A hat by milliner Kim Fraser, which was formed over a reproduction block created by author Athene Wright using 3D scanning and printing technology.

Inset: The original hat from Kim Fraser's personal collection. | All photos courtesy of the authors.

Thoroughly Modern Millinery

Replicating a 1940s hat using 3D fabrication technologies

BY ATHENE WRIGHT AND RACHEL E. POLLOCK

There are as many ways to make a hat as there are to wear one. One such method is called blocking, a process in which felt or woven straw is steamed and molded over a rigid block to shape it. Historically, most hat blocks were carved from wood, although one may find examples of antique blocks cast from metal (for mass production beginning in the 1920s) or papier mâché (for a sample collection to gauge interest in a trendy new style). Hat blocks continue to be carved from wood but are also sometimes sculpted in rigid foam or created from vacuformed plastic.

In blocking a hat, the material begins the process as a hat body—a partially formed shape similar to a felt or straw bucket or a floppy brimmed style—and by the end, is stiffened and trimmed into a finished hat design. Typically, with this method, a large portion of the shaping of the hat is imparted by the curves and planes of the block itself. Unfortunately, using a hat block is destructive over time, as the heat, steam, and tacks used in the blocking process degrade the piece over time. Humidity causes the wood to split and crack, and heavily used blocks will crumble at the base from the tension of the tightly stretched ropes and the numerous pin-holes in the wood.

A damaged antique hat block.

As a result, many of the antique and vintage hats made using this technique cannot be easily reproduced. Their blocks have since been destroyed by use or lost to time. Hat blocks, particularly in vintage styles, are an expensive commodity and significantly rarer than the hats made on them. If well cared for, a single block can be used to make hundreds of hats over the course of its lifetime.

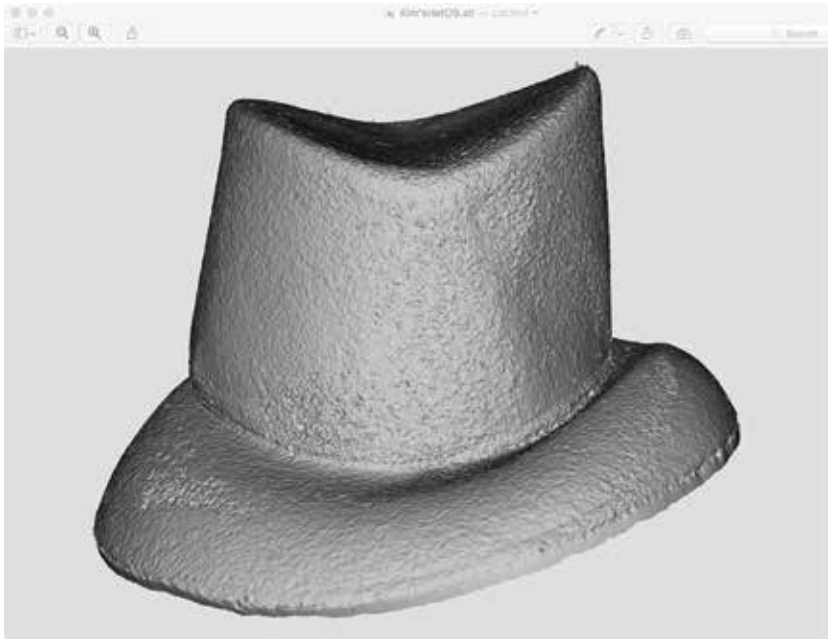
If a milliner owns a hat block and wishes to make a reproduction of it, they might create a mold of the block with plaster bandages and cast the shape using a material such as two-part foam or a wood-composite casting resin. A milliner in possession of a unique blocked hat who lacks the block on which it was made would find it difficult, if not impossible, to take a mold of the felt or straw hat without the risk of damaging it.

A new 3D fabrication technique, however, allows for the creation of highly accurate block reproductions from an extant hat using a digitized model from which a block can be reverse-engineered and cut from wood on a CNC router. Unlike other block reproduction techniques, blocks made using this method should have utility and durability equal to wooden blocks carved using more traditional methods.

Creating the Digital Model

The prototype of this hat block reproduction process began when milliner Kim Fraser of Hatnip Hats in Chapel Hill, North Carolina, approached us with a remarkable 1940s-era hat from her personal collection. She knew of our prior research on digital technologies in millinery applications and had heard of our need for a striking vintage blocked hat for the next phase of the study. Her hat was an excellent candidate for this project as its style derived predominantly from its structure and not from the manner in which it was trimmed.

UNC-Chapel Hill student Athene Wright (MFA '23) began the process by 3D scanning the hat and importing the data into Fusion 360. The scan served as a starting point for developing the block and allowed her to reproduce its scale and proportion with utmost fidelity to its original form. In theory, the shape of a hat block is essentially the same as that of the hat it produces. In practice, a block often has necessary features such as grooves for blocking ropes (known as rope lines) that do not appear on the finished hat. In Fusion 360, Wright cleaned up the scan by smoothing the shape and altering the



The raw tiff scan of the hat.

The digitally edited scan.

Using the CNC router to create the pieces of the final version of the hat block in wood.

3D model to fix minor damage present in the original hat. The ability to repair damage reflected in the scan means that even torn and moth-eaten hats can be candidates for block reproduction.

Once Wright had a clean digital model of the hat that reflected its original shape, she introduced features necessary for a hat block that would not be part of a finished hat—the rope lines, a pedestal base, and a tip press (or tolliker press). The tip press is a shaped piece of wood reflecting in positive some of the negative spaces in the block and is used to force the hat medium into the divots in the block.

Having repaired the scan and modified it to reflect the shape of a hat block, Wright sliced the model laterally into four two-inch layers. This slicing was made necessary by the technical constraints of the CNC router available—a ShopBot PRSstandard. This particular CNC had a relief maximum of two inches and was not a five-axis machine, making it impossible for the equipment to make undercuts. After a consultation with digital fabrication expert Sallye Coyle from ShopBot Tools Inc., a production plan was created. By slicing the block into layers, Wright was able to arrange the undercut pieces upside down, rendering them no longer undercut.

She created two prototypes of the block in closed-cell foam before cutting it in wood. This allowed for adjustment to points of scale and ensured that the final product would turn out correctly proportioned with no cut-path issues. During prototyping, several holes were added to the design through all the layers to facilitate the accurate lining up of the pieces with the aid of dowel rods.

Once the digital design was refined, the final product was cut from a two-inch-thick slab of bass wood. Hat blocks were historically made using bass, balsa, and poplar wood. These woods are ideal for blocks because they are dense yet soft enough to easily pin or tack into. Bass wood was chosen for this project because it is slightly harder and more durable than balsa. (The finish on the block turned out rougher than anticipated. In retrospect, poplar might have been the best choice of wood for this process.) Once cut, the pieces were stacked using dowels through the alignment holes to maintain positioning and adhered together with wood glue. The surface of the wooden block was then sanded and sealed.

Once the block was completed, milliner Kim Fraser blocked several experimental

The completed reproduction hat block (left) and the reproduced block in use (right).

hats on it. Her feedback helped to assess the quality of the results as a functional hat block. The primary issue with this initial bass block was the slightly rough surface (despite significant sanding) mentioned previously. This did not, however, prevent Fraser from using it to successfully block the hat multiple times in parasisal straw. Several coats of polyurethane could further smooth a bass block surface after carving/sanding in future.

Refining the Process

We have used this block with fur felt, wool felt, and vintage straw hat bodies. All materials resulted in faithful, lovely reproductions of the original vintage hat shape. In future carves, we will focus on continued improvement of the sanding, sealing, and finishing. Collaboration with an experienced traditional woodworker is another goal for further research.

Overall, this process was effective and accurate for the reproduction of a hat block made from an extant vintage blocked hat. The final product is a functional hat block that can be used to faithfully reproduce a unique 1940s era hat for hundreds of iterations. This project demonstrates that modern technologies such as 3D scanning and CNC routing have a place in the centuries-old world of millinery. Its success has inspired many possible other applications of this process, from the leather "Commedia dell'Arte" masks (Venetian masks) sculpted on wooden matrices to historical restoration and archiving.

Athene Wright is a second-year graduate student. She received her undergraduate degree in non-Western history from the University of North Carolina at Chapel Hill. Since graduating, she has worked at Barrington Stage Company, The Santa Fe Opera, and most recently at Bethany Joy Costumes. Her stitching credits include Angels in America, Frozen, King Kong, Skintight, Tootsie, Beetlejuice, A Christmas Carol, *and* Diana *(Broadway);* Gemini Man, Fosse Verdon, *and* Dickinson *(film and television); and Martha Graham, Alvin Ailey, and Janet Jackson's dance troupe (dance). http://athenewright.com/*

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