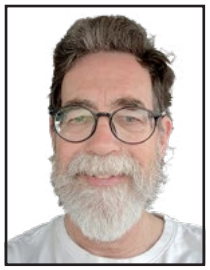


Motorizing hand-cranked automata

Automatic action for public exhibits

by Chris Hughes • Owen Sound, Ontario, Canada • Photos by the authorr

This is a discussion of how I motorized my cross-country skiing automaton, *Happy Trails* (**photo 1**), and how you can do the same for your hand-cranked pieces. *Happy Trails* is one of three automata that I motorized to display for sale at a local art gallery. It was important to me that the process be fully reversible so that the automata could be returned to hand-cranked operation if so desired, without leaving any visible marks on the box or mechanism.

Why motorize and enclose your hand-cranked automata?

Motorizing and enclosing an automaton in an acrylic or glass display case allows it to be publicly displayed, while minimizing the potential for damage to the piece. It is also important to enclose a motorized automaton to prevent someone from sticking their fingers into a now potentially dangerous mechanism.

Motorizing and enclosing an automaton may also make the piece more saleable to well-heeled clientele who are more used to pushing buttons than turning cranks. I would also venture that there is some "museum effect" in that, by enclosing, and thus safeguarding, an object, it is regarded as more valuable by the viewer.

1. Motorized *Happy Trails*.

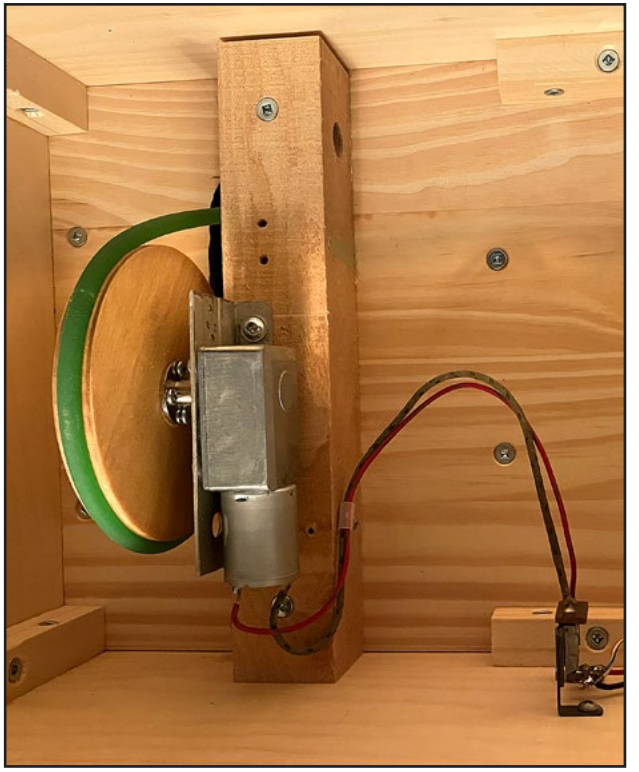
What sort of automata can be motorized?

Assuming you are planning to display your work in a public space, I would suggest only motorizing automata with robust mechanisms that you are confident will withstand repeated cycles. This would be less of an issue if you are only anticipating private use.

My first two automata had wooden gears set at 90 degrees to each other, rather than the more robust pinwheel gears I used in subsequent designs. Therefore only the later designs were considered as candidates for motorization.

I also like to avoid wood-on-wood rotational contact, where wooden shafts pass through wooden supports or whose ends are socketed in supports, as these are prone to friction and wear. I am currently using ½" (12.7mm) hardwood dowel and

2. Motor, motor flange, 12-volt charger, and timer.



3. The motor installed in the motor box.

bushings made from 17⁄32" (13.48mm) brass tubing to reduce friction in these areas.

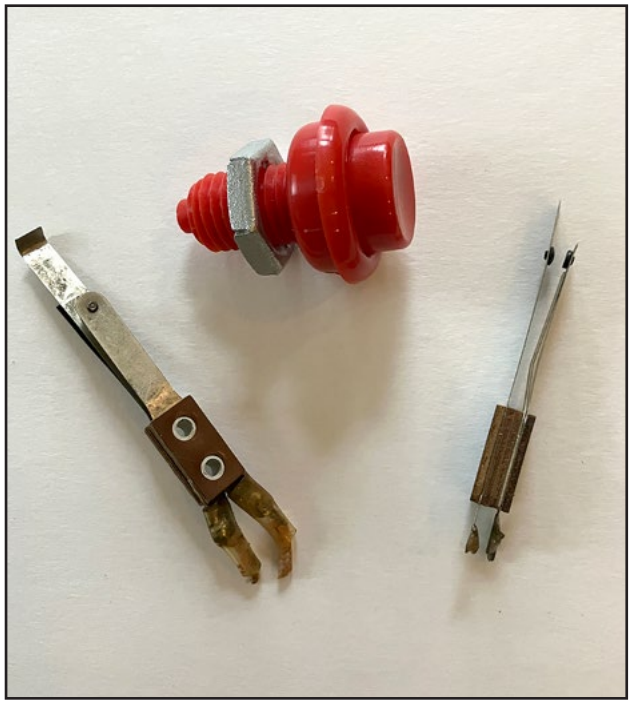
Motors

My design utilizes a 12V, 40 RPM (revolutions per minute), DC gear motor, controlled by an adjustable timer that is activated by a momentary switch, and a 12V wall-plug transformer (**photo 2**).

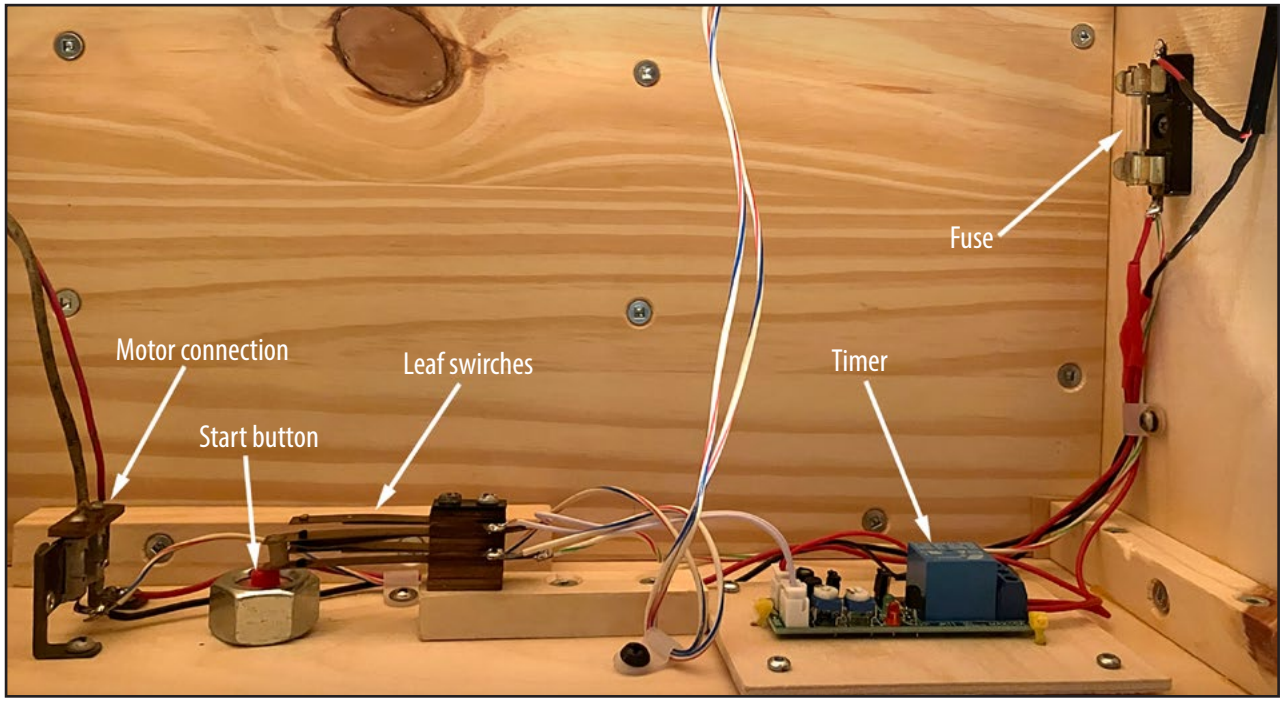
I went with 12V gear motors, as they seemed to have adequate torque, and 12V transformers are inexpensive and readily available. I initially tried a 12V motor that I found at a local surplus store but it turned out to be distractingly noisy, so I sourced the motors I now use from Amazon.

Gear motors come in a variety of RPMs. I selected 40 RPM as a middle ground. In testing one of the automata I was planning to motorize, I found that I was cranking the handle at about 60+ RPM by hand. In operation, I found that the 40 RPM motor actually delivered 30 RPM under load on the *Happy Trails* automaton. The final cranking rate can be adjusted somewhat by varying the diameter of the pulleys on the motor and the crankshaft. The direction of the motor rotation can be changed by simply reversing the polarity of the power wires.

4. The charger's electrical connector, located outside the motor box.



5. Pinball flipper button and leaf switches.



6. Motor connection, start button, leaf switches, timer, and fuse holder.

The motors I use come with 3mm (.118") threaded mounting holes, so I also ended up buying a bag of 3mm bolts online, as these were not readily available locally. I've mounted the motors on pieces of rigid sheet metal attached to wooden supports (**photo 3**).

I also purchased 6mm (15⁄64") mounting flanges online for attaching Baltic-birch drive pulleys to the motors. The mounting flanges are held onto the drive shaft with supplied Allen screws and Allen wrench.

Transformers

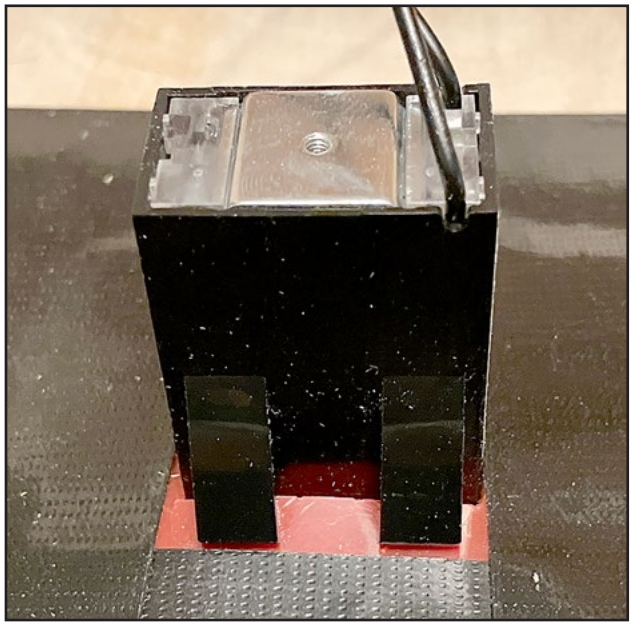
I found 12V, 1.5 amp wall-plug transformers at a local surplus store. These have a common male socket (2.1/5.5mm [.082/.216"]) at the end of the cable. The same store also had some inexpensive cable adaptors from which I was able to borrow the corresponding female socket. This allowed me to install the socket outside the motor box so that, in the event the wall charger fails, I can replace it without having to open the motor box (**photo 4**).

Timer options

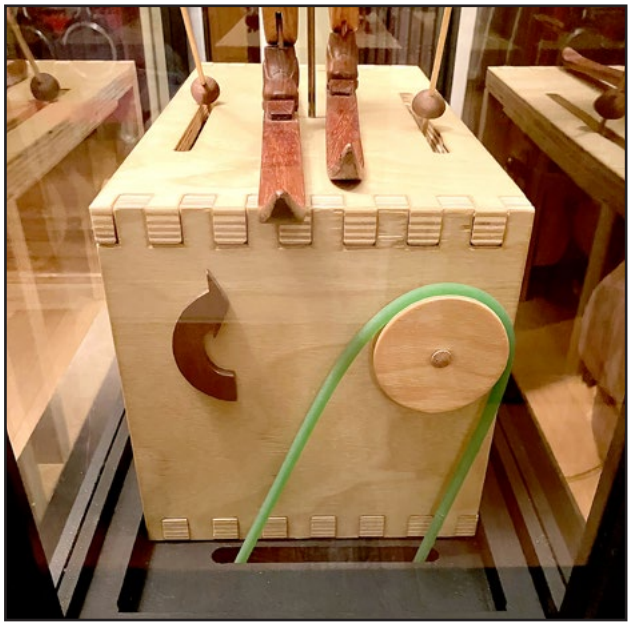
Using a timer allows the observer to put the automaton into motion, then step away to watch it from a distance, rather than being tethered to it as with a hand-cranked automaton. It also takes the distraction of the observer out of the frame for others, allowing the automaton to take center stage.

I purchased some inexpensive adjustable 12V timers from Amazon that can be set from a few seconds up to 15 minutes of operation. One of the nice options with these timers is that they can be used to start and stop the movement with a push of the button, allowing the user to select the resting pose for the figure. While the 12V timers are easy to program, care must be taken during installation, as reversing the polarity is liable to roast the circuitry.

After some experimentation I settled on a



7. 12-volt electromechanical counter mounted so that it can be read from beneath the motor box.



8. A pulley replaces the hand crank on *Happy Trails*.

20-second operating cycle for each push of the button. This seemed to be a good compromise between showing what the automaton could do while limiting undue wear on the mechanics of the piece.

The large red buttons that I used are pinball flipper buttons, available from a variety of pinball-supply companies. These are spring loaded and push against a leaf switch, also from a pinball machine (**photo 5**).

Alternatively, you could use any momentary-contact switch to either start a timer or connect the power directly to the motor if you want to go without a timer. As a safety precaution, I included a fuse holder and a 2-amp fuse in the circuit ahead of the switch, timer, and motor (**photo 6**).

Counters

As my automata were going to be displayed in the gallery for an entire month, I was curious to know how much use they would see, and if this amount of exposure would result in any visible wear or possible breakdown of my mechanisms. To that end I sourced some 12-volt electromechanical counters from Amazon so that each push of the button and subsequent 20-second cycle would be recorded.

A second switch on the start button triggers the counter each time the button is pressed. The counter is attached to a piece of plastic that is, in turn, taped over a hole in the bottom of the motor box so that the counter could be read without opening the box (**photo 7**).

Parts list and approximate cost (in Canadian dollars)

- 12-volt transformer: $10 each
- Counter: $10 each
- Timer: $9 each
- Pinball flipper button: $5 each
- 3mm x 8mm bolts: $10 per 100
- Motor: $26 each
- Motor flange: $14 for 4
- Green 6mm polyurethane belt: $12 for 10m (33')
- Clear 2mm acrylic sheet: $125/square meter ($11.60/square foot)

Pulleys

I made pulleys out of 12mm (15⁄32") Baltic birch plywood by first cutting circles on my bandsaw with a DIY circle jig. I then smoothed the outside edge on a small stationary belt sander. The circle jig requires a small hole to be drilled in what will become the center of the pulley. I then enlarged this hole to take a bolt that I secured with a nut. This I chucked into my drill press and used a securely held round file to create a groove in the outside edge of the pulley blank. I was able to position my dust collector so that it captured most of the resulting sawdust.

It is also possible to make a pulley out of three pieces of thin plywood, with the outer two cut to a slightly larger diameter. However, I think the grooved pulleys I made with the round file provide more surface area between the pulley and the drive belt.

You will need one pulley for the drive motor and one to replace the hand crank on your

automaton. This is an opportunity to adjust the desired speed of your project. If the motor pulley is larger than the crank pulley, the RPMs will be higher; if it is smaller, RPMs will be reduced.

In the case of *Happy Trails,* I used a 110mm (4 21⁄64") motor pulley and a 60mm (2 23⁄64") pulley on the automaton (**photo 8**). This increased the 30 rpm of the motor pulley (under load) to approximately 55 RPM at the hand crank pulley. *Happy Trails* was designed with an approximate 5:1 rotation reduction from hand crank to final drive through the use of two eight-tooth gears and two 18-tooth gears. The motorized version has a resulting final drive of approximately 11 RPM to complete the cycle.

Drive belts

As I was unable to source an adjustable rubber-link drive belt for use on small pulleys, I used round polyurethane drive belt material that can be joined using a soldering iron. I bought some textured 6mm (15⁄64") green belt and some smooth 5mm (13⁄64") black belt because I liked the look of it better (**photo 9**). Unfortunately, the smooth black belt proved to be more prone to slipping if there was any resistance in the mechanism, so I ended up using the textured green belt on *Happy Trails*.

I found the polyurethane belts fairly easy to make, with a little practice. I clamped a small soldering iron with a beveled tip onto my work bench. Once I had cut a piece of belt to the desired length, I heated both ends at once and quickly pushed them together until they bonded. I had a fan blowing as I bonded the belts, as the process creates a little smoke that might not be very good for you. The excess rubber that squeezed out around the joint was carefully trimmed off with a small utility knife.

The belts work well with a bit of slack. If they are the wrong size, they can only be made shorter, so I tended to make them a bit long, then cut and re-bonded them as necessary. I measured them by wrapping an uncut length around both pulleys and marking them a little larger before I cut them.

Parts list

Most of the parts mentioned in this article are fairly generic and are widely available in slightly different forms. The descriptions of each part are listed below. I suggest that you use these descriptions as key words for your own searches to find suppliers that you feel comfortable patronizing.

12-volt transformer: 12V, 1A, five-foot power supply adapter, AC 100-240V, 50/60Hz to DC 12V, 1,000mA, 12W. Adapter cord for LED strip lights / keyboard / BT speaker / router monitor / webcam CCTV camera, UL FCC
Counter: Electronic pulse counter, electromagnetic counter, 6 digits pulse counter, electronic industrial totalizer with no clear function counter (12V)
Timer: DC12V, 0-15 minutes adjustable timer switch module, delay On/Off timer, delay switch module
Pinball flipper button: Cabinet flipper button, 1 3⁄8" shaft
Leaf switch: Williams/Bally flipper leaf switch, double contact
3mm x 8mm screws: Uxcell M3x8mm machine screws, pan phillips cross-head screw, 304 stainless-steel fasteners bolts, 100 pieces
Motor: DC 12V reversible, high-torque turbo, worm-gearbox reduction electric motor, 40 RPM
Motor flange: 4 pcs, 6mm flange coupling connector, rigid guide model coupler accessory, shaft axis fittings for DIY RC model motors
Green 6mm polyurethane belt: Polyurethane round belt, rough surface, green polyurethane belt for drive transmission (6mm x 10m)
Black 5mm polyurethane belt: Harfington polyurethane round belts, 5mm dia x 16.4' (5 meters), smooth surface, PU polyurethane belt for drive transmission, black
Clear 2mm acrylic sheet: Optix .080" x 30" x 60" (2.03mm x 76.2cm x 152.4cm) clear acrylic sheet

Cabinetry

The motor box to go under the automaton was made from pine and sized so that the acrylic enclosure above would not interfere with the movement of the automaton. The

depth of the box was determined by the motor placement and the diameter of the motor pulley, with a little room to spare.

The motor was mounted to the underside of the box's deck, while the automaton box was mounted to the top side with screws through the deck. Motor wires plug into a connector mounted inside the motor box so that the deck could be removed during design and assembly.

The acrylic enclosure was the most expensive part of the motorization project. Due to cost considerations I used 2mm (5⁄64") acrylic sheets, the thinnest that I could buy locally. The *Happy Trails* enclosure required 1.07 square meters (11.5 square feet) of acrylic sheet. Due to the thinness of the acrylic sheet, I decided to join the sides with wooden edge channels that I made on my table saw.

I may try using super glue (CA) to make a box without edge channels next time. One advantage of using the edge channels was that it gave me a way to secure the acrylic box to the motor box without having to drill holes close to the edge of the thin acrylic sheet.

9. Polyurethane drive belts and a soldering iron with a beveled tip for joining cut ends.

Conclusion

I'm pleased to report that, while my three motorized automata were on display at the Artist's Co-op in Owen Sound, Ontario, for the month of November 2023, they each endured 450 to 500 twenty-second cycles with no discernible wear or damage. Alas, the exhibit did not result in any immediate sales but it did result in some excellent exposure, including an article in the local paper.

LINKS

See the motorized *Happy Trails* here: *https://youtu.be/zJevx3rCXtU*
Author's website: *https://Cphughes-art.ca/*
To see all of this issue's videos in one place, *click here*