ABSTRACTIONS AND EMBODIMENTS

NEW HISTORIES of COMPUTING and SOCIETY

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edited by
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The Baby and the Black Box

A History of Software, Sexism, and the Sound Barrier

Mar Hicks

In 1969, the year that the United States landed on the moon, a joint French-English project dubbed "Europe's Space Race" for its technological complexity and high political stakes, took off from Filton Airfield near Bristol. This plane, the Concorde, would not only break the sound barrier, it would reshape what was previously thought possible for international civilian air travel. By 1976 it was put into service as a passenger jet that could surpass Mach II, or twice the speed of sound.

This Anglo-French technological alliance had succeeded in creating the first, and to date only, supersonic passenger plane. Flying for British Airways and Air France, it could ferry passengers between New York and London, or New York and Paris, in under four hours—less than half the time of a normal jet. In an age before constantly online connection was common and a digital, wired world allowed employees of major corporations to collaborate across time zones and vast distances, the Concorde seemed to represent the vanguard of interconnectedness for business elites and the very wealthy.

Today, for people in the most privileged job classes, the importance of being physically present has receded; they can work together using the internet to collaborate daily or even cement multimillion-dollar deals. Due to the coronavirus pandemic, and the US and UK's mishandling of the crisis that caused death tolls to soar, interest in working

from home has never been higher. Many tech corporations formalized the once informal measures that allowed their white-collar engineering staff to occasionally work from home. Meanwhile, teachers, nurses, waitresses, retail workers, and many others in traditionally feminized and service-oriented jobs have found themselves thrust into harm's way in order to stave off the complete breakdown of the US economy and health care system. At the same time, the majority male workforces in white-collar prestige positions for large multinational tech corporations have been granted the privilege to work from home for the foreseeable future, and perhaps indefinitely.[1]

The current situation represents a stark reversal from the mid-twentieth century, when office attendance was mandatory for most white-collar workers, face time was crucial for promotion, and provisions for working from home were usually nonexistent. During that period, the people clamoring for work-from-home arrangements were mostly women. Though working mothers of all social classes sought such accommodations, it was white-collar women in privileged fields, like computing, who got the furthest. In the 1960s, one such group of British women, after being discarded by employers who would not allow them to be both mothers and tech workers simultaneously, helped create a new model for working from home—while also helping design the fastest, most technologically advanced passenger plane in existence. These women programmed from their kitchen tables and living rooms, conducting meetings and code reviews by telephone, and in so doing gave us a preview of the future of tech work over half a century ago.

Modernizing a Stagnant Economy

As British leaders and citizens put the devastation of World War II behind them, the nation confronted an economically grim future. Through the 1950s, British austerity measures aimed at paying off wartime debts plunged many Britons into hardship. Food rationing persisted well into the 1950s, hurting the standard of living in peacetime. Rationing of fuel also meant that people were freezing in their own homes: during the winter of 1952, this led to thousands of fatalities

when dirty-burning, lower-quality coal kept for the domestic market (so that higher quality coal could be sold abroad to pay down war debts) caused a deadly week-long smog that stopped all air and sea traffic in and out of London and led to the first clean air legislation in the world.[2]

Against this backdrop, the United Kingdom struggled to maintain some semblance of its former power. As technology and political might became increasingly intertwined during the nuclear arms race of the Cold War, the British government hastily set up a reactor in the north of England at Windscale to enrich uranium for bombs under the pretense that it was only a power plant. In their race to compete with the Soviets and to prove themselves to their American allies as nuclear equals, the UK Atomic Energy Authority literally cut corners on the project—shaving off the fins that allowed the uranium rods to dissipate heat properly—and caused a near catastrophe in 1957 that still ranks as one of the worst nuclear disasters in the world.

At the same time, British leaders increasingly began to understand that their economic future lay more in Europe than in the "special relationship" with the United States. Yet Britain tried to join the Common Market, or European Economic Community (EEC), in 1961 only to be vetoed by France, whose leadership doubted the United Kingdom would cooperate with—instead of steamroll—its European partners. In part as a result of this rejection, in 1962 the UK entered into a high-tech partnership with France as a show of cooperation and goodwill, which would become one of the most unique and ambitious international technological partnerships of the twentieth century.[3]

Aimed at showing off the nations' joint technological prowess through creating the world's first supersonic passenger jet, the project was half technological and half political. It was dubbed "Concorde" to reflect that it was meant to represent an alliance. Responsibilities for who would provision the equipment for each part of the airplane were carefully divided up along national lines—no small feat, given the interconnectedness of the plane's systems and its novel, untested design.[4]

Relations between the two nations became heated at more than one point in the years-long design and production process, with the United

Kingdom repeatedly fretting about cost overruns, while the French were determined to forge ahead. The British government seriously considered backing out in 1965 due to spiraling costs and setbacks with the design, but it did not dare because it was still seeking entry into the Common Market. British officials knew that pulling out of the Concorde project would create negative reverberations for their EEC application, proving French president de Gaulle's point that the UK could not really be trusted or relied upon to integrate itself with European goals.[5]

Portioning out the contracts to the companies that would build the different parts of the Concorde gave rise to a telling episode in the history of computing and labor that foregrounded gender, childcare, and early work-from-home jobs in cutting-edge, high technology. On the surface, this episode shows women's contributions to early computing, and is an important historical lesson on how gendered labor discrimination in high tech hurt national fortunes on both an economic and political level.[6] It shows how an explicitly feminist way of organizing a software company undid some of this sexist damage to allow the United Kingdom to advance technologically—and diplomatically—on the world stage. Below the surface, this story also highlights the contradictions inherent in technocratic, meritocratic ways of overcoming discrimination. The women in this instance were highly successful within a specific time frame and a specific situation of labor shortage that had been caused by Britain's attempts to push women technologists out of the workforce, yet their success could not undo the larger structural discrimination that it skillfully skirted.

This historical episode also connects the lived realities of many women's lives to the material needs of modernizing nations and offers insight into how telework, remote work, and "working from home" became an engine of the global economy—not just a preferable arrangement for workers. Today, "wfh" is a way to retain and foster talent, to save lives in a pandemic, and to bring technological collaborations to fruition that would have otherwise been impossible if the work were bounded by the limitations of physical presence and national borders.

Both then and now, relatively privileged workers are able to benefit from this system of labor hierarchy that allows some to work from home. This history shows how a group of women in the United Kingdom at the beginning of the computer age paradoxically succeeded in raising their own fortunes right as they found themselves being pushed out of their office-based tech jobs, by using a feminist business model that revolved around working from home.

Feminism in Technology

In 1962, a young woman named Stephanie Shirley (now Dame Shirley) found herself hitting the glass ceiling in her work in government, and then also in industry. Shirley was a child refugee of the Holocaust who had been brought to the United Kingdom as one of the 10,000 German Jewish children on the Kindertransport to escape genocide. Shirley often remarked that these grim beginnings deeply influenced her drive to succeed, saying that she felt she needed to make her life worth saving since so many others like her had died in Nazi extermination camps.[7]

As a technical worker and computer programmer, Shirley worked at Dollis Hill Research Station and later in industry with some of the brightest minds in UK technology. But despite her drive and ambition, she found herself passed over for promotion again and again. "The more I became recognized as a serious young woman who was aiming high—whose long-term aspirations went beyond a mere subservient role—the more violently I was resented and the more implacably I was kept in my place," Shirley recalled.[8]

After marrying at the age of 26, Shirley soon left her job, exasperated with the roadblocks put in the way of qualified women professionals, and had a baby. But she did not, like so many other professional women with family responsibilities, drop out of the workforce. Instead, with less than £100, Shirley set up her own software company in her home.

It was one of the first freelance programming companies in the world. She gambled on the fact that government and industry would not be able to write their own software in-house effectively and quickly

enough and would need to outsource much of their programming work. Shirley knew firsthand how government and industry employers were pressuring women—who at this time made up the majority of programmers—out of their jobs. There was a growing programmer shortage as women left or were forced out, but Shirley realized these women were also a ready pool of labor.

Using her nickname "Steve," Shirley sidestepped clients' initial sexism by signing a "man's" name to her letters soliciting contacts and contracts, allowing her young company, then called Freelance Programmers Limited, and later called F International, to get off the ground. Shirley had stationery for the company made up in all lowercase letters, both because that was the style at the time, and also as an inside joke: "because we had no capital at all," she quipped.[9]

Shirley's company was unique because it was not just business as usual except with a woman in charge.[10] Shirley set her company up as an explicitly feminist business enterprise—one that would employ some of the many women like herself who had all of the technical skills to do this very much in-demand programming work but who were being shunted out of the labor force because they had gotten married or had children.[11] At the start, Shirley managed a remote team of women programmers while working out of her home—she would play a recording of typing sounds in the background when answering the phone in order to sound professional and cover any noises her young son might make.

Shirley's first major "help wanted" advertisement for her new company, published in the *Times* of London in 1964, noted that her company had "many opportunities for retired programmers (female) to work part-time at home." In this era, the term "retirement" was used to describe the situation women, who were as young as their twenties, found themselves in when they were all but required to leave the workforce upon getting married (fig. 13.1). Shirley's ad noted that the company offered "wonderful" opportunities but would be "hopeless for anti-feminists," clearly laying out the feminist mission and subtly alerting potential recruits that the company had a woman boss.[12]

Figure 13.1. A young woman named Anne Davis wears a punch tape dress at her "retirement party" as she leaves her job at ICL, a major British computer company, to get married.

ICL News, August 1970.

The Workplace of the Future Is the Home

In 1966, Shirley's four-year-old company—through a combination of networking and an excellent record of delivering on-time software—snagged one of the most prestigious programming projects in the nation: writing the software for the Concorde's black box flight recorder. The recorder would be used not simply in the event of a crash but during the whole design process of the plane to analyze test flights and help make adjustments to the plane's design. As such, it needed to be completed quickly, and work flawlessly.

The technological feat of the Concorde required bespoke equipment—everything from the downward sloping nose that moved out of

the way to give pilots a better view of the ground as the plane landed at an uncharacteristically steep angle, to special paint to withstand the heat of flying for hours at over a thousand miles per hour. It required massive-yet-lightweight brakes, cabin radiation monitors, and windshields that could deflect a bird strike at over 500 mph, in addition to the innovative "delta wing" design to minimize drag and make the most of the massive thrust put out by its high-powered engines.

Its cockpit and cabin contained over 40,000 sensors and instruments whose readings would be funneled to the black box. Like the Space Race, the technologies designed for the Concorde trickled down into other areas. The heat-resistant rubber designed to keep its door seals intact under the friction of hours-long Mach 2 flights was adapted for use in premature infant units in hospitals because the high heat it could withstand made it possible for it to be easily sterilized.[13]

These technologies all had to be created in conversation and strict cooperation with the French side of the team, otherwise the plane would literally fall apart in the testing phase. A misunderstanding or measurement error could scrap months of work or even potentially destroy a test plane. To that end, the British and French teams set up control and command centers in Bristol, UK, and Toulouse, France, connected via a high-capacity telecommunications link, installed with the help of the British and French Post Offices. It carried communications of all kinds: from teleprinter and telephone messages to magnetic tape data transmissions, as well as facsimile transmissions of designs and drawings.[14]

Likewise, Steve Shirley's programming teams worked together linked by phone—an early requirement in her help-wanted listings was that the applicant needed to have access to a phone—but unlike the British team working on the Concorde with the French team via telelink, Shirley's workers remained in their homes, for the most part. They didn't work together in a physically centralized office space, as was the standard for white-collar professional jobs at the time. If what the main Concorde teams were doing with remote collaboration to accommodate an international partnership was unusual, Shirley's teams were going even a step beyond that in the service of accommodating women workers.

A rare image of Shirley and her staff in a machine room (fig. 13.2), using rented computer time to test and debug programs, shows the way programming in the 1960s had a completely different workflow from contemporary software development—one that was far less forgiving and required more linearity and less computer usage. One employee of Shirley's, whom Shirley recalled as being a smart programmer, was nonetheless let go for using far too much expensive computer time to test and debug her programs.[15] Writing bug-free code without much

Figure 13.2. Steve Shirley, Ann Moffatt, and co-worker Dee Shermer renting time on a mainframe, 1960s.
Photo courtesy of Ann Moffatt.

computer time to test and debug it was the mark of an excellent and careful programmer.

Baby Ex Machina

The woman who led the Concorde black box project was an experienced programmer and new mother named Ann Moffatt (née Leach). Thanks to Shirley's feminist management style, Moffatt did not get shunted out of her career like so many other women, who were encouraged or forced to quit upon marriage or having children.[16] Instead, Moffatt could work from home and balance the needs of her family with her career as a programmer.[17]

Moffatt was born in 1939, and perhaps fittingly one of her earliest memories was being put in the back of a plane to sleep while her father repaired spitfires on a British base during the war. The plane she was in was meant to stay in the hangar, but she woke up to find herself in the air. The horrified pilot then realized he had accidentally brought along a baby stowaway. Meanwhile, on the ground, her father was frantically looking for her. The plane turned around and "hastened down to the ground." She was only two years old.[18]

Growing up, she excelled at school, getting a scholarship to a prestigious grammar school. She recalls that her parents, however, didn't see the point: as a girl she was expected not to need much education, while her less academically gifted brother was encouraged throughout his schooling. Although her teachers argued for her to stay in school and then go on to university, her mother took her out of school at age 17, before she had earned the high school certificate needed to apply to college. She began working as a department store clerk, earning her school certificate at night school by passing exams in applied math, pure math, physics, and geography.

Moffatt then sought work at the UK government's Meteorological Office, in a role that was at that time usually given to men, explaining that she chose the job specifically because it offered her time off to study—her eventual goal was to get a university degree. "I was peculiar," recalled Moffatt, "because all the scientists were men . . . and so

I was looked on as this frivolous little girl who was going to uni and was clever at maths and so on, but was funny—with stiff petticoats, flouncing round the corridors and so on."[19]

From there, she went on to work at Kodak, not yet having a degree but having scored highly on the programmer aptitude test from IBM. She was offered a good job with a high salary in 1959 and began working in statistical analysis and later operations research. While at Kodak she was sent to a computer course at the British computer company Ferranti, where one of the teachers was Conway Berners-Lee, father of Tim Berners-Lee. Mary Lee Berners-Lee, Tim's mother, also worked at Ferranti as a programmer and was part of an effort to get equal pay for women there.[20]

Though Moffatt enjoyed her work immensely, at 25 she had a baby and her husband, who worked at Kodak as a chemist, did not want her to go back. But just before she had left Kodak, a co-worker had given her a newspaper cutting about a company that employed women programmers to work from home. As Moffatt explained, "The issue then was that they couldn't train enough programmers. There was a tremendous dearth . . . women programmers were leaving work and having babies and their skills were lost to the industry."[21]

After Steve Shirley started her own company, she began collecting more and more of these valuable workers, including, by 1965, Moffatt. For the first several years, Shirley managed her startup out of her home. But shortly before hiring Moffatt she rented a small office in London to take business meetings with customers, even though most staff worked remotely from their homes. Shirley interviewed Moffatt just after moving into the new office, and as Moffatt recalled, "Steve took me into an empty room and perched uncomfortably on the windowsill while I sat on a folding chair. I had dressed smartly in a 'business' suit for the interview. Dressed very casually, Steve smoked throughout the interview. I was mesmerised by Steve's open toed sandals and brightly painted toenails."[22]

Moffatt's first major assignment for Freelance Programmers was the Concorde project. Because of the complexity of this new aircraft and the rigors of testing and later maintaining it, its black box recordings needed to be analyzed after each flight, not just in the event of a crash.

This required analyzing massive amounts of data, because some sensors on the plane would record up to ten data points per second, and doing it quickly enough to keep the plane flying with minimum downtime. The data from each flight would be transferred from the black box to magnetic tape and then analyzed by computer.

Shirley's fledgling company was offered a whopping £20,000 bonus if they could get the project done in a short period of time: within the year. In the end, Moffatt supervised 11 people working on the project—all women programmers working from home, or occasionally coming together with their children in tow to work together in one person's house. The project budget would end up greatly expanding.[23]

The programming for the black box project was done in machine code, written in pencil on coding sheets, with the women using slide rules to do the needed engineering calculations. After that, the programming sheets would be picked up and thrown "in a mini [cooper]" and driven to a group of punchers for hire, and then driven back to Moffatt and her team to check over the accuracy of the punching. Finally, the cards would be taken by car to a computer center in Borehamwood, where the programs would be run on rented mainframe time. If all went well, the expected results would be sent back, and it was on to the next piece of the program. "If you were lucky," said Moffatt, "around midnight you could actually go in [to the computer center] yourself and, if you were capable of operating the computer . . . you could get closer and see how things worked."[24]

Moffatt had become the first manager of a team working entirely from home at Shirley's company, and it had turned out so well that from then on the company decided to let all of their project managers work exclusively from home. The company picked up more and more business and began to grow rapidly. By 1967, Freelance Programmers had several hundred workers.

In a photo from 1966 (fig. 13.3), Moffatt sits at her kitchen table, using a slide rule to do calculations while writing code for the Concorde. Soon after, Moffatt was promoted to technical director for the company, managing a team of what would eventually be roughly 300 home-based programmers, most of them women. "I mean I loved the work.

Figure 13.3. Ann Moffatt writes software for the Concorde as her baby daughter looks on. Moffatt's memoir, *The IT Girl,* details the story behind the photograph. Photo courtesy of Ann Moffatt.

I absolutely loved the work," recalled Moffatt. "I found yes, you could do it from home. Yes, you could even manage teams from home. You could be productive. The women were happy and productive and earning a lot of money. And we were getting lots of publicity from what we were doing."[25]

Faking IT until You Make IT

The scarcity of programming expertise, which was largely caused by the field's earlier feminization colliding with efforts in the 1960s to remove women programmers and replace them with management-aligned technocrats—men who would do both the management side and the technical side of the work—meant Shirley's company was able to tap into a deep need for outsourced programming expertise as a stopgap during this labor crisis.[26] "The company was growing. We were getting work

from the government. The British government . . . were piling work on us. We were [also] getting work from big companies," recalled Moffatt.[27]

But despite this, clients were suspicious of the company's prices. Many clients believed that Freelance Programmers must be run like a "sweat shop" in order to produce the quality of software it did on such a tight schedule. In point of fact, this reflected the contrast between the amateurish men, who were pouring into the conventional office-based workforce's programming jobs in the 1960s with little experience, and the experienced team of highly productive, expert women programmers who were working from home. The women's treatment and camaraderie within the company was not apparent to the outside, however. Several times Moffatt opened the books to allow clients to "see the statistics for their own project and see how much each person had been paid. They then realised that . . . programmers were being paid well but were very productive." The productivity of onsite programmers employed by these companies was often half that of the Freelance Programmers' staff, who were working from home. Moffatt believed the ability to work from home was extremely beneficial to productivity; this has been borne out by later studies. At the same time, the amateurishness being introduced into the "regular" programming workforce during this time of labor shortage and masculinization also impacted relative quality and customers' expectations for time to completion. For all of these reasons, Freelance Programmers continually impressed customers with their speed and work quality: by the mid-1960s roughly 70% of their contracts were repeat business.[28]

Indeed, the need for this labor was so great, and the pace of work so intense, that Steve Shirley visited Moffatt only a few hours after the birth of Moffatt's second child in 1968, nominally to congratulate her, but primarily to persuade her to take over the technical management of the company. Within ten days Moffatt was visiting clients and managing a staff of 250 people.

While Moffatt was happy with her job, her husband was growing increasingly angry at her newfound work responsibilities. One day, in a rage, he drove her car to a dealer, sold it, and came back in a taxi, saying that now that she didn't have a car she wouldn't be able to keep

her new management-level job. Furious, Moffatt went out and immediately purchased a new car, and within a few years they divorced. Moffatt went on to become the first woman on the British Computer Society council and continued to work with people at the highest levels of government and industry.[29]

The larger Concorde project continued into the 1970s, with the black box now finished. But despite their efficiency, Freelance Programmers had not been paid for their work. As the Concorde's development encountered delays and churned through ever more money—some estimate it ran over budget by well over a billion pounds—Shirley was unable to secure payment from the government for Freelance Programmers' relatively modest invoice. "I remember [the Concorde project] not really for the technology or the size, but on the financial side, because I didn't get paid for it," recalled Shirley. She had to personally visit the office of the project director, who contracted her company to do the work on several occasions, staying in the waiting room and making a general nuisance of herself because she needed the money for payroll. Eventually he sent word out through his secretary: "Tell Mrs. Shirley to come back tomorrow and her check will be ready."[30]

Concorde's Failure, Legacy, and Lessons

For all of its unrealized return on economic investment, the Concorde was a roaring technical success. It was a technological marvel that put the British back on the map after a string of internationally humiliating black eyes during the Cold War, from the Tanganyika Groundnut Scheme, to the Suez Crisis, to the Windscale disaster.[31] As nations once subjugated by the British fought for and gained their independence and British power receded, the United Kingdom floundered—struggling through multiple rounds of currency devaluation, wracked by strikes, adrift economically, and desperate to join the EEC. While the US and USSR were heading into space, the UK seemed decidedly earthbound.[32] The Concorde promised to change all that: to give the British a technological prestige project that would be the envy of the Western world and serve as an entrée into a stronger alliance with Europe.

Moffatt and her team's contributions to the Concorde helped bring the hope of a modern Britain, revitalized by technology and aligned with European industry, nearer to reality. The Concorde provided a much-needed shot in the arm, not only proving that futuristic supersonic passenger transport was possible but also that a joint venture between two nations so often at odds could be a technical success.

Yet, both the British and French knew that this was a blue-sky project that would run at an economic loss.[33] Despite taking hundreds of potential orders from global airlines, in the end only 14 planes were produced, 7 flying for British Airways and 7 for Air France on the London to New York and Paris to New York routes, respectively, at a cost many times the amount of a regular transatlantic jet ticket.[34] A by-product of a particular technological moment in the Cold War, the Concorde's popularity was undercut by cost and growing environmental concerns—its own history positioned it more as a political bargaining chip and a symbol of technological power than a viable product. When a crash led to all of the remaining Concordes being permanently grounded in 2003 after 34 years in service, no similar passenger plane would replace it.

Initially, the Concorde was also a political failure: in 1967 France blocked Britain's entry into the EEC for a third time, on the grounds that the British economy was underdeveloped. It was not until after French president Charles de Gaulle was no longer in office that the British were allowed into the Common Market in 1973, under the leadership of Conservative prime minister Edward Heath. The longer history of Britain in the EU, particularly post-Brexit, has tended to prove de Gaulle right: although the UK government wanted the economic benefits of EEC (and later EU) membership, the British remained politically unaligned with Europe, holding themselves at a remove while glorying in fantasies of reviving their past global empire.[35]

The Concorde story also shows how high technology does not indicate social progress: after entering the EEC, the UK soon fell afoul of European rules for the modernization of industry, because the UK refused to adequately implement equal pay for men and women. Britain was sanctioned twice by the EEC in the 1970s for having unequal pay and for passing equal pay legislation that was designed to meet the let-

ter of EEC law but not actually implement equal pay. The British "equal pay" and national sex discrimination acts of the 1970s largely perpetuated and submerged the gendered economic inequality the EEC demanded member states fix.[36] This was because unequal pay had for so long been foundational to the functioning and prosperity of the UK economy, with computer corporations even measuring work in cheaper "girl hours" (instead of man hours) to create products at a lower cost.[37]

Ironically, the stellar work of Ann Moffatt's team on the Concorde was an extension of the legacy of unequal pay and unequal opportunity in the United Kingdom. The work of Moffatt and her team was part and parcel of this gendered—and sexist—environment in British industry and high tech. Moffatt, Shirley, and the other women who worked for Freelance Programmers cleverly subverted the sexism of the time by developing and participating in a model of feminist tech entrepreneurship that shifted the boundaries of the modern workplace and remade working conditions for the personal and collective gain of women workers.[38] Shirley's company allowed hundreds of women to continue careers that would have otherwise been cut short or interrupted, and Freelance Programmers produced around 70 women millionaires.

Shirley's company became an exception that proved the rule of Britain's sexist labor practices, cleverly taking advantage of the labor fallout from structural sexism in UK high tech. At the same time, Freelance Programmers' default work-from-home model raised productivity while lowering overhead, and it proved that having to come into an office, and get childcare that would allow one to do so, was not required to ensure the quality or quantity of the work women performed. It showed, rather, that traditional modes of office working were in place to maintain particular ideals of control and conformity for professional workers—ones which often boxed women out of the paid workforce.

Unfortunately, much like the Concorde, the technofeminism represented by the women who programmed its black box was a band-aid on a larger, older, technochauvinist system of inequality and power differences, which could not alone produce a widespread, structural fix.[39] Both Concorde and Freelance Programmers needed to build off of

existing power structures to try to construct the future.[40] The success of Freelance Programmers notwithstanding, working from home or remotely has often been used to (re)create an exploitative and unfair economy of piecework. In the current economy, the digital piecework of the "gig" economy, as well as the tactic of using remote work to outsource internationally, disproportionately hurts women, people of color of all genders, and less affluent or privileged workers. These workers often form the silent infrastructure enriching the extractive technology corporations largely based in Silicon Valley.[41]

In addition, while the working conditions and women supervisors at Freelance Programmers were a godsend for many women, this model of employment still meant that working mothers had to do two jobs—even though it gave them the opportunity to do them simultaneously. One part of the legacy of the baby and the black box is that flexibility in working arrangements can be a double-edged sword, helping women stay in the labor market while also reaffirming larger structures that may keep them unequal players within it. To some, Moffatt's picture of her programming while watching her baby may represent how certain white women were able to flourish under conditions of scarcity and crisis by "leaning in" to their roles.[42]

As a result of this reconfiguration of work, Moffatt and her team became part of government and industry modernization in this period, and they were implicitly trusted to ascend the ranks of technocratic power, working from outside traditional workplace power structures while conserving their roles as caretakers within nuclear families.[43] Yet, many similarly qualified women like Moffatt could not use their skills after marriage. For every woman Steve Shirley employed there were hundreds—if not thousands—of women who would not get the chance to continue to fulfill their potential in the burgeoning high-tech economy. Eventually, this gendered labor drain would devastate the British computing industry, which sank into decline in the mid-1970s after several promising decades of innovation and growth.[44]

In the end, the most revolutionary part of Moffatt's work on the Concorde may have been the way it proved the viability of cutting-edge high-tech work from home at a very early stage in the digital era, pre-

saging everything that was to come in terms of labor force reorganization in high tech. Shirley's company very early on gave the lie to the idea that in-office productivity was higher or that professional results required a physical presence in a traditional, centralized office.[45] As Moffatt notes in her memoir: "Steve's companies achieved high productivity and a reputation for top quality. There has now been a lot of research on why home-based workers achieve high productivity."[46] Shirley and her employees were the vanguard of an important new way of organizing work, one that has become apparent to most executives and corporations only much more recently. Indeed, many tech companies are now poised, given the changes wrought by the COVID-19 pandemic, to let programmers work from home permanently.

The benefits of this kind of labor flexibility bring major positive change not just to industries and national economies. Work arrangements geared to life patterns that are historically more common to women fundamentally change the material condition of many women's and children's lives in ways otherwise impossible under current economic systems. This is one reason why, unlike the Concorde, Moffatt's other project from 1966 is going strong well into the twenty-first century: her daughter Claire, the baby in the photograph, is now 57 years old.

Notes

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2. Peter Thorsheim, *Inventing Pollution: Coal, Smoke, and Culture in Britain since 1800* (Athens: Ohio University Press, 2006).
3. Aeronautical Correspondent, "1,450 M.P.H. Airliner Pact Next Week," *Times* (*London*), November 24, 1962.
4. File AVIA 65/2004 (1960–1965), The UK National Archives, London. The British and French argued extensively about the spelling of the name "Concorde" with the

British preferring the English version of the word. Ultimately the French determined much of the shape of the project, including the name.

5. *Times* Correspondent, "Gen. De Gaulle's Blow to Brussels Talks," *Times* (*London*), January 15, 1963.

6. Mar Hicks, *Programmed Inequality: How Britain Discarded Women Technologists and Lost Its Edge in Computing* (Cambridge, MA: MIT Press, 2017).

7. Mar Hicks, "Oral History of Dame Stephanie Shirley," conducted January 2018, held by the Computer History Museum in Mountainview, California (available at https://www.youtube.com/watch?v=TRlSaEZhFLg), and Stephanie Shirley, *Let It Go: The Story of the Entrepreneur Turned Ardent Philanthropist,* rev. ed. 2017 (London: Andrews UK, 2012).

8. Shirley, *Let It Go,* 58.

9. Shirley, 53.

10. For more and a comparison with Elsie Shutt's similar company in the United States, see Janet Abbate, *Recoding Gender* (Cambridge, MA: MIT Press, 2012), chapter 4.

11. Hicks, Oral History Interview with Dame Stephanie Shirley.

12. Freelance Programmers help wanted advertisement, *Times* (*London*), June 26, 1964.

13. Arthur Reed, "From Hat Rack Brackets to Heavy Duty Brakes," *Times* (*London*), November 28, 1972.

14. Reed, "From Hat Rack Brackets to Heavy Duty Brakes."

15. Author's interview with Dame Stephanie Shirley, January 2018.

16. For background, see Hicks, *Programmed Inequality,* chapter 3.

17. Abbate, *Recoding Gender,* chapter 4; Hicks, "Sexism Is a Feature, Not a Bug," in *Your Computer Is on Fire,* Thomas Mullaney, Benjamin Peters, Mar Hicks, and Kavita Philip, eds. (Cambridge, MA: MIT Press, 2021); Mar Hicks, "When Winning Is Losing: Why the Nation that Invented the Computer Lost Its Lead," *IEEE Computer* 51, no. 10 (2018).

18. Australian National Library, "Ann Moffatt interviewed by Sarah Rood in the History of ICT in Australia oral history project," ORAL TRC 6470/6 (nla.obj-220401631), recorded March 3 and May 30, 2014, in Lane Cove, New South Wales.

19. Australian National Library, "Ann Moffatt interviewed."

20. Australian National Library.

21. Ann Moffatt, *The IT Girl: 50 Years as a Woman Working in the Information Technology Industry* (London: Third Age Press, 2020).

22. Moffatt, *The IT Girl,* 105.

23. Shirley, *Let It Go,* and author's interview with Dame Shirley, January 2020.

24. Australian National Library, "Ann Moffatt interviewed."

25. Australian National Library.

26. Hicks, *Programmed Inequality.*

27. Australian National Library, "Ann Moffatt interviewed."

28. Moffatt, *The IT Girl,* 119–21.

29. Ironically, given the sexist banking practices of the time, Ann was not allowed to hold the mortgage to her own house, despite earning more than her ex-husband, and she had to ask her father to sign as guarantor on the loan. Moffatt, *The IT Girl.*

30. Author's interview with Dame Shirley, January 2020. Lord Arnold Weinstock, the director of GEC (General Electric Company plc), was responsible for bringing Freelance Programmers onto the Concorde project to do the programming for the black box.

31. The loss of many former colonized territories, including India; the multimillion-dollar boondoggle to grow nuts for cooking oil in Tanzania (then Tanganyika); the Suez Crisis, which revealed the UK's diminished imperial power; and the Wind-scale disaster of 1957, when the UK's rush to enrich uranium for nuclear weapons brought it to the brink of nuclear disaster, to name just a few.

32. On the political importance of technological prestige and women's work during the Cold War, see Margot Lee Shetterly, *Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race* (New York: William Morrow, 2016).

33. CAB 168/161 (1964–1965), The UK National Archives, London.

34. By the time the Concorde was grounded in 2003 over safety concerns, tickets had reached well over $10,000 for a one-way trip.

35. On how the "soft" technological power of digital technologies has been used to extend imperial domination in the postcolonial period, see Halcyon Lawrence, "Siri Disciplines," and Kavita Philip, "The Internet Will Be Decolonized," in *Your Computer Is on Fire.*

36. Hicks, *Programmed Inequality,* chapter 4.

37. For instance, IBM UK measured its (feminized) manufacturing in cheaper "girl hours" in the 1960s. Hicks, *Programmed Inequality,* 21.

38. On the other hand, corporations used the ideal of the patriarchal family to structure workers' lives; see Corinna Schlombs, "Gender Is a Corporate Tool," in *Your Computer Is on Fire.*

39. Meredith Broussard coined the term "technochauvinism" to highlight the fact that "technological determinism" (the idea that technology determines or leads social change) ignored the racism, sexism, and white supremacy of sociopolitical systems that epitomized twentieth-century ideals of "futuristic" high tech and a more automated future. Broussard, *Artificial Unintelligence* (Cambridge, MA: MIT Press, 2018).

40. For examples of a similar dynamic, see Kelcey Gibbons, "Inventing the Black Computer Professional" in this volume; Lisa Nakamura, "Indigenous Circuits: Navajo Women and the Racialization of Early Electronic Manufacture" in this volume; Ruha Benjamin, *Race after Technology* (Cambridge, MA: Polity Press, 2019); Janet Abbate, "Coding Is Not Empowerment," in *Your Computer Is on Fire;* and Clyde W. Ford, *Think Black* (New York: Amistad, 2019).

41. See, for example, the work of activists Kristy Milland of Turker Nation (Kathryn Zyskowski and Kristy Milland, "A Crowded Future: Working against Abstraction on Turker Nation," *Catalyst: Feminism Theory Technoscience* 4, no. 2 (July 2018), and the large body of work revealing that tech companies exploit inequalities and extract labor value via "gig" work: Sarah Roberts, *Behind the Screen* (New Haven, CT: Yale University Press, 2019); Mary Gray and Siddharth Suri, *Ghost Work: How*

to Stop Silicon Valley from Building a New Global Underclass (Boston, MA: Houghton Mifflin, 2019); Safiya Noble, *Algorithms of Oppression* (New York: New York University Press, 2018); Ruha Benjamin, *Race after Technology;* Tressie McMillan Cottom, "The Hustle Economy," Veena Dubal, "Digital Piecework," Katrina Forrester and Moira Weigel, "Bodies on the Line," and Julia Ticona, "Essential and Untrusted" *Dissent* magazine, Fall 2020: Technology and the Crisis of Work.

42. Sheryl Sandberg, COO of Facebook, famously encouraged women to "lean in" and work harder within sexist systems to succeed, in *Lean In: Women, Work, and the Will to Lead* (New York: Alfred A. Knopf, 2013). The *Guardian*'s Zoe Williams described it as a "carefully inoffensive" book that perpetuated most of the sexist power structures that, on the surface, it claimed to critique. Williams, "Book Review: Lean In," *The Guardian,* March 13, 2013.

43. Not all women working at Shirley's company were operating within a nuclear family: Margaret Mears, who had initially been tapped to lead the Concorde Project but left to work in Australia at the Woomera military testing site, "had joined the company when she found she was pregnant. She was not married and had had her baby adopted at birth without even seeing him. The other woman manager, Pamela Woodman, was an unmarried mum who had decided to keep her baby." Shirley has confirmed that she also tried to hire—and help—women who were unmarried, single mothers, and also lesbians, and knew at least two trans employees who transitioned while at the company. Ann Moffatt, *The IT Girl,* 106–7, and author's interview with Dame Shirley, January 2020.

44. Hicks, *Programmed Inequality,* chapter 5.

45. Freelance Programmers kept data on their productivity to improve their workflow—much like current "agile" software development systems do. Ann wrote that this was key to the company's success, "especially the metrics used to estimate effort, time and cost and to track progress on the project." Other, more traditional companies asked Freelance Programmers if they could help them develop similar metrics to improve productivity. Ann Moffatt, *The IT Girl,* 120–21.

46. Moffatt, *The IT Girl,* 161.