the top plate using the 4 allen head screws, M6x30mm, and washers.

Now open the door and check that it moves freely.



Support the open door with a suitable object

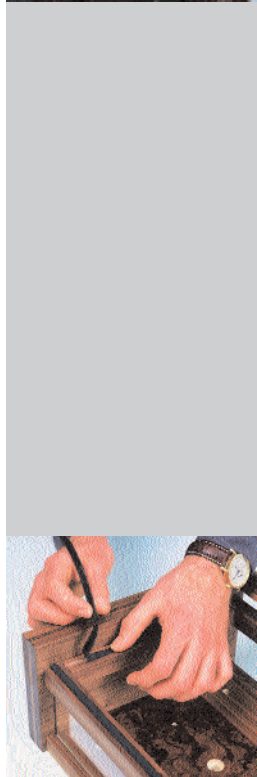
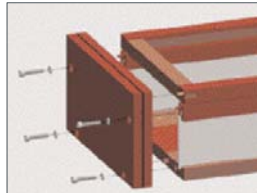
The top frieze must now be pushed into the top plate.

## Sealing the case

Fitting the seal to protect the movement from dust.

Cut the self-adhesive seal provided (box 2) into the appropriate lengths, remove the protective foil and apply the strips in the grooves of the side pieces and the top and bottom friezes.

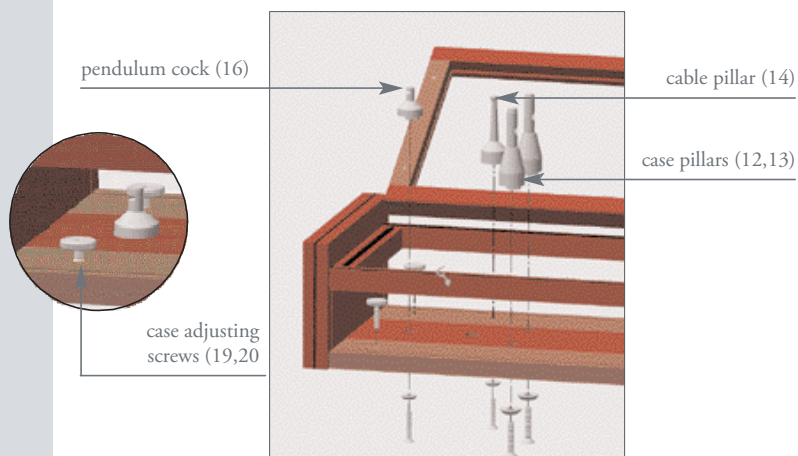
The opening of the V-shaped seal should face the inner side of the case.



# Assembling the Case

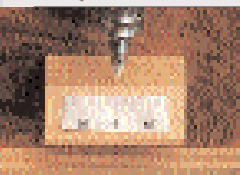
Installing the pendulum cock, case pillars and cable pillar.

The pendulum cock, case pillars and cable pillar are attached with the corresponding allen head screws. The different shapes avoid confusion. Screw the case adjusting screws into their threaded bushings.



How to install the pendulum scale

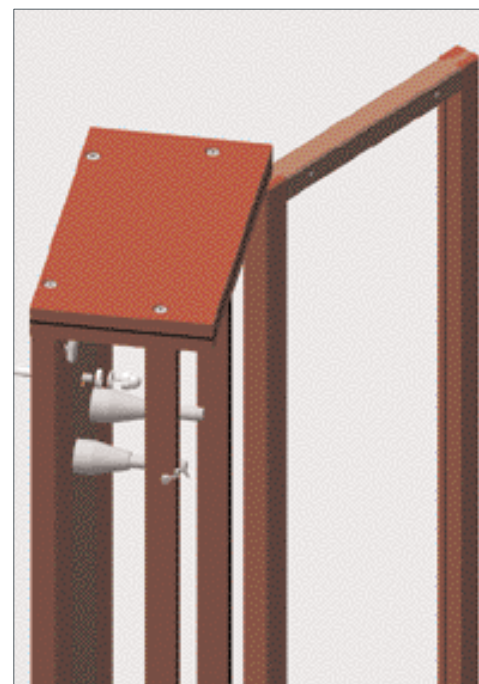
Attach the scale (5) to the scale block with the two instrument screws, 2x8mm. Push the block, with its wooden plugs, into position at the back of the case.



Choose a solid wall which can support the weight of your clock. Follow the instructions carefully to avoid damaging your case.

How to hang the case

Put the bolt-screw (18) into the wall with a suitable plug. This screw is placed at the height you want the centre of the dial to be. The thread should protrude 35mm (1.4 inches) from the wall. For the second bolt-screw (18) a second hole must be drilled exactly 780mm (30.7 inches) below the first. Hold the case on the wall with the upper case hole over the first bolt-screw, fit the



two washers (18) and tighten the cap nut. Before you level your case with the lower bolt screw we recommend assembling the pendulum so it can be used to establish the perpendicular.

Levelling the case is described on page 29



# Assembling the pendulum

 A clean working place should be available

## Tools:

For assembling the pendulum have the following tools available:

- o allen wrench 0.9mm
- o allen wrench 1.5mm

## Parts:

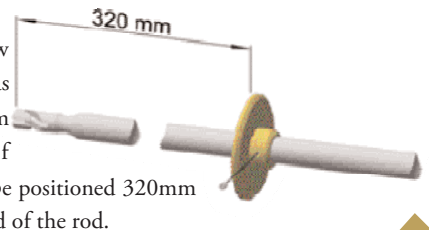
Have the pendulum parts at hand:

- ☐ o Invar pendulum rod with protective cap (33)
- ☐ o Table for fine regulation (4)
- ☐ o Beat adjustment lever (5)
- ☐ o Bushing (5)
- ☐ o Allen screw M2x12mm (5)
- ☐ o Knurled screw (5)
- ☐ o Coil spring (5)
- ☐ o Pendulum bob (1)
- ☐ o Compensation tube (6)
- ☐ o Grub screw M3x6mm (5)
- ☐ o Regulation nut (7)
- ☐ o Lock nut (7)
- ☐ o 2 Suspension springs (one is spare part)

Assembling the fine regulation table.

Fit the fine regulation table with the grub screw M2x2mm.

(The screw is already in the regulation table). The screw should face the same side as the opening of the pendulum hook (towards the back of the clock). The table should be positioned 320mm (12.6 inches) from the top end of the rod.



To avoid injury, never hold the pendulum by the regulation table.

The grub screw only clamps the table to the rod, it cannot support the full weight of the pendulum.

Installing the beat adjuster\*:

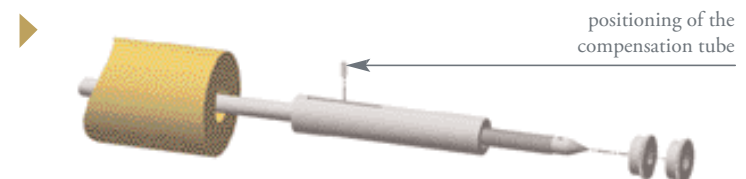


1 Put the bushing into the cross hole in the upper quarter of the pendulum rod.

2 Position the beat adjuster and attach it with the cylindrical screw inserted through the bush. 3 With the opening of the pendulum hook facing away from you, the beat adjusting lever must be on the left of the rod. The beat adjusting lever must be free to move, but not too free. Position the coil spring and the knurled screw. The screw is used to adjust the beat.

Assembling the pendulum bob and compensation tube:

Remove the protective cap. Insert the tip of the pendulum into the smaller drilling of the pendulum bob\*.

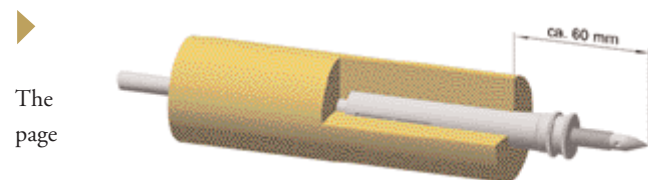


Safety information:  
When handling the pendulum rod be aware of the danger of injury from the pointed tip.

# Assembling the pendulum

With the bob further along the rod, slide the compensation tube\* on to the rod and position it with the grub screw, M3x6mm, in the elongated slot.

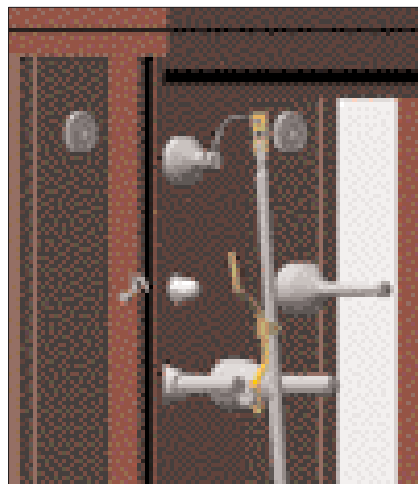
Screw on the regulation nut\* with its scale markings facing the compensation tube, add the lock nut. The pendulum bob should be positioned about 60mm (2.4 inches) from the tip of the pendulum using the rating nut.



The  
page

Installing the pendulum

Put the suspension spring\* (3) with its thin cross pin into the pendulum hook.

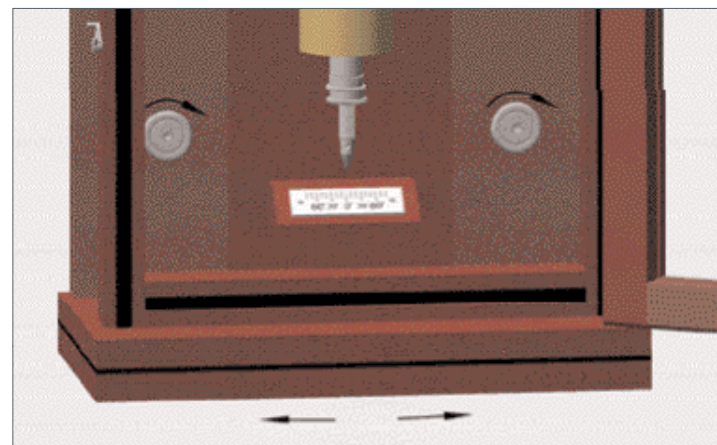


Hang the pendulum by the suspension spring in the pendulum cock with the beat adjuster facing left. Take care not to bend the suspension spring.

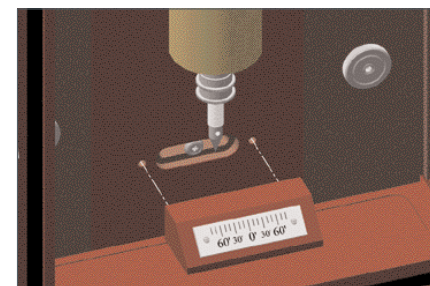
## LEVELLING THE CASE

When the pendulum is hanging in the case you can use it as a perpendicular line. Move the

base of the case side ways so that the pendulum tip points to the "0" on the pendulum scale.



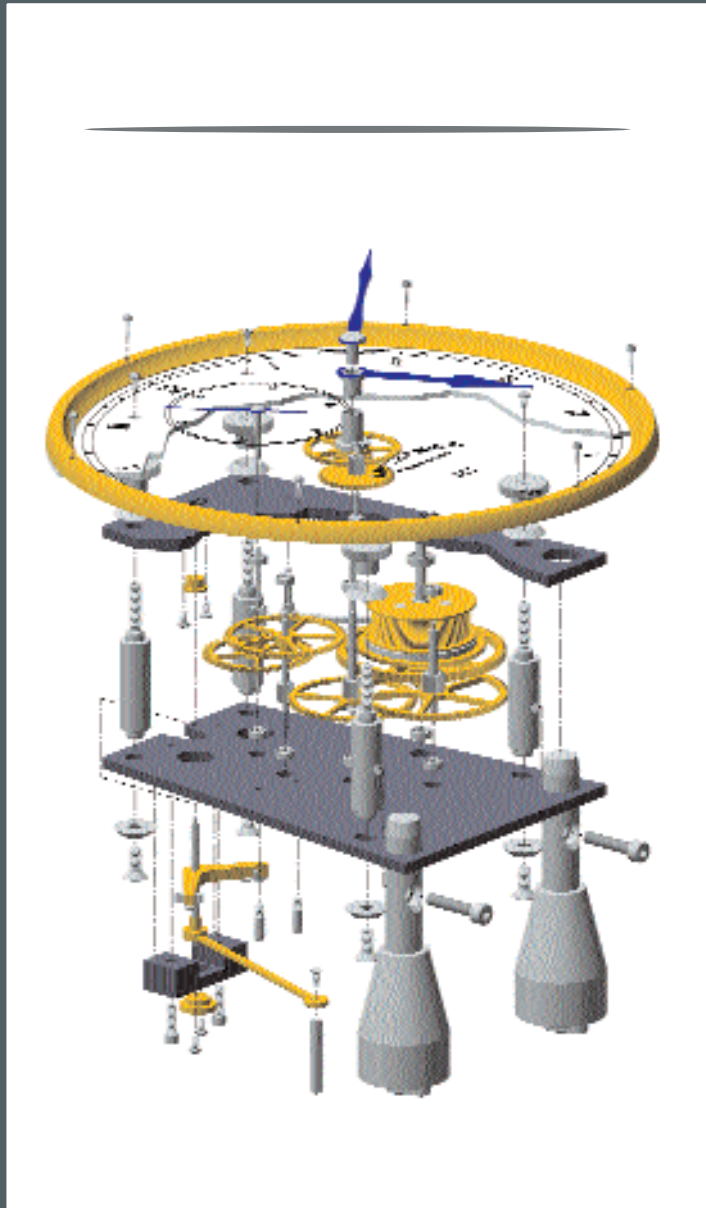
to allow for unevenness in the wall. Turn the screws clockwise so that the case has a little clearance from the wall and does not rock when pressed at any corner.



Make sure the case back remains vertical and the pendulum does not touch the case back



## Assembling the movement



Take your time and assemble the movement with concentration and care. Your working area should be clean and well illuminated.

All the components are manufactured with care. Each group of parts is packed separately. To avoid loss, dirt or damage, the bags should only be opened immediately prior to the assembly stage at which they are required.

Have the following tools available :

- ☐ o allen wrench 0.9mm (8)
- ☐ o allen wrench 1.5mm (8)
- ☐ o allen wrench 2.5mm (8)
- ☐ o allen wrench 4mm (8)
- ☐ o tweezers (8)
- ☐ o clockmaker's screwdriver (8)
- ☐ o magnifying glass (loupe) (8)
- ☐ o assembly block (2)

Tools:

The delicate parts should be stored in the compartments of the foam packaging to avoid damage and dirt.

The use of the assembly block is illustrated. To allow the assembly to proceed smoothly the instructions which follow do not include descriptions of function.

The function of the components and the way precision clocks work is described on page 64.

Note that the assembly steps should be carried out in the order they are given.

# Assembling the movement

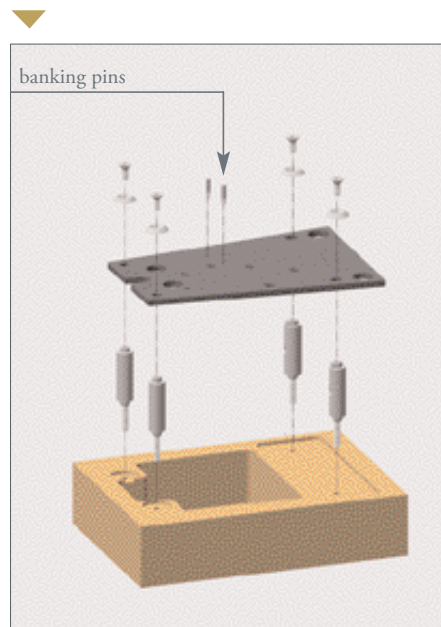
## ASSEMBLING THE BACK PLATE

### Parts:

Assembling the back plate:

- ☐ o back plate (39)
- ☐ o 4 movement pillars (25)
- ☐ o 4 washers (24)
- ☐ o 4 allen head screws M4x10mm (24)
- ☐ o 2 banking pins (24)
- ☐ o 5 ball bearings (for the back plate) (22) ("Kugellager Hinterplatine")

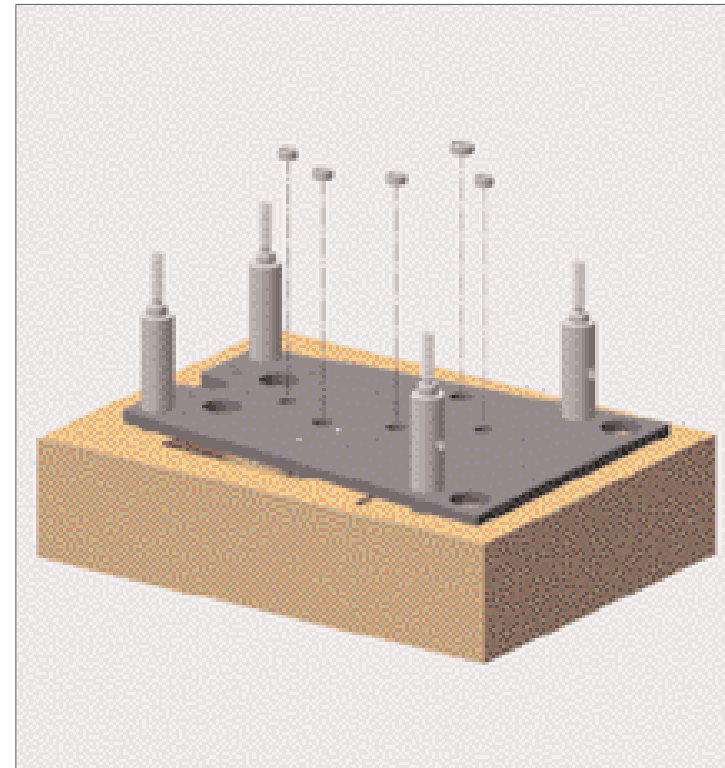
Insert the 4 movement pillars in the holes of the assembly block. Put the plate \* on the shoulders of the movement pillars\*. The engraving "Mechanica M1" on the rear of the plate should be facing upwards. Note the differently shaped pillar shoulders to avoid confusion.



Put on the 4 washers in place over the pillar ends and attach with the 4 allen head screws M4x 10mm. Screw in the two banking pins which limit the swing of the crutch.

Turn the plate over.

Turn the plate over. Using tweezers put the 5 inox ball bearings in the milled recesses. Place the bearings with the balls visible to the outside (down, at this point). Because of their different diameters the bearings will only fit into the right place.



Do not add any oil to the bearings

# Assembling the movement

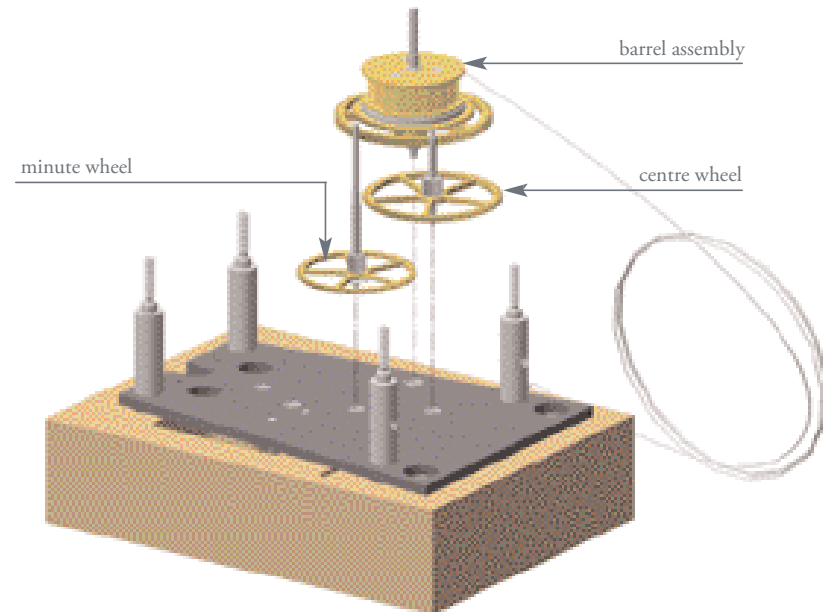
## ASSEMBLING THE GEAR TRAIN



The hardened steel arbors have not had a protective surface treatment. Touching them with your fingers may cause corrosion. Please use tweezers. Take care not to scratch the gilded surface of the wheels. Insert the shoulders of the preassembled geartrain components into the ball bearings.

Follow the illustration and position in the following sequence:

1. minute wheel (30)
2. centre wheel (31)
3. barrel wheel with steel cable (32)

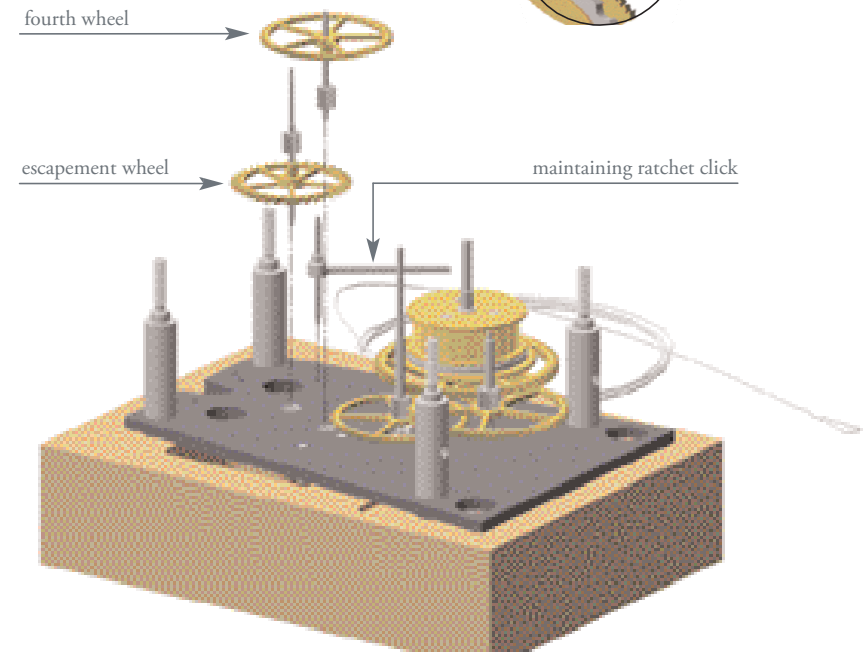
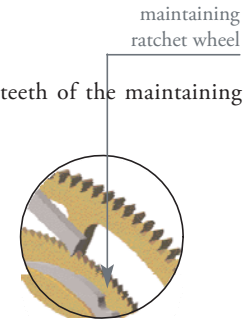


How to put the pre assembled parts in place:

1. maintaining ratchet click (21)
2. escapement wheel (28)
3. fourth wheel (29)



Note that the winding ratchet must engage the teeth of the maintaining ratchet wheel on the barrel assembly.



PREPARING AND INSTALLING THE FRONT PLATE

## Assembling the movement

Following parts are needed:

o Front plate (40)

o Pallet arbor bearing (24)

o 2 screws M2x4mm (24)

o intermediate wheel stud (24)

o 1 screw M2x4mm (24)

o 5 ball bearings (for the front plate) (22) (“Kugellager Vorderplatine”)

o 4 washers (24)

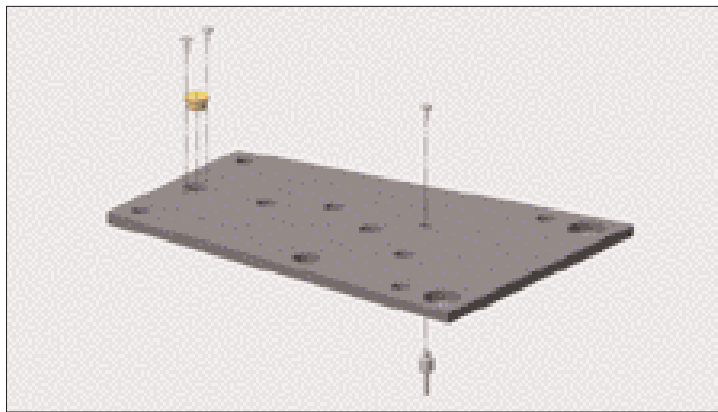
o 4 knurled nuts (24)

Put the assembly block with the partially assembled movement on one side to work on the front plate:

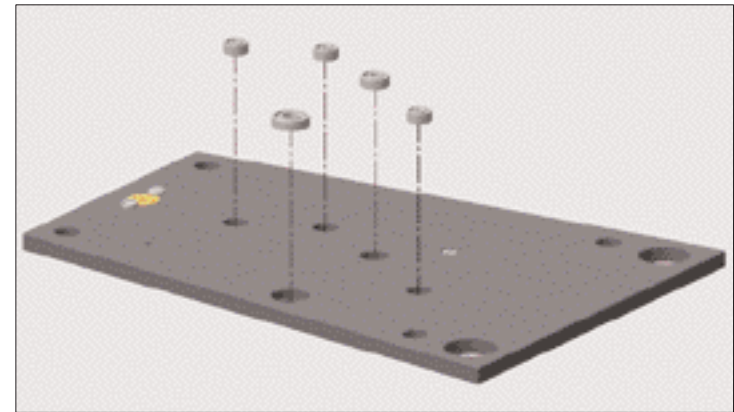
Insert the pallet arbor bearing into the milled recess of the front plate and position it with the two screws M2x4mm.

Installing the intermediate wheel stud

Install the intermediate wheel stud on the opposite side of the plate (dial side), attach it with the screw M2x4.



Insert the ball bearings in the milled recesses in the front plate. As with the backplate place the bearing so that the balls are visible to the outside of the plate. They have different diameters so cannot be put in the wrong place.



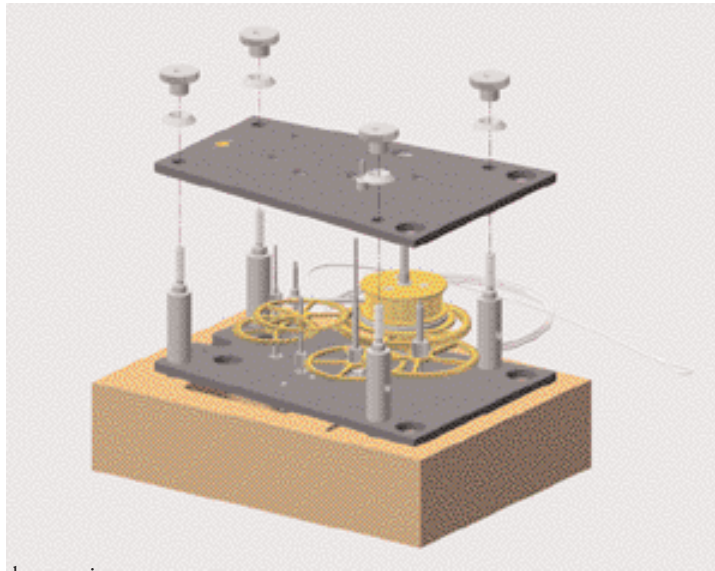
Do not add any oil to the bearings

Lower the front plate onto the partly assembled movement on the assembly block. The pivots and shoulders must be inserted into the ball bearings and holes carefully.

When the front plate is turned over the bearings are likely to fall out. If this happens, put them on the corresponding arbor in the gear train and make sure that they enter the recesses when the front plate is positioned.

Attach the front plate using the 4 washers and the 4 knurled nuts.

## Assembling the movement



down to insure easy movement.



### ASSEMBLING THE MOTION WORK \*

For the next step you need:

- o intermediate wheel (23)

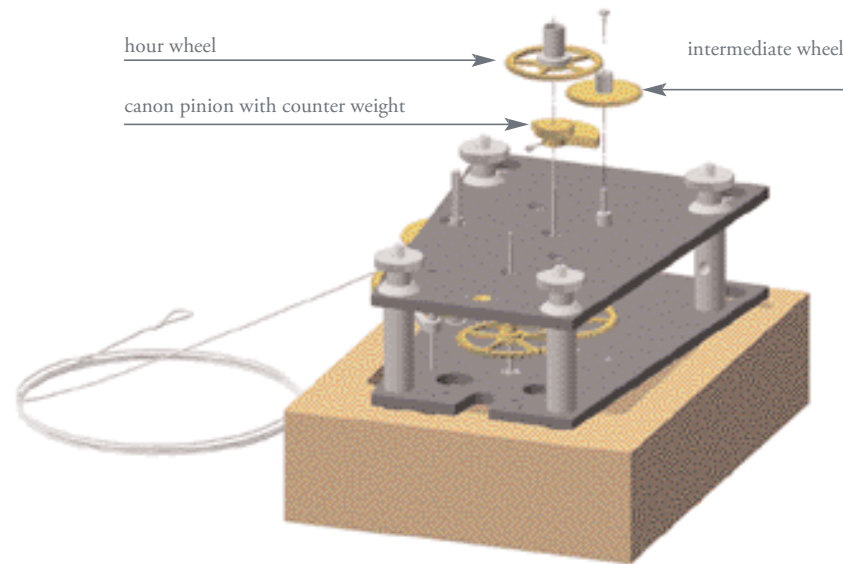
- o screw M1.4x3mm (23)
- o canon pinion with counter weight (23)
- o hour wheel with pipe (23)
- o grub screw M2x2mm (23)
- o minute hand (37)

Parts:

- ☐ Put the intermediate wheel on the intermediate wheel stud. Tighten the screw M1.4x3mm which holds the intermediate wheel in position.

hour wheel → intermediate wheel  
canon pinion with counter weight →

Check for free play and end shake in the intermediate wheel!



# Assembling the movement

wheel. Next fit the hour wheel with pipe on the minute wheel arbor.

Adjusting the minute hand with respect to the counter weight.

Place the minute hand on the square of the minute wheel arbor and align it so that it points directly away from the counter weight. Then fix this alignment by tightening the grub screw M2x2mm.

By turning the hour wheel, check that the motion work is free-moving.

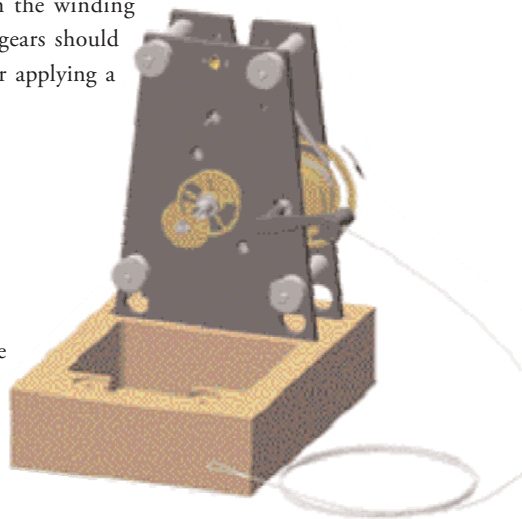
Testing the free ac

After setting the re  
tightening the gub  
movement in an upright position. By turning the barrel wheel, check the complete gear train for smooth running. Alternatively use the winding crank (box 7), turning it clockwise on the winding square of the barrel arbor. The gears should continue to turn for a while after applying a little force to the barrel or crank.

## CHECK LIST: GEAR TRAIN

End Shake of the arbors  
All arbors need to be able to move back and forth a little between the plates. You should be able to see it and feel it.

OK



## Motion Work

The wheels of the motion work should turn easily when the canon pinion is not locked.

OK

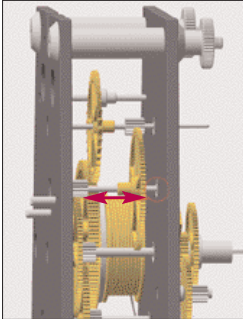


The maintaining ratchet click must engage the teeth of the maintaining ratchet wheel. It must not touch the teeth of the barrel wheel. If the maintaining ratchet is engaged, the gears should run smoothly and slow down steadily.



OK

If anything is not working properly, please give us a call. You reach us on weekdays from 9am-5pm



All parts are checked carefully before despatch.

## FITTING THE PALLET ARBOR

When you assembled and tested the gear train, identify the escapement components:

Parts you need:

- o pallet arbor bridge (26)
- o eccentric bearing (26)

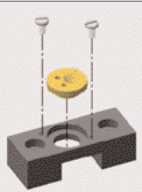


## Assembling the movement

- o 2 screws M2x4mm (26)
- o pallet arbor with crutch\* (27)
- o countersunk screw M2x6mm (26)
- o 2 socket head screws M3x10mm (26)

### Parts:

- Put the movement and assembly block aside. Insert the eccentric\* bearing into the milled recess of the pallet arbor bridge\*. The eccentric bush must be installed so that the index markers on the bush and the bridge are aligned (this is a factory setting).
- ☐
  - ☐
  - ☐
  - ☐
  - ☐
  - ☐



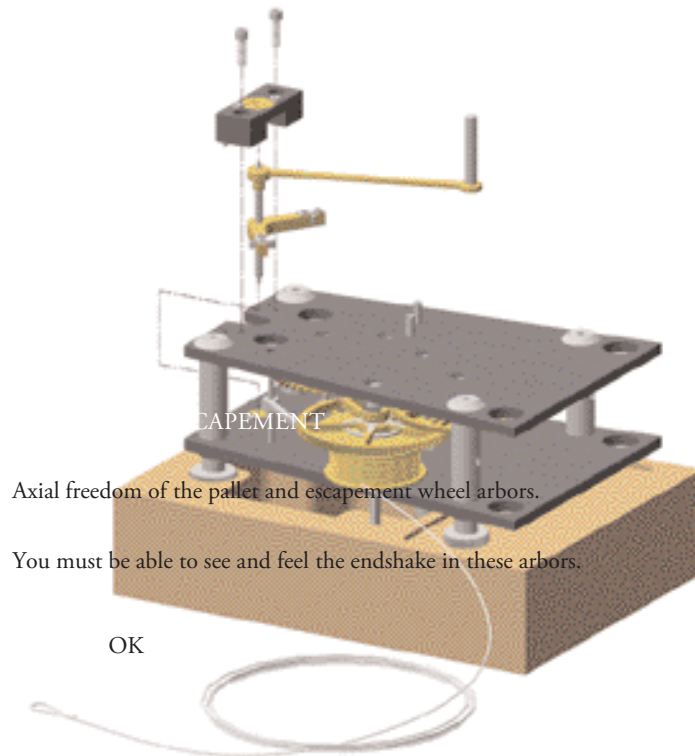
The function of the escapement\* is explained in the chapter "Escapement" on page 70

The eccentric bush is clamped with 2 screws M2x4mm. Attach the crutch pin to the crutch with the countersunk screw M2x6mm. Now the pallet arbor is ready for installation.

Put the movement on the assembly block with the engraving "Mechanica M1" facing upward. Insert the pallet arbor pivot into the bearing fitted on the front plate (page 36). The crutch must lie between the two banking pins on the back plate. The pallets of the pallet arbor must fit into spaces between teeth of the escapement wheel.

Insert the rear pivot of the pallet arbor into the eccentric bush of the pallet arbor bridge and position the bridge over the matching holes in the back plate. When you are sure both pivots are inserted in the bearings, fix the

bridge in place with the allen screws M3x10mm.



Please take care to assemble these components correctly!

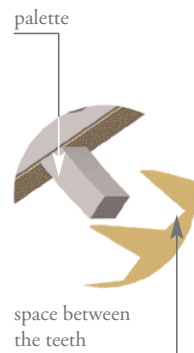


## The action of the pallet arbor

Hold the crutch centered between the banking pins. The pallets\* must be equidistant from the escape wheel. Move the crutch carefully back and forth between the banking pins.

Neither pallet must touch the base of the gap between the teeth of the escape wheel. It is easier to observe the action of the escapement if viewed through the holes in the back plate against a white background. A suitable piece of card is provided as a bookmark at the end of this book.

You find the bookmark at the end of this book

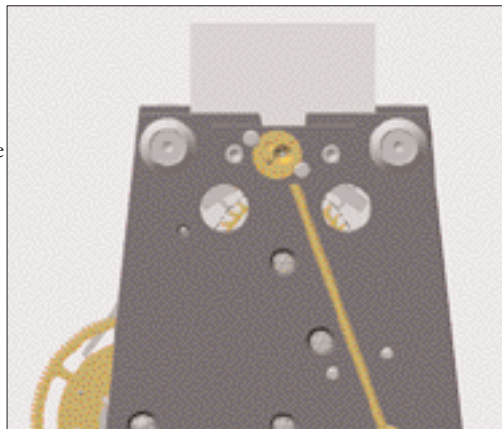


OK

Supply a little pressure the escapement through. Move the crutch slowly one tooth of the escape wheel is turning anti-clockwise.



OK

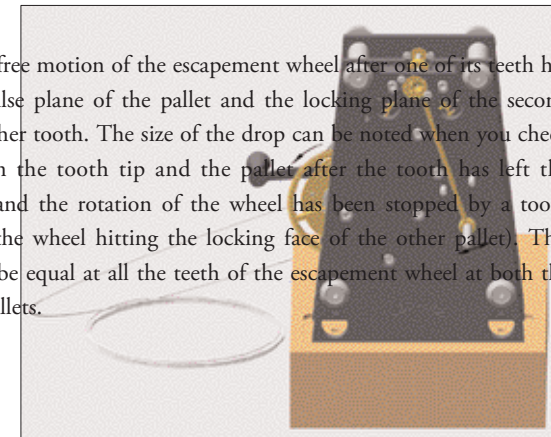


## Checking the drop\*



The drop is the free motion of the escapement wheel after one of its teeth has passed the impulse plane of the pallet and the locking plane of the second pallet stops another tooth. The size of the drop can be noted when you check the gap between the tooth tip and the pallet after the tooth has left the impulse plane (and the rotation of the wheel has been stopped by a tooth further around the wheel hitting the locking face of the other pallet). This distance should be equal at all the teeth of the escapement wheel at both the entry and exit pallets.

OK

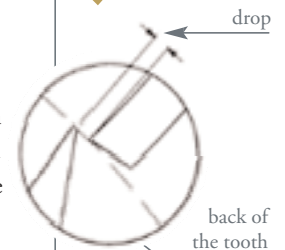


## Checking the lock

When the drop is equal on both pallets, every tooth must rest safely on the locking\* plane of both pallets. Guide the crutch carefully back and forth when the gear train has power and observe each tooth of the escapement wheel with your loupe.

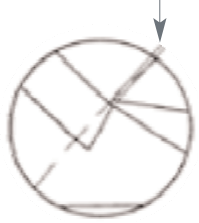


OK



## Assembling the movement

lock



◀ The escapement components have been carefully adjusted in the factory.

If, never the less, you have any problems, call us. We will be able to help you quickly and easily. Call us any week day from 9am to 5pm



Oil only as indicated

Avoid injury with the  
needle of the oil syringe.

We have adjusted the  
escapement carefully

### LUBRICATING THE ESCAPEMENT

The gear train of your Mechanica M1 has ball bearings which need no oil.

The escapement however does need lubrication. Give a little oil into the oil  
sinks\* of the pallet arbor bushes as well as the locking face of the pallets.

Caution: Too much oil is as bad as no oil.

Use only the special clock oil supplied, Möbius Microgliss D5. Be careful  
with the needle of the syringe. Keep away from children.

### FITTING THE DIAL

To complete the assembly of the movement you only need to fit the dial and  
hands.

You need:

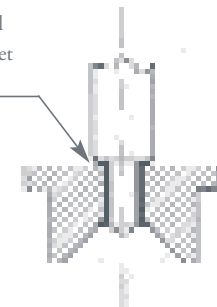
- o dial (34)
- o bezel (35)
- o 6 allen screws M1.6 x 6mm (24)
- o 4 screws M2x6mm (24)
- o hour hand (38)
- o minute hand (37)
- o second hand (38)

pallet arbor front pivot

pallet arbor rear pivot

locking face of exit pallet

The amount of oil  
needed in the pallet  
arbor bearings



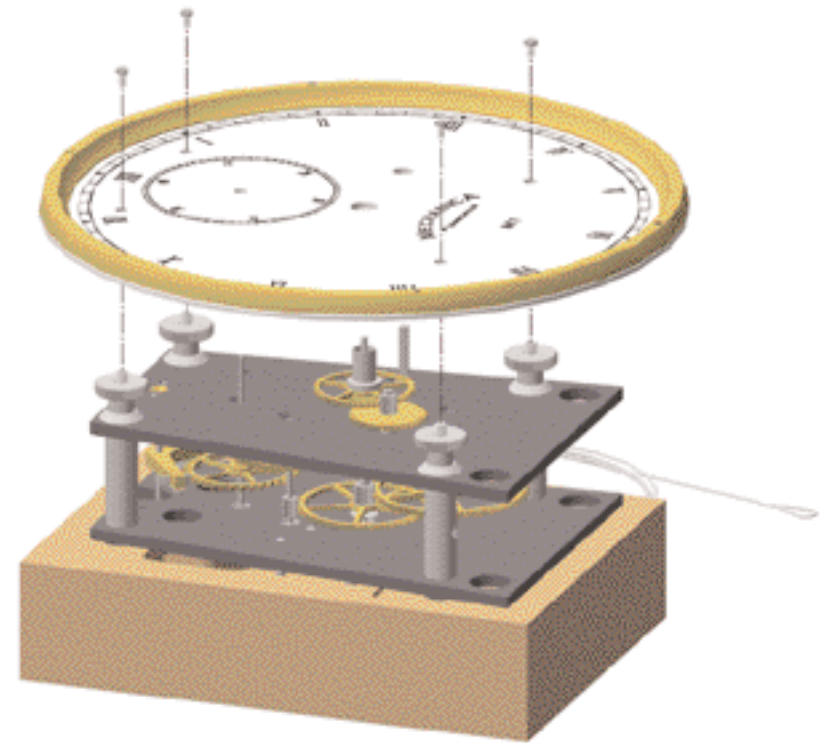
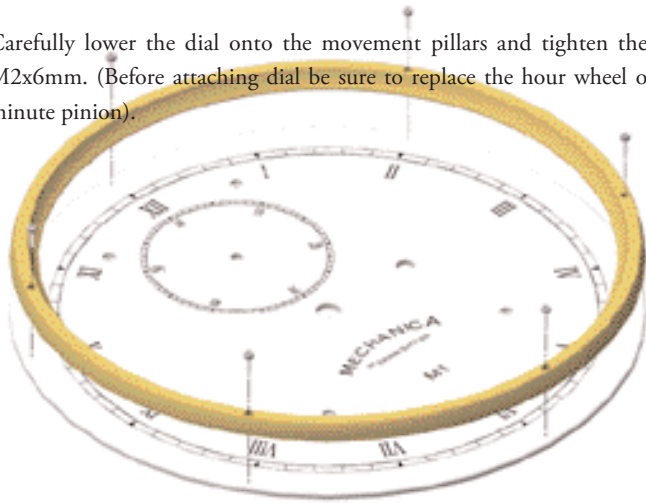
## Assembling the movement

Attach the bezel\* to the dial using the 6 allen screws M1.6x6mm.

Parts:

- ☐
- ☐
- ☐
- ☐
- ☐
- ☐
- ☐
- ☐

Carefully lower the dial onto the movement pillars and tighten the screws M2x6mm. (Before attaching dial be sure to replace the hour wheel onto the minute pinion).



## Assembling the movement



Make sure the minute hand is oriented correctly in relation to the counter weight, see illustration page 40

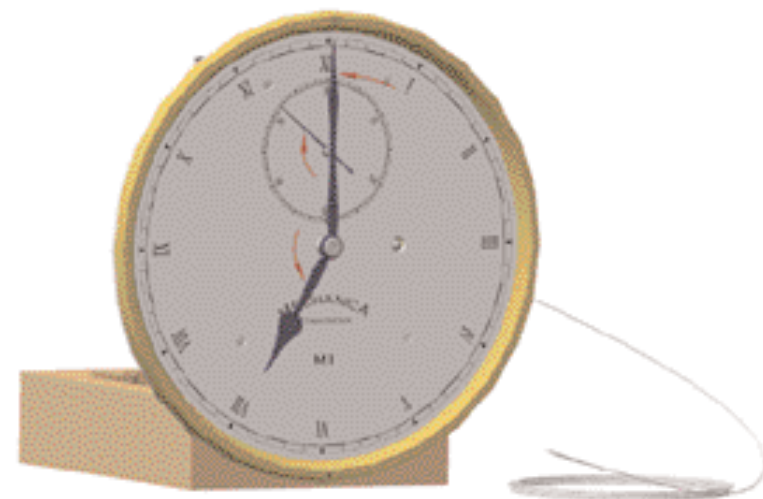
### Aligning the hands

One of the joys of a precision clock is the correct alignment of the hands in relation to the escapement, the dial and each other. Move the crutch against one banking pin back and position the second hand so that it is aligned with a division on the seconds scale. When turning it, hold the hand as close as possible to the shaft to avoid bending it.

Apply some power to the gear train by turning the winding crank and move the crutch from side to side. Check that the second hand jumps precisely from one index to the next and does not touch the dial.

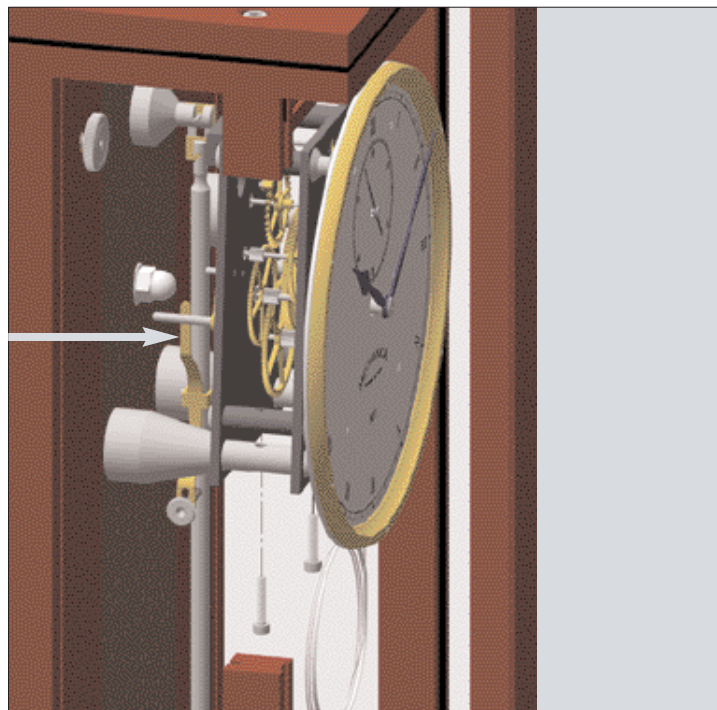
Gently move the minute hand to exactly 12 o'clock. Hold the minute hand and turn the hour hand carefully to the nearest hour marker.

Turn the minute hand through a full rotation and check that the hands don't touch or rub the dial.



## Assembling the movement

Parts:



When fitting the movement into the case, please protect the case bottom with a strip of foam material. Then, if you drop parts or tools, they will not damage the case.

2)

Place the pulley in the slot of the pulley stirrup. Push the pin through the holes in the pulley stirrup and the pulley bush. Clamp the pin by tightening the grub screw in one arm of the stirrup.

Parts:

☐

☐

☐ 3)

☐ Tighten the grub screw M6x18mm in the tungsten weight. The protruding thread is used to attach the pulley stirrup.

☐

### STARTING YOUR MECHANICA M1

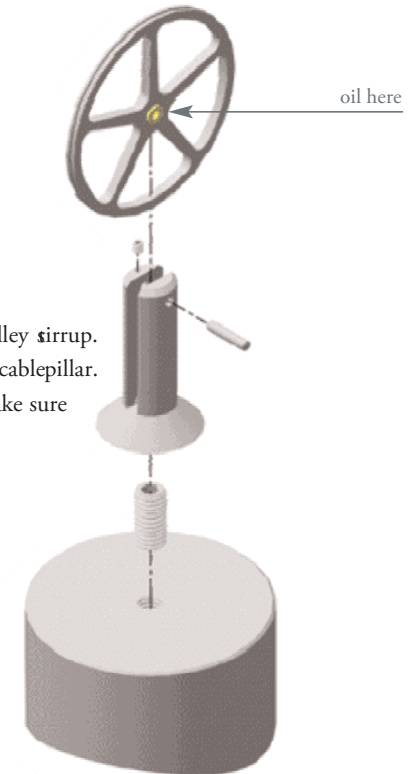
#### Hanging the weight

Unwind the cable and pass the end loop through the pulley stirrup. Hold the weight and attach the loop to the notch in the cablepillar. Never bend or kink the cable. As you lower the weight make sure the cable runs in the groove of the pulley.

#### Adjusting the beat

Place the winding crank on the winding square. Always wind the clock counter clockwise. First, wind only one turn. Watching the tip of the pendulum and the pendulum scale, move the pendulum to one side until you hear a "tick". Note the position of the pendulum at this point.

Next, move pendulum to the other side until you again hear another "tick". Read the indication on the pendulum scale again.



## Assembling the movement

If the beat is perfect, the pendulum tip should have moved the same amount to each side. If it is not you can adjust the beat by turning the knurled screw on the beat adjustment lever. If a turn in one direction does not even the beat, turn the other way.

### Winding the clock

When the beat is adjusted, you can wind the clock completely. Stop winding before the weight disappears behind the dial.

Always wind up  
counter-clockwise

### Setting the time and starting the clock

Set the clock to the correct time (guided by a radio-controlled clock or time signals). The minute hand can be turned forward and backward as required. Don't touch the second hand. To synchronise your clock with a reference time, stop pendulum when the second hand points to the 60, hold the pendulum to one side until the reference clock has reached the 60 (or the time signal has given its last 'pip') and let it swing back during the 1st second of the next minute.



## Enjoy your M1!

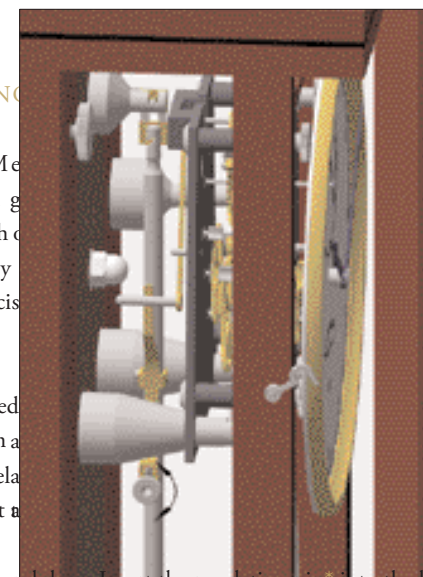
### REGULATING

When your Me...  
regulating wei g...  
time after 24 h...  
be regulated by...  
keep time precis...

Having checked...  
gain or loss in a...  
rate may be rela...  
the timing nut a...

o Stop the pendulum. Insert the regulation pin\* into the hole near the bottom of the pendulum rod.

o Hold the pin firmly so that the delicate suspension spring will not



rect time, put a...  
rod. Check the...  
by the clock has...  
m so that it will

daily rate\*; the...  
lation the daily...  
adjusting the beat...  
smaller as you use



be twisted.

- o Loosen the lower nut, the so-called lock nut, and turn the upper nut, the regulation nut; to the left one index to correct a gain of one second per day, or to the right by one index mark to correct a loss of one second per day.

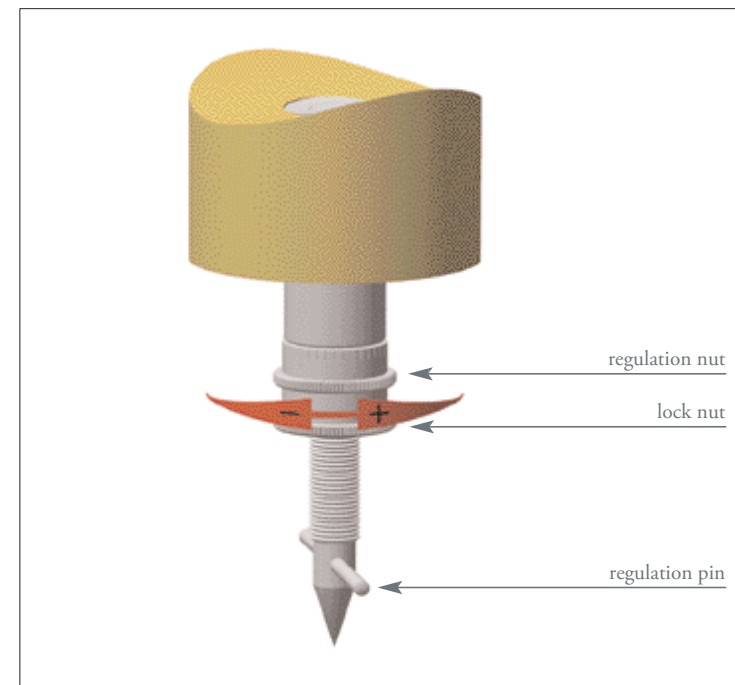
At the end of this book there is a table on which you can record the performance of your clock and the effect of the changes you made.

This will allow you to make adjustments systematically.

Calculate the new daily rate over the next 24 hours, make the necessary adjustment to the pendulum, and you will soon have an accurate clock.

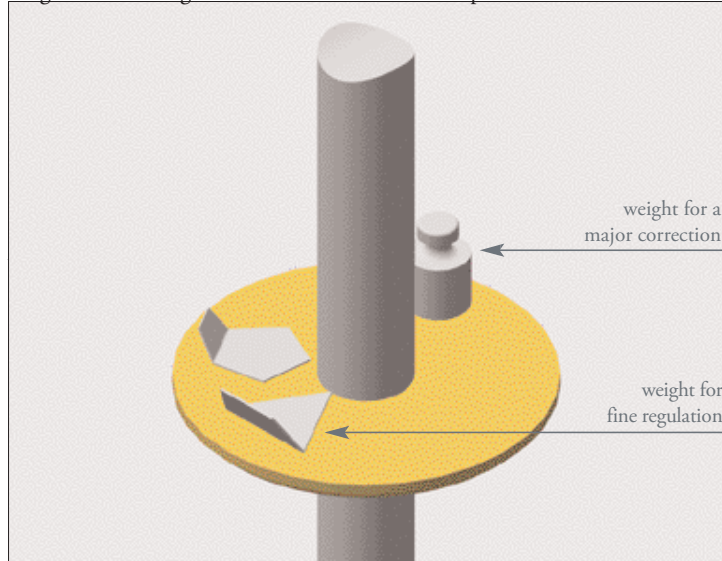
- o When this basic regulation has been achieved, tighten the lock nut gently against the timing nut.

Observe the rate of your clock over several days. As a basis for the subsequent fine-regulation\*, your clock should lose about 1 second per day.





In the centre of the pendulum rod you find the fine regulation table. When you add the small nickel silver weights supplied to this table the clock will gain. For adding or removing weights use the tweezers which can be stored, with the weights, in the hidden shelf at the base of the case. The heavier the weight added the greater the acceleration of the pendulum and the faster is



You can correct daily rates of 1-2 seconds using the weights provided. For this fine adjustment there is no need to stop the clock. When fine regulation has been achieved there should still be some weights on the table so there is something to remove should the clock start to gain.

If the clock is one second slow, add a second weight until the clock catches up and then remove it. The famous Great Clock of Westminster ('Big Ben') in London is kept to time this way – using old copper pennies!

### CARE AND MAINTENANCE

Having completed the assembly and regulation you have now made yourself a precision timekeeper.

Like any other precision instrument, your Mechanica M1 needs care and a certain amount of maintenance. The case door should be kept closed to protect the movement from dust.

Its design, and the use of ball bearings, makes your M1 an extremely low maintenance movement. Nevertheless some parts need lubrication, the escapement for example. Oil ages and loses its lubricating properties over the years. It is not simply a matter of adding more oil. After 10 to 15 years dismantling and special cleaning is required to remove the oxidized oil.

We can look after the maintenance of your clock in our workshop and refurbish or replace worn or damaged parts.

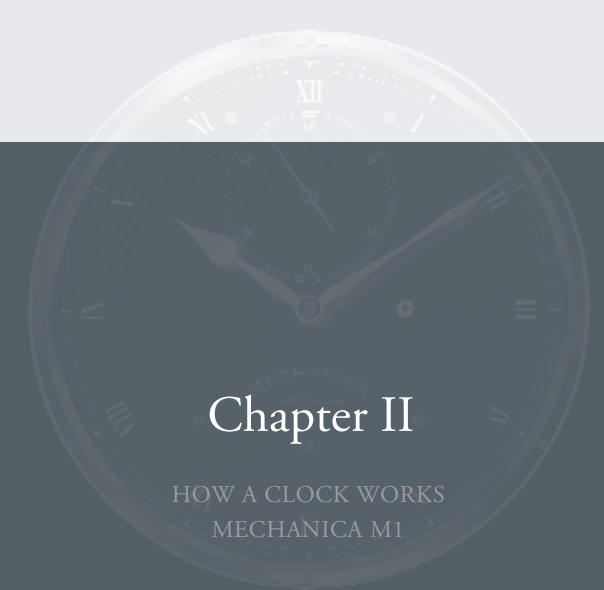
With care like this your M1 will run for centuries without problems and can be passed with pride from one generation to the next.



Never leave the case  
open unnecessarily

Maintenance can always be  
carried  
out in our workshop





## Chapter II

HOW A CLOCK WORKS  
MECHANICA M1

## INTRODUCTION

This chapter will introduce you to the operation and special design of your precision clock.

To explain the complex function of pendulum, escapement and gear train in a short and readily understandable text is no easy task. Clockmakers have a three year apprenticeship to learn the basics of clockmaking.

With this manual we not only want to enable you to assemble a precision clock, we also want to share with you our fascination of this special type of clock.

It is the interaction of natural laws with what at first glance appears to be a simple mechanism that enables us to measure time with such remarkable precision.

Clockmakers made a great effort over hundreds of years to enhance the accuracy of precision clocks.

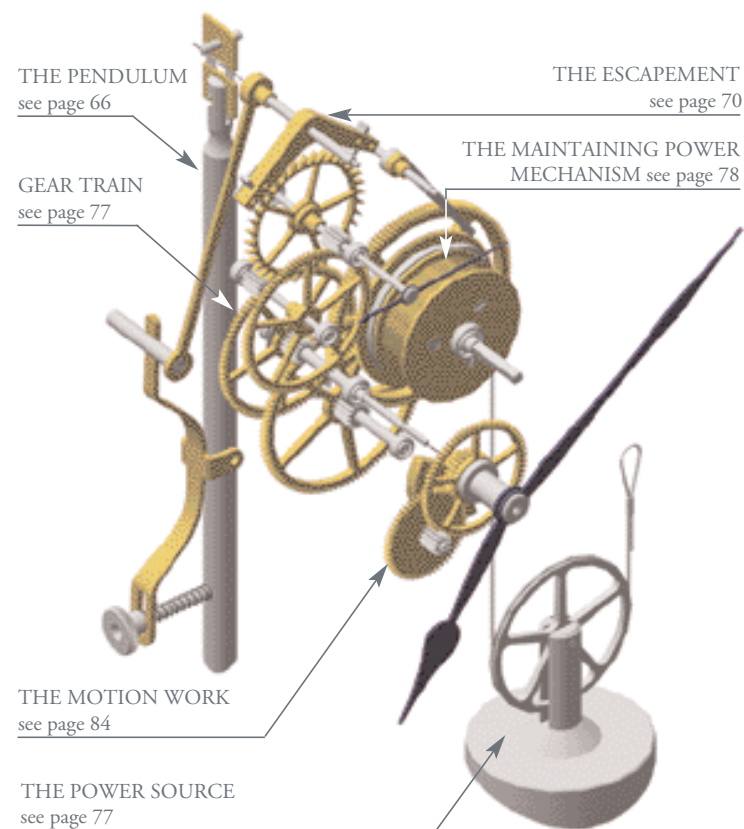
Continuing this tradition we also try to improve clockmaking by using new

material, new technologies and new design.

The fascination of a precision clock lies not only in its accuracy; when you take a closer look it is also in the simple and straightforward design. You can observe and follow the results of basic principles. A mechanical clock is something you can understand and, in the case of your M1, something you can touch.



When you take the time to understand the processes in your M1, you can share our enthusiasm with clockmaking and see your clock in a different light.



THE PENDULUM

The pendulum\* is still today's most accurate mechanical oscillation device. It divides time into precisely defined units. These are defined by the length of the pendulum and the force of gravity. This timekeeping breakthrough was discovered by Galileo Galilei in 1585. According to his observations, a pendulum has always the same oscillation time (period) regardless of its amplitude. This principle is called 'isochronism\*'. Strictly speaking it only holds at very small amplitudes.

In conclusion one can say that the accuracy of a clock pendulum is determined by constant length, constant small amplitude and a constant force of gravity.

But the length of a pendulum is dependent on external influences like temperature. An increase in temperature results in the expansion of almost all solid materials. This means the pendulum rod becomes longer. When temperature falls the effect is reversed. The result is a longer period at higher temperatures and a shorter period at lower temperatures. In order to keep the oscillation angle or amplitude\* of the pendulum constant, it is necessary to supply the energy, that is lost with every swing due to the resistance of the air and in the suspension spring\*.



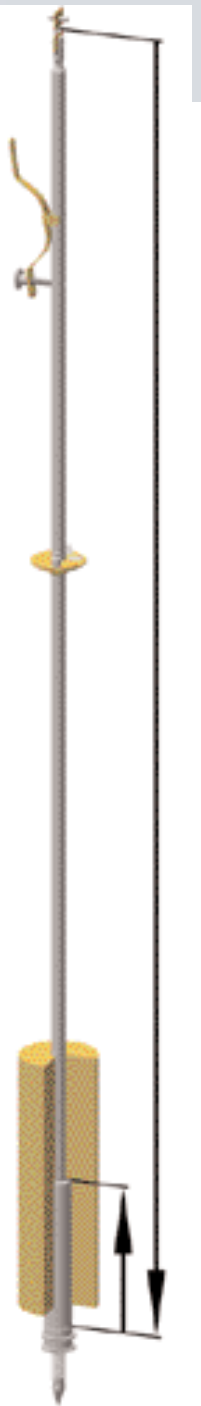
How did clockmakers over the last 400 years manage to overcome these difficulties and make an accurate clock possible? If we take a closer look at our pendulum, it consists of a pendulum rod, a compensation tube\* on which the pendulum bob sits, a regulation nut\* and a lock nut.

In the middle of the pendulum rod you see the table for fine regulation and at the upper end, the beat adjuster\*.

As we know, when the pendulum rod expands with rising temperature, our clock is slow. Therefore the use of a material with very low thermal expansion is important. At the end of the 19th century the French scientist Charles Edouard Guillaume discovered a Iron-Nickel alloy whose expansion is 10 times less than normal steel and 5 times less than wood. It is called Invar\*.

Clocks with wooden pendulum rods were accurate to only a few seconds per week. To improve the accuracy to a few seconds per month, it is not enough to simply use a Invar rod, it is necessary to compensate for the remaining thermal expansion.

This is why the so called 'compensation tube' sits on top of the regulation nut supporting the pendulum bob. This short tube is made of normal steel and has a precisely calculated length, so that its expansion is the same as the complete pendulum rod and suspension spring. Any change in the length of



# Technical information and function of the Mechanica M1

the rod is balanced by a similar change in the tube and the pendulum bob. This method of temperature compensation was invented by Siegmund Riefler in 1896 and is used in a number of precision clocks.

Next we have to consider the force of gravity. This, together with pendulum length determines the period. The force of gravity at a given location is virtually constant. It changes when you move from North to South or when you change the altitude.

Therefore a pendulum clock must be adjusted to the place where it is located. When we use the regulation nuts we change the length of the pendulum. In this way we can adjust the clock to a deviation of 1 to 2 seconds a day. But to reach an accuracy of 2 to 3 seconds a month we need to adjust the length of the pendulum (or more correctly its centre of gravity) with the fine regulation weights.

When we add weights to the fine regulation table in the middle of the pendulum rod, the centre of gravity of the pendulum is raised and the pendulum is accelerated, reducing its period. We can do this without stopping the clock.

When we remove a weight, the oscillation time is longer and the clock runs slow. In conclusion one can say that the pendulum of the M1 has all attributes that make a first class precision pendulum clock\*.

The last unanswered requirement is the provision of a constant pendulum amplitude. This is not provided by the pendulum but is due to the power that is supplied to the pendulum to keep it oscillating. This is delivered by the escapement which is the connection between the gear train and the oscillation system.



The design and function of the escapement is explained in the next chapter. We know already that it keeps the pendulum going.

Since the friction of air and suspension system is almost constant (although that of the air varies with barometric pressure and humidity), the power supplied to the pendulum must also be as constant as possible.

Power is supplied to the gear train by a weight and because the force of gravity is constant it is constant.

This is explained in the section "driving force and gear train" on page 77.



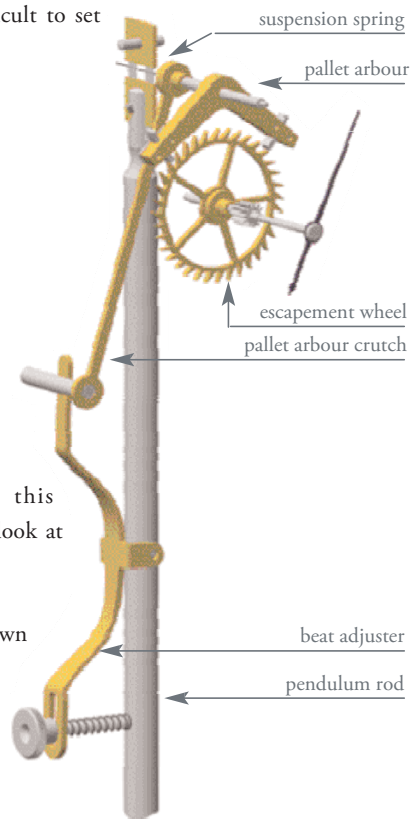
## THE ESCAPEMENT

The escapement has two important tasks. It is the connection between gear train and oscillation system. It replaces the energy that the pendulum loses through friction. In addition to this it controls the gear train. The action of the escapement is controlled by the pendulum, making it possible to 'count' the oscillations of the pendulum with the gear train and display them with the hands.

# Technical information and function of the Mechanica M1

Since the discovery of the pendulum as an oscillation device for clocks, different escapement systems were developed which worked more or less satisfactorily. In our M1 we use the so-called 'dead beat' escapement invented by George Graham in 1720.

This is why it is also called Graham escapement\*. This escapement evolved from the earlier escapements and its simplicity and reliability is unmatched. In some cases escapements were invented that work more precisely but they are much more complicated and difficult to set up.

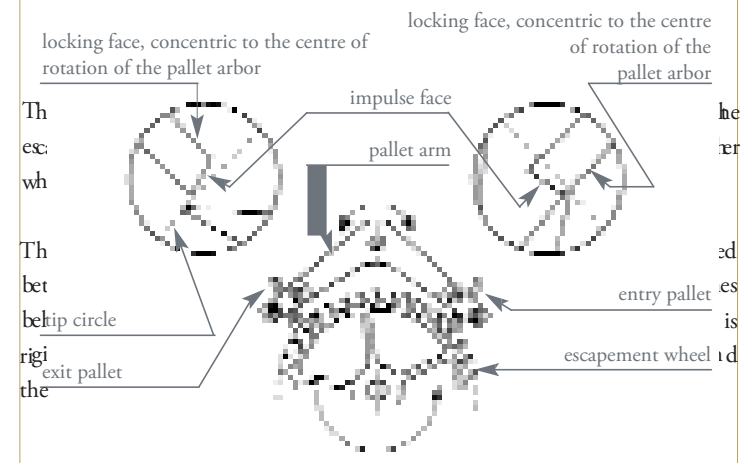


To understand the genius of this escapement, we have to take a closer look at its design and the physical basis.

The escapement and its parts are shown on figure 1



FIGURE 1



We can see that the action of the crutch as the pendulum swings causes the entry and exit pallets to engage with the tip circle of the escapement wheel. The pallets are made of hardened steel. They have a curved shape and are positioned so as to have the same centre of rotation as the pallet arbor. The ends of the pallets which engage with the tip circle of the escapement wheel are bevelled and polished. They are the impulse faces\*. The outer radius of the entry pallet and the inner radius of the exit pallet are the locking faces\*. The escapement gives a regular supply of energy to the pendulum. It is an advantage if the impulse takes place when the pendulum has its highest oscillation speed and its highest kinetic energy. This is the case when it moves through the zero position.

At this time interference with the pendulum (giving it a push) will have the



# Technical information and function of the Mechanica M1

least effect on timekeeping.

One half of an oscillation is divided into five steps that are shown in figure 2 as angular stages. The complete escapement function and the positions of the pendulum are shown on table 3A-G during one half oscillation of the pendulum.

To explain the single steps, it is important that you understand the sequence of the function.

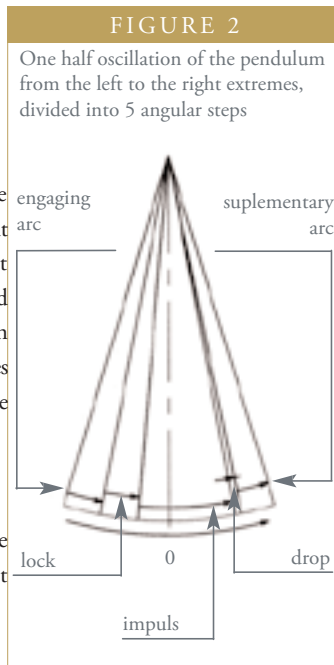
Explanation of each part of the swing

## Impulse

The impulse\* is one of the two important functions of the escapement. During the impulse the pendulum receives the necessary energy that is needed to keep it swinging. One tip of the escapement wheel slides along the impulse face and gives a partial turn to the pallet arbor. In the Graham escapement the impulse takes place as the pendulum moves through the zero position.

## The Drop

The drop\* is the free movement of the escapement wheel, after the escapement wheel tooth has left the impulse face.

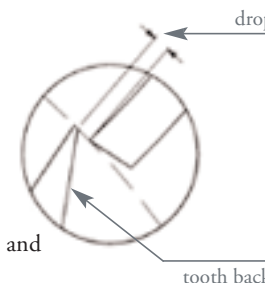


The drop is necessary so that the pallet can engage with the tip circle without hitting the back of the escapement wheel tooth at the next half oscillation. In addition a bigger drop ensures that the escapement works correctly even if the escapement wheel has small pitch errors. For a reliable escapement function it is necessary that the drop is equal on both pallets.

The escapement wheel tooth has dropped from the impulse face of the entry pallet, another tooth drops on the locking face of the exit pallet and the pendulum moves on to the end of its swing. During this time the escapement wheel is locked and the motion of the gear train is arrested.



This is the second important function of the escapement and because of this it is called dead beat escapement.



This is possible because the pallets are positioned concentrically\* and has the advantage that the friction on the locking faces is constant.

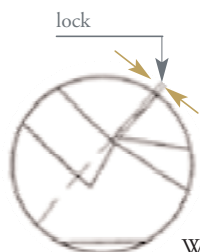
The path of the pendulum from the end of the impulse and drop to the inversion point is called supplementary arc\*. The engaging arc is from inversion point to the locking. The engaging arc plus locking should be as big as the arc between the zero position and the end of the impulse. This ensures proper function, even when the clock is not levelled perfectly and the drop is not symmetrical to the zero position of the pendulum. This problem is called 'beat error'. The beat error can be corrected by manipulating the beat adjuster on the pendulum rod. The beat error is heard when the ticking of the clock is not balanced. It sounds as if the clock is limping. By turning the knurled screw on the beat adjuster\* the relationship of the pendulum to



the pallet arbor can be changed so that the tick is even.

Finally locking has to be explained:

The lock is the small distance between the edge of the impulse face and the point on the locking face where the escapement wheel tooth lands after the drop. It's only a fraction of a millimetre but prevents the escapement wheel tooth dropping onto the impulse face and stopping the oscillation of the pendulum.



In conclusion one can say that the lock provides a safety margin when the escapement wheel has a small concentricity error.

We make the escapement wheel so precisely that we can guarantee a concentricity error\* of less than 0.02mm. The amount of lock can be adjusted by shifting one pallet in the pallet arm.

The lock of your clock is slightly bigger to ensure a proper function in serial production. As you can see on figure 2, the lock moves the impulse a little out of the zero position. Theoretically it is useful to adjust the lock to be as small as possible and then to check that each escapement wheel tooth drops onto the locking face.

This is not necessary and you should only move the pallets if you are able to

adjust them very precisely.



The same caution is necessary when making fine adjustments to the drop.

The drop must be equal on both pallets. To check the drop and lock of the preadjusted escapement, you should apply power to the gear train by pushing the crank against the winding direction. Now you can move the lever back and forth and watch with the eyeglass through the holes in the back plate how the escapement works (as described on page 44). At first check the drop.

The drop is the free movement of the escapement wheel, after a tooth leaves one pallet and another tooth is stopped by the other pallet.

We can see this by observing at the distance between the end of the impulse face and the tip of the tooth which has stopped after leaving it. This distance is the drop, and can be seen on the entry and exit pallet while moving the lever fork back and forth.

We admit that it is difficult to see any small differences and that it takes a little patience and practice. If you notice an unequal drop, it can be adjusted by turning the eccentric bushing\* in the lever bridge. When the drop on the exit pallet is too big turn the bushing a little clockwise. If it is too small turn counter clockwise.

## Technical information and function of the Mechanica M1

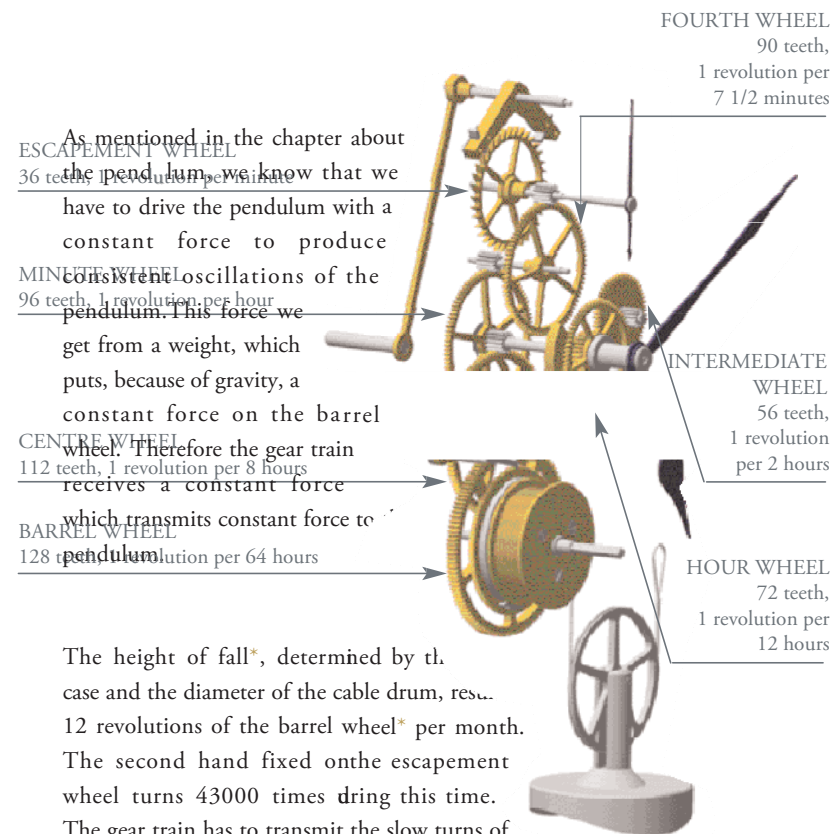
When the drop is equal, check the lock. Check if every tooth drops safely on the locking face on both pallets.

If one tooth drops on the impulse face, one of the two pallets has to be pushed deeper into the tip circle of the escapement wheel.

When adjusting the escapement it is very important to work in the right order. First adjust the drop then the lock, because turning the eccentric bushing also changes the engaging distance of the pallets to the escapement wheel.

### DRIVING MECHANISM AND GEAR TRAIN

The driving mechanism together with the gear train has to supply the escapement and the pendulum with energy. It also drives the hands.



The height of fall\*, determined by the case and the diameter of the cable drum, results in 12 revolutions of the barrel wheel\* per month. The second hand fixed on the escapement wheel turns 43000 times during this time. The gear train has to transmit the slow turns of the great wheel to the rapid motion of the escapement wheel. The force transmitted must be as constant as possible to ensure a steady impulse to the pendulum. The force is reduced in the same ratio as the gearing.

The weight is made of tungsten\* which has a higher density than the lead

## Technical information and function of the Mechanica M1

usually used. This gives your M1 an elegant appearance.

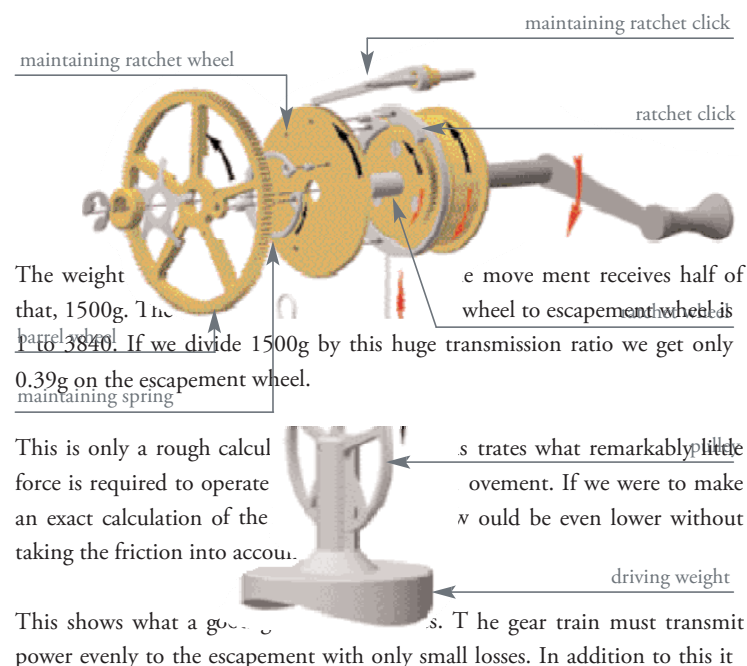
The weight doesn't hang directly on the cable drum, it works via a pulley. The driving force is halved by the pulley and so is the fall, doubling winding period.

When you wind your M1, the steel cable winds on the drum and the weight moves upwards. During this time the weight cannot put force on the gear train and the clock stops. To avoid this your M1 is equipped with a maintaining power mechanism\*. It has following parts: Maintaining wheel, maintaining click, maintaining spring.

The circular maintaining spring is positioned between maintaining ratchet wheel and barrel wheel and connects both parts. The maintaining ratchet wheel and barrel wheel can rotate freely on the barrel wheel arbor.

The winding ratchet, pivoted on a separate shaft between the plates, engages with the teeth of the maintaining ratchet wheel. The function of the maintaining power is very simple: Under normal working conditions the driving weight puts force on the barrel (black direction arrow). This, transmitted via the ratchet wheel and the click on the maintaining ratchet wheel, puts tension on the maintaining ratchet spring and drives the movement. When the clock runs down the maintaining ratchet wheel rotates freely underneath the maintaining ratchet click. When winding (red direction arrow), the weight moves upwards and cannot drive the movement, the maintaining spring wants to expand and the maintaining ratchet wheel ensures that the force is transmitted to the barrel wheel which drives the

movement during winding.



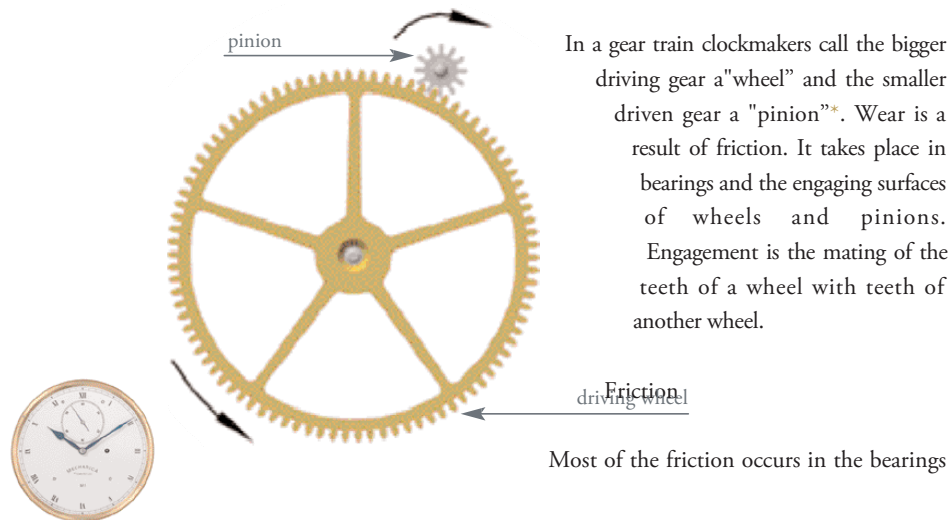
## Technical information and function of the Mechanica M1

should work for a long time without wear.

The gear train of your M1 is a completely new development. We put our more than 20 years experience building precision clocks into fulfilling the most demanding criteria for a perfect gear train.

of the wheels. In common clocks the thin pivots\* turn directly in holes of the front and back plate (most made of brass) and are lubricated with some oil. This form of bearing serves well for ordinary clocks, but has the disadvantage that because of abrasion, dirt, and evaporation, the oil loses its lubricating abilities. This increases the wear, the holes enlarge and there is a loss of driving force; the clock keeps stopping. As the bearing holes get larger the engagement distance changes producing a further loss of driving force.

For this reason some precision clocks have jewelled bearings. Even after decades these bearings show hardly any wear. To avoid friction however these bearings need oil. But every oil ages and the bearings must be cleaned and relubricated regularly to avoid damage.



The friction of these bearings is called sliding friction, because the pivot slides with its circumference along the wall of the bearing hole.

Your M1 is equipped with miniature ball bearings of stainless steel.

The friction of a ball bearing\* is called rolling friction because the inner bearing ring rolls along the outer bearing ring. The friction is very small and because of the small force the bearing needs no oil.

The maximum rotation speed of these bearings is 100 000 rpm (revolutions per minute). The fastest wheel of our clock, the escapement wheel, makes

one revolution per minute. We can be sure that our bearings don't have too much load. Only dust can cause friction, but the movement is installed in a sealed case.

These excellent bearings enable us to use less driving force. Less driving force also means less load on the teeth and thus a longer lifetime for the gear train.

Next we focus on the friction in individual wheel-pinion engagements.

A number of factors determine the amount of friction:

1. The material, especially the combination of materials
2. The shape of the wheel teeth
3. The number of teeth
4. The transmission ratio

### Materials

Your Mechanica is equipped with hardened steel pinions and brass wheels.

This is for two reasons. First the higher rotation speed of the pinions puts

more load on the teeth, therefore the material must be harder.

Second, the friction between two different materials is less than between identical materials. In clockmaking the combination of brass and steel serves well.

### The shape of teeth

Compared to other technical devices, clocks have a very high transmission ratio. This makes a special shape of the teeth necessary for a smooth power transmission. The theoretically perfect shape for this purpose was developed centuries ago, but it cannot be produced, not in the past nor in the present. We use a tooth shape that comes as close to the ideal as possible, where the teeth almost roll in the engagement and don't slide. It's called involute gearing and comes close to the ideal cycloidal\* gearing.

The number of teeth, and the transmission ratio, have a close relationship.

Experience shows that it is an advantage when as many teeth as possible engage with the other wheel at the same time. The transmission of power is then very smooth, with little friction. This is achieved by using pinions with a high number of teeth. More than 10 is ideal. Experience also shows that a high transmission ratio produces more friction, and a ratio of less than 1 to 10 is ideal.

Your Mechanica has pinions with 12, 14 and 16 teeth. The transmission ratio is between any wheel/pinion pair is between 1 to 8 and 1 to 7.5.

### The Motion Work

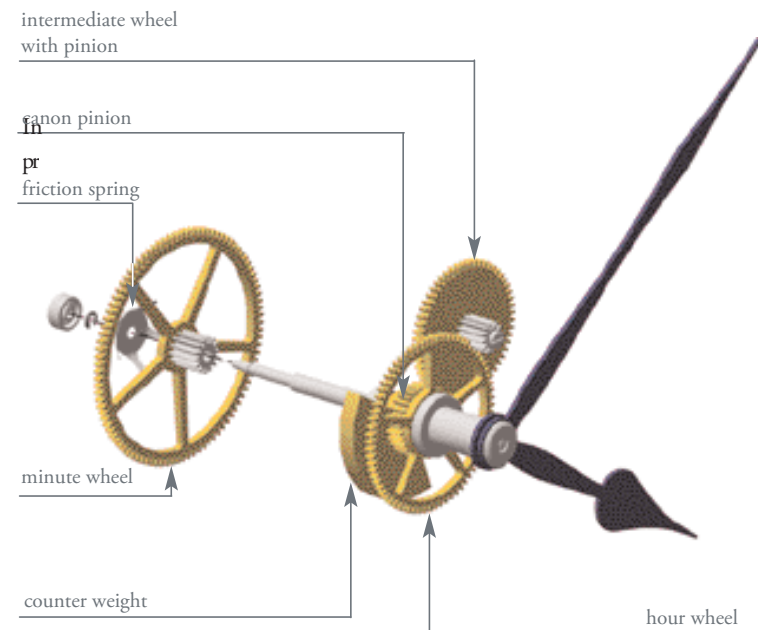
The last part to be explained is the motion work\*. The centre arbor carrying





Technical information and  
function of the Mechanica M1

We use a preloaded friction spring with 5 arms that works like a slipping clutch. A simple minute hand is very unbalanced. In the first half of an hour it supplies power to the gear train, in the second half it absorbs power producing an uneven load. It is therefore balanced with a counter weight\* out of sight behind the dial.



## A

### Amplitude

The angle through which a pendulum moves from its central position to one extreme. On the pendulum scale you can read the amplitude in minutes of arc.

### Aneroid barometer compensation

Device to compensate for the influence of the changing air pressure on the accuracy of a clock. It will be available for the M1 in the future.

### Anodise

Electro-chemical treatment of aluminium. Surface is treated in acid-bath. The result is a very durable oxidation layer. The M1 has a few anodised parts like plates, crutch and barrel.

### Arbor

Shaft in a movement.

## B

### Ball bearing

A bearing in which balls roll in a groove between the inner and outer ring. The rolling friction is very low. This is why ball bearings have very low friction and almost no wear. In the M1 the ball bearings have a very low load and need no oil.

### Barrel

Cylinder on the barrel arbor. When winding the weight the cable is wound around the circumference of the barrel. The barrel has grooves like a thread to prevent the cable from scratching.

### Barrel wheel

First wheel in the gear train. Mounted on the barrel arbor together with the barrel, the ratchet and the maintaining power device.

### Beat

The tick of the clock. Said to be in 'in beat' when the tick is even and occurs in the same position when the pendulum is approaching either extreme. The supplementary arcs are equal.

### Beat adjuster

Device to adjust the beat. With a screw you can adjust the relationship between the pallets and the pendulum by tilting the crutch.

### Bezel

Dial ring

### Blueing

Heat treatment of carbon steel. If polished or ground steel is heated to ca. 300°C an oxide builds up on the surface which appears blue.

### Brass

Alloy of copper and zinc. The gears of your M1 are made of brass. As protection against corrosion they are gold plated.

## C

### Calibre

Type of movement.

### Cannon pinion

Part of the motion work. Attached to the minute wheel arbor. Drives the intermediate wheel.

### Centre wheel

Part of the gear train. Transmits power from the barrel wheel to the minute wheel.

### Click catch

Unit consists of ratchet wheel, ratchet and ratchet spring. Locks the barrel to the gear train. In the opposite direction it allows the clock to be wound.

### CNC

Computer Numeric Controlled. Manufacturing of parts with computer

controlled turning and milling machines.

Compensation pendulum

A specially designed pendulum that does not change its length when temperature changes.

Compensation tube

Part of the pendulum. Sits on top of the regulation nuts and compensates for the linear expansion of the pendulum rod.

Concentric

Two parts or circles have the same centre.

Concentricity error

Result of production tolerances. Due to precise manufacturing in our workshop we are able to reduce the concentricity error to 0.02 millimetres.

Counter weight

The minute hand is a unbalanced lever that absorbs power for half an hour, and supplies power for half an hour. To compensate this we installed a counter weight on the cannon pinion opposite to the hand.

Crutch

Lever that connects the pallet arbor with the pendulum.

Cycloid

Generating circle. A geometrical line, that appears when rolling a circle on a geometrical contour. Has served well for gears in clocks and is still used today.

Dome

To dish. Method to enhance attraction of hands for example. For the M1 hand-domed and blued hands are available as an accessory.

## D

Drop

Free motion of the escapement wheel, after the escapement wheel tooth slipped off the impulse face of the pallet fork. Drop is necessary to avoid pallets bumping into escapement wheel teeth.

Eccentric bush

Bushing with an off-centre hole. Mounted into the pallet arbor bridge. By turning the bush, the engagement distance of pallets and escapement wheel changes and the drop can be equalized.

Engagement

Engagement is the gearing of wheel and pinion. The transmission of force is better the more teeth are in the engagement.

Escapement

Unit consisting of escapement wheel and pallet arbor. The escapement transmits the power to the pendulum that is necessary to maintain its amplitude. It also ensures that the gear train runs down gradually with the escapement wheel turning once a minute.

Escapement wheel

Part of the escapement. Wheel that engages the pallets.

In the Mechanica M1 it turns once every 60 seconds and is mounted with a bushing on the escapement wheel arbor to which the second hand is attached.

Fine regulation

Exact adjustment of period of the pendulum by adding small weights on the fine regulation table. Adding weights speeds up the clock. Removing weights

## F

slows it down.

Fourth Wheel

Part of the gear train between the minute wheel and the escapement wheel.

Friction

When designing a movement, avoiding friction is a main goal. Therefore all gear train bearings are equipped with ball bearings. Sometimes friction is necessary, for example, at a friction spring acts as a slipping clutch in the motion work, to make setting hands possible.

Friction bearing

Bearing where the pivot turns in a drilled hole. Since materials glide on each other, it is necessary to choose different materials and lubricate.

Gear train

Gear train transmits force to the escapement. It is calculated in a way that some arbors make a fixed number of revolutions relating to time measurement. These arbors carry the hands. Wheels are sometimes numbered from the slowest. Numbers vary with the running time of the clock. The month-running Mechanica has four. The escapement wheel is not regarded as a gear.

Graham escapement

Dead beat escapement. Invented 1720 by clockmaker George Graham of London. Thanks to the special shape of the pallets the escapement wheel is stationary while the pendulum makes the supplementary arc. The Graham escapement was an enormous step in precision clockmaking and has served well for centuries.

Height of fall

Distance, the weight can run down.

High grade steel

compound with other metals like nickel or chrome, gives steel special

## H

properties like anti corrosion.

Hour wheel

Part of the motion work. Turns once in 12 hours and is driven by the intermediate wheel pinion. The pipe of the hour wheel carries the hour hand.

Impulse

Process where the driving force is transmitted to the pendulum.

Impulse face

Inclined plane on the pallets. The tip of the escapement wheel tooth slides along the impulse face and transmits a driving impulse to the pendulum.

## I

Intermediate wheel

Part of the motion work. Sits on the intermediate wheel stud and is driven by the cannon pinion.

Invar

Special Iron-Nickel alloy with 36.8% nickel. Tempered Invar has a thermal expansion ten times less than steel. The alloy was invented by Charles Edouard Guillaume at the end of the 19th century. Sigmund Riefler was the first to use it 1896 as material for pendulum rods in precision clocks.

Isochronism

The constancy of the period of the pendulum with changes in amplitude. Only achievable with small changes at low amplitude.

Locking face

Curved plane on the pallet which arrests the movement of the escapement wheel.

Lock nut

Knurled nut mounted under the regulation nut and prevents the regulation nut from turning.

## L

Maintaining power mechanism

Movement unit, consists of maintaining wheel, maintaining power spring, maintaining click. Transmits power while winding the clock.

## M

Minute wheel

Part of the gear train. Riveted to the centre wheel pinion but free to rotate on the minute arbor. Linked to the train by a friction spring. Drives the fourth wheel pinion.

Motion work

Unit with two engagements. Transmits the motion of the minute hand with the ratio 1/12 on the shaft of the hour hand. Motion work has cannon pinion intermediate wheel, intermediate wheel pinion and hour wheel

Oil sink

Hemispherical hole at the outer opening of a bearing. The oil sink hold a small amount of oil as reserve.

## O

Pallet

Part of the pallet arm on the pallet arbor, made of hardened steel or jewel. The pallets are ring segments inserted in the pallet arm. The centre of the ring segments is identical with the rotation centre of the pallet arbor. The polished inclined planes are called impulse faces. In the future, jewelled pallets will be available for the Mechanica M1.

## P

Pallet arbor bridge

Bearing of the pallet arbor on the back plate.

Pendulum

Still today's best mechanical oscillation device. The period is determined by the

length of the pendulum and the force of gravity.

Pendulum bob

Heavy cylindrical weight at the lower end of the pendulum rod. You can choose from stainless steel or bronze.

Period

Strictly speaking, the time taken for a pendulum to swing from one extreme to the other and return. Clockmakers traditionally only consider the time taken to swing from one extreme to the other. Following this tradition, your Mechanica has a 5/6th second pendulum.

Pillar

Also movement pillar. Keeps distance between the plates.

Pinion

Gear with less than 20 teeth. Manufactured in most cases of hardened steel. The M1 has 5 hardened pinions. Intermediate wheel pinion, centre wheel pinion, fourth wheel pinion, escapement wheel pinion, minute wheel pinion.

Pitch

The distance between two tips of teeth, i.e. the circumference of the pitch circle divided by the number of teeth.

Pivot

Thin end of a shaft. Part of the shaft which turns in the bearing holes of the plates. The pivots in your M1 are made of hardened steel.

Plates

Hold the bearings and are the base for all other movement parts. The M1 has anodised aluminium plates.

Precision pendulum clock

Sophisticated timekeeper with extremely high accuracy. Clocks with

## R

compensated pendulums were used until the late 60's as reference time for science and official standard time.

### Rate

Daily rate is the time difference between the clock being tested and the standard time (radio controlled clock).

### Reading

The time that the clock displays.

### Regulation

Refer to fine or rough regulation.

### Regulation nut

Knurled nut at the lower end of the pendulum. With the regulation nut the pendulum bob can be raised or lowered. Shifting the bob upwards makes the clock faster.

### Regulation pin

Stainless steel pin which has to be inserted into the lateral hole at the tip of the pendulum. With this pin you can hold the pendulum when turning the regulation nut and avoid damage of the suspension spring.

### Regulation weights

Small metal pieces that make the clock run faster when put on the regulation table. With the regulation weights you can adjust your clock to an accuracy of a few seconds a month.

### Regulator dial

Classic precision clocks have this special way of displaying time with separate dials for hours minutes and seconds. This avoids the need for motion work but requires the gear train to be modified so that one arbor (for the hour hand) turns twice a day. The hour hand never obscures the seconds dial. An regulator dial for the M1 will be available in the future.

### Rough regulation

Adjusting the accuracy of the M1 with the regulation nuts at the tip of the pendulum. You can adjust the clock up to ca. 1 sec. a day.

### Spring

The beat adjuster has a coil spring.

### Supplementary arc

Oscillation phase of the pendulum. Outbound supplementary arc: pendulum travels from the end of the drop to the turning point. Inbound supplementary arc: pendulum travels from turning point to locking.

### Suspension spring

Spring steel strip between brass jaws. The suspension spring holds the pendulum.

## S

### Temper

Carefully controlled heat treatment of the Invar rods to relieve stresses in the material. Only tempered Invar rods have predictable thermal expansion.

### Torque

Turning force.

### Transmission ratio

Determined by the number of teeth in a pair of engaging gears. Expressed as the number of turns the driven gear makes when the driving gear turns once.

### Tungsten



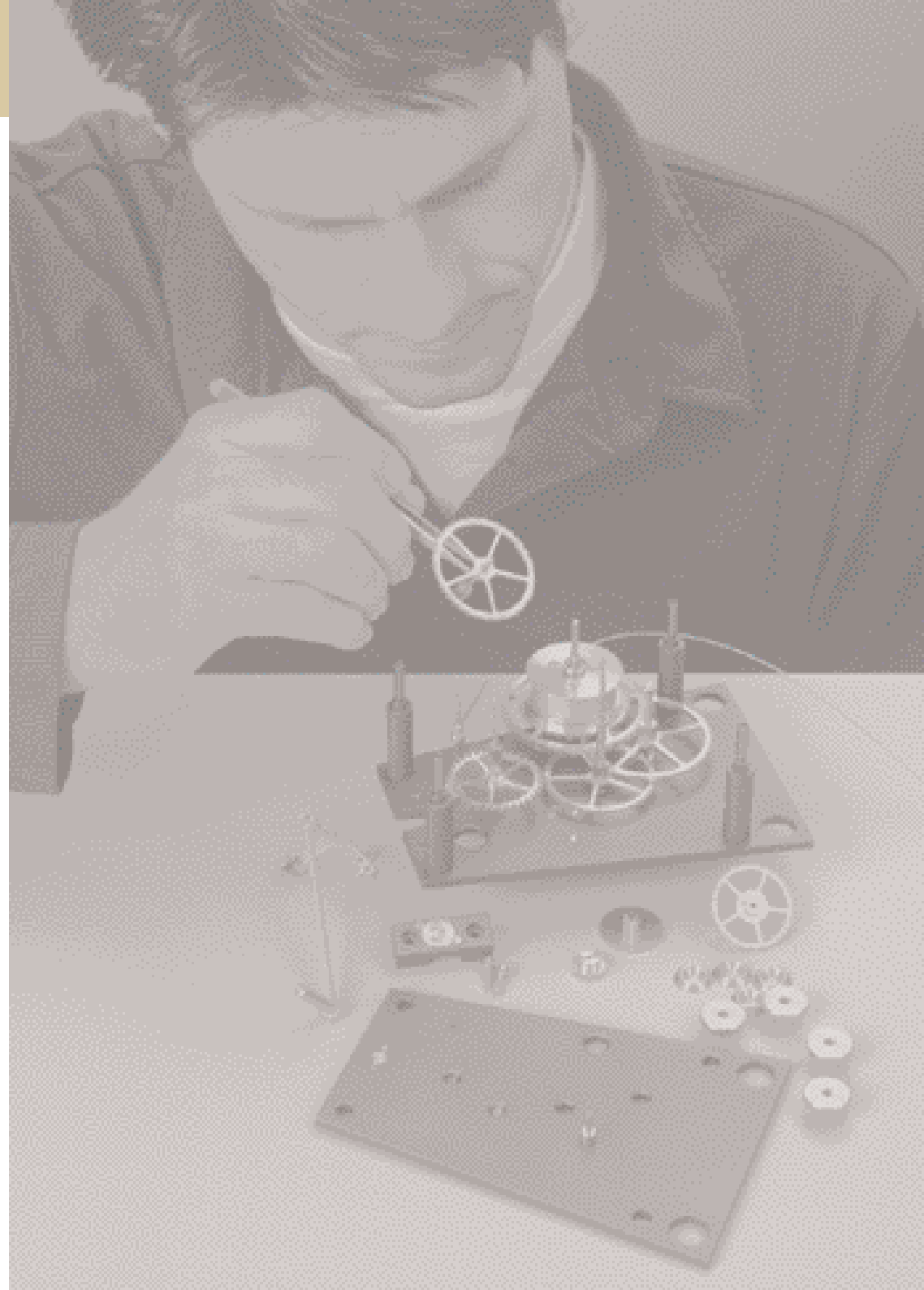
## T

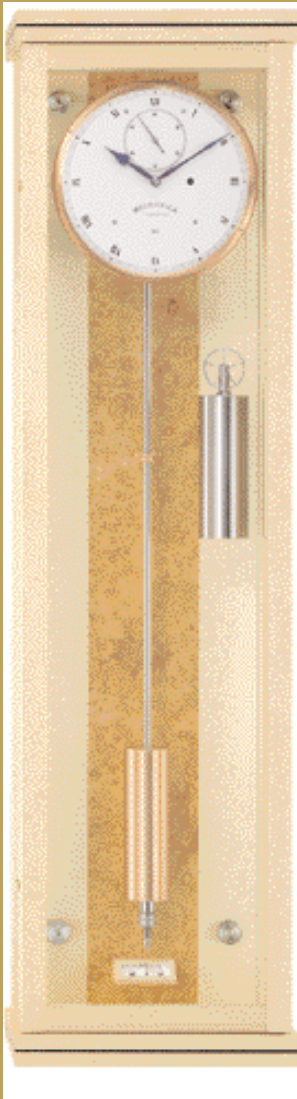
Very heavy metal, density 19.3g/cm<sup>3</sup>.

### Winding period

Time a fully wound clock will run without rewinding. The winding period depends from the height of fall, the measurements of the barrel and the gear ratio. Your M1 has a 30 day winding period.

## W





## Movement

- o Plates of 4mm thick anodised aluminium
- o All gear train arbors have ball bearings
- o Hardened steel pinions with 12, 14 and 16 teeth
- o Very fine crossed out wheels, milled, polished and gold plated
- o Graham escapement with hardened, adjustable steel pallets
- o Dial of anodised aluminium
- o Hands of steel, handmade and blued

## The clock

- o One month winding period
- o Accuracy +/- 3-4 sec. per month
- o Driving weight of solid tungsten, 3000g with pulley
- o Case made of solid untreated wood available in cherry, maple, walnut or black lacquer
- o Dust proof case
- o Secret drawer in the case bottom for accessories
- o Pendulum suspension and movement pillars directly screwed to the case back
- o Free plaque with your name engraved, made on request
- o Case dimensions: height: 1020mm (40 inches), width: 270mm (10.6 inches), depth: 145 mm (5.7 inches)

## The pendulum

- o Pendulum rod made of tempered Invar
- o Solid pendulum bob available in stainless steel or bronze
- o Temperature compensation
- o Fine adjusting table
- o 5/6 seconds invar pendulum (temperature compensated)

## The passion goes on ...

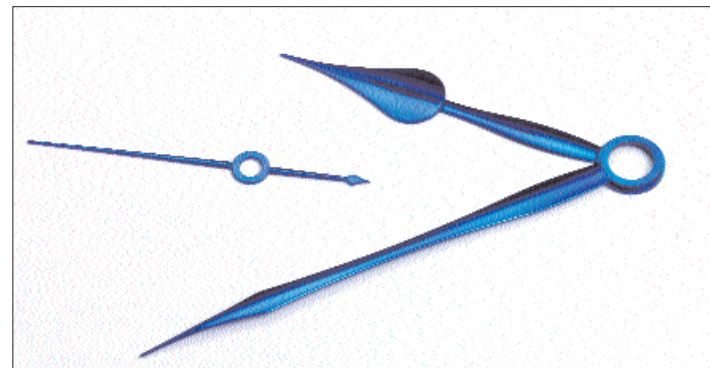
Accessories for your M1

We can offer the following options:

- o Jewelled bearings for the pallet arbour and jewelled pallets
- o Domed\* hands, polished and blued by hand
- o Barometric pressure compensation
- o Solid turned lens-shaped pendulum bob
- o Regulator dial\* with silvered dial and blued hour hand
- o Pulley in ball bearings

etc. etc. etc.

The production of these more sophisticated accessories depends on the demand; for further information please contact Müller & Sattler Uhrenbausatz GmbH or visit our web site [www.uhrenbausatz.de](http://www.uhrenbausatz.de)





Mechanica M1's  
big brother

The big brother of your Mechanica M1, the precision seconds pendulum clock '1935' by Erwin Sattler, Munich.

With the model 1935 Erwin Sattler is continuing the tradition of precision clock making in Germany. Clocks like this served as scientific instruments, perfect into the smallest detail, until the middle of the last century.

The case is 142cm (55.9 inches) high, 36cm (14.2 inches) wide and 17cm (6.7 inches) thick and is equipped with bevelled glass on three sides. It is protected by a multiple layer of black polishing varnish. The handmade domed, polished and blued hands show accurate time on an engraved and silvered regulator dial.

Because of its length, the airpressure and temperature compensated pendulum makes oscillations in second-steps. The movement has a winding period of 30 days. All parts have a high grade finish and are protected by lacquering or gold plating.

The finish on this clock is not only done for technical reasons, it should also enhance the visual appearance of the clock.

The model illustrated, '1935', and all other models of the Erwin Sattler collection are not available as kits. They are sold only in selected clock or watch stores.

If you share the fascination of clocks with us, we would be happy to send you the free Sattler catalogue including a dealers list.

Erwin Sattler OHG o Großuhrenmanufaktur o Killerstraße 7  
D-82166 Gräfelfing

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[www.erwinsattler.de](http://www.erwinsattler.de)

Notice

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