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Textiles and Electronics

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Edited by Ebru Kurbak

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Stitching Worlds: Exploring Textiles and Electronics
Edited by Ebru Kurbak

This book results from the arts-based research project *Stitching Worlds* carried out between May 2014 and June 2018 at the Department of Industrial Design 2, University of Applied Arts Vienna, and is published in conjunction with the exhibition titled *Stitching Worlds*, on view at the Angewandte Innovation Laboratory (AIL), Vienna from April 9 through April 27, 2018.

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Project Outline and Team

This book results from the arts-based research project *Stitching Worlds* carried out between May 2014 and June 2018 at the University of Applied Arts Vienna.

Stitching Worlds blends the territories of textiles and electronics by investigating textile technologies as controversial means for manufacturing electronic objects. The investigation was conducted with critical and artistic intentions through the creation of past-, present-, and future-tense narratives. What if electronics emerged from textile techniques such as knitting, weaving, crochet, and embroidery? How would technology be different if craftspeople were the catalysts to the electronics industry, via textiles manufacturing? The project expands on the tension created by the use of highly traditional textile techniques for making functioning electronic technology. By revealing unexpected potentials of often-undervalued knowledge and skills, *Stitching Worlds* questions commonly accepted societal value systems and their implications.

The research was organized in four parallel and interconnected tracks: (1) hands-on "experimentation" on creating textile-based electronic components, (2) "theoretical study" into the broader, "transdisciplinary topics of the project, (3) continuous speculation" through prototyping objects and installations, and discovering new and stimulating forms of artistic expression, and (4) "reflection and dissemination" towards understanding our own practice within the larger field of contemporary modes of artistic production.

The project was carried out in exchange with large networks of collaborators, designed to trigger the artistic creation of objects and installations that expose imagined, plausible-fictive worlds of textiles and electronics. The material outcome was exposed to a critical audience through the exhibition of the same title that accompanied this book.

Core Team

Ebru Kurbak, *Principal Investigator / Project Leader*
Irene Posch, *Key Researcher*
Matthias Mold, *Electronics Engineering Assistant*

Collaborators

Anthony Dunne and **Fiona Raby**, The New School (New York, US), formerly School of Design, Royal College of Art (London, UK)
Thomas Geisler, Werkraum Bregenzerwald (Andelsbuch, AT), formerly MAK (Vienna, AT)
Lars Hallnäs, Swedish School of Textiles, Smart Textiles Design Lab, University of Borås (Borås, SE)
Arif Kurbak and **Tuba Alpyıldız**, Department of Textile Engineering, Dokuz Eylül University (İzmir, TR)
Werner Pramel and **Heidemarie Hohenbüchler**, Department of Art and Design, HTBLVA Spengergasse (Vienna, AT)
Participants of eTextiles Summercamp, 2014–2015 (Paillard, FR)

Guest Artists

So Kanno (Berlin, DE / Tokyo, JP)
Hannah Perner-Wilson and **Mika Satomi**, KOBAKANT Art Collective (Berlin, DE)

External Experts

Onur Akmehmet, *Economics* (İstanbul, TR)
Susanne Frantal, *Embroidery* (Vienna, AT)
Sophie Fürnkranz, *Textile Restoration and Metal Threads* (Vienna, AT)
Mark Miodownik, *Materials Science* (London, UK)
Jussi Parikka, *Media Theory* (Southampton, UK)
Martin Schneider, *Craft and Computation* (Mainz, DE)

Critiques

Ekmel Ertan, amberPlatform (İstanbul, TR / Berlin, DE)
Emiko Ogawa and **Hideaki Ogawa**, Ars Electronica Future Lab (Linz, AT)

Fiona Raby

Foreword: Stitching Worlds, Building Walls, Designing Drones

Somehow, in the sinuous and fluid world of textiles it is hard to imagine aggressive knitting, militarized embroidery, or confrontational crochet.

Why do I say this? It's New York City and we are designing drones. These things are on my mind. As design practitioners, designing, making, thinking, writing, happen together.

I live on a different continent now, dislocated from a previous life. During the four years of *Stitching Worlds*, so much has changed. A new chorus began—women in pink knitted hats took control and made a stand while rich self-absorbed men blasted cars into space, designed ridiculous walls, demanded processions of military spectacle in urban streets, and proposed guns for teachers in schools. New borders, partitions, and divisions appeared, shaped by language, in places where previously there were none. Intolerance grew and with it a coercive polarization.

Outrage proliferates.

And in Vienna, two small new lives began; an instant family and new priorities. These four years seem to straddle a period of time that could have been a decade, or even two.

In this shifted, altered world, complex and contradictory spaces are no longer tolerated. The world became smaller, coarser.

Why would you crochet an electrical switch?
Why would you embroider a 350 centimeter-long computer with gold thread?
Why would you knit a radio jumper?
Why would you create knitcoin, an alternative digital currency?

These are not easily recognized technological infrastructures.

Stitching Worlds fires the imagination. If the electronics industries had been shaped through traditional textile techniques, using textile machines, would craftswomen have produced drones? I'm not so sure, but I know if they had, they would be very different. Perhaps these flying machines would have been more awkward and less aerodynamic, slightly unconventional, distinctive, and more convivial, with the purpose of gathering people together for social and even intellectual pleasure.

Sometimes the world I find myself in feels like it is a given that it is the only one possible, the only viable and realistic one, and any contemplation of alternatives is perceived as foolish or whimsical. "Unrealistic" can mean "undesirable" making the creation of undesirable realities even less possible for everyone. Is imagination under threat? Is imagination just too unrealistic?

Who decides what is real and what is not?

The drones we are designing are not invasive, aggressive, nor militaristic. We study contemporary technologies closely—computer-controlled autonomous vehicles, sound cannons for crowd dispersal, unmanned aircraft for intrusive observation and bomb delivery. Dystopia leaks into everyday living. An invitation to an exhibition in London arrives by email: HOPE TO NOPE, Graphics and Politics 2008-2018. Three words capture a decade of deterioration.

Something as small as changing an N back into an H is a playful typographic form of resistance. Spaces in which to move creatively are getting smaller. These alternative flying machines use the latest autonomous capabilities, but rather than militaristic forms, these machines are unrealistically large and voluminous, delicate, light, quiet. Awkward but not inelegant, they move gracefully. Forms that perhaps should never be airborne hang in the air. The sound cones held beneath use their technological strength to whisper with precision, the voice, calm and gentle in the ears of the walkers as they move beneath, quietly absorbed in rural peacefulness and in each other's company. The simple act of walking together removes us from everyday realities; minds are open again.

In a noisy, attention-grabbing world, just how quiet and understated is it possible to be? How possible is it to exist and flourish quietly, industriously, and with determination? Tireless, slow, meticulous, persistent, and with nuance. There are many forms of resistance. Tucked away on the second floor of the Di'Angewandte, is the *Stitching Worlds* studio. A portal into an alternative world of alternative values, a time pocket of focus and detail. A place I took great pleasure in visiting, to sip tea and discuss ideas, surrounded by machines for sewing, for computing, for knitting, for testing circuits, a 3D printer, multiple colored threads, of copper, of gold, of wool. Crochet patterns with relays and beads that flicker on and off, strange wooden test structures with multiple spools clamped to tables and surfaces strewn with odd-looking

bespoke tools—fingernail strippers, ohm tailor tapes, etextile tailor scissors, multimeter probes. Fibers that contain sound, fibers that carry current. The latest experiments with handcrafted textiles for electromechanical relays to create a functioning 8-bit universal computer. Textiles, computing, electronics, and two incredible craftswomen and their team come together. And very different kinds of products, objects and outputs take form. Celebratory, joyful, inspirational.

In New York we design airborne objects that drift slowly across landscapes. Enzo Mari's book of furniture, *Autoprogettazione,* is closely studied—the last thing one would consider when thinking of militaristic drones and precisely why now, it takes on new significance. Modest materials, awkwardly composed, in slightly idiosyncratic combinations—these are not engineering solutions. Mari introduced open source before open source was even an idea; he was motivated to provide access to processes of making for everyone. What if as designers we could provide access to processes of imagining? Ideas that challenge and expand possibility, opening up alternative realities that previously would have remained unimagined.

The computers, radios and sound devices, produced within the *Stitching Worlds* studio do not fit within the values and norms of the world that exists now, at least in Europe. Does this make them unrealistic? They actively and defiantly resist, by attempting to expand the rapidly narrowing choices provided by current technological and economic frameworks. Instead, they expertly hint at a different world shaped and materialized by different values.

Perhaps, as designers, unreality is the only thing we have left—a tool for loosening the grip of the reality we find ourselves within, to help think beyond known frameworks, and to shift our thinking. In this way, design might begin to contribute to a proliferation of multiple alternative worlds existing in the collective imagination, enlarging it to provide a richer conceptual space of imagining for everyone. *Stitching Worlds* does this with great finesse.

New York City, February 2018

Ebru Kurbak

Introduction: Art, Technology, and Fancywork

Every year, around thirty brilliant people from around the world meet for the eTextile Summer Camp at the Paillard Centre d'Art Contemporain in Poncé sur le Loir, a contemporary art center in a small village at the entrance of the Loire Valley in France. The participants, who spend their days knitting, weaving, crocheting, and printing circuits, identify themselves in different ways; artists, crafters, makers, tinkerers, educators, performers, textile designers, fashion designers, interaction designers, technologists, engineers. Seeing how our material and technical interests as well as our daily professional practices overlap within such a diverse group, brings out the questions typical to art practices at the intersections of art and technology, art and science, and art and crafts: What is it that makes what we do at *Stitching Worlds* particularly art research? How can we describe the sensibility that shapes and frames our work as art practice?

Indeed, some of the practical experiments that were carried out during the *Stitching Worlds* project easily could have taken place at a global hardware company, or in the medical, clothing, and fashion industries, on the way to invent the next killer "wearable" thing. And some of them could have taken place at a knitting circle meet-up in the neighborhood wool shop on a Wednesday evening. We all know that today we can no longer identify art through material, format, technique, or context. Instead, some of us artists are now directed by our "intentions." What sets *Stitching Worlds* apart—and also makes it art—is thus the intentions behind the project. Artistic and critical intentions that shape creative processes that "do something to us, set us in motion, alter our understanding and view of the world, also in a moral sense."[1] Intentions to which we hold on throughout the whole research process, by letting continuous self-reflection guide us.

One of the main premises of the project is a refusal of the typical, uncritical understanding of research and invention as progressive, utilitarian, and therefore unbiased processes. There is, of course, plenty of critical daily discourse on whether or not an invention might be used maliciously, as well as possible social, cultural, ethical and environmental effects of an end product that enters our daily lives. What gets less attention is that every invention is highly political already in the making process it introduces, in resonance with the Foucauldian sense of knowledge and power. Every technological invention comes with a production process, and involves particular skills, materials, tools, and techniques. Inventors make deliberate

1
Henk Borgdorff, *The Conflict of the Faculties: Perspectives on Artistic Research and Academia* (Leiden: Leiden UP, 2012), p. 45.

choices about their making processes, which in turn either keep or reorganize the existing societal structures. In industrial research, the choices are often made according to profit-oriented values. In artistic research, however, the defining criteria can be set based on values other than financial profit.

Thinking of ornamental needlework as a component of an art/technology project is not something we take for granted. The medium of textiles was deliberately chosen because of the extremely provocative medium it provides in challenging our assumptions, expectations, and desires about what constitutes technology. Textile crafts, which are often associated with the non-political context of the home, are not only perceived as feminine but also as non-ideological, non-intellectual, and therefore trivial. The utilization of these techniques in the production of currently worshipped electronic technologies is intended as an experiment that might reveal "the distribution of the sensible" in Ranciere's terms.[2] Ranciere argues that an existing appointment of parts and positions in a system based on distribution of spaces and forms of activity eventually determines in what way various individuals have a part in the system. Artistic practices are "'ways of doing and making' that intervene in the general distribution of ways of doing and making."[3] The research carried out in *Stitching Worlds*, in other words, should not be understood as solely instrumental in creating expressive art objects and installations. In addition to the instrumental dimension of the research, the research process is conceived as art practice. The project proposes the creation and presentation of knowledge in the marginal space of needlework as artistic strategy.

In this respect, the aim of the *Stitching Worlds: Exploring Textiles and Electronics* is to reflect on, capture, and represent the essence of the project. The book does not aim to be an exhaustive documentation of the project; rather, it is one of the many possible outcomes of the project, along with a documentary blog, an exhibition, and several artworks. The *Stitching Worlds* book intends to provide a particular glimpse of the multilayered nature and methodologies of the project. Accordingly, the editing process of the book also was treated as part of the artistic research process and the book is envisioned as a reflection work in itself. The book is arranged in sections, but, linear reading is not required. The contents of the book are singular elements in different formats that are complete in themselves. Scholarly articles, visual essays, interviews, and documentation of the artworks are

2
Jacques Ranciere, *The Politics of Aesthetics: The Distribution of the Sensible*, translated by Gabriel Rockhill (London: Continuum, 2006), p. 12.

3
Ibid., p. 13.

meant to provide insights into the project by sharing practical experiments, thoughts, concepts, reflections, and impressions from field trips.

Following the foreword written by Fiona Raby, who wonderfully captures the contrast presented by the quietness of the project as opposed to the hard-technology research carried out in the world of drones, the book is divided into three loosely grouped thematic sections. "Mapping the Breeding Grounds" focuses on laying out the territory for making textile electronics with a focus on alternative makers. It provides a peek into the discoveries of the bottom-up study carried out during the project, on the alternative materials, techniques, manufactories, and skills in question, which inspired the forming of the ideas in the first place. "Crafting Realities" provides insights into a critical exploration towards what it would mean to enable textiles craftspeople as the producers of electronic technology. The underlying question is how the qualities of craftsmanship would influence what constitutes technology, and not only introduce new production ecologies, workspaces, tools, and processes but also new values and criteria to evaluate technology. Finally, inspired by historical moments when the worlds of textiles and electronics have curiously intersected, "Alternative Histories, Counterfactual Futures" looks at imagining textile electronics objects from alternate histories, presents, and futures as critical and artistic strategy. Merging fragments of the two domains is proposed as an interventive way to question the structures behind the societal underestimation of feminized skills.

The *Stitching Worlds* project and the resulting book should not be read as a recipe for a particular alternative desired world. We hope to contribute and further inspire the plurality that is needed in the values and priorities that shape research, and ultimately the world at large, and provide a potential stimulus for the emergence of other alternative research projects.

Mapping the Breeding Grounds

Profit-oriented industries, which develop product ideas with a focus on "potential consumers," are hardly led by any other criteria than profit maximization in their top-down decisions about where, how, and by whom the products will be manufactured. An artistic exploration into making textile electronics with a focus on "alternative makers," on the other hand, brings about a bottom-up study of features and availabilities of the alternative materials, techniques, manufactories, and skills in question, to inspire the forming of the ideas in the first place. This demands making a close theoretical—i.e. philosophical, historical, ethical, and juristic—study of the alternative making scene; it also requires leaving the safe zone of the research laboratory and letting those complex grounds speak for themselves. "Mapping the Breeding Grounds" reveals fragments of the potential territory on which textile electronics could emerge.

Lars Hallnäs

The Textile–Thinking Paradox

Over time, each reasonably well-established area of practice develops a certain characteristic way of thinking. There is a certain way of thinking in mathematics, a certain way of thinking in design practice, and so on.

A gradually emerging way of thinking shapes the area in question in a certain sense; as an area of practice, it is quite reasonable to view this as the/an overall form of the area. It is, of course, not possible to provide a non-trivial, precise definition of a way of thinking, but we *can* discuss aspects and certain fundamental characteristics of the thinking that defines a given area of practice.

Textile thinking, the way of thinking that defines the overall form of textile-design practice, has much to do with material, texture, yarn, pattern, etc., as fundamental notions. But the textile-design formula, the definition of the construction itself, occupies a very special place. There is something paradoxical about this. It is as if material disappears and there is only form left and at the same time, as if it is only a matter of material construction with no form.

A Textile-Design Paradox

There is no form; there is no material; there is only form; there is only material; form and material collapse into a definition: the textile-design formula. All of this relates to a design practice; it is thinking within a process of designing.

What sort of paradox is this? The famous logical paradoxes we know from philosophy are all in one way or another related to the duality between truth and falsity. Take the liar paradox as an example:

> A Cretan, Epimenides, said "All Cretans are liars."
> Is what Epimenides said true?

Another more direct version of this is the sentence "This sentence is false." Assume "This sentence is false." is true, then it seems to be false by just reading what is says, but that, on the other hand, means that it is true. This is of course absurd and that is what is paradoxical about the liar.

The characteristics of the textile-design paradox are different in many respects. In the case of the textile-design paradox, there is something, a textile, that has no form and/or no material; or, form and material are the same. This is paradoxical since it is a philosophical axiom that things have form and that form tells us about the way in which material builds a thing. We may thus derive the following:

> Every thing has a form, therefore, textiles are not things;
> materials build things, therefore, textiles are not things.

It is this, that textiles are not things, that is the kernel of the textile-thinking paradox. It is paradoxical since everything must be something. This is not thinking based on a logical paradox, but thinking that seems to be based on hairsplitting nonsense.

A textile is surely a thing. There is of course a form: the way in which material, the yarn, builds the textile's deep structure and the textile's surface texture.

But what is this thing? It is somehow just material, or just form, or just a textile formula that collapses form and material into a non-form and non-material something. When we then use it to construct household textiles (a curtain, a tablecloth, a towel, a napkin), or garments, or textile things for technical use, etc., then textile things appear where textiles are the materials that build these things.[1]

Textiles are not things, the no-thing thinking
A thing is not just something; it *is* a thing, not something waiting to become a thing. Take the piano as an example. If we know how to play the piano, we certainly know what a thing it is. The textile folded over the chair on the other hand tells us something about waiting. It is *waiting* to become some thing.

It is not material that builds textiles, the no-material thinking
Material is whatever things are built of; yet, textiles are material, not things. It is a building material, not a built thing; but, of course, it is yarn and constructions build structures. Yes, but it is *building*, not built.

It is definitions that build textiles; the textile-formula thinking
In the process of designing, definitions define things in a state of becoming. In a near-field reading of a textile, it dissolves into a definition, a textile formula. In that sense, a definition is what builds a textile; the yarn is the all-important ink with which it is written. Thus, defining is building that which is the building material itself; it is *defining* itself.[2]

1
Linnéa Nilsson, *Textile Influence: Exploring the Relationship Between Textiles and Products in the Design Process*, University of Borås Studies in Artistic Research 15 (Borås: University of Borås, 2015).

2
Karin Landahl, *The Myth of the Silhouette: On Form Thinking in Knitwear Design*, University of Borås Studies in Artistic Research 16 (Borås: University of Borås, 2015).

Textile form (textile material) is local; the local-form thinking
The form of a thing resides in the way in which material builds the thing. The textile builds material and it is only locally that we see form, how the material itself is built, it is *localizing* form.

Taking Ways of Textile Thinking Somewhere Else

It is easy to see the impact of taking ways of thinking somewhere else. Consider, for example, the fundamental impact of mathematical ways of thinking in many areas of research;[3] or ways of thinking inherent in the design of modern, computer-based communication tools and the huge impact they have had on communication and interaction in society.[4]

What could it mean, then, to take textile thinking elsewhere?[5] That is, to take elsewhere ideas about a design object characterized by

> waiting to be a thing,
> building things,
> localizing form,
> defining itself.

What we see is not a thing, but something waiting to be a thing, building a thing, localizing form, and defining itself. It is something that travels constantly in between local form and global material.

With respect to waiting and the localizing of form, it is easy to find examples, such as a perspective on city planning where we focus only on the connections of streets, letting the city grow on its own or really any form of network where we focus only on the form of connection: how things connect and fit together rather than their places in an already planned, comprehensive thing. It is very easy here, and perhaps tempting, to think in political terms, but it is a way of thinking that is much more difficult than it might appear to be.

Textile Precision

Is textile thinking then nothing more than a form of materials-design thinking? And is then the textile-thinking paradox really no paradox at all?

3
Eugene Wigner, "The Unreasonable Effectiveness of Mathematics in Natural Sciences," *Communications on Pure and Applied Mathematics* 13, no. 1 (1960): 1-14.

4
Mark Weiser, "The Computer for the 21st Century," *Scientific American* 265, no. 3 (1991): 94-104.

5
Cf. ArcInTexETN Research Program, http://www.arcintexetn.eu.

Textile design is materials design in a certain sense and thus it is a form of materials-design thinking. In the process of designing we construct a material, but the material—the yarn—is somehow already there and so what is left is only form, local form; thus material properties also are local to some extent. This is one way to understand the idea of textiles as being adaptable and responsive materials: the only-form/no-form paradox of textile thinking. The yarn presents the design so we can see the form: the only-material/no-material paradox of textile thinking. All this brings confusion into the idea of textile form and textile material:

> What is textile form?
> What is textile material?

One way to frame these questions is through the idea of precision. We use metal, plastics, etc., to build precise things. Textiles are different. Textile precision is different.

Precision is a matter of measuring. Measuring textiles, we have to go back to the logic of the definition that builds it. But we have to do that by viewing this logic through the yarn that writes the definition in concreto. It builds things simply, in local form, and complexly, in global form. Precision is local since at each point we can trace the definition, but global form goes beyond the definition. In this sense, precision is very different from the precision we meet in areas where global form comes first.

What is textile precision as a foundational element of textile thinking? The formal definition of a textile, the textile formula, is clear and logically precise. The way the yarn builds the textile, and in concreto displays what the definition defines, introduces the other pole in a duality between form and material. It is also here that we see the duality between form and expression: the way in which the material builds the textile and that which displays the textile. Textile precision lives in this duality.

Take the simple example of a textile fabric blowing in the wind, set in motion by an electrical fan or just hanging there on a clothesline. In terms of electricity and the mechanical behavior of the fan, the example is simple with respect to precision: we know the logic of the fan.

But when it comes to the textile blowing in the wind, the example is perhaps not so simple. Once the textile is set in motion, it becomes a very complex thing. What does it mean

to know the logic of such a thing? In principle, it is possible to describe the mechanics involved and predict its behavior with precision, but is that what textile precision is all about, just another "chaotic," very complex thing?

From a more mundane, everyday perspective, a textile blowing in the wind is not a chaotic thing. We certainly know its logic and what it is: a textile thing. This logic goes back to the wind as a force of motion of course, but at the heart of the logic we have the given textile formula and the yarn that writes its definition in the concrete type: is it woven; is it knitted and how is it knitted; is it thick wool, or thin silk yarn, or what is it? The chemistry, the mechanics of this, the wind-flow analysis, etc., tell us one story of this, but that is the story of a complex system, not the elementary textile thing we see as it hangs blowing in the wind on the clothesline.

Is this an example of the distinction Heidegger makes between *Vorhandenheit* (things being present-at-hand) and *Zuhandenheit* (being ready-at-hand)?[6] On one hand, there is a thing that is just there, present in our everyday life, and on the other hand a thing that we turn into an object of a careful scientific analysis. No, this is not what it is all about, since that would somehow mean that reflective textile design aesthetics is something we derive, or something we might derive, from the chemistry and mechanics of textile systems.

So what does it mean to be precise about this textile thing from the perspective of textile (design) thinking? It is not to be able to describe a complex, dynamic system in mathematically precise terms. It is how to understand the simple thing, not the complex thing. The mathematically precise description of the textile blowing in the wind as a complex, dynamic system is certainly something that deepens our understanding, but it talks about something else. A complete acoustical analysis of a performance of, say, a cantata by Johann Sebastian Bach does not tell us very much about the music.

The issue of textile precision becomes very clear in matters of functionality. Just consider precision in functional garments and electronic textiles: the taped seams, short-circuits, power supply, communication connections, and exactness in positions. Concepts such as "here" have only a local meaning; once a textile becomes a textile thing, this idea of "exactly here" becomes blurred and somehow fades away. Textile precision dwells in the paradoxes of textile thinking.

6
David Weinberger, "Three Types of Vorhandenheit," *Research in Phenomenology* 10, no. 1 (1980): 235-50.

To know the definition, the textile formula, and to understand what it means to write this definition in a given yarn. There is a precision in defining and a precision in writing and a paradoxical relation in between them both. Precision is not about being able to say in detail, and with "ordinary" precision, what will happen when the textile is blowing in the wind, but to know what that is as a textile thing: experience, tacit knowledge, the mystical knowledge of practice. There is really nothing mystical here, no mystical tacit knowledge developed by unreflected practice.

Precision is the degree of exactness. A certain degree of simplicity in definitional logic, a certain degree of clarity, elementarity in the textile formula. A certain degree of expressional clarity in writing, the yarn, the ink, how we use it to write according to the given formula, i.e., the act of displaying the formula.

This opens up for certain expressions of textile things, such as the textile blowing in the wind on the clothesline. When we talk about precision here, it is exactly this, the relation between writing and defining that opens up for this expression. This is not precision as exactness of arc degree or preciseness measured in terms of nanometer. It is aesthetic precision in a relation between defining and writing, a relation between form and expression, that opens up for accuracy in expression.

It is not a matter of precision in the overall global behavior of a textile thing in use. Textile precision is not about the exactness in behavior of the textile as a complex dynamic thing hanging there on the clothesline. It is precision in what opens up for this complex behavior. It is the way in which the writing interprets the definition and the way in which the definition explains the writing, a duality of precision in between the precision of interpretation and the precision of explanation. What is central for textile thinking is that this precision is local.

I see the textile blowing in the wind and looking closely, I can see the weaving pattern and the yarn that writes it. I understand that this, the wind and the placement on the clothesline is what builds the thing I hear and see flapping.

The paradoxes of textile thinking, as well as the notion of textile precision, goes hand-in-hand with the idea of textiles being flexible materials. We all know what that means, at least intuitively. A flexible material is in general terms "characterized

by a ready capability to adapt to new, different, or changing requirements."[7] So this is what happens when we fold a textile thing, a garment or a cloth; it is ready to adapt to the new situation of being folded and as such, perhaps stored away. Thus, in textiles there is a ready capability to adapt, "to make fit (as for a new use) often by modification."[8]

What does it mean to design for readiness to adapt to new or changing requirements? This is somehow what the textile thinking paradox discussed here is all about. That we change perspective in form thinking, from the global shape, the global structure to the local neighborhood, the local connections. That we change perspective in design thinking from the ready-to-use things to the waiting material.

Presented with a paradox, we naturally want to understand what is wrong. One way to understand the logical paradoxes is that we assume too much somehow in reading them. "This sentence is false"; here we assume that the sentence really says about itself that it is a false sentence. There is certainly a lot involved in that.

> There is no form; there is no material;
> there is only form; there is only material.

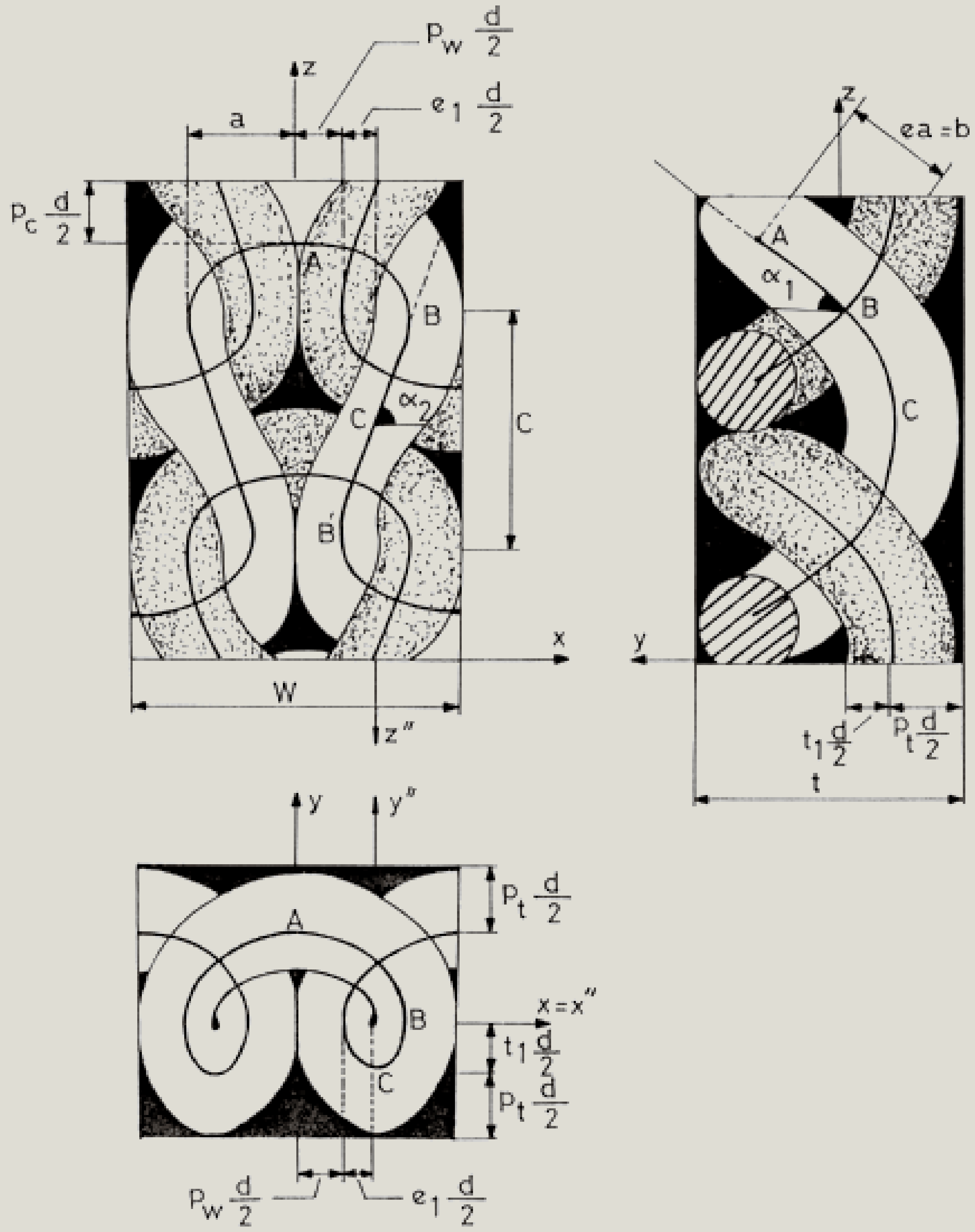
Is this not just a pair of clear contradictions: there is no X versus there is only X? Reasoning, thinking as we go about things in the process of textile designing: on the one hand this is just a matter of material, but on the other hand, it is just a matter of form. The collapsing of these two perspectives into a textile formula—mathematically abstract as pure form and tactile concrete written in yarn—connects them and opens up to interaction in between them.

7
Merriam-Webster, s.v. "flexible," accessed January 30, 2018, https://www.merriam-webster.com/dictionary/flexible.

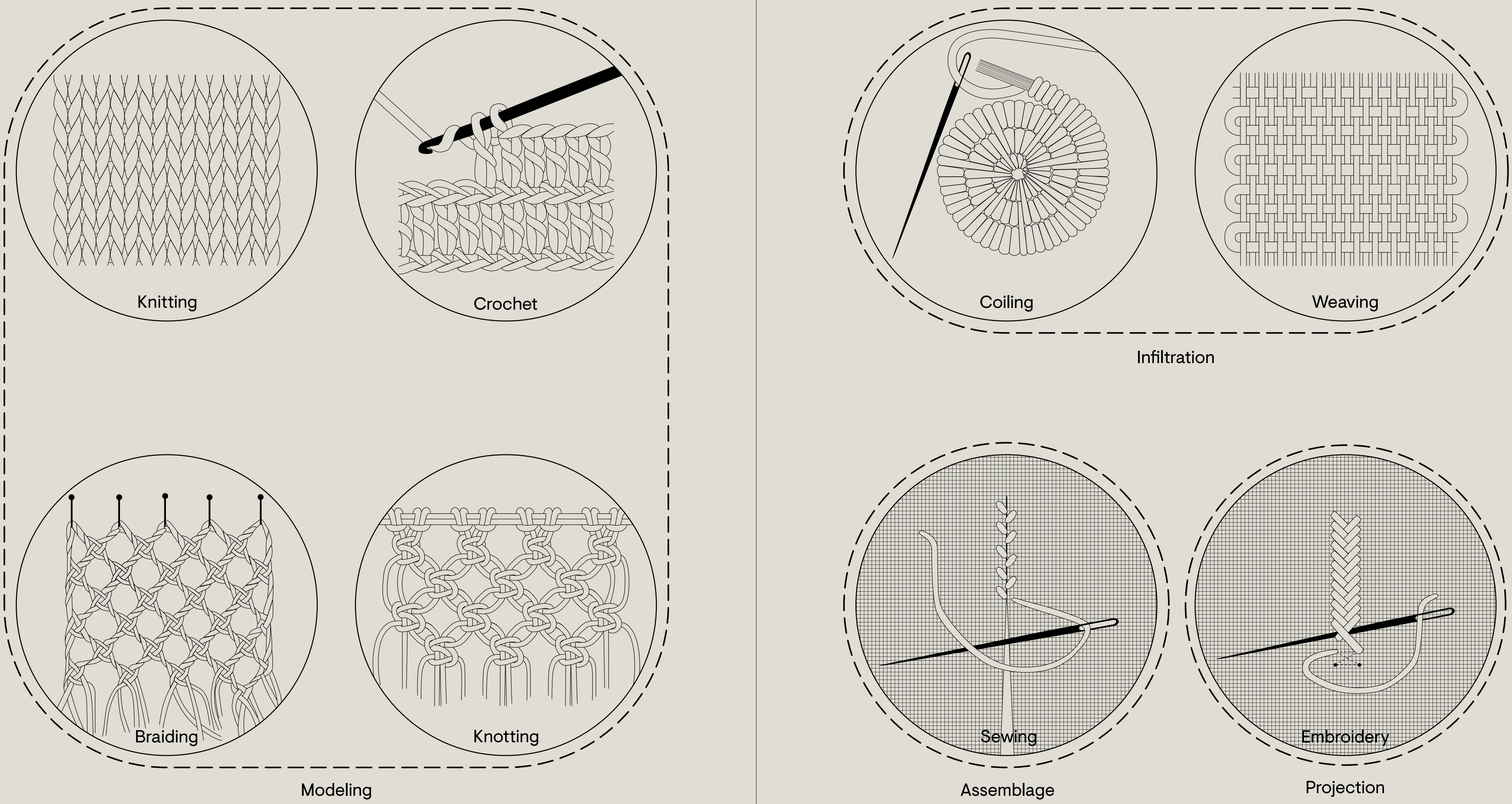
8
Ibid.

Techniques

Textile techniques, in essence, are fabrication methods. Just like methods in metal or plastic fabrication such as bending, welding, casting, extruding, and laminating, textile techniques, too, are ways of organizing matter in three-dimensional space and forming utilizable objects. Techniques such as knitting, looping, netting, crocheting, weaving, knotting, coiling, twining, braiding, felting, embroidery, and sewing employ different tools and machines in the making and give way to create diverse structures. Looking at textile techniques from this perspective and studying their precise singular structural properties in combination with alternative materials inspire new and inventive objects with distinctive functions.



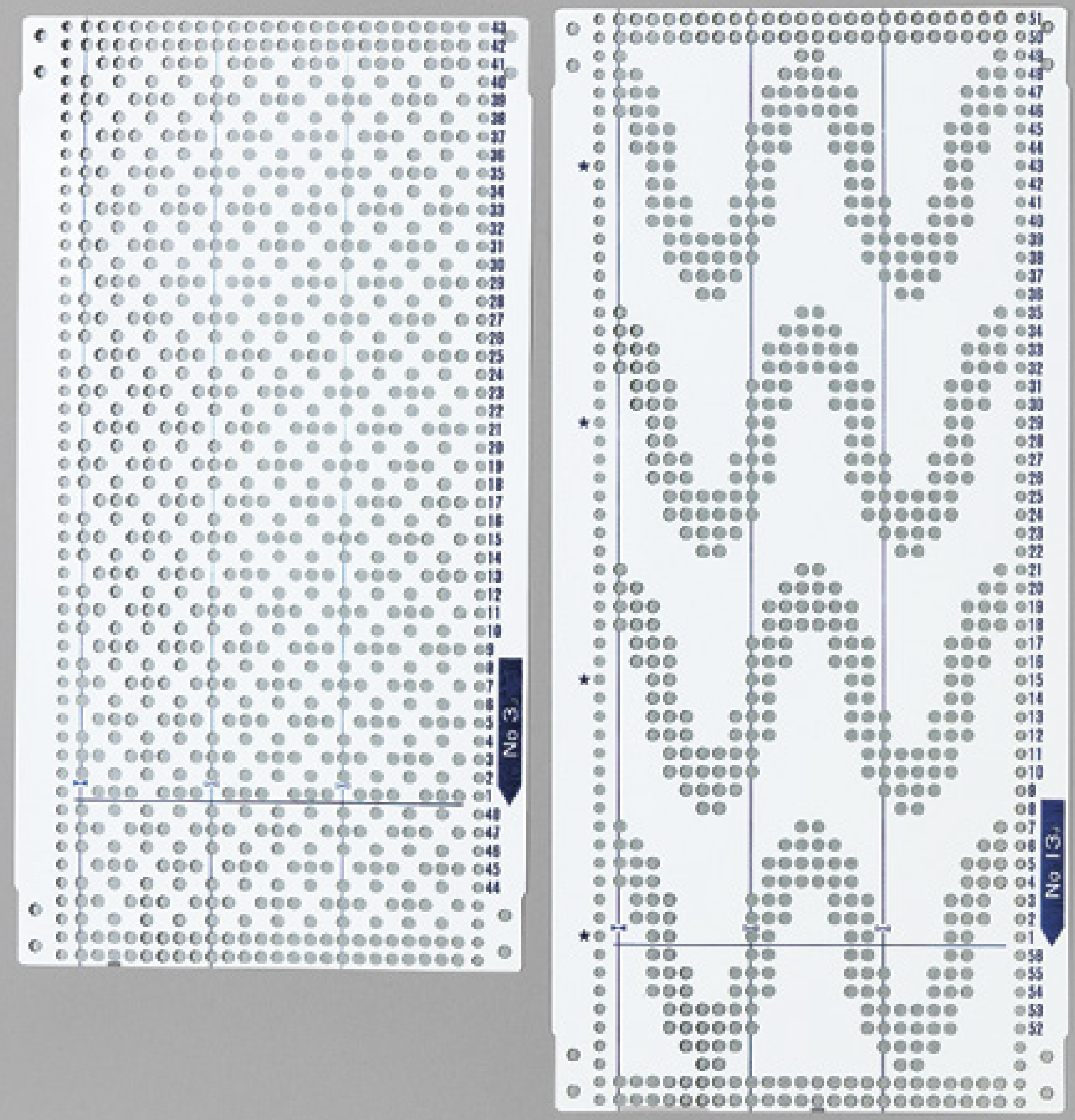
Anatomy of a plain knit loop including yarn swellings
(Geometric model and illustration (1998) by Arif Kurbak)



Textile techniques as fabrication methods (Illustrations by Stefanie Hilgarth, based on original illustrations in the *Encyclopedia of Needlework* (1886) by Thérèse de Dillmont)

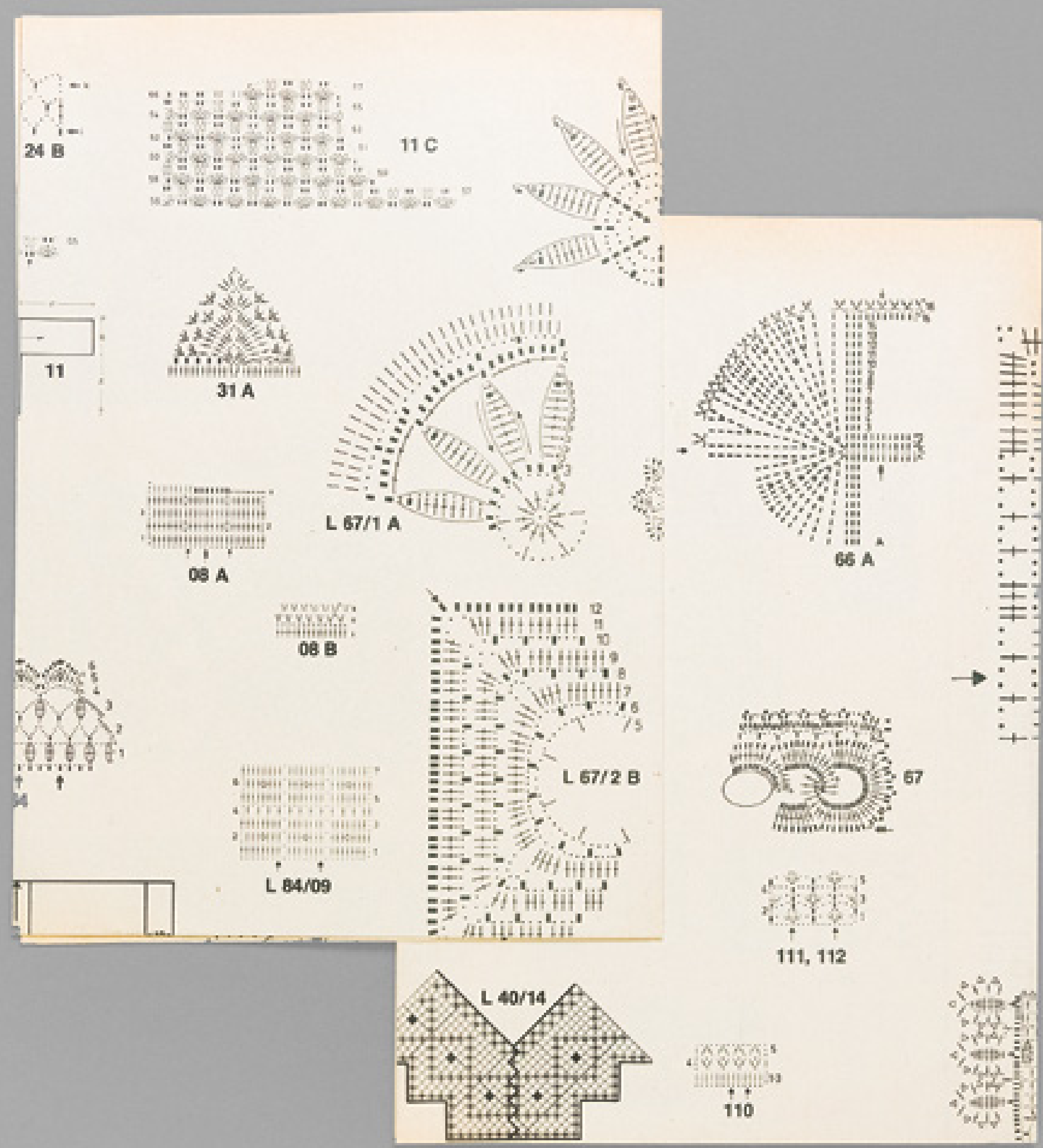
Patterns, Instructions, Formulas

"I can change those immaterial plans as many times I want. I can restore the changes, save the changes, erase the changes, export the changes. Because it's only data, it's weightless and immaterial. [...] I can offshore it to India, email it to China, get it back within a day... I've got an object processor! I'm crunching shapes! I'm processing objects!" In *Shaping Things*, Bruce Sterling illustrates a future in which "the model is the message" and all physical objects are mere printed hard copies of immaterial models. Textiles, by nature, are a unique category of things that have always been capable of fulfilling this vision. The pattern is the blueprint, the model, the code. Patterns and instructions can be rapidly saved, copied, and distributed; hence, textiles can be manifested in their physical form at different times and places, over and over again.



Punched cards for a domestic knitting machine
(Photographs by Elodie Grethen)

Instructions for hand knitting
(Photograph by Elodie Grethen)



Crochet patterns
(Photograph by Elodie Grethen)

Martin Schneider

Codes of Craft and Conduct

Whenever crafters meet in online communities to exchange patterns, questions of attribution and copyright arise. While patterns are often freely exchanged and adapted, as they always have been, they increasingly become a commodity that is sold on Etsy and other platforms. This article presents a thought experiment that shows how codes used to represent textile patterns and codes governing their exchange could be intertwined in ways that would allow traditional copyright to grow into domains where it is considered cancerous. After a short overview of how the current state of copyright applies to the domain of textiles, we introduce the quine-textile, a special kind of textile that uses the universality of code to open up a dystopian future where some companies can protect textile patterns for an excessive amount of time, calling for hackers to break this kind of protection. I would like to thank the knitting hacker "Ada Oppenheimer" for revealing the imminent danger looming in a seemingly harmless computational device.

Copyright and Where It Came from

There are two systems in place known by the names of "copyright" and "*Urheberrecht*," respectively. While they have historically very different roots, they have become assimilated by international treaties and are mostly identical now. Both systems were invented as a reaction to how easy the act of copying has become, thanks to the technology known as the printing press. While the Anglo-Saxon copyright was invented to protect publishers' investments, *Urheberrecht* (author's right) originated in the German legal tradition of balancing the rights of the creative individual with society's rights.[1] Even though copyright was adapted over time to be as general as possible and cover all kinds of media, its historical roots still show, and lawyers agree that written text and images are copyrighted while this is usually not the case for textiles.

The neglected role of textiles may be due to the dominance of the printing press over the weaving loom. The printing press has always been used to inexpensively replicate and disseminate information, a crucial role in an information-driven society, but the role of textiles has been mostly reduced to one of functionality. Interestingly, the Jacquard loom, often considered the precursor of computer technology, used a textile image-reproduction technology that preceded

1
Sebastian Deterding, Philipp Otto, and Valie Djordevic, "Urheberrecht und Copyright: Vergleich zweier ungleicher Brüder," *Bundeszentrale für Polititsche Bildung*, July 15, 2013, http://www.bpb.de/gesellschaft/medien/urheberrecht/169971/urheberrecht-und-copyright.

Figure 1
Portrait of Joseph Marie Jacquard
by Didier Petit & Co.

and outperformed halftone printing as used in newspapers since the 1870s. A portrait of Joseph Marie Jacquard (figure 1), jacquarded by Didier Petit and Co. in 1839, features a digital image programmed in binary code, spread over 24,000 punch cards.

Textiles have been used as an informational medium in various epochs and cultures, and projects such as *News Knitter* have cast a light on parallel universes in which the knitting loom might become the new printing press with fashion trends outcycling the weekly and daily newspapers at the pace of your favorite news feed.[2] Unfortunately, in our version of the universe textiles are still not widely conceived as a storage or information medium. However textiles do have the potential to encode all kinds of information including images, and when they do they become subject to copyright law.

Copyright in Textiles

Copyright in craft is a topic of great mystery. The status of textiles with respect to copyright varies across the globe, and because there are only very few cases that made it to court, crafters are left to their own speculative interpretations of the law, or the opinions of lawyers. Unfortunately this article can only add to this mystery: the author of this article has no background in law whatsoever and, to underline this lack of expertise on the topic I'd like to point out that "the information herein does not constitute and may not be relied upon as legal advice." (A magic spell that is believed to protect the author from actual lawyers or other evil spirits, as well as accusations of unauthorized practice of law.)

The Intellectual Property Office of the United Kingdom has recently decided to shed some light on copyright in handicraft and has issued a dedicated copyright notice on "knitting and sewing patterns."[3] Since the details of copyright vary from country to country, we can only hope that other countries follow suit, issuing similar sources of enlightenment. The publication addresses a couple of frequently asked questions, and is highly recommended.

One example that is fiercely debated on the internet is whether or not the creator of a pattern has any control over what is done with that pattern. Copyright law in the US is very clear about the fact that copyright does not protect ideas, methods,

2
Ebru Kurbak and Mahir M. Yavuz, *News Knitter* (2007), accessed March 14, 2018, http://casualdata.com/newsknitter.

3
Intellectual Property Office [UK], "Copyright Notice: Knitting and Sewing Patterns: Copyright Notice Nr. 4/2015," accessed March 16, 2018, https://www.gov.uk/government/publications/copyright-notice-knitting-and-sewing-patterns.

or systems: "In no case does copyright protection for an original work of authorship extend to any idea, procedure, process, system, method of operation, concept, principle, or discovery, regardless of the form in which it is described, explained, illustrated, or embodied in such work" (other countries' copyrights have similar phrases to prevent the cancerous growth of copyright to domains where it does not belong). This clause means that the wording of a knitting instruction could be protected as a literary text whereas the plain knitting instruction itself cannot, because it qualifies as a process described by the instruction.

US copyright does not apply to "useful articles" and clothing is explicitly mentioned as an example of a utilitarian object exempt from copyright.[4] In a 1934 US court decision, the court not only made it clear that copyright granted for a registered pattern did not extend to the dress, they also considered it self-evident that it's not possible to register a textile: "The dress itself could hardly be classed as work of art and filed in the Register's office."[5]

While it is possible to register textile designs (such as patterns printed on textiles) and collections of jewelry, fashion is excluded from US copyright.[6] Of course there are other ways in which textiles may be protected, such as patent law which provides a dedicated class for textile inventions but the time and cost for filing a patent are impractical for the average knitting pattern.[7]

Freedom to Copy as Human Right

According to Article 27 of the Universal Declaration of Human Rights, "everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits." Or, in other words: everyone has the freedom to copy. The articles goes on to state that "everyone has the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author."[8] This means that all humans should be credited and paid for their creative work. It does not entitle any individual or company to inhibit the freedom to copy. It is a common misunderstanding that copyright should be exclusive to the author, and that its primary use is to prevent copying by others. It is often assumed that "intellectual property" that

4
U.S. Copyright Office, "Useful Articles," Factsheet FL103 (2013), accessed March 16, 2018, https://www.copyright.gov/fls/fl103.pdf.

5
"Jack Adelman, Inc. v. Sonners & Gordon, Inc., 112 F. Supp. 187 (S.D.N.Y., 1934)," *Justia*, accessed March 16, 2018, https://law.justia.com/cases/federal/district-courts/FSupp/112/187/1749285.

6
Christine Cox and Jennifer Jenkins, "Between the Seams, A Fertile Commons: An Overview of the Relationship Between Fashion and Intellectual Property," *Ready to Share: Fashion & the Ownership of Creativity* (USC Los Angeles, 2009), accessed March 16, 2018, https://learcenter.org/pdf/RTSJenkinsCox.pdf.

7
U.S. Patent and Trademark Office, US Patent Classification System, "Class D02: Apparel and Haberdasery" (2002), accessed March 16, 2018, https://www.uspto.gov/web/patents/classification/uspcd02/defsd02.pdf.

8
United Nations General Assembly, "Universal Declaration of Human Rights," Resolution 217 A (Paris, 1948), accessed on March 16, 2018, http://www.un.org/en/universal-declaration-human-rights.

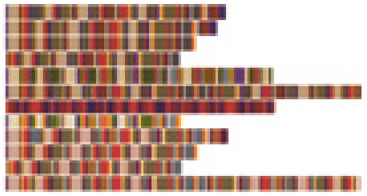


Figure 2
Color sequences of scarfs worn by Dr. Who in various episodes, screenshot from Kris Miller's scarf-o-matic (http://tardis.scienceontheweb.net/scarf/scarf-maker.php).

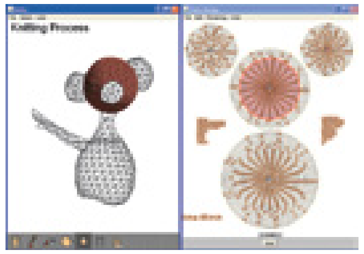


Figure 3
Knitty Software by Yuki Igarashi.

results from artificial scarcity is necessary to pay the author, but this is really against the idea of the freedom to copy. With the rise of prosumer devices such as home knitting machines, embroidery machines and 3D printers, the means of production are passed to the individual crafter shifting the power balance in favor of the individual, thus challenging a centralized producer/consumer ecosystem. As a result companies increasingly see individuals as their enemy, against which "intellectual property" needs to be protected. Companies are trying to limit and control the fundamental act of copying, which is, and always has been, the basis of biological and cultural evolution. Especially in the realm of craft and fashion, which is so deeply rooted in human cultural expression, keeping individuals from spreading or copying patterns or styles, should be considered equally frivolous as inhibition of free speech or freedom of religion.

Most copyright laws have special clauses to allow culture to flourish, such as exceptions for private use, science or education, but these exceptions are often eroded by lobby groups, or rendered invalid by technical means of protection (DRM). Even though copying is often looked down upon as a lowly derivative act, it is the basis of all creative and human culture and copyright should be considered a fundamental freedom rather than a law to protect commercial enterprises.

Inseparable Textiles

Consider a sheet with knitting instructions for a *Dr. Who* Scarf released by the BBC.[9] The sheet is protected by British copyright, whereas the sequence of colors and stitches (figure 2) most certainly isn't. You would actually copy the original scarf by following the instructions but this act only constitutes a copyright infringement if the scarf was considered a "work of artistic craftsmanship" (a specialty of UK copyright law). If taken to court, chances are, the scarf would share the fate of the baby cape, the patchwork bedspread, and the star trooper helmet, none of which were considered objects of artistic craftsmanship.[10]

Things might look quite a bit different if the knitting pattern contained images, symbols or figures protected by copyright or trademark law. The BBC considered this to be the case when a fan published knitting patterns for monsters featured in *Dr. Who* episodes.[11]

9
Ted Mills, "The BBC Creates Step-by-Step Instructions for Knitting the Iconic Dr. Who Scarf: A Document from the Early 1980s," accessed on March 16, 2018, http://www.openculture.com/2015/12/instructions-for-knitting-the-iconic-dr-who-scarf.html.

10
Intellectual Property Office [UK], "Repeal of Section 52 of the Copyright, Designs and Patents Act 1988: Guidance for Affected Individuals, Organisations and Businesses," accessed on March 16, 2018, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/606207/160408_guidance_s52_final_web_accessible.pdf.

11
BBC News, "Dr. Who Fan in Knitted Puppet Row," last updated May 14, 2008, accessed March 16, 2018, http://news.bbc.co.uk/2/hi/entertainment/7400268.stm.

In the US, textiles are considered "useful articles" so copyright does not apply, no matter how decorative they are. However "pictorial, graphic, or sculptural features that can be identified separately from, and are capable of existing independently of, the utilitarian aspects of the article" can indeed be copyrighted.[12] A recent court ruling about cheerleader uniforms made clear that this refers to conceptual separability rather than physical separability.[13]

The Knitting Code

As mentioned before, the sequence of knitting stitches conveyed in a pattern sheet is not copyrightable in and of itself. So, if a group of freedom hackers decided to unleash knitting patterns from their copyright-infested pattern books by turning the instructions into pure code of knitting stitches and sharing them on the internet, copyright won't stop them. Computer formats for hand and machine knitting are readily available (see KnitML[14] and Knitting Assembly Language[15]).

Even if a knitting pattern was released as a copyrighted sequence of stitches, there still is an infinity of transformations that can change the stitch sequence, without changing the resulting textile. (Such as inserting and dropping stitches, knitting bottom-up instead of top-down, etc.) 3D software such as Knitty[16] or Autoknit[17] (figure 3) could also disassemble the simulated structure into a sequence of stitches that has no resemblance to the original knitting instruction whatsoever. These automatically created knitting instructions could then be knitted at home by hand or with a low-cost knitting machine.

In case the knitted object itself was protected by copyright law, the personal use doctrine granted by most national copyrights, would still allow for private copies as is the case for 3D printing.[18] But note that personal use has become more and more restricted in an attempt to counteract file sharing. For example, Germany permits only copies for up to seven close friends; Austria allows only copies made from a publicly available source, etc. To prevent the classification of patterns as software, crafters could resort to a low-tech approach. Instead of transmitting the instruction, they could pass the finished items or swatches by postal service, thus providing a template for recrafting the item by hand. The practice of keeping patterns

12
Copyright Law of the United States, 17 U.S.C. "Chapter 1: Subject Matter and Scope of Copyright": §101 – Definitions, accessed March 16, 2018, https://www.copyright.gov/title17/chapter1.pdf.

13
George Thuronyi, "U.S. Supreme Court Clarifies Separability Analysis in its Ruling on Star Athletica, LLC v. Varsity Brands, Inc.," *Library of Congress*, April 6, 2017, https://blogs.loc.gov/copyright/2017/04/u-s-supreme-court-clarifies-separability-analysis-in-its-ruling-on-star-athletica-llc-v-varsity-brands-inc.

14
K2G2 Craftopedia article on "KnitML" (March 2009), last modified March 25, 2009, accessed March 16, 2018, http://www.k2g2.org/wiki:knitml.

15
James McCann, Lea Albaugh, et al. "A Compiler for 3D Machine Knitting," *ACM Transactions on Graphics 35*, July 24, 2016, https://www.disneyresearch.com/publication/machine-knitting-compiler.

16
K2G2 craftopedia article on "Knitty (software)," last modified March 3, 2014, accessed March 16, 2018, http://www.k2g2.org/wiki:knitty.

17
Vidya Narayanan, Lea Albaugh, et al. "Automatic Machine Knitting of 3D Meshes," *ACM Transactions on Graphics*, forthcoming in 2018, accessed March 16, 2018, https://textiles-lab.github.io/publications/2018-autoknit.

18
Elsa Malaty and Guilda Rostama, "3D printing and IP law," *WIPO Magazine* (February 2017), accessed March 16, 2018, http://www.wipo.int/wipo_magazine/en/2017/01/article_0006.html.

as samples is as old as the textile trade, and ancient pattern books often contain samples that serve as a template for the skillful crafter.[19]

Quine Fabrics

If you are comfortable with the idea of knitting as code, it won't strike you as unusual to use textiles as a storage medium. The most straightforward way to store data in a knitting swatch is to translate a binary sequence of zeros and ones into a sequence of knits and purls. The stored data can then be read from the fabric by means of fabric analysis.[20] Now, by combining the ideas of knitwork as data-storage and knitting instructions as code, we can create what is known as a quine in computer science.

A quine is a computer program that can print its very own code.[21] Correspondingly, a quine fabric is a piece that has the instructions of how to create it built right into it. When you follow the instructions encoded in a quine pullover you would get an exact copy of that pullover, including the instructions. In terms of copyright this means that you not only copied a textile (and legally so) but the instructions as well, in the literal form they were provided, resulting in full copyright protection. This nasty hack would allow the black-hat copyright crowd (those that use copyright to prevent copying) to create objects that are inseparable from their copyrighted instructions. Whoever sells patterns for quine fabrics or quine 3D prints could prevent you from creating unauthorized copies of their objects until 70 years after they die.

In practice, the instructions act like a watermark that could be blanked out or modified by a skilled textile hacker. The only way to safeguard a quine fabric against this attack would be to make sure that the instructional stitches are of functional importance to the structural integrity of the piece. Both creating and breaking quine textiles would require the minds of the most skillful crafter-hackers of their time.

Copyfuck and Cybercraft

To demonstrate that textile quines are not merely a thought experiment but a very real threat, a hacker of the KLF (Knitting Liberation Front) who goes by the name "Ada

19
Karen Larsdatter, "18th Century Textile Sample Books," personal website: *18th Century Notebook*, accessed March 19, 2018, http://www.larsdatter.com/18c/textile-sample-books.html.

20
K2G2 Craftopedia article "Fabric Analysis," last modified June 9, 2009, accessed March 14, 2018, http://www.k2g2.org/wiki:fabric_analysis.

21
Wikipedia article "Quine (computing)," last edited February 28, 2018, accessed March 16, 2018, https://en.wikipedia.org/wiki/Quine_(computing).

Oppenheimer" has created a language called copyfuck. Copyfuck is obviously an homage to an esoteric programming language called brainfuck: in the same way that brainfuck is supposed to mess with your brain, copyfuck was willfully designed to challenge copyright, allowing the creation of knitting quines.

Oppenheimer, who did not want to reveal her true identity, told me she considered it highly important to publish copyfuck in print. It seems she had discovered knitting quines quite a while ago but kept her knowledge from the public. But then, the renowned knitting machine hacker Fabienne Serrière called for her peers to create quines to be sold on KnitYak, a little shop for computational knitwear.[22] As a result KnitYak now offers two machine-knit quines—one coded in Python[23] (figure 4), the other in Perl[24] (figure 5). Even though these aren't knitting quines in the strict sense (they are programs made of text that create pixel patterns rather than knitting instructions that create knitting instructions), Oppenheimer panicked.

She was concerned someone might be able to obtain a patent on knitting quines, leaving textile copyright abuse in the hands of a single party. Thus, when I was looking for experts on craft and copyright in a darknet forum dedicated to cybercraftivism, Oppenheimer approached me to point out that if I published a copyfuck quine in my article, she argued, this would count as prior art and prevent textile quine patents from the get-go.

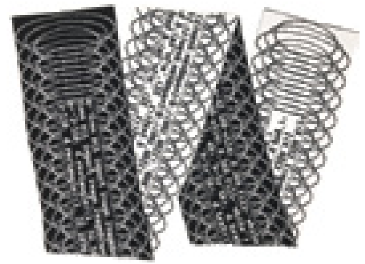


Figure 4
Python quine scarf by Alexander Grupe, knitted and photographed by Fabienne Serrière.

Figure 5
Perl quine scarf by Ken Shirriff, knitted and photographed by Fabienne Serrière.

The Knitting Quine

For the purpose of demonstration, let us consider a very simple language. It has only four commands, which can be used to create any knit and purl pattern. The commands are "`k`", "`p`", "`[`" and "`]`". The letters "`k`" and "`p`" code for a knit or a purl stitch and the brackets are used to mark a section that is to be repeated twice. To create a 4/4 rib stitch, you could write "`kkkkppppkkkkpppp`", "`[kkkkpppp]`", "`[[kk][pp]]`" or even "`[[[k]][[p]]]`".

Each repeat created by brackets generally reduces the length of the instruction. (Repeats are an abstraction used to identify symmetry in the desired pattern. Finding and using those abstractions is a creative act, so a specific knitting instruction is indeed as copyrightable as a poem.)

22
Fabienne Serrière, Twitter post, November 29, 2017, https://twitter.com/fbz/status/936117740560990209.

23
KnitYak, Product Page, "Python Quine Scarf - Black and White Acrylic" (2018), accessed March 16, 2018, https://knityak.com/products/python-quine-scarf-black-and-white-acrylic.

24
KnitYak, Product Page, "Perl Quine Scarf - Black and White Acrylic" (2018), accessed March 16, 2018, https://knityak.com/products/perl-quine-scarf-black-and-white-acrylic.

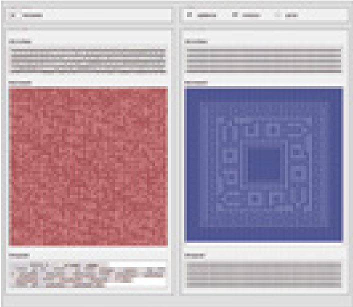


Figure 6
Copyfuck compiler by bitcraftlab showing a swatch provided by Ada Oppenheimer.

Now, each of the four commands can be represented by two bits, or knit/purl combinations. For example, if you want to encode "`[[[k]][[p]]]`" into knitwork you would use the sequence "`kp kp kp kk pk pk kp kp pp pk pk pk`". If a bracket is not closed, the sequence will not be knitted at all, so "`k[p`" will only result in the output "`k`". On the other hand, when a closing bracket that is not preceded by an opening bracket is encountered (like in "`[kp]]`") a special quine operator is summoned that will output the original code followed by its interpretation, separated by a closing and opening bracket. To provide an example: the sequence "`[kp]]`" is translated to "`[kp]][kpkp`". If we treat this output as a knitting instruction, we see that the first part "`[kp]]`" results in "`[kp]][kpkp`", and the second part creates no output at all because the bracket is never closed: we just created a program that can output its own code. In plain knitting stitches the program can be spelled out as "`kp kk pp pk pk kp kk pp kk pp`".

A slightly more complex version, known as knitfuck++ uses the four different operators "`repeat`," "`mirror`," "`invert`," and "`eval`" to allow for more efficient and creative abstractions. Ada Oppenheimer has provided me with an example (figure 6) that uses "repeat" and "mirror" to encode symmetries in a pattern, while using "invert" to allow for the reversal of knit and purl instructions in successive rows. You can play with it on the website which accompanies this article.[25]

While general-purpose programming languages such as Python require some extra code to create quines, copyfuck is a domain-specific language that was designed to make the creation of quines extra easy. In copyfuck, the instruction contained in the first part (the intron) is clearly separated from the pattern contained in the second part (the expression). In this sense copyfuck does not provide an effective way to protect knitting instructions, since anyone could just randomly replace occurrences of "`[k]`" by "`kk`", to free the quine from copyright protection. However copyfuck is just a toy language and one could easily conceive of more complex knitting languages and patterns where the instructions are not only an integral part of the pattern, but of the whole piece: if the stitches coding the instructions are the ones that hold it all together, it becomes increasingly difficult to rewrite them without destroying the fabric.

25
Martin Schneider, *Copyfuck* (interactive web app) (2018), http://www.bitcraftlab.com/copyfuck.

Casting Off

After writing the above section on knitting quines, I sent it to Oppenheimer and she was quite satisfied, but I still had to finish this article. Normally you would use the last section to sum everything up, pointing out new questions arising from your observations and the bright future of the exciting research that lies ahead. But I was not so confident.

I was afraid Oppenheimer's preemptive strike might backfire. Even if no single company could get a patent on textile quines, we could still face a cold war of craft, where every company would use quines to protect their patterns. Leaving crafters scared of knitting patterns of unknown origin and every stitch you make is potentially owned by corporations. I just couldn't come up with a nice ending and the deadline was overdue so I decided to—once again—go to the cybercraft chat for help:

```
OPPENHEIMER   why don't you just write a regular
              article and finish it with the
              conversation we are having right now?
BITCRAFTLAB   you can't do that. that would be very
              unscientific and depressing. It should
              be something encouraging. something
              about quines being useful after all
OPPENHEIMER   so why don't you end it with a quote
              and then some?
BITCRAFTLAB   a quote? like what?
OPPENHEIMER   "It is a profound and necessary truth
              that the deep things in science are
              not found because they are useful;
              they are found because it was
              possible to find them."
BITCRAFTLAB   wow. that's profound.
OPPENHEIMER   and necessary
BITCRAFTLAB   is this really your quote or did you
              just copy it?
OPPENHEIMER   Does it matter?
BITCRAFTLAB   I don't know. I have to finish that
              article
OPPENHEIMER   brb
```

This is how our conversation ended. I copied it into my article, but when I returned to the chat Ada Oppenheimer was gone.

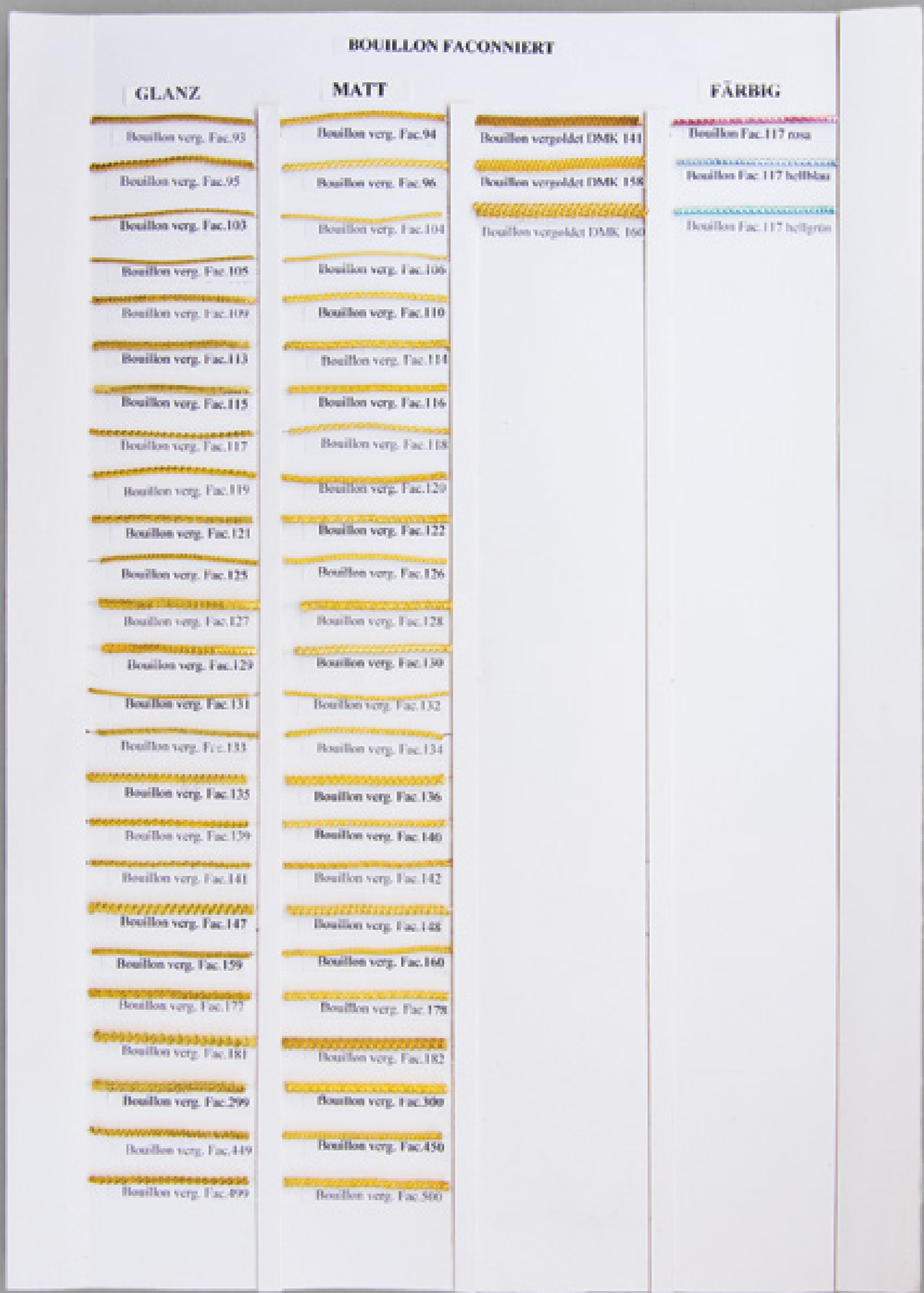
Materials

The invention of the string is dated to sometime between 20,000 to 30,000 years ago and metallic threads, composed of valuable metals and other fibers, have existed for over 2,000 years. Metallic threads have since been used widely in needlework in different parts of the world to signify power, majesty, and royalty, mainly due to their glittery visual appearance. However, taking a closer look at these metallic threads, one may discover that they also have the capacity to conduct electricity and that they are suitable for use in creating functioning electronic circuits and devices. Their conductivities depend on the types of metals they embody, such as gold, silver, copper, and steel, and on the ways the threads are constructed. Based on their properties, different traditional metallic threads can be used to create different electronic components, such as connectors, resistors, capacitors, coils, switches, and sensors.

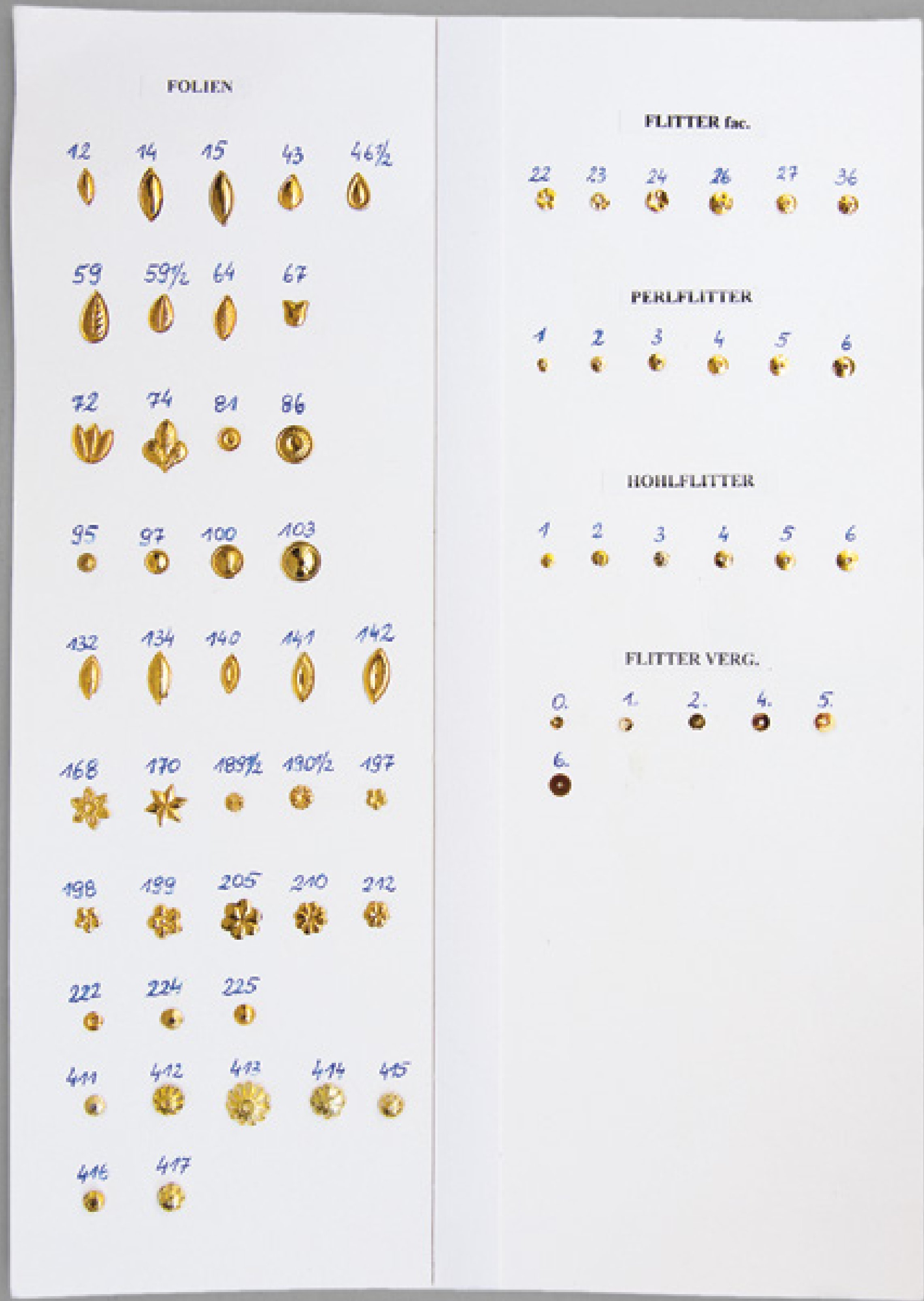
Shopping for conductive threads with the help of a multimeter at the traditional Viennese passementerie manufacturer M. Maurer (Photograph by Elodie Grethen)

Detail from the window display, M. Maurer, Vienna
(Photograph by Elodie Grethen)

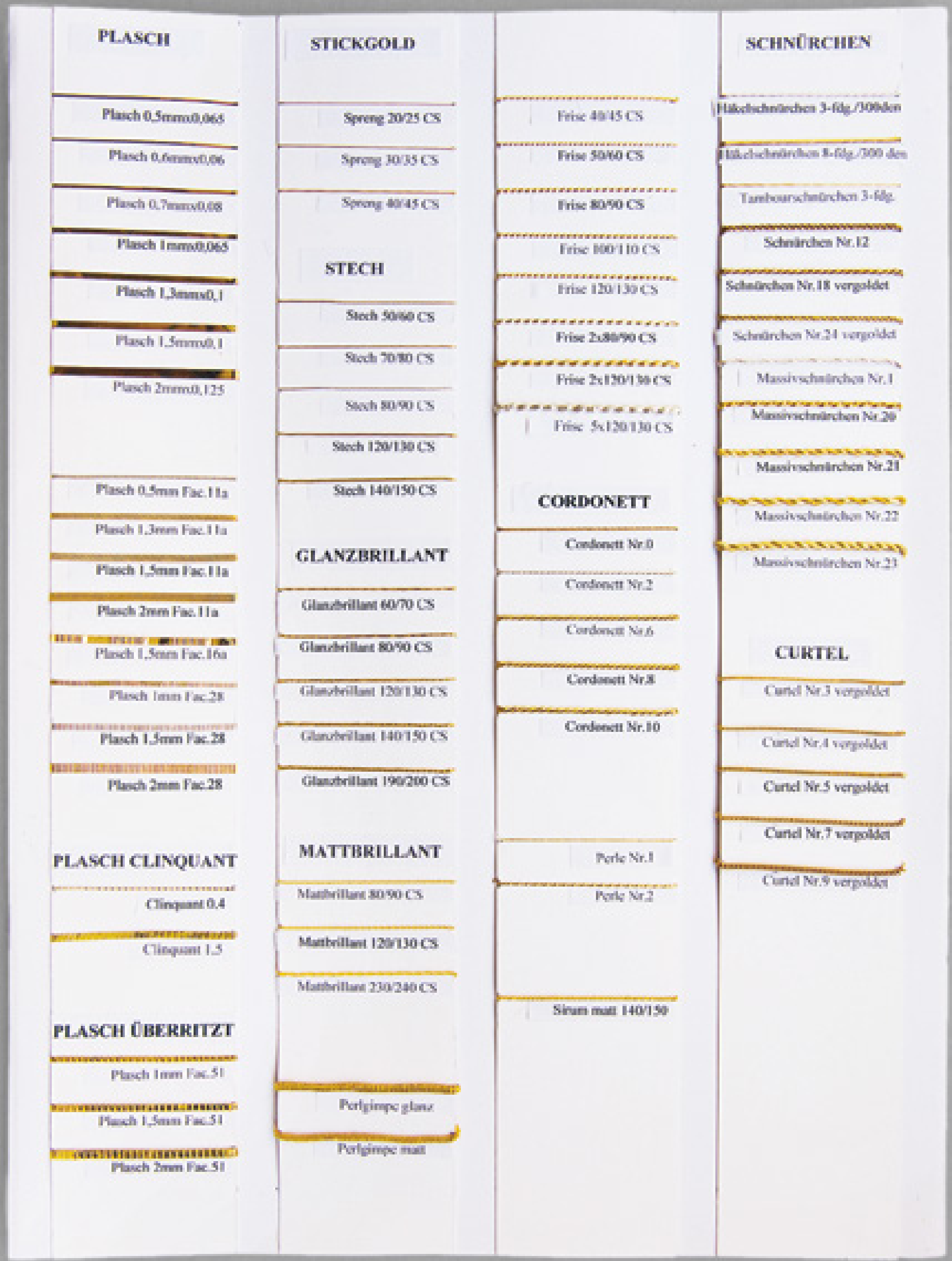
The last-standing traditional Viennese passementerie manufacturer M. Maurer, on Kandlgasse in the 7th district in Vienna (Photograph by Elodie Grethen)



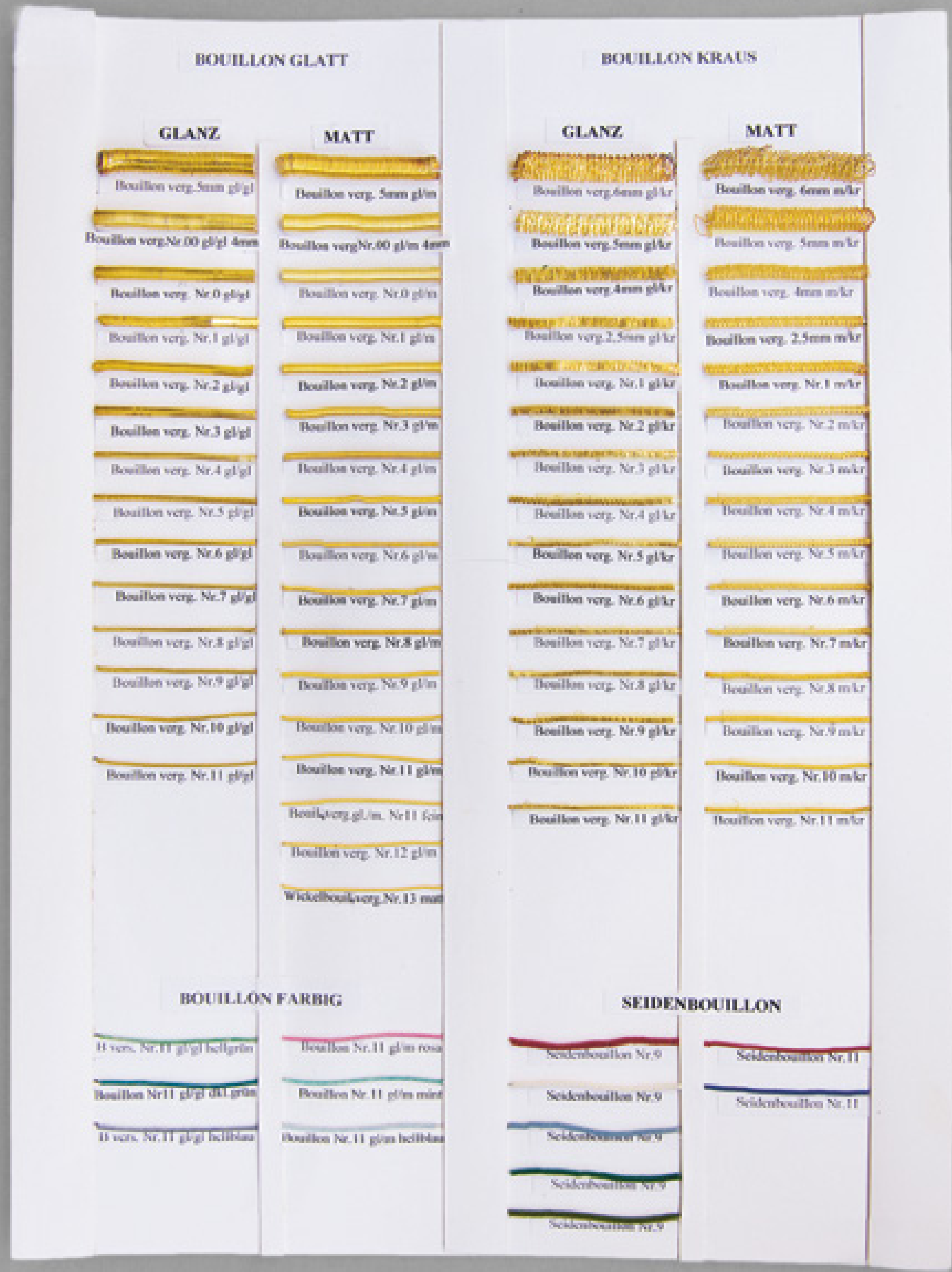
Gold faconnee samples, M. Maurer, Vienna
(Photograph by Elodie Grethen)



Gold gilt samples, M. Maurer, Vienna
(Photograph by Elodie Grethen)



Gold plate, passing, and jaceron purl samples,
M. Maurer, Vienna (Photograph by Elodie Grethen)



Gold and silk bullion samples, M. Maurer, Vienna
(Photograph by Elodie Grethen)

Silk wrapped around
stainless steel
69% silk,
31% stainless steel

Linen wrapped
around stainless steel
83% linen,
17% stainless steel

Bamboo wrapped
in copper wire
67% bamboo,
33% copper

Silk wrapped around
stainless steel
69% silk,
31% stainless steel

(Photograph by Elodie Grethen)

Hand-spun yarn
from stainless steel-
polyamide blend

Stainless steel thread

Stainless steel fibers blended
with polyamide fibers

Stainless steel slivers

Stainless steel thread

Stainless steel fibers
blended with wool fibers

(Photographs by Elodie Grethen)

Conductive materials collected by Beate Maria Friedl
from various places (Photograph by Elodie Grethen)

Conductive ribbons bought at the Les Puces flea market
in Paris (Photograph by Elodie Grethen)

Production Landscapes

Textile handcrafts were once vital for basic activities such as fishing or for making tools and fabrics for clothing, bedding, and even sails as well as other important instruments in human life. They have become increasingly redundant especially since the Industrial Revolution and the appearance of steam-powered textile mills. However, the knowledge and techniques developed throughout history are still out there, mostly being used in the creation of decorative domestic objects. Craftspeople, whose textile handcrafting skills are currently undervalued, provide a rich resource to explore as potential production landscapes for textiles with new functions. Being one of the major influences to engender the Industrial Revolution, the machine-based textile industry offers a grand landscape for exploration as well. Since the emigration of the production of textiles to low-cost countries in the 1990s—first to Turkey, then to China, Bangladesh, and other places—the associated machinery and human resources especially in Central Europe have been fairly underused and remain open for creative probing.

A braiding machine at the M. Maurer manufactory, Vienna (Photograph by Elodie Grethen)

View from the workshop at the M. Maurer manufactory, Vienna (Photograph by Elodie Grethen)

Badges hand-embroidered with gold thread, M. Maurer, Vienna (Photograph by Elodie Grethen)

A market stall that sells self-made, handcrafted goods,
Tire Market, Turkey


Handmade trousseau items,
Tire Market, Turkey

Crocheted items on sale, Guangzhou, China (Photograph by Antoine Turillon)

A shop that sells high quantity textile items handcrafted by rural Cantonese women, Guangzhou, China

Woman carrying out detailed manual work
at an electronics factory in Shenzhen, China
(Photograph by Antoine Turillon)

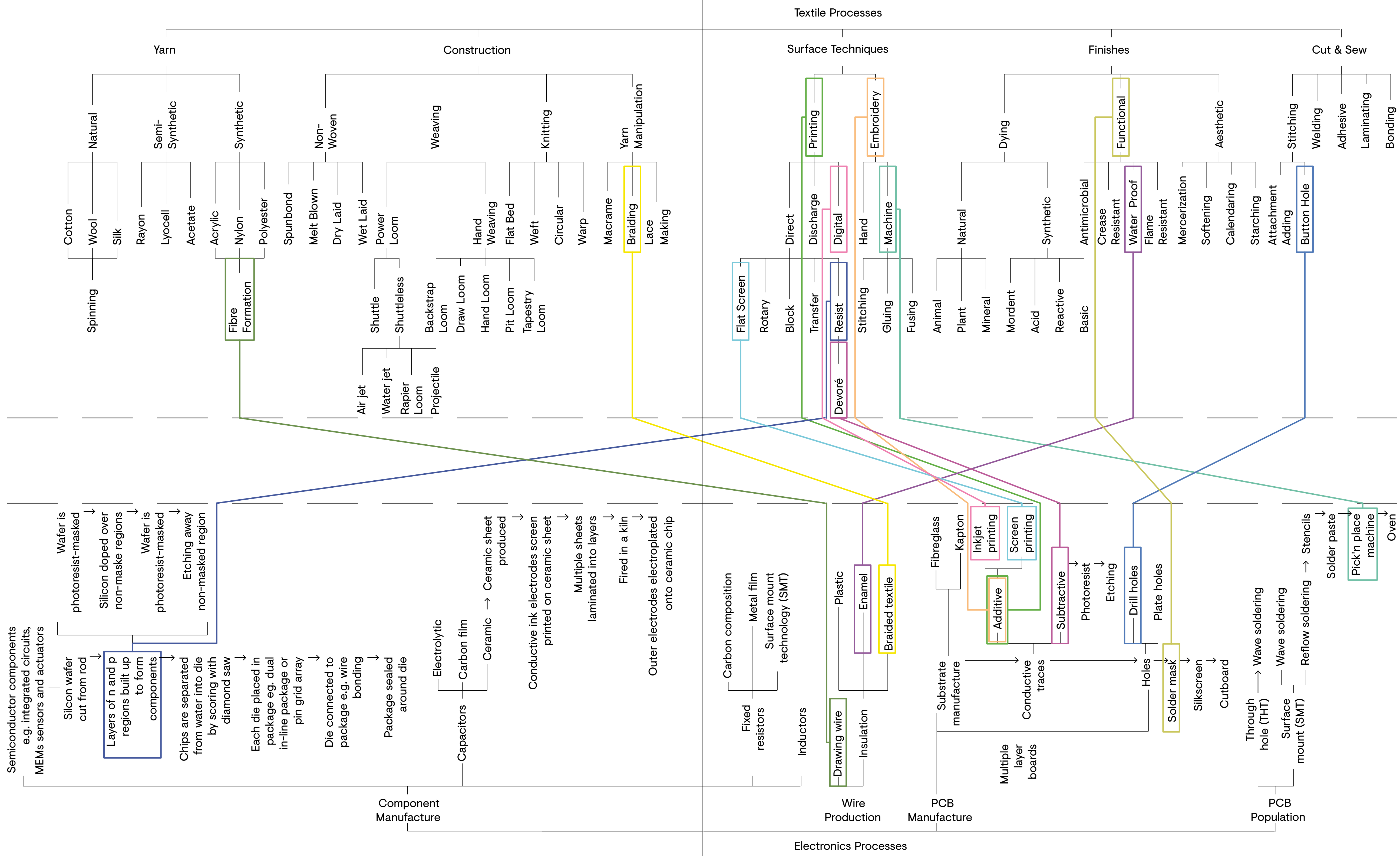
Tincuta Heinzel, Mili John Tharakan,
Ebru Kurbak, Rebecca Stewart

Parallel Industries

Scaling up the production of textile electronics from crafted singular artifacts into mass-producible industrial products is a challenging endeavor. Textiles and electronics industries are the two of the oldest and most significant manufacturing industries in terms of global trade of finished goods. They have grown separately—parallel to each other—for too long, and in return, both industries have become highly resistant to modifying their processes. In order to create an industry for textile electronics, textiles and electronics industries have to be flexible and adopt features from each other. Neither of these long-established industries see the potentials of accommodating the needs of the other yet.

The products of textiles and electronics industries are diverse; but at a closer look, these seemingly separate worlds are linked to each other in many aspects. First of all, as both industries have largely migrated to the same low-cost countries since the 1980s, their manufacturing facilities are mostly located in close geographical proximity, albeit the conception and design phase is still left in the West. Correspondingly, it is also not uncommon for the same people, especially the low-skilled workers, to shift between jobs in the two industries and get acquainted with parts of both processes. And, finally, despite how entirely dissimilar their manufactured goods seem, there are striking resemblances in the nature of the making processes, machines, and techniques. Addressing the challenge of the industrialization of textile electronics, the *Industrial Cross-Pollination Map* is a methodological proposal for identifying links between the two industries as potential points of intervention.

The *Industrial Cross-Pollination Map* was created through identifying the individual processes of electronics and textiles industries. These were then mapped and connections were drawn between the processes of two industries in terms of materials, machines, and techniques, which were in turn linked. These links provide inspiration for imagining possible new methods in industrial textile electronics. For example, the process of “devoré” in the textile industry and the process of “subtractive conductive trace making” in electronics are very similar in that they both use subtraction as a surface modification method. This similarity represented with a link on the map might prompt using devoré as a subtractive circuit making method for textile electronics. As such, the *Industrial Cross-Pollination Map* inspires the creation of new products and fabrication methods; it is not a comprehensive documentation but rather a proposal that encourages finding more links.



Industrial Cross-Pollination Map (2015-2018),
Tincuta Heinzel, Mili John Tharakan, Ebru Kurbak, Rebecca Stewart
(Illustration by Gülçin Çuhacı)

Crafting Realities

Today's consumer electronics industry is engrossed in mass-producing "black boxes,"—technological objects that conceal the messy electronics under glossy outer shells, designed to be made and used without any knowledge of the internal workings. This style is countered by some DIY and "maker" approaches that suggest "transparent boxes," made by individuals that prioritize technologies that are self-made and open; however, they often content themselves with sole functionality. "Crafting Realities" is a critical exploration, which probes an alternative profile, the textiles craftsperson as the producer of electronic technology. If, as Richard Sennett suggests, craftsmanship is "the desire to do a job well for its own sake," what kind of electronic artifacts should we expect this basic human impulse to breed? By involving actual skillful craftspeople, technology meets handcrafted finesse, delicacy, and self-expression. New tools and new criteria emerge. Crafting realities with pleasure and dexterity challenges the prevalent assumptions about technology, skill, and labor, and the associated social, cultural, and economical implications.

Irene Posch

Handcrafting the Digital

Textile crafts and computational technologies crossed paths centuries ago. Prominent examples include: the invention of the Jacquard weaving loom, as an early, digitally controlled machine; or the weaving of magnetic-core memories as random-access memory for early computers. While the first example falls in the category of a digitally aided craft, the woven random-access memory actually qualifies as a handcrafted digital artifact. Despite these important roles textile routines had in the course of computer history, textiles are not usually considered as being contributive or essential to technological artifacts.

Challenging this assumption, I focus on manual textile craft routines as possible techniques for fabricating electronic and digital objects. The material used, the artifacts produced, as well as the people stereotypically mastering the field—women—make textile crafts interesting for their perceived opposition to digital and electronic technologies. I am interested in considering textile routines and materials as constructive for technological artifacts, and exploring what this might make us alive to.

A distinct quality of textile crafts, compared to others such as woodwork, metal work, or ceramics, is that the creation of the material is an essential part of the craft. It starts with the spinning of the thread, the decisions about which fibers or filaments to use that define the thread's qualities. The crafts building upon spun threads also have long traditions of including diverse materials—textile and non-textile (beads or zippers, for example)—for functional and aesthetic reasons. In addition, textile routines are not exclusively bound to textile material. Any material fulfilling certain dimensional and flexibility qualities can be structured in textile systematics. Here, I want to discuss briefly two works of textile craft processes and artifacts, emerging from an approach to handcrafting electronic and digital objects, which build a practical ground for reflections about such a practice.

In 2010, I knitted wool gloves that included a silver thread as a conductive material to integrate an electronic circuit within the knitted artifact. I designed the pattern so that forming a fist would close a circuit to power LEDs mounted on the glove. If no fist is formed, the switch is open, and the glove looks like any other woolen glove with some beads embroidered on its top. The design idea was to have a warm glove that can be worn when biking at night in winter,

Figure 1
Above: a pair of liturgical papal gloves, sixteenth century, silk and metal thread, knitted, Textiles and Carpets Collection, MAK – Austrian Museum of Applied Arts / Contemporary Art. Photograph by Irene Posch. Below: *Early Winter Night Biking Gloves*, 2010, wool, metal thread, LED, and coin cell battery, knitted. Photograph by Irene Posch.

and when a hand sign is given to indicate turning left or right, LEDs light up at the back of the hand to give a signal to traffic behind.[1]

This was a first step towards exploring textile patterns to hold electronic functions; how interactive artifacts can be built through manual crafting skills in a textile medium. I used knitting as a routine to design the glove as a whole, including the electronic circuit, directly in the making, fabricating an integrated textile circuit. In the final artifact, the conductive silver thread and the isolating wool equally contributed to the successful building of the garment as well as the circuit. A different pattern would alter the visual appearance of the glove as well as the electronic properties embedded.

The pictures in Figure 1 show two pairs of knitted gloves with metal threads: one is a pair of liturgical papal gloves from the sixteenth century; the other pair is the *Early Winter Night Biking Gloves* that I described above. The liturgical papal gloves demonstrate skills and materials used in the sixteenth century, in this case silk and metal threads in a knitted artifact, exquisite materials for high-ranked clerical officials. The *Biking Gloves* are equally knitted, using wool and metal thread, only this time the design was driven by electronic functionality and everyday use. While the coin cell and the LEDs included in the *Biking Gloves* are electronic components only developed in the twentieth century, the other materials and techniques used to build this interactive electronic glove have been available and practiced for centuries.[2] Looking at the two pairs next to each other, one can imagine how the pattern from the sixteenth century could also fit the function of the *Biking Gloves*; how the golden rims on the fingers could be one conductive end of the switch, touching another finger or the palm of the hand to close the circuit. It becomes an intriguing thought experiment to consider the skills, materials, and patterns used in historic artifacts as potentially functional in the context of contemporary technology designs.

The example of the gloves demonstrates the use of materials genuine to a textile crafting practice to build a functioning electronic circuit. Skilled hands and knitting needles form the materials into a three-dimensional object, following a pattern that defines the arrangement of the conductive and insulating material into the functional and visual artifact. Only the LEDs had to be added in a separate step, embroidered onto the final artifact like beads. The resulting object is a hand-knitted, interactive electronic artifact, custom made

1
Irene Posch, “Early Winter Night Biking Gloves” (2010), accessed March 1, 2018, http://www.ireneposch.net early-winter-night-biking-gloves.

2
Sophie Fürnkranz, “Metallstickerei im Außereuropäischen Raum: Beispiele aus der Sammlung des Weltmuseums Wien,” *Technologische Studien* 2 (2005).

to individual aesthetic demands, the size of the hand, and the desired electronic functionality. It is the equivalent of a circuit board, but in individual chosen form and material and directly incorporating some of the desired electronic functions, like the switch. The similarity of the skills and materials used to make the historic pair of papal gloves and the electronically interactive gloves raises the question as to why this combination did not happen much earlier,[3] why these materials and skills that have been practiced for centuries in many different cultures did not play a bigger part in technological innovation of the twentieth century.

Crafted Logic, created in the context of the *Stitching Worlds* research project, takes such an approach a few steps further. The goal of *Crafted Logic* was to explore to what extent textile materials and manual textile routines can be utilized to craft a computer out of textiles. We started the experiment by designing an active electronic element made entirely out of textile routines, a relay consisting of coiled copper wire, a magnetic hematite bead from a jewelry store, and metal threads. When powered up, the coiled copper wire acts as an electromagnet. Depending on the polarization of the electromagnet, the positive or negative pole of the magnetic bead is attracted.[4] Changing the polarization of the electromagnet by changing the input signal results in a turn of the magnetic bead. This movement can be exploited to show different visual effects,[5] or to electromagnetically control opening and closing contacts. The latter corresponds to the functionality of a relay, an electronic component first developed around 1835[6] and later used to build the first programmable, fully automatic digital computers.[7] The two states of the textile relay can be interpreted as two logical states, 0 and 1, and consequently become the basis for crafting logic operations.[8]

Figure 2 shows embroidery executing the logic operation of an exclusive or (XOR) gate. Next to it a 7400 chip is pictured, a 14-pin IC (integrated circuit) containing four two-input NAND gates, optimized for mass production. Depending on how these NAND-gates are connected, the same chip can implement all logic gates and be inserted wherever a logic operation is needed in a circuit. This chip was widely used in mini- and mainframe computers between the 1960s and the 1980s and is still used today in various electronics applications.[9] These two artifacts differ greatly in their materials, the routines, skills, time, and tools used to produce them, as well as their visual appearance. One is efficiently packaged, engineered for the widest possible

3
An early example of textile materials and electronic components is Orth and Post’s work utilizing traditional metal organza, including metal threads from India as a base layer to connect individual components on top. LEDs, microcontroller and portable power sources are available for much longer though. See E. Rehmi Post and Margaret Orth, “Smart Fabric, or ‘Wearable Clothing’,” *First International Symposium on Wearable Computers, Digest of Papers* (Los Alamitos, CA: Institute of Electrical and Electronics Engineers, 1997), pp. 167-68, doi: 10.1109/ISWC.1997.629937.

4
“Textile Relays,” accessed March 14, 2018, http://www.stitchingworlds.net/experimentation/textile-relays.

5
For example, *1-bit Textile* (2015) by Ebru Kurbak and Irene Posch as part of *eTextile Swatchbook*. See “1-BIT TEXTILE for the eTextile Swatch Exchange 2015,” accessed March 14, 2018, http://www.stitchingworlds.net/experimentation/1-bit-textile-for-the-swatch-exchange-2015.

6
Tapan K. Sarkar et al., *History of Wireless* (Hoboken, NJ: John Wiley & Sons, 2006).

7
Designed by Konrad Zuse, the “Z 3” was presented in 1941 and included over 2000 relays. It is assumed to be the first working, programmable, fully automatic digital computer. See Walter Conrad, ed., *Geschichte der Technik in Schlaglichtern* (Mannheim: Meyers Lexikonverlag, 1997).

8
Paul Scherz and Simon Monk, *Practical Electronics for Inventors*, 3rd ed. (Columbus, OH: McGraw-Hill Education, 2013), pp. 800ff.

9
“7400 Series,” last modified March 8, 2018, accessed March 14, 2018, https://en.wikipedia.org/wiki/7400_series.

Figure 2
Above: XOR Gate, hematite beads, metal thread, silver paint, and cotton, embroidered. Photograph by Irene Posch. Below: 7400 chip, PDIP packaging, manufactured by Texas Instruments. The chip is approximately the size of a single bead used in the embroidery pictured above. Image from Wikimedia Commons, Stefan506.

application, mass-produced, and sealed in a black box. The other is laboriously crafted by hand, has a single function and is hardly usable in any commercial application; it is a unique artifact whose pattern reveals its function. Still, both have essentially the same use; both are integrated circuits, ICs that can implement a logic XOR function. For other logic functions, the legs of the chip need to be connected differently; in the embroidery the pattern must change so the individual relays are reconnected to implement a different function. If the according changes are made, both are capable of implementing all logic gates. They become building blocks for any digital device.[10]

Having realized a single logic gate through textile crafting routines meant that eventually a computer could be embroidered, if only the number of textile relays is increased and the pattern is designed to connect individual elements to fulfill necessary logic operations. To realize this, we turned to traditional knowledge and materials. Austria used to have a strong, female-driven metal embroidery tradition producing artifacts for royal and bourgeois houses along with clerical garments.[11] This led to dedicated schools, patterns, and course books, and local shops spreading the material during the monarchy. While the art of gold embroidery is less prominent today than it used to be, we found a skilled gold embroiderer to teach us the craft and a shop to sell us material. Finding the correct material, though, required a lot of testing, as the electronic quality of a metal thread is not something of historic importance, and thus not part of the knowledge traditionally passed on with the craft.

The pictures in Figure 3 show a traditional artifact, a gold-embroidered hat, a traditional costume from northern Austria. Next to it is a detail of *The Embroidered Computer*, consisting of hundreds of connected textile relays. The material used in both examples is very similar, gold thread and gold bullion, complemented with beads and paillettes on the hat, and magnetic hematite beads and enamelled copper wire in the case of the computer. The gold hat displays traditional motives, the detail of the computer shows a pattern evolving from the functional connections of individual relays, the gold strings being at the same decorative and conducting the signal between individual beads.

These two examples, knitting an interactive glove and embroidering a computer, show some distinct aspects of electronic and digital technology as possible results of textile

10
Irene Posch and Ebru Kurbak, “CRAFTED LOGIC: Towards Hand-Crafting a Computer,” In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA ’16)* (New York: ACM, 2016), pp. 3881-84, doi: 10.1145/2851581.2891101

11
See, for example, Amalie von Saint-George, *Die Kunst der Goldstickerei. Nebst einer Anleitung zur Verwendung der Goldstickerei in Verbindung mit Application* (Vienna: Verlag der “Wiener Mode,” 1890).

crafting practices. Informed by the practical experience of making these artifacts, I want to discuss some insights that such an approach might have. This includes the process of crafting technological artifacts, skills, and materials deemed important in the making, as well as divergent approaches to technology resulting therefrom.

Handcrafting digital and electronic objects demands foremost crafting skills, a fundamentally different prerequisite than other electronic making/assembly practices. It incorporates crafts and materials not previously connoted to the electronic or computational domain and manifests itself in how the artifact comes into being, and consequently in its visual appearance and possible use. David Pye describes craftsmanship as using any kind of technique or apparatus, in which the quality of the result is not predetermined, but depends on the judgement, dexterity and care which the maker exercises as he works. The quality of the result is continually at risk during the process of making.[12] Contrary to that, during mass production, the quality of the result is predetermined. This might require a large degree of judgement, dexterity, and care before the production process starts, but once started there is no possibility for variation.[13]

The production of conventional electronic components fundamentally relies on the certainty of repetitively producing a precise functionality as the core quality of the result. They are packaged in uniform cases to ensure a standardized integration of distinct components towards producing the final artifacts. The visual appearance of the components is usually not important, as they are hidden in a box or underneath the surface. These needs can be met by mass production routines and designs that ensure a best possible use-to-capacity result in a set of components that the user can then combine into diverse artifacts.

Contrary to that, crafting electronic or digital functionality inherently results in custom form and functionality. The function as well as the form depend on the maker’s choices and skills that render a design into a physical artifact. As individually fabricated objects, these decisions do not have to consider standardized values or connections for easier integration with other elements of the artifact, as all of it is custom made to fit a specific goal. Customizing a design to fit precisely the actual needs does not manifest in additional manual work, but rather spares the crafter from producing parts of a function that will never be used. The resulting material or object, rather than component, is a unique handmade electronic or digital artifact.

Figure 3
Above: “Linzer Mädchenhaube” dated to 1995 and embroidered by Anna Maria Pregartner. This is a traditional gold hat for an unmarried woman, a so-called *Mädchenhaube*, made up of gold thread, gold bullion, paillettes, and beads. Photograph by Kati Pregartner. Below: detail from *The Embroidered Computer*, 2018, gold thread, gold bullion, copper wire, and beads, embroidered into textile relays, patterned to form an 8-bit computer. Photograph by Irene Posch.

12
David Pye, *The Nature and Art of Workmanship* (Bethel, CT: Cambium Press, 1968), p. 20.

13
Ibid., p. 21.

In order to knit, embroider, or crochet electronics, it is not essentially necessary to understand electronics; it would be enough to precisely follow a crafting pattern or design. Comparable to the knitting of a sweater, the more experienced a crafter is, the safer she or he will feel deviating from the given pattern and adapting that design to personal needs. When knitting a sweater, the final artifact is defined by the materials and colors chosen and the pattern and stitches holding them together. When crafting electronic artifacts, these materials, patterns, and stitches not only define the visual and haptic appearance, but also the invisible as well as intangible electronic qualities. Which materials are used, if they are conductive, resistive, or insulating, and how they are arranged with each other, results in specific electronic functions. Usually invisible digital and electronic qualities become defining conditions to the pattern that forms the function in electronic textile crafts.

To the attentive crafter, such an approach can be a pathway into the principles of physics, a tangible experience of how individual electronic properties are physically constructed. The material properties that define specific functions can be seen and touched, and only the arrangement of them produces the desired electronic functionality. Knowledge about the material and the technique that structures it reveals the essential laws of physics underlying the electronic components. If adequate tools are used, the electronic changes can be observed during the textile making, allowing a reflective integration of aesthetic as well as functional aspects in the practice.[14] Also, if not crafting an artifact oneself but looking at the final craft object, its scale provides a possibility to visually and tangibly retrace the electronic and digital construction.

Making an electronic artifact through manual textile routines means it can also be unmade through inversing or unraveling stitches. As in traditional textile making, unmaking becomes essential to undoing mistakes. It can also be a way to recycle an element no longer used, reusing the material to build a new artifact, or function. The glove could be unraveled, and materials reused to knit a different glove design, or size, with the same functionality, or even a completely different cloth. What has been done to stitch, knit, crochet, etc., a desired artefact, can mostly be reversed and undone without disrupting the material used.

The awareness that making a mistake is not ruining all work done so far, proved important in the making of the artifacts presented above. When working with other amateur and expert embroiderers on the gold embroidery of the computer, they were often reluctant to start, asking: “Can I do something wrong?” to which I answered, “Yes, you can do many things wrong. But also, everything is handmade and if not done well enough can be taken apart and made again, so fixing a mistake will take some time, but will not be fatal to the artifact.” This did reassure the embroiderers. I assume, because they knew the craft and risks involved in embroidery work, they could estimate the potential damage they could do, as well as know what it would take to fix it. The electronic functionality became an implicit element of a domain they felt comfortable in. It was no longer an external and abstract aspect of the work they did not know how to deal with.

14
Irene Posch, “Crafting Tools,” *Interactions* 24, no. 2 (2017): 78–81, doi: 10.1145/3038227.

As a process, “Handcrafting the Digital” is an intervention into the way we generally assume electronic and computational technologies to be made. As artifact, it is an inquiry into possible material alternatives in electronic making, considering not only the final function but also the making to be a relevant aspect of a human’s interaction with technology.

Handcrafting digital and electronic artifacts is a distinct way of interacting with computational technology. The artifacts resulting from such craft practices present an alternative scenario for constructing electronic and digital objects, but they also provide a new angle to understanding the physical principles that underlie contemporary technological products and open up to new craft expertise to contribute to the field. The interplay of conductive, resistive, and insulating materials to form specific electronic functions becomes a tangible experience and way of understanding, paired with an active engagement into how we assume and desire making and experiencing digital and electronic technologies. It has the potential to offer insight into the underlying structures of technological artifacts, to question aesthetic and functional qualities that we’ve grown accustomed to, and to potentially enable new forms of interacting with technology, both in the making and the using.

Crafted Logic

2015
Ebru Kurbak, Irene Posch

Mixed-media installation.
Cotton, copper, silver, hematite, paper, video.

Engineering assistance
by Matthias Mold

Crochet work by Şehnaz Akışık, Kerime Koşar, Hülya Öğreten, Sebahat Sönmez, Belgin Taner, Meral Tınmaz, and Sevil Yüksel

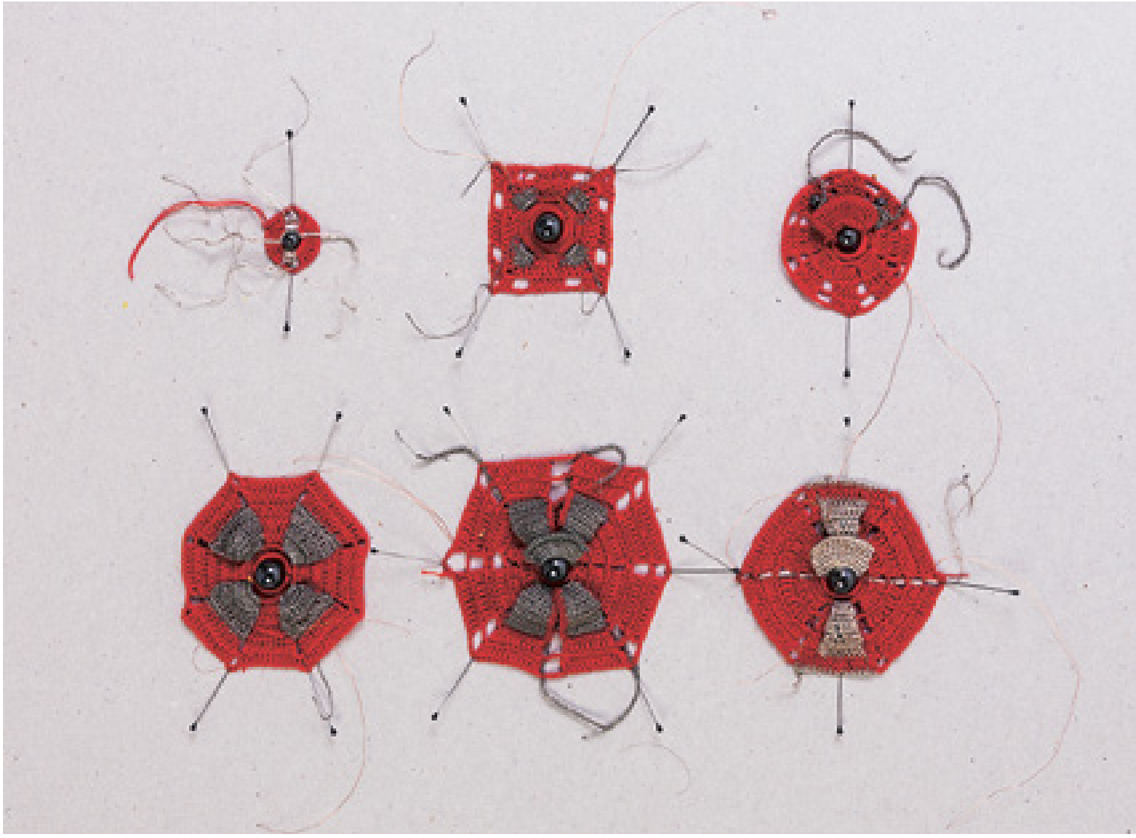
Video by Sıla Ünlü

Workshop organized by amberPlatform in the scope of amber'15 Festival: "Laboro Ergo Sum—I work therefore I am."

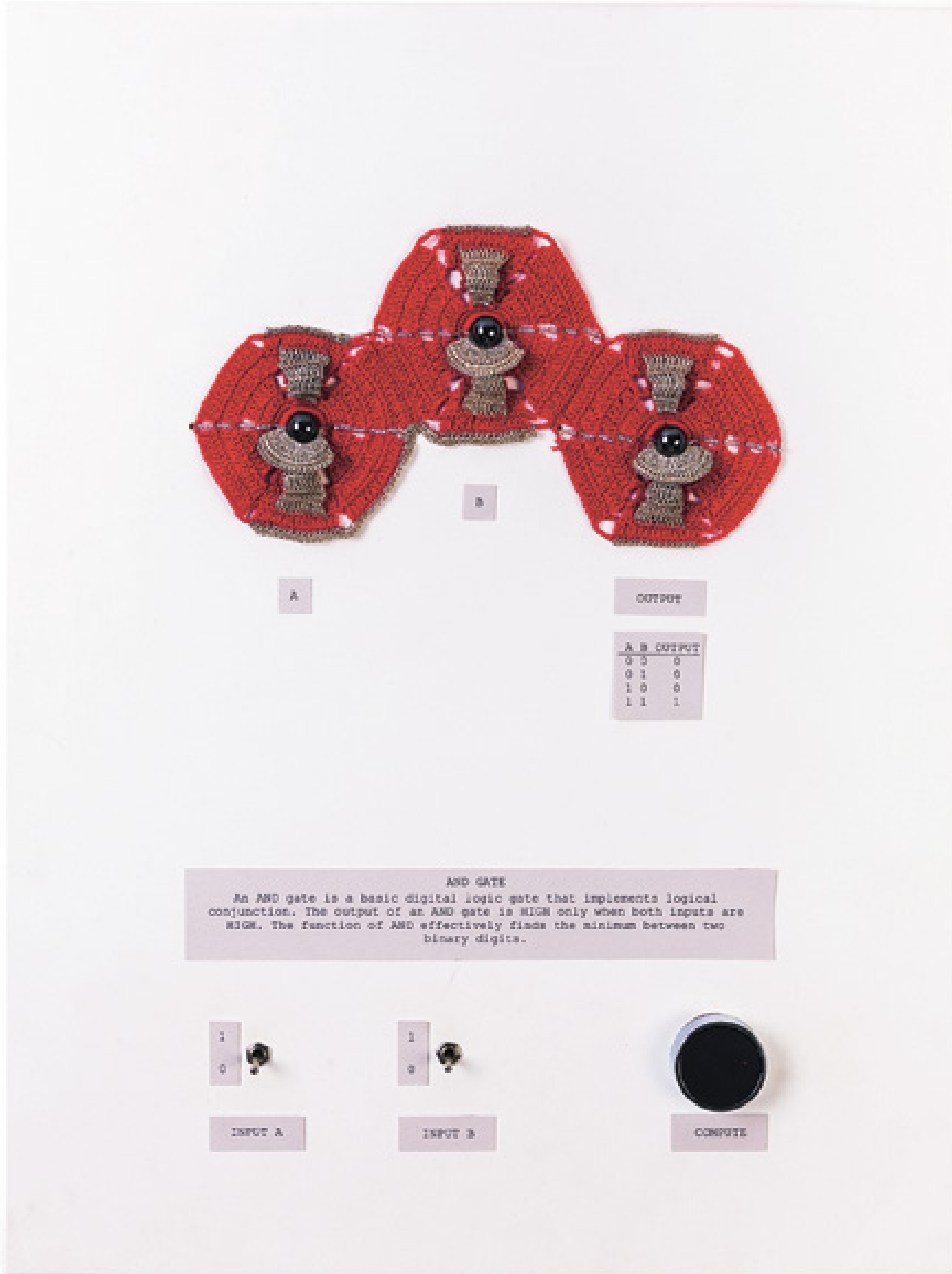
Crafted Logic is an experimental process that focused on exploring traditional local needlework techniques as methods to develop electromechanical switches, logic gates, and eventually an Algorithmic Logic Unit (ALU) of an electromechanical computer. The process started with testing the potential of two different crafting techniques—crochet and hand embroidery—and continued with opening the crochet-based process to a group of skillful women in Turkey.

The women in Turkey are largely skilled in crochet, practiced, especially in rural Anatolia, as part of a long tradition of the wedding trousseau. The wedding trousseau is typically handmade over several years by the bride and other female members of the family, and contains delicate objects, such as doilies, towels, beddings, tablecloths, curtains, and clothes, which symbolize skill, wealth, and dignity. This tradition leads women to spend significant time practicing and gaining a high-level expertise, especially in crocheting, one at a time, circular, square, and hexagonal small "motifs," to be combined into a larger textile object later on. The practice, however, often remains in the domestic realm, and only female peers having the same obligation appreciate the skill and competence. The participatory component of *Crafted Logic* is an attempt to probe this relatively undervalued expertise in an alternative context, by involving the crochet experts in the process of using threads with conductive properties and making functional electronic components and objects. The process involved elaborating the pattern for a functional, crocheted, electromechanical switch motif and creating a functioning ALU under the advice of and in collaboration with the skillful women.

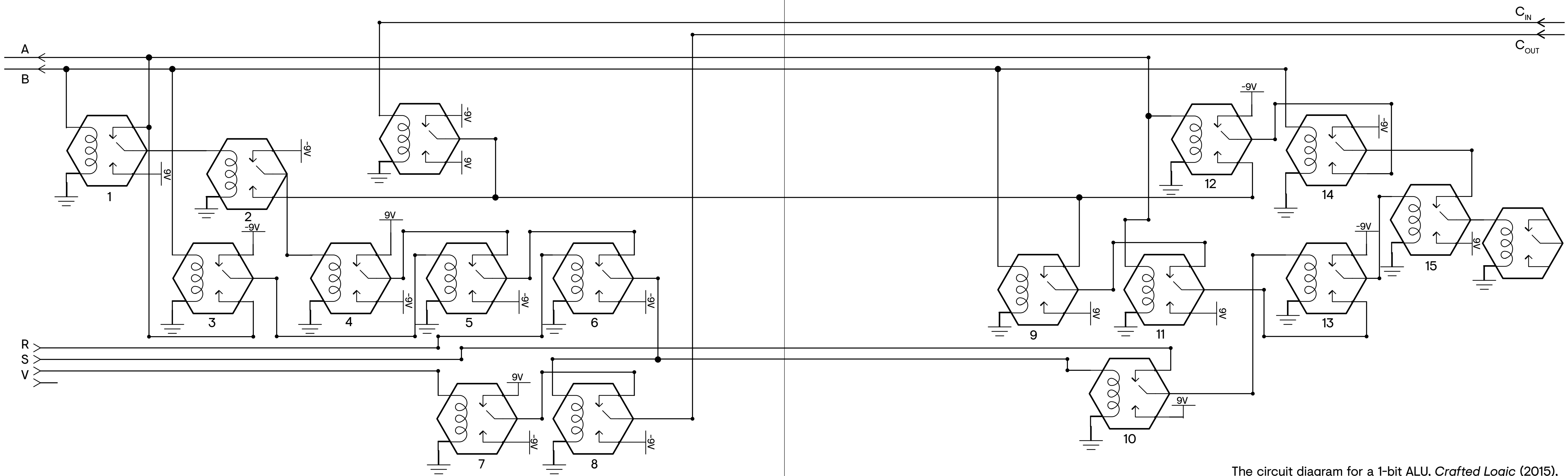
Detail from the exhibition, *Crafted Logic* (2015),
Ebru Kurbak, Irene Posch (Photograph by Elodie Grethen)



Study models for developing a crocheted
electromechanical switch, *Crafted Logic* (2015),
Ebru Kurbak, Irene Posch (Photograph by Elodie Grethen)

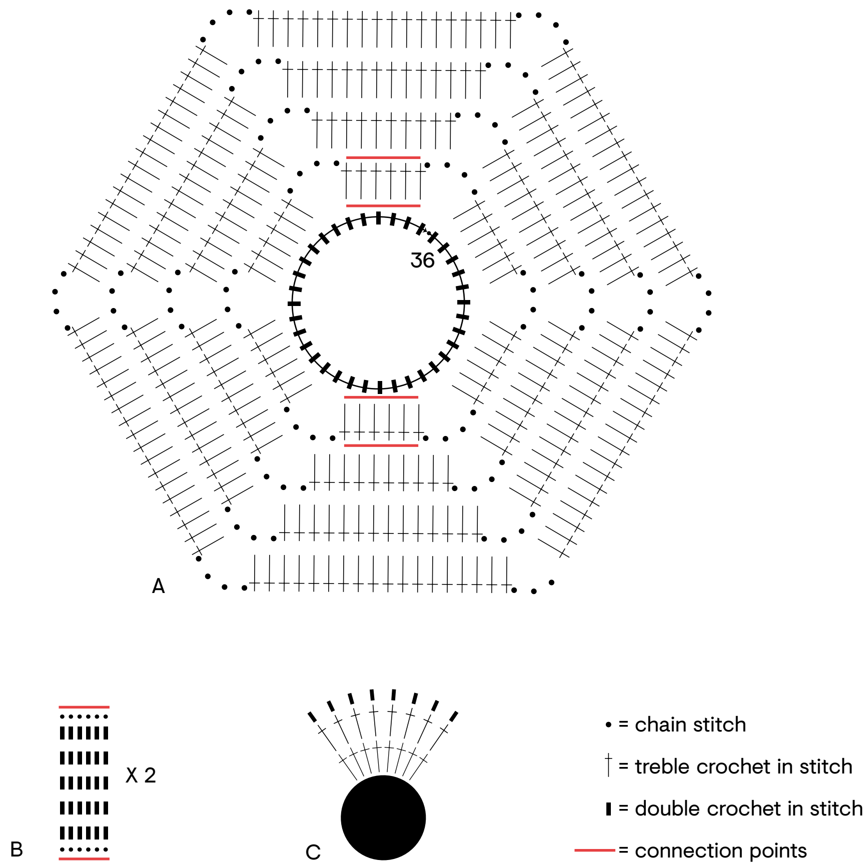


A crocheted AND gate, *Crafted Logic* (2015),
Ebru Kurbak, Irene Posch (Photograph by Elodie Grethen)

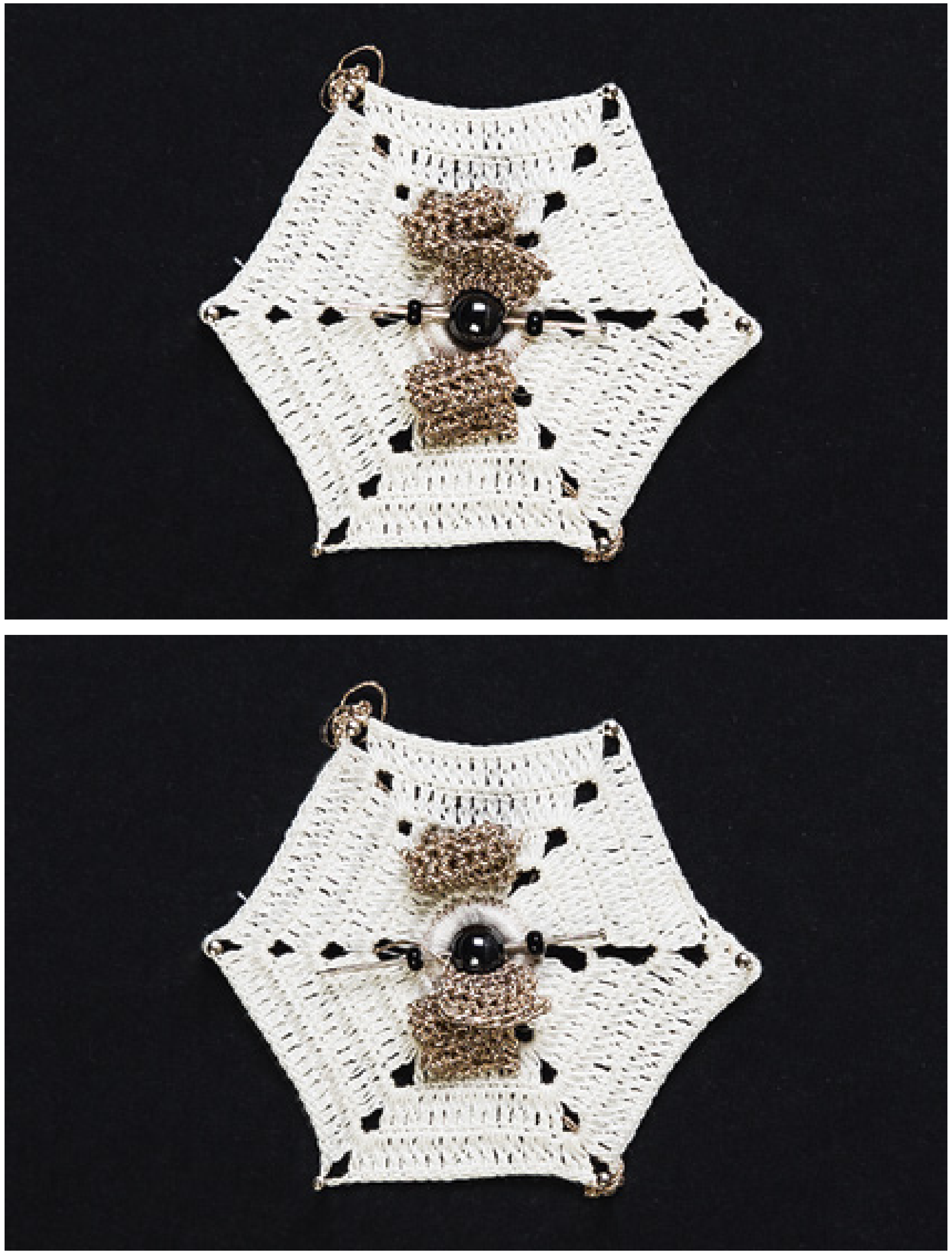


The circuit diagram for a 1-bit ALU, *Crafted Logic* (2015), Ebru Kurbak, Irene Posch (Circuit design and diagram by Matthias Mold)

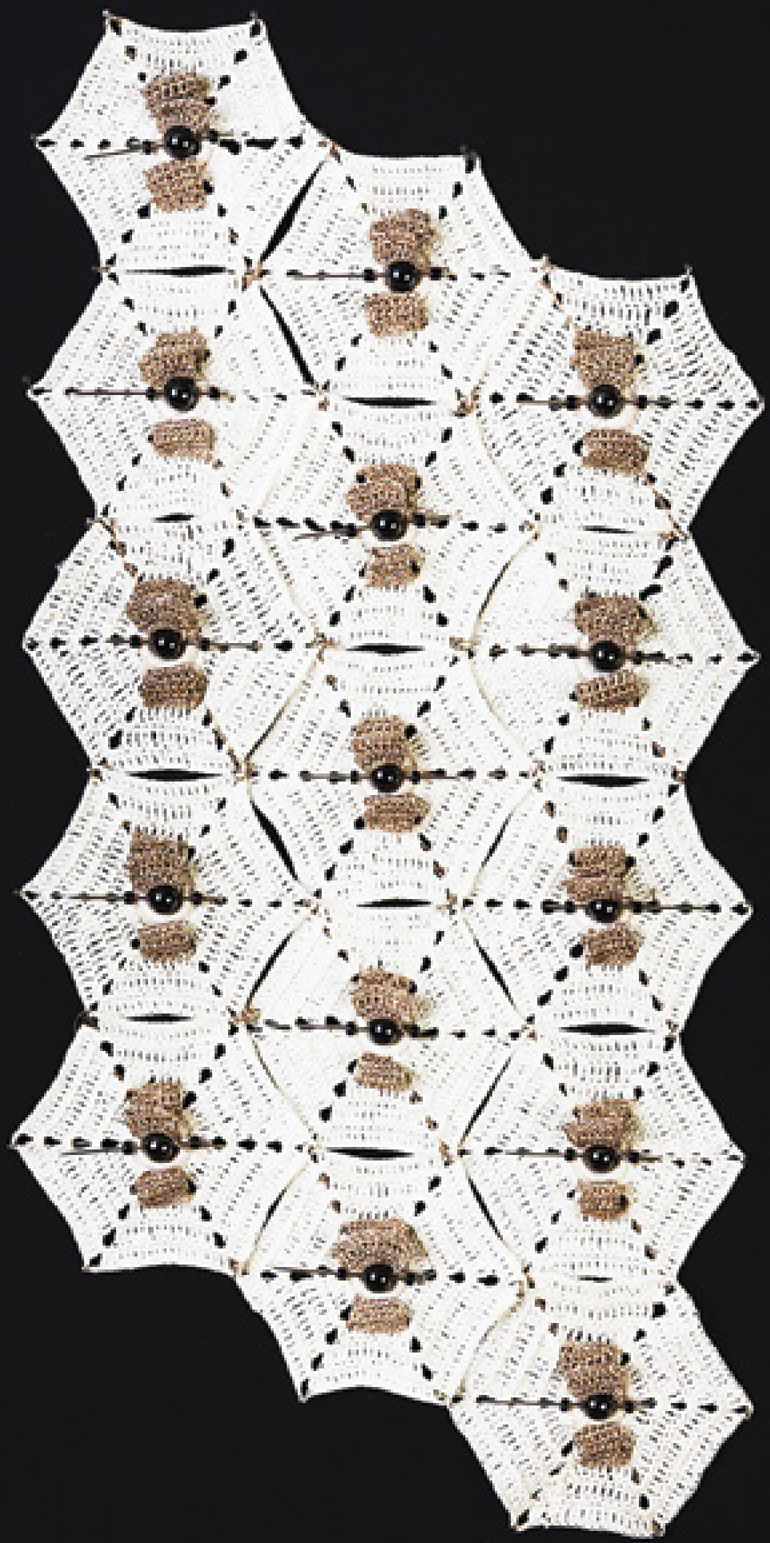
Screenshots from the documentary video of the workshop conducted with crochet experts in Istanbul, *Crafted Logic* (2015), Ebru Kurbak, Irene Posch (Video by Sıla Ünlü)



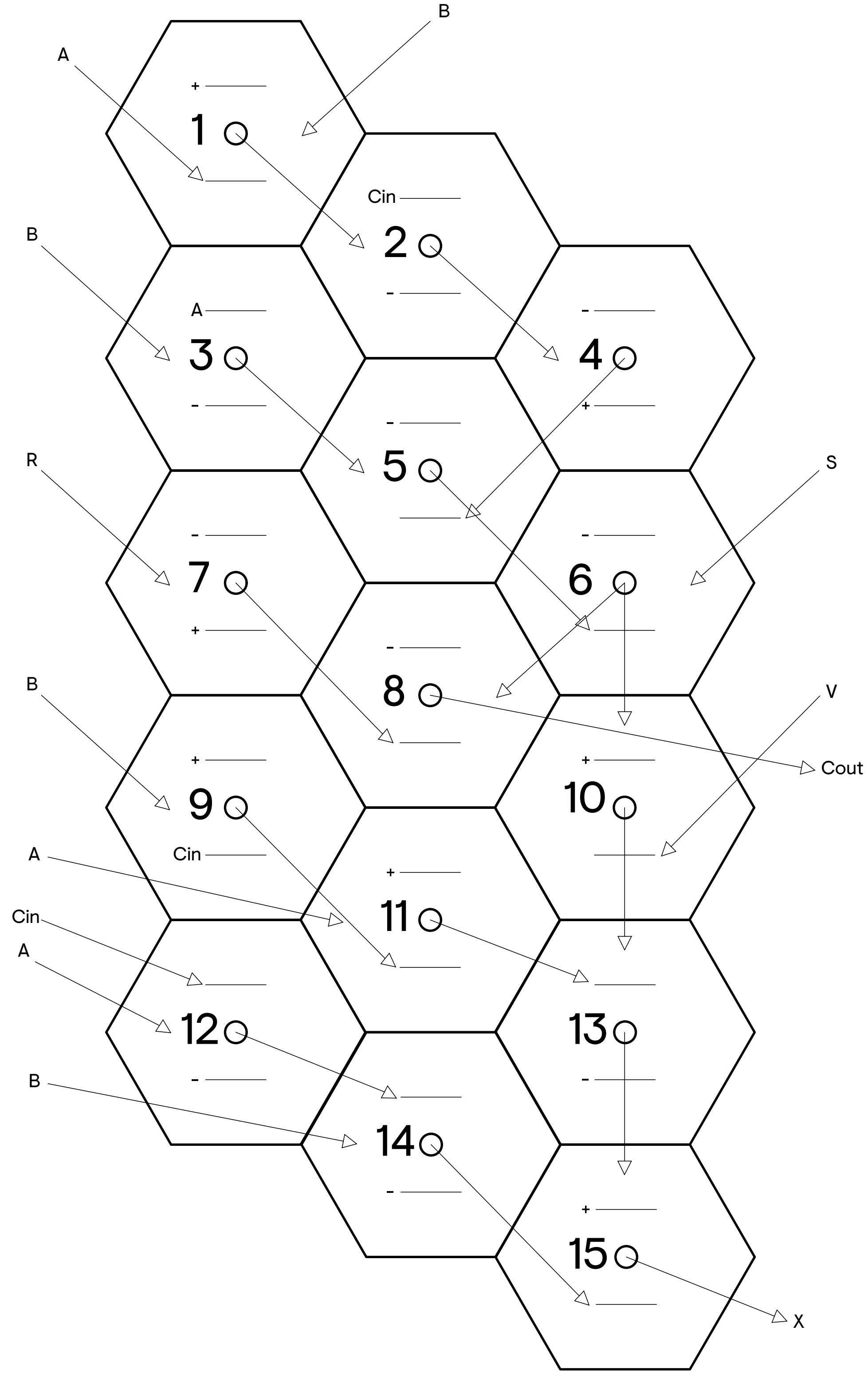
The pattern for a crocheted electromechanical switch,
Crafted Logic (2015), Ebru Kurbak, Irene Posch
(Illustration by Alice Herbreteau)



Final crocheted switch design shown in “0” and “1” positions,
Crafted Logic (2015), Ebru Kurbak, Irene Posch
(Photograph by Elodie Grethen)



The crocheted ALU, *Crafted Logic* (2015),
Ebru Kurbak, Irene Posch (Photograph by Elodie Grethen)



Connections schematics of the crocheted ALU,
Crafted Logic (2015), Ebru Kurbak, Irene Posch

Ekmel Ertan

Crafted Logic for a Different—Big—Machine

I am thinking of media art in the 1960s, artworks such as *Schotter* by George Nees,[1] *Hommage à Paul Klee* by Frieder Nake,[2] and other works produced when the computer was a new medium for art. While these were about creating visual artworks and, in a way, mimicking the conventional art of the time; nevertheless, they immediately sparked discussions about the relation of art and technology. The artists were basically using the military technologies of the time! This was one of the main concerns for artists in the 1960s, especially in the US; other concerns were the new art form's social role and the commercialization of art. In 1971, Frieder Nake published an article titled "There Should be No Computer Art."[3] He wrote "Sorry! But I don't have any new works" on the invitation letter to (New) Tendencies 5, in 1973.[4] In 2014, in a rejoinder to the statement he had made forty-three years ago, Nake wrote "the myth of the big machine, I believed, was propagated by its aesthetic products more successfully than by its usual numeric applications."[5] Perhaps Nake was right. Perhaps media art did help the big machine to penetrate all aspects of our lives. At the end of the day, all the *prophecies, all the facts that* the media artists warned us about, have come true.

Media art has always had a strong critical path, especially in the 1960s, 1970s, late 1990s, and early 2000s. However, following this critical path became more difficult in the post-digital era, as the artists lost their distance from the medium. Postmodern neoliberal politics went hand in hand with digital technologies, with the "big machine." The success of neoliberalism is wired into the digital realm, from the society of control to algorithmic governance, to labor and self-exploitation. Media art lost its critical stance due to the ubiquity of digital technology and its penetration into everyday life, the institutionalization and commercialization of the media art scene, and the predominance of the noise created in every field by the perplexity and transitivity of neoliberal concepts and discourse.

Stitching Worlds makes an important artistic statement that questions the foundations of the digital and takes a unique approach in deconstructing "digital" from the viewpoint of the arts-based research project. Ebru Kurbak and Irene Posch's *Crafted Logic*, a work they developed in the scope of *Stitching Worlds*, is about creating electronic switches and logic gates, with the traditional crochet technique using conductive threads. What they created in the end is a functioning ALU (arithmetic logical unit) of an 8-bit computer. However, this particular computer is supposed to be made at home using

1
George Nees, *Schotter*, 1968-1970, lithograph from a computer-generated graphic, Victoria and Albert Museum, London.

2
Frieder Nake, *Hommage à Paul Klee*, 1965, screen-print from a plotter drawing, Victoria and Albert Museum, London.

3
Frieder Nake, "There Should Be No Computer Art," *PAGE: Bulletin of the Computer Arts Society* 18 (October 1971): 2pp.

4
Ekmel Ertan and Darko Fritz, *Histories of the Post Digital: 1960s and 1970s Media Art Snapshots* (İstanbul: Akbank Sanat and amberPlatform, 2014), p. 56. Also available at: http://postdigital.amberplatform.org

5
Ibid., p. 64.

sophisticated crafting knowledge and the labor of women, and with an embedded aesthetic evolved over centuries and throughout the cultures.

Globally, women in the digital sector hold approximately a quarter of the jobs and only thirteen percent of the jobs that require specific ICT (information and communications technology) skills. We can safely say that digital technology is a male-dominated industry. Can we thus assume the digital world's relation to power, from war technologies to the control society, is a consequence of this fact? In *Crafted Logic*, Ebru and Irene give the main role to female labor, but not in a context where women are found only in low-skilled and low-paid jobs. On the contrary, the artists are suggesting a paradigm change. Through seeing their work, one starts to imagine the digital—industry—differently, as an industry based on sophisticated female labor and knowledge without compromising its relationship with the social context and tradition. This is not only about science, or more specifically, technology; it questions the premise of the "digital revolution." When and how did we realize that we needed such a revolution? We know from world history that revolutions are not sustainable without a cost. Indeed, we are suffering from the consequences of the digital revolution, which brought about the rise of neoliberalism. Perhaps what we needed was not a *digital revolution* but an *evolution* based on the needs of individual human beings: the natural person, not the legal person. Let's imagine that a computer was something that women handcrafted. What would an *industry* founded on such fundaments have to offer the world?

In their practical work, Ebru and Irene collaborate with women; they learn from and develop together with them. They extend their practical knowledge and experiments by working with women from different cultures, from Europe and Turkey to China, South America, and beyond. They collect different traditions and techniques of textile handcrafts while developing new knowledge by combining their experiences with new technologies. This brings a brand new aesthetic approach to the digital and connects worlds that we never would have imagined coming together. This is, in its essence, a participatory art practice. When I invited the artists to show *Crafted Logic* at Amber Art and Technology Festival in Istanbul, I did not simply invite them to exhibit the finished product, but wanted to include the process of creating it as part of the artwork. The artists communicated with local women, made workshops

with them, found out new forms and crochet techniques for creating electronic components, documented the process, and collaboratively prepared the exhibition. This was what made the work "real" in the sense that the final outcome—the art object(s)—established a strong connection with its theoretical/conceptual background, which was actually and continuously formed in the course of these processes. As a curator, I am highly interested in such collaborative processes: the formation of the work and the process initiated by artists and developed collaboratively along the way. This collaboration brings high technology down to earth among the people, not as a commodity, but, on the contrary, as a tool and medium with which to work/develop things and ideas.

In its entirety, *Crafted Logic* could not have been realized as anything other than a research process based on collaborative learning and creation. In that sense, it is also a good example of what artistic research is or can be; it requires high-level scientific and technological knowledge, engineering, and experimentation. However, when the artists decided to take their experiments to another level by producing electronic components through textiles, they needed the type of knowledge that the textile industry or, typically, women had to offer. As an artistic choice, the artists started working with women, and this choice eventually brought new openings and new directions to their work; questioning/implying the value of craft, tradition, DIY, women's labor, the type(s) of knowledge rendered insignificant, knowledge-power relations, non-commodity oriented research and development, and last but not least, digital technology itself. Of course, this is my speculation on the flow of things; it could also go in the other direction or—most probably—continuous mutual interaction of all parts; but all of this was (and is) only possible through artistic research. Not many artists work in this way and likely no scientist or technologist does, either.

If you look at the artworks that combine digital technologies and textiles, you will find artistic implementation/utilization of existing—digital—technologies; those might also be socially critical works. But *Crafted Logic* does not take digital technology as a given; it is much more radical than that. On the one hand, it recreates digital technologies; it poses fundamental ontological questions on the other. Even more remarkable is its potential to produce a political discourse. In that context, this is an activist artwork that draws attention to female labor, international working conditions, and most importantly, the regimented production of knowledge, among many other issues. Last but not the least, it challenges the conventional relation of science and technology: without technology, science is an abstract concept. Scientific concepts and findings enter our lives as technologies. Science—as a concept only!—is pure and lies above ideologies or politics, but technologies are not. *Crafted Logic* plays with this conventional relation of science and technology.

From a media-archaeology perspective, this project poses important questions: "media archaeologists have begun to construct alternate histories of suppressed, neglected, and forgotten media that do not point teleologically to the present media-cultural condition as their 'perfection.' Dead ends, losers, and inventions that never made it into a material product have important stories to tell."[6] *Crafted Logic* is doing what media archaeology does in a different, reversed way; lead from today to an imaginary beginning. Artists do not take an obsolete technology and research it as—at least some—media archaeologists might do; instead, they create a highly elaborate but actually obsolete technology to do the same; to narrate their stories of the digital.

In the 1970s, Nake criticized his generations of artists—and himself—for legitimizing the *big machine* through art. Many critical digital artworks have been created since then. However, *Crafted Logic* is not one such digital artwork that utilizes given digital technology to criticize the digital condition; on the contrary, it suggests another technology in which a holistic critique (critical approach) is embedded in and through the interrelation of science and technology. To conclude, I would add, Ebru and Irene recreate anew "the big machine" with its myth inverted; they propose reading the whole story backward.

6
Erkki Huhtamo and Jussi Parikka, "An Archaeology of Media Archaeology," in *Media Archaeology: Approaches, Applications, and Implications*, ed. by Erkki Huhtamo and Jussi Parikka (Berkeley: University of California Press, 2011), p. 4.

Testing a crocheted switch, *Crafted Logic* (2015), Ebru Kurbak, Irene Posch (Photograph by Elodie Grethen)

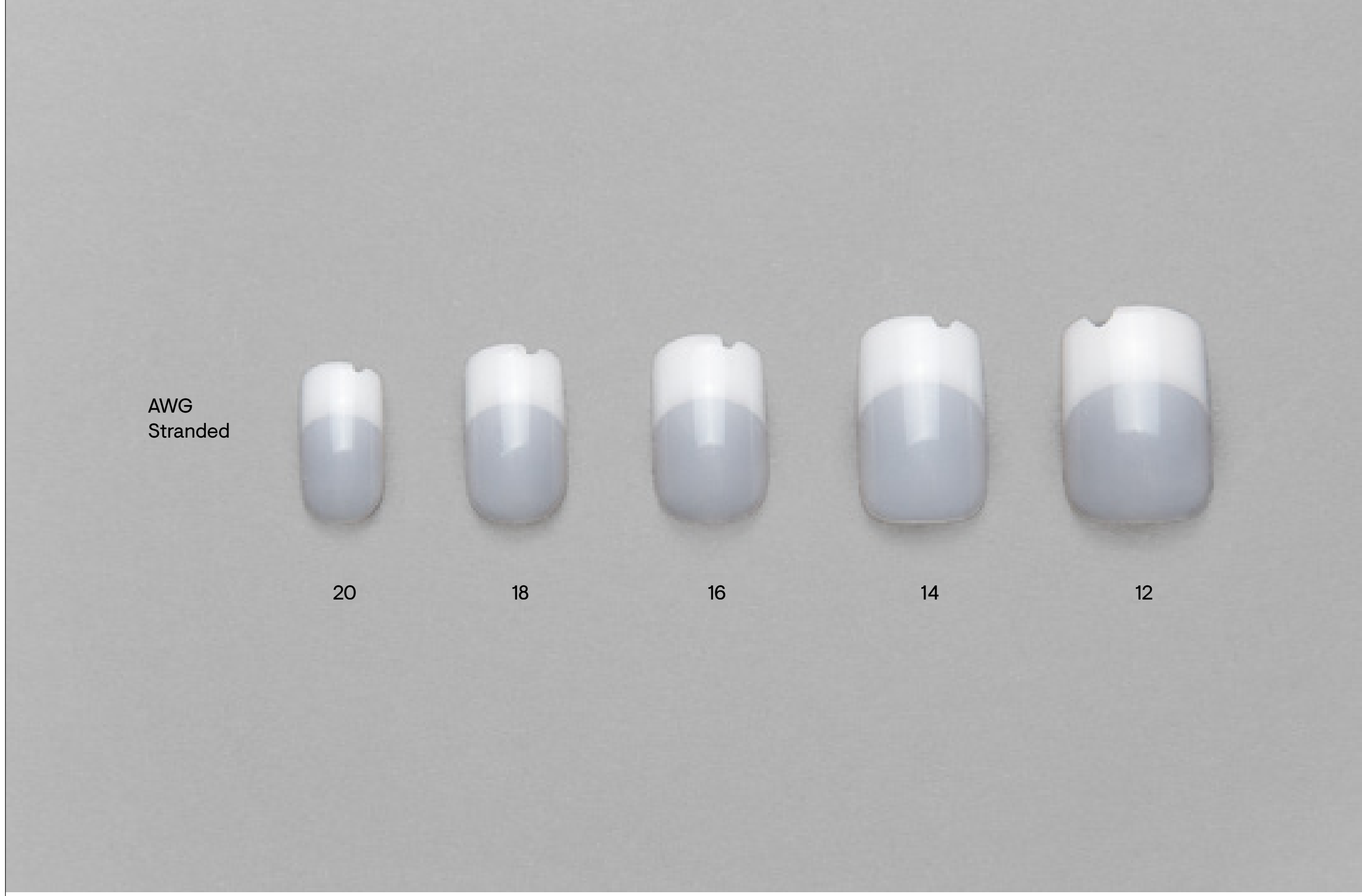
Tools We Want

2014–2018
Ebru Kurbak, Hannah Perner-Wilson,
Irene Posch, Mika Satomi

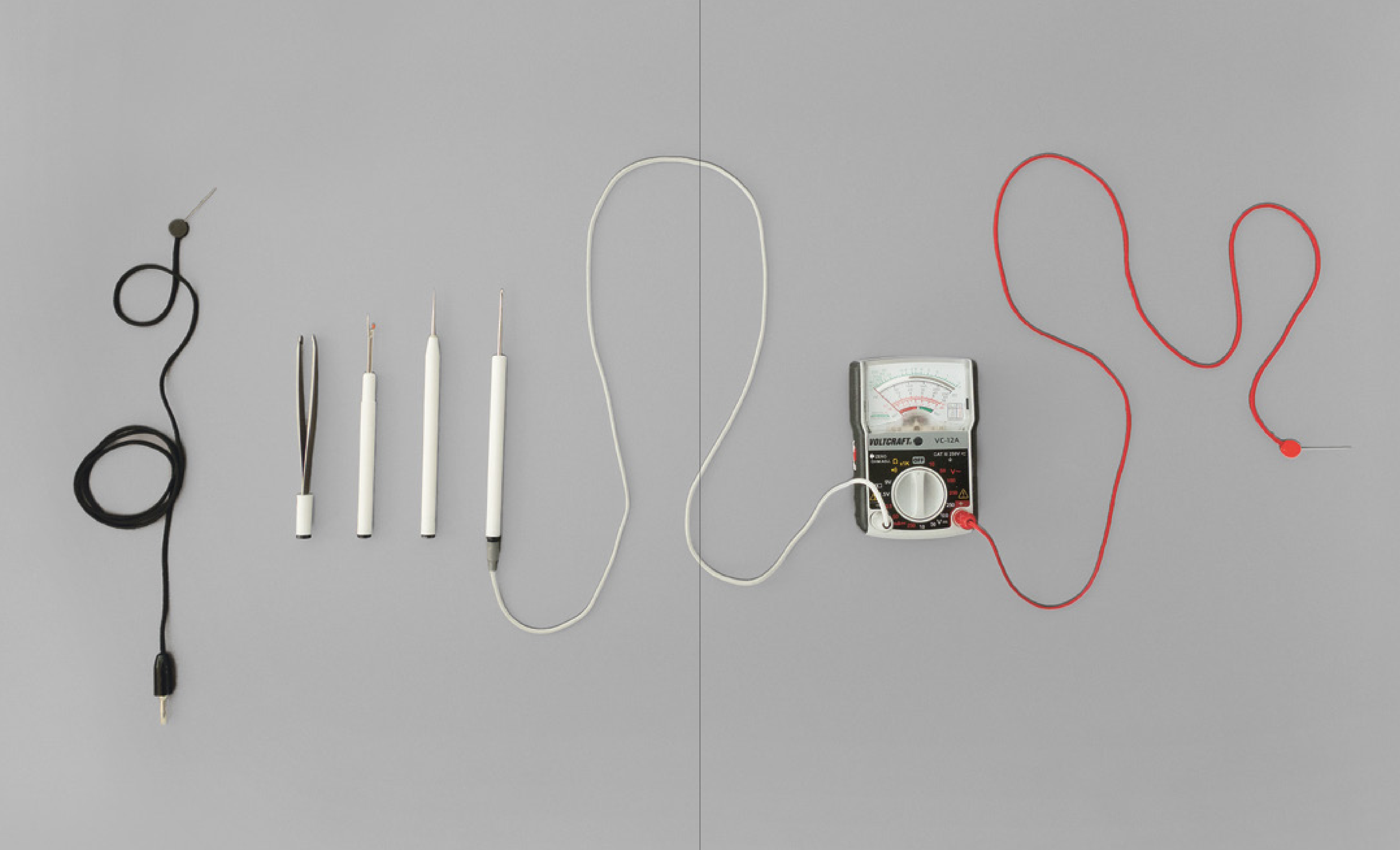
Objects.
Tools made of diverse materials.

Since ancient history, the isolated development of applied professions, from shoemaking to dentistry, has resulted in the elaboration of different sets of tools that fit the precise particular needs of that very profession. In today's world, however, many of the disciplinary boundaries are being challenged by cross-disciplinary approaches; and the available tools fail to fulfill the needs of the practitioners. *Tools We Want* emerged from the desire to imagine, design, and build functional tools for electronic textile practices, which have been bound to borrowing their tools from the formerly isolated domains of textiles and electronics. Four practitioners came together, sought inspiration at workspaces of various other professions, discussed their practices and the limits of the tools they used, and developed a variety of individual ideas and prototypes in conversation with each other. The output of this collaboration then became a growing depository of ideas in the form of a website—toolswewant.at—and a number of physical tools to be elaborated over time through using and refining.

In the *Stitching Worlds* exhibition, a curated selection of four tools is put on display: the *Ohm Tailor's Tape* by Ebru Kurbak, the *Fingernail Strippers* by Hannah Perner-Wilson, the *Needlework Probes* by Irene Posch, and the *eTextile Tailor's Scissors* by Mika Satomi. The tools on display, beyond being one of the many practical extensions to the artists' toolkits, are chosen for the way they visually communicate the straddled position of cross-disciplinary practices like electronic textiles, and form a commentary on socially constructed stereotypes about skills and competencies.



Fingernail Strippers (2014), Hannah Perner-Wilson
(Photograph by Elodie Grethen)



Needlework Probes (2014–2017), Irene Posch
(Photograph by Elodie Grethen)

Ohm Tailor's Tape (2018), Ebru Kurbak
(Photograph by Elodie Grethen)

eTextile Tailor's Scissors (2018), Mika Satomi
(Photograph by Elodie Grethen)

Interview with Onur Akmehmet

How to “Make” Money

EK (Ebru Kurbak) Onur, in our regular correspondence in the course of *Stitching Worlds*, we discussed the concepts of craftsmanship and labor and their relation to the economy and economic value. You often referred to one’s “distance to money.” Can you explain a little more about what you mean by that term?

OA (Onur Akmehmet) “Distance” in this respect refers to something you walk upon or circle around on a continual basis with a destination in mind. Over time, the divergence of products/services and the convergence of available currencies have meant that a diverse range of activities—from the attainment of childhood education to posting on social media—are increasingly measured by their respective distances leading into money. The shortest distance to money in many cases is through money. Monetary structures have functioned as super-players, diminishing or increasing that distance at will. The resulting motives culminate in a form of behavior resembling musical chairs. Incentives are aligned such that one does not wander away from the line of chairs—highly institutionalized central/commercial banks. Anything else would mean getting off the path, falling out of the circle. And if you stay on the path, the destination is still in the mind but not in the reality. There will only be one left with the chair, and in all likelihood it won’t be anybody you know.

EK What about today’s digital currency and its miners? Is the human condition really any different in the era of digital currencies? How do you see the relationship between labor and economic value, shaped by the practice and culture of digital mining?

OA As digital currency has emerged in the last decade, the digital mining processes have introduced a non-centralized structure in the making of currencies, providing a shield from the political creation of money for some. However, the accelerated market valuation of crypto currencies, the spread of their usage, and the glorified block-chain transparency do not remedy the situation. Let’s take the example of using electricity produced by the human body and transforming it to currency. The leap here is quite phenomenal for our times: one lies all day on a bed and makes “money.” Indeed, lying in a bed with wires stuck to one’s skin is a form of production, the body being used as a raw material. Nevertheless, we might look at this example and assert that the individual has been reduced to its neurological impulses and that forms of agency have become non-existent; or, less drastic and much more common, sitting in front of a laptop all day and mining crypto currencies is akin to being a mechanical Turk. In this form of production, artistic, intellectual, and communal traits are on the back burner. Uniformity breeds uniformity. The value of human activity continues to be reduced to its distance to money.

EK In one of our previous conversations, we “coined” the keyword Knitcoin, as a tool to discuss and understand the various degrees of distance one can imagine between labor and economic value. What if, for a moment, I asked you to really imagine a revival of the idea of handcrafting currency as opposed to the digital mining of it? What qualities and concerns does such a fictive world bring to your mind? Does this reveal any new remarks on our actual current condition?

OA Yes, it does. Assuming that the story of production told via land, labor, raw materials, capital, and technology is still a vibrant one, the idea is to imagine all sorts of new what-if-spaces in which all five are combined, albeit with dynamic contributions, yet combined nonetheless. Any thoughts about works of this kind need to ask of its experimental design, what does it mean to be human in a material world? The architecture of new physical, digital, and mental spaces needed for this kind of endeavor is not currently present either at national printing presses or in servers at undisclosed locations. Through handcrafting, we might get an opportunity to position currency like any other product in the marketplace. With a form in the three-dimensional world, visible to the eye, which has a texture, feel, smell, and it may even be responsive to touch. Knitcoin arose from a need to introduce form that is not merely paper, metal, software, etc. This effort requires production processes of currency to become as “valuable” as the final product. In visualizing such a world, how would the injection of the human experience within money-making ensure that tradability, liquidity, traceability, distinguishability, and uniformity needs are met? To address each concern and come up with a convincing answer would not be a conceivable task: the answer lies in the notion that requiring all of these issues to be addressed is not necessary. That is the revival! Handcrafting will not necessarily fulfill all the requirements. Because these requirements were manufactured, pun intended.

EK Is there a way out of this? Must our future be built upon spaces where people blindly abide by such manufactured requirements? Is there an alternative to economic value?

OA I’m proposing more of a redefinition of what economic value is rather than an alternative to economic value. Not bringing back what was assumed to be right the first time around, but rather introducing innovative design into how we think about economics. That is the way out. Simply, what is exchanged and stored as economic value need not be uniform. Just like stories, each story is stored and exchanged—and each one is unique.

The Knitcoin Edition

2018
Ebru Kurbak

Installation.
Paper, wood, wool.

Economics consultancy
by Onur Akmehmet

The Knitcoin Edition is a material commentary on the current human condition shaped by the recent accelerated market valuation of cryptocurrencies. Manual labor and economic value have been in a constantly changing relationship throughout the history of humanity, from the time when people who lived along the Silk Road used textiles as currency (literally “making” money through tediously brocading and hand-weaving silk), to the rupture created between the two by immaterial money markets dominating the world of finances. Emerging cryptocurrencies, shadowed by the justified thrill they create with the promise of decentralized structures, are further transforming this relationship. A human condition that is perceived to be new has arisen from the delegation of the making of money to the computer by “currency mining,” while the investors themselves are immersed in the continuous monitoring of trading charts.

The Knitcoin Edition is an intervention in the well-known board game Monopoly to evoke speculation on the implications of this type of pseudo non-labor, which in some aspects has come full circle to the ancient practice of being invested in the laborious making of the currency itself. The proposal is to replace the game’s paper play money with “knitcoin” without changing the rest of the rules. When players need play money, they must knit it. The installation invites the audience to speculate on the consequences of such a system. Monopoly is proposed intentionally as a self-reflexive component, since the game itself was originally invented as a critical tool to demonstrate the unfair consequences of the system it now iconically represents.

The Knitcoin Edition (2018), Ebru Kurbak
(Photograph by Elodie Grethen)

The Workshop

The workshop defines the craft. It differs from a corporate, prefurnished workspace, as it progressively evolves with the individual needs of the craftspeople while their skills and knowledge mature. It gets filled with handpicked items day by day and does not only become a backdrop of inspiration and convenience for the craftspeople, but also represents the boundaries of their skills and interests to the outer world—a textile-electronics workshop filled up slowly in time without a predefined formula. Reinstalled in the final exhibition of the research project, the *Stitching Worlds* workshop showcases the surfacing and maturing of a unique craft, providing a final opportunity for the craftspeople to revisit unfinished experiments that have remained in their minds.

Exhibition view, the reconstruction of the *Stitching Worlds* workshop (Photograph by Elodie Grethen)

Exhibition view, the reconstruction of the *Stitching Worlds* workshop (Photograph by Elodie Grethen)

Detail, the reconstruction of the *Stitching Worlds* workshop (Photograph by Elodie Grethen)

Alternative Histories, Counterfactual Futures

The knowledge and skills required for working with textiles and electronics are perceived to be completely dissimilar, and are often associated with female and male gender stereotypes, respectively. However, as a matter of fact, the textile industry lent its concepts, tools, machines, and people to the electronics as well as computing and communication industries many times in its long-lasting history, and inspired some of the groundbreaking technological advancements that have come to define our lives today. In most of those occasions, the mingling of the two domains happened only temporarily, ending with the industries adopting what they borrowed and going their own separate ways. What if we took those crossover moments as inspiration for imagining alternative histories, presents, and futures? What would the props in those alternative realities look like? How would our perception of the two domains be altered in the presence of technological objects that candidly expose the vital role of feminized skills?

Ebru Kurbak

Fiberpunk: Inventing Feminine Pasts

In her *In Other Worlds*, Margaret Atwood tells us what wonder tales can do. They can give us hope by pointing out that our current undesirable conditions are not necessary: "if things can be imagined differently, they can be done differently."[1] They also can interrogate social structures by showing what things might be like if they were rearranged.[2] In this short essay, I discuss an artistic strategy that explores "making" technological things differently, with fibers and needlework, and with moral intents comparable to those of Atwood's wonder tales. It involves works created during the *Stitching Worlds* project, such as the *Embroidered Computer* and the *Yarn Recorder*. What does it mean to embroider a functioning electromechanical computer utilizing golden threads, or to create a recording and playback device that uses yarn as the recording medium? What does it mean to imagine, create, and display alternative technologies that belong to the past and not the future? How can standing before a technological object that gently speaks of another time, another dimension, and another maker, subtly evoke different ways of conceiving the world?

Imaginable Possible Futures

The "possibilities cone" presented by Taylor in 1990,[3] and then by many others, including Hancock and Bezold in 1994,[4] Voros in 2003,[5] Candy in 2010,[6] and Dunne & Raby in 2013[7] with slightly different names and illustrations, introduces the idea of "possible futures" as opposed to *the future* in the shape of a cone (figure 1). The model consists of an endless number of futures distributed in different areas that contain possible, plausible, probable, and preferable scenarios. Probable futures are represented by the narrowest cone in the center, which contains what will most likely happen. Plausible futures are relatively easy to imagine based on the conditions of today. Found at the intersection of probable and plausible futures, preferable futures are what we want to happen. As they set a premium on human agency, preferable futures have rightfully received the most attention in the studies mentioned above.

Possible futures, the largest cone in the model, refer to anything that may happen in the future, including things difficult to imagine from the perspective of today. The "possible futures" cone provides an interesting space to explore. Definitions of it differ. For Hancock and Bezold, it "encompasses everything we can possibly imagine."[8] Yet, for Dunne and Raby, it excludes fantasy and denotes scenarios that are scientifically possible,

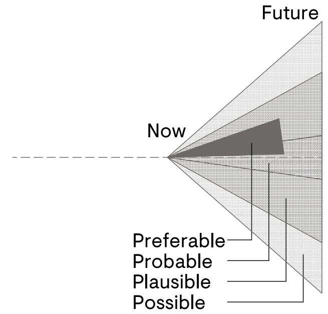


Figure 1
The possibilities cone based on the illustration "PPPP" in Dunne and Raby, *Speculative Everything*, p. 5.

1
Margaret Atwood, *In Other Worlds: Science Fiction and the Human Imagination* (London: Virago, 2012), p. 103.

2
Ibid., p. 62.

3
Charles W. Taylor, *Creating Strategic Visions* (Carlisle, PA: Strategic Studies Institute, 1990), pp. 14-15.

4
Trevor Hancock and Clement Bezold, "Possible Futures, Preferable Futures," *Healthcare Forum Journal* 37, no. 2 (March-April 1994): 23-29.

5
Joseph Voros, "A Generic Foresight Process Framework." *Foresight* 5, no. 3 (2003): 10-21, doi: 10.1108/14636680310698379.

6
Stuart Candy, "The Futures of Everyday Life: Politics and the Design of Experiential Scenarios" (PhD diss., University of Hawai'i at Mānoa, 2010), pp. 34-35.

7
Anthony Dunne and Fiona Raby, *Speculative Everything: Design, Fiction, and Social Dreaming* (Cambridge, MA: MIT Press, 2014), p. 5.

8
Hancock and Bezold, "Possible Futures, Preferable Futures," p. 24.

with a path from where we are today to where we are in the scenario.[9] For me, the word possibility connotes an objective category of what may happen, regardless of what the subject is capable of imagining. Thus, if the model needs to be understood from the point of view of the subject, the possible futures become “imaginable possible futures,” thereby limited by what is imaginable, conceivable, graspable, understandable by the subject.

Unimaginable Futures of the Past

When we look at the past and consider developments in technology, we perceive these developments as a series of cause(s) and effect(s), often as a linear progression. When the history of technology is considered, as in the ways it is narrated at the Computer History Museum in Mountain View or the Technical Museum in Vienna, the official, linear model always makes perfect sense. Standing in front of an electromechanical computer that is the size of a room with an embedded ashtray on the input panel for the smoking operator, we do not question whether or not this is really the object that led to the small device we carry in our pockets. It is easy to draw the line retrospectively. Yet, how little did the person who invented that thing know about what the future of that object would be! As Fisher says, “it is worth recalling that what is currently called realistic was itself once ‘impossible’.”[10] Indeed, what we are experiencing today was not only impossible in the past but it was not plausible, or, for many, even imaginable.

The biggest threat to the limits of what we can imagine is our assumptions. Those opinions, biases, and expectations of which we are unaware or do not question. These could have been shaped by our experiences, beliefs, culture, family, and, ultimately, society at large. Therefore, the imaginable possible futures cone is a highly political category. Our assumptions shape the way we deal with the world and can only be contested by encountering the “other”: other beliefs, values, and doings, which show us that things in fact can be seen, understood, and done differently. There is a direct relationship between how deeply embedded our assumptions are and how vulnerable they are to being disrupted, as expressed in the last lines of Fisher’s *Capitalist Realism*: “the very oppressive pervasiveness of capitalist realism means that even glimmers of alternative political and economic possibilities can have a disproportionately great effect. […] From a situation in which

9
Dunne and Raby, *Speculative Everything*, especially pp. 70-71.

10
Mark Fisher, *Capitalist Realism: Is There No Alternative?* (Winchester: O Books, 2009), p. 17.

nothing can happen, suddenly anything is possible again.”[11] Other worlds, values, beliefs, and ways of doing things, as presented in wonder tales, be they through a literary text or a physical object, can have a similarly “disproportionately great effect” when they confront the deepest, simplest, and strongest of our assumptions and show us what hitherto has been unimaginable. The more we believe something is “the truth,” the more we blindly base our dealings with the world on it, but when it is challenged, this kind of “truth” becomes more vulnerable.

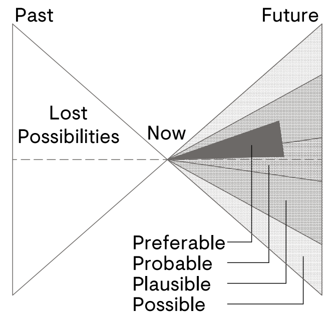


Figure 2
The lost possibilities cone.

Lost Potentials of the Past

The person who created the electromechanical computer looks at the future with the experience, knowledge, desires, and capabilities they have. Uexküll explains this phenomenon with his theory of the Umwelt,[12] wherein every living being has a bubble around it that filters the way it experiences and interacts with the world. The nature of this imaginary filter is dictated not only by the biological capacities of the being, but also by its experiences, knowledge, and desires. This way of looking at the world is similar to the concept of “affordance” as discussed by Gibson and Norman: what every object around us affords is subject to change through the filter with which we look at it.[13] Based on this way of viewing a subject’s relations to the world, I propose drawing a second cone, an exact mirror reflection of the possibilities cone, from the place we are standing now towards the past (figure 2). I suggest that this “lost possibilities” cone, which works like a prism that refracts daylight into colors, can be an interesting instrument to probe boundaries of human imagination. Only through this lens, shaped by today’s experiences, knowledge, desires, and capabilities, can we see things in history that could have happened but did not, not always because they were not preferable, but because they were not imaginable.

In *Women’s Work*, Barber tells how in the second millennium BCE textiles and tin were transported together from Assyria to Anatolia.[14] This must have been an arduous, days-long journey, not only for the donkeys carrying the goods but also for the merchants. It is mind-opening to read that the two materials that are essential to the making of the *Embroidered Computer*, for example, textiles and tin, had traveled together for days hundreds of years ago. The materials were present, at the same time and place, but the knowledge was not there.

11
Ibid., p. 81.

12
Introduced in Jakob von Uexküll, *Umwelt und Innenwelt der Tiere* (Berlin: Springer, 1909). See also Kalevi Kull, “Jakob von Uexküll: An Introduction,” *Semiotica* 134, no. 1 (2001): 1-59.

13
See James J. Gibson, *The Ecological Approach to Visual Perception* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1986); Donald A. Norman, *The Design of Everyday Things* (New York: Doubleday, 1988).

14
“Tin is heavy, however—too heavy to load much of it onto a donkey’s back. But mixed with textiles […] the load is well balanced. Tin and textiles: That’s what the Old Assyrian traders carried for nearly two hundred years from Ashur in northern Mesopotamia to their trade colonies in central Anatolia. The tin belonged to the merchants, but many of the textiles were the produce and property of the womenfolk”: Elizabeth Wayland Barber, *Women’s Work – The First 20,000 Years: Women, Cloth, and Society in Early Times* (New York: W. W. Norton, 1995), pp. 169-70.

Many moments in history can be explored from the lens of today. In her translation of an article on Charles Babbage's "Analytical Engine" written by Luigi Federico Menabrea, Ada Lovelace interprets Babbage's invention and writes the first ever computer program in her appended notes, where she infamously comments, "we may say most aptly that the Analytical Engine *weaves algebraical patterns* just as the Jacquard-loom weaves flowers and leaves."[15] What if, Ada Lovelace, already in the 1840s, fed up with Babbage failing to complete the machine, had invented the "difference loom," a loom that did algebraic calculations and produced textiles as output?

Almost a century later, on September 9, 1947, the pioneering computer scientist Grace Murray Hopper taped a moth to the logbook of the Harvard Mark II computer. The project team was looking for the source of a glitch in the system when they discovered the live moth stuck between the relays of the electromechanical computer. Hopper wittily noted next to the bug: "Relay #70 Panel F (moth) in relay. First actual case of bug being found."[16] Hopper also was a crochet and embroidery enthusiast.[17] What if her recording the incident about the moth, a bug that is strongly associated with textiles, had given her the inspiration to create a handcrafted computer? What if Hopper had acted on the possibility to use centuries old metallic threads for their electrical capacities?

Excavating Feminine Pasts and Fiberpunk

Despite the many moments at which electronics and textiles have intersected in the past, they connote completely dissimilar worlds today. One is sharp, the other one is fuzzy, one is cold, the other warm, one is industrial, the other domestic. And, at the level of craftsmanship, one is men's domain, the other women's work.

When we talk about "technology" today, we hardly refer to textiles. One of the oldest technologies on earth, textiles are regarded as obvious, intuitive; they are taken for granted. The spindle was invented before the wheel and was the archetype of all rotating things. And, the invention of the string, referred to as the String Revolution by Barber, revolutionized human life by enabling hunter-gatherers to make tools by tying objects together, to go into caves, to fish, and to make sails for ships to discover new lands.[18] Strings were used as currency in antiquity. They influenced the invention of computation technology through the invention of the punch-card operated Jacquard loom. And, with the appearance of the spinning jenny, they gave rise to the Industrial Revolution. Textile manufacture, once upon a time, utilized so much technology that it created an anti-technology movement, the Luddites.

15
Luigi Federico Menabrea, "Sketch of the Analytical Engine Invented by Charles Babbage" [translated by Ada Lovelace], In *Scientific Memoirs, Selected from the Transactions of Foreign Academies of Science and Learned Societies, and from Foreign Journals*, Vol. 3, edited by Richard Taylor (London: Richard and John E. Taylor, 1843), p. 696.

16
The "Log Book with Computer Bug," in the collections of the National Museum of American History in Washington, DC. See http://americanhistory.si.edu/collections/search/object/nmah_334663.

17
In December 1980, Hopper recalled: "Then – on Christmas day every year after we've had Christmas dinner, my family tells me what they'd like the next year. Which means that there are several Afghan sweaters, Scandinavian patterned mittens, stuff like that that are on order. So I've had to make those. And there are various needlepoint things I just finished, a needlepoint rug for the bedroom for my sister's doll's house. I make things. I'm busy every minute. And then there's all the reading on computers." *Oral History of Captain Grace Hopper* (Mountain View, CA: Computer History Museum, 1980), p. 50. Available at: http://archive.computerhistory.org/resources/text/Oral_History/Hopper_Grace/102702026.05.01.pdf

18
See Barber, "The String Revolution," in her *Women's Work*, pp. 42-70.

Textiles, especially at the level of handcrafts, are undeniably undervalued. For example, comments in the 2008 documentary video *Moon Machines*, describing the 1960s Apollo computer, epitomize such evaluations. In order to make a reliable memory for the Apollo mission, computer scientists had to send the computer program to a factory where women literally wove the software into the core rope memory. Commenting on this, Dick Battin, Director of the MIT at the time, said, "We called it the LOL method, the little old lady method," before swiftly adding "Not very nice. Today you couldn't say those."[19]

A full discussion on the reasons why textiles have become the craft of women par excellence, and not of men, has to remain for a future study,[20] although in the modern day it may relate to "the hierarchy of domestic and professional work."[21] This devaluation has involved not only women's work but also all the properties that connote it. Being fuzzy, soft, repetitive, and decorative are qualities with negative connotations. These properties of textiles, automatically attributed to women, conflict the dominant assumptions and expectations from technology and the technician. Women's practice and women's work in the field of technology development may not be forbidden, but is certainly limited by such assumptions.

Fiberpunk thus is a proposal for challenging these common assumptions by imagining wonder tales in which needlecraft techniques, materials, and skills are brought into contexts that are outside the domestic domain. The premise is that the assumption of needlework as trivial women's work can be challenged by a functioning technological object that presents the intricacy, sophistication, and intellect embedded in it. The space of speculation that works such as the *Embroidered Computer* and the *Yarn Recorder* provide is open for further exploration. In these works, a true construction of an alternative reality narrative is intentionally left aside. Instead, the objects are imagined, created, and presented by putting functionality in the foreground, and the artworks are made with dexterity and patience, with the joy of re-inventing the wheel, or rather the spindle!

19
First aired on television in June 2008, *Moon Machines* is a documentary series consisting of six episodes directed by Christopher Riley, Duncan Copp, and Nick Davidson. See *Moon Machines. Part 3: The Navigation Computer*, 22:43.

20
A convincing starting point for an argument may be found in Brown's essay, where she states that societies have relied on women for activities such as cooking, spinning, weaving, and sewing because those activities were compatible with the demands of childcare. Mothers had to take on tasks that were child safe and not far from home. The two crucial, hard, and time-consuming tasks, textiles and hunting, were distributed between women and men. See Judith K. Brown, "A Note on the Division of Labor by Sex," *American Anthropologist*, New Series 72, no. 5 (October 1970), pp. 1073-78.

21
Rozsika Parker and Griselda Pollock, *Old Mistresses: Women, Art and Ideology* (London: I. B. Tauris, 2013), p. 70.

Interview with Mark Miodownik

Material Pasts, Presents, and Futures

EK (Ebru Kurbak) Mark, can you name a few breakthroughs in the history of materials in which you think everything could have gone differently? What historical materials science moments make you speculate the most about an alternative history and an alternative present?

MM (Mark Miodownik) The Ancient Egyptians used glass only for decoration and ornamentation and couldn't have known that the material would provide the platform for the inventions of modern physics, chemistry, biology, and much more. Even the Romans, who were great innovators in glass and who invented the glass window, didn't predict how important the material would be. It was the invention of the glass lens that turned out to be crucial for the birth of science. It led to the development of astrophysics and biology, through the development of the telescope and the microscope, respectively. Other innovations in glass had a huge impact, such as the development of borosilicate glass and the test tube, without which the subject of chemistry would essentially not exist. So without glass it's very likely we wouldn't have had a scientific revolution, and things would have been very different.

EK What about the current tendencies in your field? What are the research subjects that are currently in demand in contemporary materials science practices? And, which dominant values of our era do you think determine those research priorities?

MM Traditionally, approaches to materials selection and development were experimental and therefore slow. Much progress has been made, but it still takes decades to optimize suitable materials for a technological application. A principal reason for this long discovery process is that materials design is a complex, multidimensional optimization problem and the data needed to make informed choices usually do not exist. Theory blossomed in the twentieth century, but its actual use in the invention of new materials is still limited.

The US federal government's Materials Genome Initiative recommends a change in methodology from a fragmented, experimentally based approach to a more integrated, theory- and data-led approach. This sounds appealing but this approach misses one very important issue, namely, that there has been an increased specialization of materials practitioners, to the point where the scientists, technologists, and microscopists (i.e., the materials science community) involved in the development of new materials now move in both academic and social circles widely separated from those of industrial designers, architects, artists, makers (i.e., the materials arts community). It is the materials arts community who are experts in understanding the needs of society and therefore the materials requirements for future cities, energy, food and drink, and healthcare.

There is much at stake, because materials have an immense cultural and environmental significance and the introduction of new materials by an isolated materials science community holds the prospect of further deepening the rift between scientists and society. Some combination of this material-arts approach and the materials genome approach is likely to be the hallmark of materials laboratories in the twenty-first century.

EK If you were given endless time and resources today—unconditionally—to suggest some "critical materials science" research about absolute alternative subjects, which worries would you choose to address? Which social, ethical, or political values do you think should guide the research in your field?

MM For me it's about getting the multidisciplinary approach right. Take the example of the development of new wound dressings, which are crucial for treating many chronic diseases. The first issue is that this sort of problem does not fit into the realm of classical materials science and engineering activities, so it tends to be ignored. The functionality of wound dressings is distributed across many scales, from the nanoscale of their antibacterial function, to the microscale of the membrane layers controlling humidity, to the mesoscale of their fluid-handling properties, to the macro-scale of their form-fitting attachment to the body. Moreover, aesthetic properties, such as smell and color, are important and can dramatically affect how patients feel about their treatment and condition. This affects recovery rates, which then has a huge impact on both the costs incurred by hospitals and the patients' wellbeing. Thus, developing new wound healing systems not only means solving physical and biological problems, as well as issues of disposal and recycling, but also requires an understanding of the look and feel of materials and their context in a health-care or domestic setting. As our materials needs in every area of our lives grow more sophisticated, so too do the solutions become more complex. This is true not just for medical devices, but for all materials applications involving humans.

EK What are your thoughts on the material influence(s) of the immense amount of electronic technology we produce today? What materials are we running out of?

MM The materials required for city infrastructure, such as copper for electrical and electronics applications, tungsten for tools, or lithium for batteries are neither plentiful nor geographically widely distributed throughout the world. Factors such as rarity, the geographical location of ores, and the unpredictable impact of political and economic factors can and will limit supply. A recent example was the export restrictions placed by China on the export of rare earth metals in 2010. There was a price hike for metals such as neodymium, which rapidly became economically important for the development of electric vehicles, and supply for companies outside China was restricted. These types of occurrences have seen certain countries, such as the US, reinstate lists of strategic materials which are deemed important for national security, such as tungsten. When you consider that a smart phone built in 2015 contains half of the elements of the periodic table, it becomes clear that as our material wealth becomes more complex in terms of its composition, so it becomes more vulnerable to uncertainty of supply and price fluctuations.

EK How about the future? What do you imagine our material concerns to be in, for example, a hundred years from now?

MM Whatever people think about the rapid pace of change in the past, the fundamental arrangement of materials on the planet has not changed. There are living things that we call life, and there are non-living things that we call rocks, tools, buildings, and so on. As a result of our greater understanding of matter, this distinction is likely to become blurred. By 2050, bionic people, augmented with synthetic organs, bones, and even brains, could become normal. Just as we become more synthetic, so our engineered environment might change to become more lifelike, with living buildings and self-healing bridges. Perhaps, we will succeed in developing wearable exoskeleton underwear that will allow us to live and play tennis even when we are 100 years of age.

Whatever happens, it seems certain that humanity's love affair with stuff is not going to end any time soon. Materials are, quite literally, a physical reflection of who we are, and as long as we are changing, so will our material world. The day we stop evolving will be the day we stop inventing new materials.

Yarn Recorder

2018
So Kanno, Ebru Kurbak

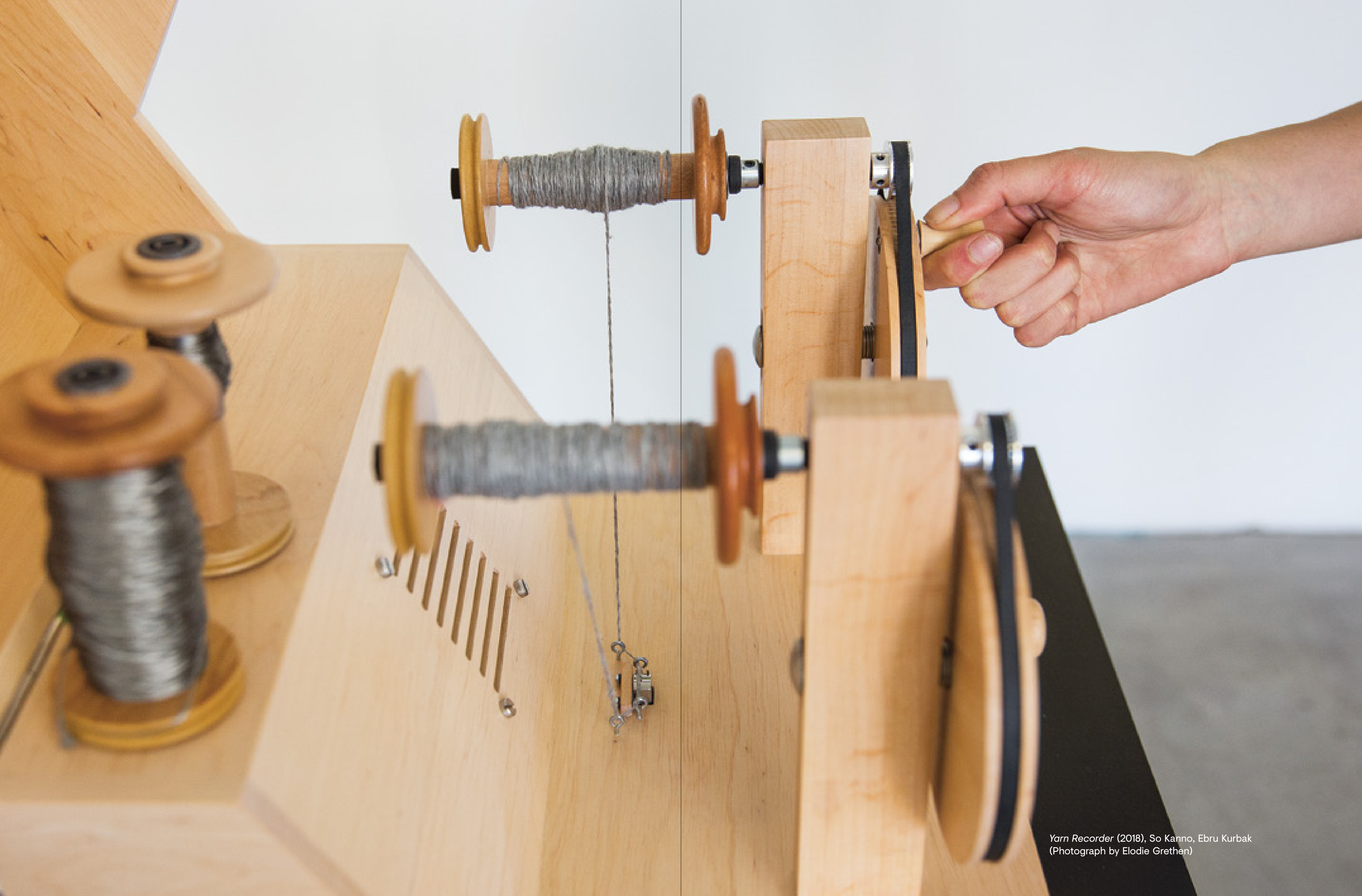
Interactive object.
Wood, stainless steel, electronics, sound.

Developed as a continuation of the “Magnetic Recording on Fibers” workshop (2014) carried out by So Kanno, Ebru Kurbak, and Irene Posch with the engineering assistance of Matthias Mold.

The *Yarn Recorder* is a device for recording and playing sound, which curiously utilizes spools of yarns and threads as the recording media. In its visual appearance, the object resembles wooden yarn-winding tools used to unwind hanks of handspun yarn onto bobbins or reels before the process of hand weaving. In its technical capacity, it is a magnetic recording and playback device that can record and play sounds on yarns that contain steel fibers.

The “spindle” is one of the oldest technologies on earth, even older than the wheel. It is undoubtedly the archetype of all rotating things that have been invented since then: car wheels, geared machines, tape recorders, CD players, propellers, and countless other technologies. From prehistoric ages up until the Industrial Revolution, spinning yarn for weaving cloth in the home was among the most important necessities of life. With the mechanization of textile-making processes, hand spinning has lost its position as a necessity, at least in Europe, and has become a process for manufacturing luxury goods if not a hobby. As a result, the societal value given to the process of hand spinning has drastically changed, as far to make it hard for us to conceive the influence of the simple spindle on the development of the complex and sophisticated technologies of today. The *Yarn Recorder* intends to reveal this fascinating link through playful interaction, as a commentary on the changeability of the value of things.

Yarn Recorder (2018),
So Kanno, Ebru Kurbak
(Photograph by Elodie Grethen)



Yarn Recorder (2018), So Kanno, Ebru Kurbak
(Photograph by Elodie Grethen)

Interview with Jussi Parikka

Gendered History of Making

EK (Ebru Kurbak) Jussi, your media-archaeological, theoretical work and the arts-based research realized in *Stitching Worlds* seem to originate from similar places: both acknowledge that *things* do matter in the ways in which they contribute to the shaping of our world—the underlying structures, value systems, ideologies, and so on. In developing your theory, you previously analyzed many artworks. What do you think are the different interacting points of our respective approaches? How do you interpret works like ours, which aim at a critical understanding of technology through the creation of a new technological object, a *thing*?

JP (Jussi Parikka) I think there are a couple of interesting, overlapping themes in play. On the one hand, what I find exciting is how *Stitching Worlds* speaks to the speculative sense. While the term "speculative" might be somewhat overused by now (after speculative design, speculative realism, and what not), in this case it is a good shorthand for imaginary pasts and futures that are summoned through the practice of textile electronics. In what situation—world—would textile electronics have taken place? What sort of social relations are embedded in what is weaved? Then of course, it is also about the materials: how materials speak both to the senses (the tactility of electronics) and to their political histories that are always gendered and in this case, extend to the different sort of gender history of technological skill and labor.

Hence, technological things speak as dynamic events; they start to unfold histories, situations, and practices. I work at Winchester School of Art and with many practice-based scholars and artists on how material practices produce knowledge. One particular field close to my interests is of course media archaeology, especially in how it is practiced by artists working with archival sources, with imaginary pasts and in many cases by juxtaposing different material realities that start to open up, like in this case, the prepackaged electronic world. The mass-produced electronic culture is brought into a new kind of tactile proximity and as such, as part of a different regime than merely of viewing/using in the consumer sense. Giuliana Bruno's work on surfaces of screens, textiles, and spaces has already established this relation between texture-ologies of multiple material (media) worlds, and I would argue that your work speaks to this sense, too, even if less about visual media or cinema but about computational culture.

EK In some of our experiments, such as the *Embroidered Computer* or the *Yarn Recorder*, we chose to remake existing things with alternative materials, rather than proposing a new piece of technology with a new function. A similar strategy, although with different materials and a different intention, can be seen in Joe Davis's phenomenal work, *Bacterial Radio*. I am curious about how you respond to such works. Is it possible to talk about an agency of blunt materials that the technology is made of, even if functional elements and protocols remain the same?

JP Working with alternative—or unexpected—materials is both related to what I mentioned about the speculative sense in the above, and a strategy perhaps reminiscent of the methods in speculative design. But in your case, like in Joe Davis's work, speculative design and art are curiously connected to media archaeology. Working with alternative materials is also a reminder of standardized materials in the first place: Why this material instead of that? What are the material support systems that make media communicate? What is the long trail of materials that needs to be put in place before something can become part of social practices? Davis's *Bacterial Radio* is a great reference point for a couple of reasons. While it works with something that could be located in a media-archaeological context (not just a historical investigation into radios, but also into their material conditions of existence), it connects with contemporary concerns of technological change in the context of synthetic biology and biotech. It mobilizes materials which are anyway part of electronic communication culture—referring namely to silicon-based materials—but also includes a science-fictional sense of technologies that are not built, but grown. Yet, it feels denaturalized in all the right ways: the amount of care, consideration and work that goes into grown technologies is a reminder that any ecological metaphor for technology is embedded in a range of social practices. These examples of textiles or biological materials of technology are good reminders of the experimental systems in which technologies are first born as laboratory products, and as such, returned to alternative, almost fictionalized laboratories. However, when I say fictionalized, your project points out the very real alternative genealogies of practice to which they connect, like crocheting in Turkey.

EK Imaginary media made of alternative materials, naturally, reveal imaginable alternative makers. How much has the "maker" end of digital technology been in the focus of media archaeological studies? Can we talk about an always existing "maker culture" from a historical perspective? What is the significance of different maker personas throughout history and the implications thereof? And, what do they reveal about today's maker culture?

JP There's so much going on around the notion of *maker*, both in ways that make it a term suitable even for business schools and in ways that problematize it so that it becomes more than just a temporary trend. From the celebratory stance emerging from *Make* magazine to the critical maker-scholars who have started to place it as part of more complex histories (including recognizing the often masculine stance of making), it has grown to be a more interesting concept for a range of practices. Early examples of the digital enthusiasm for making was already present in Sandy Stone's ACTLab at UT Austin since the 1990s, and we have to be able to remember these earlier laboratory-situated humanities practices that connected the notion to critical theories too, such as queer theory and cultural studies. Hence, when Digital Humanities nowadays taps into the reservoir of potential of making as a knowledge practice it is both an interesting expansion of humanities work and also should be able to remember that various studio practices, earlier examples, histories of media, and technological art included a rich set of examples that often remain unacknowledged.

Aptly, Debbie Chachra (2015) voiced "Why I Am Not a Maker": the term marks a location for a particular set of practices that are accepted as making while ignoring a range of other practices and perhaps one could add, materials; it has a gendered—even masculine—tone, although of course one has to be aware of how it has been mobilized by critical work including in feminist contexts. But Chachra's consideration is constantly worthwhile to keep in mind: "The cultural primacy of making, especially in tech culture—that it is intrinsically superior to not-making, to repair, analysis, and especially caregiving—is informed by the gendered history of who made things, and in particular, who made things that were shared with the world, not merely for hearth and home."

Hence, it is best to look at practices in feminist hackerspaces and queer makerspaces. I am thinking here of Melissa Rogers's (2018) work as she articulates how practices of stitching and crocheting can act as practices where also the digital is problematized. One can narrate alternative histories of the digital as part of the crafts skills, of working with weaving, crocheting, stitching, and enabling a different set of histories for algorithms, patterns, and numbers that account for the emergence of the computational.

Of course, many practices have expanded from mere technological tinkering to include various arts, crafts, skills, and techniques in the context of making: different studio practices, needlework, hardware hacking, coding, printing techniques and more. And of course, to refer to textile practices further complicates making. In her book *Bauhaus Weaving Theory*, T'ai Smith (2014) is one of the scholars who has done important work in integrating the history of twentieth-century textiles into media-theoretical discussions. In a similar way, I see how there is constant potential to build on the link between media, history, textile, and art practices, and to use this bundle to question some of the assumptions about electronic culture in ways that pick it apart creatively and with a sense of community, too. I see your work as part of a series of experimental projects that engage in different ways with this link between textile, technology, and media.

Approaching this link from the other angle, Sachiyo Takahashi's and Sidney Fels's *Sound Weave* uses analog media—audio tapes—as part of their generative weaving installation. Besides employing "old obsolete media," i.e., the tapes, it plays with the scale of weaving and grows into a massive size. In other ways, Canadian experimental film maker Kelly Egan has made her film quilts *c: won eyed jai* and recently *Athyrium filix-femina*, both extending practices in experimental film and reminding of earlier female pioneers in visual arts (respectively, Joyce Wieland and Anna Atkins). In the latter film, the process also includes another detail about fabrication—the use of the cyanotype process and the original recipe by Atkins—which lends itself both to technical-chemical visuality and was also used in various textiles, from drapes to clothing.

EK Through *Stitching Worlds*, we fabricate an alternative—technological—reality, which I like to call "fiberpunk," touching upon imposed gender roles and proposing a different type of tinkering and tinkerer. In your work entitled *A Media Archaeology of Ingenious Designs*, you seem to suggest a similar concept based on an alternative geopolitics of technology. Can you tell us more about that work? Should we read it as a critique of steampunk's dominance of current alternative technological cultures, and as an attempt to restore plurality?

JP *A Media Archaeology of Ingenious Designs* was a project collaboration with Ayhan Ayteş that was invited for the İstanbul Design Biennial 2016. Building on Ayhan's own work and his earlier role as part of the ZKM's "Allah's Automata" exhibition, we wanted to investigate the alternative geographies of technology and automata in the Middle East. Building on some historical contexts such as the inventor Al-Jazari's work and manuscripts, but in contexts of contemporary critical design, our exhibition section was also meant as a way to invent alternative situations, sets, timelines of media, for example, past imaginary media contexts in Turkey and in the Middle East, as ways to participate in the current, constantly active politics of history (such as the neo-Ottoman wave in politics and popular culture). As such, it was an expansion from the themes of steampunk (for example, as used by William Gibson and Bruce Sterling) to the Middle East and long-term histories that also speak to contemporary geopolitics.

I continued this collaboration by doing some theoretical writing, too. Recently, I published work on the more contemporary contexts of Arab and Gulf futurism as they are visible in contemporary art (Parikka 2018). But I still connected it to the related themes of politics of history, using the idea of counterfuturisms (a nod to Michel Foucault and to Nicholas Mirzoeff) as ways to investigate the role imaginary temporality plays in experimental art and media.

As for fiberpunk, I love the term and also want to observe how it resonates with some of the interesting things articulated in contexts of queer making and queer makerspaces. Following again Melissa Rogers, I believe that this form of fiberpunk—both as a narrative of imaginary media and as a situated practice—can queer usual assumptions about the digital and be more about texture, messiness, touch, and embodiment, to paraphrase Rogers (2018). And to quote her (where she might be implicitly echoing Sadie Plant): "Fiber crafts materially encode information in their media and structure: *they matter*." New materialism returns with a crafted vengeance!

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The Embroidered Computer

2018
Ebru Kurbak, Irene Posch

Installation.
Linen, gold, silver, copper, hematite, wood.

Computer circuit design and simulation software by Matthias Mold

Generative pattern development by Raimund Krennmüller

Embroidery consultancy by Susanne Frantal

Metal threads consultancy by Sophie Fürnkranz

Crafting assistance by Pascale Ballieul, Abdulrahman Ghibeh, Ramona Hirt, Ngo Thi Dao Nha, Katta Spiel, Isabella Wöber, with special thanks to Eva Ganglbauer, Anna Masoner, and Angela Posch

Making-of video by Ulrich A. Reiterer / UAR Media

The Embroidered Computer is an 8-bit universal electromechanical computer comparable to early mainframe computers that were built in the 1950s in terms of its capacity and workings. The distinctive feature of *The Embroidered Computer*, however, is in the manufacturing; it is handmade through traditional gold embroidery and does not incorporate any regular electronic components. The piece demonstrates the possibility to make a computer from scratch through long-established alternative materials and skills. Through its mere existence, it evokes one of the many imaginable alternative histories of computing technology and stories of plausible alternatives to our present daily lives.

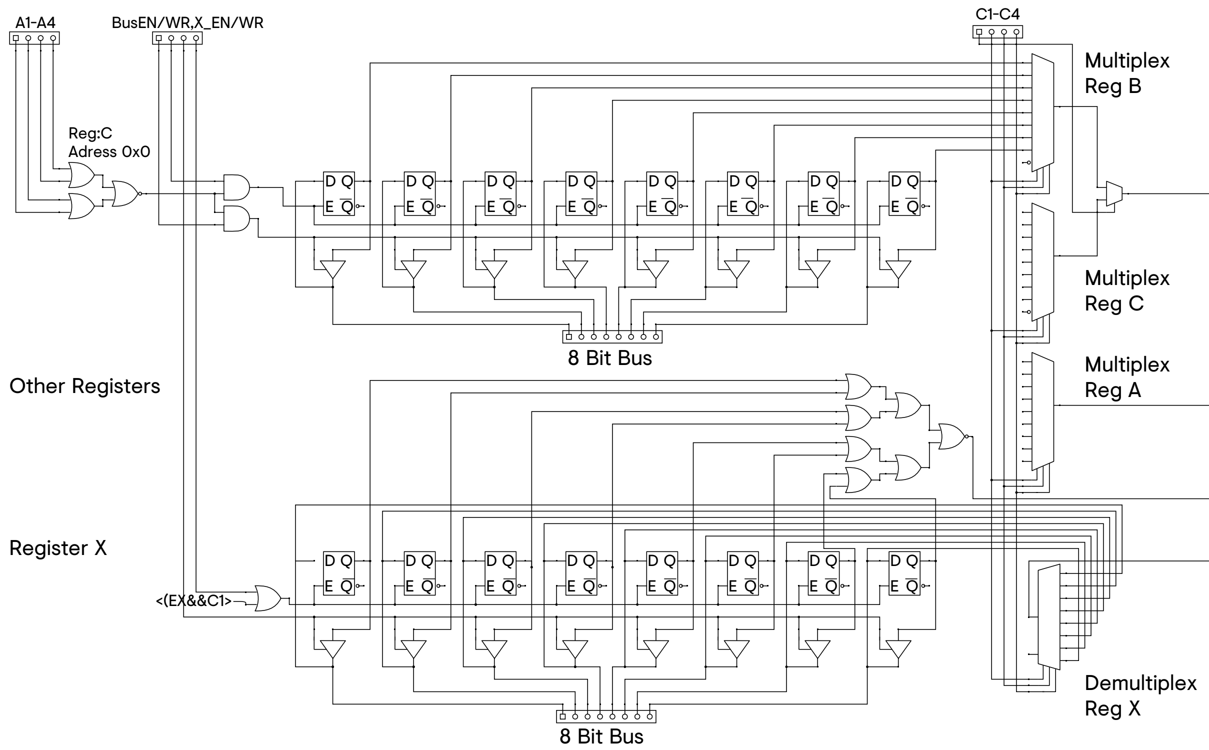
The smallest unit of *The Embroidered Computer* is a gold-embroidered electromechanical switch (relay), which is made of a handmade copper coil, a magnetic hematite bead, and adjacent gold and silver conductive surfaces. When an electric current passes through the coil, it generates a magnetic field, which affects the magnetic bead that sits in its center. Based on the direction of the passing electric current, the bead flips to one of the two directions and leads to the closing of one of the two contacts. Each switch, by receiving inputs and generating outputs in this way, channel the electric current to other switches through the connecting golden threads and make complex logical operations possible. In its complete design, the computer includes a total of 369 switches, constituting an 8-bit computer with 1-bit ALU multiplexed to four registers with an 8-bit register width and two additional storage registers.

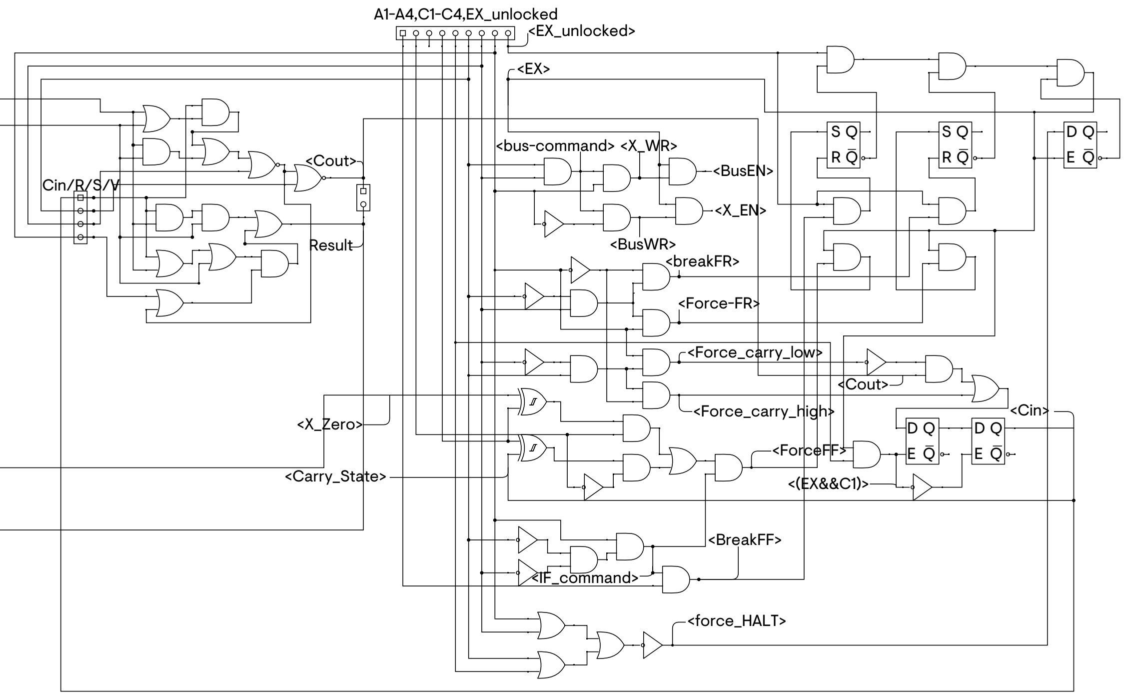
The Embroidered Computer (2018), Ebru Kurbak, Irene Posch
(Photograph by Elodie Grethen)

Study models for an embroidered switch,
The Embroidered Computer (2018), Ebru Kurbak, Irene Posch
(Photograph by Elodie Grethen)

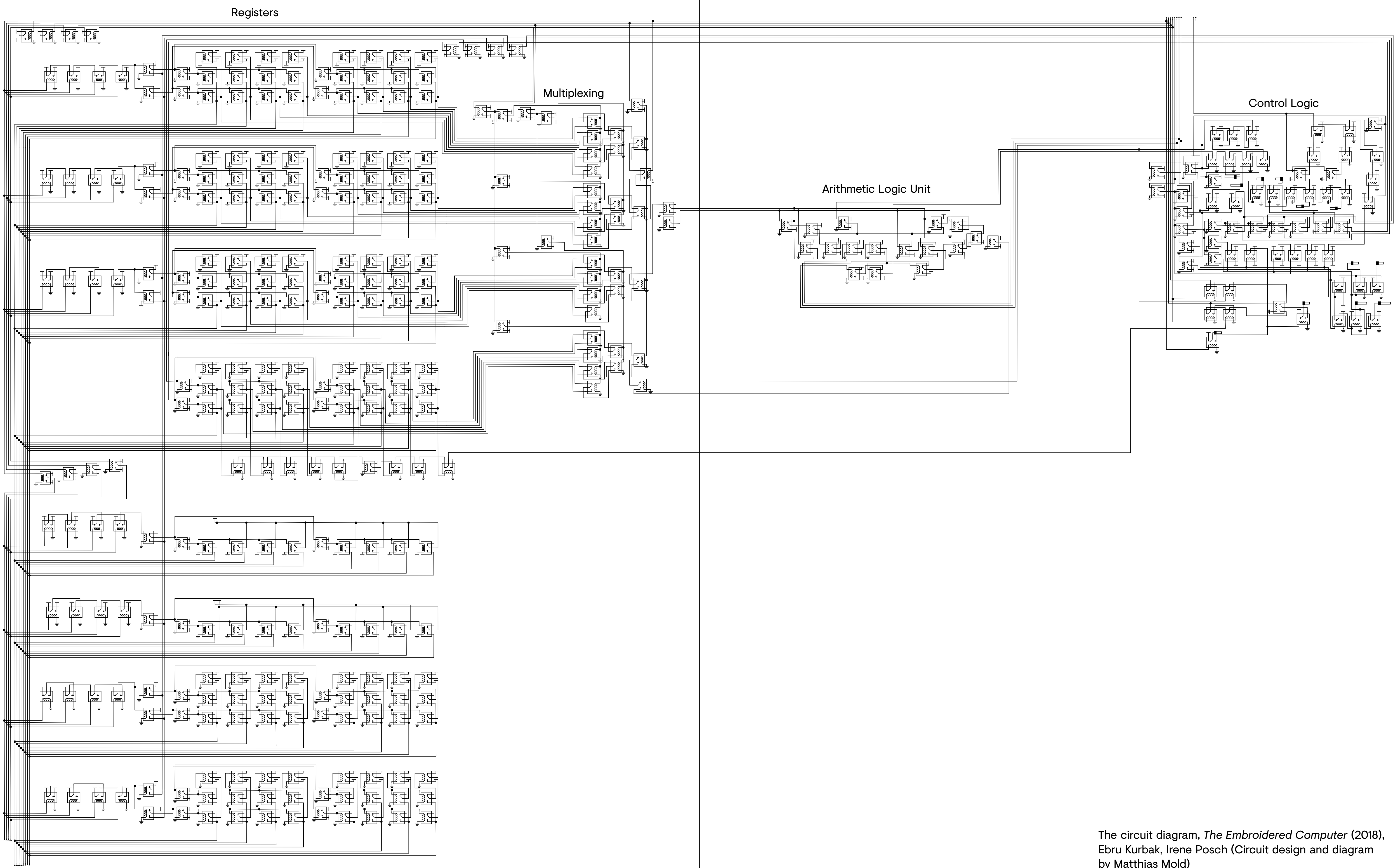
The final design of the embroidered switch shown in “0” and “1” positions, *The Embroidered Computer* (2018), Ebru Kurbak, Irene Posch (Photograph by Elodie Grethen)

Materials, *The Embroidered Computer* (2018),
Ebru Kurbak, Irene Posch (Photographs by Elodie Grethen)

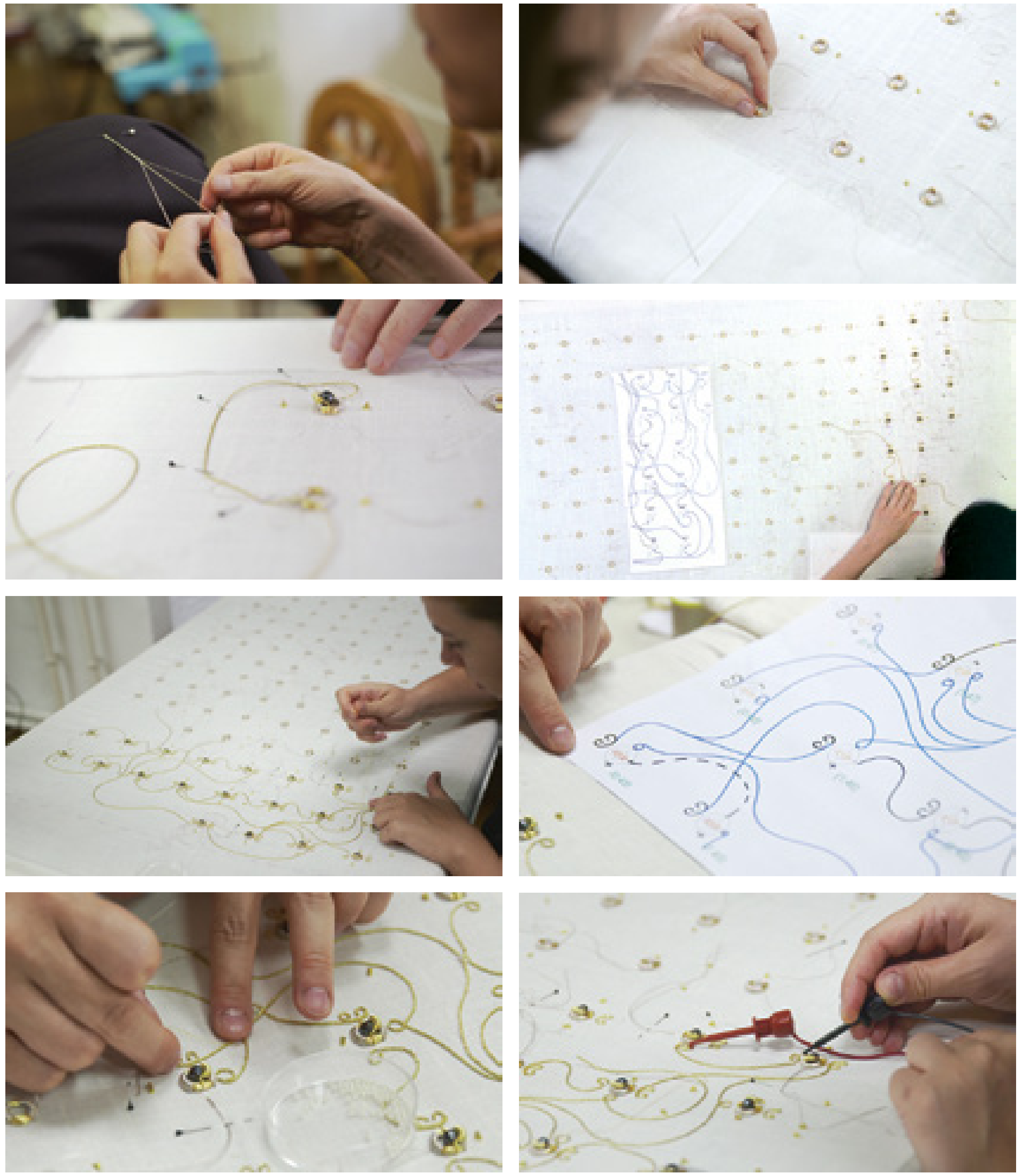




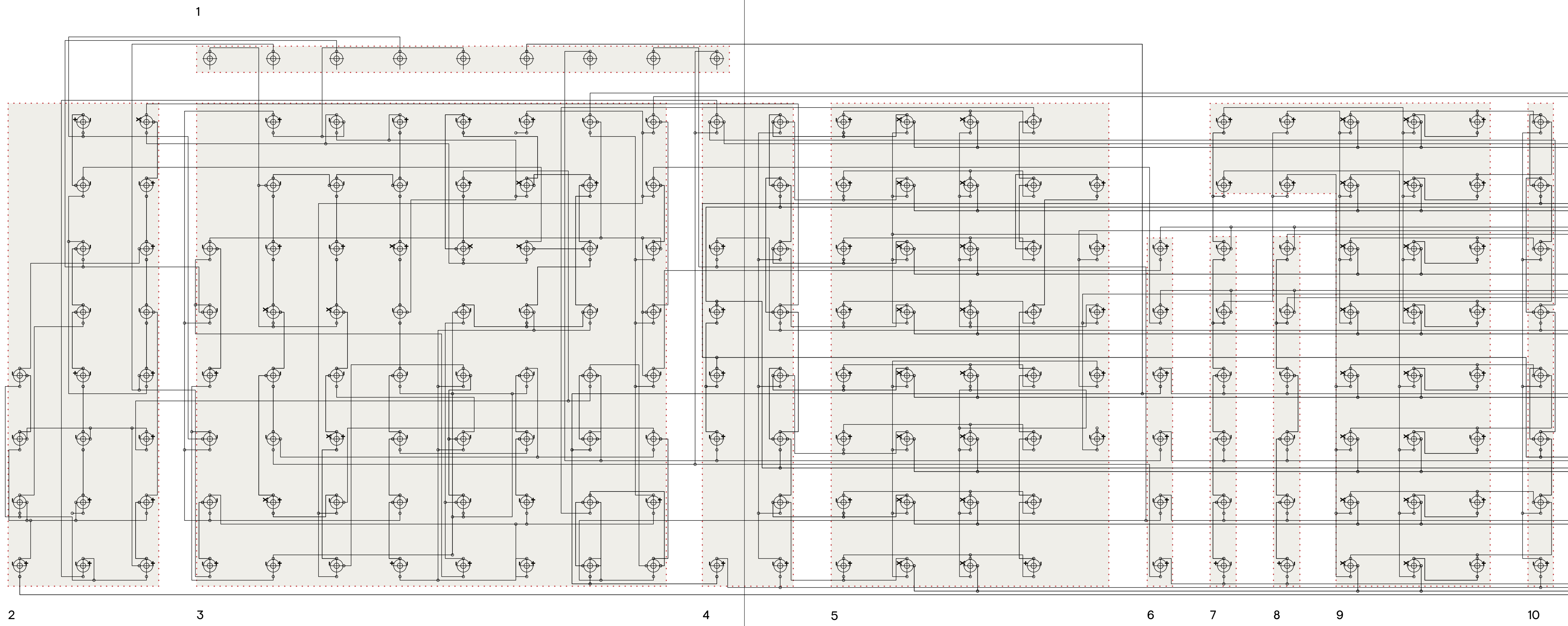
The logic diagram, *The Embroidered Computer* (2018), Ebru Kurbak, Irene Posch (Circuit design and diagram by Matthias Mold)



The circuit diagram, *The Embroidered Computer* (2018), Ebru Kurbak, Irene Posch (Circuit design and diagram by Matthias Mold)



Screenshots from the making-of video,
The Embroidered Computer (2018),
Ebru Kurbak, Irene Posch (Video by Ulrich A. Reiterer)



1 Program Input
2 ALU
3 Control Unit
4 Multiplex for X Register
5 X Register
6 Bus Control Amplifiers
7 Address Decoder for B Register
8 Address Decoder for C Register
9 B Register
10 Multiplex for B Register

Computer-generated pattern showing the positions of the 369 switches and their connections, *The Embroidered Computer* (2018), Ebru Kurbak, Irene Posch (Generative pattern development by Raimund Krenmüller)

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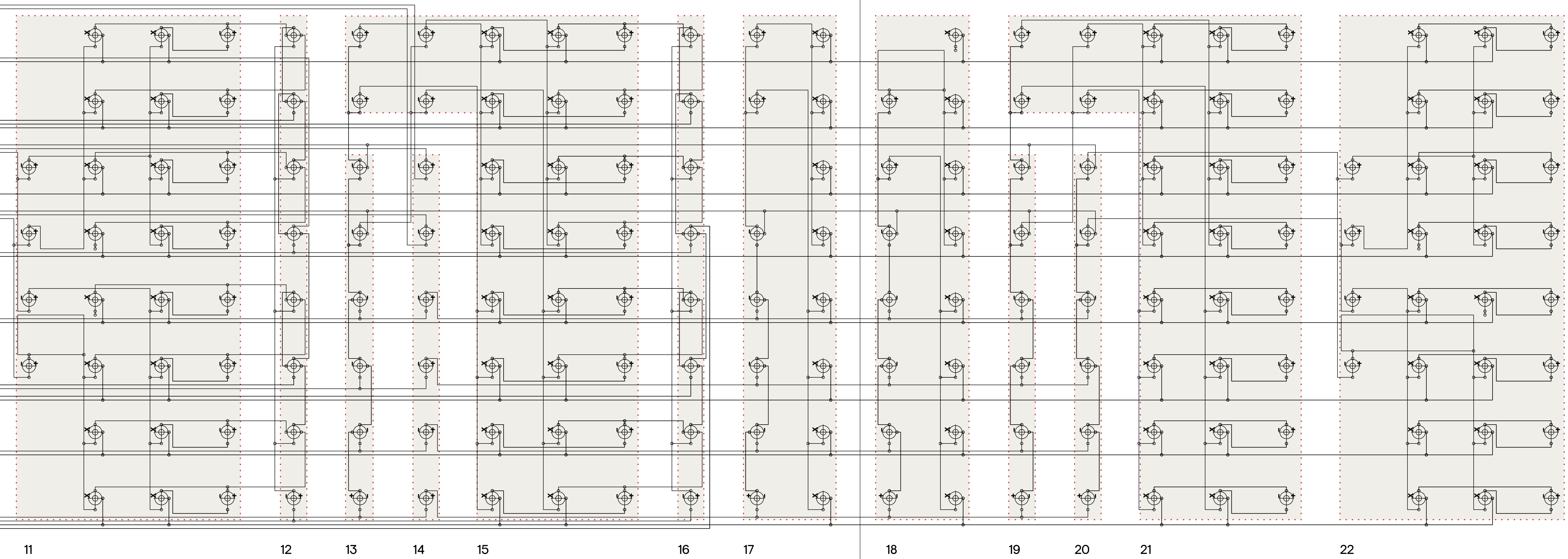
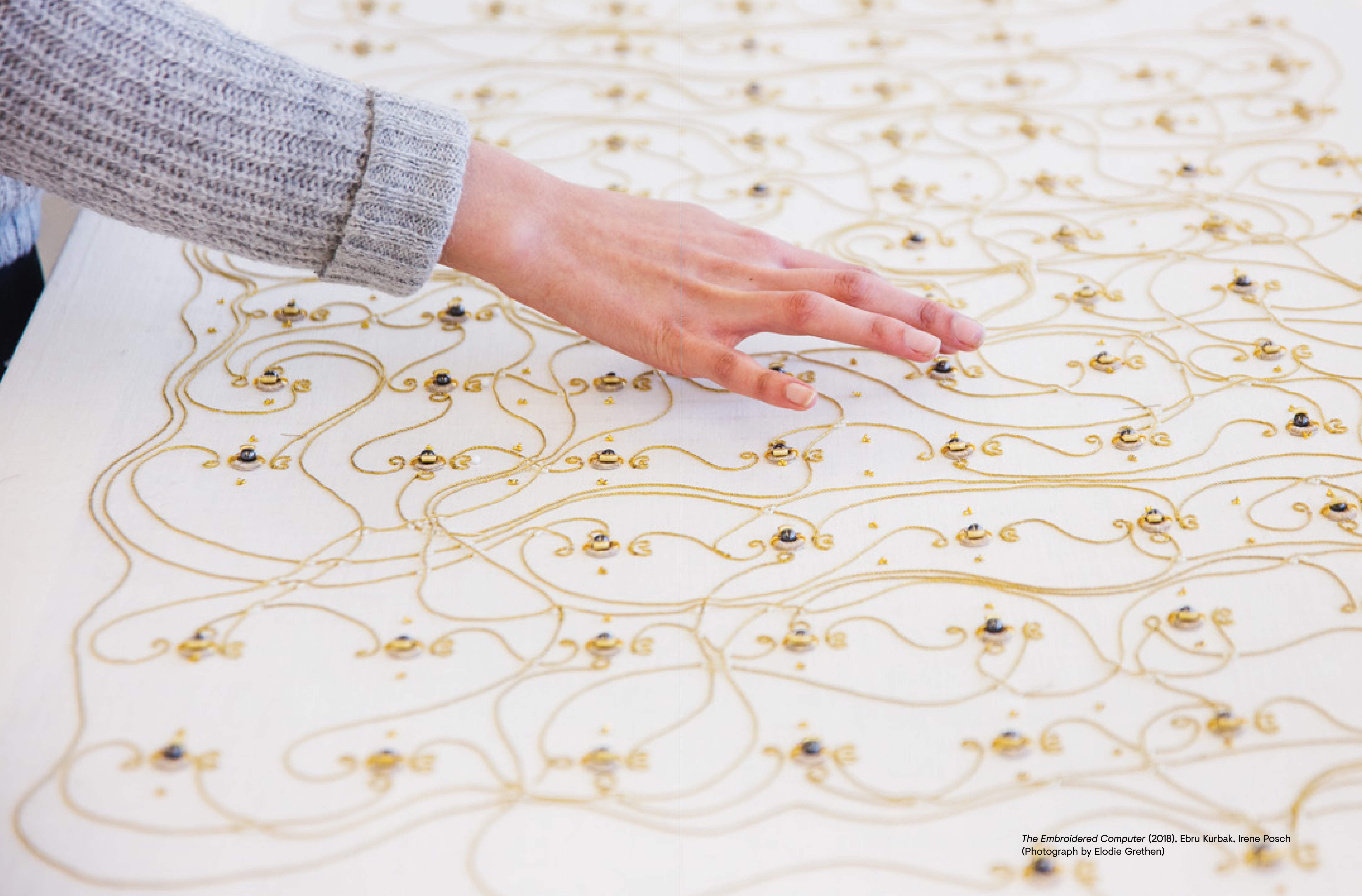


11 C Register
12 Multiplex for C Register
13 Address Decoder for A Register
14 Bus Control Amplifiers
15 A Register
16 Multiplex for A Register
17 Input Register 1
18 Input Register 2
19 Address Decoder for General Purpose Register 1
20 Address Decoder for General Purpose Register 2
21 General Purpose Register 1
22 General Purpose Register 2

Computer-generated pattern showing the positions of the 369 switches and their connections, *The Embroidered Computer* (2018), Ebru Kurbak, Irene Posch (Generative pattern development by Raimund Krenmüller)



The Embroidered Computer (2018), Ebru Kurbak, Irene Posch
(Photograph by Elodie Grethen)

Prototype for the input interface,
The Embroidered Computer (2018),
Ebru Kurbak, Irene Posch
(Photograph by Elodie Grethen)

Detail, *The Embroidered Computer* (2018), Ebru Kurbak, Irene Posch
(Photograph by Elodie Grethen)

Biographies

Onur Akmehmet

İstanbul, TR
After graduating from Grinnell College (US) in 1994, Onur Akmehmet earned his MA in Economics at University of California, Santa Barbara (US) and his MA in Social Sciences at Universiteit van Amsterdam (NL). In 2004, at Istanbul University (TR), he wrote his PhD dissertation on the examination of consumer habits in disinflationary eras. Following his doctoral degree, Akmehmet held academic positions in the United States, first as a postdoctoral scholar at Harvard University and later as a lecturer at Tufts University, where he taught developmental and growth economics. Between 2011 and 2018, Akmehmet has co-hosted *Adaptasyon*, a weekly economics and technology podcast. Bitten by the podcast bug, upon returning to his hometown İstanbul in 2013, Onur co-founded a network where he currently produces storytelling podcasts and live events in both Turkish and English.

Ekmel Ertan

İstanbul, TR / Berlin, DE
Ekmel Ertan works as a curator, cultural manager, educator, and artist. He is the founder and artistic director of İstanbul-based amberPlatform / BIS (Beden-İşlemsel Sanatlar Derneği / Body-Process Arts Association), a research and production platform on art and new technologies. Since 2007, he also has been the director of the international "amber Art and Technology Festival" in Istanbul. He has been working as an independent curator as well as working as site coordinator and director of international projects in Turkey and Europe. As an artist, he has exhibited his new media installations, photography, and collaborative performance works in Turkey, Europe, and the US. Between 1999 and 2006 he taught new media design at İstanbul Bilgi University (TR), İstanbul Technical University (TR), and Yıldız Technical University (TR), and between 2006 and 2014 he was Lecturer at Sabancı University (TR).

Lars Hallnäs

Borås, SE
Lars Hallnäs is Professor of Interaction Design at the Swedish School of Textiles, University of Borås (SE). He also is coordinator for the Marie Skłodowska-Curie European training network ArcInTexETN, and chair of the Swedish National Research Council's committee for artistic research. Hallnäs has a background in philosophy and mathematical logic and is Docent in Logic at Stockholm University (SE). Besides research in design theory, he has conducted research in mathematical logic, computer science, and experimental interaction design. Hallnäs has an education in musical composition and has been active as a composer since the 1970s.

Tincuta Heinzel

Loughborough, UK
Tincuta Heinzel is an artist, designer, and curator interested in the relationship between arts and technosciences. Following visual arts, design, and cultural anthropology studies in Cluj (RO), she completed her PhD in Aesthetics and Art Sciences in 2012 at Paris 1 University (FR) with a thesis on the foundations of interactive textiles aesthetics. She initiated, curated and/or coordinated several projects, such as "Artists in Industry" (Bucharest, RO, 2011–2013) and "Haptosonics" (Oslo, NO, 2013). As an editor, she published *Art, Space and Memory in the Digital Era* (Bucharest, RO, 2010) and coordinated *Studia Philosophia's* issue on the "Phenomenology of Digital Technology" (no. 3 / 2010). For now, under what she labels as "aesthetics of imperceptibility," she is investigating the aesthetic issues of nano-materiality. She was fellow of the French Government between 2002–2003, DAAD Research Fellow in 2005 at ZKM (Karlsruhe, DE), artist in residence at KHM – Kunsthochschule für Medien Köln (DE) and Fulbright Fellow at Cornell University (US) in 2017. Heinzel is Senior Lecturer at Loughborough University (UK) and Visiting Professor at "Ion Mincu" University of Architecture and Urbanism Bucharest (RO).

Mili John Tharakan

London, UK
Mili John Tharakan loves all things textile and has been practicing in the field of etextiles over the last decade. Her interest lies especially in the merging of electronics with crafts, textile materials and techniques, creating products that lie at the intersection of textiles and gadgets. A postgraduate from Manchester Metropolitan University (UK), John Tharakan has held research positions with the Mixed Reality Lab at the National University of Singapore (SG) and the Smart Textiles Design Lab at the Swedish School of Textiles (SE), researching various smart and etextile topics. In 2014, under the mother company Welspun, she set up TILT, a company developing Smart Home Textiles for the consumer market with a focus on developing etextiles solutions for the home. Her current interest lies in understanding and resolving the challenges of scaling etextiles for production, and designing great smart home textile experiences for the consumers.

So Kanno

Berlin, DE / Tokyo, JP
So Kanno graduated from the Design Informatics of Musashino Art University (JP) and completed his master's degree at the Institute of Advanced Media Art and Science in Ogaki (JP). He considers the essential change of things brought about by the evolution and change of technology, and creates works to bring a new perspective upon them. In 2018, he got the Excellence Award from the art division of Japan Media Art Festival with the project "Avatars," which was commissioned by Yamaguchi Center for Arts and Media (YCAM) in 2017. Kanno was part of major group shows such as the ARTISTES & ROBOTS at Grand Palais in Paris 2018 and the Aichi Triennale 2016, among other shows in Japan and elsewhere.
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Ebru Kurbak

Vienna, AT
Ebru Kurbak an artist and designer. In her artistic work, she is driven by her interest in the hidden political nature of everyday spaces, technologies, and routines, and how the design of the ordinary is involved in shaping individual and societal values, practices, and ideologies. She received her MSc in Architecture from İstanbul Technical University (TR). Before working at the University of Applied Arts in Vienna (AT) as Project Leader of *Stitching Worlds*, she lectured at the Departments of Visual Communication Design and Photography and Video at İstanbul Bilgi University (TR) and the Department of Space & Design Strategies at the University of Arts and Industrial Design in Linz (AT). She carried out artistic residencies at La Gaité Lyrique (Paris, FR), LABoral (Gijon, ES), V2_ (Rotterdam, NL), and Eyebeam (New York, US) and has shown her work at international platforms such as the Ars Electronica Festival (Linz, AT), ZKM (Karlsruhe, DE), Siggraph (US), Vienna Design Week Microwave New Media Arts Festival (Hong Kong), TodaysArt Festival (Den Haag, NL), and Piksel Festival (Bergen, NO) among others. Kurbak was the recipient of Erste Bank MoreValue Design Prize in 2015.
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Mark Miodownik

London, UK
Mark Miodownik is a materials engineer and Professor of Materials and Society at University College London (UK). He is the author of the award-winning bestseller *Stuff Matters*, a guide to the material world, and the science, history, engineering, and culture that underpins it. He also is a regular presenter on BBC TV's science and engineering programs. Miodownik was included in *The Times* 2010 list of the top 100 most influential people in science in the United Kingdom. In 2013, he won the Royal Academy of Engineering Rooke Medal, and in 2014, he was elected a Fellow of the Royal Academy of Engineering and he won the Royal Society Winton Prize.
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Matthias Mold

Vienna, AT
Matthias Mold is an electrical engineering student at the Vienna University of Technology (AT). He also studied electrotechnics at HTL Hollabrunn (AT). His expertise lies in embedded programming, circuit design, and measurement engineering. He assisted in server controlling and energy grid maintenance. Currently he is working on an extension of his bachelor's thesis project, a high-power, low-resolution rotational projector, and he is tutoring an embedded programming course mandatory for electrical engineering students. He plans to finish his MSc in Embedded Systems with a focus on systems engineering. A member of the *Stitching Worlds* core team, Mold worked as the engineering assistant and contributed to the project with his theoretical and practical electronics and programming knowledge. He is particularly proud of the simulation suite for the textile computer, which he programmed from scratch for this specific purpose.

Jussi Parikka

Southampton, UK
Jussi Parikka is Professor at the Winchester School of Art, University of Southampton (UK) and Docent of Digital Culture Theory at the University of Turku (FI). His books have addressed a wide range of topics relevant to a critical understanding of network culture, aesthetics, and media archaeology of contemporary society. These include the media ecology-trilogy *Digital Contagions* (2007; 2nd ed. 2016), the award-winning *Insect Media* (2010), and most recently, *A Geology of Media* (2015), which addresses the environmental contexts of technical media culture. This topic was continued in the booklet *A Slow, Contemporary Violence: Damaged Environments of Technological Culture* (2016). In addition, Parikka has published such books as *What is Media Archaeology?* (2012) and edited various books including *Writing and Unwriting (Media) Art History* (2015, with Joasia Krysa) on the Finnish media art pioneer Erkki Kurenniemi, and *Across and Beyond: — A Transmedia Reader on Post-digital Practices, Concepts, and Institutions* (2016, with Ryan Bishop, Kristoffer Gansing and Elvia Wilk).
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Hannah Perner-Wilson

Berlin, DE
Hannah Perner-Wilson combines conductive materials and craft techniques to develop new styles of building electronics that emphasize materiality and process. She creates working prototypes to demonstrate the kinds of electronic artifacts we might build for ourselves in a world of electronic diversity. A significant part of her work goes into documenting and disseminating her techniques, making them available for application by others. Since 2006 she has been collaborating with Mika Satomi, forming the collective KOBAKANT. In 2009, they published an online database titled "How To Get What You Want." In 2015, Perner-Wilson joined an expedition to the jungle of southern Madagascar which inspired her to start producing *A Wearable Studio Practice*, a collection of wearable and portable items that make it easier to become nomadic in your practice of making and manipulating the world. She received her BSc in Industrial Design from the University for Art and Industrial Design Linz (AT) and her MSc in Media Arts and Sciences from the MIT Media Lab (US). Her thesis work focused on developing, documenting, and disseminating a Kit-of-No-Parts approach to building electronics.
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Irene Posch

Vienna, AT
Irene Posch is a researcher and artist. Her work explores the integration of computational technology into the field of art and craft, and vice versa, and the cultural and aesthetic implications thereof. She worked as Key Researcher for the *Stitching Worlds* project, of which she was the co-initiator. She is currently engaged in doctoral studies at the Institute for Design and Assessment of Technology, TU Wien (AT). She was Artist in Residence at the V2_Institute for the Unstable Media Rotterdam (NL), Eyebeam NYC (US) and Columbia University (US). Her research and practice has been presented at international venues, including the Future Everything Festival (Manchester,UK), ZKM (Karlsruhe, DE), V&A (London, UK), Ars Electronica (Linz, AT), Laboratore Arte Alameda (Mexico City, MX), Biennale Internationale Design St. Etienne (FR), Works Gallery (San Jose, US) and the MAK (Vienna, AT).
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Fiona Raby

New York, US
Fiona Raby is Professor of Design and Social Inquiry at The New School in New York (US), and Co-director of the Designed Realities Lab. Between 2011 and 2015, she was Professor of Industrial Design at the University of Applied Arts in Vienna (AT) and Reader in Design Interactions at the Royal College of Art, London (UK). She has been teaching courses in Architecture, Computer Related Design and Design Interactions since 1995. She is a partner in the design studio Dunne & Raby. She is co-author, with Anthony Dunne, of *Design Noir* (2001) and *Speculative Everything* (2013). Their work has been exhibited at MoMA in New York (US), the Pompidou Centre in Paris (FR), and the Design Museum in London (UK), and is in several permanent collections including MoMA, the Victoria and Albert Museum, and the Austrian Museum of Applied Arts. Dunne & Raby received the inaugural MIT Media Lab Award in 2015.

Mika Satomi

Berlin, DE
Mika Satomi is a designer and an artist exploring the field of eTextiles, Interaction Design, and Physical Computing. She has been a guest professor at the Weissensee Art Academy Berlin (DE) for five semesters. Satomi has worked as a researcher at the Swedish School of Textiles (SE) and at the Distance Lab, Scotland (UK) in the field of practice-based design research. She holds a BA in Graphic Design from Tokyo Zokei University (JP), and an MA in Media Creation from IAMAS (JP). Since 2006, Satomi has been collaborating with Hannah Perner-Wilson, forming the collective KOBAKANT, creating artistic projects in the field of eTextiles and Wearable Technology Art. She is the co-author of the etextile online database "How To Get What You Want."
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Martin Schneider

Mainz, DE
Martin Schneider works and teaches at the intersection of art, code, and crafts. He is the founder of bitcraftlab, an imaginary lab dedicated to exploring the convergence of craft and computation. He owns a couple of knitting machines and a laptop. He teaches algorithmic thinking and creative coding at the University of Applied Sciences in Mainz (DE). Schneider is deeply intrigued by the dynamics and aesthetics that can emerge from simple programs and he likes to explore concepts of mathematics, self-organization, evolutionary design and artificial life. He collaborated with artists on installations involving video games, computer-augmented crafts, generative video processing, neural networks, drones, lasers, and a pool of ballpit balls. With the help of some great people, Schneider initiated a couple of events such as the rule110 winter workshops on cellular automata, turtle craft workshops on computational embroidery, and the textile resistance lecture series.

Rebecca Stewart

London, UK
Rebecca Stewart is Lecturer in the School of Electronic Engineering and Computer Science at Queen Mary University of London (UK) where she is a member of the Centre for Digital Music and Centre for Intelligent Sensing. In 2011, she co-founded Codasign, an arts/technology company that teaches children and adults how to use code and electronics in creative projects. During that time, Stewart also collaborated with artists and designers on interactive projects and installations and published *Adventures in Arduino*, a book for teenagers about learning microcontroller basics through paper crafts. Since returning to Queen Mary University in 2016, her research has examined the intersection of wearable computing, e-textiles, and spatial audio with a focus on interactive technologies for the performing arts.

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Stitching Worlds blends the territories of textiles and electronics by investigating textile technologies as controversial means for manufacturing electronic objects. The investigation was conducted with critical and artistic intentions through the creation of past-, present-, and future-tense narratives. What if electronics emerged from textile techniques such as knitting, weaving, crochet, and embroidery? How would technology be different if craftspeople were the catalysts to the electronics industry, via textiles manufacturing? The project expands on the tension created by the use of highly traditional textile techniques for making functioning electronic technology. By revealing unexpected potentials of often-undervalued knowledge and skills, *Stitching Worlds* questions commonly accepted societal value systems and their implications.

www.stitchingworlds.net

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