Stitch Formation in Rotary Hook Sewing Machines

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ABSTRACT

Most modern general-purpose sewing machines form a *lockstitch* by way of the *rotary hook* technique. The working of this system can be quite mystifying, and depends on a clever design worthy of a magician's kit. In this article, we explain how the rotary hook mechanism produces a lockstitch.

INTRODUCTION

The lockstitch

Most "serious" modern domestic sewing machines and an important class of industrial sewing machines form what is called a *lockstitch*. The concept can be easily seen in figure 1.

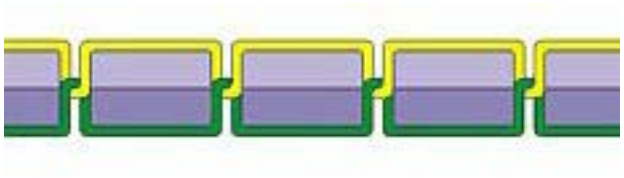


Figure 1. The lockstitch

The stitch is formed with two threads, one coming from above, thorough the eye of the needle (yellow in the figure) and one coming from below, from a bobbin located in the bed of the sewing machine (green in the figure).

A little thought will reveal that this must be done with some very clever mechanism, since in effect the two threads are twisted about one another (a full twist per stitch) despite coming from two "stationary" sources.

The rotary hook system

The majority of domestic lockstitch machines, and many industrial lockstitch machines, form the lockstitch with a mechanism called the *rotary hook* system. We will see it in operation shortly.

There are two major configurations in which the rotary hook lockstitch mechanism is deployed.

In many domestic machines, the rotary hook operates in a horizontal plane, about a vertical axis. The bobbin is placed directly in a "bobbin case" (again, both lying in a horizontal plane) located within the rotary hook mechanism. Its location is normally just below the needle, and the area is accessed by removing or sliding aside part of the machine's throat plate.

In other machines, the rotary hook operates in a vertical plane, about a horizontal axis. This axis may either run "across" the machine (along the direction of normal fabric travel) or it may run parallel to the sewing machine arm (along the direction from the needle to the rear handwheel of the sewing machine).

In either case, the bobbin is often held, in a vertical plane, in a little "cartridge" (called the *bobbin case*) that is placed into a another part (called the *hook basket*) located within the rotary hook mechanism.

It is easiest to discern, by visual observation, the operation of the rotary hook mechanism in a horizontal bobbin machine. However, graphic illustration of the principle is most easily done for a vertical plane bobbin machine, and we will illustrate the principle for that form. Later, we will look into a typical application of the horizontal bobbin form.

LOCKSTITCH FORMATION

The principal

Figure 2 shows, in a quasi-animated form, the formation of a lockstitch by a rotary hook mechanism in the vertical plane bobbin configuration. The illustration, for clarity, takes some liberties with certain actual details.

In frame 1, the needle has just started its stroke downward.

In frames 2 and 3, we see the needle penetrating the fabric sandwich. Not shown (it should be figure 2-1/2) is that the needle goes a little deeper than shown in frame 3, and is already retreating by the time of frame 4. The thread is not pulled up through the fabric by the upper mechanism during this initial part of the upstroke. The result is that the thread slightly "buckles" in the area just above the needle eye. This forms a loop that can be easily caught by the point of the rotary hook (dark gray in the figures), as seen in frame 4.

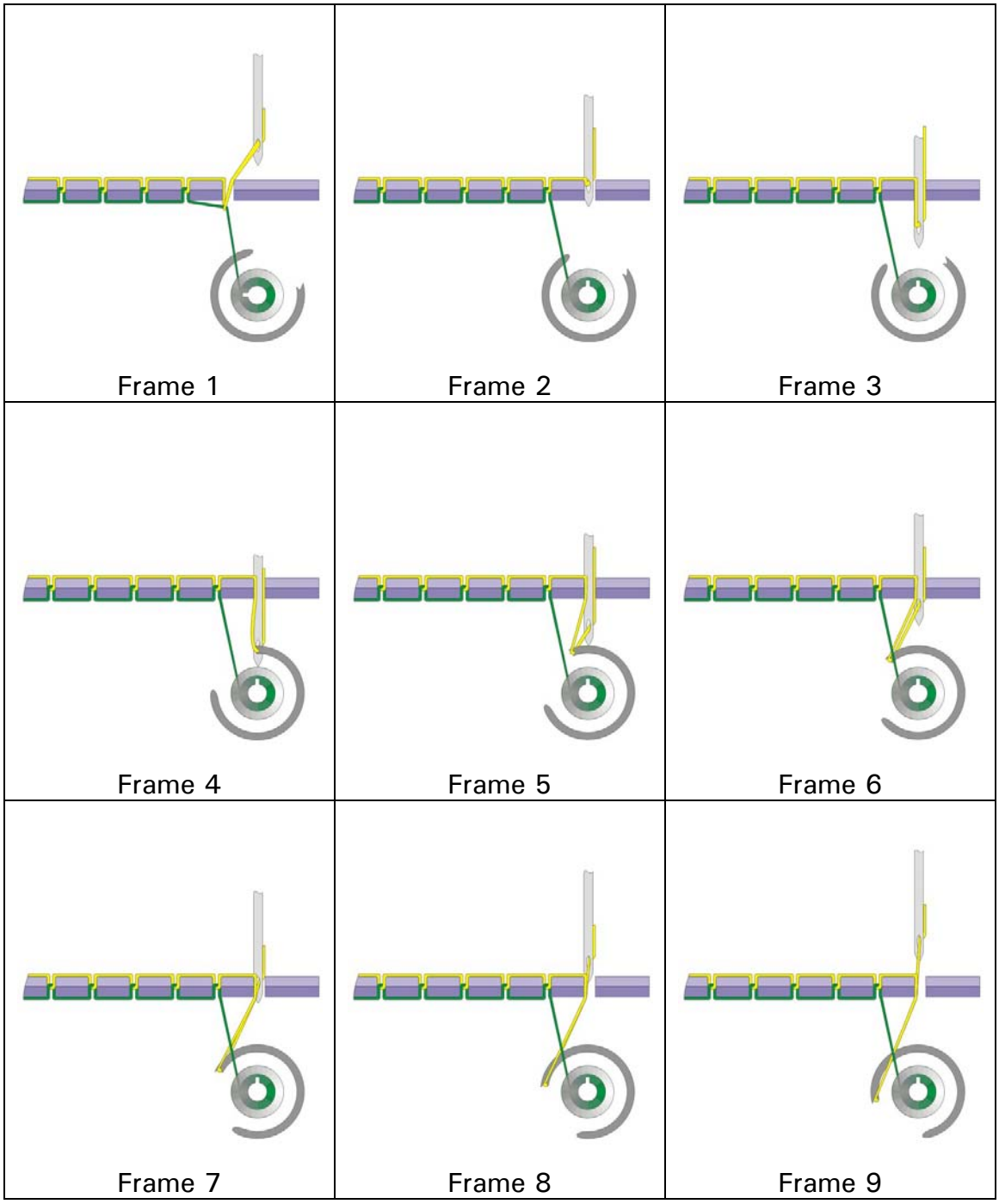


Figure 2a. Thread formation (frames 1-9)

In frames 7 through 16, the loop of thread is carried entirely around the bobbin (the shaded gray disk with the green load of thread shown on it), with the result that the upper (needle) thread encircles the lower (bobbin) thread, as needed to form the stitch.

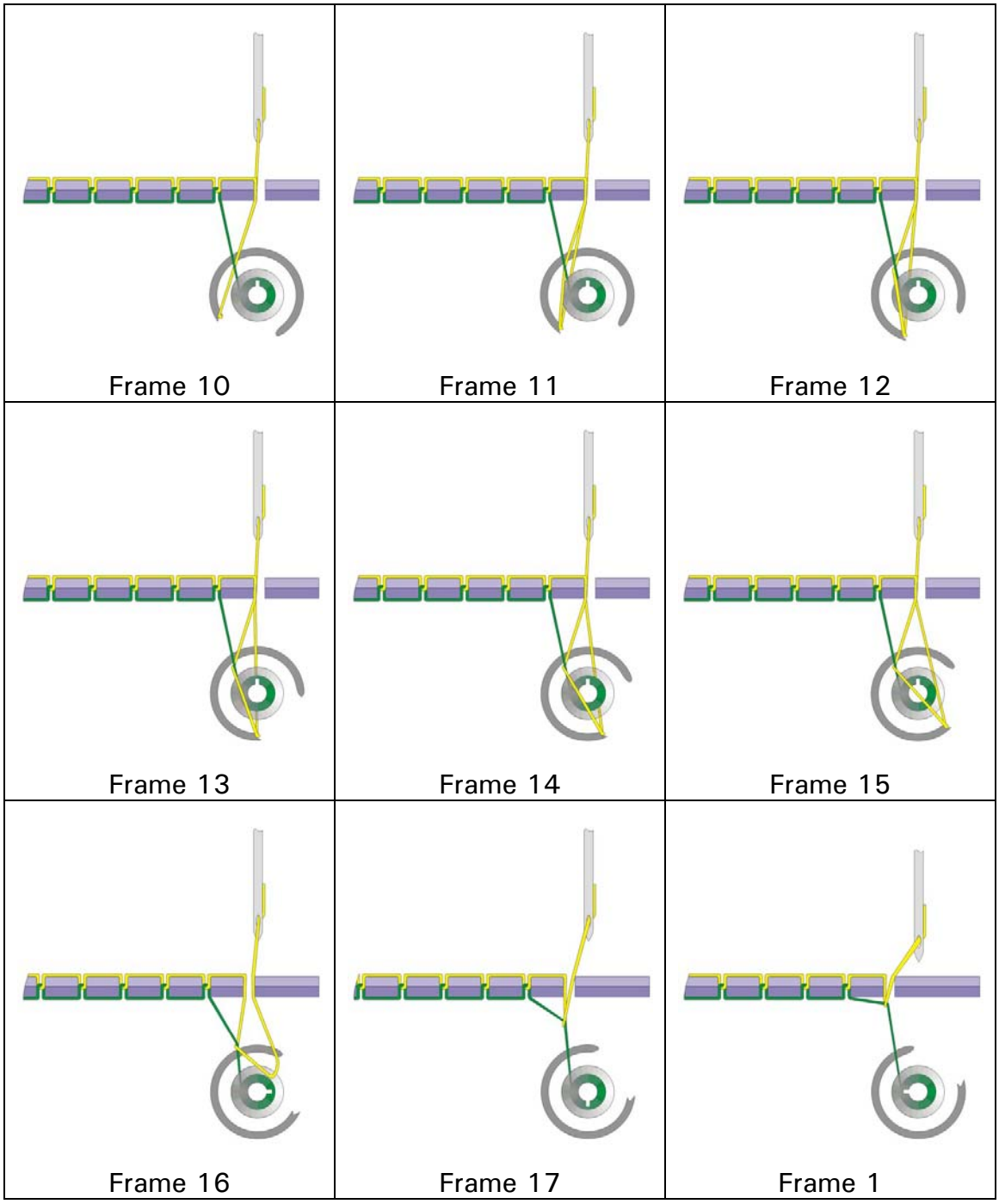


Figure 2b. Thread formation (frames 10-17)

A magical happening?

The discerning reader may say at this point, "Whoa! How can this be? The bobbin is held on some shaft, which must be held by a bracket or something fastened to the machine frame. How can the upper needle thread pass completely behind the bobbin (and its holder), as we seemingly see in frames 11-25?"

Figure 3 allows us to see this seemingly magical happening more clearly (from frame 14).

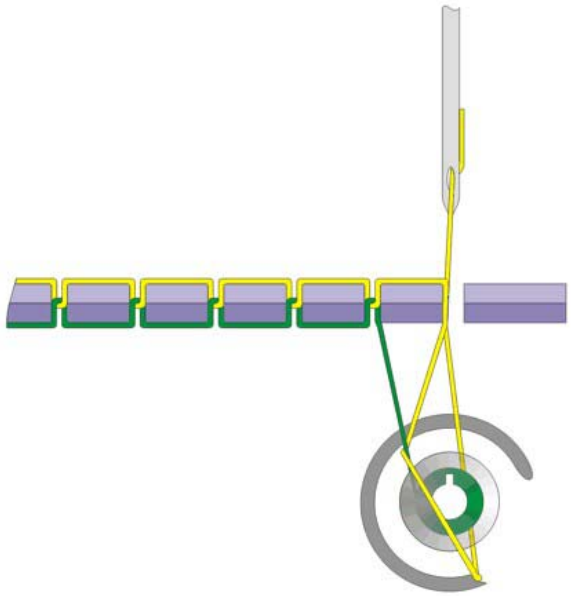


Figure 3. Closeup of thread passing behind the bobbin

This is where a very ingenious design concept, worthy of a magician's kit, comes in. We see it schematically, in cross section, in figure 4. (Again, here, the details vary somewhat from those of the actual parts, in the interest of clarity.)

We must note here one of the "liberties" of the earlier illustration, which showed the rotary hook located "on the front side" of the needle (you may have wondered how it was supported). In the mechanism we examine here (and in the typical actual situation), it is located to the rear of the needle.

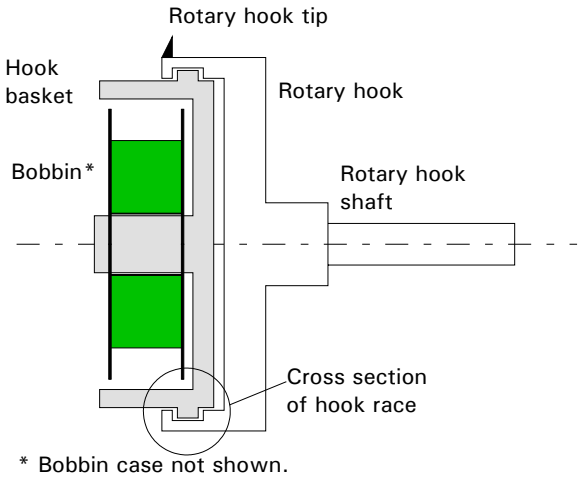


Figure 4. Support of hook basket by rotary hook wheel

We see the rotary hook mounted on a shaft through which it is turned continuously by a gear train running from the drive motor.

The Bobbin (in the cup-like bobbin case, not shown in the figure) is held on a shaft in the hook basket. The hook basket is held in the rotary hook with a rotary joint (so the rotary hook wheel can turn while the hook basket does not—what keeps it from turning we will see in a little while). (The part of the rotary joint on the rotary hook is formally called the "hook race", a channel in which the hook basket "runs".)

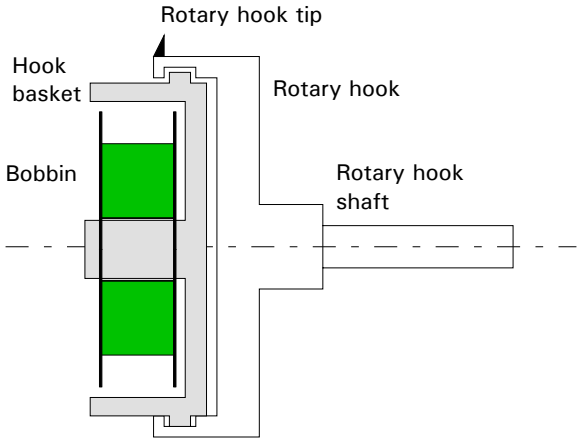


Figure 5. Joint clearance taken up downward

But the joint is "loose". There is significant play between the two mating parts. In figure 5 we see that play being taken up in the downward direction by the weight of the hook basket (as it would be with the mechanism at a standstill). Still, the two parts "interlock" enough that the hook basket cannot escape from its position inside the rotary hook wheel.

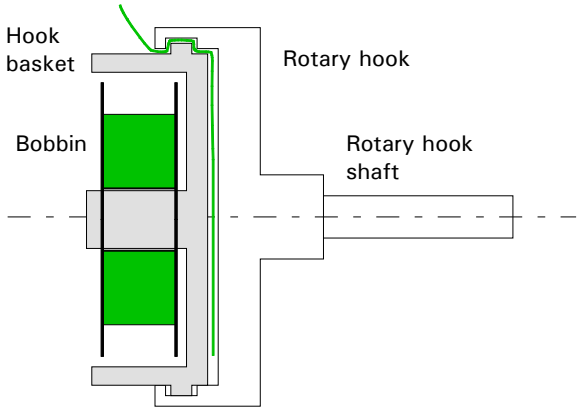


Figure 6. Thread slipping through clearance at top

When the rotary hook tries to pass the rear of the loop of top thread behind the bobbin and hook basket (as shown in frames 12-15 of figure 2), the thread is able to slip through the clearance between the

two parts of the joint and thus get behind the hook basket. We see this in Figure 7.

As the thread loop (toward the end of its adventure) needs to pass under the bottom of the hook basket and "escape", it lifts up the case to open the clearance there. We see this in figure 7:

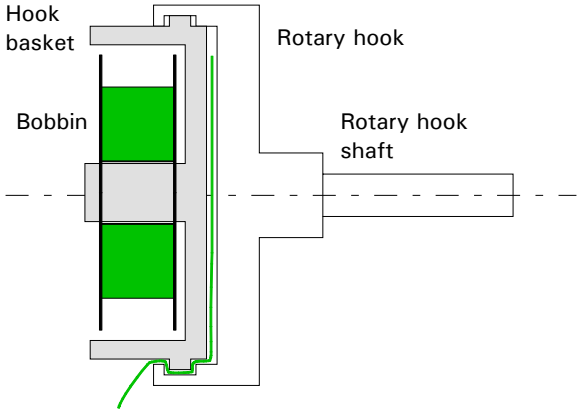


Figure 7. Thread slipping through clearance at bottom

This is how the rear of the loop of thread is able to "magically" pass fully around a "fixed" item that seems to be fastened to the machine frame.

Preventing rotation of the hook basket

Of course, it is necessary that the hook basket not be able to rotate while the rotary hook rotates. If there were some "arm" on it to prevent rotation, this would interfere with the passage of the upper needle thread as we saw above.

Again, a "loose fit restraint" comes into the picture. Figure 8 shows the hook basket locating tab. It extends from an arm mounted to the machine base. The tab fits loosely into a notch at the near top edge of the hook basket, preventing it from rotating (it can of course wiggle back and forth a little bit). During the last part of the passage of the loop of upper thread around the hook basket, one limb of the loop weaves its way between the tab and the edges of the notch to "escape".

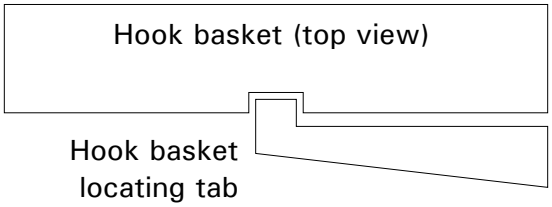


Figure 8. Hook basket locating tab

THE REAL THING

Illustrative Juki mechanism

Figure 9 shows the rotary hook assembly from some unidentified Juki industrial sewing machine. It is typical of those seen on a number of brands of basic industrial machines or the "semi-industrial" machines often used for machine quilting.

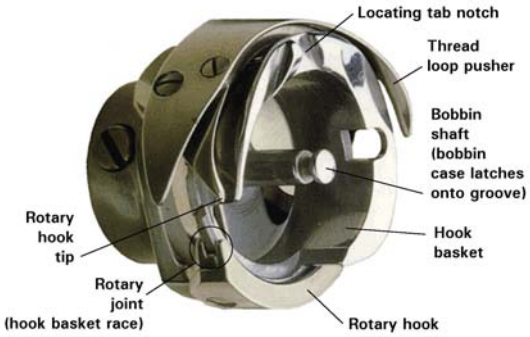
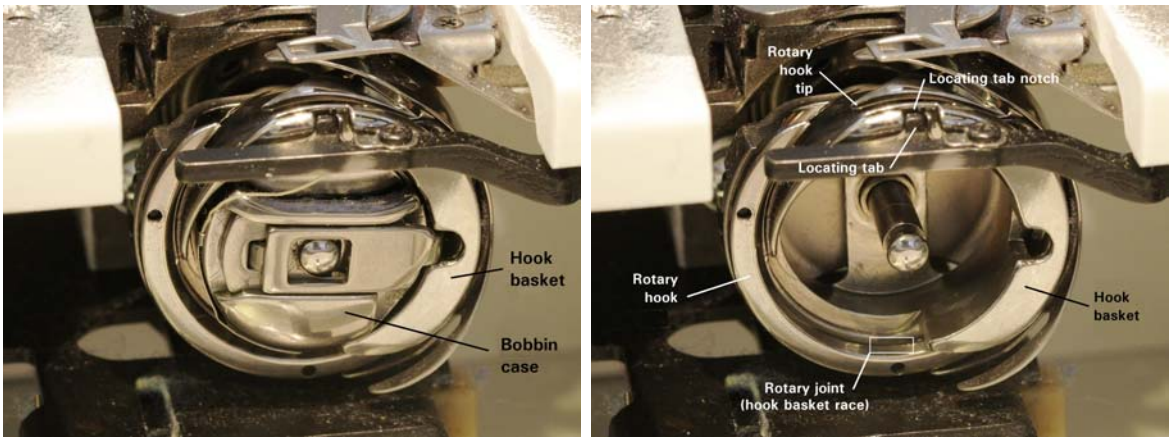


Figure 9. Juki rotary hook assembly

Several of the features we discussed on our "tutorial" illustration are labeled. The feature I have labeled "thread loop pusher" is a complex part on the rotary hook that helps guide the thread loop in its magical journey around the bobbin, bobbin case, and hook basket.

NewJoy Crystal Quilter/Janome 1600P mechanism

Figure 10 shows the actual rotary hook mechanism on a NewJoy Crystal Quilter sewing head (essentially identical to the mechanism of a Janome 1600P industrial sewing machine).



A. Bobbin in place **B. Bobbin removed**

Figure 10. New Joy Crystal Quilter rotary hook mechanism

Panel A shows the mechanism complete. We see the bobbin in the bobbin case, in turn seated in the hook basket. The friction

arrangement to control the tension of the bobbin thread is on the bobbin case (we see the thread issuing from it).

Panel B shows the bobbin (and bobbin case) removed. We can see the rotary joint (rotary hook race) through which the hook basket is held in the rotary hook (but not as clearly as in the Juki mechanism, seen in Figure 9, owing to a difference in the overall contours of the parts).

We also see the hook basket locating tab (on its arm) engaging the notch in the hook basket. Again, this is a loose fit, as the thread must snake around the tab in making its final escape in its travel around the hook basket. On the side that is struck by the notch as the rotary hook rotates, the tab has a resilient spring bumper to minimize recurrent shock.

Note the D-shaped notch on the right of the hook basket. With the bobbin case fully in place, a tab on the right of the bobbin case latch plate (not the latch lever) engages this notch, properly indexing the bobbin case in the hook basket.

While the bobbin case is being inserted, proper alignment is facilitated by two small projections from the "roof" of the hook basket, around which a wide slot in the top of the bobbin case passes.

HORIZONTAL BOBBIN ARRANGEMENT

The majority of domestic sewing machines do not use the vertical bobbin arrangement we have so far studied, but rather a horizontal bobbin arrangement.

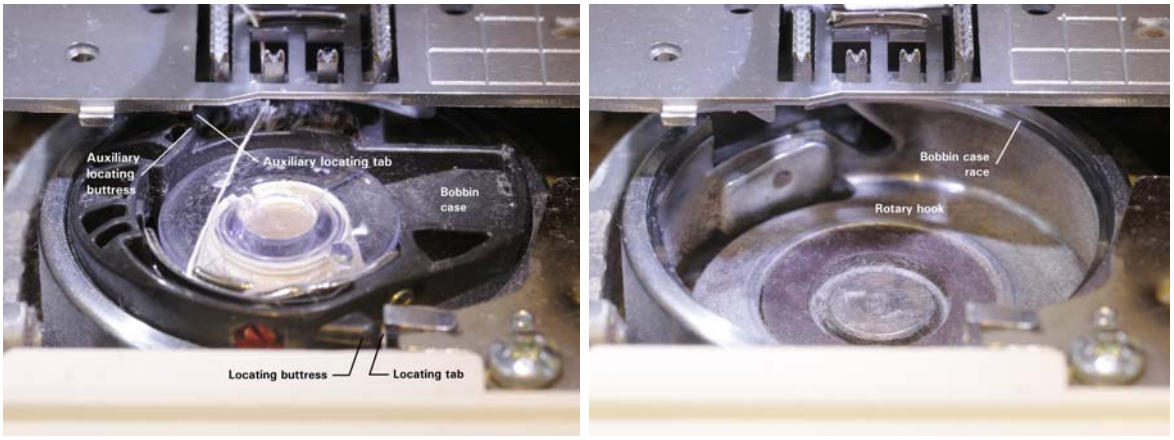
It differs in that usually the bobbin is not placed in a bobbin case which is then placed in a hook basket. Here, there is only what in effect corresponds to the "hook basket". The bobbin drops directly into it. Thus here **it** is called the "bobbin case". The friction arrangement to control the tension of the bobbin thread is on it (we see the thread issuing from it).

In this arrangement the bobbin case is not "trapped" in the rotary hook wheel by the rotary joint (as is the hook basket in the vertical bobbin arrangement). The joint (rotary hook race) is open on its top side, and the bobbin case is just held in place by gravity.

Figure 11 shows the horizontal bobbin arrangement on a Baby Lock Crafter's Choice domestic sewing machine.

Panel A shows the mechanism with the bobbin and bobbin case in place. The main locating tab works against a "locating buttress" on the bobbin case to prevent the case from rotating counter-clockwise from the proper position (the direction in which the rotation of the

rotary hook wheel will try to give it). As we saw before, the tab has a resilient spring face.



A. Bobbin and case in place **B. Bobbin and case removed**

Figure 11. Baby Lock Crafter's Choice rotary hook mechanism

An auxiliary locating tab (mounted under the throat plate, and hard to see in this picture) works against an auxiliary locating buttress on the bobbin case to keep it from being accidentally rotated clockwise very far from its proper position. (A small displacement will be rectified as soon as the rotary hook wheel begins to rotate.)

In panel B the bobbin and bobbin case have been removed, allowing a better view of the rotary hook. We see the open structure of the bobbin case race (the "rotary joint").

Figure 12 shows the rotary hook from a different perspective (and with the wheel rotated slightly from its "rest" position, in order to give an improved view of the rotary hook tip.

Figure 12. Closeup of rotary hook tip (Baby Lock)

ACKNOWLEDGEMENTS

Figure credit

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Copy editing

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