Operations Manual for the Astronomical Skeleton Clock

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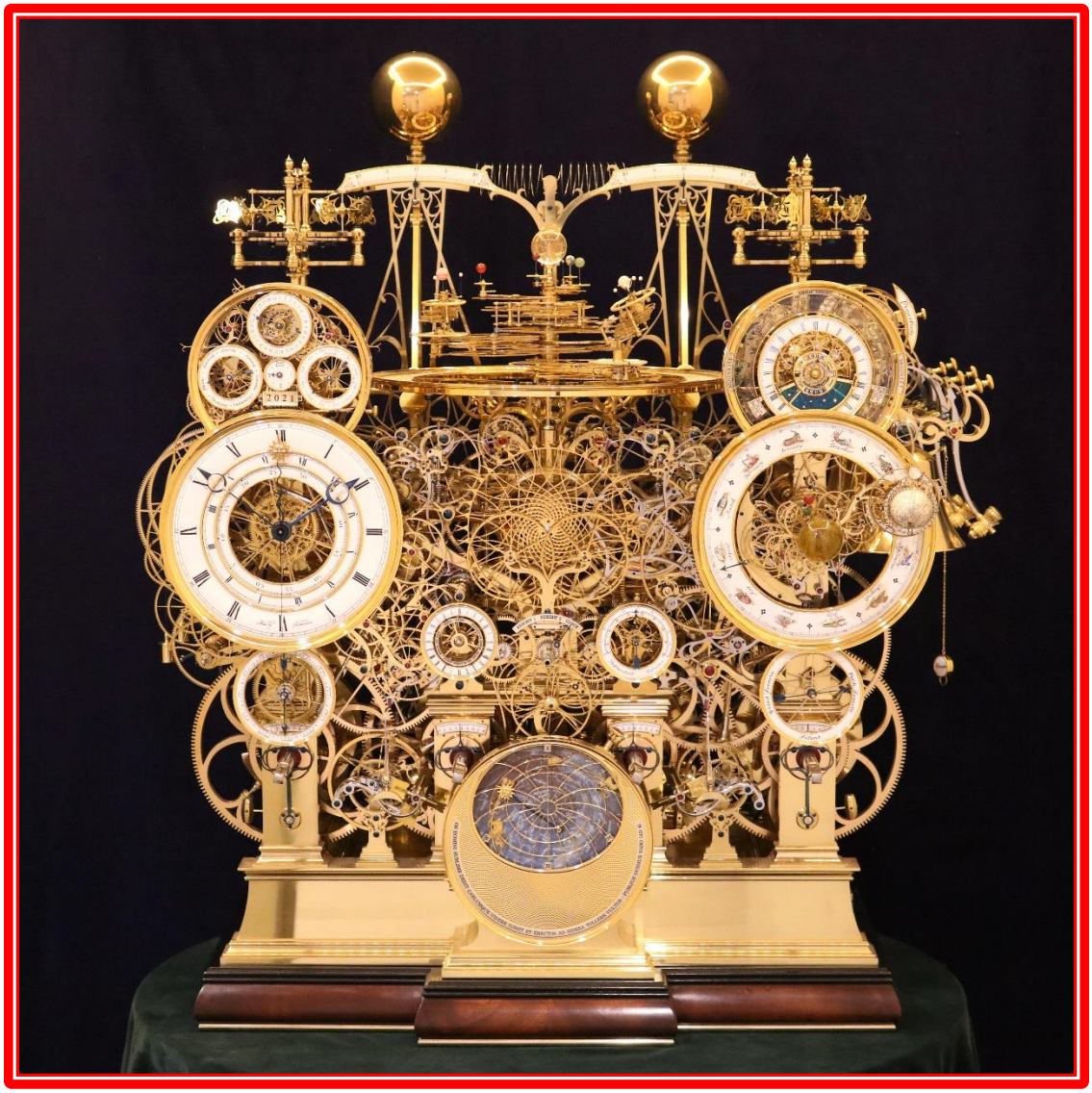

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Section 1

Preliminary procedures to move the Astro-skeleton clock and set it upon its permanent location

This section examines the special apparatus and parts needed to ensure the machine can be successfully moved and safely placed on any table top that is strong enough to support the machine.

The cradle:

Fig. 1. The cradle assembled

A custom made aluminum apparatus was made to safely move the clock to and carry it before any of the removable complications, pendulums and escapement are attached. This reduces the weight of the machine to 180 lbs. (82 kg.). The cradle is designed to be held between two men. It is equipped with shaped rubber cushions where it connects with the clock base to ensure that it will not mar the surface, Fig, 2. The cradle is designed to be able to be deployed with the wood surround, Fig. 3.

The cradle can be used with the clock fully built out, but this is not recommended and should only be used for a very short lift, Fig. 4. The weight at this point comes to about 230 lbs. (105 kg.) and as can be seen in fig. 5 this becomes a dangerous lift. ⚠Note! If this option is chosen be sure to remove the upper balance balls and install the locking bracket and knobs as described in Section 2. The bracket can be seen secured in place, but the upper balance balls would not normally be attached, Fig. 5. ⚠Note! The clock ***must never be moved without the cradle*** or there is a risk of the base racking resulting in catastrophic failure of the machine.

Fig. 2. Rubber base supports

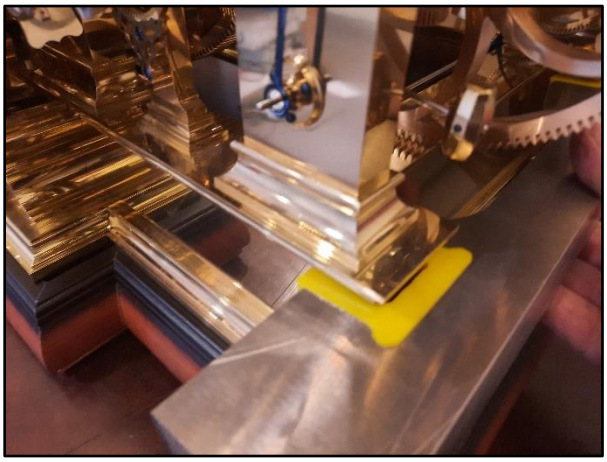


Fig. 3. Base supports in place, note wood surround

Fig. 4. Cradle in place - not recommended

Fig. 5. Two person move – not recommended

The aluminum support block:

The brass flatbed base of the clock, while being made of substantial brass stock, is made from four pieces. Upon the flat bed base are eight tall pillars that support the majority of the over 550 wheels, in particular the four main trains represented by the time, celestial, quarter and hour strike trains. It has been shown that if the frame is allowed to rack, that is a corner is raised without additional support, the frame will twist. This will result in the frame coming out of alignment from a perfectly flat plane. The tall pillars will amplify any deformation and will result in the binding of the wheels in various locations resulting in catastrophic failure of the machine.

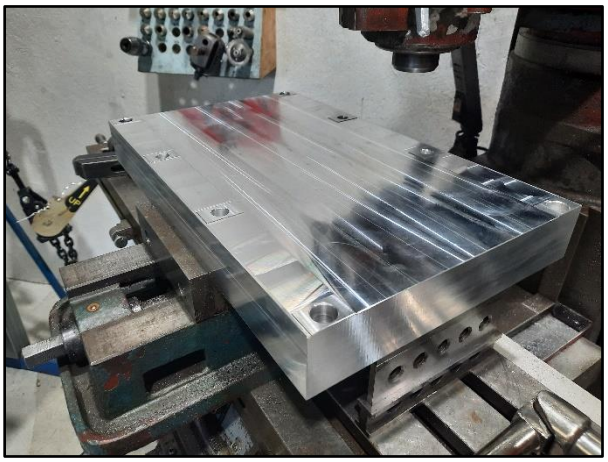


Fig. 6. Aluminum base block being milled

Fig. 7. Block installed under the clock

The clock has been supplied with a rectangular, milled 2.5” (65 cm) thick aluminum block that is designed to support the clock’s brass base on a perfectly flat surface. The clock brass base has four locating pins to ensure that the clock base locks into correct position into the aluminum block. There is no orientation requirement. ⚠Note! The block is an essential element to keep the base and therefore the clocks integrity intact. The clock should not be set up solely on its brass frame no matter how certain the table top is seen as a perfect plane.

To correctly locate the block on a table and within the base outline of a glass case, one need only be sure the block is equidistant from the interior perimeter of the case base.

The wood base surround:

To hide the aluminum base block a decorative wood surround has been supplied and need only be placed around the aluminum block after that block has been placed in its final position. After that is done the machine can be *carefully* lowered onto the aluminum block aligning the pins in the base of the clock into the locating holes in the aluminum base.

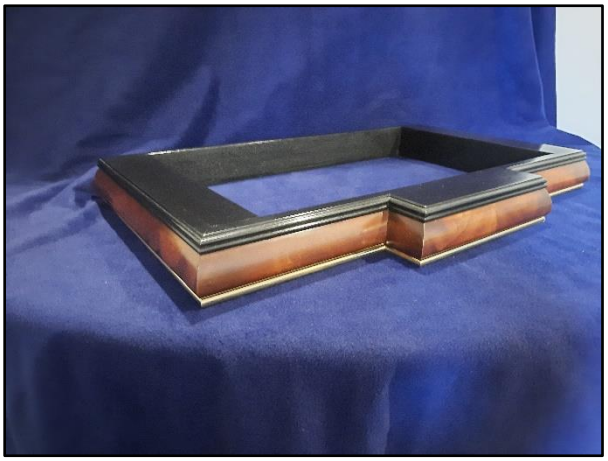


Fig. 8. The wood surround

Fig. 9. Wood surround in place,

Section 2

Assembly of Astro-skeleton to point of running before installation of complication modules

Steps for post-delivery reassembly of the Astro-skeleton clock. ⚠Note! Most of what is described corresponds to the videos on file. However these were made as the clock was disassembled, so their order is a reversed for reassembly and a few things were later discovered to be better done in a different order; these will be noted. What is presented below is what one would do upon delivery of the clock. Some videos are obvious such as the unpacking of an assembly occurring after its installation. While I will save all of these specialty packing boxes, there is no guarantee they will survive, so these will not be described.

Each description is as detailed as possible in case at some point in the future the videos are lost. Otherwise, using this instruction manual along with the videos and with some care and patience, it should be a straightforward job.

Below are a list and brief description of each video's contents. They are listed in reverse order so as to be used for reassembly, but can be put in ascending order for disassembly in the future.

#00075. Balance securing caps and installing cross drive, pre-shipping. This video is really only useful for the time the clock is disassembled for shipping. One could secure the cross drive to clock as was done when shipped to me or could be shipped separately, making this video superfluous.

#00074. Install the balances
#00073. Secure balance bearing caps
#00072. Install escape wheels *
Secure escapement pallet assemblies *
#00071. Install cross drive train, right hand side, also see video #75
#00070. Install spiral cross arbor for right hand remontoire fly governor
#00069. Install calendar module
#00068. Unpack calendar module from shipping box
#00067. Install Sun/Moon module
#00066. Unbox the Sun/Moon module
#00065. Secure strike/repeat weight *
#00064. Preparing the tellurion dial, removing drive wheel
#00063. N/A
#00062. Install tellurion dial
#00061. Install mean time dial *
#00060. Secure mean time dial hands *
#00059. Fitting moons and other misc. part onto the orrery module
#00058. *Missing*
#00057. Unpack orrery and its dial from shipping box
#00056. Secure orrery dial to orrery module
#00055. Install orrery onto clock

#00054, *Missing*
#00053. Unpack tellurion module
#00052. Re-packing tellurion module
#00051. Securing the Earth globe to the tellurion module
#00050. Securing Earth globe to tellurion module, continued
#00049. Install tellurion module
#00048. Install the planisphere module
#00047. Secure lower remontoire weight band to weight *
#00046. Secure upper remontoire weight band to remontoire sickle mount *
#00045. Secure balance cross bands to balances * *How is the proper tension achieved?*
#00044. Secure balance springs and suspenders *
#00043. Secure balance springs and suspenders, continued in close up *
#00042. Secure balance balls *
#00041. *Dud*
#00040. Start clock *

The way the actual assembly differs from the order of the videos is as follows:

#00074. Install the balances
#00073. Secure balance bearing caps
#00071. Install cross drive train, right hand side, also see video #75
#00070. Install spiral cross arbor for right hand remontoire fly governor *
#00045. Secure balance cross bands to balances * *How is the proper tension achieved?*
#00044. Secure balance springs and suspenders *
#00043. Secure balance springs and suspenders, continued in close up *
#00072 – reverse order of video putting in escape wheels first and then the pallet assemblies *
#00047. Secure lower remontoire weight band to weight *
#00046. Secure upper remontoire weight band to remontoire sickle mount *
#00065. Secure strike/repeat weight *
#00061. Install mean time dial *
#00060. Secure mean time dial hands, synchronize with strike train *
Mount bell set (no video)
#00042. Secure balance balls *
#00040. Start clock *

Completion of the steps above brings the clock to the point where it should run all of the main trains, show time on the mean solar dial as well as hearing the bell set. The machine then can be tested for proper running before securing the complication modules. The instructions below reference each newly arranged video. Those videos have been marked with an asterisk.

Installing the balances: Video 00074

1. ⚠Note! Remove the cross drive assembly located on the rear of the clock first. Balances cannot be installed until this is done as this assembly must be threaded through the balances' lower triangular openings. (See: Installing the cross drive). Omitting this step may cause damage to the cross drive and balances!

2. Secure the balance locking plate knurl nuts onto the lower balance threaded rod. This will supply a downward bias to the balances to keep them from swinging wildly.

3. Unscrew upper bearing caps, these are marked A – D and are not interchangeable

Fig. 1. Detail of right hand balance (as seen from rear), lifted into clock on slight angle

4. Install right hand balance as seen from the rear making sure to clear any obstructions and gently lower the balance with the rear end slightly tilted downward so it seats first into the open balance support bracket. ⚠Note! This balance has a control pad that touches the reverse coup-perdu escapement anti-friction control wheel from the top, that pad must rest upon the small control wheel that protrudes from the reverse coup-perdu escapement from the right (*as seen from the front*). Be sure to gently lower the front until it is touching the anti-friction wheel and is seated onto the front balance bracket, Fig. 1.

A. There is knurl control knob for adjusting the left-to-right depthing of the jeweled escapement coup perdu pallets. This should not need adjustment but can be used if the escape wheel sounds out of beat, Fig. 2 and Fig. 3.

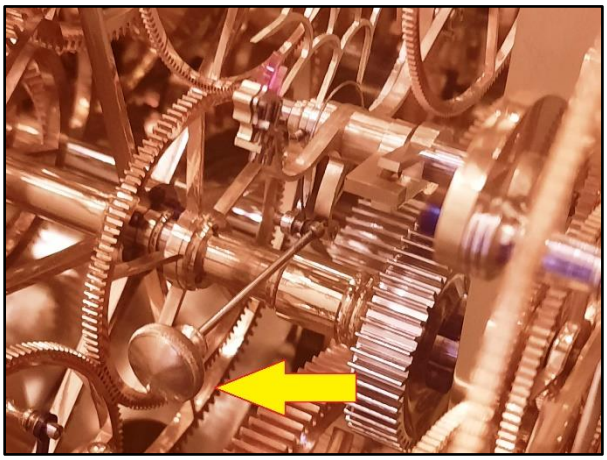


Fig. 2. Beat regulation knob for seconds coup perdu

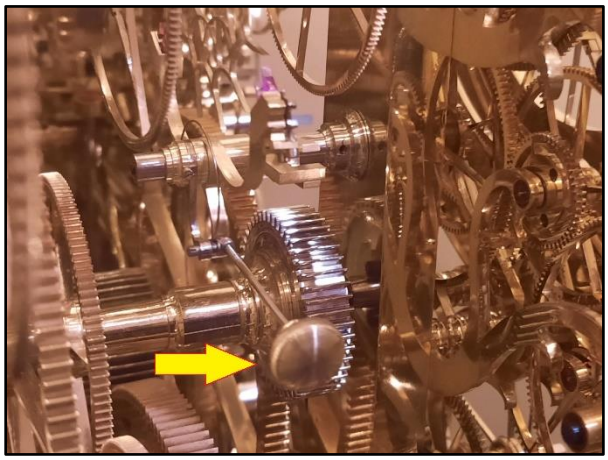


Fig. 3.

5. Left hand balance is installed the same as the right *except* that when the balance is lowered home onto the final seating on the balance support brackets the balance tri-arbor set must be horizontal so as to rest on the front and rear supports at the same time due to clearance issues with the front balance's anti-friction wheel set-they must be perpendicular to avoid hanging up

6. Secure the balance support upper bearing caps. These are all marked A though D and must not be interchanged. This step is also shown in Video 00073

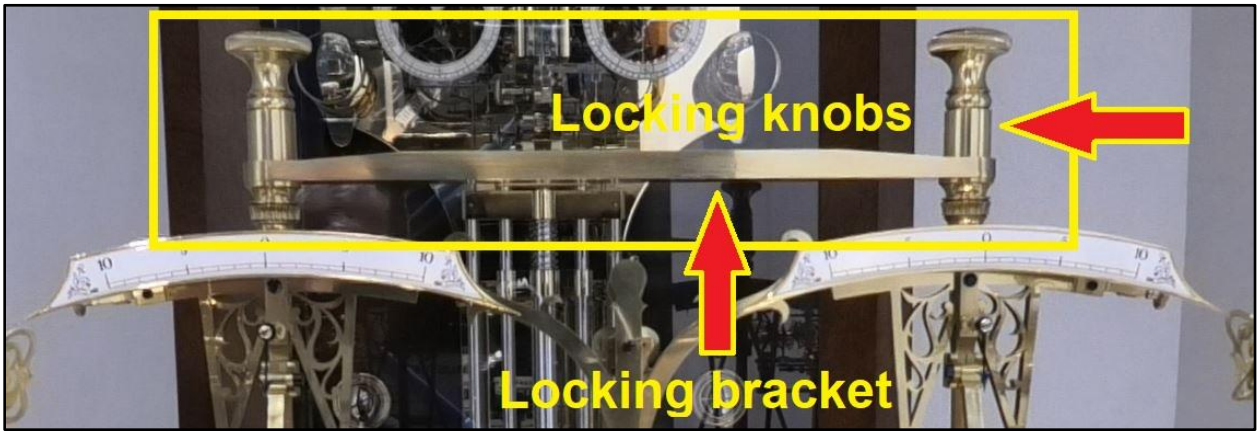


Fig. 3. Pendulum locking bracket

7. Remove the two locking bracket knurl nuts from the bottom balance threads. Place locking bracket onto the two upper balances taking note that the taper side is up, flat side down; and lock in place using the two knurl locking nuts, Fig. 3. ⚠Note! Doing this at this time is essential to hold the balances steady for all further assembly steps. Omitting this will result in damage!

Installing balance upper bearing caps: Video 00073

1. If not already done, the hour strike rack needs to be dropped to provide clearance for the front right hand cap. This is done by moving the repeat cycle lever to cycle the strike rack release levers. Install all for bearing caps.

Installing the cross drive from the time to strike trains: Videos 00071, 00075

1. ⚠Note! this system will be installed as received so they must be removed before installing the balances (see installing the balances). Failure to do so will result in damage to the cross drive and balances.

2. ⚠Note! This system comes in two pieces, left and right. And each is located through the lower triangular sections of the balances.

A. Secure left hand assembly by inserting upper frame that has a half circular notch on its right side and slip that through the left hand lower balance triangular section and then behind the slightly loosened screw in the center balance spring support frame while the other end has its pillar screwed into a hole on the main strike pillar on the left. That screw has already been loosened but not removed to extract the cross drive before the balance installation.

B. The right assembly has an extra wheel that will be secured by a taper pin. ⚠Note! This wheel must be removed before installation of the assembly as its rim is in the way of a screw securing that assembly. Install right hand assembly in same way. ⚠Note! It is a good idea to have both screws finger-tight until installation is complete so the pair are correctly seated under the center frame pillar screw, then tighten the screw to secure these to the center frame and then tighten the other two screws on the ends of each assembly.

C. Replace the wheel, the wheel collar and its taper pin on the right hand assembly and check for freedom of wheel movement.

Install spiral cross arbor for right hand remontoire fly governor: Video 00070

1. Open jeweled cock on main frame cross pillar behind and under the right hand fly governor tower is removed.

2. The arbor is marked as received with a tag attached to the bevel wheel that will be mated onto the cock. At some point a punch mark will be good to apply to the one of the inside bevel wheel to match one on the cock if in the future the tag is omitted.

3. Insert arbor pivot into the removed cock pivot hole and position it loosely where it goes onto the frame cross pillar from where it was removed.

4. Insert opposite pivot into the cock on the time train, taking care to keep the arbor in alignment.

5. Insert cock back into the frame rod taking care not to jam it into the tight recess.

6. Insert screw and secure the cock

7. Check for freedom of movement. There should be just a small bit of end shake.

Secure balance cross bands to balances: Video 00045

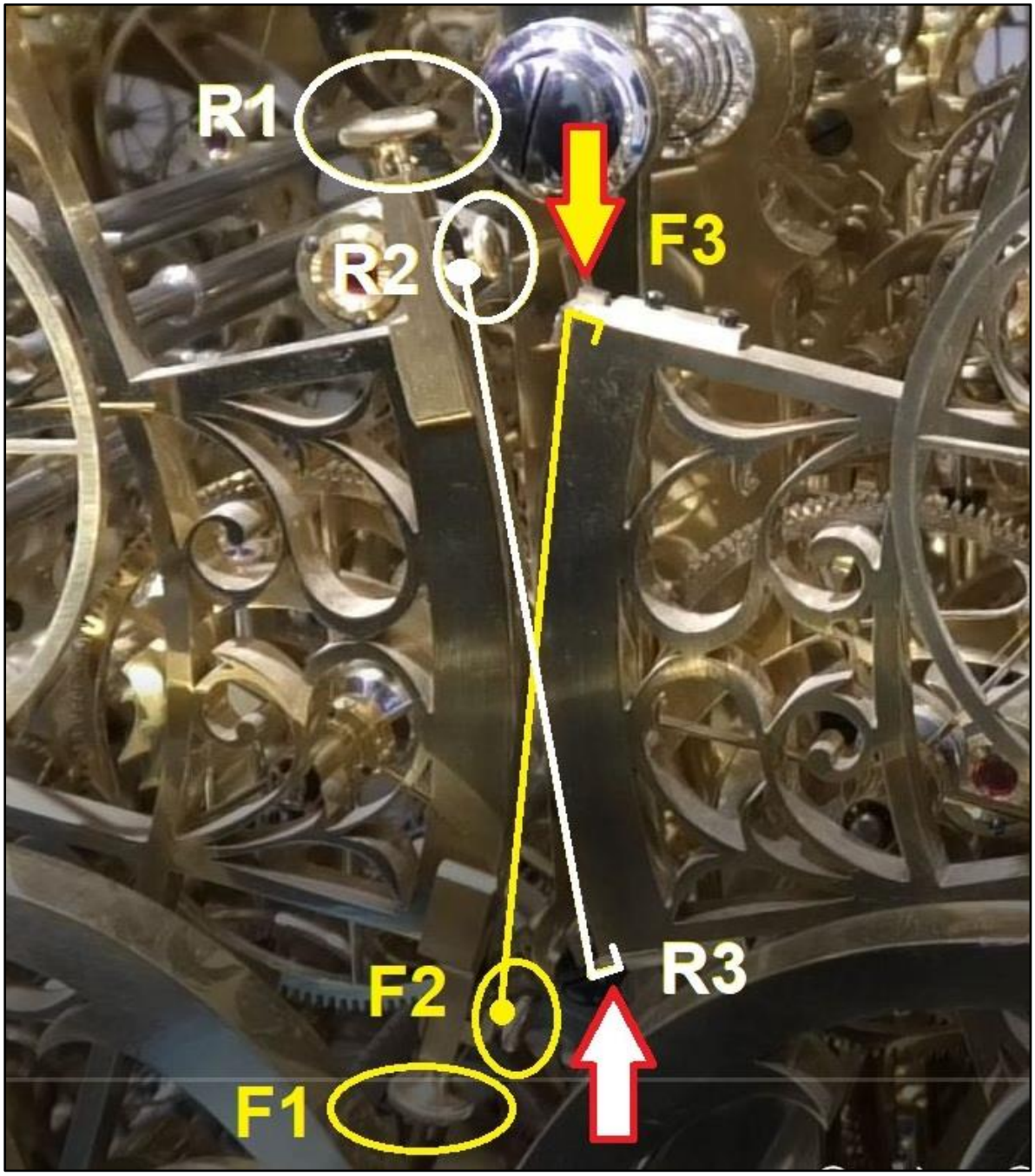


Fig. 4. Cross band detail. F = Front, R = Rear. Install front band first, then rear band

Fig. 4. Each cross band is secured from one end by a hook that connects into the balance recess, at points F3, R3. The other end has part with a hole that is secured to a sliding tensioner with a pin mounted to a threaded knurl knob which when tightened secures that end to the slider, F2, R2. The slider is adjusted by the larger knurl knob, F1, R1. With the balances already locked, each slider should be equally snug (tensioned). With the balances locked the beat pointers should be both pointing to the centre of the beat plate. 0 degrees. When the cross bands are fitted and all slack removed by the tensioning knobs the balances should be set up symmetrically. When running no flex or slack should be seen in the cross bands, but they should not be tight. Once the springs are mounted and the balance bracket lock removed there may be some trial and error to get this just right. F=Front, R=Rear as seen from the front of the clock, but should not be needed

⚠Note! These are placed on top of tags labeled “front cross band” and “rear cross band” as designated from the front view of the clock. ⚠Note! Do not remove any of these parts from the tray until you are ready to install each one, there are no identifying marks on the parts and they are NOT interchangeable, Fig. 5.

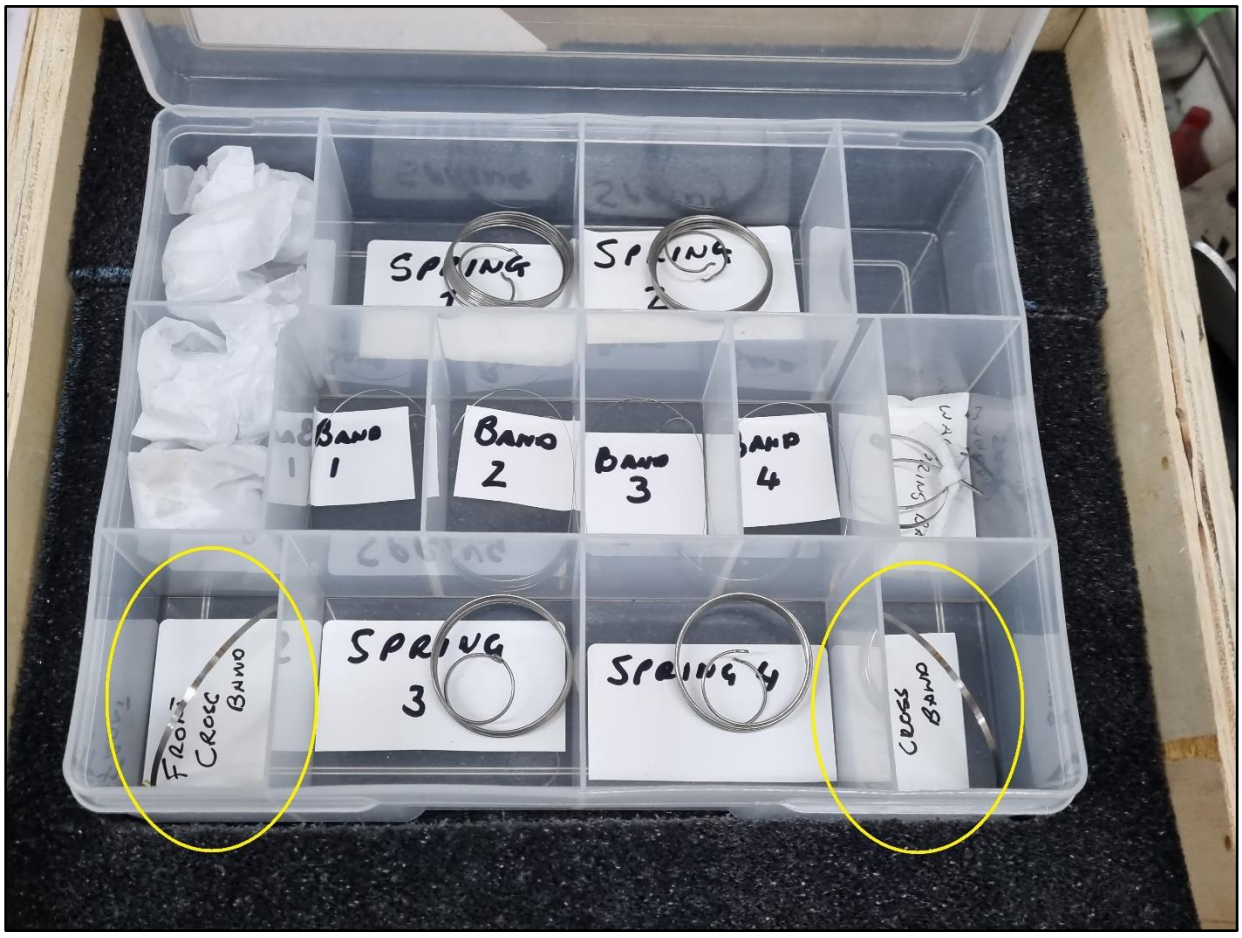


Fig. 5. Spring and band location identification

Secure balance springs and suspenders: Video 00044 and 00043

⚠Note! Balance springs are *mirrored left to right and top to bottom*. The numbering corresponds to those found on the balance balls. As seen from behind, #1-top left, #2-top right,

#3-lower right, #4-lower left. This can be checked by looking for the number markings on the balance threaded rods.

Fig. 6. Thumb screw that holds spring suspender band is pre-adjusted (1). Locate band and secure by tightening small thumb screw (2) through hole on large band plate. Hook spring first on the adjustment band from the vernier scale (arrow 2) then on the small square block hole tensioning band (arrow 3). Orientation should be as in photo. Do this for the remaining three springs. There may still be the need for minor trial and error to get the balances perfectly aligned.

Fig. 6. Balance spring and suspender detail

Installing the main escapement wheels: Video 00072

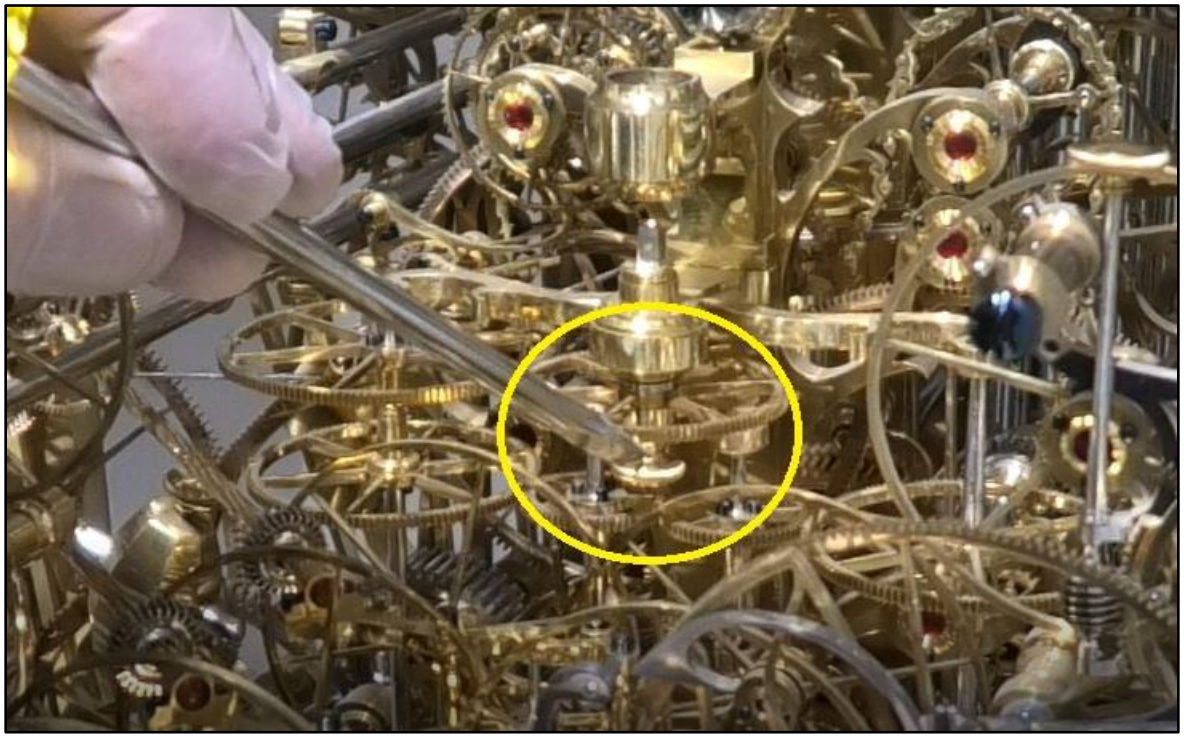


Fig. 7. Detail showing orrery horizontal wheel obstruction

The escape wheels ride on a set of ant-friction wheels and so may be lifted out. There are no fastening devices. One need only position the escapement wheels so they clear obstacles and rest on the ant-friction wheels. ⚠Note! There is a horizontal wheel on the orrery drive that will prevent the rear of the escapement arbor from being lowered straight down. One need only move the rear end a bit to the right while still over the rear set of anti-friction wheels to clear this and then can be set into position, see end of screwdriver in the photo above.

Installing the escapement pallets assemblies: Video 00072

1. Each pair of escapement pallet assemblies come as a unit and are secured by one screw. Each assembly has a pair of locating dowels. Align the dowels and gently push the assembly home onto the balance. The same procedure is done for the remaining pallet assembly. They are then secured by a screw which is already in the balance so finding the right location is readily identifiable (arrow1), Fig. 8. There is a left and right assembly, they cannot be confused.

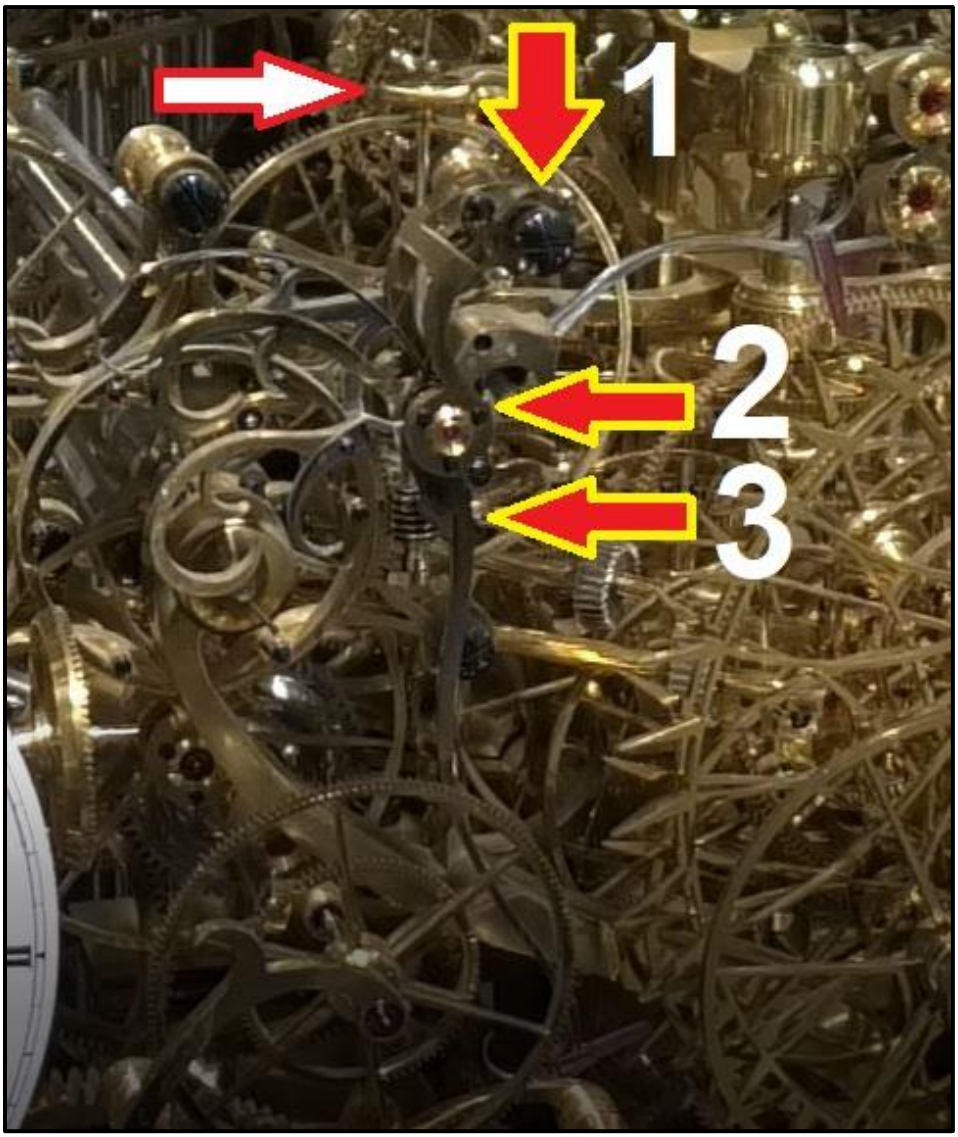


Fig. 8. Detail of escapement pallet assembly

2. ⚠Note! There is a knurl knob attached to a rod that rises vertically from each pallet assembly. This is used to adjust the beat of the pallet assembly by rotating it clockwise or counterclockwise around the center of the escapement assembly. These have been set and should not need to be adjusted, (white arrow), Fig. 8.

3. ⚠Note! There are also a pair of adjusting screws that can be used to adjust the escapement's upper compositor which holds the jeweled pallet and the same is for the lower compositor. This will adjust the depthing of each pallet. These too are set and should not need adjustment, (arrows 2 and 3), Fig. 8.

4. ⚠Note! Check to see that the escapement pallets are centered on the escape wheel teeth. This can adjusted by moving each balance from front to back until they are centered. This should be already centered, but the adjustment is accomplished using the two knurled knobs located on the ends of each balance just beyond where they rest in the balance support frame. ⚠Note! To adjust the front knob one may have to remove the escapement as it is somewhat in the way, but a careful operator should be able to do this without the removal.

At this point any side force on the balance antifriction wheels need to be removed. It is done like this.

1. Check that the lower antifriction wheels on all four antifriction assemblies are free to spin and are not touching the balance arbour. They only perform a safety retaining function.

2. Then first lift the front antifriction frame until the lower antifriction wheel is pressing on the underside of the balance arbour. Then check that both upper antifriction wheels can spin freely, you may need to bias the antifriction wheel assembly slightly to the left and then to the right to free the opposite upper antifriction wheel. Each antifriction wheel should spin very freely.

3. Lower the weight of the balance back onto the balance arbour and check the lower antifriction wheel again for free rotation. When running the lower wheel can sometimes be seen to be rocking independently to the balance.

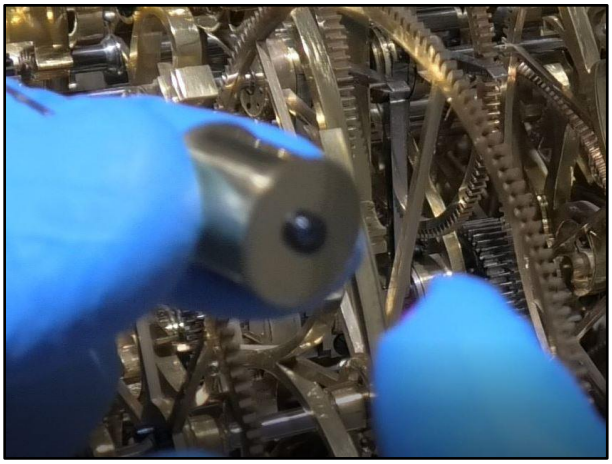
⚠Note! This relieving process must be done to both front and rear antifriction wheel assemblies. It is difficult, but may be necessary, to perform this exercise when the balance balls are installed due to the fact that you have to lift the weight of the balance and two balls to check the upper antifriction wheels on the rear assemblies. It is best to do this process now and hopefully it will not need to be repeated with the heavy balance balls attached..

Secure lower remontoire weight band to weight: Video 00047

The pair of remontoire weights are identical as are the bands. There is a set screw at the neck of each weight that secures the band. Each has a dimple where the screw was attached.

Secure upper remontoire weight band to remontoire sickle: Video 00046

Fig. 9. Remontoire weight band clam



Fig, 10. Base of weight showing lead shot fill hole

The other side of each remontoire weight band has a right-angle bend and is secured to the sickle-shaped mount on each remontoire rocking cage with a separate clamping device that sits atop the sickle mount and clamps the band when the screw is tightened, Fig. 9. Each weight has a screw at the bottom that allows one to fill or empty lead shot to obtain the proper drive mass, Fig. 10.

Secure strike/repeat weight: Video 00065

The strike and repeat weight has the same configuration as the remontoire weights described above and is secured in the same way. This completes the strike train, it should now be ready to synchronize with the time train

Install bell set: – there is no video for this step.

Small bell to the front, large bell to the rear. The bells are screwed onto the projecting thread under the bell support bracket. They are tightened by hand reasonably tight.

The bells and balance balls are not lacquered as they are easily removed and look much better bare than Lacquered.

Install mean time dial: Video 61

Fig. 11. Pair of latches at bottom of mean time dial

Fig. 12. Single securing latch at top of mean time dial

The mean time dial is securing with three latches, two at the bottom, Fig. 11 and one at the top, Fig. 12 The dial slides over three pillars matching up to the holes in the back of the dial and each has a circular groove that lines up with the position of the latches, designed to fit the dial snugly when they are engaged.

Secure mean time dial hands, synchronize with strike train: Video 00060

The strike train should now be fully functional. As received all trains have been fully let down so using the main trains winding key turn the far right two winding drums two clicks. The train will probably begin moving immediately as strike and locking racks and levers have all been put out of place. Once the striking sequence has stopped set the strike indicator to ‘petit sonnerie’.

1. Insert the demonstration key into the key square located below the 7 o’clock position. *Slowly* crank the key clockwise until you see the strike train begin to set up, then just enough to trip the train. When under petit sonnerie it will play the number of quarters that the racks are currently set to via their respective cams. For the easiest setting, try to have the bells indicate the full hour so the minute and hour hands can be set exactly at their corresponding number.

2. Each hand is mounted to a pipe that has a pair of slots so these will secure to the mating attachment with a tight friction fit. Start with the hour hand then the equation of time hand. First set the equation of time dial just below the mean time dial to the correct date. Then use an equation table that is easily found on the internet to see the time difference in minutes from the mean time. Since the mean time minute hand will later be set at 12 o’clock, one can set the equation hand at this time.

3. Put 2 clicks winding on the two left winding drums, the time and celestial trains, The Wagner remontoire should load.

4. Move the Balances to allow the clock to tick until one remontoire carriage reloads.

5. Place the Second hand gently on its arbor at the 12 o'clock position.

The time and strike train are now synchronized.

6. Rotate Robin remontoire feed ratchet until the remontoire releases. ⚠Note! The upper, larger, weight was shipped and tied at its upper limit with the smaller tied at the bottom. If the main weight touches the lower weight pan before the remontoire cycles, hold the 'S' shaped arm until the main weight is lifted a bit higher, i.e. delay the release. Refer to video 00083.

Replace beat plates: Video 00075

Towards the end of this video the beat plates are replaced. In video 74 where the balances are being installed the beat plates are still there. Later it was discovered that the installation process is made easier if the plates are first removed so they will be when the clock is received. Secure the beat plates and rotate the indicator pointer to their upright positions to read off the dial. With balances at rest the pointers should read at the center of the dial, i.e. zero.

Secure balance balls: Video 00042

⚠Note! The balances at this point must still be locked together with locking bracket.
1. Install two lower balance balls taking care to have a grip on the bottom as they wall fall away until engaging the end of the balance thread, take care not to knock the ball on the clock frame or plinth directly below.

2. *Carefully* unscrew to locking plate nuts and remove locking plate.

3. While holding the balance steady screw the two top balance balls, they will stay safely on the protruding spikes that continue after the end of the threaded portion. ⚠Note! All four balls are marked and must be replaced correctly. There are indicator marks on the edge of each ball hole opening and balance screw. The order is from the rear view: 1-left, upper. 2-right, upper. 3-left, lower and 4-right, lower. These also correspond to the springs and spring suspenders.

Start clock: Video 00040-N

1. Set up the remontoire. If either of the escape wheels allow the pallet stones to slip while ticking, hold that pallet in the escape wheel tooth so that the tooth cannot pass for one tick and observe again. Do this until no slipping is observed. This should not be needed to be done more than 3 times.

2. Pull one balance to the 8 degree mark and let go. If both balances do not match on the beat plates, an adjustment must be made with the cross bands. The way to avoid this is to be sure both are equally snug while the locking bracket is in place that will ensure both pendulums are at the zero point.

Other debugging:

1. Lift one upper escapement pallet to release the remontoire drive to its escape wheel.

2. Hold the same upper pallet in one tooth of the escape wheel for three ticks. This will set up the balance of power to both escape wheels.

3. If a pallet is seen slipping on an escape wheel tooth, hold it in the escape wheel for 1 tick

Notes:

Section 3.

Installation of Astro-skeleton removable complication modules

Once the operator has assembled the machine to the point where reliable running has been established the attachment of the various complication modules may now proceed.

The modules are attached in the following order:

Calendar
Sun/Moon, rise-set
Tellurion
Planisphere
Orrery

Calendar: Video 00069

1. ⚠Note! The calendar is driven by a diagonally mounted wheel visible behind the mean solar dial at the 10 o'clock position. The cock holding a pair of jewel pivots is mounted to the calendar assembly. When the calendar is removed or installed the jewel that supports the diagonal wheel pivot will come away. It is important to be sure the wheel and its arbor are supported as the cock comes away to prevent it from falling, thus damaging the pivot and/or jewel in the opposite end. It is important that when the calendar is being installed that one properly support this at the correct angle to avoid chipping the jewel in the cock attached to the calendar, Fig. 1.

2. The correct positioning of the diagonal calendar drive wheel is adjacent to the intersection of two large wheels as sown in Fig. 2. ⚠Note! One way to keep this in position while installing the calendar is to apply a piece of Rodico®. Be sure to use this product, as it is designed to leave no trace on the metal surface. Do not use simple modeling clay as it will leave a grease spot. One can see in this photo that the space between the diagonal and other two wheels is rather small as demonstrated by the small dental tool, so a small piece will do. Otherwise one will have to hold the calendar as it is being attached to the clock while holding steady the drive wheel.

3. The entire calendar module is held to the clock by a single thumb screw, Fig. 3. This is located on the inside of the pillar near the top. It connects through a hole and into the calendar module. It has steady pins for a perfect positioned fit.

4. Hold the calendar around the bezel or grip the bezel and rear frame near a spacer pillar to prevent stressing the frame. ⚠Note! Do not touch the spring loaded logic gates located near the perimeter of the calendar near the 7 to 8 o'clock position. These can be easily displaced.

5. Position calendar to fit closely to the steady pin holes while carefully matching up the empty pivot on the calendar cock to that of the drive wheel. The rear pivot should already be inserted and the assembly either held by hand to align into the empty pivot hole in the cock, or adjust the wheel if held in Rodico®.

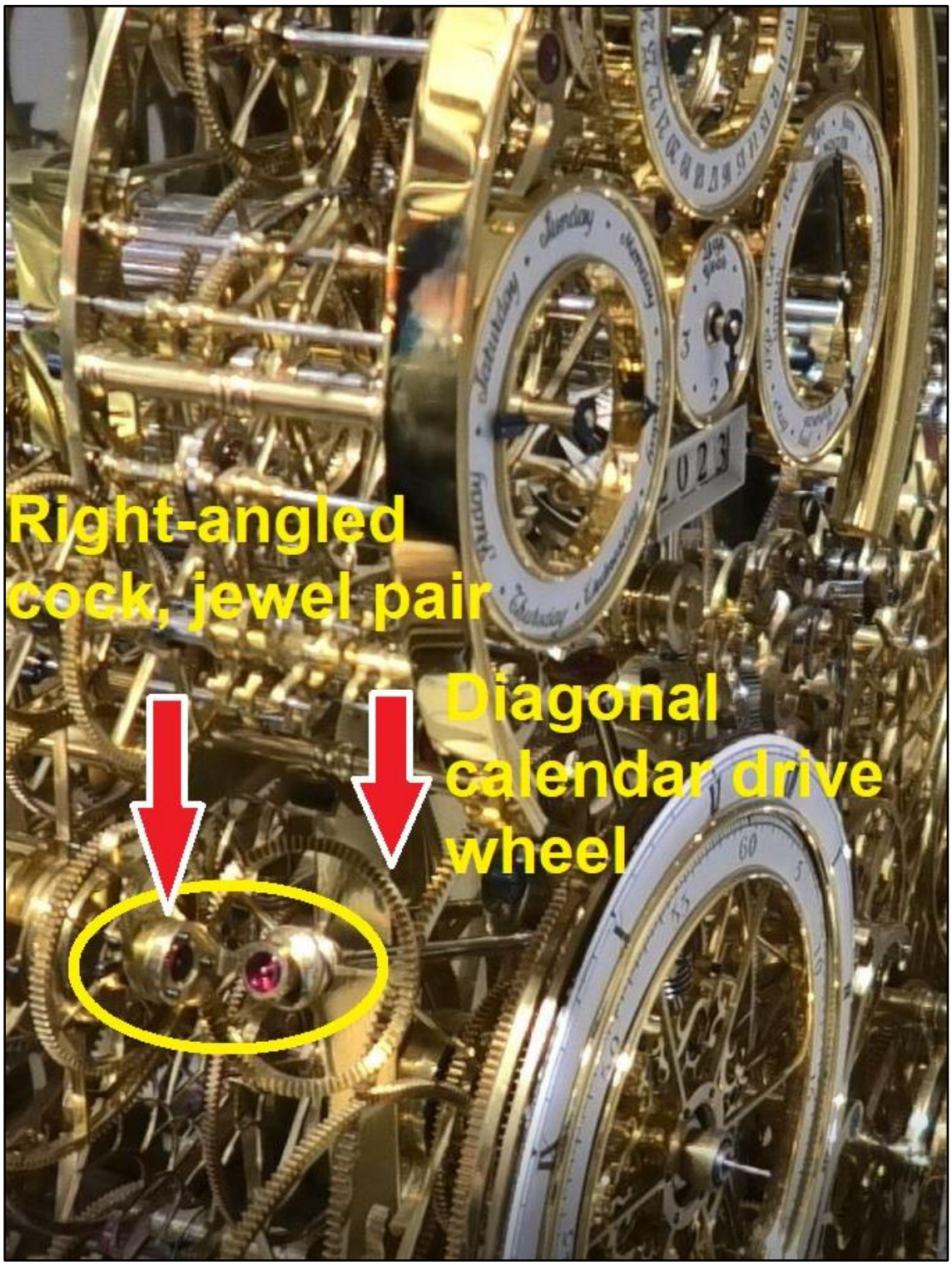


Fig. 1. Cock and left jewel mounted to calendar, right jewel supports diagonal calendar drive wheel.

Fig. 2. Center of circle shows near intersection of calendar drive wheel and two others.

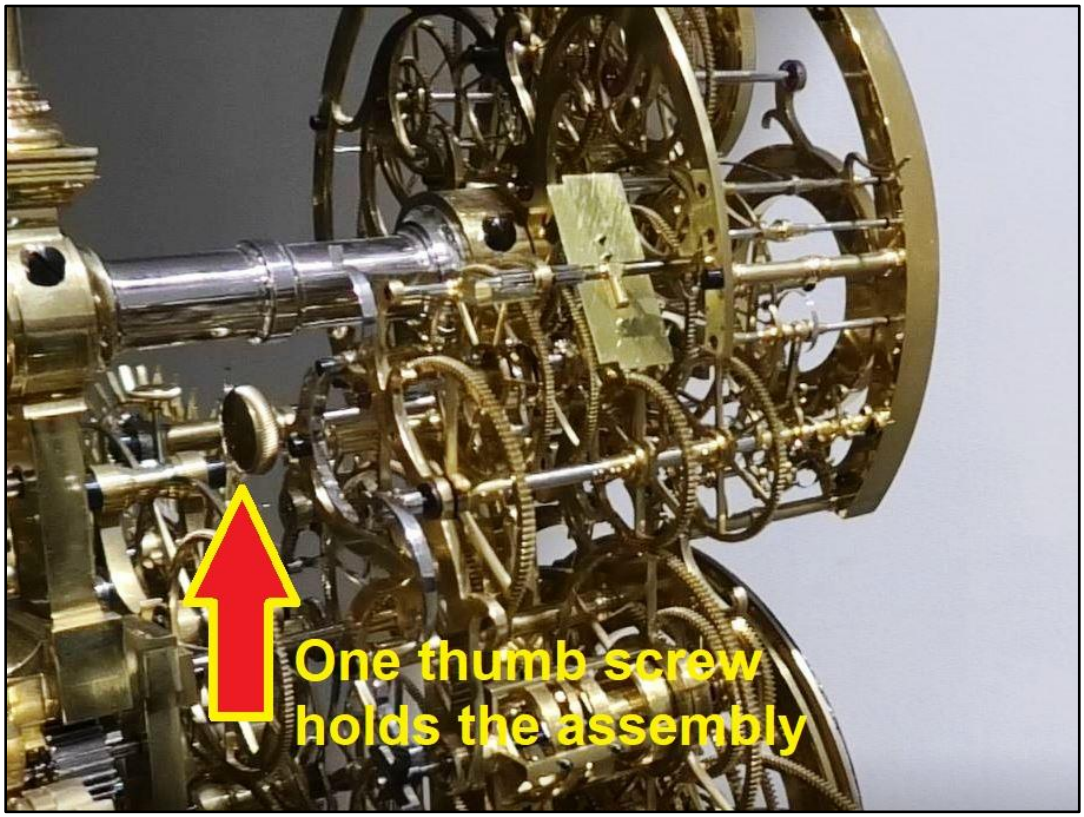


Fig. 3. The arrow shows where the single securing thumb screw is positioned behind the pillar

Sun/Moon, rise-set: video 00067

1. ⚠Note! Before beginning, the strike must be set to Grande sonnerie on the strike dial below. This resolves a clearance issue with access to the release lever for installation of this module

2. This module has a cylindrical recess in the center of the rear dial readout support structure, upper circled area, Fig. 1. This fits onto a mating bayonet style mount on the top of the right hand pillar, lower circled area. There is a locking lever that actuates a set of pins that rotate about 30° with the lever. They fit into the slots on the pillar mount and the whole mating is made accurate by a pair of locating pins. Before beginning be sure the lever is rotated, counterclockwise until it stops.

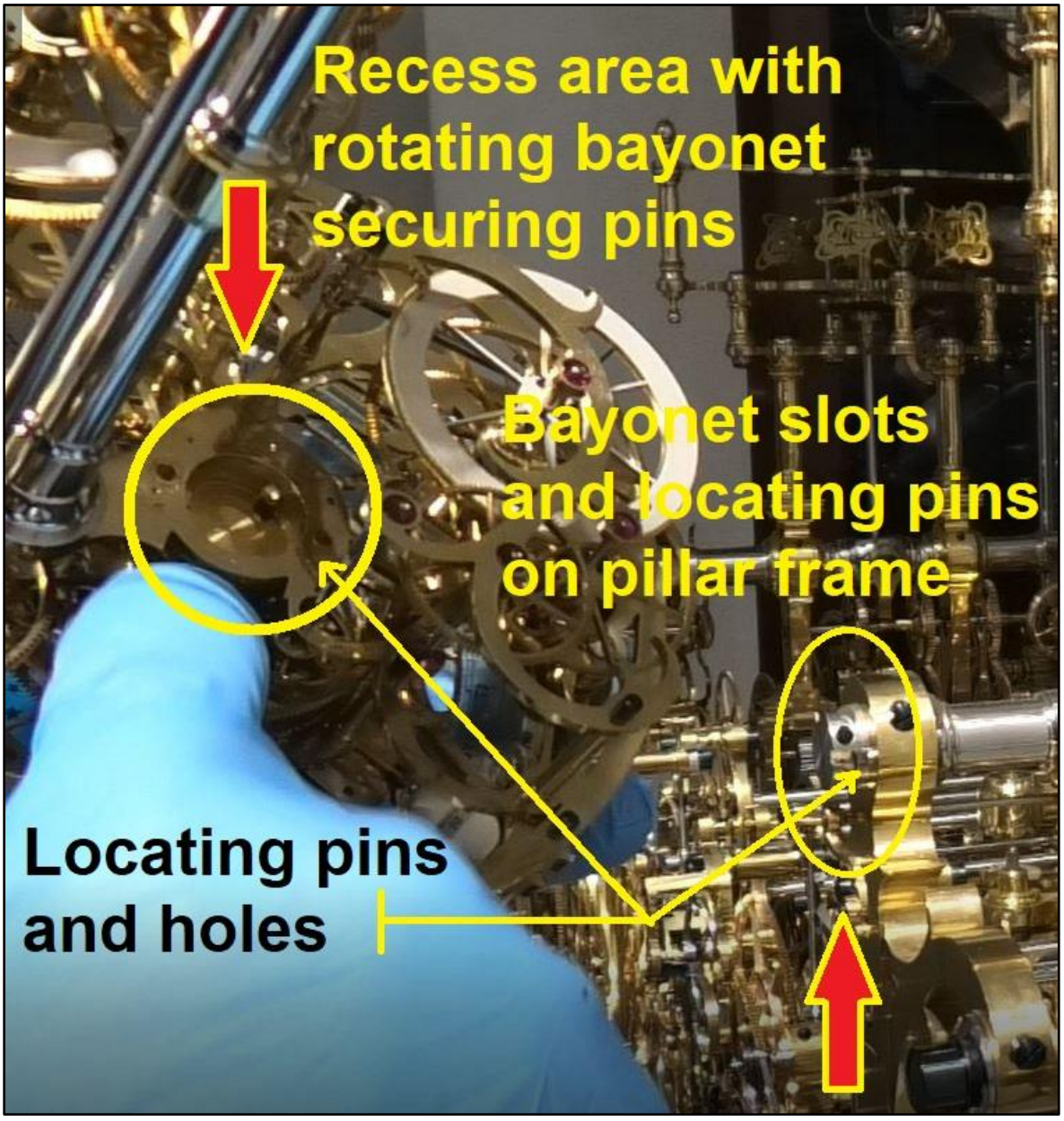


Fig. 1. Depiction of recess area on Sun/Moon; bayonet mount, slots on frame pillar, locating pins and holes.

3. *Carefully* angle the front (dial) of the module slightly towards the clock with the tail a bit outside, Fig. 2. One needs to raise the length of the module slightly over the strike hammer mechanism and then lower just behind the mechanism. At this point the entire module should be able to be parallel to the arbors of the clock and the recess on the rear of the module can be backed onto the bayonet mount on the machine's pillar frame with a bit of small wiggling. The slots on the frame bayonet mount are machined to fit the keys on the lever, so if there is any resistance, move the locking lever a bit either way until they slot into place.

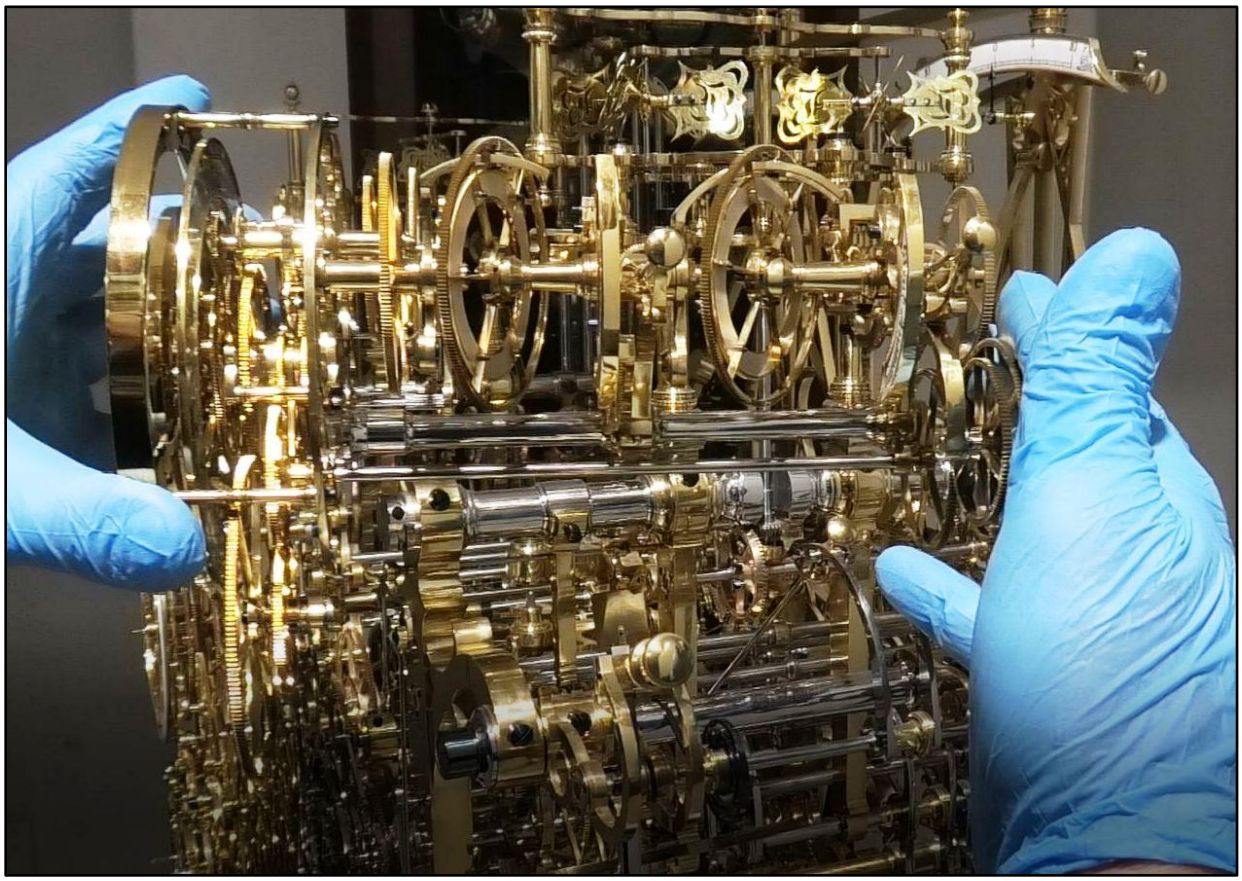


Fig. 2. Sun/Moon module being positioned into place

4. Once the module is seated, the locking lever knob can be moved clockwise, Fig. 3. ⚠Note! The lever should move without hanging up if they have been properly seated into their slots and should display a bit of tightness toward the last few degrees of movement. This is because the slots in which the lever's keys slide into have a slight radial angle to draw the module tightly onto the pillar's bayonet mount. The knob is spring loaded and designed to push a pin into a hole at the end of the lever's travel to keep it in place. ⚠Note! *Be sure that the pin is fully engaged in the hole to prevent the lever from working loose.* This is the only point upon which the Sun/Moon module is secured to the machine and a catastrophic failure could occur if the module works loose from its mount. Check for freedom of wheel movement throughout.

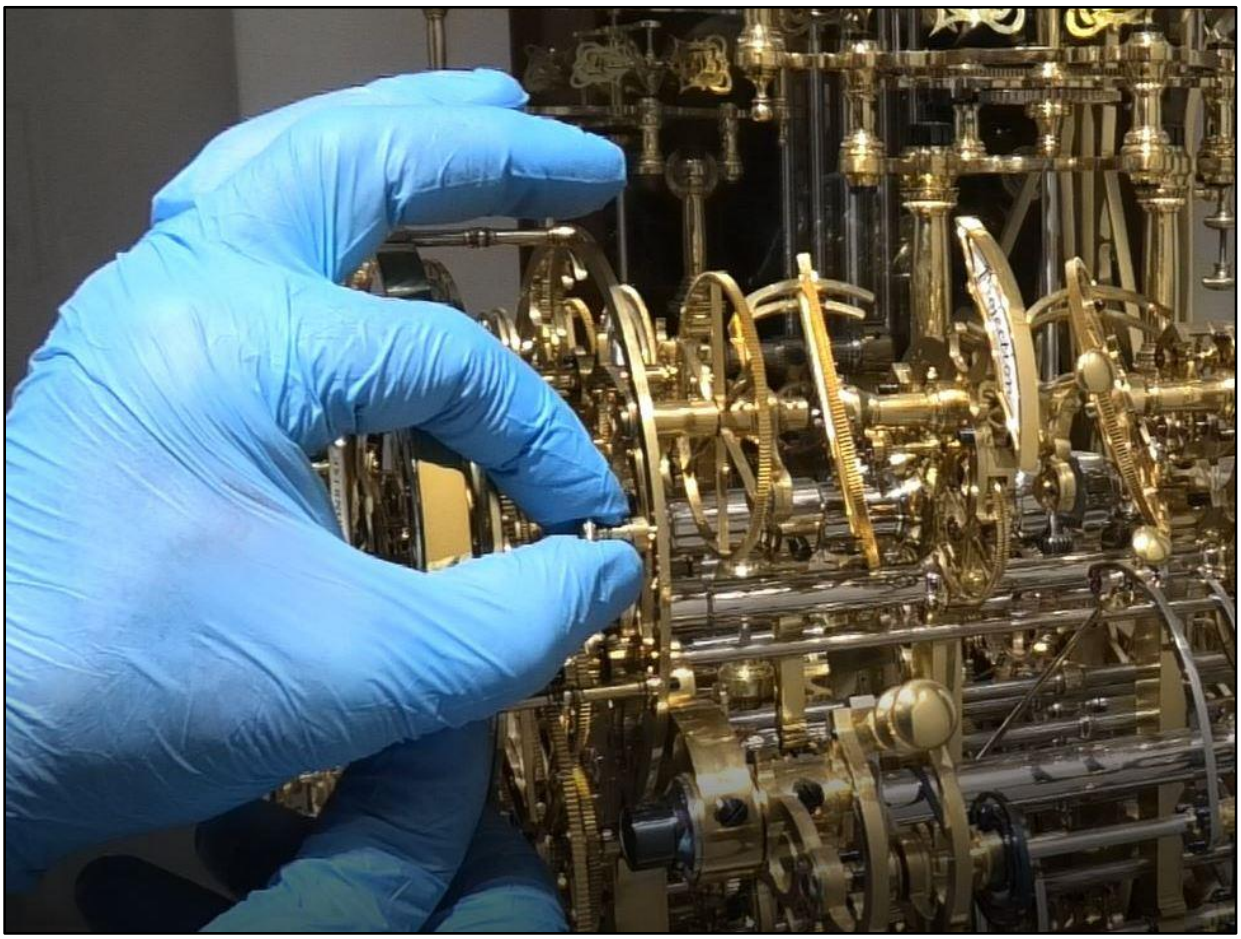


Fig. 3. Locking lever knob being set into secure position, once knob is released a pin should seat into a mating hole to keep the lever in position.

Tellurion:

Assemble and install tellurion dial. Videos 00062, 00064

⚠Note! The Sun/Moon, rise-set module with its dial must be installed before the tellurion dial can be secured.

1. Assemble idler wheel to the rear of the dial. The idler wheel assembly must be attached to the rear of the dial. Fig. 1 shows dial as received. First remove the right hand dial latch as seen from the rear. The idler wheel is attached to a bracket which has locating pins that fit the bracket into the dial frame. Each of the two latches has a spacer, put this back and then secure the right hand latch. Later when the dial is secured to the clock, two pillars located on the clock pillar fits into the two holes in the dial ring, Fig. 2. Take care when handling any dial work to not use any excessive pressure or twisting forces.

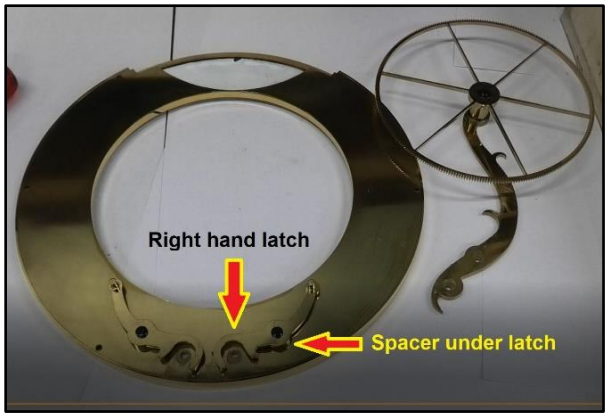


Fig. 1. Tellurion dial as received

Fig. 2. Assembled tellurion dial

2. Attach the tellurion dial. ⚠Note! The upper portion of the tellurion dial is held by the lower end of the Sun/Moon, rise-set dial. The upper portion of the tellurion dial has a pair of female slots, Fig.3, which fit into the male notches, Fig. 4 of the Sun/Moon rise-set dial. Therefore that module must first be installed.

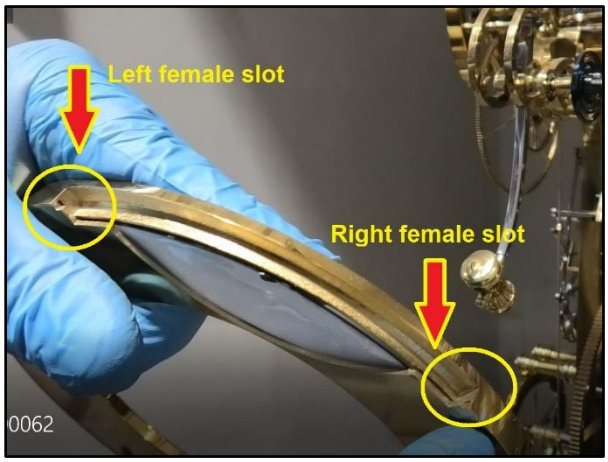


Fig. 3. Left and right female slots, top of tellurion dial

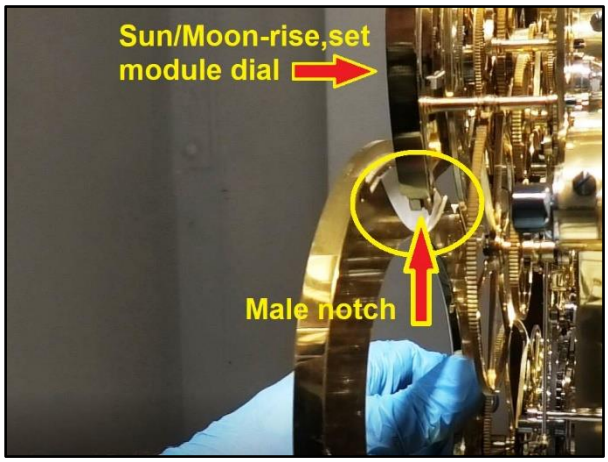


Fig. 4. Detail of male notch, bottom Sun/Moon dial

3. Carefully slide the dial with idler wheel to the left as seen from the front to the point where the idler wheel is close to its mating wheel. Then align top of tellurion dial so the slot positions are aligned to the notches at the bottom of the Sun/Moon, rise-set dial and move dial toward vertical to allow them to slide together. At the same time the pillar pair on the frame should slide into the mating holes located at the bottom of the tellurion dial. Carefully push the dial home on the pillars while watching that mating notch/slots are aligned and the idler wheel is now meshing with its mating wheel and everything is turning freely. Latch pillars to secure the dial. Fig. 5

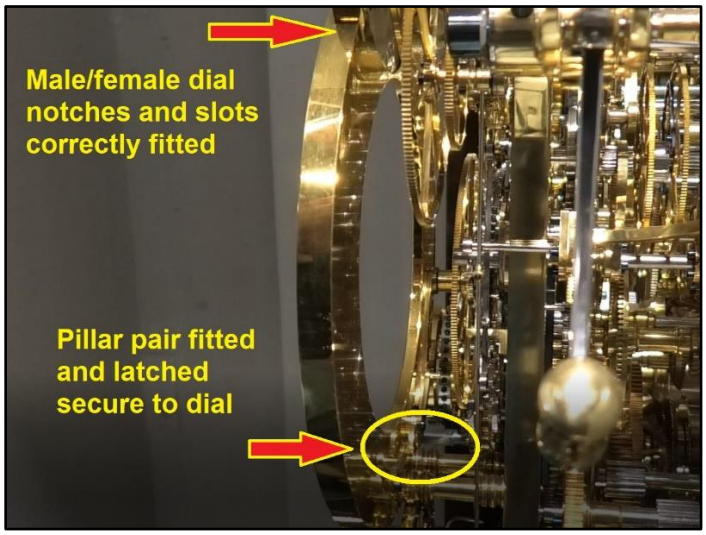


Fig. 5. Tellurion dial corrected fitted and secured

Install tellurion module. Video 00049

1. ⚠Note! Before beginning, the strike must be set to Grande sonnerie on the dial directly below. This resolves a clearance issue with access to the release lever for installation of this module. ⚠Note! If the front, smallest bell is installed, it should be removed to make the installation easier. ⚠Note! The tellurion has a demonstration stand that is made to safely hold the module on a table top, be sure to locate this and secure the tellurion module to the stand prior to any further work.

2. Locate the tellurion mount on the clock frame and note where the locking pin (key) slot is located (about the 10 o'clock position), Fig. 6. Locate the locking pin (key) on the tellurion module, Fig. 7. Check to see that the locking lever is rotated fully counterclockwise.

3. Grasp tellurion module by top of sun and the rear of the tellurion assembly between the wheel assembly and the rear drive wheel at the axial center, Fig. 8. Carefully align the pin to slot and keeping the module vertically aligned push the assembly onto the mounting spigot carefully noting that the main drive wheel located at the very rear of the tellurion wheel assembly is properly meshing with its mating wheel, Fig. 9.

4. Locking lever is still in unlocked position fully to the left. Grasp the spring-loaded knurl knob or use the button repeat pull tool as shown in Fig. 10 to pull the knob to the right until it stops, just past the 12 o'clock position. Take care that the spring-loaded pin is not being dragged across the surface of the clock pillar to prevent scratching. There is a depression in the frame for the spring loaded pin to insert to keep the lever in the locked position. Fig. 11. ⚠Note! *Be sure the pin is seated firmly in the frame hole, failure to do this could cause catastrophic failure of the module should it come loose from its mount*. Tellurion module is now successfully mounted to the machine.

Fig 6. Locate pin (key) slot

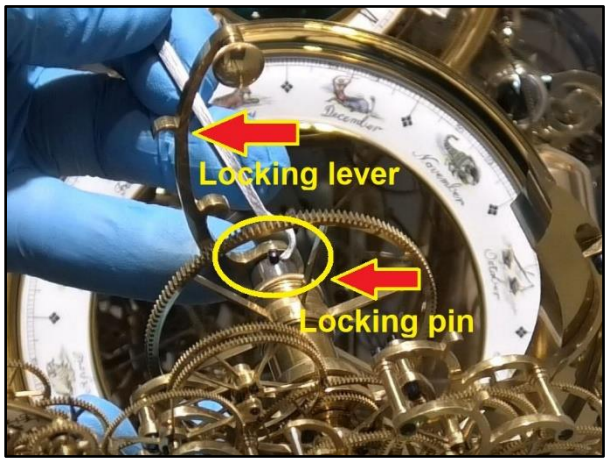


Fig. 7. Locate pin (key), ensure locking lever is fully counterclockwise

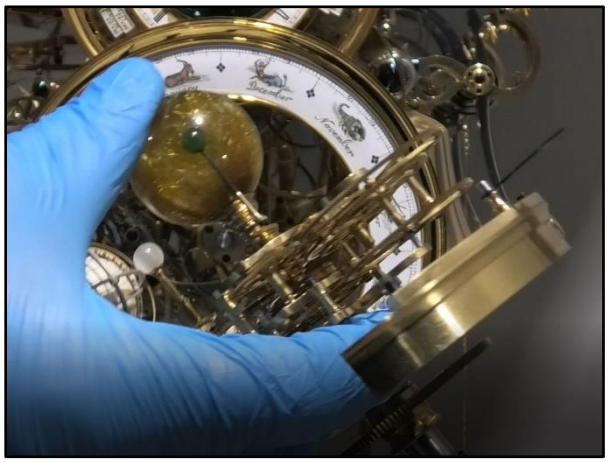


Fig. 8. Proper method of holding tellurion assembly

Fig. 9. Insertion of assembly with key aligned

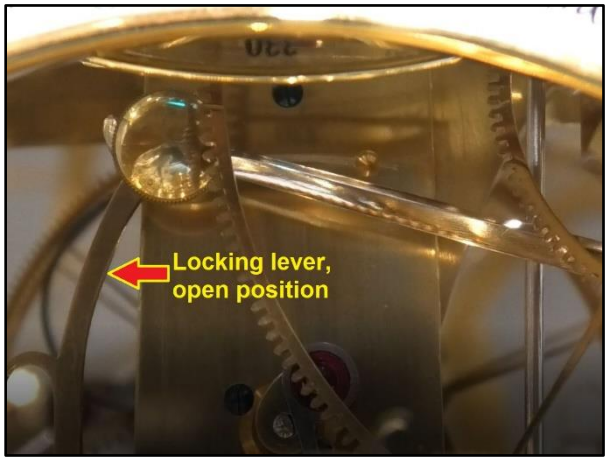


Fig. 10. Locking lever in open position, leftward

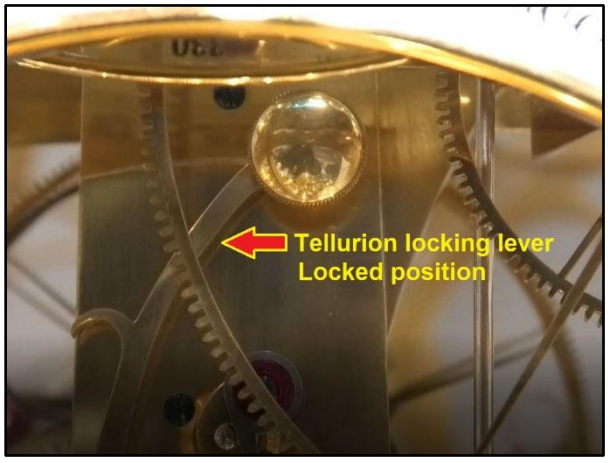


Fig. 11. Locking lever in secure position, rightward

Planisphere: Video 00048

The planisphere is attached to the base of the machine using the same bayonet design as that is used for the Sun/Moon, rise-set module. There are a pair locking levers that have three pins (keys) which rotate about 35° with the movement of the lever, Fig. 1.

1. Each lever is ‘mirrored’ that is rotating the left lever as seen from the rear counterclockwise and the right lever clockwise (pulling each one outward) puts the bayonet keys into the unlocked position.

2. The planisphere is slid onto the pair of bayonet mounts on the clock base with the keys aligned through the keyed slots, Fig. 2. As with the Sun/Moon module these slots are slightly angled axially so when the levers are moved to their locked position the planisphere module will be drawn tightly to the base frame. Locking is done by moving both levers *simultaneously* inward to prevent racking and binding the action should be smooth with slight resistance towards the last few degrees as the module is drawn tightly to the base frame. ⚠Note! Check carefully that the rear wheel at the top of the planisphere module is correctly aligned and is meshing with its mating wheel. The module hangs about a millimeter above the wood base surround when fully secured so take care not to drag it across the wood surface when mounting to the bayonet mounts to prevent marring of the finish. Fig. 3. Shows the correct mating of the planisphere and clock base molding.

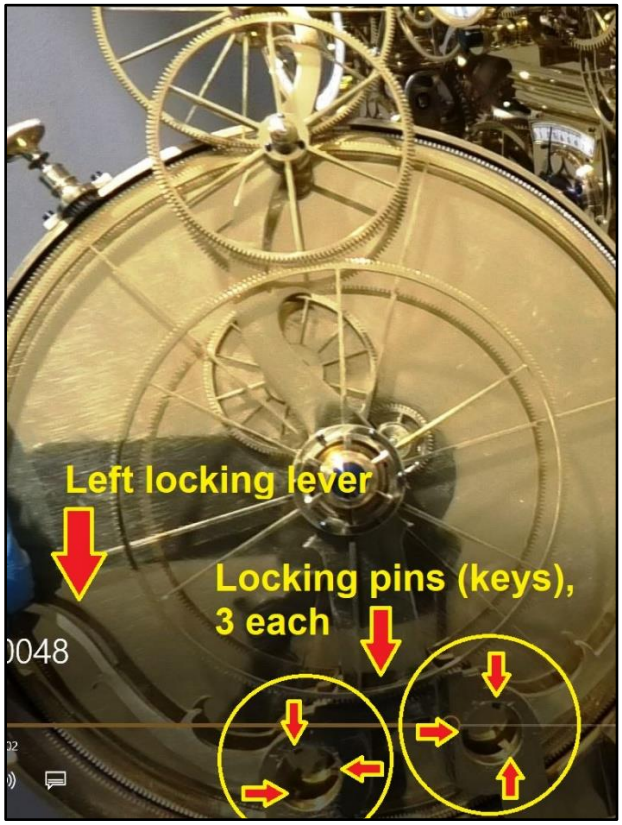


Fig. 1. Circled areas each show three interior keys

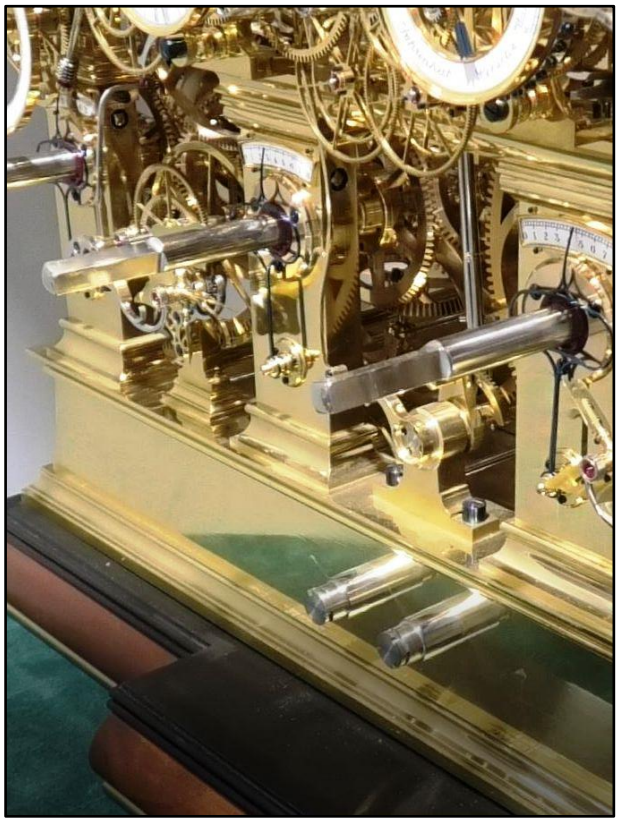


Fig. 2. Pair of mating bayonet mounts on the base

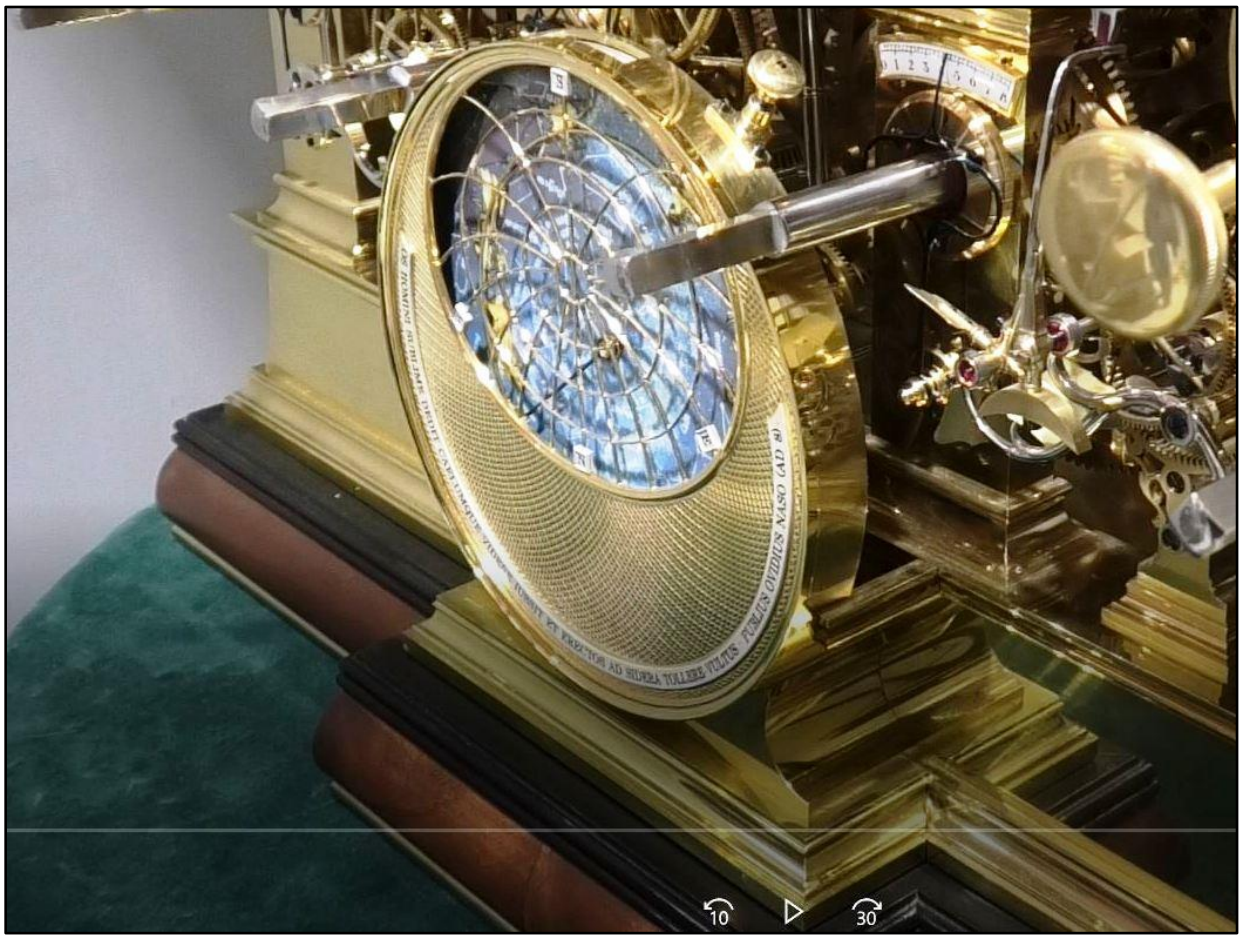


Fig. 3. Planisphere correctly positioned revealing very little space between module and clock bases

Orrery:

Attach dial to orrery: Video 00056

⚠Note! The orrery has a demonstration stand that is made to safely hold the module on a table top, be sure to locate this and secure the orrery module to the stand prior to any further work. Fig. 1. ⚠Note! The orrery dial is 12” (30.5 cm) in diameter and so is fairly fragile and too heavy to ship as one piece with the orrery. As with all the enamel dial work care must be made not to use any excessive or twisting forces.

1. All of the arms have a spur protruding from the bottom, but one is slightly smaller because of clearance issues when the module is installed. With the module on its stand rotate the arms until the arm with the small spur is located at the 10 o’clock position as seen from above.

2. Move the armatures that have Jupiter and Saturn until they are superimposed in alignment at the 6 o’clock position.

3. Rotate the dial until the zero degree point, between the zodiac signs of Aquarius and Pisces is at the 6 o’clock position. The dial can then be *carefully* tilted to first thread the Jupiter and Saturn armatures through the center dial opening and then positioned so as to have the rim of the dial lay flat and fit equally on the four dial support brackets. There are alignment notches to indicate the correct fit, Fig. 2.

4. If the dial is fitted correctly, the four holes in the dial supports will align to those threaded holes in the dial back plate. ⚠Note! Before securing the screws be sure the dial is *laying flat* across all of the support brackets. Failure to do this will result in damge to the dial work.

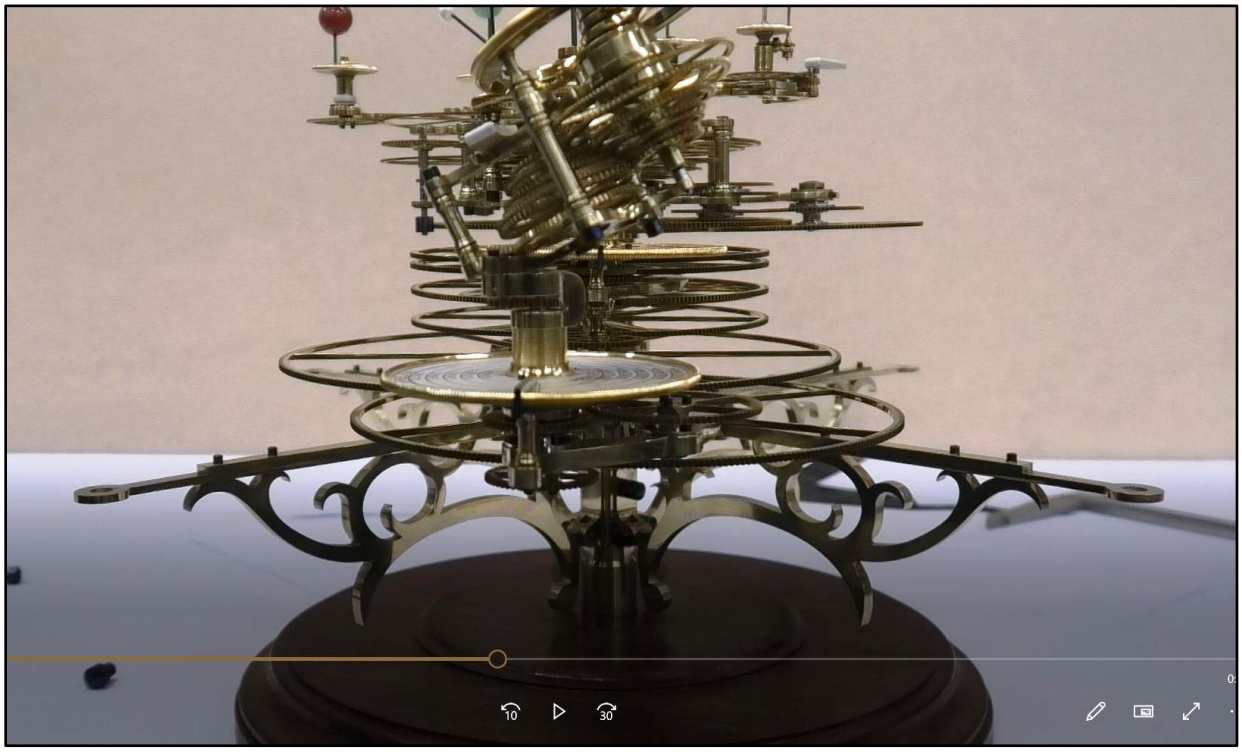


Fig. 1. Orrery module mounted on demonstration stand

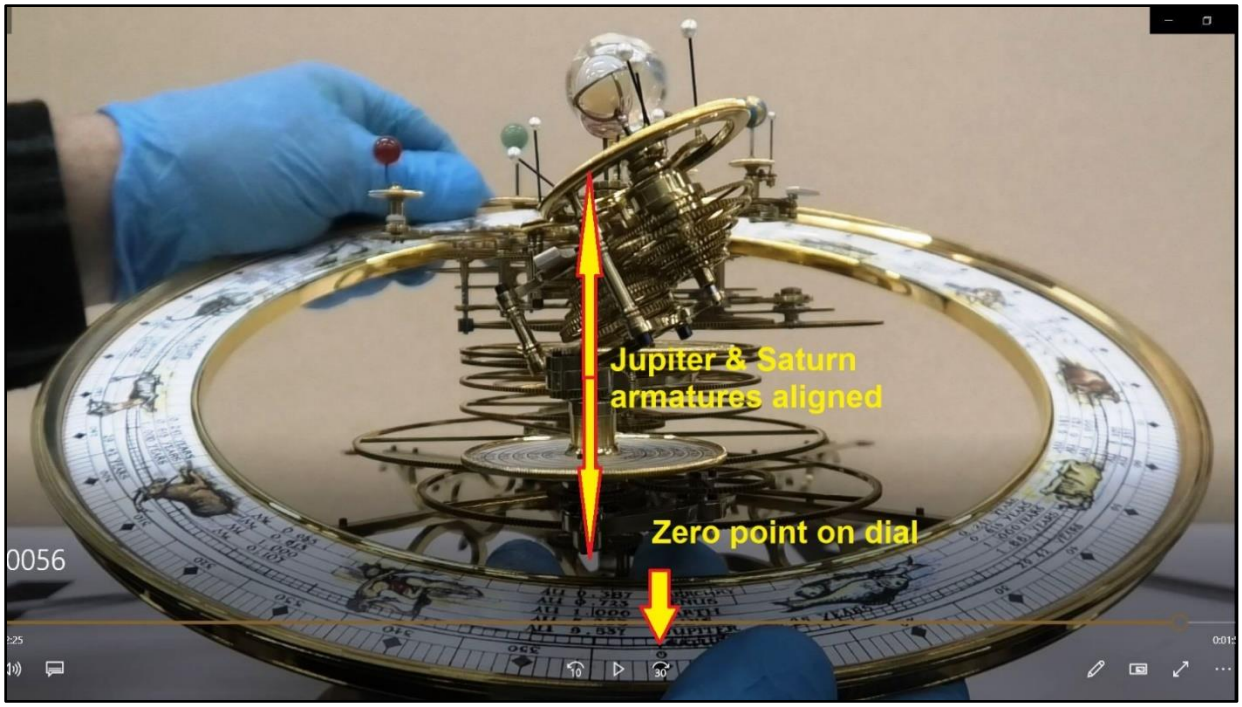


Fig. 2. Jupiter and Saturn aligned, dial tilted to thread planets through dial opening; note zero point position

Install orrery module. Video 00055

⚠Note! Before beginning the installation of the orrery module the main demonstration key must be used to position the demonstration selector to ‘Exhibit 1’, Fig. 3. Note the one smaller spur out of four on the dial support arms. The orrery position is keyed and the correct position is with this arm at the 10 o’clock position as seen from above, Fig. 4.

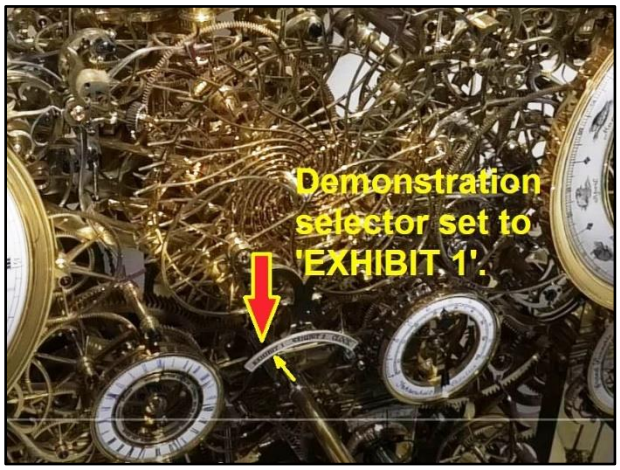


Fig. 3. Set demonstration selector to EXHIBIT 1

Fig. 4. Set arm with small spur to 10 o’clock position

To seat the orrery set it upon the mount with the zero point on the dial directly at the 6 o'clock position. Grasp the dial support frames (and move the Jupiter and Saturn armatures out of the way as is convenient to do so) and *gently* wiggle the orrery a few degrees back and forth while *gently* applying downward pressure until it stops, Fig. 5.

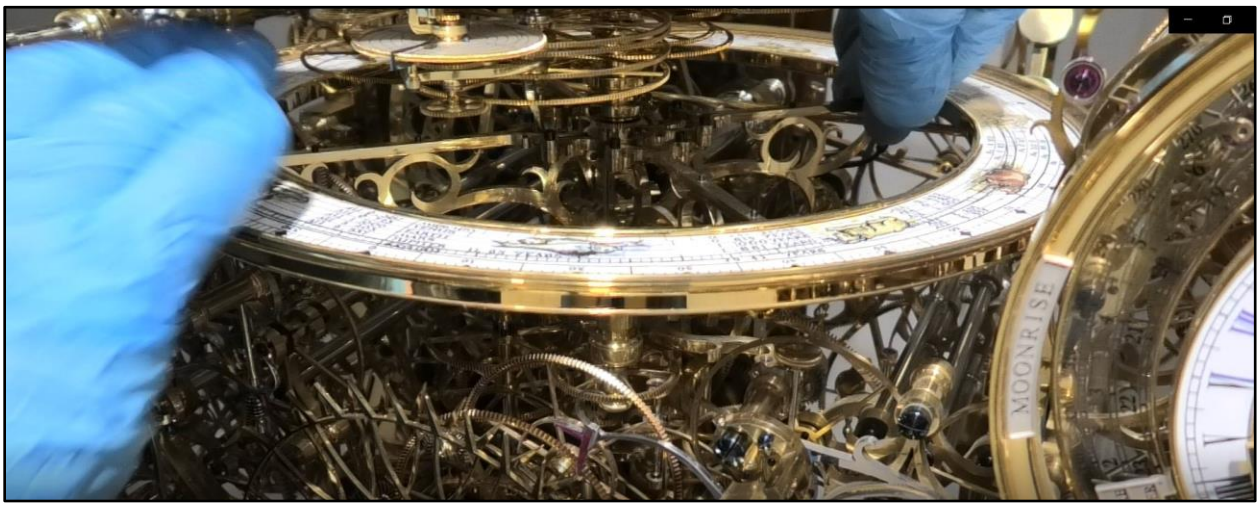


Fig. 5. Grasp orrery by the dial arm supports and wiggle back and forth with downward pressure to seat

To be sure the orrery is fully seated check that there is no gap between the female tube connected to the orrery and the male tube mount on the clock. The orrery may even work when powered in demo mode, but if it is still not fully seated the outer planet of Saturn will conflict with surrounding structures, Fig. 6 and Fig. 7. The problem is that the male drive square from the clock is not aligned with the female square recess in the orrery. Slightly loosen orrery and move drive wheel slightly and *gently* wiggle until the orrery is fully seated, Fig. 8.

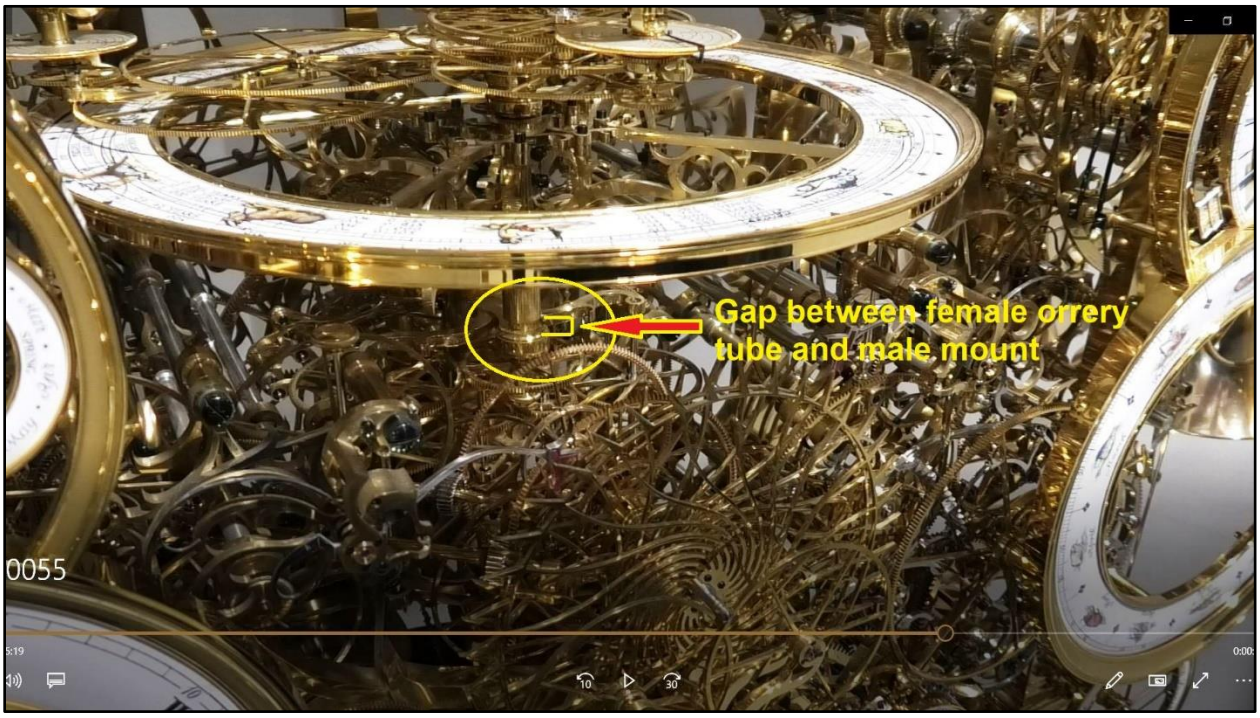


Fig. 6. Here the orrery is not seated properly as evidenced by a gap.

Figures 7 and 8 show the difference between the orrery being incorrectly and correctly seated.

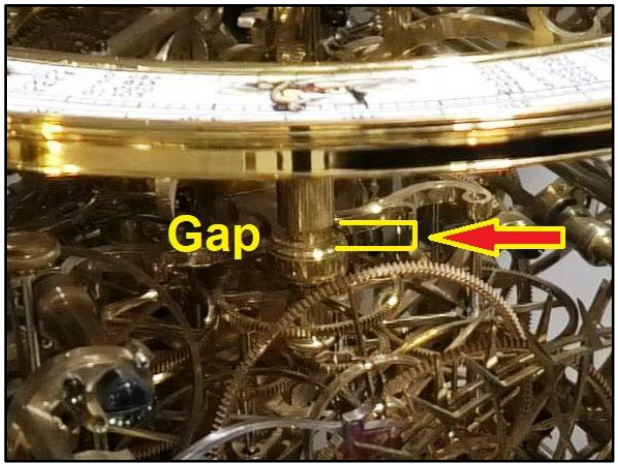


Fig. 7. Orrery incorrectly seated as evidence by gap

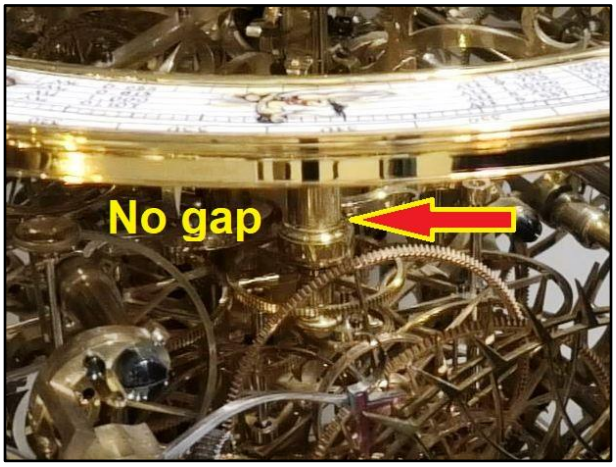


Fig. 8. The orrery properly seated with no gap.

Notes:

Section 4.

Setting up the Astronomical skeleton clock

⚠ Note! It is best to stop the clock when performing a major setup, have at least two or three clicks winding on the time and celestial trains

For this example the clock will be set to 12 Noon on June 6. 2022

The use of the demonstration keys: Video 00024

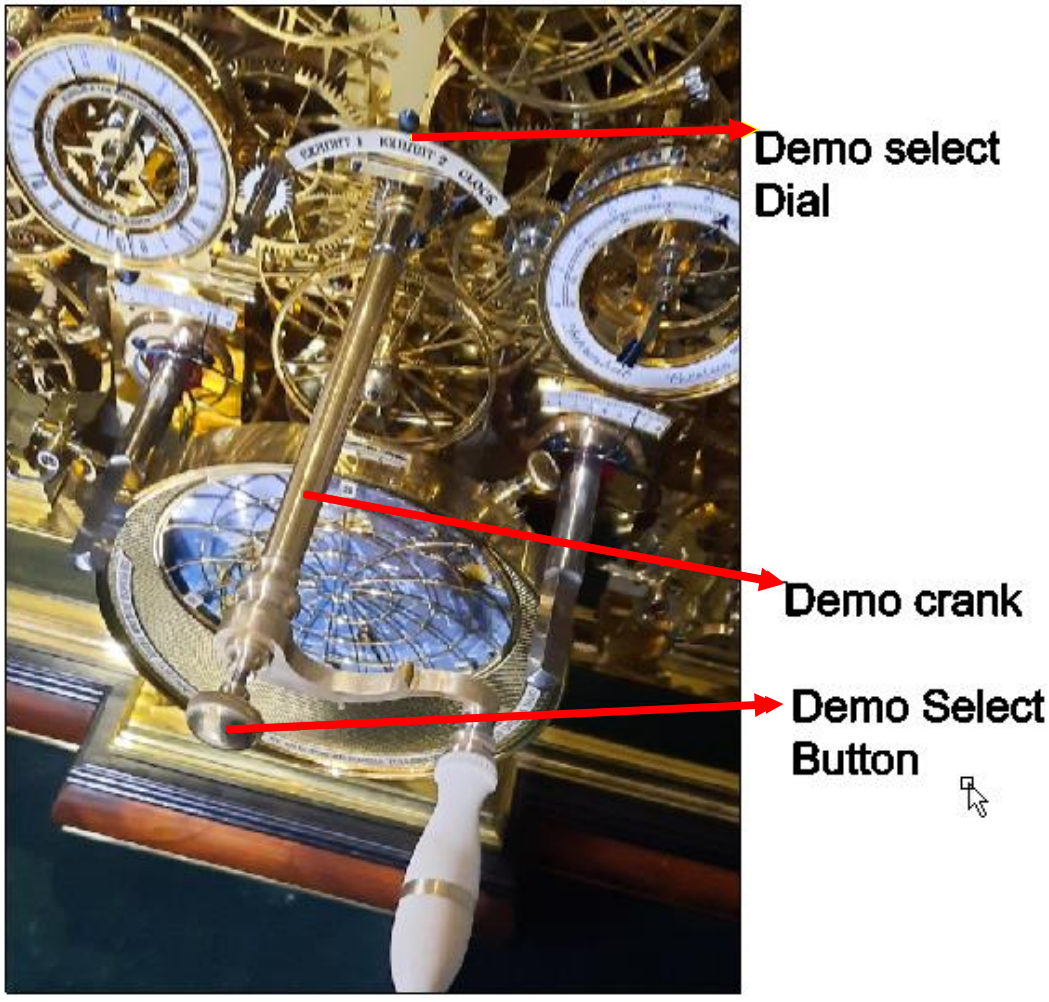


Fig. 1.

1. Slide the crank onto the square.
2. Push the demo select button until some resistance is felt.
3. Gently screw the button into the demoselect arbour intil a slight resistance is felt. It should not be screwed tightly.
4. By pulling the button the demo select can be rotated over to Exhibit 1 or 2 By pushing, it can be rotated back into Clock mode.

Exhibit 1: PULL, Drives the orrery only, at high speed
Exhibit 2: PULL, Drives all complications
Clock: PUSH, The Celestial train is locked to and driven by driven by the clock.

A Sun/Moon Dial: video 00025-A

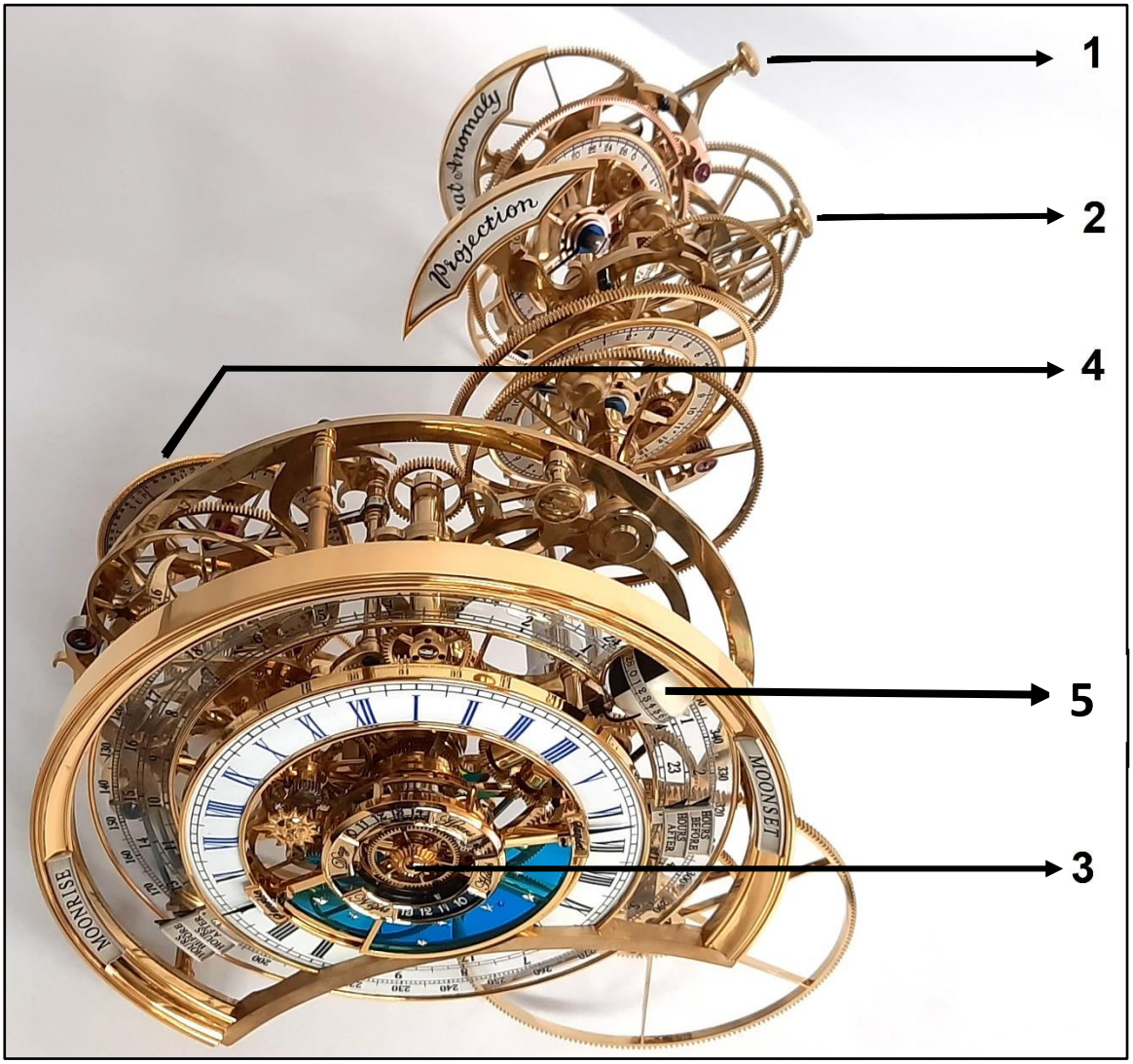


Fig. 2. This module is shown out of the clock to make idetification of adjustments easier to see

1. Set the demo select to ‘Exhibit 2’, this unlocks celestial drive from the clock
2 Set the Great Anomaly to the correct day in the cycle by means of setting knob (1)
3. Set the Projection to the correct day in its cycle by means of the setting knob (2)
4. Set moon to the correct Hour Angle by cranking the demo handle in Exhibit 1 mode.
5. Lock the Siderial train by pushing in the button on the demo crank and rotating to Clock.
6. Spin the Moon around with your gloved fingers until the age of the moon is correct (5)
⚠Note! The information regarding the correct figures for the Hour Angle, Great Anomoly and Projection and Moon phase can be looked up for the particular day.
7. Set the Sun Hand to the correct time by means of the knob (3) in the centre of the Sun/Moon dial
8. Set the horizon shutters year dial (4) to the correct date.

B. International Time Dial: Video 00026-B

Chicago pointer

Fig. 3. International time dial, Chicago set to 12 Noon.

1 Rotate the international time dial manually on its clutch untill the Chicago pointer is pionting to the correct time, Noon. Fig. 3. Do not rotate using keyed arbor.

C. Equation of Time Dial: Video 00027-C

Fig. 4. Equation of time setting dial

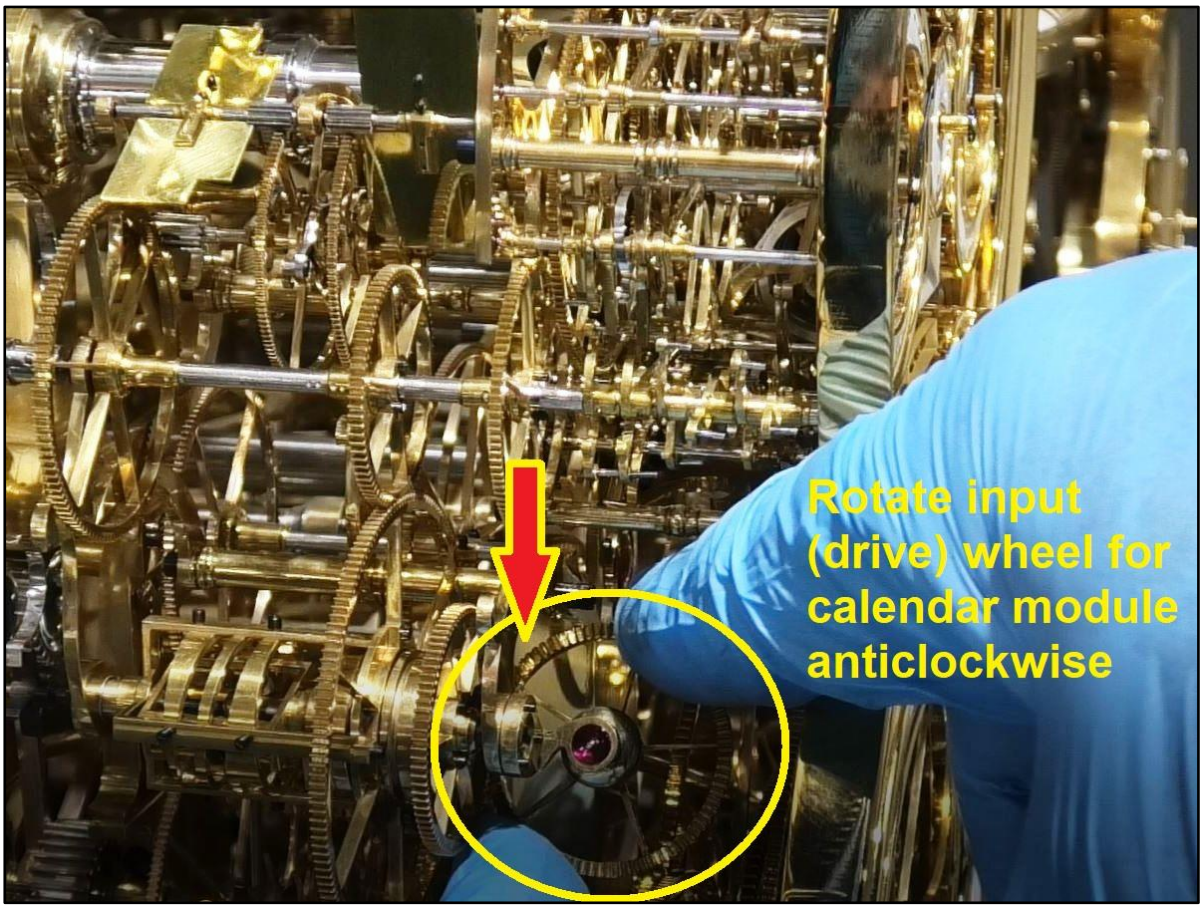
Rotate the Equation of Time setting dial by means of the setting tool inserted onto the square centre arbor (5) untill the pointer is at June 6thth. This is NOT what Fig. 4. shows

D. Set The Celestial train to Midnight: 00028-D

1. With the selector set to ‘EXHIBIT 2', turn the Demo Select Crank anticlock wise until the International Time Dial for the Chicago pointer rotates from 12 Noon to 12 Midnight. This facilitates the setting of the Calendar to trip at midnight, (Part E).

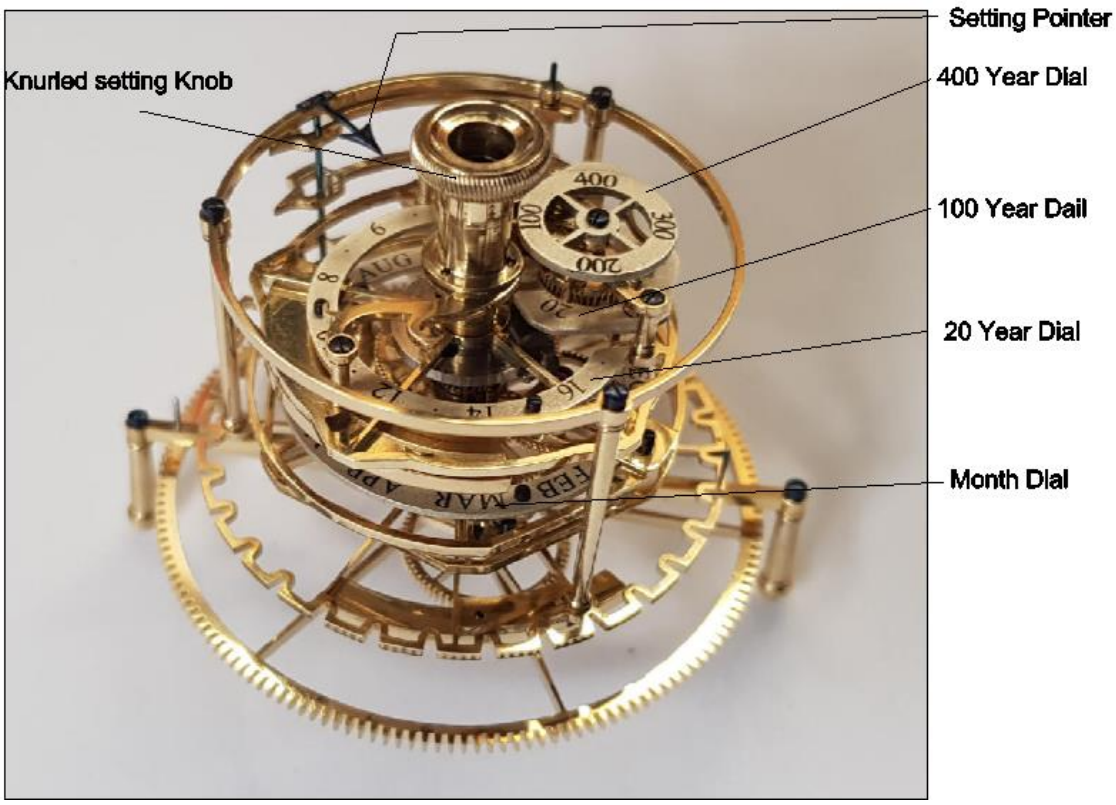
2. Lock the the celestial drive by pushing the Demo select button and rotating to the ‘CLOCK’ position.

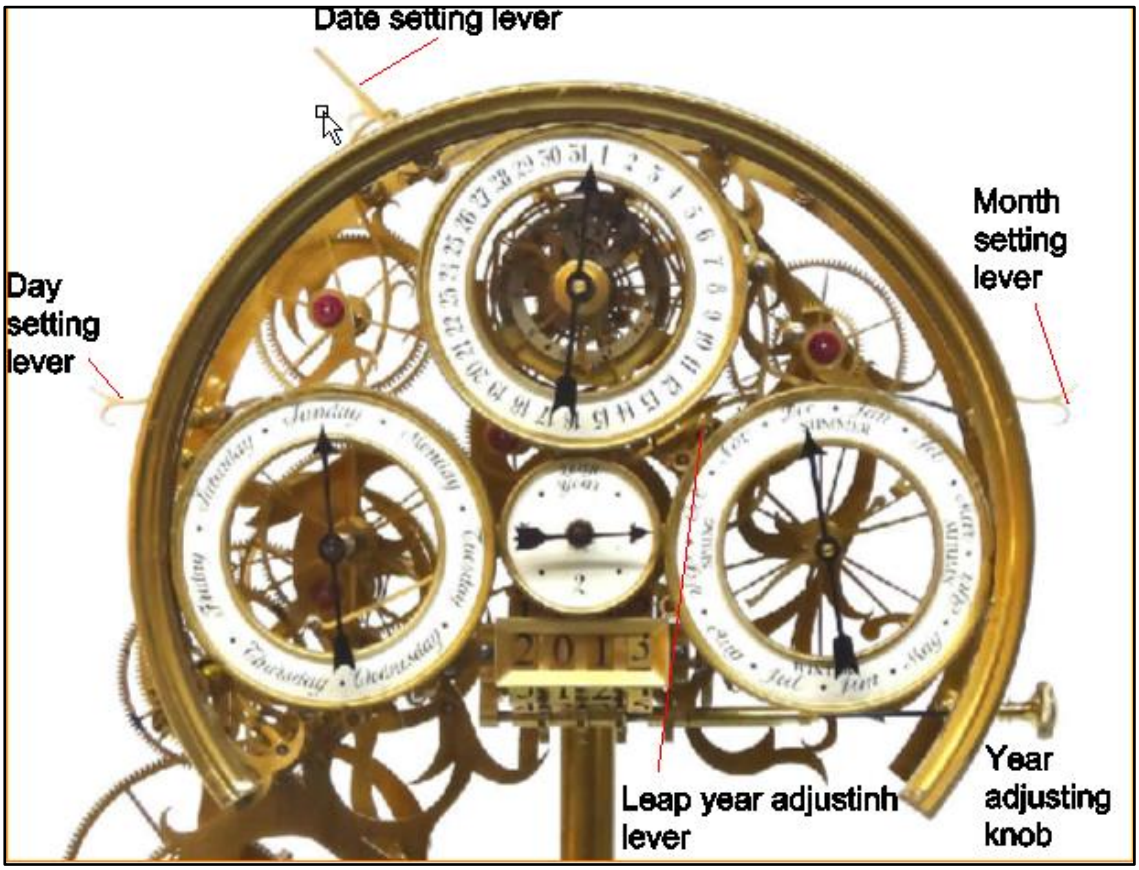
E. Setting the Calendar to trip at midnight: Video 00029-E



Rotate the input gear anticlockwise on the Calendar until the calendar trips. This is the gear in the diagonal arbour behind the dial with a clutch button on it behind a jeweled cock. Grip the gear between gloved fingers and rotate slowly and carefully untill the calendar trips.

F. Setting up the calendar:





Set up the leap year calculator: Videos 00030-F through 00033-F

This is set up initially for 1 January of the year we are in at present, 2022. Video 00030-F
It may be easier to remove the date hand to set up the calculator. It is on a light friction fit sleeve. To remove the hand, grasp the centre boss of the hand and carefully pull it off. Pull directly in line with the centre shaft, do not pull sideways, the hand should slide of easily. Do not force.

1. Calculate the years after the last 400 year skipped leap year. This was in 2000.
2. Establish what year we are in, 2022
3. Subtract 2000 from 2022 and we are 22 years into the next 400-year cycle.
4. Lift the date setting lever and rotate the calculator until December on the month dial is directly behind the setting pointer
5. Release the setting lever
6. While holding the setting lever to keep it engaged, rotate the knurled setting knob until the 0 on the 20-year dial, the 0 on the 100-year dial and the 400 on the 400-year dial are all in line under the setting hand Fig. 2. No more than a maximum of twenty turns will be required for a full four hundred years. One turn is 20 years. This brings the calculator to the year 2000.
7. Rotate the knurled setting knob forward 22 years on the setting dials. That means one complete turn for 20 years and another 10th turn to have the number 2 on the twenty year dial under the setting hand. This brings the calculator to the year 2022, Fig. 3.

The calculator assembly is now set up for the correct year, 2022.

Fig. 1. Leap year calculator in initial state (not set)

Fig. 2. 400 yr., 100 yr., and month dials are all aligned under setting hand, calculator set to December 2000

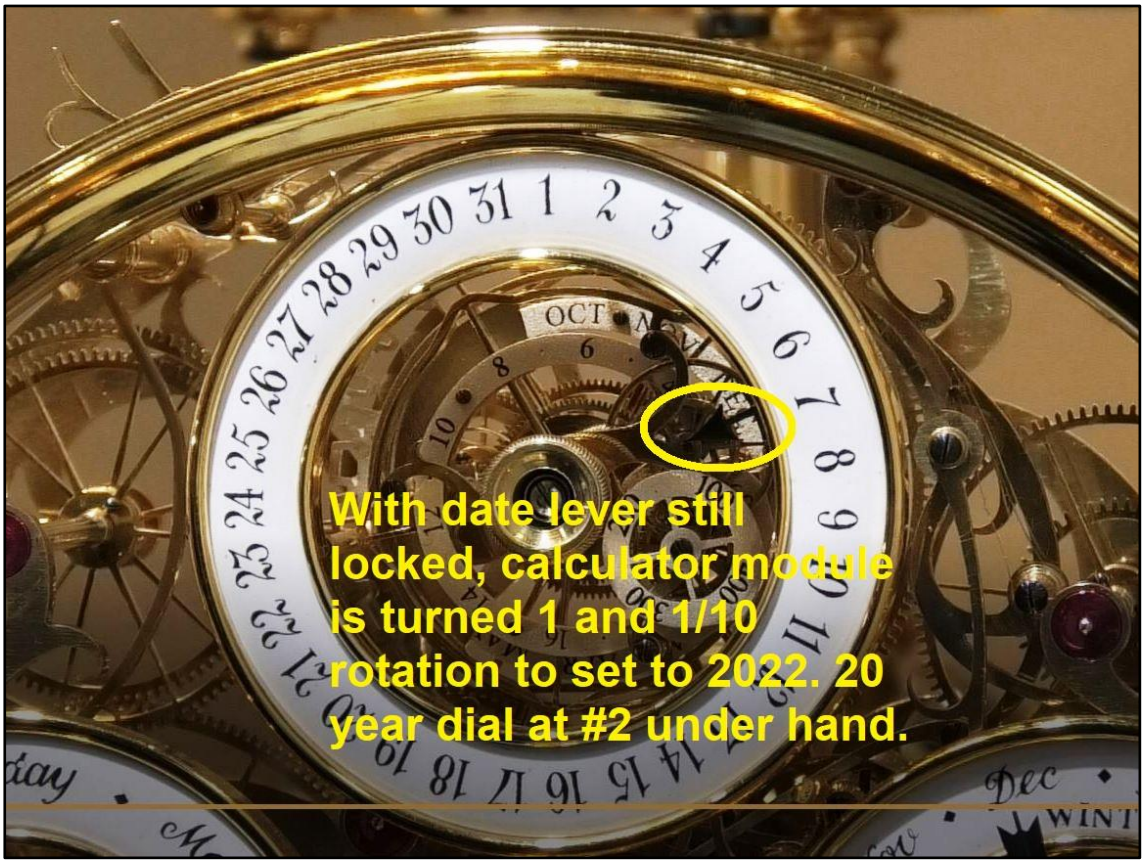


Fig. 3. Calculator module rotated 1 and 1/10 clockwise rotation. #2 on 20 yr. dial under setting hand. Calculator set to December 2022

To set the Date hand to January 1, 2022: Video 00031-F

8. Lift the date setting lever and spin the complete calculator until the correct month is behind the setting pointer, the date detent should be let in against the left side of the cut out detent wheel and the detent should be biased right and the date hand should be pointing to 1, (see photos below). The cut out on the index wheel is where the crenulated rim is missing for purposes of the month variations and February leap year exceptions to be supplied as needed by the calculator's 'surprise pieces'. The detent has a small swing allowing it to be pushed a bit to the left when the index wheel is turned slightly counter clockwise, Fig. 4 and to the right when the index wheel is turned clockwise, Fig. 5. To correctly position the date hand the index wheel should be turned clockwise to make the detent move fully to the right when engaged at the beginning of the index wheel gap, Fig. 2. Then insert the pointer hand to match the dial on 1. To replace the hand, it is positioned as above and pressed on gently holding it by the centre arbor boss. The calendar is now set to January 1st. 2022. It may be necessary to remove the hand to make major adjustments, as described in prior steps.

To set the Date hand to June 6, 2022: Video 00032-F

9. Lift the Date setting lever and rotate the knurl knob (which will also rotate the date hand) five turns to go from January 1 to June 1 and then to the 6th to the correct date. The calculator will rotate with the hand. The date dial is now set to June 6, 2022.

Fig. 4. Detent lever biased to the left, as a result of the index wheel rotated counter clockwise, wrong position

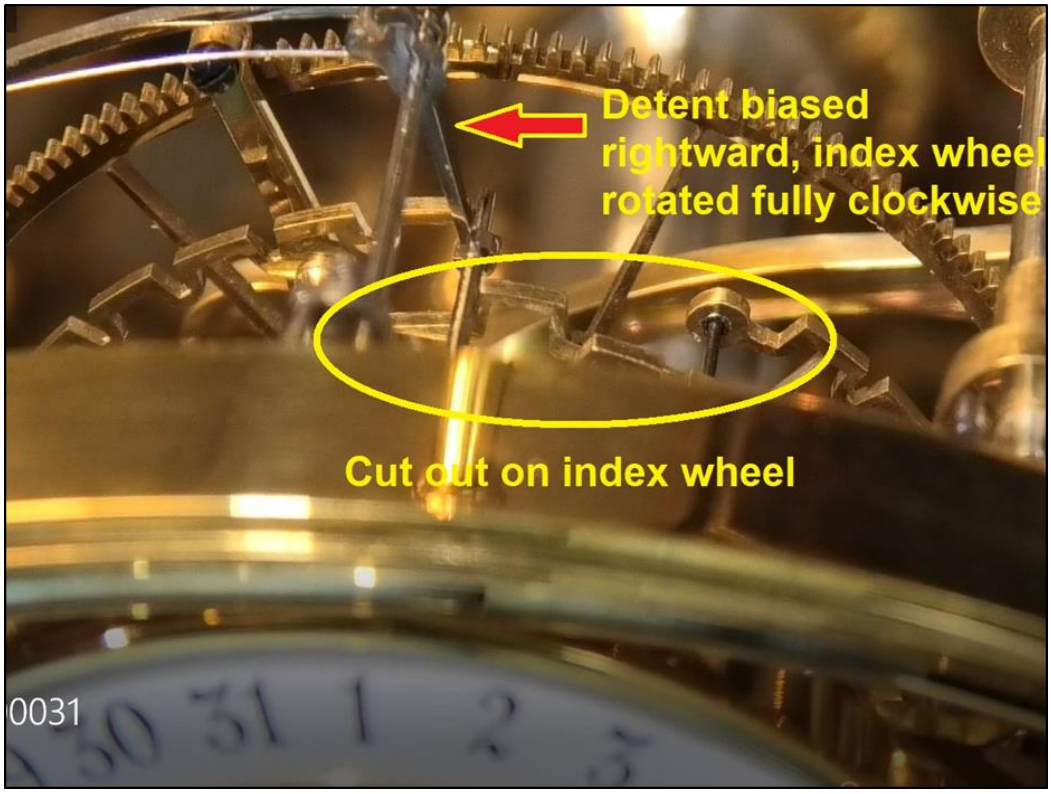


Fig. 5. Detent lever bias rightward as a result of the index wheel rotated clockwise, the correct position

The set the day of the week: Video 00033-F

10. Lift the day of the week setting lever and rotate the hand to the correct day of the week.
11. Release the setting lever and check that the detent is seated in the slot in the day wheel.

To set the month: Video 00033-F

12. Lift the month setting lever and rotate the month hand to the correct month.
13. Release the setting lever and check that the detent is seated in the slot in the month wheel.

To set the leap year hand: Video 00033-F

14. Divide the current year by 4 and set the leap year hand to the remainder: 2022 divided by 4 is 505.50 or 505 and 2 years, so set the leap year hand to 2
15. Lift the Leap year adjusting lever and rotate the Leap year hand to the correct number.
16. Release the setting lever and check that the detent is seated in the slot in the leap year wheel.

To set the year: Video 00033-F

17. Push in the Year adjusting knob and rotate it until the correct year is displayed.
18. Release then Knob to reconnect to the clock

To set the Calendar trip to Midnight, Chicago time:

19. Set the Mean time dial to midnight using adjustment tool on arbor square near 7 o'clock
20. Set the Demonstration drive to EXHIBIT 2'.
21. Set the international time dial to midnight in Chicago
22. Rotate the calendar drive input gear until the calendar trips

WITH THE CELESTIAL TRAIN SET AT MIDNIGHT:

G. Planisphere Dial: 00034-G

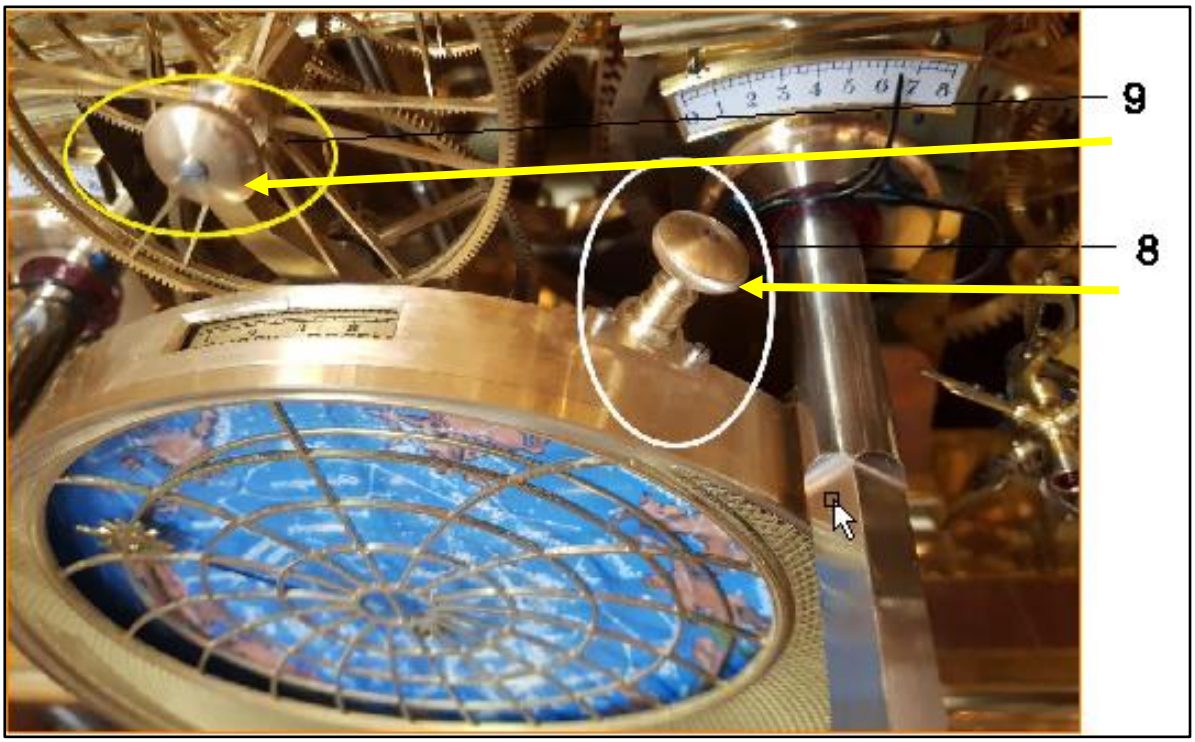


Fig. 1. Planisphere setting knobs, left sets the Sun; right sets the planisphere star disk and its date as seen in aperture at the top of the planisphere bezel

1. Set the Star Disc so that the correct date is aligned with the pointer at the centre of the opening on top of the Planisphere mask by means of the setting button (8) at two o'clock position on the edge of the Planisphere mask. This is accomplished by depressing the button to engage it and then turning the button while depressed. Make sure the setting button springs back to the disengaged position when setting is complete, Fig. 1.

2. The sun is then positioned pointing vertically downward by means of rotating the setting button (9) at the 12 o'clock position above the Planisphere mask, Fig. 1.

H. Mean Time Dial: Video 00035-H

1. Set the Strike/Silent pointer to Silent. This is to prevent the strike mechanism from resetting many times during a major hand setting process.

2. Set the Mean time hands to the correct time by rotating the time setting square arbour at the 35 minute mark with the setting tool, for this example to 12 Noon

3. Set Sidereal time by rotating the inner dial spokes with gloved fingers until the correct time is displayed. This can be looked up.

I. Set the Demo Dial to Exhibit 1:

Crank the Sidereal train until the Chicago Pointer on the International Time dial is matching the time on the Mean time dial, 12 Noon. Set the Demo select hand on the dial back to Clock.

J. Orrery: Video 00036-J

All planet and moon functions are on clutches so each can be gently pushed around to the correct position.

K. The strike is self-correcting and needs no setting up: Video 00037-K

To synchronize the Mean Time Hands with the strike mechanism:

When replacing the mean time hands:

⚠Note! This was also covered in Section 2. Video 00060

1. Rotate the time setting square clockwise slowly until the clock strikes the full hour.

2. The hour and minute hands must be carefully pushed onto the arbours matching exactly the hour struck.

3. Rotate the hands with the setting tool on the arbor square located at 7 o'clock and check that the hands are exactly in the correct place when the hour is struck and adjust if necessary.

4. Move the Balances to allow the clock to tick until one remontoire carriage reloads.

5. Place the Second hand gently on its arbour.

L. Tellurian: Video 00038-L

Fig. 1. Tellurion assembly

Mercury, Venus, the Moon, the Moon Orbit cam and the Planisphere arm are all on clutches and can be adjusted with gloved fingers to the correct position

1. The tilt of the earth's axis is fixed and must be set when the Tellurian is installed in the clock so that the tilt is pointing vertically upward so that the Northern hemisphere is closest to the sun then the earth is at the 6 o'clock position and the month pointer is on the 31st of June. This can be done by moving the latitude ring until it is the vertical position with northern hemisphere nearest the Sun.

2. The node ring can be manually rotated (Moon orbit cam), the correct setting can be looked up.

3. The Sidereal and Lunar months will then be automatically correct.

4. The Tellurion arm is then set to the correct date on the main dial by the month pointer below the Earth.

5. The Earth is then carefully spun around to the correct time using the Degree scale.
⚠Note! Take exceptional care not to bend the sunrise/set pointers and the moonrise/set pointers.

Once the clock is set up the complications should all remain in phase and the international time dial and any of the year setting dials can then be used to set the Celestial Train to the correct date and time.

M. Set International Time Dial to Chicago time: Video 00039-M

1. Set the demonstration selector from ‘CLOCK’ to ‘EXHIBIT 2’.

2. Crank the demonstration key clockwise until Chicago on the international time dial moves from 12 o’clock midnight, where it was last set, to the time on the mean solar dial. This is at 12 o’clock noon on the video.

3. Set demonstration selector back to ‘CLOCK’.

The clock’s complications are now all set to 12 Noon on June 6, 2022, and will remain locked together. If the celestial train is demonstrated in forward or reverse the complications will all stay in synch relative to each other. One can then bring those back to the current day and time after the demonstration by reading the current date off the following dials: calendar, tellurion dial, orrery dial, equation dial, year dial for the horizon shutters on the Sun/Moon module. The time can be read off the international time dial and compared to the mean time dial. ⚠Note! The mean solar time dial is completely independent from the celestial demonstration drive. So no matter how long the operator is in demonstration mode the time, as long as the pendulums are operating, will remain telling time and can thus be the reference for the correct time to bring the celestial demonstration back to the starting point.

One exception is if the selector is set to ‘EXHIBIT 1’ and the orrery is demonstrated separately, at this point it is not in synch with the rest of the celestial train. One can still bring it back to within a day using the orrery dial, and then relock it back to the celestial train by selecting ‘EXHIBIT 2’. The celestial train can then be locked and driven by the clock by selecting ‘CLOCK’.

To start the clock

N. Wind the clock: Video 00040-N

1. Be sure all four trains have at least three to four clicks on their respective springs.

2. Gently push a balance until the pointer on the beat plate is at 8 degrees. Release the balance and the clock should start running.

3. Lift one upper escapement pallet to release the remontoire drive to its escape wheel.

4. Hold the same upper pallet in one tooth of the escape wheel for three ticks. This will set up the balance of power to both escape wheels.

5. If a pallet is seen slipping on an escape wheel tooth, hold it in the escape wheel for 1 tick.

Notes: