

SHELBY DOYLE & LESLIE FOREHAND –
**Fabricating Architecture: Digital
Craft as Feminist Practice**

I WOULD RATHER BE A CYBORG THAN A GODDESS.

— DONNA HARAWAY, A MANIFESTO FOR CYBORGS [1]

This is a call for the development of a more robust theoretical position about the gender implications of advanced parametric design and the use of machines to design and fabricate architecture. As digital fabrication has made material the network conditions of cyberfeminism, it is time to revisit the relationships between feminism, architecture, and technology. [2] We propose a framework that relies upon intellectual traditions of feminism and deliberately focuses on developing technologies as a locus of power and influence in architecture. Architecture has been slow to fully acknowledge, incorporate, and integrate women into its practices. [3] Within the building profession, digital technology has emerged—and in many ways, is still emerging—as a site of architectural influence: those who control the process of design through technology control architecture. CNC fabrication and robotic construction are cultivating new cultures of digital craft, and in searching for future opportunities, we would do well to recall the long history that links craft and feminine labor. By looking again at the often-neglected contributions of Ada Lovelace and the Jacquard loom to computation and digital fabrication in the nineteenth century or a more recent project such as the Elytra Filament Pavilion, we might see how this digital moment has been framed by feminist craft rather than the more familiar origin stories that surround computation.

Advanced parametric design and fabrication rely upon historical methods typically associated with domestic labor, such as weaving, ceramics, and embroidery. This can be seen in the rise of digital practices such as woven pavilions, 3-D-printed ceramics, and sewn electric circuits. Architecture can learn much from this shadow history, and the figure of the cyborg is central to this narrative. According to Donna Haraway, a cyborg is a hybrid creature composed of organism and machine. Defying easy categorization, cyborgs occupy a speculative part of our cultural imagination and are vital participants in the history of technology. [4] They are witnesses to crucial moments in what Manuel De Landa defines as the “migration of control” from human hands to software systems—or in the cases looked at in this essay, the migration of control from female and domestic *craft* to the masculine and industrial *digital*

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[1] Donna Haraway, “A Manifesto for Cyborgs: Science, Technology, and Socialist Feminism in the 1980s,” *The Haraway Reader* (New York: Routledge, 2004), 39.

[2] Cyberfeminism was coined in 1994 by Sadie Plant to describe the intersection of feminism and new media technologies such as the Internet and cyberspace.

[3] Lian Chikako Chang, “Where Are the Women? Measuring Progress on Gender in Architecture,” *Association of Collegiate Schools of Architecture*, October 2014, [link](#).

[4] For a sense of the depth of thought that cyborgs have invited, see Fiona Hovenden, Linda Janes, Gill Kirkup, and Kathryn Woodward, eds., *The Gendered Cyborg: A Reader* (New York: Routledge, 2000), 110.

production. [5] The cyborg embodies Donna Haraway's "ironic dream of a common language for women in the integrated circuit" a phrase borrowed from Rachel Grossman and referring to women in a world fundamentally restructured through the social relations of science and technology. [6] Grossman's world is not reliant upon technological determinism but rather presents historical systems—and a contemporary milieu—dependent upon structured relations between people and technology. [7] Not always visible or legitimized, cyborgs are present within current and past technologies providing "spaces for disguise, concealment, and masquerade." [8] Making their contributions evident is a subversive, disruptive, and powerful force in architecture: skills required for survival under increasingly techno-human conditions. [9] What is at stake is nothing less than the continuation—or the undoing—of past hierarchies enforced by the ownership of both technology and technology's narratives. In defiance, the cyborg (woman-as-technologist) must reveal her history, build her technology, code her world, write her scripts, distribute her tools, and methodically disrupt the systems of those constructing, documenting, and disseminating technology.

Cyborg practices and histories are both/and—resisting binaries that fail to exhaust the full gradient of possibilities, binaries that are limiting to the very conception of innovation. Cyborg practices may not be easily recognized

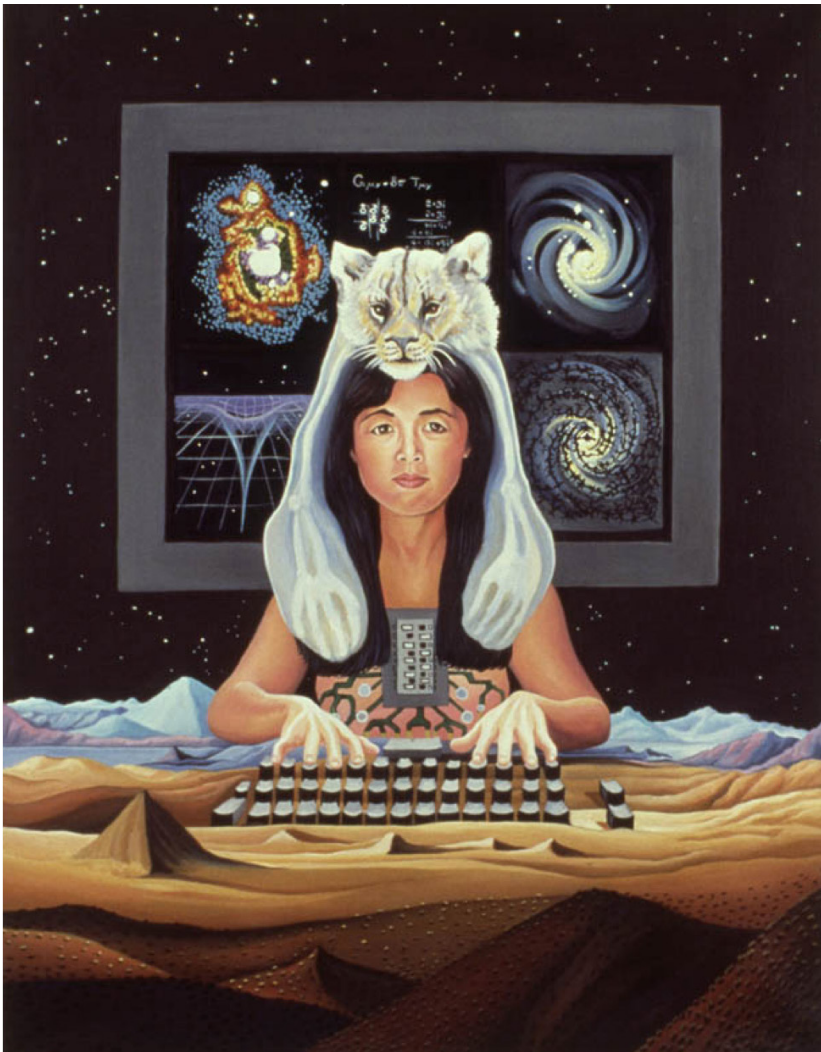
[5] The context for the phrase is "the long process of migration of control, which Jacquard started by effecting a transfer from the human body to the machine..." Manuel De Landa, *War in the Age of Intelligent Machines* (New York: Zone Books, 1991), 164.

[6] Grossman writes that new technologies are mediated by social forces and that if we learn to read these webs of power, we might learn new couplings and coalitions. Rachael Grossman, *Women's Place in the Integrated Circuit* (Somerville, MA: New England Free Press, 1980).

[7] Plant explores the relationship between women and machines and documents the networks and connections implicit in nonlinear systems and digital machines. Sadie Plant, *Zeroes + Ones: Digital Women + the New Technoculture* (New York: Doubleday, 1997).

[8] The phrase "spaces for disguise, concealment, and masquerade" is taken from a discussion of Plant's work in "Cyberspace/Cyberbodies/Cyberpunk: Cultures of Technological Embodiment," Peter Fitting's introduction to *Zeroes + One*, 163–165.

[9] Sandoval asserts that "the colonized peoples of the Americas have already developed the cyborg skills required for domination under techno human conditions as a requisite for survival under domination for the last three hundred years." Chela Sandoval, "Re-entering Cyberspace: Sciences of Resistance," *Dispositio/n*, vol. 19, no. 46 (1994): 76.



Lynn Randolph, *Cyborg*, 1989. The painting, which was the product of collaboration with Donna Haraway, became the cover art for several editions of Haraway's *Simians, Cyborgs, and Women*, 1991. Courtesy of Lynn Randolph.

as cyborgs, and therefore it is necessary to seek out and recategorize many practices mislabeled or misrepresented as merely digital. To be clear, cyborg practices are not necessarily female practices; though projects such as Neri Oxman's Silk Pavilion and Jenny Sabin's Lumen are cyborg, it is not due to the gender of their authors but instead the legacy of their methods. Therefore, cyborg practices also include Achim Menges's research pavilions and Joshua Stein's Data Clay, which rely upon domestic traditions of filament winding and ceramics as much as they rely upon narratives of biomimicry, robotics, and science. Uncovering cyborg and cyberfeminist histories of technology offers new ways of thinking about digital production, the sites of its labor, and the modes of its fabrication.

The Digital Turn

Women in the United States are historically underrepresented in architecture (15 to 18 percent), engineering (4.5 to 13.7 percent), and construction (2.6 percent), although increasing numbers of women trained as architects during the twentieth century. [10] The discourse of digital craft is one of the most vital frontiers in the ongoing imbalances of the field. However, technology is not self-correcting, without challenging the incumbent social structures the imbalances will remain the same. The year 1992 marked what Mario Carpo called the "digital turn" in architecture, a moment when computation became more integrated into architectural design. [11] Twenty-five years after this turn, architecture has been transformed by technologies that offer many new potentials for material practice, presenting opportunities to subvert current power structures—just as they can also help calcify them—and providing tools for a feminist practice of the present and future.

As architecture was making its supposed digital turn, new theories of feminism were emerging, among them cyberfeminism and feminist technoscience, which were engaged in theorizing, critiquing, and exploiting the Internet, cyberspace, and new-media technologies. Judy Wajcman's book *TechnoFeminism* was particularly influential in these discourses. [12] According to Wajcman, women have always been designers and manipulators of technology, as their role as laborers—harvesters, weavers, potters, and caretakers of the domestic economy—placed them into an early and intimate relationship with technology. [13] During the Industrial Revolution, however, the meaning of technology transformed from including "useful or domestic arts"—such as needlework, metalwork, weaving—to a more limited definition of applied science. [14] Despite women's continued contributions to technology, "a series of competing images of the true objects of technology emerged," as Ruth Oldenziel puts it in *Making Technology Masculine*, dividing "female fabrics" from "male machines." [15] The so-called Information Revolution may well be poised to repeat the subjugations of the Industrial Revolution. Current digital craft accounts deny the cyborg and suppress the narrative of woman-as-technologist: the resulting fight for recognition can be seen in the narrative of who is an "architect."

The Other: Architect vs. the Woman Architect

[10] "Built by Women (BxW)," *Beverly Mills Architecture Foundation*, [link](#).

[11] Mario Carpo, *The Digital Turn in Architecture 1992–2012* (Chichester, UK: Wiley, 2012).

[12] Judy Wajcman, *TechnoFeminism* (Cambridge, UK: Polity, 2004), 15.

[13] Judy Wajcman, *Feminism Confronts Technology* (Cambridge, UK: Polity Press, 2000).

[14] Jutta Weber, "From Science and Technology to Feminist Technoscience," in *Handbook of Gender and Women's Studies*, ed. Kathy Davis, Mary Evans, and Judith Lorber (London: SAGE Publications Ltd., 2006), 397–414.

[15] Ruth Oldenziel, *Making Technology Masculine: Men, Women, and Modern Machines in America, 1870–1945* (Amsterdam: Amsterdam University Press, 1999), 26.

In *The Architect: Reconstructing Her Practice*, Francesca Hughes argues that women, due to their exclusion from the core of practice, were more likely to invent a practice in architecture. [16] The spirit of her assertion is that women create a way into architecture by developing alternative practices, for example, careers in theory, community outreach, and education rather than traditional “building” careers. [17] However, the metrics of the profession still fall short of equity and prompt a difficult question: should architecture’s definition shift to incorporate existing “female” practice, or should these forms of practice be absorbed into existing definitions, thereby abandoning their status as “other”?

In the introduction to her edited volume *The Social and the Poetic: Feminist Practices in Architecture, 1970–2000*, Patricia Morton explains, “almost all of the essays in this book identify, explicitly or implicitly, the female as ‘other,’ and it is from this marginalized position that women writing on architecture today are exploring history, the uses of public space, consumerism, and the role of domesticity in search of ‘ways into’ architecture, often through alternative forms of practice and education.” She goes on to write, with reference to frameworks of otherness offered by feminist thinkers such as Simone de Beauvoir and Judith Butler, that “otherness” in regard to feminism “produces a double bind for women in architecture: declaring oneself ‘woman’ or ‘feminist architect’ is to accept marginality within the profession and give tacit validity to the binary opposition of architect vs. woman architect.” [18]

The 1990s saw a number of important books that brought feminist and queer discourse into an explicitly architectural milieu and presented theories of “otherness.” Seminal works such as Beatriz Colomina and Jennifer Bloomer’s *Sexuality & Space* (1992), Diana Agrest’s *The Sex of Architecture* (1996), Aaron Betsky’s *Queer Space: Architecture and Same-Sex Desire* (1997), and Joel Sander’s *Stud: Architectures of Masculinity* (1996) provided much needed theoretical frameworks for architecturally specific discourses on gender. [19] Frameworks introduced included third-wave feminism and post-feminism discourses, queer theory, intersectionality, and the experience of non-white women to feminist discourse, as well as the claim that gender equality has already been achieved via the first two waves of feminism. The 1990s were a pivotal moment in architectural gendered discourse; however, much in society and architecture’s understanding of gender have changed in the twenty-five years since these ideas were presented. There remains ample room for revisiting, rethinking, and identifying relationships between gender and space hidden within everyday practice. [20]

In 1979, the poet Adrienne Rich identified the conundrum facing women who seek acceptance and equality within dominant power relations:

THERE’S A FALSE POWER WHICH MASCULINE SOCIETY OFFERS TO A FEW WOMEN WHO “THINK LIKE MEN” ON THE CONDITION THAT THEY USE IT TO MAINTAIN THINGS AS THEY ARE. THIS IS THE MEANING OF FEMALE TOKENISM: THAT POWER WITHHELD FROM THE VAST MAJORITY OF WOMEN IS OFFERED TO FEW, SO THAT IT MAY APPEAR THAT ANY TRULY QUALIFIED WOMAN CAN GAIN ACCESS TO LEADERSHIP, RECOGNITION, AND REWARD... [21]

[16] Francesca Hughes, *The Architect: Reconstructing Her Practice* (Cambridge, MA: MIT Press, 1998), xvii.

[17] Catherine Ingraham, “Losing It in Architecture: Object Lament,” in Hughes, *The Architect*, 151.

[18] Patricia Morton, “The Social and the Poetic Feminist Practices in Architecture, 1970–2000,” in *the Feminism and Visual Culture Reader* (2003): 277.

[19] Diana Agrest, Patricia Conway, and Leslie Kanes Weisman, *The Sex of Architecture* (New York: Harry N. Abrams, 1996), 15. See also Beatriz Colomina and Jennifer Bloomer, *Sexuality and Space* (New York: Princeton Architectural Press, 1996); Aaron Betsky, *Queer Space: Architecture and Same-Sex Desire* (New York: William Morrow & Company, 1997); Joel Sanders, ed., *Stud: Architectures of Masculinity* (New York: Princeton Architectural Press, 1996).

[20] Contemporary examples include James Benedict Brown, Harriet Harris, Ruth Morrow, and James Soane, *A Gendered Profession* (London: RIBA Publishing, 2016); and the forthcoming special edition of *Log* edited by Jaffer Kolb. See “Queering Architecture,” *Log* 41 (Fall 2017), [link](#).

[21] Adrienne Rich, *Ms.* (September 1979): 43.

Within this construct many women shy away from identifying themselves as “feminist architects,” preferring to conform to the profession’s masculine norms rather than be further marginalized as feminine or female architects. Rethinking these binaries creates possibilities for women as simultaneously architects and technologists—cyborgs—identifying new forms of architectural practice and defining new areas of discipline that occupy the periphery and, from this position, influence or displace the center. The role of technologist is a viable strategy for subverting traditional notions of the profession: no longer dependent upon wealth as a precursor for professional standing, technology can serve as a disciplinary entry point not reliant upon institutional structures, even though currently institutions are often the powerbrokers of nascent technology.

The history of the professionalization of the architect provides insight into where evolution may occur. For example, the Royal Institute of British Architects (RIBA) rooted its values in public interest, encouraging a profession that rejected traditions of craft and tradesmen. On the assumption that no client could trust the trades, the architect became an independent consultant who ensured fair dealing between craftsmen and clients. In 1834, at the formation of the RIBA, the question of gender diversity was nonexistent, a direct reflection of prevailing attitudes in the construction industry. The model of the architect’s office was a domestic household, with the architect as master and toiling designers as domestic servants—a model that still exists to this day in a climate of underpaying and nearly nonexistent overtime pay. These traditions of the professionalization have excluded women architects. For instance, man-to-man privileges were culturally necessary to successfully solicit and retain clients and contractors, eliminating a woman’s ability to network and thrive. [22] This was the climate of the profession of architecture 180 years ago, and many of these stereotypes endure still.

[22] Paul Finch, “Prisoner of Gender of the Equality of Uncertainty,” in *Desiring Practices: Architecture, Gender, and the Interdisciplinary*, ed. Katerina Rüedi, Sarah Wigglesworth, and Duncan McCorquodale (London: Black Dog Publishing Ltd., 1996), 36.

Does Technology Have a Gender?

As a subset of architecture, technology has been categorically overlooked in studies on gender diversity in architecture. While research in gender equity often champions progressive ideas of who can be an architect, existing research tends to harbor conservative conceptions of what being an architect entails. Technology is still typically dismissed as infrastructure, which means that organizations such as Equity by Design [EQxD], Parlour, and Architexx tend to overlook its professional presence in favor of more conventional metrics: licensure, salaries, and awards. Because technology is so important to the future practice of architecture, its reflection of (and possible role in promoting) gender inequality within the profession must be critically examined.

In the nearly three decades since the digital turn, the number of women in the profession of architecture has increased, though the number of women entering the field of design technology remains disproportionately small. In 2014, statistics released by the Association of Collegiate Schools of Architecture noted that women make up slightly more than 40 percent of architectural graduates in 2013 (up from 25 percent in 1985); 25 percent of designers in the profession; and 18 percent of major design awardees in the 2010s (up from 3 percent in the 1980s). [23] Despite these advances, only

[23] Chang, “Where Are Women Now?” [link](#).

5 percent of technology directors at North American architecture firms are women, according to Zweig White’s 2013 information technology survey. [24]

In some respect, the lack of women specializing in design technology is unsurprising given that the practice combines fields that have historically been lacking in gender equity: management, information technology, computer science, and architecture. [25] At the moment, control over computer-aided design—who develops the tools and who administrates them within the profession—rests overwhelmingly with men. This creates a situation where inequalities can become institutionalized, even as other aspects of the profession become more diverse. While technology presents an opportunity for women to challenge stereotypes and privileges, its implementation is not gender neutral. Technology, as object, subject, and network, can either challenge or reinforce existing gender structures. Now that technology dominates the design process, the technologist occupies a crucial position from which to define how the profession works and who works within it.

Unforgetting ADA and Cyborg Looms

In her article “Unforgetting Women Architects: From the Pritzker to Wikipedia,” Despina Stratigakos writes, “Forgetting women architects has also been imbedded in the very models we use for writing architectural history.” [26] Recently, gender discussions in architecture have been reenergized by the denied petition to the Pritzker Architecture Prize in 2013 demanding recognition for Denise Scott Brown as an equal in her work with Robert Venturi—the Pritzker decision reiterated that structures of power in architecture remain slow to acknowledge women’s contributions to the profession. [27]

Moreover, the frequent omission of women from computer science history perpetuates the misconception that women neither historically contributed nor are contemporarily interested in the field. [28] Much of the computation work done in architecture is inherited from computer science, and with this inheritance comes not only knowledge but also bias. Forgotten, for instance, is the fact that the computer programming, perceived today as masculine work, originated as feminized clerical labor—De Landa’s “migration of control” was from the physical labor of female “computers” to the intellectual labor of male “programmers.” [29]

A similar evolution occurred in textiles. When weaving moved out of the household and into the marketplace, men took over the loom, and it became associated with industrial, not domestic, production. In “The Future Looms,” Sadie Plant asserts that “the computer emerges out of the history of weaving, the process so often said to be the quintessence of women’s work. The loom is the vanguard site of software development.” [30] Nowhere is this association more visible than in the connection between the Jacquard Loom and the Analytical Engine of Charles Babbage and Ada Lovelace. The structure of the mechanical Analytical Engine is essentially the same as the computer design of the electronic era: arithmetic logic, conditional branching and loops, and integrated memory: a system of data-manipulation rules that can be termed “Turing complete” or computationally universal. [31] Lovelace wrote, “We may say most aptly that the Analytical Engine weaves algebraic patterns just as the Jacquard loom weaves flowers and leaves.” In the Jacquard loom, replaceable

[24] Daniel Davis, “Where Gender Inequity Persists in Architecture: The Technology Sector,” *Architect*, October 28, 2014, [link](#).

[25] Davis, “Where Gender Inequity Persists in Architecture,” [link](#).

[26] Despina Stratigakos, “Unforgetting Women Architects: From the Pritzker to Wikipedia,” *Places Journal*, April 2016, [link](#).

[27] Women in Design petition, “The Pritzker Architecture Prize Committee: Recognize Denise Scott Brown for Her Work in Robert Venturi’s 1991,” *Change.org*, [link](#).

[28] Jennifer S. Light, “When Computers Were Women,” *Technology and Culture*, vol. 40, no. 3 (July 1999): 455–483.

[29] Steve Henn, “Episode 576: When Women Stopped Coding,” *Planet Money*, October 17, 2014, podcast, [link](#).

[30] Sadie Plant, “The Future Looms: Weaving Women and Cybernetics,” in *Cybersexualities: A Reader in Feminist Theory, Cyborgs, and Cyberspace*, ed. Jenny Wolmark (Edinburgh, UK: Edinburgh University Press, 1999): 46.

[31] For additional information on Turing’s work, see Andrew Hodges, *Alan Turing: The Enigma* (New York: Random House, 2012).



The binary principle embodied in the punched-card operation of the Jacquard loom was inspiration for the data processing machines to come, and the use of replaceable punched cards to control a sequence of operations marked an important step in the history of computing hardware. Courtesy of Douglas W. Jones, University of Iowa.

punched cards controlled a sequence of weaving operations as the ability to alter a pattern correlated to changing cards: computation as physical labor. Serving as a conceptual precursor to the development of programming and data entry, the Analytical Engine drew from these logics.

In 1842, Louis Menabrea, an Italian military engineer wrote *Sketch of the Analytical Engine Invented by Charles Babbage*. Lovelace's English translation of this text was published in 1843, along with her notes, which exceeded the length of the original book and illuminated its foundation in the Jacquard loom. Ada Lovelace's notes were labelled alphabetically from A to G. In note G, she describes an algorithm for the Analytical Engine to compute Bernoulli numbers. It is considered by some the first published algorithm ever specifically tailored for implementation on a computer, and consequently Ada Lovelace has often been cited as the first computer programmer. More than one-hundred years passed until the Analytical Engine was put to use—a lag that inspired William Gibson and Bruce Sterling to write *The Difference Engine*, a steampunk tale set in the mid-1850s in which the software designed was already running. This shadow history, one of possibilities lost, makes us question what digital futures in the present are being made invisible. [32] Over 100 years after her published algorithm, the United States Department of Defense created the computer language ADA, acknowledging Lovelace's often forgotten legacy. She lives on in the software that carries her name "secreted in the software of the military machine"; a cyborg haunting the innards of a technology which long denied her contributions. [33]

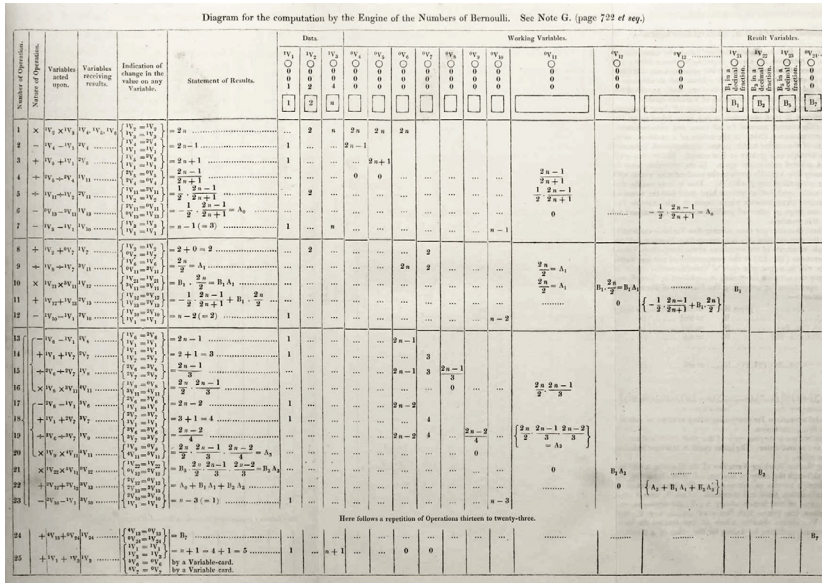
The Elytra Pavilion as a Spinster

The spinster is another cyborg, one that exists in advanced computational construction projects such as the Elytra Filament Pavilion. The pavilion is celebrated as "the first architectural-scale load-bearing structure to be produced entirely through a robotic coreless filament winding process." [34] If we accept the premise that computational work and digital craft can also be read

[32] William Gibson and Bruce Sterling, *The Difference Engine* (London: Victor Gollancz Ltd., 1990).

[33] Mike Featherstone and Roger Burrows, eds., *Cyberspace/Cyberbodies/Cyberpunk: Cultures of Technological Embodiment* (London: SAGE Publications, Ltd., 2000), 163–165.

[34] Jan Knippers, Riccardo La Magna, Achim Menges, Steffen Reichert, Tobias Schwinn, and Frédéric Waimer, "ICD/ITKE Research Pavilion 2012: Coreless Filament Winding Based on the Morphological Principles of an Arthropod Exoskeleton," *Architectural Design*, vol. 85, no. 5 (September 2015): 53.



Ada Lovelace's notes from *Sketch of the Analytical Engine Invented by Charles Babbage* by Luigi Menabrea, 1843. Diagram of an algorithm for the Analytical Engine for the computation of Bernoulli numbers.

through the legacy of domestic and feminist labor then an alternative reading of the Elytra Pavilion is revealed.

The Pavilion is widely recognized within the architectural technology community as a site of innovation that showcases the impact of emerging technologies at the intersection of robotics, architectural design, engineering, and manufacturing. The University of Stuttgart Institute for Computation Design (ICD) authored the project and the Victoria and Albert Museum (V&A) hosted the installation in 2016. [35] Promotional material from both the ICD and V&A emphasizes the design and engineering innovation of the structure: “it will highlight the importance of engineering in our daily lives and consider engineers as the “unsung heroes” of design, who play a vital and creative role in the creation of our built environment.” [36] The glass and carbon fiber canopy is inspired by the structures of the forewing shells of flying beetles, known as elytra, and it was fabricated using an innovative robotic winding technique. It is not surprising then, that it is typically discussed through frameworks of biomimicry, computation, robotics, and fabrication.

Filament winding is a technique of combining filaments (reinforcements) with resins (matrices) wrapped around a mandrel or shell to produce solid vessels with high strength-weight ratios ranging from rockets to golf club

[35] The preliminary research and design process are well-documented in international journals, presented at conferences (Advances in Architectural Geometry, Fabricate, Association for Computer Aided Design in Architecture), and disseminated via popular design media (*Dezeen, Design Boom, and ArchDaily*).

[36] “V&A Engineering Season,” Victoria and Albert Museum, [link](#); and Thomas Auer, Moritz Dörstelmann, Achim Menges, and Jan Knippers, “Elytra: Filament Pavilion,” *Institute for Computational Design and Construction*, [link](#).



The Elytra Filament Pavilion at London's V&A museum was robotically fabricated through a filament-winding technique. The project was designed and constructed by a team of architects and engineers at the University of Stuttgart's Institute of Computational Design. © Victoria and Albert Museum, London.

handles. Filament winding, a direct descendent of weaving, “has depended largely on equipment from textile engineers and designers. Tensioning devices are adapted from the textile industry. Adjustable bars, spring-loaded clamps, camel backs, and brakes on the wrapped warp for tension control during filament winding have long been used by knitters and weavers. The equipment to control the angle of winding with its traversing mechanism was originally developed for winding or roving on tubs or warps of yarn on cones. Even some of the rotating mechanisms for filament winding owe their concepts to the textile industry. Thus, the new and unique filament-winding industry has made full use of the pertinent historical techniques developed by the textile industry.”

[37]

Weaving and fiber manipulation have often been dismissed as women’s work, only to be industrialized as tools of power for commercial gain.

[38] The omission of the gendered history of fiber winding and spinning has multiple implications: it preferences the historic value of industry over craft, and is symptomatic of the push for interdisciplinary design research that aligns with engineering and science professions. [39] What is at risk is another dismissal of female technological contribution: much like Lovelace’s often invisible legacy in the creation of the computer.

[37] Dominick V. Rosato and Cornelius Sherman Grove, *Filament Winding: Its Development, Manufacture, Applications, and Design* (New York: Interscience Publishers, 1964), 7.

[38] Eric Broudy, *The Book of Looms: A History of the Handloom from Ancient times to the Present* (New York: Van Nostrand Reinhold, 1979), 123.

[39] Charles Babbage, “On the Economy of Machinery and Manufactures,” *Philosophical Magazine*, series 3, vol. 1, no. 3 (1832), 208–13.



Engraving of Emma Lady Hamilton, 1761–1815, mistress of Lord Horatio Nelson, as “The Spinster.” Courtesy of Alamy Stock Photo.

Rather than the Silicon Valley bros (or what Deamer calls “stereotypical hipsters” [40]) of parametric conferences, perhaps the Elytra Pavilion’s owes more to the spinster, a term that originally meant a spinner of thread and a job typically done by unmarried women. [41] The migration from the occupational term “spinner”; to the colloquial “unmarried woman” was likely in reference to economic status. During the late Middle Ages, married tradeswomen had greater access to raw materials and the market (through their husbands) than unmarried woman did, and therefore unmarried women ended up with lower-status, lower-income jobs such as combing, carding, and spinning wool. [42] These jobs did not require access to expensive tools like looms and could be done at home. Spinsters are among Haraway’s cyborgs, the “illegitimate child” of every binary: dominant society and oppositional social movements, users and used, human and machine, subject and object, “First” and “Third” Worlds, male and female. [43] When understood as a cyborg—a figure mutating social norms—the historic spinster is, perhaps, not a marginalized technician but rather a historic figment of our future, where robots emulate her work and build in her legacy.

[40] In a lecture to CalArts on November 16, 2003, titled “Parametric Schizophrenia,” Deamer states: “When I go to parametric conferences, I see a world of young hipsters dressed in black, showing images of the screens they have fabricated, talking about the labs they’re working in.” The original text can be found in “Parametric Schizophrenia,” in *The Politics of Parametricism: Digital Technologies in Architecture*, ed. Manuel Shvartzberg and Matthew Poole (London: Bloomsbury Academic, 2015); the lecture can be read here, [link](#).

[41] For the transition from spinner to spinster, see Naomi Braun Rosenthal, *Spinster Tales and Womanly Possibilities* (Albany: State University of New York Press, 2002), 10; and Jacqueline K. Dirks, “Spinster Tales and Womanly Possibilities. By Naomi Braun Rosenthal,” *Journal of American History*, vol. 90, no. 2 (September 2003): 671–672.

[42] For additional context regarding the type of work relegated to single women, see Claudia Goldin, “The Work and Wages of Single Women, 1870–1920,” *Journal of Economic History*, vol. 40, no. 1 (March 1980): 81–88; and Jackie M. Blount, “Spinsters, Bachelors, and Other Gender Transgressors in School Employment, 1850–1990,” *Review of Educational Research*, vol. 70, no. 1 (March 2000): 83–101.

[43] The original text reads “Haraway’s cyborg is the ‘illegitimate’ child of dominant society and oppositional social movement, of science and technology, of the human and the machine, of ‘First’ and ‘Third’ worlds, of male and female, indeed of every binary.” Chela Sandoval, “New Sciences: Cyborg Feminism and the Methodology of the Oppressed,” *The Cybercultures Reader*, ed. David Bell and Barbara Kennedy (London: Routledge, 2000): 377.