This is part 1 of 2 on servicing the 400-day (Anniversary) clock.

This article will be a 2-part series devoted to the servicing of the 400-day or Anniversary clock by Michael P. Murray. Mike was AWI's 400-day clock repair bench course Instructor. The 400-day course is a 2-day "hands on" affair with the students working on the clock that they bring and Mike can accommodate anywhere from 8 to 16 students. For more information about Mike please see his Website at: **http://www.atmosman.com/400dayin.html**. This article is **copyrighted** to the author and references.

Members,

In my initial series on the 400-day clock, we will cover final assembly right through final timing. My assumption is that we all know the basics but it's the last seemingly basis steps where most of the troubles occur when servicing this slightly temperamental timepiece.

My goal in writing these articles is to get you past many of the pitfalls and erroneous assumptions. There are no real "secrets" and I hope to enable anyone who reads this by dispelling any fears or myths. So if you're not currently servicing the 400-day, I urge you to give them another try.

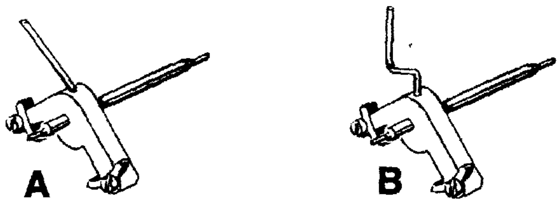
Series Assumptions

A quick mention of what I expect as the "basis". You're checked for and corrected any pivot, tooth, or gear depthing problems (depthing problems are extremely rare), used a mainspring winder to remove and install the mainspring, cleaned and lubricated same, pegged all pivot holes, polished all pivots and pivot shoulders, polished the anchor pin and the inside of the fork tines, and cleaned all parts. My last assumption is that you have one of the editions of Horolovar's the "400-day Clock Repair Guide". My personal preference is the latest edition, the 10th, and I'll be using that as my reference and for examples.

Test of Train Operation

First assemble the movement up to but NOT including the anchor or "verge", if you prefer. Leave off the motions works, suspension spring and don't mount it to its base. With the movement assembled, place a tiny drop of your favorite oil on all pivot holes. Wind the mainspring ½ a turn and the train should run freely. If not then please determine why and remedy the situation. Look for anything you'd look for in any other clock movement, broken, tapered, or bent pivots, broken, bent or cracked teeth, broken, bent or cracked pinions and arbors, pivot shoulders must be at a right angle to the pivots, lack of or too much end shake in all arbors, pivot freedom or lack of it in their holes and so forth.

Okay, the movement is moving smoothly. Before you take off the remaining power and install the anchor, check that the anchor pin is vertical to the pallets. A quick check is to lay it on a flat surface with the pallets down. The anchor pin must be perpendicular to the flat surface. If not then you can slightly bent the anchor pin or its' "bushing", if it's so equipped. (Notes: The original anchor pins for Gustav Becker clocks are hardened and should not be bent until they have been annealed. Some of the Kundo miniatures were equipped with an anchor pin bent backwards. This caused poor pendulum rotation. The solution (B below) is too replace the anchor pin with one that has been bent at a slightly smaller than right angle (backwards), then straight toward the plate and finally bent a slightly less than a right angle to come in contact with the fork.



Most anchor pins are threaded and screwed into the pallet base but I have seen these pins soldered. Just be sure how the anchor pin is secured and if it's hardened, BEFORE you make any adjustments and have a look on pages 42 & 43 in the 10th edition, for most of the variations on anchors and escape wheels. If you do bent the anchor pin then repolish it and I use 4/0 steel wool followed by 4/0 emery paper.

Remove the remaining power, install the anchor and wind the mainspring one turn. Use your finger as the fork and slowly rock the anchor pin back and forth and check each escape tooth for lock and drop.

This Graham deadbeat escapement must have equal and tight drops and the locks must occur above the pallet faces. The pallets should have an **initial** lock of only about 1/32 inch (0.8 mm) above the pallet face, too deep a lock will cause the clock to stop (the suspension fork can't turn far enough each way to unlock the pallets) and if it is too shallow the escapement will "flutter", causing the clock to gain a large amount of time. Ideally, lock and drop will be equal for all entry and exit pallets.

Please DON'T adjust the pallets unless you are absolutely sure they need adjusting. I have never come across a factory set escapement that was incorrect. Past "repair" intervention is almost always the case for poor escapement action.

There is not much angular motion of the pallets and this makes the relative position of the escape teeth and pallet length essential. The pallets should be of equal length and you'll have to measure this if the escapement presents a problem. The best explanation and adjustments of the Graham deadbeat escapement is covered on pages 42 to 52 in the10th edition.

Suspension Unit "Manufacture"

So far we have good transfer of power and good escapement action. Now we head for the suspension unit. Here's where the problems usually occur for the repair person.

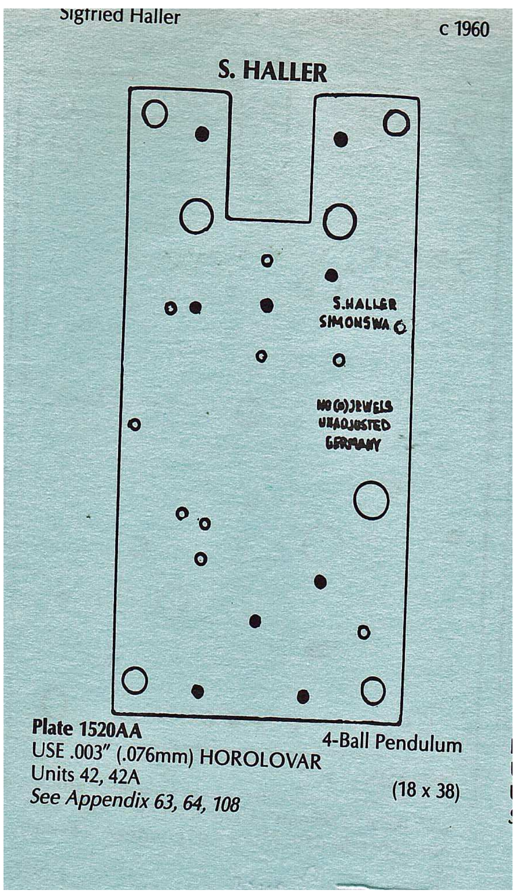
I ALWAYS purchase genuine Horolovar suspension springs. I state this simply because all the material in the 10th edition is predicated on using that spring. I always make it myself but you can purchase units already made, if they are Horolovar. When making the suspension unit, you must use "Sections 9 and 10" of the Repair Guide. In using these sections, we should understand all the information that is given to us. I'm going to use plate # 1520AA, which is found on page 152.

Section 9 is laid out in alphabetical order using the first letter in the first word on the back plate. As an example, S. Haller would be found under the letter "S".

One of the most important things to remember when using Section 9 is that Horolovar tries to illustrate as many back plates as possible but many times the information about a particular set of back plates is exactly the same. As in the group of 4 back plate illustrations associated with plate # 1520, which can be found on pages 151 and 152.

You should see four back plates in this series from plate # 1520 to plate # 1520AAA. If you look at the information given it is **exactly** the same for each plate. Some groups of plates will have the same information with some slight variations. I point this out because I don't want you to become obsessed with finding the exact back plate configuration. A little common sense will help a great deal when using Section 9.

I'll explain each bit of information, which is found on each back plate in Section 9 and each suspension unit in Section 10 of the Repair Guide. The following illustrations are very close to scale but not an exact duplicate of what you will find in the Horolovar 400-Day Clock Repair Guide 10th edition. I'll work from top to bottom and left to right concerning the back plate information in Section 9 of the Repair Guide.



Explanations

Sigfried Haller made this movement around 1960.

The upper left corner indicates who the manufacturer is and the upper right corner indicates the approximate date the movement was made.

Below the back plate illustration we find the following:

The plate # (Plate 1520AA) is just used for identification purposes by Horolovar.

4-ball Pendulum indicates the style of pendulum.

USE .003" means the thickness of the Horolovar suspension spring to be used.

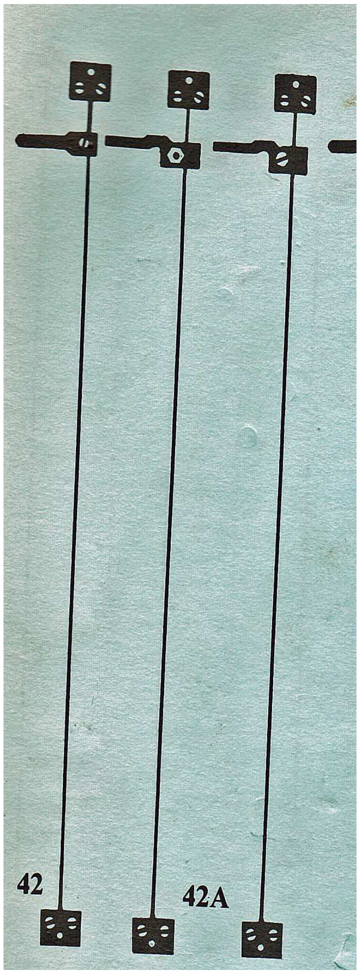
Units 42, 42A (See below) indicates what suspension unit to make based on the illustrations in Section 10.

(18 x 38) indicates the size of the mainspring required in this movement. Horolovar, in Section 17, list most of the sizes of mainsprings used in 400-day clocks. The 18 indicates the width of the mainspring and the 38 indicates the inside diameter of the mainspring barrel.

The Appendix 63, 64, 108 refers to Section 18 of the Repair Guide and these notes or illustrations contain miscellaneous information such as schematics, special manufacturing information, various improvements, and other interesting information that you and your customer may like to know.

In general, the Repair Guide is the “bible” for all 400-day work but it is not without errors and all know errors are covered in AWI’s Bench Course on the 400-day clock. I have the privilege of being AWI’s Instructor for these clocks and all incorrect information in the 10th edition of the Repair Guide, and all special circumstances are covered in detail during the 2-day bench course on the 400-day clock.

The information below is found in Section 10 of the Repair Guide.



42- S. HALLER STANDARD 70 – USE .003” (.076mm) HOROLOVAR
8 beats per minute

42a - S. HALLER STANDARD 73 – USE .003” (.076mm) HOROLOVAR
8 beats per minute
This Unit is functionally the same as Unit 42, but is equipped with a better-designed fork.

<u>Explanations</u>

The 42 and 42a are the Unit references from Section 9.

The standard refers to the size of the movement.

The 70 and 73 refer to the approximate date these suspension units went into service.

Again the suspension spring thickness is mentioned.

8 beats per minute is the proper running speed and this will be used to time the clock.

Most times there is a note about the particular suspension unit and these notes are **extremely** helpful and useful.

The Repair Guide, Section 10, covers all manufacturers from 1949 to present but it does not cover many suspension units manufactured before that date. That’s not to say Section 10 is useless for movements made before that date but what it does say is that **exact** duplicates of those earlier movements suspension units may not be in Section 10. This may mean that you may have to adjust the total length of the suspension spring slightly and/ or the position of the fork.

If you do not find a particular back plate in Section 9 and need to make the suspension unit, then use Unit 6789 (Unit 9) from Section 10. An easy length check for clocks with pendulum cups on their bases is to observe the position of the center shaft of the pendulum as it relates to the cup. In general, the bottom tip of the center shaft should be ½ of the way down this cup. This change in production was to reduce suspension spring and beat troubles arising from customers moving the clock. If the center shaft touched the cup, either on the cup sides or bottom, then the extra friction will stop the clock and if it’s too high then the cup will be rendered useless from its original purpose. Please be aware that if the pendulum has been dropped or otherwise mistreated then the center shaft may be bent. You must take the pendulum completely apart and correct this because the shaft will occasionally hit the sides of the cup and stop the clock.

On older clocks there is no standard Unit except for the Jahresuhrenfabrik models (most of these use Unit 6789A), you will have to assemble by trial and error. Just be sure the suspension spring is long enough for the pendulum to be about 1/4" to 3/8" above the base, and start with the fork about 1/4" below the top block.

I use the actual page from Section 10 of the 10th edition for my template. You can photocopy the particular page and use that as your template. Or you can use a strip of Styrofoam to secure the bottom block and place it underneath the photocopy if you prefer. Whatever method you are comfortable with is fine as long as you attain the results required.

The suspension spring must be free from any bends or kinks. If it is slightly angled then don’t worry about this because the weight of the pendulum will straighten this out once it is installed.

Please be sure that the suspension spring is perfectly centered in both the top and bottom blocks and that it intersects the fork at the same position as in the Repair Guide. The position of the spring inside the fork is also the center but it may not look like it because this is the theoretical center for the total weight of the fork.   Here’s a “trick” I use is to align the fork. Make sure that the position of the bottom of the fork tines is in line with the top of the fork tines in the illustration. This raises the position of the fork slightly (by exactly the tine width) and almost always eliminates any “flutter” associated with the escapement. I also turn the fork with the tines facing down wherever possible. This allows the transfer of power to be more efficient.

Please make sure that the suspension spring is in each block as deep as the block hole or block pin will allow and I always take both blocks and the fork completely apart in order to check for fragments of old suspension springs, which will impair their holding ability.

For those who are unaware, “flutter” is when the running movement impulses back and forth (escapes) very rapidly when the fork is about to enter its zero position. “Flutter” will cause the clock to run very fast and will only be present for a short period of time, as the clock enters the zero position. Zero is the position of the escapement where the impulse of one pallet is just about to end and the impulse of the other is about to begin. This is a term for when there is absolutely no power being generated to the pendulum. Another way to look at it is that zero position is the point where the pendulum comes to rest. In a motionless movement, one of the pallets may be in contact with the escape wheel because of power on the movement.

Flutter usually occurs when the fork is set too low. The lower the fork position, the more power is transferred to the pendulum and a much greater chance of flutter. Conversely, the higher the fork position, the less power to the pendulum and a lesser change of flutter. Obviously, some sort of compromise must be reached so that the clock will have sufficient power and keep good time. I believe my “trick” of marginally raising and flipping the fork, accomplished that nicely. Please be aware that most miniature and midget 400-day movements do not allow enough room for this raising of the fork procedure. In that case, just follow the illustration exactly.

In next month’s article, we will mount the movement to its base and install the completed suspension unit and pendulum. We will check the fork for proper “fit” in the arbor pin and set the beat, which is another critical and misunderstood area. Then we will review final assemble, install the motion works, and regulate and adjust the timing our overhauled 400-day clock.

This is part 2 of 2 on servicing the 400-day (Anniversary) clock.

Last month we tested the train for smooth running, manufactured the suspension unit and discussed Sections 9 and 10 of Horolovar's 400-day Clock Repair Guide, 10th edition.

Now we will mount the movement to its base and install the completed suspension unit and pendulum. We will check the fork for proper "fit" in the arbor pin and set the beat. Then we will review final assemble, install the motion works, and regulate and adjust the timing on our overhauled 400-day clock.

Installing the Suspension Unit and Suspension Fork Adjustment

Mount the assembled movement to the base and install the suspension unit and pendulum. First look at it whether or not the total length of the suspension and pendulum looks "right". The pendulum cannot touch the base of the clock and must look aesthetically pleasing. What I mean by pleasing is that the pendulum is about 1/4" to 3/8" above the base. For clocks with pendulum cups on their bases, observe the position of the center shaft of the pendulum as it relates to the cup. In general, the bottom tip of the center shaft should be ½ of the way down into this cup. This change in production was to reduce suspension spring and beat troubles arising from customers moving the clock. If the center shaft touches the cup's bottom then the extra friction will stop the clock and if it's too high then the cup will be rendered useless from its original purpose. Please be aware that if the pendulum has been dropped or otherwise mistreated then the center shaft may be bent. You must take the pendulum completely apart and correct this because the shaft will occasionally hit the sides of the cup and stop the clock. Be sure the upper suspension block is "snug" in the suspension bracket. It should be just loose enough to allow back and forth movement with the pendulum attached and move without kinking the suspension spring. If it is too loose, use a shim of paper or thin brass to fill the space.

Assuming that you followed last month's article, the mainspring should still have one complete turn. Check the clearance between the fork tines and the anchor pin. The tines should be parallel, and the clearance should be just enough to see daylight between the anchor pin and one tine when the pin is pressed against the opposite tine just as the clock escapes (this assumes there is power on the mainspring). This clearance can be pre-set when assembling the suspension unit, by using a 1-mm diameter wire as a gage. Most anchor pins are very close to 1-mm diameter. If the clearance is too small, the fork will bind on the anchor pin at either end of the pendulum swing and not allow the pallets to unlock from the escape wheel teeth, thus stopping the clock. If the clearance is too large, there will be a loss of power due to the anchor pin not staying in contact with the fork for the full swing, and this can also cause the clock to stop or have poor pendulum rotational amplitude.

Winding and Setting the Beat

Wind the clock about half way, and we will now look at probably the most misunderstood area and that is to have the movement "in beat" with adequate overswing of the pendulum.

Initial Beat Setting

A simple check can be made by first allowing the pendulum to come to rest. Then, by hand, carefully rotate the pendulum until you observe an escape wheel tooth drop onto a pallet. Release the pendulum. If it rotates until the opposite pallet contacts the escape wheel tooth (escapes) and then stops, the clock is in beat. If it does not escape, turn the suspension saddle slightly in the direction of the side that did not escape and repeat the procedure. If the opposite pallet does escape but the pendulum continues moving (“overswing”) then turn the suspension saddle slightly in the opposite direction you initially allowed the pendulum to turn (swing) and repeat the procedure.

Checking the Overswing and Fine Tuning the Beat

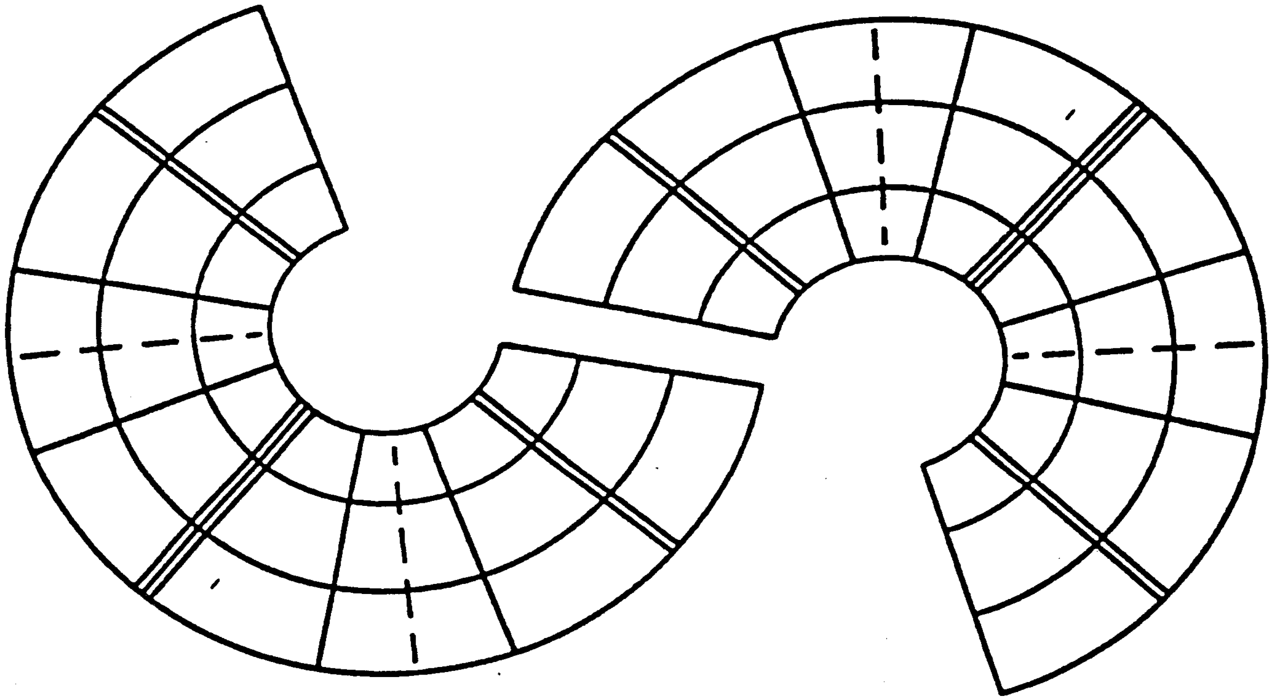
When the clock is perfectly in beat the pendulum should turn exactly the same amount to either side after each pallet locks (this is called overswing). Overswing can be checked visually using any of the following three methods (a, b, & c), first turn the pendulum by one-half turn in either direction to start the clock:

a. Use a beat amplifier to hear the "tick" as each pallet locks. Place a beat adjusting quadrant under the pendulum (see below and this is found on page 52 of the 10th edition), and following one point on the pendulum. Mark its position on the quadrant at the point of each tick; also mark the end of swing in that direction. The difference between the point of tick and the end of swing on each turn is the amount of overswing. Looking from the top of the clock from the back, turn the suspension saddle clockwise if overswing is too little to the left, and counterclockwise if it is too little to the right. Saddle adjustments can make a large change in overswing because any increase of overswing in one direction is decreasing the same amount in the other direction.

b. Watch the escape wheel action through the observation holes, or by looking at its reflection in the front plate. You will be able to see the escape wheel "jump" as each pallet unlocks / locks, mark the pendulum positions accordingly. Adjust the overswing as necessary.

c. With the motion works and hands in place, set the minute hand at 20 minutes to the hour, and watch the action of the minute hand. It will "jump" as each escape wheel tooth is released, which corresponds to the lock of the pallets. Adjust the overswing as necessary.

When you are finished here, there should be a total of at least 1" overswing (1/2" in each direction at the pendulum outer periphery). If this is not met, there is some reason for power loss or maladjustment and the clock is unlikely to run very long.



Beat Adjustment for Some Disk Pendulums

The earliest 400-days did not have a suspension saddle or suspension bracket. Therefore it was necessary to bend the suspension spring just below the top block in order to place the movement in beat. Some of the early suspension brackets had a very, very subtle “throw” and did not give you much in the way of placing the clock in beat on these early disk pendulum clocks. These brackets should only be used for the finest in beat "tuning". Most brackets do allow for adequate beat adjustment and should be all that is necessary assuming that you have checked the position of the anchor pin in relation to the pallets and made sure that the anchor pin is “straight up” before setting the beat, as was mentioned in the first article.

The next adjustment should only be made if the clock is in the customer’s or your home and where they or you are going to display the clock. I mention this because the adjustment is easily displaced by moving the clock or by removing / installing the pendulum.

Let's say the clock is over swinging on the clockwise turn of the pendulum. In this case, clockwise as observed by looking down on the clock from above and from the back. The anchor pin is being moved from left to right by the fork. That means that the anchor pin is too far over toward the right and must be moved left in order to center it. Another way to look at it is that the right pallet is too deep and the left is too shallow but this is **NOT** an escapement problem because in the first article we checked for proper locks and drops.

Normally, you would have corrected this problem in your shop because the anchor pin and/or it's mounting are not easily moved and any attempt to move the pin or mounting **must** be made in your shop with the clock anchor removed from the movement.

Now back to my quick beat “fix”. Move the disk away from the back plate (or remove the disk and move the bottom block away) and this action moves the fork away and finally out of contact from the anchor pin. Take a pair of tweezers and slightly move the fork toward the right. This, in effect, bends or twists the suspension spring, which has a definite effect on the beat of the clock. It is very easy but very subtle. This takes practice and patience and you will be surprised just how much bending the suspension spring can affect the beat. If you’re brave, you can grab the suspension spring just below the top block and make your bent there. I've noticed with all disk pendulums and ball pendulums without a base cup, that moving the clock with the pendulum attached usually affects the beat to some degree, however small.

<u>**Final Assembly and Regulation**</u>

I like to test the movement without the motion works for at least a few hours and overnight is preferred. Once you are satisfied that the movement is running strong, the clock is in beat and you have at least 1” total overswing (1/2” in each direction), now it’s time to “time” the clock.

<u>**Manual Timing**</u>

All clocks will regulate differently for different pendulum swings. The “normal” pendulum swing (amplitude) must be established before you can time the clock. This means that the clock should be running for at least 15 minutes, which will allow the pendulum to “find” its normal amplitude.

Once accomplished, find the exact unit from the Repair Guide in Section 10. Take a look at the “Beats per Minute” information. Unit # 42 of Section 10 calls for a .003” suspension spring and the clock should be running at 8 beats per minute.

Use a beat amplifier and a stopwatch. Place the alligator clip of the amplifier as close to the pallets as possible and “clip” it onto a clock plate post or on the anchor bridge screw. Start the stopwatch at exactly the same time as the audible “tick”. Then start counting the ticks using the next tick, the tick following the start of the stopwatch, as tick number one. When tick number 8 is reached, stop the stopwatch at exactly the same time as the audible tick. You could also install the minute hand and use its motion as your tick. But again, make sure the clock has reached the proper pendulum amplitude before you start timing.

The stopwatch should read exactly 60 seconds when the eighth tick is reached, in this particular example. If your reading is less than 60 seconds then the clock is running fast and must be slowed and if your reading is over 60 seconds then the clock is running slow and must be sped up.

When making timing adjustments to the pendulum, please observe the total swing of the pendulum because you can start the pendulum at the point of the normal amplitude and speed up your timing process for the next timing test.

Electronic Timing

By far the easiest way to time a 400-day is the use of an electronic timer. The best thing about using electronic timing is accuracy and the fact that you do **not** have to place the minute hand on the clock, as you may have to do with manual timing (above).

The timer should have a reading of at least 2 decimal places to the right after the decimal point. Most timers read in beats per hour and you need to know the number of teeth on the escape wheel, so you can "set" the preset average (the amount of "counts" you are telling the timer to register). Take the number of escape teeth and multiply it by 2 because each escape tooth "hits" the two pallets of the anchor. The reasoning is that electronic timers measure one complete revolution of the escape wheel.

Place the alligator clip of the timer as close to the pallets as possible and "clip" it onto a clock plate post or on the anchor bridge screw. Set the preset average, or counts, to the escape wheel teeth times 2 and record your results after the timer has updated its readout at least twice.

Using the same example as above, 8 beats per minute, then a perfectly running clock will read 480.00 beats per hour. If your reading is less than 480.00 then the clock is running slow and must be sped up and if your reading is over 480.00 then the clock is running fast and must be slowed.

Regulating the Clock

Please be aware that the 400-day delivers much less power than most other clocks, therefore any extra friction from the motion works, minute shaft tension washer or spring, or hands will result in a stopped clock.

Once you are satisfied with the timing, install the motion works, dial, and hands. Wind the clock fully and this is when you should be on guard for escapement flutter. If this occurs, then raise the fork slightly until the flutter stops.

On 3-ball and 4-ball pendulums, a round, knurled "regulating disc" (about the size of a nickel) is at the top. When turned, it will make the balls go toward, or away from, the center of the pendulum. The direction in which the regulating disc should be turned to make the clock go faster or slower depends upon the design of the pendulum. Look for the letters F or A (fast) and S or R (slow) on top of, or near, the regulating disc.

On disc pendulums of pre-World War II clocks, there are two little disc weights, which can be moved by turning a threaded steel rod with a key. They will go toward the center of the pendulum (turn key toward F or A to make the clock go faster) or away from the center (turn key toward S or R to make the clock go slower). A double-end key for both regulating and winding may be available for this clock and the customer should be given one if they don't already have one.

Final Thoughts

I've hear many repair people say that the total rotational amplitude of the pendulum must be a certain rotation. This is a myth. If you have the ½" or more of overswing in both directions, then the total rotational amplitude is irrelevant. I've seen 400-day clocks running and keeping good time with as little as a half rotation of the pendulum in one direction and conversely I've seen 400-days with 1 ½ rotations in one direction.

In general, correctable plate and pivot wear will not be found when servicing the 400-day. The pivot holes should never need bushing and may occasionally need some closing. The reason for this is that these movements are one of the slowest "beaters" in the clock world and are very made well. This slow beat translates into very little pivot movement and therefore very little pivot hole wear. Occasionally, I see some pivot hole "slop" in the great wheel and the next wheel up. I have also seen some slop in the anchor pivot holes and that's about it. I don't see correctable wear that often in these movements and that includes the pivot's "finish".

Many think that 400-day's are lousy timekeepers. They will not compete with the finest clocks but they should be within a minute or two a month. Just because of their name, it does not mean that these clocks will keep good time over an entire year. I suggest that my customers wind their 400-day clock, twice a year. I suggest New Year's Day and July 4th for obvious reasons. These clocks will keep reasonable time over a six-month period.

400-day movements generally have a great deal of end-shake when compared to other movements. I have no good idea why this is but I can assure you that this is normal for these movements.

Horolovar sells a Repair Warranty booklet and it can be found on pages 65 through 67 of the 10th edition. This booklet is a **must** for any repair person overhauling the 400-day for the public. I implore you order these booklets directly from Horolovar. Unfortunately, I've seen this booklet on various Web sites and these people past this off as their own work. Horolovar sells these booklets at their cost.

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Lancaster, OH 43130
740-277-7083
E-mail address: horolovar@gmail.com
Web site address: http://www.thehorolovarcompany.com/

The last know manufacturer of mechanical Anniversary clocks is S. Haller. They are still producing, what I call a "version" of the mechanical "400-day" but it is only designed to run 6-months on a full wind. If you are interested in this "last of its kind" then contact one of the companies below.

Siegfried Haller Uhrenfabrik GmbH
Talstrasse 23
79263 Simonswald
Germany

Phone: + 7683 9100 0 or Fax: + 7683 9100 38
Email address: haller@halleruhren.de

That + in front of the telephone and fax indicates the country code (Germany).

The U.S. Dealer/Importers are

Loricron Clock Company
3463 Sherbrooke Drive
Cincinnati, OH 45241-3282
800-637-9964; 513-733-5488; or Fax: 513-733-070
They carry S. Haller clocks under the Loricron name.

Haller Clock Company
P. O. Box # 566
Forest, VA 24551
804-525-2114 or Fax 804-525-3827

I hope you have learned something from these two articles and I again urge you to consider making the 400-day part of your offered repair service or hobby. The 400-day is relatively easy to work on and they only have to be wound twice a year. The line of styles seems endless and because production of the "true" mechanical 400-day clock came to an end in the mid 1980's, they are now in limited quantity but that number is in the tens of millions. They are an eye catcher and somewhat mysterious in their operation to the "lay" person and peek interest and comments.

If you have any questions about what we covered here or on what is covered in the bench course, please feel free to E-mail me at:

Mike@atmos-man.com

Mike is AWI's 400-day clock repair bench course Instructor. The bench course is a 2-day "hands on" affair with the students working on the clock that they bring and Mike can accommodate anywhere from 8 to 16 students. Additional information about Mike is located on his Website at the following Web address: **http://www.atmosman.com/400dayin.html**. This article is **copyrighted** to the author and references.

References:

AWI's Bench Course material
Horolovar's 400-Day Clock Repair Guide, 10th edition
NAWCC's Field Suitcase Workshop by John Hubby
"The Torsion Times", a publication by NAWCC's Chapter # 168