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Creating a Bird Automaton

A Full Technical Description

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Introduction

In October 2019, the *HJ* published my article 'A Surprise Automaton', which was a brief account of a miniature violin and case that housed a secret: two tweeting bird automata. Here, I give a more detailed description of the design and construction of this unique piece.

The Inspiration

Form watches were made in Europe, primarily in the nineteenth century. They are watch movements housed in shaped and decorated gold or silver cases. The 'forms' that they take would vary; fruits such as apples or pears were typical, as were insects or musical instruments, perhaps harps or violins. Form watches are highly decorative, luxury items; the enamel was often inlaid with gold *cloisonné* wires and then overlaid with a painted decoration fired on. As expected, they have conventional lock and fly springs for the case lid, to be able to open and read the watch dial. **Figure 1** shows a form watch housing a verge watch movement.

Figure 1. Form watch housing a verge watch movement.

I had already made a number of pieces that are enamelled over engine-turned patterning. Furthermore, I was attracted by the work of the late Phil Barnes, who made use of various types of hand-engraved decoration covered with vitreous enamel.

I therefore decided to make a small scale violin with a hand-engraved decoration, covered in a suitably coloured enamel to replicate the manner of the wooden construction. It was tempting to make it house a watch movement, such as a good quality verge one that lacked its original, probably gold, case. In the end, though, I rejected this idea in order to make a unique item. I did, however, adopt the bulbous shape of these stringed instrument case styles, based on the need to house a circular watch movement, resulting in a more 'cello-like' result. **Figure 2** shows my finished piece from the outside. The birds are hiding within, but we will get to those.

Figure 2. The finished piece.

The Case

The body and back were each formed by hydraulic pressing of 0.8 mm thick sterling silver sheet into a violin-shaped Perspex cut-out using urethane rubber, which is highly flexible and returns to its original shape, **Figure 3**. The attractively domed form for both the body and the back then had the edges knocked over to create a stiff rim. For the body, now 60 mm long by 42 mm wide, a shaped strip was bent to match the inside profile of the rim. It was a bit tricky to bend the strip to fit neatly, but patience won and it was then soldered in position.

A stiffening plate was also soldered into the body at the neck end, and a hinged joint fitted for the back. Care was required in making the joint fit well so that the back closed neatly; after enamelling there is little scope to change this. The fingerboard, neck and peg box of the violin were built up from silver sheet to recreate the look of a real instrument with four pegs. A strip of thin silver sheet was rolled up and soldered to the end of the peg box to form the decorative scroll.

As a means of attaching the neck to the body, enough thickness was left in the neck to have two blind tapped holes for internal screws. Consideration also had to be made in the assembly for subsequent engraving and enamelling of the body and the underside of the finger board, **Figures 4A and 4B**.

Two small pieces were soldered in position inside the back prior to enamelling: a short post as a part of the lid lock to engage the lock spring, and a pad near the joint to seat the tip of the fly spring. All soldered joints prior to enamelling were done with 'hard' grade silver solder (melting point 745–778°C) to minimise any risk of softening during the enamelling processes. I chose not to use 'enamelling' grade, melting point 730–780°C because it flows a little less easily.

Four tuning pegs were turned up from hard silver wire to fit their peg box holes, and the pegs were drilled to suit the correct positions for each string. A slightly raised portion at the peg end of the fingerboard serves to lift the strings and four vee-cuts were engraved in to allow each string to sit neatly and securely.

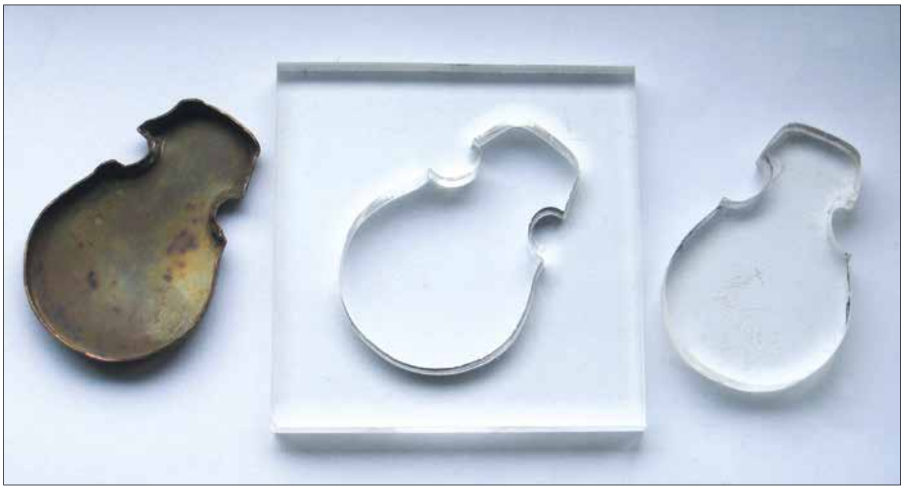

Figure 3. Perspex profile and trial pressing in gilding metal

Figure 4A. Components and assembly of body, back and neck parts; overall length 98mm. See also Figure 4B.

Decoration and Enamelling

Once the body construction phase was complete, the engraving was begun. A shallow chamfered recess was engraved around the perimeter of both the body and the back (to retain and give a neat edge to the enamel). Within this, a series of many straight cuts was made with a rounded engraving tool, to simulate the appearance of wood. On the front of the body, the cuts were all aligned with the central axis to copy the fine straight grain spruce used in real instruments. On the back, in the manner of matching pieces of maple, cuts were angled in from either side to create a straight centre 'line', again copying the real instruments. Engraving on the neck was done in a fine chequer-board pattern and on the sides in simple vertical lines to replicate the straight grain on full size instruments, **Figures 5 to 7**.

I chose Light Ruby Red enamel (Schauer transparent enamel SJE 116, firing temperature 730–770°C) to create a rich, 'varnished' wood effect, knowing that red enamel can be rather fugitive and become a bit brown in colour after too many firings. Within the engraved areas, three layers were fired on, stoning down between each layer to get an even surface and colour. The neck was enamelled on the lower surface with the Light Ruby Red, and the domed fingerboard on top was enamelled with a matt black enamel, leaving a bare metal strip along each edge. The loose tailpiece, with four holes drilled for anchoring the strings, was enamelled with a glossy black. My intention was to keep its appearance in line with what a full-size string instrument would look like. Particular care was taken during the design and assembly stages to minimise the chances of solder coming into contact with the enamel, since this can lead to problems of enamel security and colour change.

There were some challenges to overcome. It was important to leave certain areas, such as the edges of the body, the edge of the fingerboard, peg holes and edges of the end scroll free of enamel. In addition, whilst the formed shape and turned edge made the hinged back more rigid and hence more resistant to deformation during firing, unfortunately some did still occur, **Figure 8**. A thin coat of white counter-enamel was therefore fired on the inside of the back, to help even out the thermal stresses on cooling, but the neat fitting of the joint was still affected. The remedial step taken was to put a close fitting blued steel rod through the part of the joint on the back, fire to soften the enamel, remove the hot back quickly from the kiln, place it on a steel sheet with the steel rod supported at one side and press the hot enamel

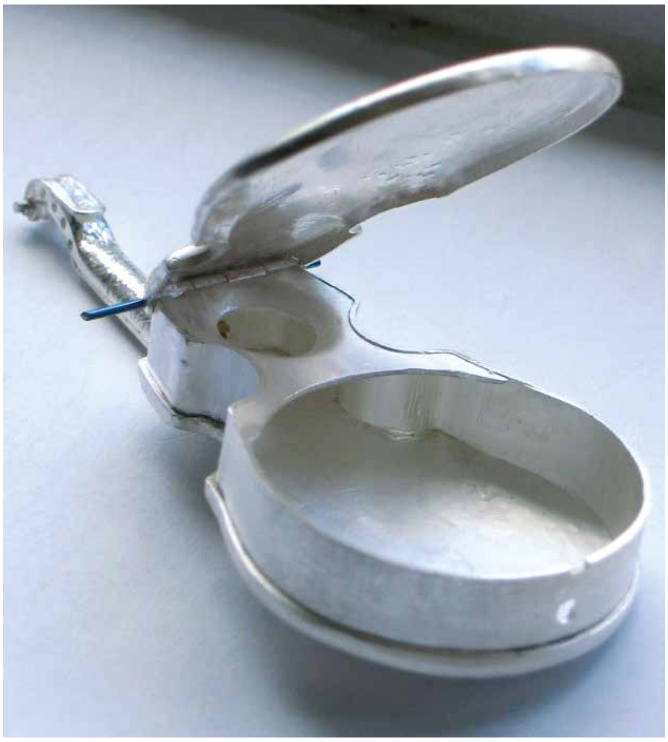

Figure 4b.

with a heavy steel object (an old iron) to shape it back into a better 'flatness'. This (stressful process!) had to be done twice to achieve a satisfactory outcome.

I carried out some trials with various colours, as well as black and gold, for painting enamels as possible extra decoration. Two F-holes (the sound holes on violins) were then painted on to the top of the body in matt black enamel and fired. The main body, being much stiffer, did not suffer any undesirable deformation, but the risk of causing further distortion to the back through more firing persuaded me not to apply any further decorative enamel on to that surface. I could make a spare back to try this extra decoration, but will it ever come to the top of the priority list?

Automata Design

As my previous projects have involved small, mechanical performing birds, I decided to try to incorporate them again and create something unique by fitting them into the small space available. At the outset, there were only outline ideas for the mechanism; the design decisions developed in stages. It was a key requirement that the mechanism would be enclosed within the case and be released to perform.

Two birds, supported in a carriage and moving in tandem, seemed to fit the bill to give a balanced appearance. To allow the bird carriage to rotate on pivots between closed and open positions, mounting blocks were designed for each side of a sub-base plate, each provided with a screwed-in pivot to support the carriage. Within the carriage, each bird requires a mounting stem allowing rotation by a pinion drive system beneath. To enable contrary rotation, the two pinions can be driven simultaneously using a double sided rack. This approach is found in a few antique singing bird boxes to provide either contrary or sometimes co-rotation (see Further Reading).

The other vital requirements were for a system to lock and unlock the carriage, combined with the need to move

Figure 5. Engraving in progress on the top of the instrument within the engraved recess at the edge.

Figure 6. Wall soldered in position and engraved with vertical grain.

Figure 7. Engraving of matched grain on the back.

Figure 8. Distortion of back prior to correction.

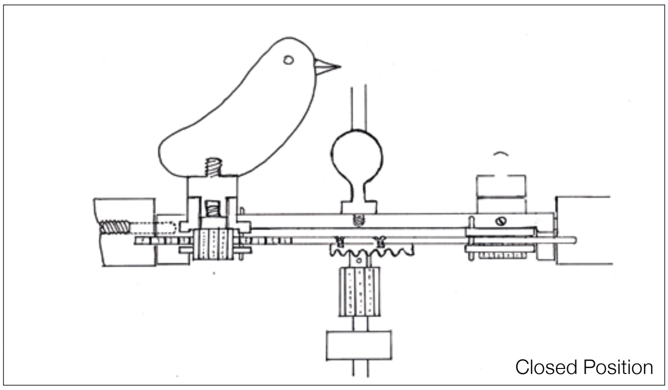

Figure 9. Diagram of racks and pinions.

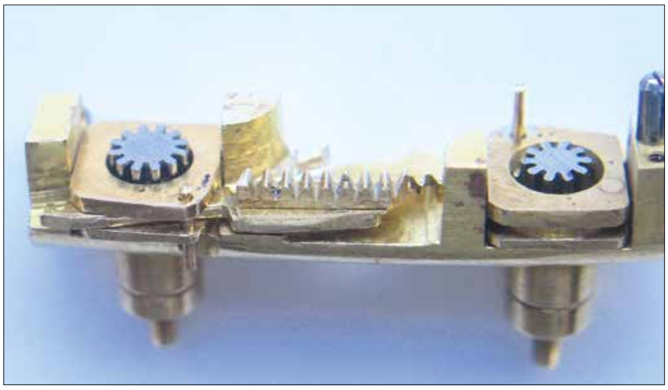

Figure 10. Double sided rack retained by pins and on a tangent to the two bird pinions, with the short rack attached.

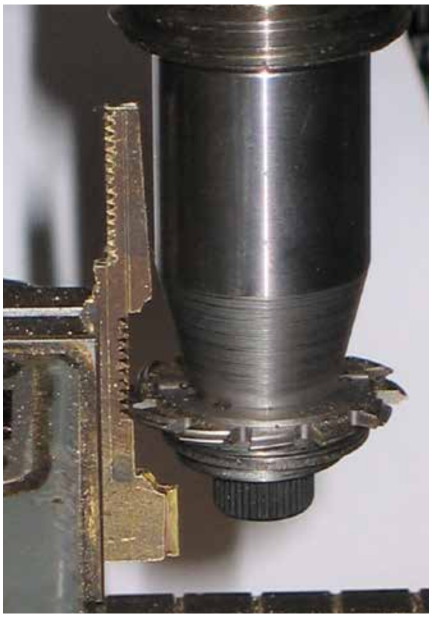

Figure 11. Milling teeth on second side of the rack.

Figure 12. Main base plate with lock and fly springs screwed in position.

this rack easily from side to side, as well as provide reliable engagement when the birds were released from their closed, i.e. lying, position.

To allow easy rack movement, I first considered a rack which could be pulled or pushed from one end as in some antique bird boxes, perhaps with a spring added for reversing it. Eventually I rejected this idea due to the need for adequate space at one end of the rack, which was not easily compatible with a carriage which rotated. Total rack travel was unlikely to be large in this space, but to achieve a reasonable degree of bird movement, the double sided rack travel needed to be as long as practicable. The limits were set by the need for the carriage to rotate to its closed position without impeding the rack.

The solution, with the birds being set to be in their closed/lying position, was to have the rack at its right-hand limit of travel. This would bring the left-hand end just clear of the end of the carriage, allowing unimpeded rotation. The right-hand end of the rack needed to extend beyond the right-hand end of the carriage, requiring the mounting block to be cut away to allow 90 degrees of rotation of the rack and carriage to the upright position. The rack could then be moved to travel to and from its left-hand limit. In this design, the rack has to be moved to its right-hand limit on closure. I decided to move the rack from beneath. This required a small pinion on the central operating rod to engage with another short piece of rack, attached in the centre of the double sided rack, **Figure 9**. On release (rotation) of the carriage, the short rack can come into engagement with the pinion below on the operating rod. The slight freedom of movement of the main rack enables the short rack to drop into engagement without jamming. This was a key feature of the design for this cramped space, which proved to be very successful.

The central operating rod was also chosen to serve the purpose of both releasing the catch for the hinged back and to release the bird carriage from closed to upright position.

Construction

The double sided rack was 0.8 mm thick and 34 mm long. The short rack, at 8 mm long, was made a little thicker to allow adequate depth for its two retaining countersunk screws through from the top side of the main rack. Both racks were in brass and cut with 0.25 module cycloidal teeth (tooth pitch was 0.79 mm), with a round-bottom wheel cutter. An important aspect was that because the double-sided rack ran across the tangent of the two bird pinons, the subsidiary rack had to be attached so as to move normal to the centre line of its drive pinion, **Figure 10**. Correct depth of engagement of the main rack with the bird-rotating pinions was achieved by each having a pin to retain the rack from behind. This allowed the rear face of the rack to be reduced (parallel with the line of action) until depthing was as it should be. It was different at each side because I chose to have a 10-leaf pinion on one side and a 12-leaf on the other (2.9 mm and 3.4 mm diameters respectively) to create different amounts of movement in each bird for the same rack travel. Correct engagement of the small rack with the driving pinion (10 leaf 0.25 module) was by fitting a shim beneath it. **Figure 11** shows the milling of teeth on the second side of the rack.

Each bird pinion (EN8 steel) was made with a short 10BA thread to screw securely into the brass bird stem; the stem ran freely in a round brass insert in the carriage. These two inserts, which were each secured with a steel side screw, each had a turned slot around their base to locate the rack and allow it to slide easily across the pinions. On the top of each bird stem a 1.2 mm thread projected to allow the bird body to be screwed into position.

Lock and fly springs were cut from sheet steel and shaped to fit within the available space, **Figure 12**. After hardening and tempering, considerable patience was required to make them fit and operate correctly with the correct stiffness. As an aid for the fly spring, it was fitted with an adjustable and lockable wedge between it and the base plate to allow its stiffness to be set more easily. Each spring was secured to the base plate with two 10BA steel screws.

The design of the release and re-locking system for the bird carriage was left until the bird rotation system was completed, to allow various options linked to the central operating rod to be considered. **Figure 13** shows the carriage and birds in the closed position. Reliable operation in the available space was paramount. The method adopted ensured that the carriage was captive by a brass pin driven from behind by a soft coil spring. The pin was located in a hole in the closed carriage and a flange at the other end of the pin located freely in a slot in the central actuation rod, so that when the central rod was pressed the pin was withdrawn releasing the carriage to rise smartly, driven by its strong wire spring, **Figures 14 and 15**.

The actuation rod ran through the two rigid pillars also attached to the sub-base plate, and between

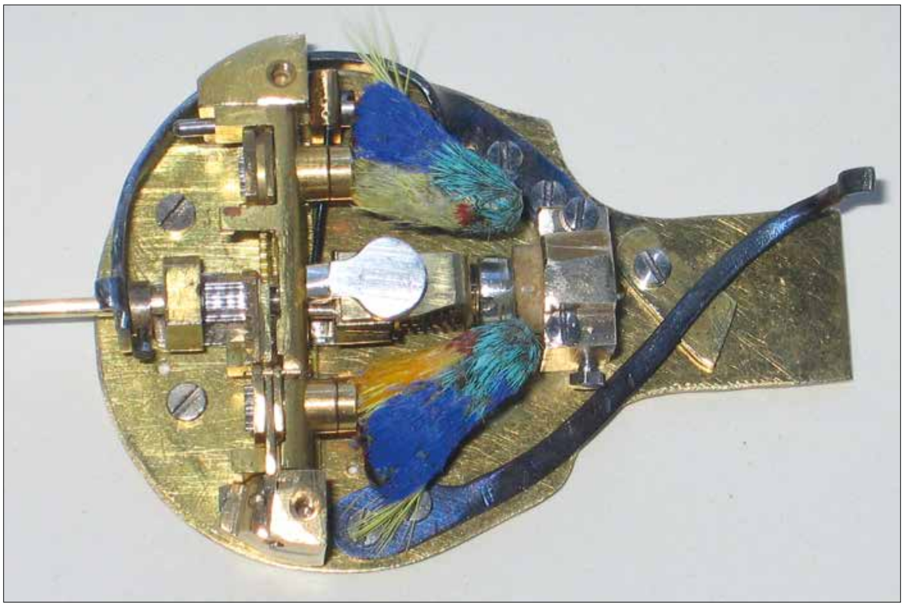

Figure 13. The carriage and birds in the closed position.

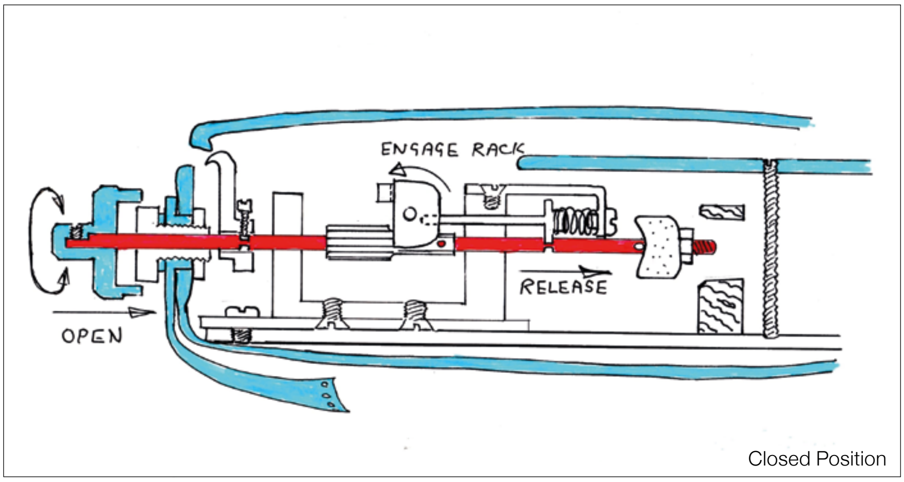

Figure 14. Diagram showing back and carriage release systems.

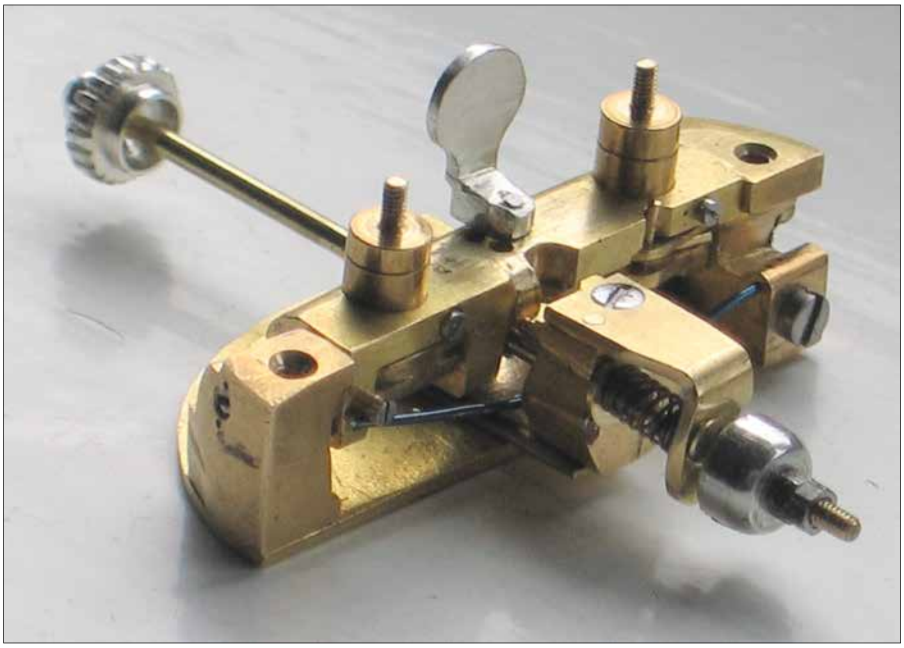

Figure 15. The carriage assembly on the sub-base plate, in the open position.

Figure 16. The open position showing silver operating button and the engraved and pierced silver grille (Hallmark 2019).

the pillars the rack drive pinion was pinned on to the rod. Clearly the position of each component on the central rod was important to obtain the correct sequence of actions. During construction, alignment of these pillars and other parts was with a rod running from outside the case through a central hole in the end wall, allowing them to be screwed on to the correct position on the sub-base plate and the main plate. The tailpiece which holds the ends of the strings is attached to the body by a 6BA steel screw and nut, drilled through for the actuating rod.

A final addition to the automata was a small device to create a bird-type noise, a suggestion from a friendly automaton maker and collector. He kindly gave me an original bird-call device to study, in which a pewter plug rotates and binds in a hardwood block, with a light dusting of powdered wood resin. This binding creates the tweeting noises. I adopted the same approach and fitted a miniature version. A wooden block is screwed on to the base plate, with its hole aligned with the axis of the actuating rod. On the end of the rod is a turned block of pewter, screwed on with a 12BA thread and secured with a small cross screw to prevent it from loosening. Correct positioning of the block is vital to allow adequate engagement on pressing the control rod. An occasional top up of resin dust helps, too.

It was very helpful to be able to prove the reliability of the complete carriage system on the sub-plate while I was considering how I would assemble the mechanism. On assembly, the main plate was first inserted, secured by a threaded brass rod through the silver inner body. The partly assembled sub plate was then added followed by individual components such as springs and so on. The strings were made from 18ct gold and drawn down to 0.4 mm. They were fitted in the annealed condition so that on fitting they would harden and set, and hopefully better retain their position in use. The bridge was made from 9 ct gold, shaped and pierced to look like a miniature of the real thing. Since it could be easily dislodged, two special measures were taken. Firstly, the bridge had a slightly wider than normal base soldered on. Secondly, just below each of the nicks in the bridge for the four strings, a small hole was drilled through which the strings were threaded. This provided a convincing appearance but with increased security for both bridge and strings. A silver tab was screwed into the top of the carriage to provide a finger piece for use during closing.

The pierced and engraved silver grille, attached with two silver screws, hides the mechanism but allows the two birds to appear from their repose. Because the beaks were chosen to be rather prominent, the starting position is with the birds slightly angle outwards to prevent their beaks fouling.

The birds are solid brass with thin copper wings soldered on, the whole then covered in a layer of zephyr (thin fish skin), painted an ochre colour. The beaks were filed up from pieces of bone and glued in. Lots of very small layered feathers were glued on to the bodies, followed by attaching mini ruby watch end stones for eyes. One bird is slightly larger and more brightly coloured than the other. This is intentional, as it is a wiser older bird which has a 12 leaf pinion and moves less.

Safe Operation

The sequence of operation is therefore as follows:

1. Carefully remove the violin from the case.
2. Hold the body between finger and thumb, clear of the violin back, and avoiding the strings. Press the button gently to release the lid catch and allow the lid to fly open.
3. Press the button more firmly, releasing the bird carriage.
4. Rotate the button carefully, being aware of the limits of safe travel to cause rotation of the birds.
5. Press the button firmly and rotate at the same time. This will engage the pewter plug and make the tweet noses.
6. Rotate the button to bring the birds and rack to the right-hand limit.
7. Press the button firmly whilst at the same time press on the central finger piece causing the birds to fall, and engage the carriage lock. The finger piece ensures that there is no need to press on the feathered birds themselves.
8. Release the button.
9. Press on the lid at the tail piece end with two pairs of fingers to engage the case lock spring, taking care not to disturb the strings, bridge or tail piece, **Figure 16**.

Postscript

To protect the finished piece, a violin-style case was made out of thin hardwood. This was covered with very thin stained hide, lined with plush velvet and fitted with silver hinges and a special locking clasp. These were all attached to the thin wooden case with 1 mm diameter silver nuts and bolts, as a secure means of attachment, **Figures 17 and 18**.

I also made a duet music stand out of sterling silver as a complementary accessory for the completed model. This is to a similar scale. It is essentially Victorian in style and has a tri-form base, a round stem with means for vertical adjustment, supporting a pair of hinged frames for sheet music. Each frame has a pair of recessed hinges at the top, and a hinged bracket to support it in various positions, **Figure 19**.

Further Reading

Geoffrey T. Mason, *Mechanical Singing Bird Tabatieres* (London: Robert Hale, 2000). ISBN 0 7090 6303 2

Christian Bailly, *Oiseaux de Bonhear (Flights of Fancy)* (Antiquorium, 2001), ISBN 2 940019 28 2

These excellent books are now available only second-hand.

Figure 19. Silver duet music stand (Hallmark 2019).

Figures 17 and 18. The finished violin and case.