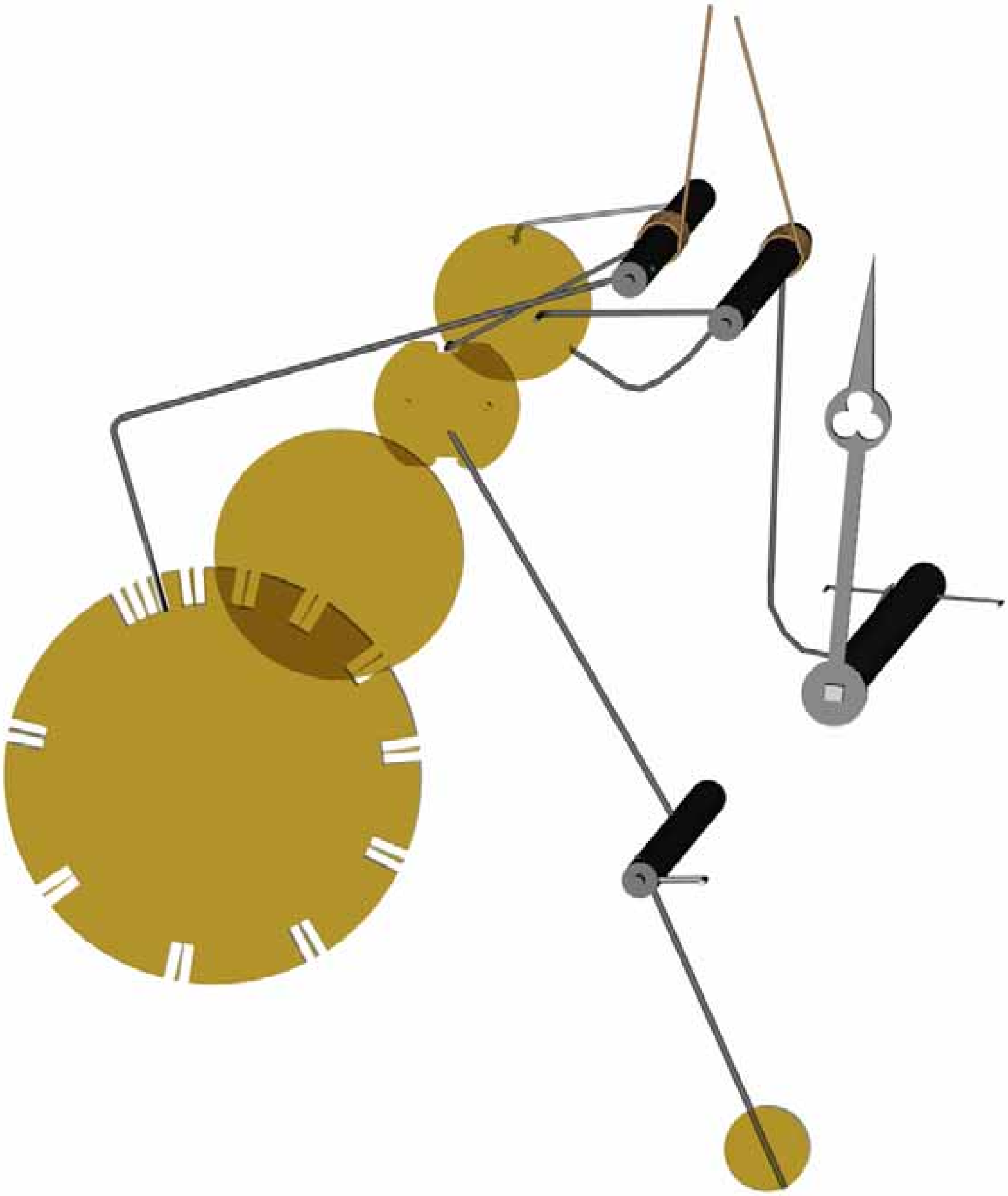
The Levers of American Striking Movements



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INTRODUCTION

American movement strike lever arrangements are a bit more complicated than they look. The first time I was asked to adjust one of these (and I'm quite sure I was set up) I was able, after a bit of bending and guesswork, to get the levers to cooperate and do what they were supposed to do. During the course of trying to figure out just what they were for, however, I found myself adjusting in circles and getting more frustrated with each adjustment. Unbeknownst to me, the movement I was handed was one of those with which even the best of us has problems. The levers have to be adjusted just right or suffer the consequences. This exercise taught me the lesson that proper lever adjustments are key to the reliability of the movement. It doesn't matter how well the rest of the movement is restored, if the levers haven't received the proper attention there will be problems with running, striking, or both.

The following is a presentation of two generic lever arrangements which, hopefully, will enable you to understand specific and unique lever configurations. The first configuration, most commonly found in eight-day movements such as the Seth Thomas model 89's and others, has a stop/warning pin on the 4th wheel (see fig. 1). The hammer pins in this configuration are on the maintenance cam $_{(I)}$ or 3rd wheel. The second configuration discussed later in "Part 2", found in thirty-hour and some 8-day clocks, uses the maintenance cam $_{(I)}$ as the stop/lock and has the warning pin on the butterfly. The hammer pins are commonly found on the 2nd wheel $_{(J)}$.

This work was designed to be a bench-side aid, which is why some information is identical in parts 1 and 2. It may be advisable, therefore, to have an American, count wheel, striking movement on hand to aid the reader in identifying the levers and their relationships while reading this material.

History

American strike levers have their roots in the strike work of English and European timepieces. As is often the case, advancements in horology are brought about by necessity. Those clockmakers who ventured to America in the eighteenth century brought an intimate knowledge of the methods of obtaining a reliable striking process. Unfortunately, the materials available to them for producing timepieces and strike work were costly, as they had to be imported. Only the wealthy could afford to own a striking clock in America in the eighteenth century and the number was so small many clockmakers turned to other trades. It was therefore a relatively short time before the necessity for producing an inexpensive timepiece brought about changes in the construction of movements.

Eli Terry's patent in 1816 of an inexpensive striking clock movement shows the ingenuity and adaptability of clockmakers. Terry found American hard woods to be a readily available, inexpensive material to replace the brass of the movements. This allowed him to mass-produce timepieces which the common American could afford. Many clockmakers followed his example and over the next few years the profit in producing an American clock was sufficient that an industry was born. The levers of striking clocks became thin, inexpensive segments of soft steel wire, instead of the thick, flat pieces of wrought iron common to clocks of the previous century. They were affixed to wooden arbors, easy to produce, and readily adjustable. They varied slightly from manufacturer to manufacturer but still retained the basic form and function of their English counterparts. This is not to say certain elements were not rearranged. One example is the innovation of relocating the strike release pin(s) which were moved from the minute wheel to the rear of the center shaft.

The invention of rolled brass in the mid nineteenth century allowed American clockmakers to return to producing clock movements out of sturdier material. The brass was thin, inexpensive, relatively hard, and didn't need to be imported. The strike levers were again affixed to steel arbors but retained their soft steel wire construction, as it was easy to produce and adjust. Relatively few changes took place in the construction, shape, or function of American strike levers over the next seventy years and it wasn't until the 1920's that they once again became flat pieces of steel reminiscent of their early English counterparts. Instead of being cast, hand-made pieces, these levers were machine stamped out of steel sheets. The process was accurate enough that very little adjustment of the levers was required and, in fact, this style of lever was adjustable only by rotating it on the arbor.

Sadly, the American clock industry is now all but nonexistent and no American striking clocks are being mass-produced. Korea, China, and Japan are producing movements with strike work virtually identical to those the American clock industry was producing at its peak and these levers will still be encountered in new clocks today.

Part 1: "WARNING WHEEL AS STOP" CONFIGURATION

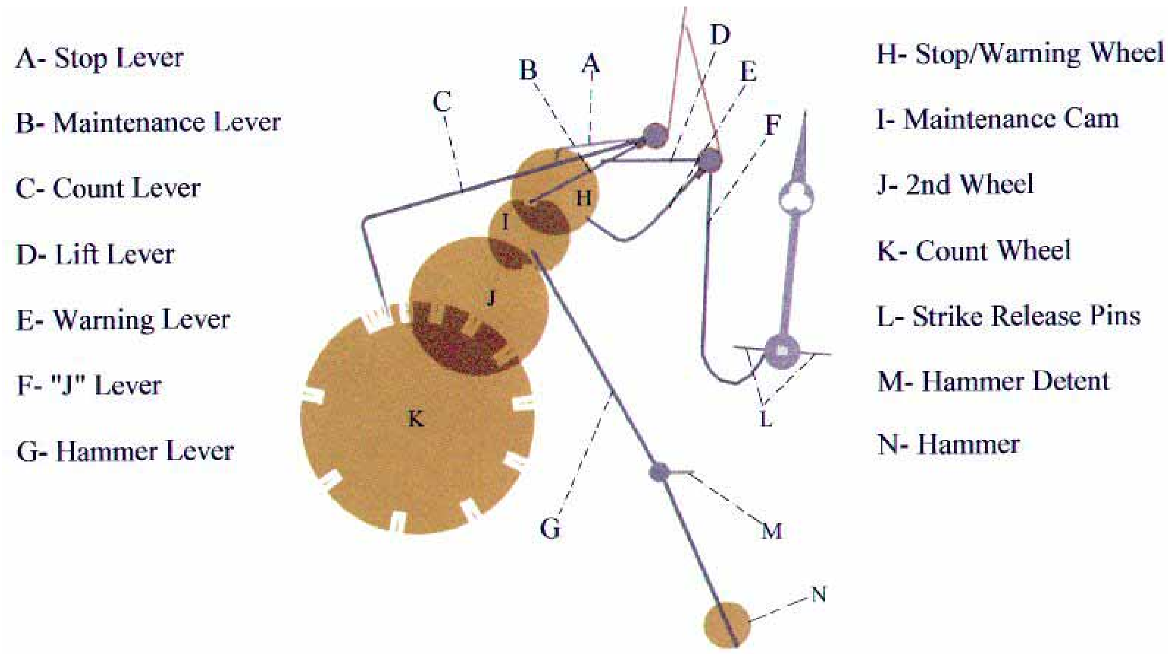


Figure 1

THE LEVERS (fig. 1 - 3)

In order to discuss the levers we must first identify them and describe their function. Note: These are grouped according to the arbor to which they are attached.

<u>A – Stop Lever</u>: This lever *stops* the strike train by intersecting the path of the stop pin mounted on the stop/warning wheel $_{(H)}$.

<u>B – Maintenance Lever</u>: The function of this lever is two fold. First, this lever *maintains* the clearances needed for the stop lever $_{(A)}$ and the count lever $_{(C)}$ when continuing the strike process. This allows the strike train to run until stop conditions are met. Second, the maintenance lever $_{(B)}$, by dropping into the notch in the maintenance cam $_{(I)}$, allows the stop lever $_{(A)}$ and count lever $_{(C)}$ to fall into a stop/lock position.

<u>C – Count Lever</u>: This lever *counts* the strike by being held up until it falls into a stop notch on the count wheel $_{(K)}$. When the count lever $_{(C)}$ drops into a deep or stop notch on the count wheel $_{(K)}$, the maintenance lever $_{(B)}$ is allowed to drop deeper into the notch on the maintenance cam $_{(I)}$, and the stop lever $_{(A)}$ drops far enough to catch the stop pin stopping the strike process. Strike will continue as long as the count lever $_{(C)}$ is resting on the rim of the count wheel $_{(K)}$ and not in a stop notch.

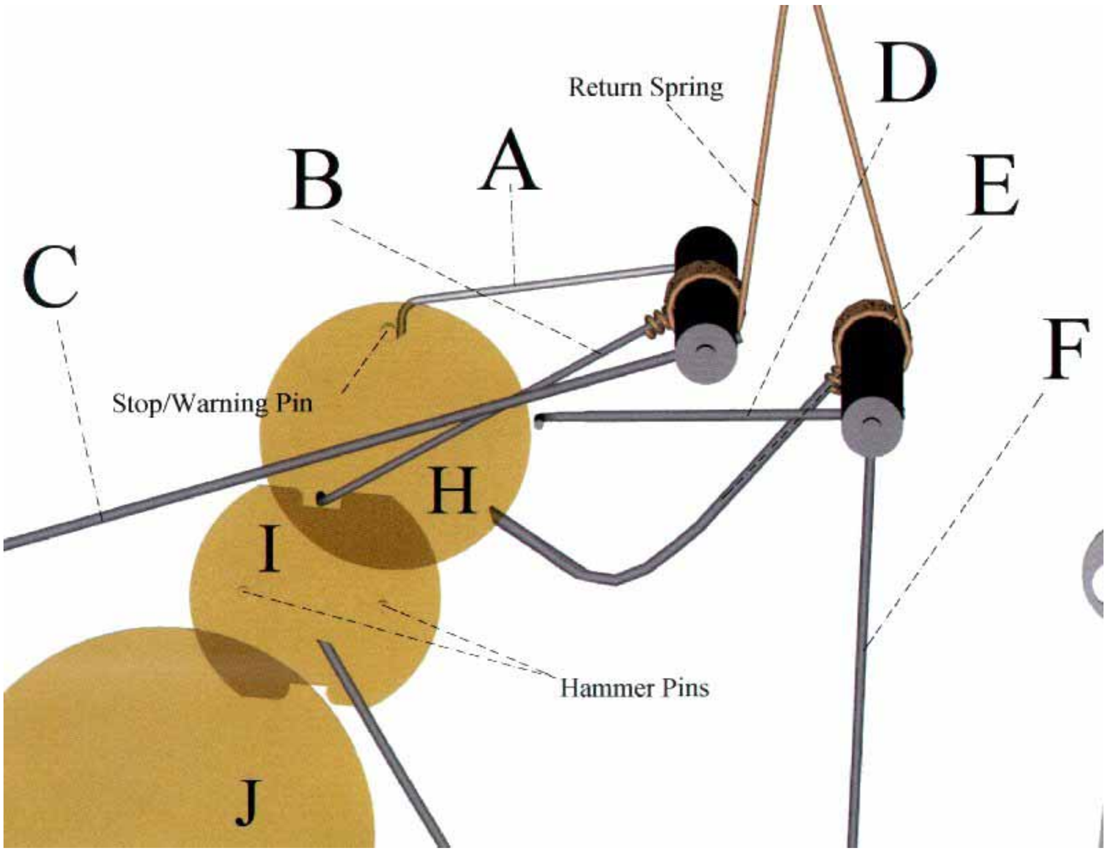


Figure 2: Lever detail.

<u>D – Lift Lever</u>: This lever's function is to *lift* the stop lever $_{(A)}$, maintenance lever $_{(B)}$, and count lever $_{(C)}$ so that the strike train is released from the stop position.

<u>E – Warning Lever</u>: This lever catches the warning pin (same as the stop pin in this instance) and holds the strike train until the precise point of strike release is reached. The short amount of release (or run) and arrest of the strike train just prior to strike is called *warning.*

<u>F – "J" Lever</u>: This lever, called the "J" lever because of its shape, could just as well be called the strike release lever as its function is to release the strike train from stop into warning and from warning into strike at specific times. It is also the means by which the other levers are lifted into position for the coming strike action. Some "J" levers are designed to allow the minute hand to be turned backwards. These are generally flattened on the end and twisted in such a way to allow the strike release pins $_{(L)}$ to force the "J" lever $_{(F)}$ out of the way and pass by when turned back.

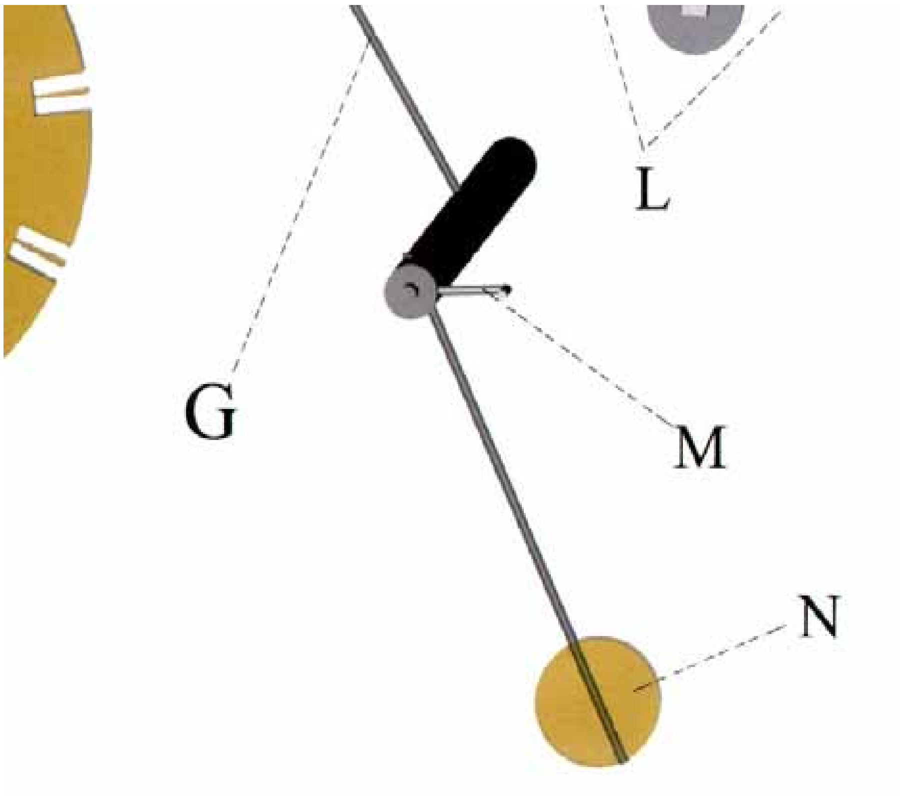


Figure 3: Hammer arbor detail.

G – Hammer Lever: This lever raises the *hammer* $_{(N)}$ and releases it to produce a blow or strike on a rod, gong, or bell.

M – Hammer Detent: This pin *stops* the *hammer's* recoil motion and maintains the position of the hammer lever $_{(G)}$ so that it returns to the same place following each hammer blow. This allows the hammer pins to engage the hammer lever $_{(G)}$ in a consistent manner and give a consistent strike.

N – Hammer: This is the piece which contacts the bell, gong, etc…

L – Strike Release Pins: These pins are attached to the center shaft and engage the "J" lever $_{(F)}$, lifting it to produce the *release* of the strike at a specific point.

WORKING TOGETHER

Having identified all of the levers, we will now look at the process of striking to see how these levers relate to one another.

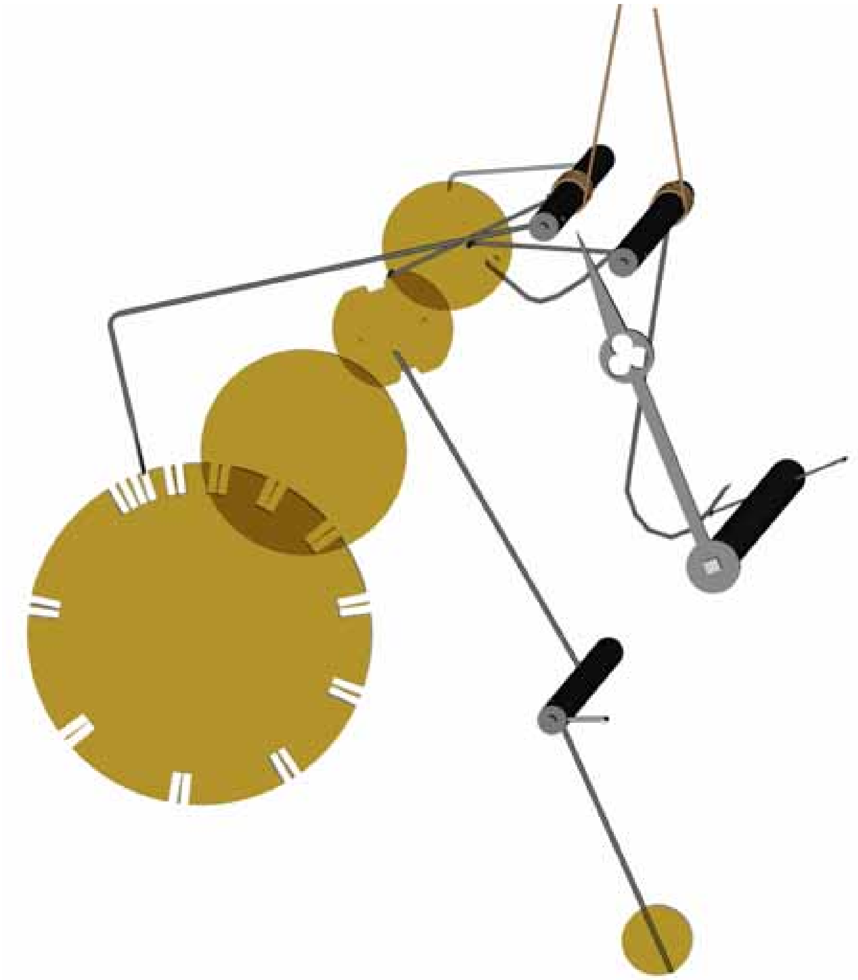


Figure 4: The strike train in warning.

Warning

Somewhere between 10 and 3 minutes before the hour or half-hour, the strike release pins $_{(L)}$ raise the "J" lever $_{(F)}$ which in turn raises the lift lever $_{(D)}$ sufficiently to engage and push up the count lever $_{(C)}$. The levers are lifted higher and higher until the stop/warning pin is released from the stop lever $_{(A)}$. This allows the strike train to "go into warning". The slight rotation of the maintenance cam $_{(I)}$, during warning, pushes the maintenance lever $_{(B)}$ out of the notch and lifts it slightly. This disengages the lift lever $_{(D)}$ from the count lever $_{(C)}$, raises the stop lever $_{(A)}$ to guarantee clearance of the stop/warning pin, and lifts the count lever $_{(C)}$ almost out of the stop notch. The stop/warning pin is caught by the warning lever $_{(E)}$, which has been raised along with the "J" lever $_{(F)}$, and the warning process is complete. This is needed for power conservation to allow the movement to lift levers a little at a time instead of all at once and to gain a more accurate and consistent strike release point. Warning is different and separate from the short amount of run of the strike train just prior to hammer lift.

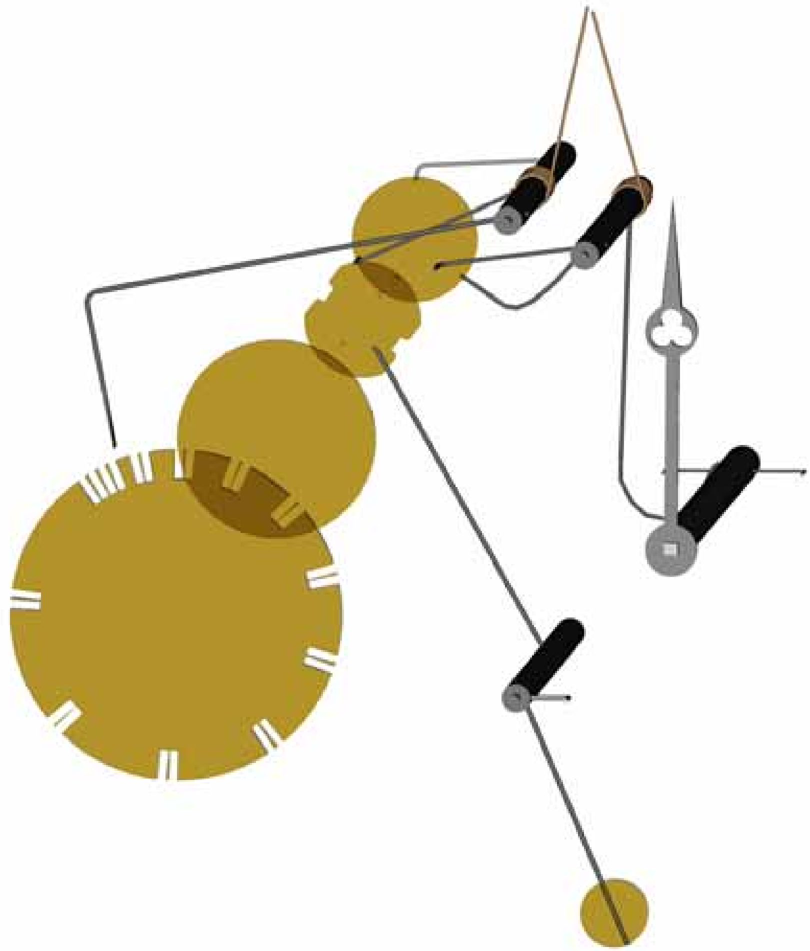


Figure 5: The strike train at strike.

Beginning-Strike

The center shaft continues to rotate lifting the "J" lever $_{(F)}$ with the strike release pins $_{(L)}$ until the hour or half-hour when the "J" lever $_{(F)}$ is released and rapidly returns to its original, at-stop position. This causes the warning lever $_{(E)}$ to release the warning/stop pin and allows the strike train to run free. At this point several things happen almost simultaneously. The maintenance cam $_{(I)}$ rotates and the maintenance lever $_{(B)}$ is pushed onto a cam lobe. The stop lever $_{(A)}$ is lifted for maximum clearance of the stop pin. A hammer pin on the maintenance cam $_{(I)}$ begins to engage the hammer lever $_{(G)}$. The count lever $_{(C)}$ is lifted well clear of the stop notch on the count wheel $_{(K)}$. The count wheel $_{(K)}$ rotates under the count lever $_{(C)}$ towards the next count notch on the rim or another stop notch. It is important to note that there is a short amount of run of the strike train just prior to hammer lift by the hammer pins. This is necessary for the movement to be allowed to gain momentum before lifting the hammer.

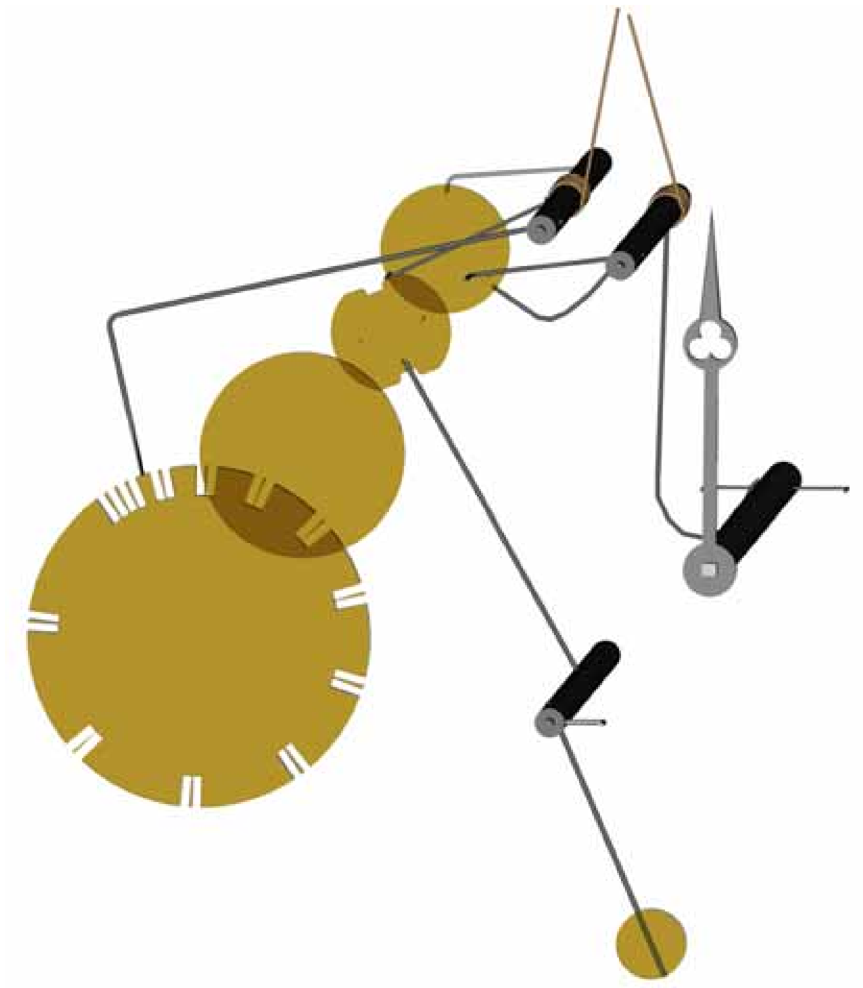


Figure 6: The strike train at mid-strike.

Mid-Strike

At the hour, the strike train must continue to run and deliver the proper number of blows for that hour. The critical moment that determines whether the strike train stops or continues is at the point when the maintenance cam $_{(I)}$ presents the notch to the maintenance lever $_{(B)}$ allowing the count lever $_{(C)}$ to be lowered onto the count wheel $_{(K)}$. For strike to continue, the count lever $_{(C)}$ is lowered onto the rim of the count wheel $_{(K)}$ instead of a stop notch, which keeps the stop lever $_{(A)}$ raised sufficiently to clear the stop pin. Once the stop pin passes the stop lever $_{(A)}$, the maintenance cam $_{(I)}$ lifts the maintenance lever $_{(B)}$ and the strike process continues.

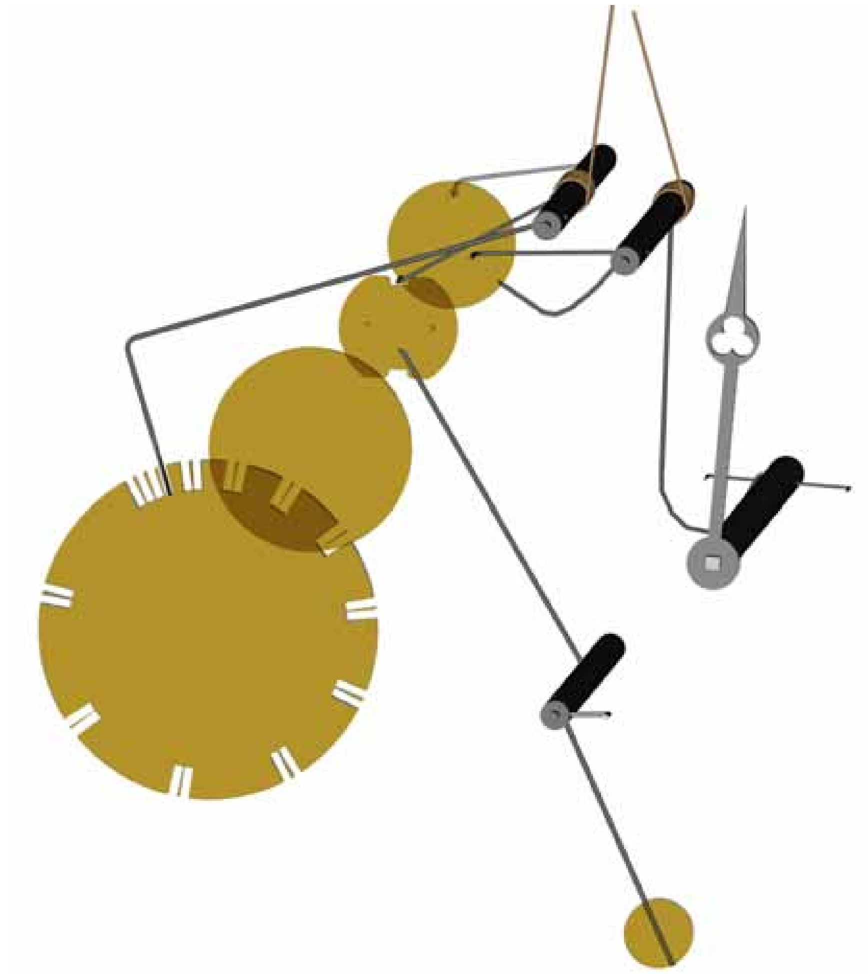


Figure 7: The strike train at stop.

Stop

Again, the critical point in the striking process is when the maintenance lever $_{(B)}$ reaches a notch in the maintenance cam $_{(I)}$. If the count lever $_{(C)}$ falls into a stop notch at this point, the stop lever $_{(A)}$ will drop sufficiently to catch the stop pin and the strike process will stop.

WEAR PROBLEMS

Anytime there are two independent, moving surfaces, which, repeatedly over time, come into contact with one another, there will be an abrasion and wear of both surfaces. This is especially true of American clock levers and pins. It is important to recognize the problems that wear can cause and how to deal with them. Levers left unrestored can cause a myriad of headaches since wear changes the geometry of the action of the lever causing the movement to work harder to accomplish its task.

I believe that the repair of levers should be part of a thorough restoration process, which includes polishing pivots, bushing worn bearing holes, servicing mainsprings, etc…not just a quick fix to solve the problem. Restoring levers cannot be done while they are still inside the movement! Be sure to remove the power from all trains before disassembling the movement and take any special notes necessary to aid in reassembly.

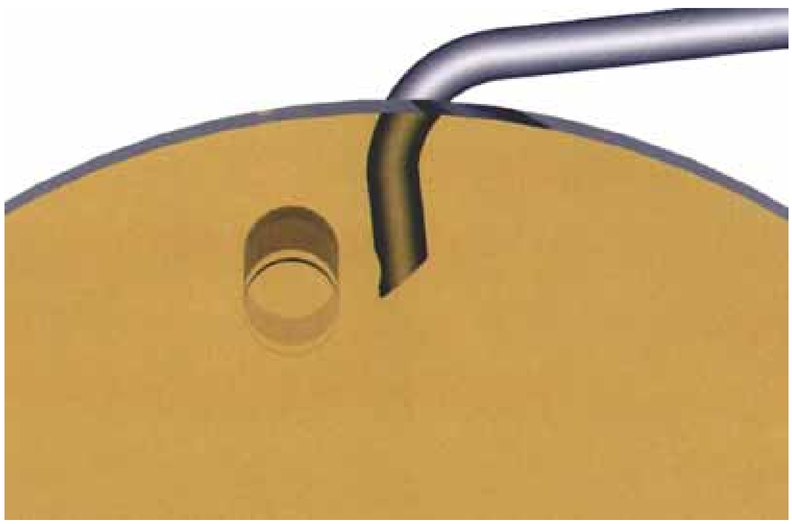


Figure 8: Wear on the stop lever.

Stop Lever $_{(A)}$ and Stop/Warning Pin: The stop lever $_{(A)}$, with continual pounding by the stop pin, will develop an indentation where the stop pin comes to rest. If this wear is not dealt with, the indentation will be a sticking/locking point and could cause the movement to stop sometime just prior to warning as the levers are lifted. The tip of the stop lever $_{(A)}$ should not be rounded. A rounded edge will not allow a clean release of the stop pin. The beveled, inner edge of the tip of the lever allows a clean release of the stop pin and a nice, solid front edge reduces the chance of the lever being kicked out of the way by the pin. Check for burrs at the edge of the tip of the stop lever $_{(A)}$. The stop/warning pin will also develop an indentation but, surprisingly, not as severe as the stop lever $_{(A)}$. In general, all that needs to be done with the stop/warning pin is to straighten it. The wear can be left as is provided it is not worn more than 1/4 of its diameter. Also, check for damage as a result of the stop lever $_{(A)}$ tipping the topside of the stop pin due to previous improper adjustment. If the stop pin shows too much wear or damage, replace it.

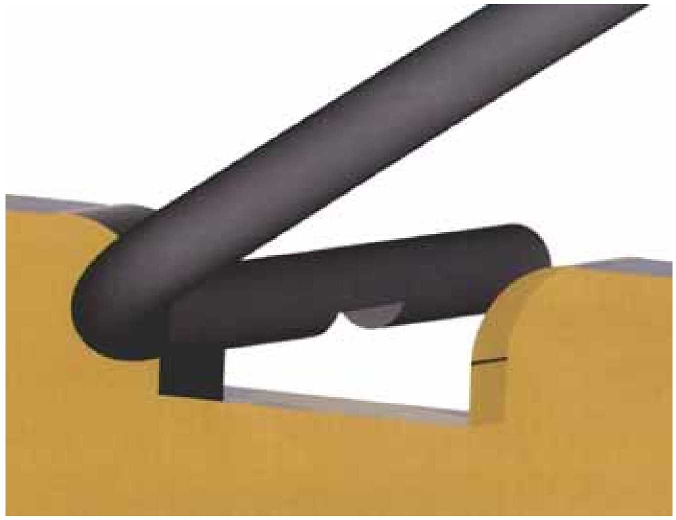


Figure 9: Wear on the maintenance lever.

Maintenance Lever $_{(B)}$ and Maintenance Cam $_{(I)}$: The maintenance lever $_{(B)}$ will show the most wear due to it being in almost constant contact with the maintenance cam $_{(I)}$. If this wear isn't addressed the strike process could become unreliable depending on whether the maintenance lever $_{(B)}$ is riding on the wear spot or not. The rubbing surface of this lever will have to be filed round again and then brightly polished, or replace the lever if less than 50% of the original diameter remains. The top surface of the maintenance cam $_{(I)}$, although not showing any visible wear, should also be nicely polished. This will provide the least friction for the rubbing surfaces.

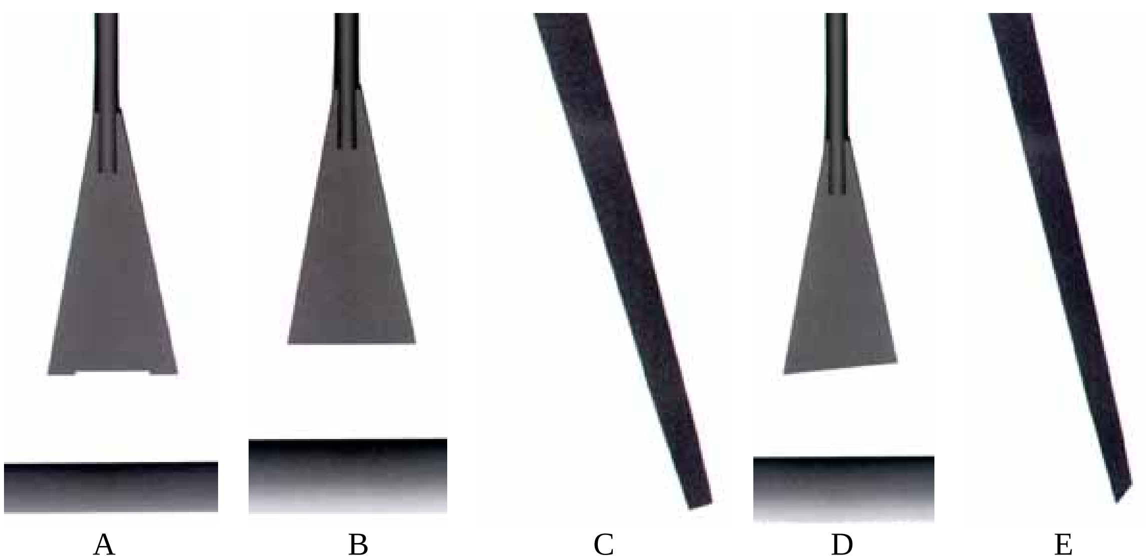


Figure 10: Showing **A**-Wear on the count lever, **B & C**- correct shape of paddle edge after filing, **D & E**- incorrect shape of paddle edge after filing.

Count Lever $_{(C)}$ and Count Wheel $_{(K)}$: The paddle end of the count lever $_{(C)}$ will show varying degrees of wear depending on the type of movement. In all cases, however, the wear should be filed out. A combination of the pounding action of the lever and the motion of the count wheel $_{(K)}$ as it is in contact with the lever, will cause a notch to be cut in the lower knife-edge of the paddle. Care should be taken to maintain the correct shape of the paddle edge. (See figure 10.) Watch for burrs on the outer edges of the tip of the paddle following the filing process. The count wheel $_{(K)}$ may show some wear along the rim and in the stop notches but this should negligible and more of a polished area than groove. Generally, the count wheel $_{(K)}$ can be left as is provided the wheel is true and there are no bent teeth.

Lift Lever $_{(D)}$: There is generally no wear on the rubbing surface of this lever but any dimple in the mating lever should be addressed. Examine the under side of the count lever $_{(C)}$ where the lift lever $_{(D)}$ rubs. Check for wear, rough spots, or burrs and polish as necessary.

Figure 11: Wear on the warning lever.

Warning Lever $_{(E)}$ and Stop/Warning Pin: Like the stop lever $_{(A)}$, the warning lever $_{(E)}$ will develop an indentation where the stop/warning pin comes to rest. There will also be wear visible due to the slide of the pin down the lever. If not dealt with, the results will be the same as in the stop lever $_{(A)}$ and the movement could stall in warning. A rounded tip will be a problem here as well. If the warning pin were to land on the rounded tip of the warning lever $_{(E)}$, the lever and pin could lock and stall the movement. Treat the pin the same as the stop pin by straightening or replacing if damaged.

J" Lever $_{(F)}$ and Strike Release Pins $_{(L)}$: Only slight wear is generally visible in these areas. However, like the stop lever $_{(A)}$ and the warning lever $_{(E)}$ any wear on the "J" lever $_{(F)}$ work face could be a problem. Polish out any dimples, look for rounded tips, and watch for burrs. On the "J" levers with the set back feature, look for a groove on the face of the paddle caused by repeated set back. Polish out the wear but in extreme cases the groove is deep enough to weaken the lever and it should be replaced. The release pins may show wear similar to the stop/warning pin and can generally be left as is. Polishing the wear out of the release pins could cause the strike points between the hour and half-hour to be quite different. If this problem is present, see *Adjustments and Clearances: Strike Release Points: Strike Release Pins $_{(L)}$*.

Figure 12: Wear on the hammer lever and hammer pins.

Hammer Lever $_{(G)}$ and Hammer Pins: The hammer lever $_{(G)}$ will develop an indentation and slide wear due to the rubbing of the hammer pins along its surface. The wear should be polished out and the tip checked for improper roundness and burrs. The hammer pins will often show significant wear. This is generally not a problem as the pins are worn evenly throughout and won't affect the rhythm of the strike. Check for bent pins and straighten. If the wear is significant enough to warrant replacement (more than 50% of diameter) all of the pins should be replaced to ensure maintaining the proper rhythm.

Hammer Detent $_{(M)}$ and Hammer $_{(N)}$: Very little wear will be found on the hammer detent $_{(M)}$ as it has a tendency to bend rather than wear and other than a few adjustments (discussed later) it can be left as is. The hammer $_{(N)}$ should be checked for missing or dry, flaking leather as well as leather that has been beaten down to the hammer head $_{(N)}$. These conditions will cause a tinny, metal on metal sound. Replace the leather if necessary. A drill bit, just smaller than the hole in the hammer $_{(N)}$ and twisted by hand, works well for "digging" out the old leather. Solid hammers, or those without leather, may show wear in the form of a flat spot due to repeated blows but may be left as is.

Arbor Pivots and Pivot Holes: Lever arbor pivots may be left in as is condition provided they don't exhibit any burrs or other damage that may cause them to stick in their pivot holes. It is not necessary that they have a brightly polished surface since they aren't under pressure and don't rotate more than a few degrees. The pivot holes will generally not show wear and can stand to be a little loose. The hammer arbor pivot hole should be bushed if too loose as this will cause undue noise and irregular tempo in the strike.

Methods of Removing Wear: One of the quickest and easiest methods of removing the dimples, dents, and scrapes from the surface of levers is to take them to the buffer/polisher. White rouge and a felt buff will leave the surface of the lever rounded and shiny. Have respect for the buffer/polisher. A felt buff can grab and twist a lever into something totally useless! Another, safer, method is to round-file the wear off of the lever. Place the lever, worn side up, on the almost closed jaws of a small vise and rotate the lever as you file. Follow up with finer grades of sandpaper or buff sticks until the surface is nice and shiny or finish up at the buffer/polisher. This method takes a little more practice and it is difficult to maintain the roundness. Round filing will generally be necessary in removing the wear on the maintenance lever $_{(B)}$ as the groove is usually deep. Some flatness is ok here as that will produce a larger work surface resulting in longer wear. Be sure to remove all polishing compound residue left on the levers before installing them in the movement.

Lever Return Springs: Most levers require a return spring to guarantee a reliable and proper function. The springs should maintain the levers in their proper positions when the movement is inverted but not be so tight or strong as to cause undue pressure on the strike train. The springs should be of light weight brass spring wire (28 – 30 gauge) on all except the hammer lever $_{(G)}$ which requires a heaver brass spring wire (22-24 gauge) to deliver a hard hammer blow. The springs should be of brass instead of steel and wound in such a manner that when the "tail" is pulled, the lever will be forced in the at rest direction as opposed to the lifting direction. One end of the wire should be wound around the base of one of the levers and continue around the lever arbor for several turns. The other end should be tied off either on a pillar post, the edge of the plate, or a post specifically designed for the purpose. It is not important which lever on the arbor is used, whether the wire is wound front to back or back to front, or which post/plate the tail is tied to. It is very important that the spring works in the proper direction, not interfere with the workings of the movement, and is not so tight that it binds the lever arbor when lifted. The best test is that it just holds the lever in its at rest position when the movement is held up-side-down. Old brittle return springs should be replaced before the movement is reassembled. Springs can be tied in place after assemblage but with more difficulty.

REPAIRING SEVERE DAMAGE

<u>Replacing Levers:</u> Levers that have been broken and are now too short to be adjusted properly should be replaced. The diameter is 0.60" – 0.65" in most cases. The lever is mounted into the arbor through a hole and then the lever end peened to tighten the lever in place. Use a small, flat punch to push the old lever out of the hole in the arbor. Use the old lever as a pattern in measuring and shaping the new lever. Select a steel that is soft so that it will bend without fracturing, and is the same diameter as the old lever. Cold rolled steel is ideal for this purpose. Be sure the new lever is long enough to allow for shaping. The hardest part of replacing a lever is getting it tightly affixed to the arbor. File a slight taper on the end of the lever so that it can be fit snugly into the hole in the arbor and just protrude out of the other side. Hold the lever tightly in a vise, clamped just under the arbor with a little lever showing above the vise. Peen the end of the lever until the lever is good and tight. An alternate method is to machine a shoulder on the lever instead of filing a taper. This gives the arbor something to rest against while peening. Other methods such as knurling the end or flattening the end could be used as long as the lever is secure in the arbor. Once the lever is tightly inserted into the arbor it can be shaped and fitted to perform like the original.

<u>Soldering Levers:</u> I do not promote soldering levers, however, it is something that can be properly done without damaging the lever or ruining its looks. Don't use solder to tighten a lever, however. Tightening levers should be done by the methods described in *Replacing Levers* above. Soldering should only be done at a break and only if the break isn't in a working area. Use a hard silver bearing solder (5% Ag) that will hold up under stress. Remove any excess solder by round filing the area until the break becomes invisible. Be sure to clean the flux off of the lever. Solder, even silver solder, won't last in an area that is susceptible to wear so if a break is near a working surface the lever must be replaced.

<u>Missing Levers:</u> When faced with replacing a missing lever it is necessary to understand what the lever was supposed to do. Once this is fully understood the shape of the lever should be apparent. Most levers will have very few bends, be a consistent diameter, and shaped to provide the best leverage for the ease of the movement. Use the existing levers as a guide for size and historical information as a guide for shape. Expect to have to fit and file to get the best possible replacement.

MOVEMENT ASSEMBLY

Part of having the levers work properly is getting the strike train assembled in the movement in proper relationship to the levers. Setting a wheel one tooth off will cause an unnecessary adjustment of a lever. The following steps will aid in the proper alignment of the gears to the levers.

1. Install the time and strike train.
2. Weave levers into proper positions.
3. Arrange the 3^{rd} wheel/maintenance cam $_{(I)}$ so that the maintenance lever $_{(B)}$ rests in the middle of the notch with the count lever $_{(C)}$ resting on the side of the count wheel $_{(K)}$ simulating a stopped position.
4. Arrange the stop/warning wheel $_{(H)}$ so that the stop pin hits the proper side of the stop lever $_{(A)}$.
5. Make sure the previous relationships haven't changed.
6. Assemble the plates together.
7. Attach the lever return springs to their posts and check for proper tension and clearance. The springs should have just enough tension to keep the levers in position when the movement is turned up side down. Too much tension and the movement will stall. Be sure the “tail” of the spring doesn’t interfere with the operation of either train.

Once the movement is back together check the following relationships:

Stop Lever $_{(A)}$ to Stop Pin

Make sure the strike train is not in, or about to go into, warning by rotating the strike release pin $_{(L)}$ away from the “J” lever $_{(F)}$. Check the location of the stop pin. It should be fairly close to the stop lever $_{(A)}$. Rotate the stop wheel $_{(H)}$ until the stop pin comes to rest against the stop lever $_{(A)}$. You may have to pull the count lever $_{(C)}$ to the side of the count wheel $_{(K)}$, in order to simulate a stop notch and get the stop lever $_{(A)}$ to engage the stop pin.

Maintenance Lever $_{(B)}$ to Maintenance Cam $_{(I)}$

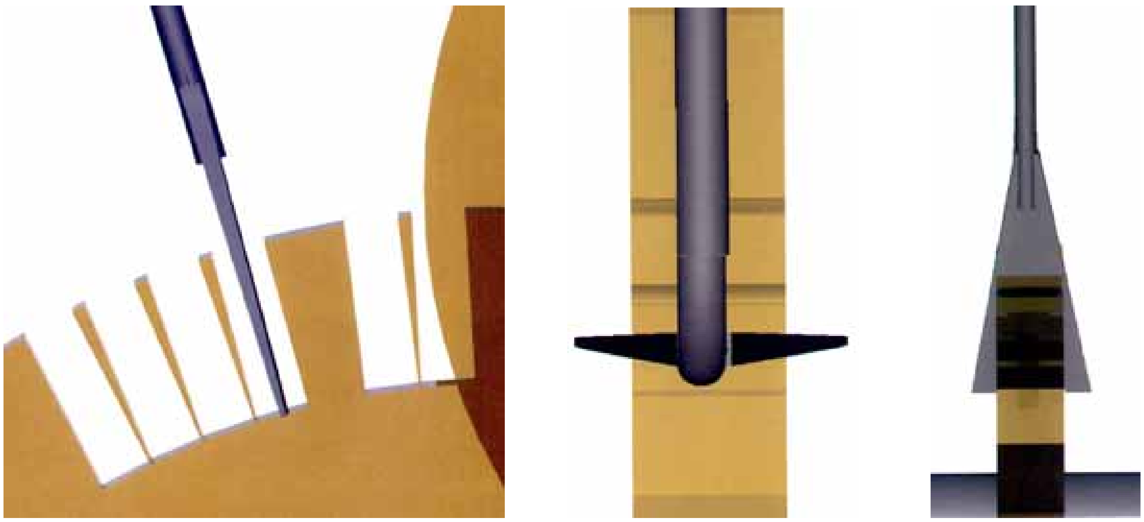
Without disturbing the strike train from its previous position, examine the maintenance lever $_{(B)}$ and observe whether it is in the middle of the notch on the maintenance cam $_{(I)}$. This is where proper assembly pays off! If the lever isn’t close to the middle then the stop/warning wheel $_{(H)}$ will need to be reset. Loosen the plates a bit at the top and spread them with finger pressure until the pivot of the stop/warning wheel $_{(H)}$ comes free. This will enable you to disengage the pinion of the stop/warning wheel $_{(H)}$ from the 3^{rd} wheel/maintenance cam $_{(I)}$ and rotate it independently. Either rotate the stop/warning wheel $_{(H)}$ the appropriate direction for the maintenance lever $_{(B)}$ to be more in the middle of the maintenance cam $_{(I)}$ or move the maintenance cam $_{(I)}$ while maintaining the position of the stop pin to the stop lever $_{(A)}$. Re-assemble the plates. With a little practice this will become easier.

ADJUSTMENTS AND CLEARANCES

Oil the pivot holes and add power to the train.

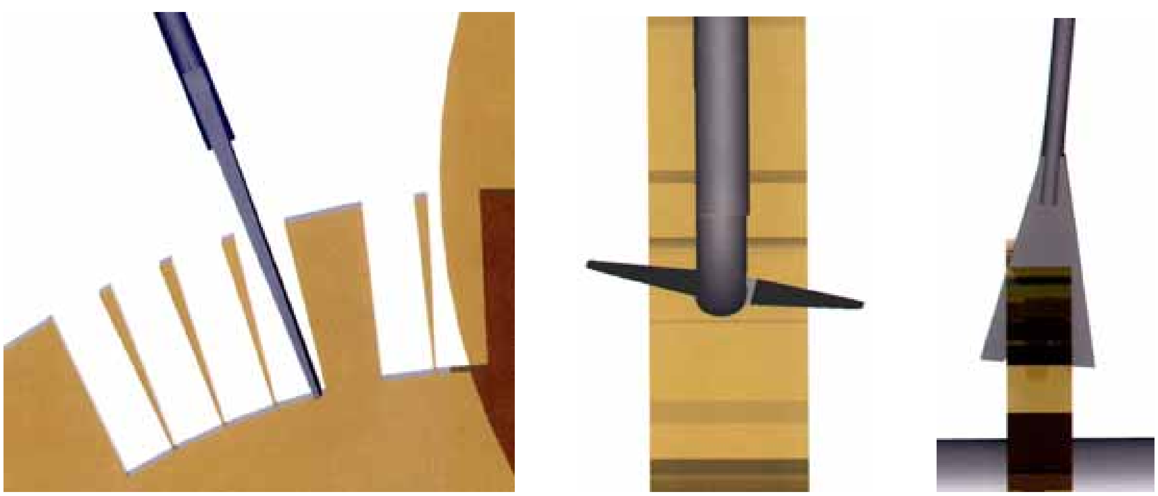
<u>Movement at Stop</u>

Rotate the center shaft to be sure the strike train is **not** in warning.



A B C

Figure 13: Correct attitude of count lever: **A-** radial and in the middle of a stop notch; **B & C-** square in all directions.



A B C

Figure 14: Incorrect attitude of count lever: **A-** Not radial nor in the middle of a stop notch; **B & C-** not square in all directions.

Control the motion of the strike train by keeping a finger on the butterfly. Slowly let the strike train advance until the count lever $_{(C)}$ falls into a stop notch and the stop pin rests on the stop lever $_{(A)}$.

Count Lever $_{(C)}$: The count lever $_{(C)}$ is the most likely lever to be out of adjustment since it protrudes outside the protection of the plates and is easily bent when handling the movement. In some extreme cases the count lever $_{(C)}$ may need to be adjusted up or down to allow the stop pin to rest on the stop lever $_{(A)}$. Adjusting the count lever $_{(C)}$ up or down will change the positions of both the maintenance lever $_{(B)}$ and the stop lever $_{(A)}$. It is important to become familiar with their ideal positions to know whether a single adjustment of the count lever $_{(C)}$ will solve what appears to be two other levers out of adjustment.

Reshape the end of the count lever $_{(C)}$ until the action brings it in the middle of the stop notch in the count wheel $_{(K)}$. You may have to lengthen or shorten the arm of the lever by using a pair of round-nosed pliers at the bend. To make the arm longer, use the fat part of the pliers and squeeze. To make it shorter use the narrow part of the pliers and twist. This will enable you to hit a different notch at a more optimal angle. The count lever $_{(C)}$ must also be true side to side. It should hit the stop notch in the middle of the paddle, be square in all directions, and be on a radius of the count wheel $_{(K)}$. (See figures 13 and 14.)

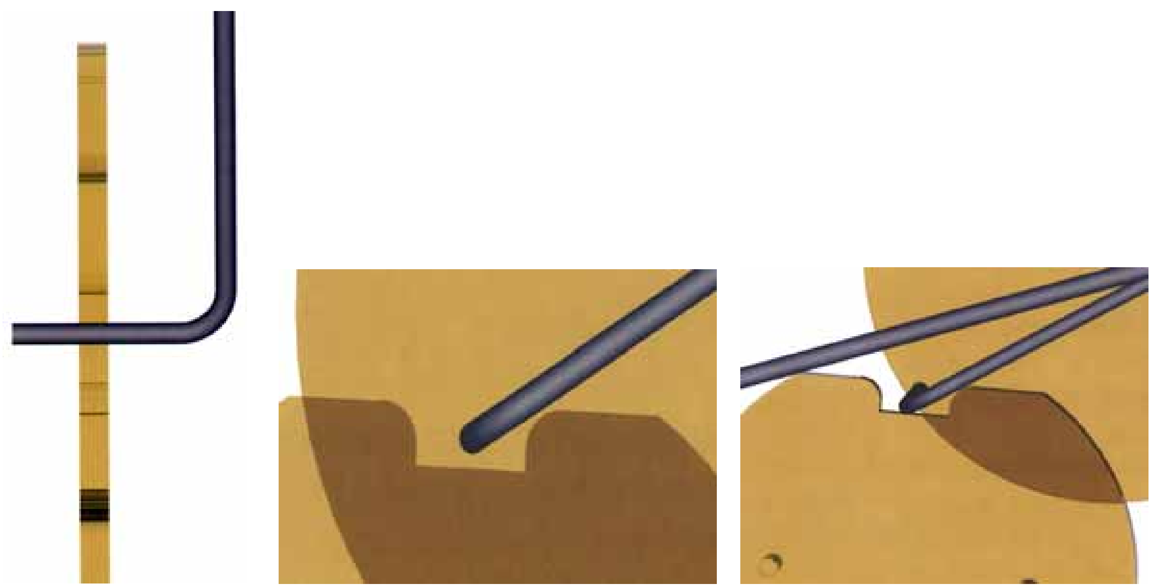


Figure 15: Correct attitude of maintenance lever. Square in all directions and centered in the notch.

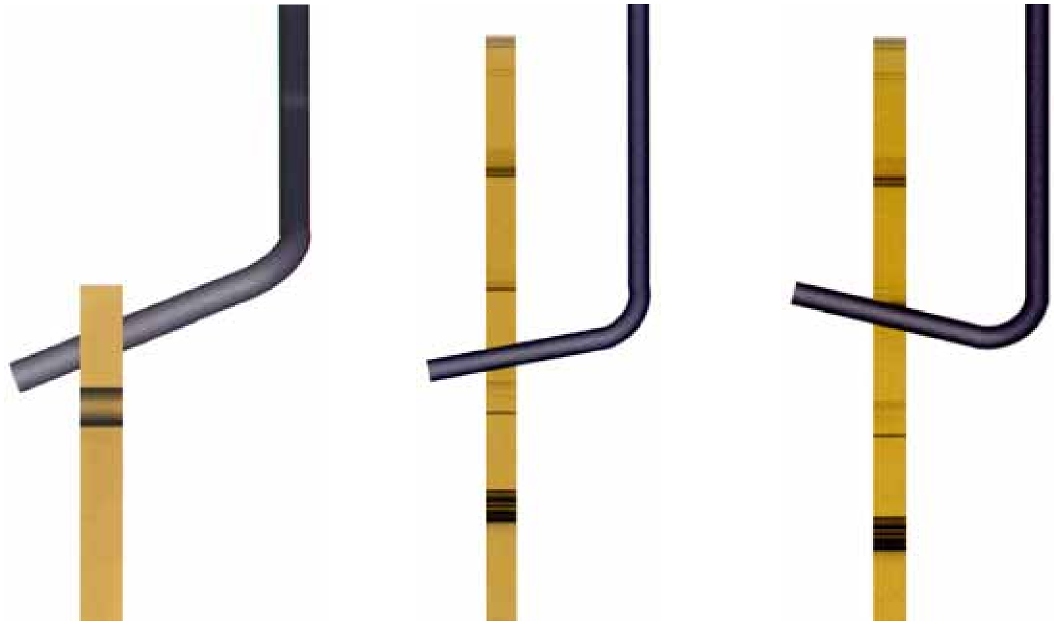
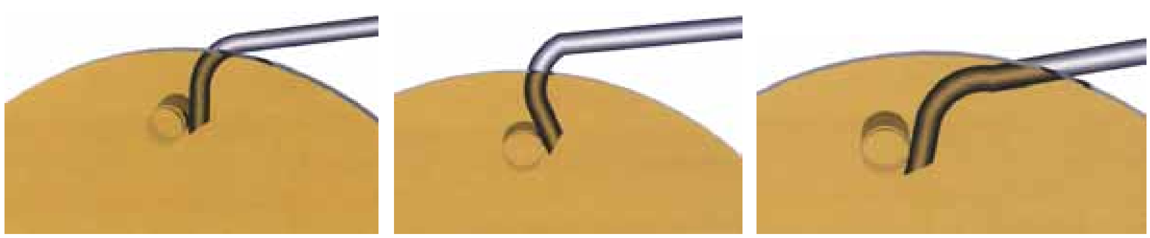


Figure 16: Incorrect attitude of maintenance lever. Not square in all directions and not centered in the notch.

Maintenance Lever $_{(B)}$: Again, with the strike train in the stop position, examine the location of the maintenance lever $_{(B)}$. It should be in the middle of the notch in the maintenance cam $_{(I)}$. A little tweaking to get it in the middle is acceptable so long as it isn't over done and the lever doesn't ride the cam twisted at an angle. The maintenance lever $_{(B)}$, when at stop, should not touch the bottom of the notch. If it does, adjust it slightly so that it is well away but be aware that this condition may be caused by a count lever $_{(C)}$ being adjusted too high.



A B C

Figure 17: **A-** Showing correct, radial alignment of stop lever. **B-** Stop lever incorrectly adjusted. This will cause the lever to be pushed out of the way resulting in a strike-on situation. **C-** Stop lever incorrectly adjusted. This will cause the stop lever to bind resulting in a stall of the movement.

Stop Lever $_{(A)}$: The stop pin should lock on the stop lever $_{(A)}$ but don't adjust the amount the pin dwells on the lever at this point. The lever should not be twisted or so close to the stop/warning wheel $_{(H)}$ that it could rub. It should contact the stop pin on the half of the pin closest to the wheel to avoid bending or breaking the pin over time. The working face of the lever should be radial from the stop/warning wheel $_{(H)}$ pivot. If outside the radius, the stop/warning wheel $_{(H)}$ will have to recoil or back up for the lever to be released. This requires more force and will drag or stall the time train. If inside radial, the stop pin will exert a lifting force on the lever and could force the lever out of the way resulting in a run-on. (See figure 17)

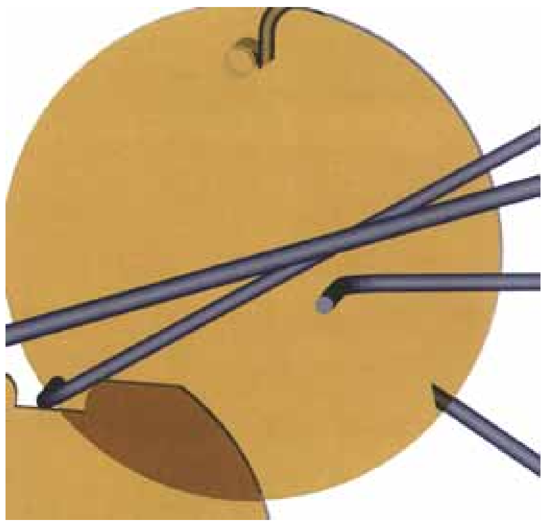


Figure 18: View of the lift lever at stop just below and not touching the count lever.

Lift Lever $_{(D)}$: The lift lever $_{(D)}$ should be below the count lever $_{(C)}$ and not touching. Bend it away if it is touching. Fine tuning the lift lever $_{(D)}$ will come later.

Movement in Warning

Rotate the center shaft with the minute hand until the levers start to rise and watch for the warning process. This should happen 10 minutes to 3 minutes before the hour.

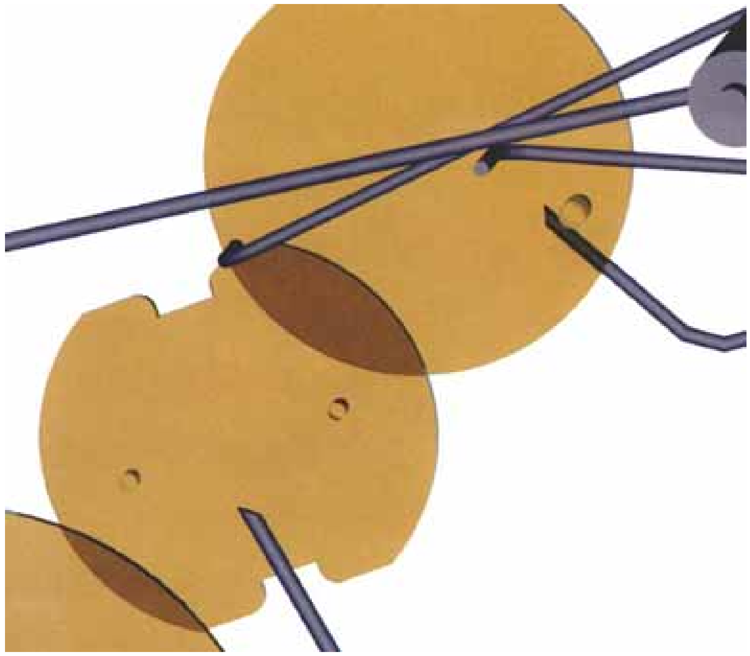


Figure 19: Strike train in warning. The lift lever has come into contact with the count lever and raised it sufficiently to release the stop/warning pin. The stop/warning pin has been arrested by the warning lever, the maintenance lever is resting on the upward slope of the maintenance cam, and the hammer lever isn't being raised by the hammer pins.

Warning Lever $_{(E)}$: Watch the action of the stop/warning wheel $_{(H)}$ as the warning lever $_{(E)}$ is raised against the stop/warning pin when the minute hand is rotated from the start of warning until just before it is released. The stop/warning pin should land on the warning lever $_{(E)}$ by roughly 3 pin diameters. If an adjustment is made, be sure to check that the pin clears the warning lever $_{(E)}$ while in strike. If the warning lever $_{(E)}$ is not radial to the stop/warning wheel $_{(H)}$ there will be recoil of the wheel as the warning lever $_{(E)}$ is lifted. The wheel will be forced back against the direction of rotation by the warning lever $_{(E)}$ and could cause a stall of the time train. This is a common problem and although it can't always be corrected the recoil should be minimized. Ideally, the warning lever $_{(E)}$ should be adjusted so that it operates on an arc that intersects the center of the stop/warning wheel $_{(H)}$ much like the stop lever $_{(A)}$. Not all movement configurations will accommodate this adjustment, however, so try to achieve the least amount of recoil possible.

A B C

Figure 20: **A-** “J” lever and release pins in warning. **B-** “J” lever with set-back feature at stop. **C-** Top view of “J” lever with set-back feature showing the beveled nature of the lever. This allows the release pin to push the lever out of the way when the center shaft is rotated counter-clockwise.

“J” Lever (F): Check the position of the “J” lever (F). It should be well on the strike release pin (L) and never have a chance to pass in front or behind, missing the pin. Adjust as needed. If the movement has the set-back feature on the “J” lever (F) (See figure 20: B & C), pay special attention to the end shake in the arbor and center shaft. Push the “J” lever arbor against the back plate and pull the center shaft against the front plate and recheck “J” lever (F)/release pin (L) relationship. The pin should be well on the “J” lever (F) and never pass by. Now, reverse the end shake positions and check for ease of set back. The pin should hit on the bevel, or twisted portion of the lever, pushing it out of the way and not lock on the lever. Adjust as needed.

Lift Lever (D): If warning occurs too early or too late, adjust the lift lever (D) up or down to compensate. A lift lever (D) that is too low will cause the strike train to go into warning too close to the hour. A lift lever (D) that is too high will cause the strike train to go into warning too early. In an extremely low case, the lift lever (D) won’t raise the other levers high enough to release the stop/warning pin causing a failure to strike. In an extremely high case, the lift lever (D) causes the count lever (C) to be trapped against a pillar post or another lever resulting in a stalled movement. As with the other levers, several functions have to be balanced for proper adjustment. The lift lever (D) must lift the count lever (C) enough that the stop pin clears the stop lever (A) by 0.010” – 0.015”. Lifting it more is not needed but may be necessary in order to keep warning between 10 and 3 minutes before the hour.

Maintenance Lever (B): Once in warning, the maintenance lever (B) should be resting (even if only slightly) on the upward slope beyond the notch of the maintenance cam (I). If not, go back to “Movement at Stop” and readjust from there.

Movement in Strike

Rotate the center shaft and catch the butterfly just after the stop/warning pin is released as the “J” lever $_{(F)}$ drops off of the release pins.

Figure 21: View of the closest approach of the stop/warning pin to the warning lever during strike.

Warning Lever $_{(E)}$: Control the rotation of the stop/warning wheel $_{(H)}$ until the stop/warning pin reaches its closest approach to the warning lever $_{(E)}$. The tip of the lever should be close to the pin but not touching at this point. Adjust the lever so that it is near the pin but not touching. A comfortable distance would be at least .010” from the pin. Be sure the lever isn’t twisted so that it might come in contact with the wheel. The stop/warning pin should clear the warning lever $_{(E)}$ at all times when not in warning.

Next, allow the train to run sufficiently so that the maintenance lever $_{(B)}$, riding on the maintenance cam $_{(I)}$, raises the count lever $_{(C)}$ to its maximum.

Figure 22: View of the count lever at its highest lift point during strike.

Count Lever $_{(C)}$: The count lever $_{(C)}$ should clear the count wheel notches by a comfortable margin (at least 0.020"). If the count lever $_{(C)}$ is being raised too high, it is wasted motion and simply adds to the wear of the maintenance lever $_{(B)}$. If it is too low it risks not clearing the notches causing a jam of the strike train. In either case, adjust the maintenance lever $_{(B)}$ to give the count lever $_{(C)}$ its correct clearance.

Hammer Lever $_{(G)}$: Observe the amount of travel of the head of the hammer $_{(N)}$ as the strike train advances. The head should lift 1 to 1 ½ hammer head widths from rest until the hammer pin just drops the hammer lever $_{(G)}$. If the travel of the hammer head $_{(N)}$ is more or less than one hammer head width, adjust the hammer detent $_{(M)}$ to compensate. This adjustment will have to balanced with the need to avoid having hammer lift during warning. Keeping the hammer lever $_{(G)}$ in the exact middle of the space between hammer pins may not be possible but is more important than the amount of hammer lift because "hammers on the rise" should be avoided at all costs. A hammer being lifted in warning may cause the strike train to stall when released into strike due to power drain and not enough momentum. Notice where the hammer lever $_{(G)}$ comes into contact with the hammer pins. Adjust the lever so that it contacts the middle of the pins and can't come into contact with the wheel itself. Also, be sure the pins contact the lever a comfortable distance away from the tip of the lever. Too close to the end and the hammer pin will jam on the end of the lever causing a stall.

Figure 23: View of the count lever during strike resting on the rim of the count wheel and not in a stop notch.

Keep the strike train going until the count lever $_{(C)}$ comes to rest on the rim of the count wheel $_{(K)}$ and not in a stop notch.

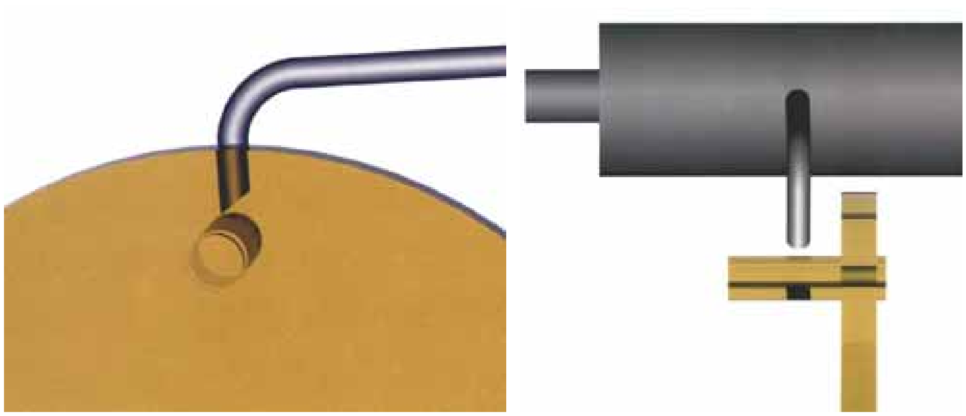
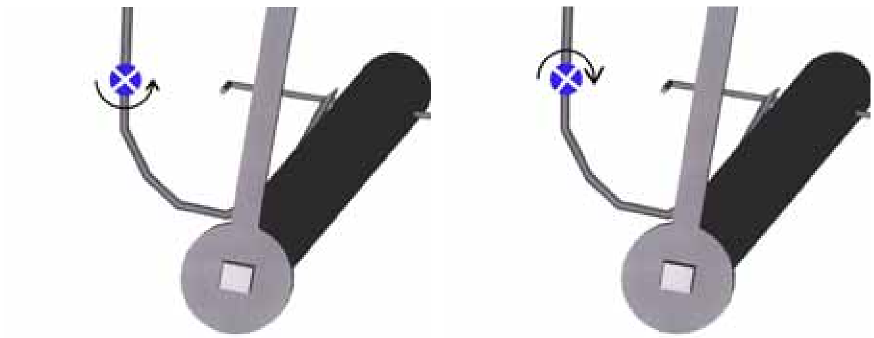


Figure 24: Views of the stop pin and stop lever at their closest approach during strike.

<u>Stop Lever $_{(A)}$</u>: Watch the stop pin's relationship to the stop lever $_{(A)}$ as it passes underneath. The stop pin should clear the tip of the stop lever $_{(A)}$ with the barest amount of space (about .010"). If it doesn't clear, or there is too much space, adjust the stop lever $_{(A)}$ for proper clearance. This should give the maximum amount of lever face for the stop/warning pin to rest against at stop. If not, then sacrifice some of the clearance to ensure that the stop pin is locked securely onto the face of the stop lever $_{(A)}$.

Allow the strike train to continue striking and watch for solid stop. At stop, the count lever $_{(C)}$ should be squarely in a stop notch on the count wheel $_{(K)}$. The maintenance lever $_{(B)}$ should be in the center of the maintenance cam $_{(I)}$ (not touching the bottom). The stop pin should rest solidly on the stop lever $_{(A)}$. The hammer lever $_{(G)}$ should be in between, and not touching, hammer pins.

Strike Release Points



A B

Figure 25: The blue dot shows the proper adjusting point on the "J" lever to change the strike release point. **A-** Bending in the direction of the arrow will cause the strike point to occur later. **B-** Bending in this direction will cause the strike point to occur earlier.

"J" Lever $_{(F)}$: With a finger on the butterfly, rotate the minute hand until the "J" lever $_{(F)}$ is released. Note where the minute hand is in relation to the release point. If strike release occurs before the hour, bend the "J" lever $_{(F)}$ as shown in figure 25-A. If strike release occurs after, bend the "J" lever $_{(F)}$ as shown in figure 25-B. Unfortunately, this is a hit or miss, painstaking process since it often requires having a dial for a reference. You can get close by using a pivot hole that is directly above the center shaft as a reference or a fast/slow adjuster if it is centered on the top of the movement. Realize that any adjustment of the "J" lever $_{(F)}$ could also change the adjustment of the lift lever $_{(D)}$ necessitating a re-adjustment of that lever.

Strike Release Pins $_{(L)}$: Continue rotating the minute hand until the half-hour is released. If the release point is early or late at the half-hour but correct at the hour, then the half-hour strike release pin $_{(L)}$ must be adjusted (not the "J" lever $_{(F)}$). Bend clockwise or counter clockwise as needed so that the strike points agree. If looking at the center shaft from the front then bending the strike release pin $_{(L)}$ in a counter clockwise direction will cause the strike release point to occur later.

It is easy to get bending in circles and frustrate yourself and too much bending will work-harden the steel wire. Be careful not to break any levers or your frustration will continue. It is important to do things in order:

1. Assemble the movement properly.
2. Adjust at stop and check clearances.
3. Adjust in warning and check clearances.
4. Adjust in strike and check clearances.
5. Adjust the strike release points and check clearances.
6. Quick repeat of #'s 1-5 to be sure nothing is out of adjustment.

OILING

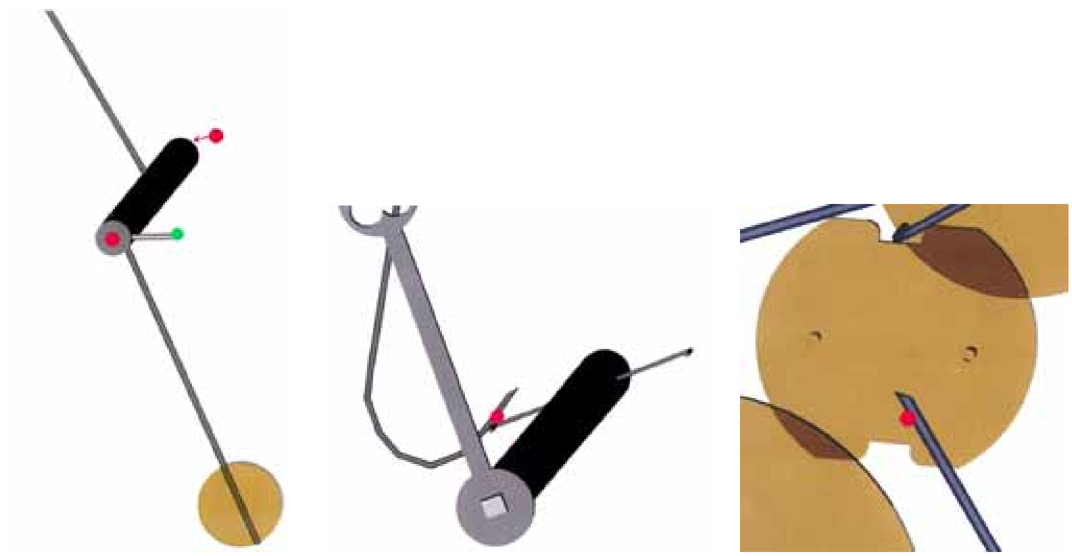


Figure 26: Oiling diagram 1. Red dots designate where a minimal amount of oil should be applied to the lever surfaces. Note: The hammer arbor pivots are the ***only*** lever pivots that receive oil. The green dot on the hammer detent denotes where a dab of grease should be applied.

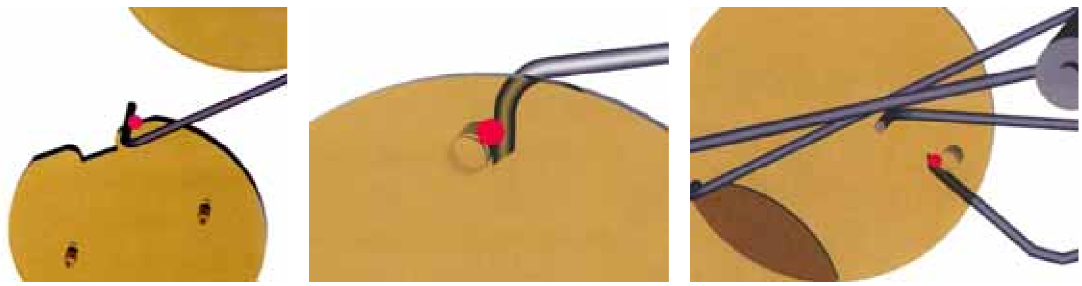


Figure 27: Oiling diagram 2. Red dots designate where a minimal amount of oil should be applied to the lever surfaces.

The pivot points of the hammer lever $_{(G)}$ are the *only* lever pivots that receive oil. If the other lever pivots are oiled they will become sticky over time and become unreliable. The working surfaces of the levers should all be oiled but with as little as possible. (See oiling diagrams.) The hammer detent $_{(M)}$ should have a drop of grease applied where it comes into contact with the movement to help dampen the noise and action of the hammer's recoil.

USEFUL TOOL

By now it should be clear that you won't be able to avoid tweaking the levers a bit in order to get them in their proper positions. A useful tool to accomplish this is a wire bender. You can make one out of an aluminum gutter nail and a piece of old broom handle (or a file handle). Cut off 3-4 inches of broom handle. Hammer the nail into the end of the handle 1-2 inches. Cut off the head of the nail and slot the end (0.070" – 0.080") to fit comfortably over a lever. Round off the edges of the slot so they don't mar the levers. This tool will enable you to reach inside an assembled movement to fine tune those hard to reach levers.

FINAL ADJUSTMENT

Once the movement is back in the case there is one final adjustment that will need to be made. The hammer arm will need to be shaped so that the hammer $_{(N)}$ hits square and doesn't come to rest against the gong, bell, or rod. It should deliver a solid blow and rebound without rehitting until drawn back for another blow. The hammer $_{(N)}$ and hammer arm should be free to travel for the entire strike without interfering with the pendulum, case, movement, alarm, etc... Reshape the hammer arm until these conditions are met.

Part 2: "MAINTENANCE CAM AS STOP" CONFIGURATION

Unfortunately, not all striking clocks are identical nor do they utilize the same lever configurations. The previous example has the strike process arrested by the stop pin coming in contact with the stop lever $_{(A)}$. In some movements, most notably thirty hour clocks, the strike process is halted when the stop/maintenance cam $_{(I)}$ comes into contact with the stop/maintenance lever $_{(B)}$ as it drops into the notch on the stop/maintenance cam $_{(I)}$. This style will be discussed next and, along with the previous discussion, will cover most of the lever styles incorporated in American clocks.

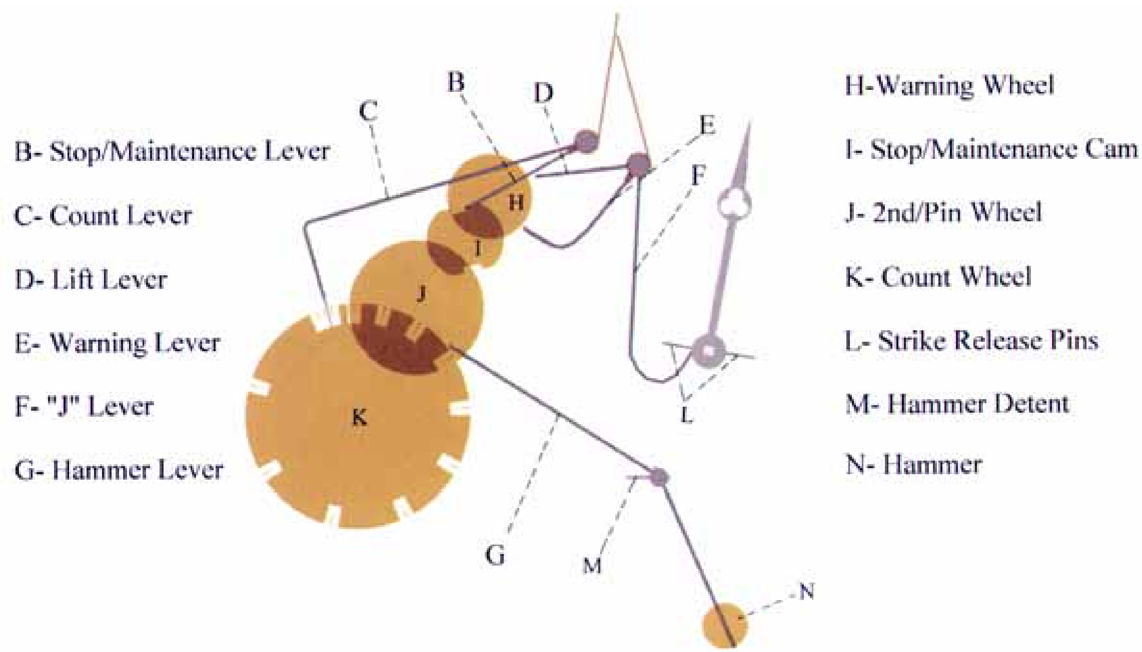


Figure 28

THE LEVERS (fig. 28 - 30)

In order to discuss the levers we must first identify them and describe their function. Note: These are grouped according to the arbor to which they are attached.

B – Stop/Maintenance Lever: The function of this lever is two fold. First, this lever *maintains* the clearances needed for the count lever $_{(C)}$ when continuing the strike process. This allows the strike train to run until stop conditions are met. Second, the stop/maintenance lever $_{(B)}$, by dropping into the notch in the stop/maintenance cam $_{(I)}$, arrests the strike train by coming in contact with the stop face of the notch in the stop/maintenance cam $_{(I)}$.

<u>C – Count Lever</u>: This lever *counts* the strike by being held up until it falls into a stop notch on the count wheel $_{(K)}$. When the count lever $_{(C)}$ drops into a deep or stop notch on the count wheel $_{(K)}$, the stop/maintenance lever $_{(B)}$ is allowed to drop deeper into the notch on the stop/maintenance cam $_{(I)}$ and drop far enough to catch the stop face of the notch halting the strike process. Strike will continue as long as the count lever $_{(C)}$ is resting on the rim of the count wheel $_{(K)}$ and not in a stop notch.

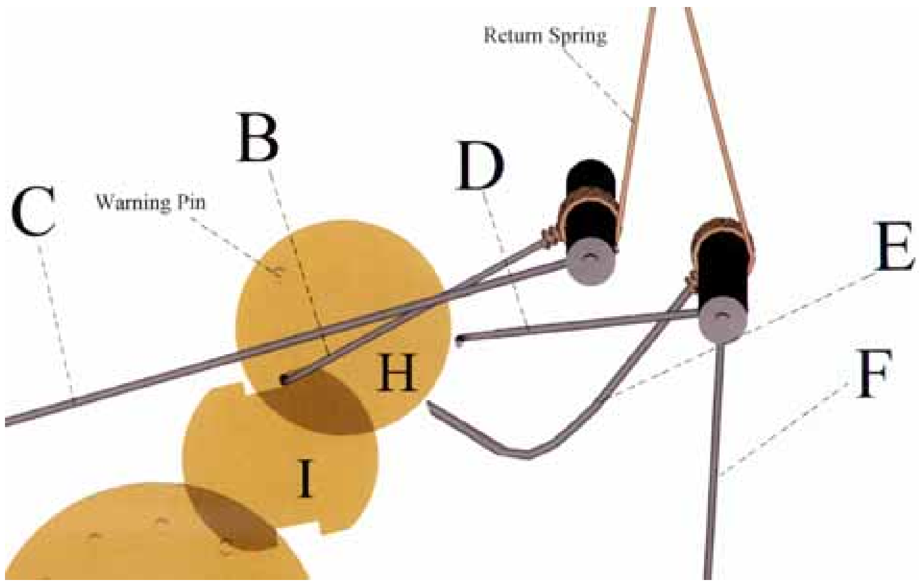


Figure 29: Lever detail.

<u>D – Lift Lever</u>: This lever's function is to *lift* the stop lever $_{(A)}$, stop/maintenance lever $_{(B)}$, and count lever $_{(C)}$ so that the strike train is released from the stop position.

<u>E – Warning Lever</u>: This lever catches the warning pin (usually on the butterfly) and holds the strike train until the precise point of strike release is reached. The short amount of release (or run) and arrest of the strike train just prior to strike is called *warning.*

<u>F – "J" Lever</u>: This lever, called the "J" lever because of its shape, could just as well be called the strike release lever as its function is to release the strike train from stop into warning and from warning into strike at specific times. It is also the means by which the other levers are lifted into position for the coming strike action. There is generally no allowance for the set-back feature in this lever configuration.

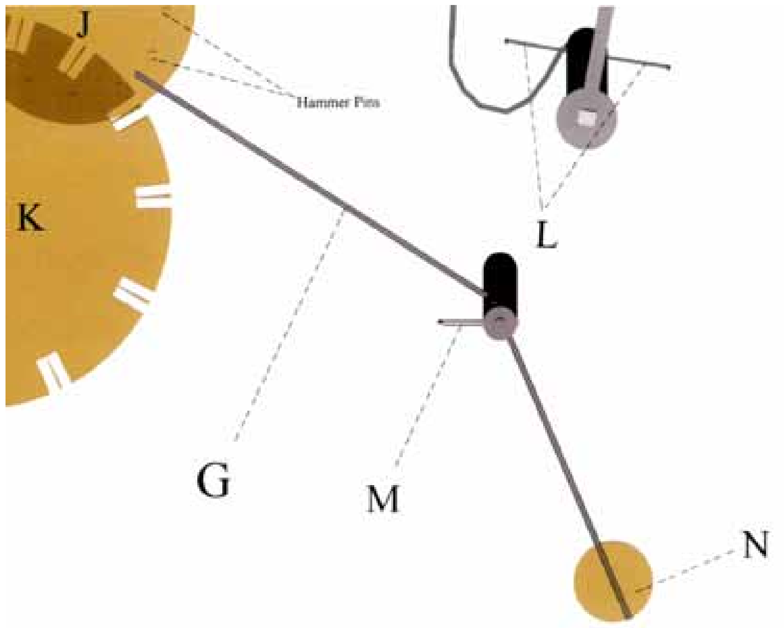


Figure 30

<u>G – Hammer Lever</u>: This lever raises the *hammer* (N) and releases it to produce a blow or strike on a rod, gong, or bell.

<u>M – Hammer Detent</u>: This pin *stops* the *hammer's* recoil motion and maintains the position of the hammer lever (G) so that it returns to the same place following each hammer blow. This allows the hammer pins to engage the hammer lever (G) in a consistent manner and give a consistent strike.

<u>N – Hammer:</u> This is the piece which contacts the bell, gong, etc…

<u>L – Strike Release Pins</u>: These pins are attached to the center shaft and engage the "J" lever (F), lifting it to produce the *release* of the strike at a specific point.

WORKING TOGETHER

Having identified all of the levers, we will now look at the process of striking to see how these levers relate to one another.

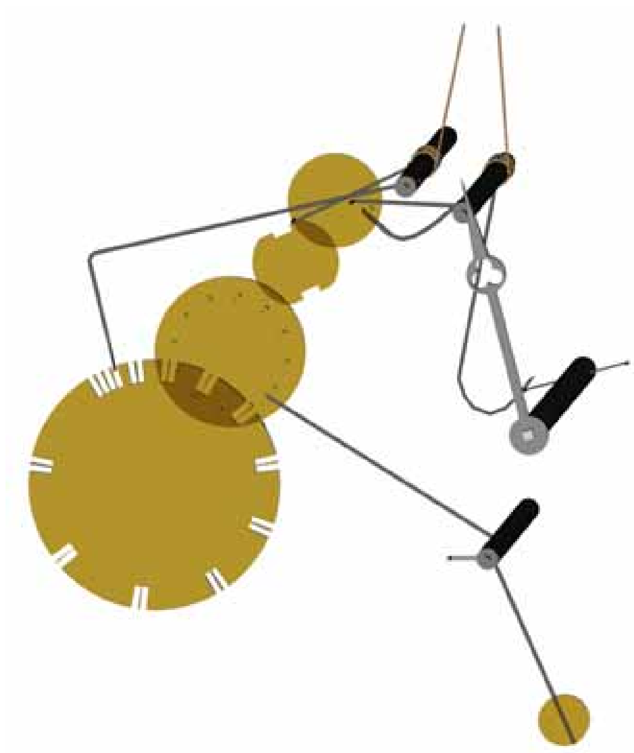


Figure 31: The strike train in warning.

Warning

Somewhere between ten and three minutes before the hour or half-hour, the strike release pins $_{(L)}$ raise the "J" lever $_{(F)}$ which in turn raises the lift lever $_{(D)}$ sufficiently to engage and push up the count lever $_{(C)}$. The levers are lifted higher and higher until the stop/maintenance lever $_{(B)}$ is released from the stop face of the stop/maintenance cam $_{(I)}$. This allows the strike train to "go into warning". The slight rotation of the stop/maintenance cam $_{(I)}$, during warning, pushes the stop/maintenance lever $_{(B)}$ out of the notch and lifts it slightly. This disengages the lift lever $_{(D)}$ from the count lever $_{(C)}$ and lifts the count lever $_{(C)}$ almost out of the stop notch. The warning pin is caught by the warning lever $_{(E)}$, which has been raised along with the "J" lever $_{(F)}$, and the warning process is complete. This is needed for power conservation to allow the movement to lift levers a little at a time instead of all at once and to gain a more accurate and consistent strike release point. Warning is different and separate from the short amount of run of the strike train just prior to hammer lift.

Beginning-Strike

The center shaft continues to rotate lifting the “J” lever $_{(F)}$ with the strike release pins $_{(L)}$ until the hour or half-hour when the “J” lever $_{(F)}$ is released and rapidly returns to its original, at-stop position. This causes the warning lever $_{(E)}$ to release the warning pin and allows the strike train to run free. At this point several things happen almost simultaneously. The stop/maintenance cam $_{(I)}$ rotates and the stop/maintenance lever $_{(B)}$ is pushed onto a cam lobe. A hammer pin on the 2nd/pin wheel $_{(J)}$ begins to engage the hammer lever $_{(G)}$. The count lever $_{(C)}$ is lifted well clear of the stop notch on the count wheel $_{(K)}$. The count wheel $_{(K)}$ rotates under the count lever $_{(C)}$ towards the next count notch on the rim or another stop notch. It is important to note that there is a short amount of run of the strike train just prior to hammer lift by the hammer pins. This is necessary for the movement to be allowed to gain momentum before lifting the hammer $_{(N)}$.

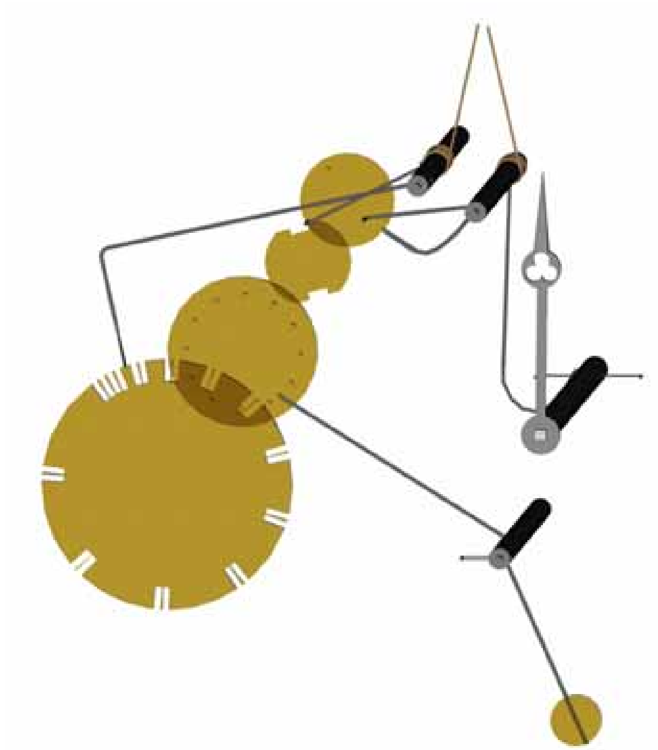


Figure 32: The strike train at mid-strike.

Mid-Strike

At the hour, the strike train must continue to run and deliver the proper number of blows for that hour. The critical moment that determines whether the strike train stops or continues is at the point when the stop/maintenance cam $_{(I)}$ presents the notch to the stop/maintenance lever $_{(B)}$ allowing the count lever $_{(C)}$ to be lowered onto the count wheel $_{(K)}$. For strike to continue, the count lever $_{(C)}$ is lowered onto the rim of the count wheel $_{(K)}$ instead of a stop notch, which keeps the stop/maintenance lever $_{(B)}$ raised sufficiently to clear the notch in the stop/maintenance cam $_{(I)}$. Once the stop/maintenance lever $_{(B)}$ passes the notch in the stop/maintenance cam $_{(I)}$, the stop/maintenance cam $_{(I)}$ lifts the stop/maintenance lever $_{(B)}$ and the strike process continues.

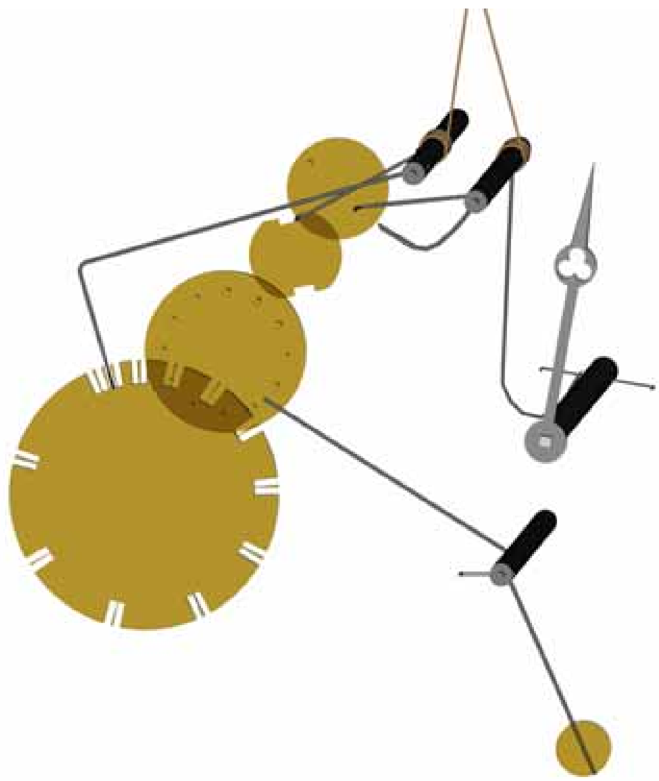


Figure 33: The strike train at stop.

<u>Stop</u>

Again, the critical point in the striking process is when the stop/maintenance lever $_{(B)}$ reaches a notch in the stop/maintenance cam $_{(I)}$. If the count lever $_{(C)}$ falls into a stop notch at this point, the stop/maintenance lever $_{(B)}$ will drop sufficiently to catch the stop face of the notch in the stop/maintenance cam $_{(I)}$ and the strike process will stop.

WEAR PROBLEMS

Anytime there are two independent, moving surfaces, which, repeatedly over time, come into contact with one another, there will be an abrasion and wear of both surfaces. This is especially true of American clock levers and pins. It is important to recognize the problems that wear can cause and how to deal with them. Levers left unrestored can cause a myriad of headaches since wear changes the geometry of the action of the lever causing the movement to work harder to accomplish its task.

I believe that the repair of levers should be part of a thorough restoration process, which includes polishing pivots, bushing worn bearing holes, servicing mainsprings, etc…not just a quick fix to solve the problem. Restoring levers cannot be done while they are still inside the movement! Be sure to remove the power from all trains before disassembling the movement and take any special notes necessary to aid in reassembly.

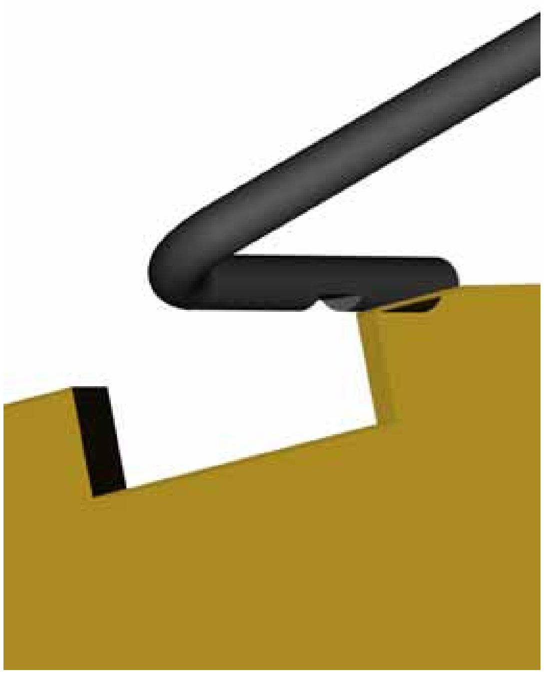


Figure 34: Wear on the stop/maintenance lever.

Stop/Maintenance Lever $_{(B)}$ and Stop/Maintenance Cam $_{(I)}$: The stop/maintenance lever $_{(B)}$ will show the most wear due to it being in almost constant contact with the stop/maintenance cam $_{(I)}$. If this wear isn't addressed the strike process could become unreliable depending on whether the stop/maintenance lever $_{(B)}$ is riding on the wear spot or not. The rubbing surface of this lever will have to be filed round again and then brightly polished, or replace the lever if less than 50% of the original diameter remains.

The top surface of the stop/maintenance cam $_{(I)}$, although not showing any visible wear, should also be nicely polished. This will provide the least friction for the rubbing surfaces. Special attention should be paid to the stop face in the notch of the stop/maintenance cam $_{(I)}$. This face will develop an indentation due to the hammering action of the stop/maintenance lever $_{(B)}$ as it arrests the strike train. If left as is, the indentation may trap the lever and not allow the strike train to be released. Another condition frequently found is in the upper edge of the notch no longer being square and sharp but tipped round. This is caused by the stop/maintenance lever $_{(B)}$ being out of adjustment and tipping off the top edge of the stop face of the notch as the lever passes during the strike process. A rounded edge will cause the stop/maintenance lever $_{(B)}$ to be bounced out of the notch and result in a run-on condition. It will usually be necessary to file this stop face to correct these conditions but care should be given to the angle at which the face is filed as well as how much material is removed. (See figure 36.) If there is more than one notch in the stop/maintenance cam $_{(I)}$ it will be necessary to ensure that they are treated *exactly* the same. If not, the stop points will be different causing the degree of warning to vary and resulting in "hammer on the rise" or a hammer lever $_{(G)}$ that doesn't quite drop off of the hammer pin before stop occurs.

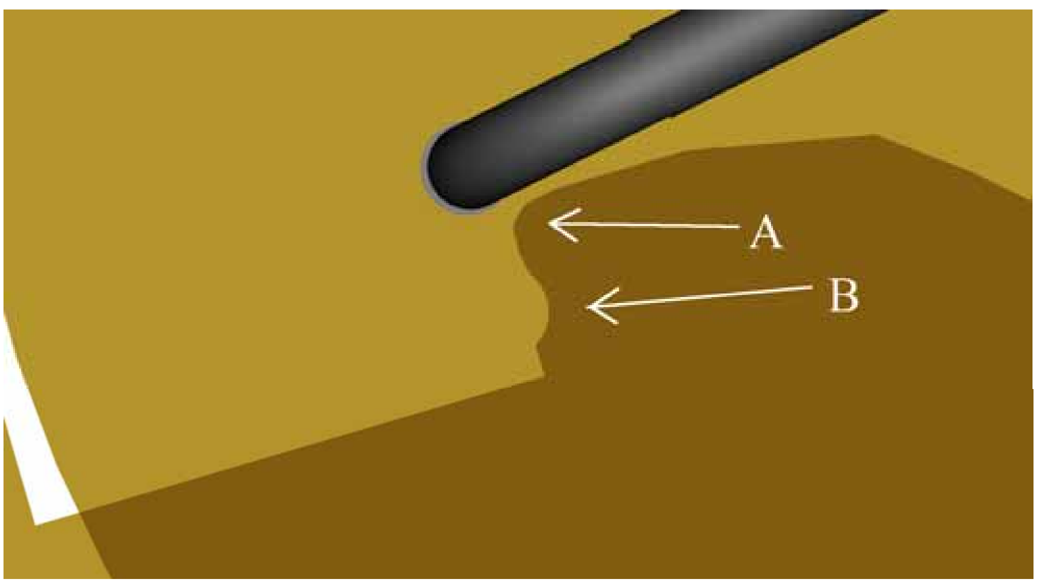
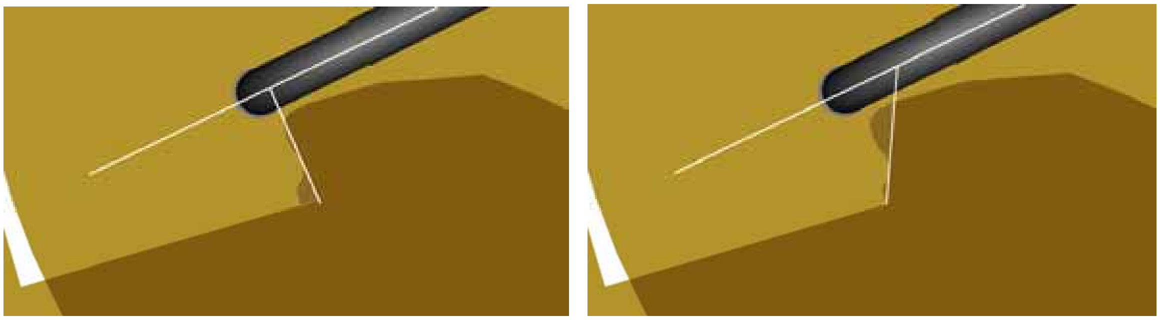


Figure 35: View of the stop/maintenance lever and the stop face of the stop/maintenance cam showing…
A: the rounded off top edge which could cause strike-on.
B: the indentation in the stop face which could cause a failure to strike.



A B

Figure 36

A--Correct angle of stop face. Notice the stop face is at right angles to the stop/maintenance lever. Care should be taken to remove as little material as possible. In this example, notice the top edge of the stop/maintenance cam's stop face hasn't been completely squared off. Only remove enough material to ensure a reliable stop and eliminate the indentation.

B--Incorrect angle of stop face. Filing at this angle will cause the stop/maintenance lever to skate off of the stop face.

A B C D E

Figure 37: Showing **A**-Wear on the count lever, **B & C**- correct shape of paddle edge after filing, **D & E**- incorrect shape of paddle edge after filing.

<u>Count Lever $_{(C)}$ and Count Wheel $_{(K)}$</u>: The paddle end of the count lever $_{(C)}$ will show varying degrees of wear depending on the type of movement. In all cases, however, the wear should be filed out. A combination of the pounding action of the lever and the motion of the count wheel $_{(K)}$ as it is in contact with the lever, will cause a notch to be cut

in the lower knife-edge of the paddle. Care should be taken to maintain the correct shape of the paddle edge. (See figure 37.) Watch for burrs on the outer edges of the tip of the paddle following the filing process. The count wheel $_{(K)}$ may show some wear along the rim and in the stop notches but this should negligible and more of a polished area than groove. Generally, the count wheel $_{(K)}$ can be left as is provided the wheel is true and there are no bent teeth.

Lift Lever $_{(D)}$: There is generally no wear on the rubbing surface of this lever but any dimple in the mating lever should be addressed. Examine the under side of the count lever $_{(C)}$ where the lift lever $_{(D)}$ rubs. Check for wear, rough spots, or burrs and polish as necessary.

Figure 38: Wear on the warning lever.

Warning Lever $_{(E)}$ and Warning Pin: The warning lever $_{(E)}$ will develop an indentation where the warning pin comes to rest. There will also be wear visible due to the slide of the pin down the lever. If not dealt with the movement could stall in warning as the warning pin binds against the warning lever $_{(E)}$. A rounded tip on the lever will be a problem here as well. If the warning pin were to land on the rounded tip of the warning lever $_{(E)}$, the lever and pin could lock and stall the movement. In general, all that needs to be done with the warning pin is to straighten it. Any wear on the pin can be left as is provided it is not worn more than 1/4 of its diameter. Also, check for damage as a result of the warning lever $_{(E)}$ tipping the topside of the stop pin due to previous improper adjustment. If the warning pin shows too much wear or damage, replace it.

J" Lever $_{(F)}$ and Strike Release Pins $_{(L)}$: Only slight wear is generally visible in these areas. However, like the warning lever $_{(E)}$ any wear on the "J" lever $_{(F)}$ work face could be a problem. Polish out any dimples, look for rounded tips, and watch for burrs. The release pins $_{(L)}$ may show wear similar to the warning pin and can generally be left as is. Polishing the wear out of the release pins $_{(L)}$ could cause the strike points between the hour and half-hour to be quite different. If this problem is present, see *Adjustments and Clearances: Strike Release Points: Strike Release Pins $_{(L)}$.*

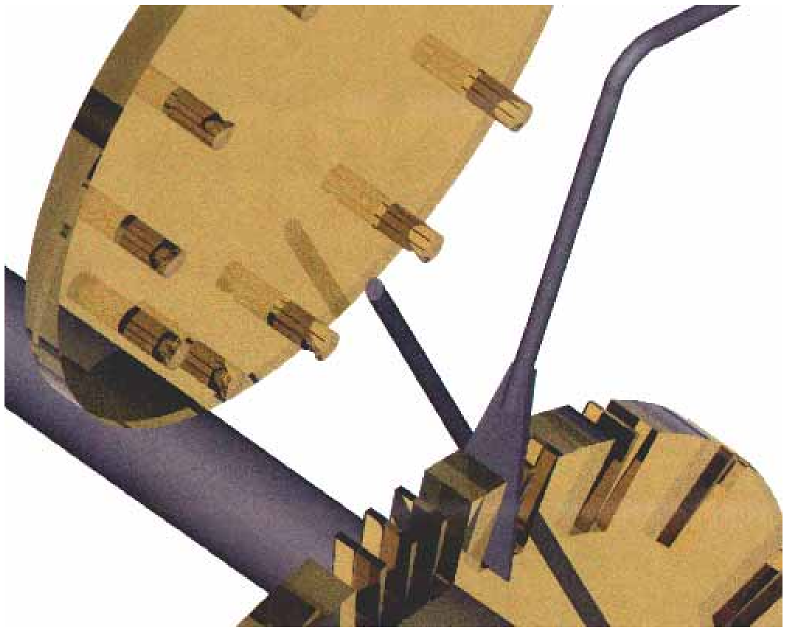


Figure39: Wear on the hammer pins.

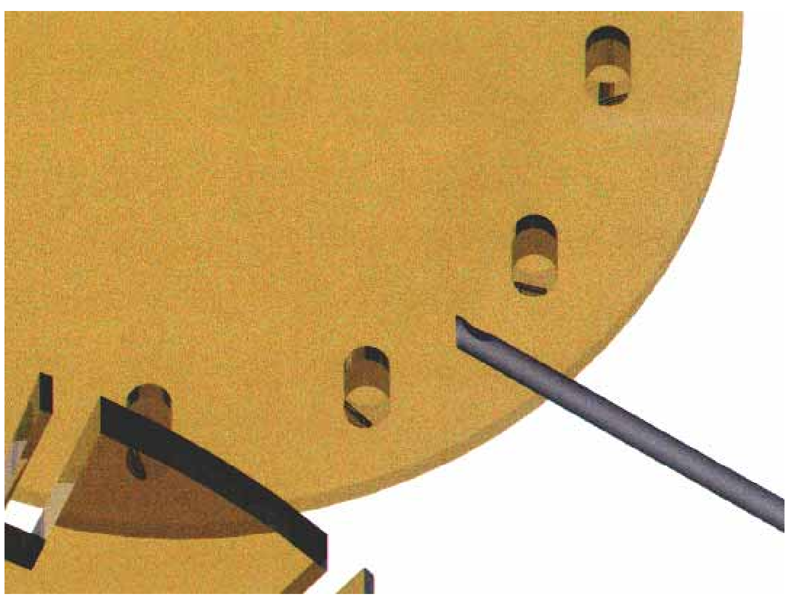


Figure 40: Wear on the hammer lever.

Hammer Lever $_{(G)}$ and Hammer Pins: The hammer lever $_{(G)}$ will develop an indentation and slide wear due to the rubbing of the hammer pins along its surface. The wear should be polished out and the tip checked for improper roundness and burrs. The hammer pins will often show significant wear. This is generally not a problem as the pins are worn evenly throughout and won't affect the rhythm of the strike. Check for bent pins and straighten. If the wear is significant enough to warrant replacement (more than 50% of diameter) all of the pins should be replaced to ensure maintaining the proper rhythm.

Hammer Detent $_{(M)}$ and Hammer $_{(N)}$: Very little wear will be found on the hammer detent $_{(M)}$ as it has a tendency to bend rather than wear and other than a few adjustments (discussed later) it can be left as is. The hammer $_{(N)}$ should be checked for missing or dry, flaking leather as well as leather that has been beaten down to the hammer head $_{(N)}$. These conditions will cause a tinny, metal on metal sound. Replace the leather if necessary. A drill bit, just smaller than the hole in the hammer $_{(N)}$ and twisted by hand, works well for "digging" out the old leather. Solid hammers, or those without leather, may show wear in the form of a flat spot due to repeated blows but may be left as is.

Arbor Pivots and Pivot Holes: Lever arbor pivots may be left in as is condition provided they don't exhibit any burrs or other damage that may cause them to stick in their pivot holes. It is not necessary that they have a brightly polished surface since they aren't under pressure and don't rotate more than a few degrees. The pivot holes will generally not show wear and can stand to be a little loose. The hammer arbor pivot hole should be bushed if too loose as this will cause undue noise and irregular tempo in the strike.

Methods of Removing Wear: One of the quickest and easiest methods of removing the dimples, dents, and scrapes from the surface of levers is to take them to the buffer/polisher. White rouge and a felt buff will leave the surface of the lever rounded and shiny. Have respect for the buffer/polisher. A felt buff can grab and twist a lever into something totally useless! Another, safer, method is to round-file the wear off of the lever. Place the lever, worn side up, on the almost closed jaws of a small vise and rotate the lever as you file. Follow up with finer grades of sandpaper or buff sticks until the surface is nice and shiny or finish up at the buffer/polisher. This method takes a little more practice and it is difficult to maintain the roundness. Round filing will generally be necessary in removing the wear on the maintenance lever $_{(B)}$ as the groove is usually deep. Some flatness is ok here as that will produce a larger work surface resulting in longer wear but realize that a sharp stop edge will damage the stop face of the stop/maintenance cam $_{(I)}$. Be sure to remove all polishing compound residue left on the levers before installing them in the movement.

Lever Return Springs: Most levers require a return spring to guarantee a reliable and proper function. The springs should maintain the levers in their proper positions when the movement is inverted but not be so tight or strong as to cause undue pressure on the strike train. The springs should be of light weight brass spring wire (28 – 30 gauge) on all except the hammer lever $_{(G)}$ which requires a heaver brass spring wire (22-24 gauge) to deliver a hard hammer blow. The springs should be of brass instead of steel and wound in such a manner that when the "tail" is pulled, the lever will be forced in the at-rest direction as opposed to the lifting direction. One end of the wire should be wound around the base of one of the levers and continue around the lever arbor for several turns. The other end should be tied off either on a pillar post, the edge of the plate, or a post specifically designed for the purpose. It is not important which lever on the arbor is used, whether the wire is wound front to back or back to front, or which post/plate the tail is tied to. It is *very* important that the spring works in the proper direction, *not* interfere with the workings of the movement, and is not so tight that it binds the lever arbor when lifted. The best test is that it just holds the lever in its at rest position when the movement is held up-side-down. Old brittle return springs should be replaced before the movement is reassembled. Springs can be tied in place after assemblage but with more difficulty.

REPAIRING SEVERE DAMAGE

Replacing Levers: Levers that have been broken and are now too short to be adjusted properly should be replaced. The diameter is 0.60” – 0.65” in most cases. The lever is mounted into the arbor through a hole and then the lever end peened to tighten the lever in place. Use a small, flat punch to push the old lever out of the hole in the arbor. Use the old lever as a pattern in measuring and shaping the new lever. Select a steel that is soft so that it will bend without fracturing, and is the same diameter as the old lever. Cold rolled steel is ideal for this purpose. Be sure the new lever is long enough to allow for shaping. The hardest part of replacing a lever is getting it tightly affixed to the arbor. File a slight taper on the end of the lever so that it can be fit snugly into the hole in the arbor and just protrude out of the other side. Hold the lever tightly in a vise, clamped just under the arbor with a little lever showing above the vise. Peen the end of the lever until the lever is good and tight. An alternate method is to machine a shoulder on the lever instead of filing a taper. This gives the arbor something to rest against while peening. Other methods such as knurling the end or flattening the end could be used as long as the lever is secure in the arbor. Once the lever is tightly inserted into the arbor it can be shaped and fitted to perform like the original.

Soldering Levers: I do not promote soldering levers, however, it is something that can be properly done without damaging the lever or ruining its looks. Don’t use solder to tighten a lever, however. Tightening levers should be done by the methods described in *Replacing Levers* above. Soldering should only be done at a break and only if the break isn’t in a working area. Use a hard silver bearing solder (5% Ag) that will hold up under stress. Remove any excess solder by round filing the area until the break becomes invisible. Be sure to clean the flux off of the lever. Solder, even silver solder, won’t last in an area that is susceptible to wear so if a break is near a working surface the lever must be replaced.

Missing Levers: When faced with replacing a missing lever it is necessary to understand what the lever was supposed to do. Once this is fully understood the shape of the lever should be apparent. Most levers will have very few bends, be a consistent diameter, and shaped to provide the best leverage for the ease of the movement. Use the existing levers as a guide for size and historical information as a guide for shape. Expect to have to fit and file to get the best possible replacement.

MOVEMENT ASSEMBLY

Part of having the levers work properly is getting the strike train jigged in the movement in the proper relationship to the levers. Jigging a wheel one tooth off will cause an unnecessary adjustment of a lever. The following steps will aid in the proper alignment of the gears to the levers.

1. Install the time and strike train.
2. Weave levers into proper positions.
3. Arrange the 2nd/pin-wheel $_{(J)}$ so that the hammer lever $_{(G)}$ is between two hammer pins or has just dropped off of a hammer pin.
4. Arrange the 3rd wheel/stop-maintenance cam $_{(I)}$ so that the stop/maintenance lever $_{(B)}$ rests on the stop face of the notch.
5. Arrange the warning wheel $_{(H)}$ so that the warning pin is approximately 180^{o} away from the warning lever $_{(E)}$. (See figure 41.)
6. Make sure the previous relationships haven't changed.
7. Jig the plates together.
8. Attach the lever return springs to their posts and check for proper tension and clearance. The springs should have just enough tension to keep the levers in position when the movement is turned up side down. Too much tension and the movement will stall. Be sure the "tail" of the spring doesn't interfere with the operation of either train.

Once the movement is back together check the following relationships:

Stop/Maintenance Lever $_{(B)}$ to Stop/Maintenance Cam $_{(I)}$

Make sure the strike train is not in, or about to go into, warning by rotating the strike release pin $_{(L)}$ away from the "J" lever $_{(F)}$. Check the location of the stop/maintenance lever $_{(B)}$. It should be hard against the stop face of the notch in the stop/maintenance cam $_{(I)}$. Rotate the warning wheel $_{(H)}$ until the stop/maintenance lever $_{(B)}$ comes to rest against the stop face of the notch. You may have to pull the count lever $_{(C)}$ to the side of the count wheel $_{(K)}$, in order to simulate a stop notch on the count wheel $_{(K)}$ and get the stop/maintenance lever $_{(B)}$ to engage the stop/maintenance cam $_{(I)}$.

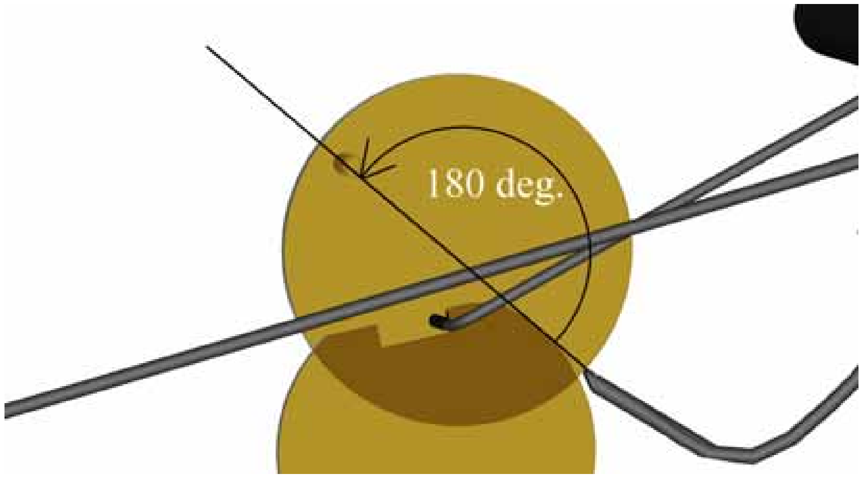


Figure 41: Showing 180^o of warning with the strike train at stop.

Warning Lever $_{(E)}$ to Warning Pin

Without disturbing the strike train from its previous position, examine the relationship between the warning lever $_{(E)}$ and the warning pin. The pin should be approximately 180^o away from the warning lever $_{(E)}$. (See figure 41.) Too much warning and the strike train will advance sufficiently to pick up a hammer $_{(N)}$ in warning causing "hammer on the rise" and too little could risk a stall due to insufficient clearance of the stop/maintenance lever $_{(B)}$. This is where proper assembly pays off! If the warning pin isn't close to optimal then the warning wheel $_{(H)}$ will need to be reset. Loosen the plates a bit at the top and spread them with finger pressure until the pivot of the warning wheel $_{(H)}$ comes free. This will enable you to disengage the pinion of the warning wheel $_{(H)}$ from the 3rd wheel/stop-maintenance cam $_{(I)}$ and rotate it independently. Rotate the warning wheel $_{(H)}$ the appropriate direction for the warning pin to be approximately 180^o away from the warning lever $_{(E)}$ while maintaining the position of the stop/maintenance lever $_{(B)}$ hard against the stop face of the notch in the stop/maintenance cam $_{(I)}$. Re-assemble the plates. With a little practice this will become easier.

Hammer Lever $_{(G)}$ to Hammer Pins

With the strike train in a stop position, check the location of the hammer lever $_{(G)}$ and be sure it is between two hammer pins and not in a position where it is being raised. If the lever is being raised, one solution is to re-jig the movement and be sure the pin wheel $_{(J)}$ and hammer lever $_{(G)}$ are in the proper positions. Another solution, described later, is to adjust the lever to clear the hammer pins. This unwanted condition of the hammer lever $_{(G)}$ resting on the hammer pins during stop or warning is called "hammer on the rise" and is a hurdle the strike train may not be able to overcome. It can be very difficult to avoid having a hammer $_{(N)}$ lifted and in some movements the hammer lever $_{(G)}$ to hammer pin relationship is very unforgiving and must be jigged into place rather than adjusted. In those cases, follow the method of separating the plates and rotating wheels described above until: 1) the stop/maintenance lever $_{(B)}$ is engaged on the stop face of the notch in the stop/maintenance cam $_{(I)}$, 2) the warning pin is approximately 180^o away from the warning lever $_{(E)}$ and 3) the hammer lever $_{(G)}$ has just been released by a hammer pin.

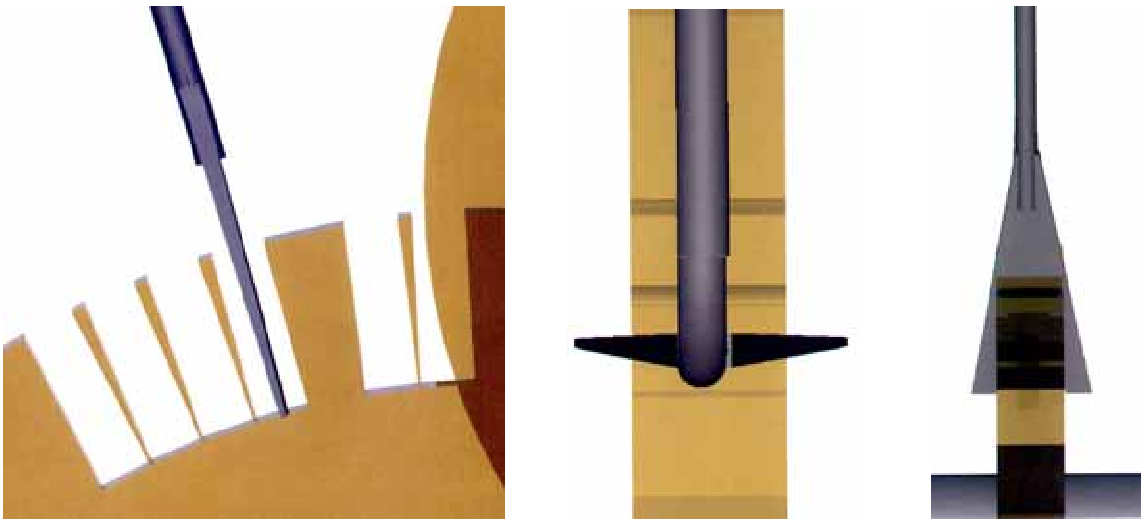
ADJUSTMENTS AND CLEARANCES

Oil the pivot holes and add power to the train.

<u>Movement at Stop</u>

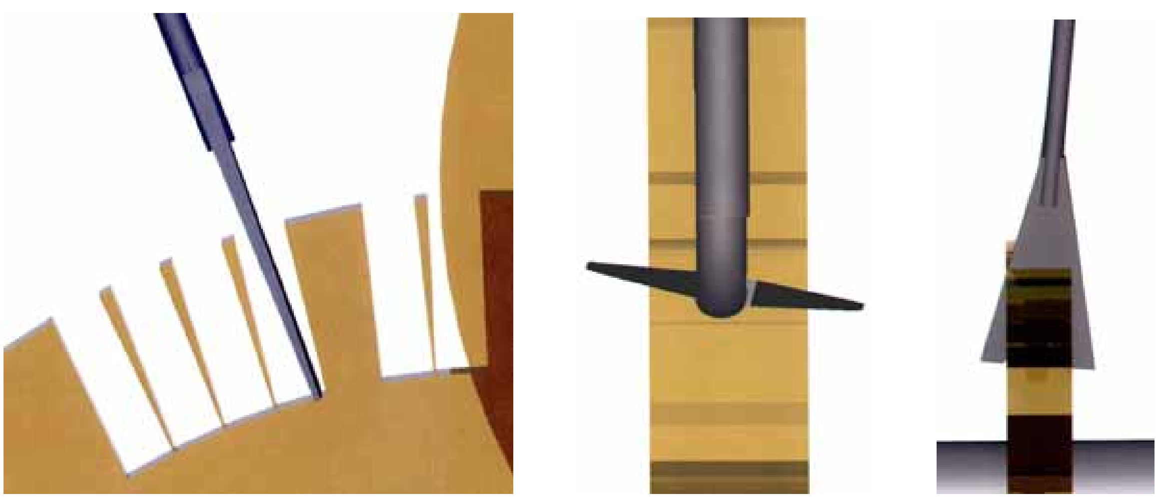
Rotate the center shaft to be sure the strike train is **not** in warning.

Control the motion of the strike train by keeping a finger on the butterfly. Slowly let the strike train advance until the count lever $_{(C)}$ falls into a stop notch on the count wheel $_{(K)}$ and the stop/maintenance lever $_{(B)}$ is hard against the stop face of the notch in the stop/maintenance cam $_{(I)}$.



A B C

Figure 42: Correct attitude of count lever: **A-** radial and in the middle of a stop notch; **B & C-** square in all directions.



A B C

Figure 43: Incorrect attitude of count lever: **A-** Not radial nor in the middle of a stop notch; **B & C-** not square in all directions.

Count Lever $_{(C)}$: The count lever $_{(C)}$ is the most likely lever to be out of adjustment since it protrudes outside the protection of the plates and is easily bent when handling the movement. In some extreme cases the count lever $_{(C)}$ is so far out of adjustment that it may need to be adjusted up or down to allow the stop/maintenance lever $_{(B)}$ to drop into the notch in the stop/maintenance cam $_{(I)}$. This should be considered a macro adjustment as fine tuning is done on the stop/maintenance lever $_{(B)}$

Reshape the end of the count lever $_{(C)}$ until the action brings it in the middle of the stop notch in the count wheel $_{(K)}$. You may have to lengthen or shorten the arm of the lever by using a pair of round-nosed pliers at the bend. To make the arm longer, use the fat part of the pliers and squeeze. To make it shorter use the narrow part of the pliers and twist. This will enable you to hit a different notch at a more optimal angle. The count lever $_{(C)}$ must also be true side to side. It should hit the stop notch in the middle of the paddle, be square in all directions, and be on a radius of the count wheel $_{(K)}$. (See figures 42 - 43.)

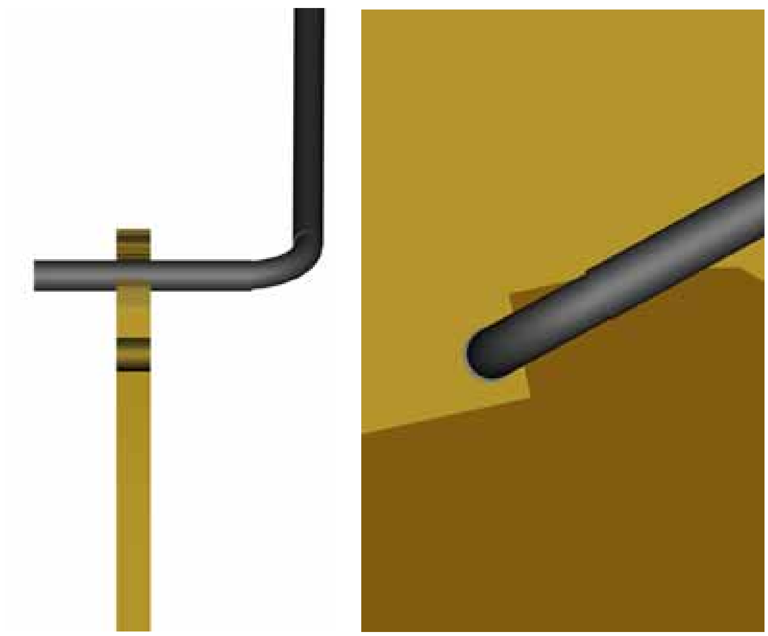


Figure 44: Correct attitude of stop/maintenance lever. Square in all directions.

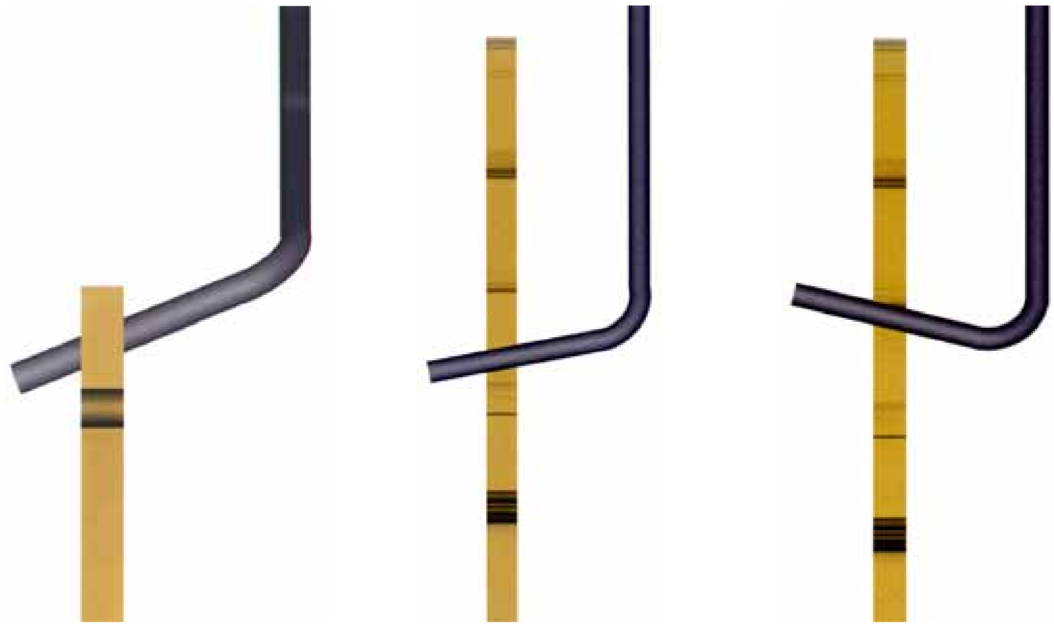


Figure 45: Incorrect attitude of stop/maintenance lever. Not square in all directions.

<u>Stop/Maintenance Lever $_{(B)}$</u>: Again, with the strike train in the stop position, examine the location of the stop/maintenance lever $_{(B)}$. It should be well on the stop face of the notch in the stop/maintenance cam $_{(I)}$ and not so close to the top edge that it could jump out. The lever should be square in all directions and, when at stop, should not touch the bottom of the notch. If it does, adjust it slightly so that it is well away but be aware that this condition may be caused by a count lever $_{(C)}$ being adjusted too high.

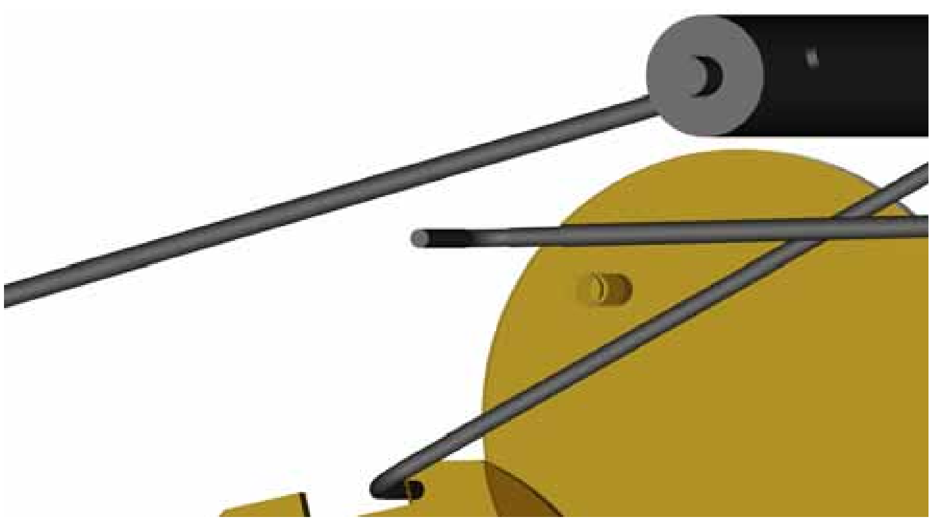


Figure 46: View of the lift lever at stop just below and not touching the count lever.

Lift Lever (D): The lift lever (D) should be below the count lever (C) and not touching. Bend it away if it is touching. Fine tuning the lift lever (D) will come later.

Hammer Lever (G): Some adjustment of the hammer lever (G) may be necessary in order to avoid the "hammer on the rise" condition and maintain the lever between two hammer pins. Adjusting the lever to a severe angle should be avoided as this will cause either the hammer pins to miss the lever or excessive lifting of the hammer (N). The hammer lift should be adjusted with the hammer detent (M).

Movement in Warning

Rotate the center shaft with the minute hand until the levers start to rise and watch for the warning process. This should happen 10 minutes to 3 minutes before the hour.

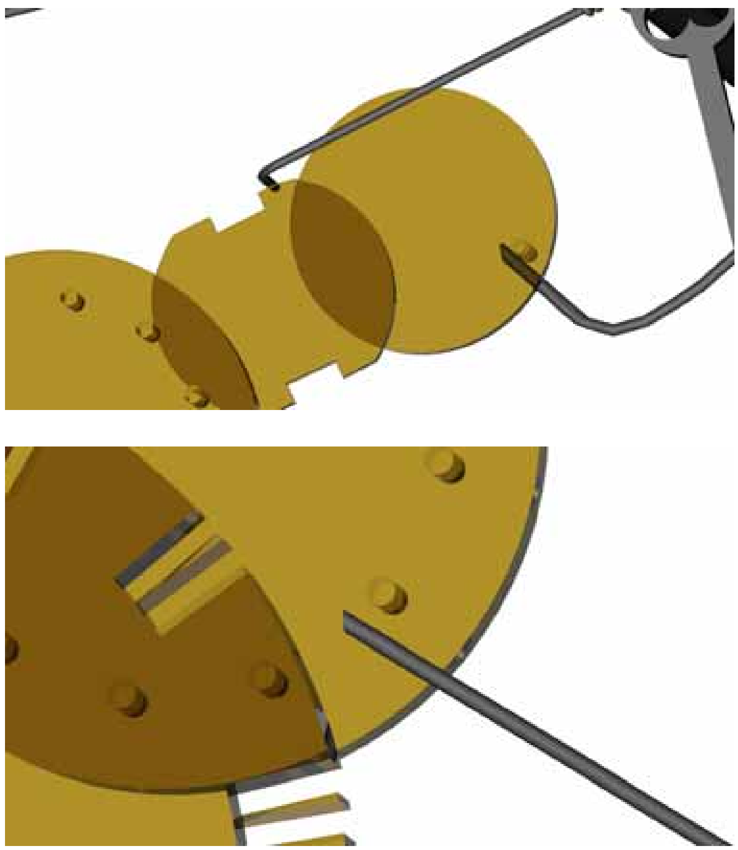


Figure 47: Strike train in warning. The lift lever has come into contact with the count lever and raised it sufficiently to release the stop/maintenance lever. The warning pin has been arrested by the warning lever, the stop/maintenance lever is resting on the upward slope of the stop/maintenance cam, and the hammer lever isn't being raised by the hammer pins.

Warning Lever $_{(E)}$: Watch the action of the warning wheel $_{(H)}$ as the warning lever $_{(E)}$ is raised against the warning pin when the minute hand is rotated from the start of warning until just before it is released. The warning pin should land on the warning lever $_{(E)}$ by roughly 3 pin diameters. If an adjustment is made, be sure to check that the pin clears the warning lever $_{(E)}$ while in strike. If the warning lever $_{(E)}$ is not radial to the warning wheel $_{(H)}$ there will be recoil of the wheel as the warning lever $_{(E)}$ is lifted. The wheel will be forced back against the direction of rotation by the warning lever $_{(E)}$ and could cause a stall of the time train. This is a common problem and although it can't always be corrected the recoil should be minimized. Ideally, the warning lever $_{(E)}$ should be adjusted so that it operates on an arc that intersects the center of the warning wheel $_{(H)}$. Not all movement configurations will accommodate this adjustment, however, so try to achieve as little recoil possible of the warning wheel $_{(H)}$.

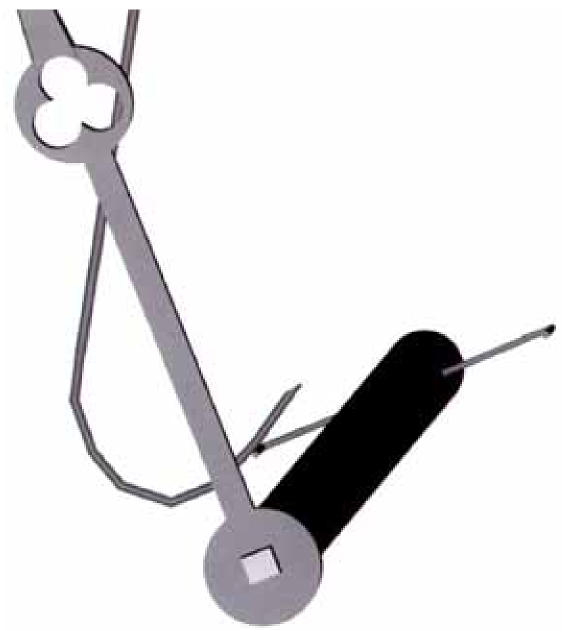


Figure 48: "J" lever and release pins in warning.

"J" Lever $_{(F)}$: Check the position of the "J" lever $_{(F)}$. It should be well on the strike release pin $_{(L)}$ and never have a chance to pass in front or behind, missing the pin. Adjust as needed. Pay special attention to the end shake in the arbor and center shaft. Push the "J" lever arbor against the back plate and pull the center shaft against the front plate and recheck "J" lever $_{(F)}$/release pin $_{(L)}$ relationship. The pin should be well on the "J" lever $_{(F)}$ and never pass by.

Lift Lever $_{(D)}$: If warning occurs too early or too late, adjust the lift lever $_{(D)}$ up or down to compensate. A lift lever $_{(D)}$ that is too low will cause the strike train to go into warning too close to the hour. A lift lever $_{(D)}$ that is too high will cause the strike train to go into warning too early. In an extremely low case, the lift lever $_{(D)}$ won't raise the other levers high enough to release the stop/maintenance lever $_{(B)}$ causing a failure to strike. In an extremely high case, the lift lever (D) causes the count lever (C) to be trapped against a pillar post or another lever resulting in a stalled movement. As with the other levers, several functions have to be balanced for proper adjustment. The lift lever (D) must lift the count lever (C) enough that the stop/maintenance lever (B) clears the stop face of the notch in the stop/maintenance cam (I) by 0.010" – 0.015". Lifting it more is not needed but may be necessary in order to keep warning between 10 and 3 minutes before the hour.

Stop/Maintenance Lever (B): Once in warning, the stop/maintenance lever (B) should be resting (even if only slightly) on the upward slope beyond the notch of the maintenance cam (I). Fine tune the lever during mid-strike.

Movement in Strike

Rotate the center shaft and catch the butterfly just after the warning pin is released as the "J" lever (F) drops off of the release pins.

Figure 49: View of the closest approach of the warning pin to the warning lever during strike.

Warning Lever (E): Control the rotation of the warning wheel (H) until the warning pin reaches its closest approach to the warning lever (E). The tip of the lever should be close to the pin but not touching at this point. Adjust the lever so that it is near the pin but not touching. A comfortable distance would be at least .010" from the pin. Be sure the lever isn't twisted so that it might come in contact with the wheel. The warning pin should clear the warning lever (E) at all times when not in warning.

Next, allow the train to run sufficiently so that the stop/maintenance lever $_{(B)}$, riding on the stop/maintenance cam $_{(I)}$, raises the count lever $_{(C)}$ to its maximum.

Figure 50: View of the count lever at its highest lift point during strike.

Count Lever $_{(C)}$: The count lever $_{(C)}$ should clear the count wheel notches by a comfortable margin (at least 0.020"). If the count lever $_{(C)}$ is being raised too high, it is wasted motion and simply adds to the wear of the stop/maintenance lever $_{(B)}$. If it is too low it risks not clearing the notches causing a jam of the strike train. In either case, adjust the count lever $_{(C)}$ to give the correct clearance.

Hammer Lever $_{(G)}$: Observe the amount of travel of the head of the hammer $_{(N)}$ as the strike train advances. The head should lift 1 to 1 ½ hammer head widths from rest until the hammer pin just drops the hammer lever $_{(G)}$. If the travel of the hammer head $_{(N)}$ is more or less than one hammer head width, adjust the hammer detent $_{(M)}$ to compensate. This adjustment will have to balanced with the need to avoid having hammer lift during warning. Keeping the hammer lever $_{(G)}$ in the exact middle of the space between hammer pins may not be possible but is more important than the amount of hammer lift because "hammers on the rise" should be avoided at all costs. A hammer $_{(N)}$ being lifted in warning may cause the strike train to stall when released into strike due to power drain and not enough momentum. Notice where the hammer lever $_{(G)}$ comes into contact with the hammer pins. Adjust the lever so that it contacts the middle of the pins and can't come into contact with the wheel itself. Also, be sure the pins contact the lever a comfortable distance away from the tip of the lever. Too close to the end and the hammer pin will jam on the end of the lever causing a stall.

Figure 51: View of the count lever during strike resting on the rim of the count wheel and not in a stop notch.

Keep the strike train going until the count lever $_{(C)}$ comes to rest on the rim of the count wheel $_{(K)}$ and not in a stop notch.

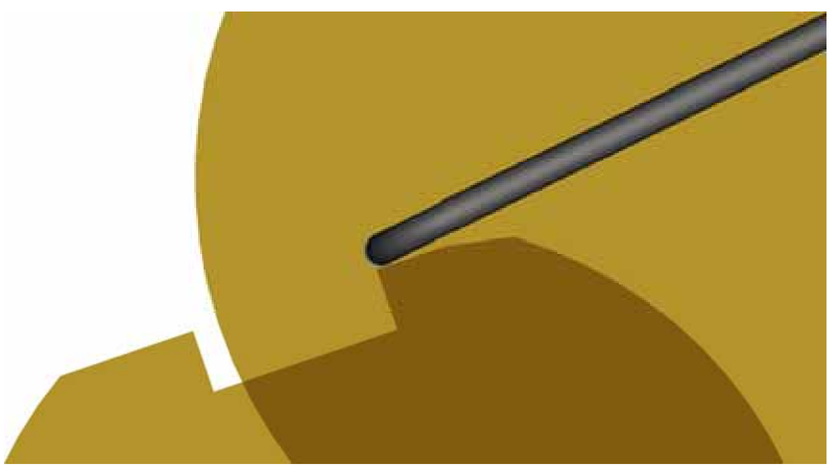


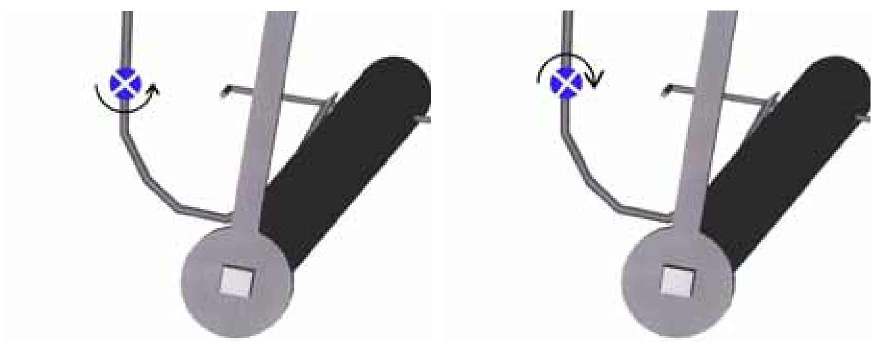
Figure 52: View of the stop/maintenance lever and stop/maintenance cam during strike.

Stop/Maintenance Lever $_{(B)}$: Watch the stop/maintenance lever's $_{(B)}$ relationship to the stop/maintenance cam $_{(I)}$ as the lever approaches the stop face of the notch on the cam.

The stop/maintenance lever (B) should clear the edge of the notch with the barest amount of space and contact the cam just after the notch on the upward slope of the cam. If it doesn't clear, or there is too much space, adjust the stop/maintenance lever (B) for proper clearance. This should give the maximum amount of stop face for the stop/maintenance lever (B) to rest against at stop. If not, then sacrifice some of the clearance to ensure that the lever is locked securely onto the stop face of the notch.

Allow the strike train to continue striking and watch for solid stop. At stop, the count lever (C) should be squarely in a stop notch on the count wheel (K). The stop/maintenance lever (B) should be on the stop face of the notch of the stop/maintenance cam (I). The hammer lever (G) should be in between, and not touching, hammer pins.

Strike Release Points



A B

Figure 53: The blue dot shows the proper adjusting point on the "J" lever to change the strike release point. **A-** Bending in the direction of the arrow will cause the strike point to occur later. **B-** Bending in this direction will cause the strike point to occur earlier.

"J" Lever (F): With a finger on the butterfly, rotate the minute hand until the "J" lever (F) is released. Note where the minute hand is in relation to the release point. If strike release occurs before the hour, bend the "J" lever (F) as shown in figure 53-A. If strike release occurs after, bend the "J" lever (F) as shown in figure 53-B. Unfortunately, this is a hit or miss, painstaking process since it often requires having a dial for a reference. You can get close by using a pivot hole that is directly above the center shaft as a reference or a fast/slow adjuster if it is centered on the top of the movement. Realize that any adjustment of the "J" lever (F) could also change the adjustment of the lift lever (D) necessitating a re-adjustment of that lever.

Strike Release Pins (L): Continue rotating the minute hand until the half-hour is released. If the release point is early or late at the half-hour but correct at the hour, then the half-hour strike release pin (L) must be adjusted (not the "J" lever (F)). Bend clockwise or counter clockwise as needed so that the strike points agree. If looking at the center shaft from the front then bending the strike release pin in a counter clockwise direction will cause the strike release point to occur later.

It is easy to get bending in circles and frustrate yourself and too much bending will work-harden the steel wire. Be careful not to break any levers or your frustration will continue. It is important to do things in order:

1. Assemble the movement properly.
2. Adjust at stop and check clearances.
3. Adjust in warning and check clearances.
4. Adjust in strike and check clearances.
5. Adjust the strike release points and check clearances.
6. Quick repeat of #'s 1-5 to be sure nothing is out of adjustment.

OILING

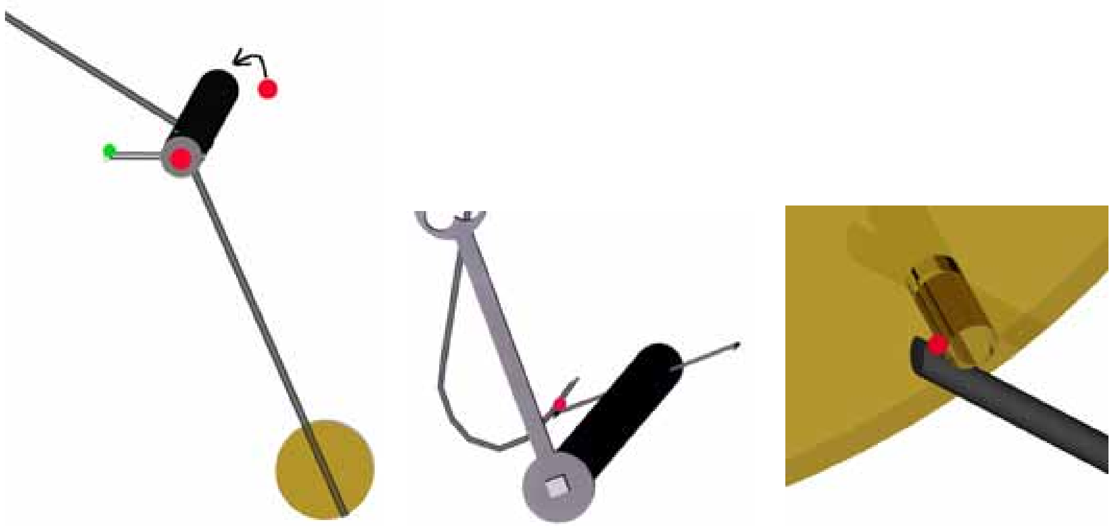


Figure 54: Oiling diagram 1. Red dots designate where a minimal amount of oil should be applied to the lever surfaces. Note: The hammer arbor pivots are the *<u>only</u>* lever pivots that receive oil. The green dot on the hammer detent denotes where a dab of grease should be applied.

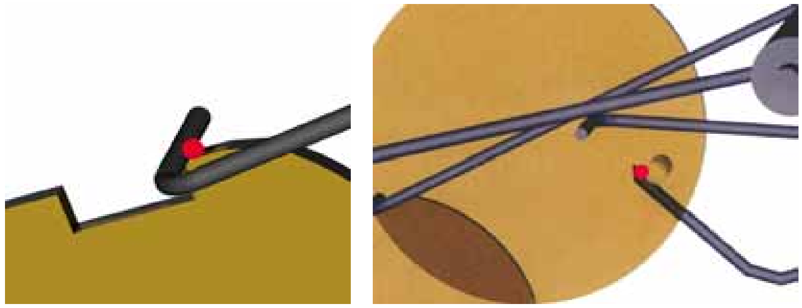


Figure 55: Oiling diagram 2. Red dots designate where a minimal amount of oil should be applied to the lever surfaces.

The pivot points of the hammer lever $_{(G)}$ are the *<u>only</u>* lever pivots that receive oil. If the other lever pivots are oiled they will become sticky over time and become unreliable. The working surfaces of the levers should all be oiled but with as little as possible. (See oiling diagrams.) The hammer detent $_{(M)}$ should have a drop of grease applied where it comes into contact with the movement to help dampen the noise and action of the hammer's recoil.

FINAL ADJUSTMENT

Once the movement is back in the case there is one final adjustment that will need to be made. The hammer arm will need to be shaped so that the hammer $_{(N)}$ hits square and doesn't come to rest against the gong, bell, or rod. It should deliver a solid blow and rebound without rehitting until drawn back for another blow. The hammer $_{(N)}$ and hammer arm should be free to travel for the entire strike without interfering with the pendulum, case, movement, alarm, etc... Reshape the hammer arm until these conditions are met.

ADAPTING THIS TO YOUR MOVEMENT

Hopefully, by now, you have a greater understanding and respect for the service, care, and restoration of the levers of American striking movements. Unfortunately, it would be impossible to cover each and every style variant and include the specific problems inherent to each. That is why learning some universal properties common to all types of mechanisms is a must for a successful restoration. Keeping these in mind will aid you when confronted with something for the first time, something that is unique, or something that has been "made to work." Hopefully, these guidelines will also be applicable to the more complicated chime lever arrangements.

1. Know what the purpose of a lever is and how it functions with the other levers. It is impossible to adjust a lever without knowing what it is supposed to do.

2. Most levers will be straight and true with a minimal amount of bends. Where bends do occur, they will generally be at right angles.

3. Minimize friction on the lever by being sure it is free to move and has all rubbing surfaces free from wear, polished, and clean.

4. Minimize the amount of energy required to lift and release a lever while at the same time maximizing the stability of the lever. For example, a stop lever should be adjusted to work at right angles to the stop so that the lever uses a minimal amount of energy to be released while at the same time having the maximum stopping power.

5. Avoid a lever that is adjusted so that, as it is lifted, the train must work backwards or recoil. For example, a poorly adjusted warning lever will cause the warning wheel to recoil as the lever is raised just prior to strike. This condition robs the time train of power as it tries to rewind the strike train.

6. Pay special attention to a lever's proximity to other parts of the movement. Examine the lever's action and be sure it ***can't*** interfere with anything. For example, a warning lever that is adjusted too close to the warning wheel could catch the wheel if the end shakes are at an extreme.

7. Consider what effects the adjustment of a lever will have ***before*** adjusting it. For example, don't adjust the stop lever and the maintenance lever when all that is needed is to adjust the count lever.

8. Don't oil lever pivot points.

Resources and Additonal Reading

1. Special *"Thank You!"* to Jerry Faier, CMC for his training, expertise, and input.

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