Ruth Oldenziel

Making Technology Masculine

Men, Women and Modern Machines in America 1870-1945

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Introduction

Mcns love affair with technology is something we rake for granted. Only when that affair runs amok is it likely to dicit any serious commentary at all. The editors of *The New York Times* considered the subject of male rcchnophilia sufliciencrly newsworthy to devote a rrcnr-page article to it in 1986 when Robcrr Morris, Jr., generated "the biggest computer gridlock" ever known. His program jammed over 6000 computers in the United States, including some in the military computer network. Women and girls "use computers; men and boys love rhc m. Alld that difference appears to be a critical rcaso n that computers in America remain a prcclominanrlv male province," the article declared. It went on to report that women "are almost without exception bystanders in thc passionate romance rhar men conduct with these machines, whether in computer science laboratories, video game parlors, garages or dens."

N ut only journalists recognized the gendered aspects of rhc computer incident. \Vhen commenting on his son's obsession with computers, the student's own farher, onc of the govern mcnt» most respected computer sccuri ty experts, wryly remarked: "I had a feeling rhi, kind of th ing would come to an end the day he found our about girls." j-Jc added, "Girls are more of a challenge.m Both the *Times* journalist and Morris SI'. suggested that a widespread male cultural pattern of passion with technology had endangered America's military and national security interests. Jf taken to the extreme, rhar passion might have dire consequences, indeed. Most commentators paid attention to the effects rather than to the underlying source of that love affair: after all, men's attraction IO technology was, and still is, considered a matter of fact rhat needs no further explanation.

Whenever women enter computer rooms and consrrucrion sites as designers, hackers, and engineers. however, they need to be accounted for and explained. For decades scores of newspapers have reported, commented, and elaborated on the many "first" women who trespassed the male technical threshold as engineers, prescnring thcm ofren as news. Duri ng the ninerecnrh ccnrury Lrnily Rocbiing (1841-1902), her husband's business partner during his twcnry-ycar-long illness, elicited commentary when she helped supervise the construction of New York City's Brooklyn Bridge. For years, Katc Gleason (1865-1933) was routed to be the

first women engineer even though many lesser known women were also working in the field at the time. No doubt respond: ng to the governmental campaigns to recruit women as technical personnel, *The Christian Science Monitor* claimed in 1943 that Isabel Ebel was "the only woman aeronautical engineer of the Unired Airlines staff.' Even after the war emergency, *The New York Times* considered the graduation of Audrey Muller newsworthy enough to call her "the first woman ill the history of the University of Michigan to receive a bachelor in naval architecture." 1n the home town of General Electric Co., all employer of scores of women in rech nica1 posi rio ns for ma ny decades, *The Schenectady Gazette* srill clairncd in 1960 rhar Lconore Traver was JUSt one of the very few women in the coun try pursu ing a career in civil engineering, ignoring the thousands who had preceded her. And as late as 1970, a Philadelphia city paper celebrated Candace Martin, "the first woman member of the Local 4 E Inrcrnarional Union of Operating Engineers, [who is] a field engineer on the construction site."[2] From New York to California engineering journals, corporate newsletters. and local newspapers singled out women who trespassed on the male domai n of engineering, often adding local touches and highlighting them with photographs to suit the particular occasion. The publicity on women engineers – one might even call it overexposure - shows how we continue to view their entry into the technical domain as an exotic hut more likely an cxccpri onal, strange, and alien event. Ir also illustrares how we forget, erase, and (rcrinvcnt the history of women. More importantly. these reports show how we consider technology men's natural domain - a penchant that does need explanation, however.

Morris' male romance with rech nology has a history, albeit it a short one. There is nothing inherently or naturally masculine about technology. The representation of men's native and women's exotic relationship with technology elaborates on a hisrorieal, if relatively recent and twen ticrh-ccn tury W cs[ern tendency to view technology as an exclusively masculine affair. The public association between technology and manliness grew when male middle-class attention increasingly focussed its gaze on the muscular bodies of working-class men and valorized middle-class athletes, but discrnpowcred the bodies of Native Americans, African Arncricans, and women, Si mila rly rhe erasures o f w(.rkcrx, Narive Ameri eans, A(rican Americans, and women from the technical domain was not accidental. This occurred when scores of working-class women entered the lahor market and confronted new machines in the: r jobs as cigar makers, secretaries, switchboard operators, and dress makers: when middle-class women organized both inside and outside the women's movement to stake out new terrains and implement new agendas; and when educated middle-class women sought access to literature, chemistry, medicine, and law, shaping new protcssiona] identities. The links berwcen technological change and gender relations developed neither in isolation

nor independently. Insread, they shaped each orher. In the cultural grammar of the rwenrierh century, the simultaneous erasure and overexposure of flesh-and-blood women engineers like [bel, Muller, and Travel' evolved together with the shaping of a new technical world inscribed as male.

Making Technology Masculine explores the historical origins of Morris Jr.'s love affair with computer networks in which women had no place; it traces the development of a mascul inc mystique with and of a female fear of technological change in the last hundred years; it examines how American engineers began to lay claim to a new knowledge domain they called technology while making universal claims for it; it describes how American engineers and their allies employed discourse, language, and narrative strategies and pracriced a style of engineering that came to suppOrt this gendered division of cultural labor, In these settings, women entered the seen e actively piorri ng their own narrativcs around fictional engi ncers to counrer their male colleagues on the subject as professional women writers; they tu rned up insisting on taking their place in the technical arena as engineers. They also appeared silenced as wives and daughters in the autobiographical aCCOLlIHS male engineers constructed. The book is rhus a venture that goes beyond a narrative of women's participation in or exclusion from past technological undertakings to chart how notions of gender and technology construct each other. It treats rhe absencc of flesh-and-blood women in technological matters in its relation to their persistent and haunting metaphorical presence.

Men, too, quite emphatically enter these pages at work in their relationships with both women and other men different in class and crhniciry. They enter the stage in search of their own version of male identity as professionalizing engineers looking for culrura] resources to upgrade their occupation; as snuggling rank-and-file memhcrs living ill fear of being declassed and demasculi nizcd: and as writers, visual artists, and social scicn risrs in search of their own professional identities by electing engineers as their new models of white manliness and chaning a revitalized malc identity for the middle claxs. Th is book therefore does not deal with women simply as the exclusive bearers of gender. It focuses its gaze on men as gendered male as they shape their stories, professional strategies, and identities:

Focussing one's gaze on men helps ro understand why technology developed into a powerful symbol of male, modern, and western prowess; how machines like cars, bridges, trains, and planes have become the measures of men, from which women have been excluded as a matter of course; why corsets have been banished to the basements of the modern classification systems of technology; why women - when they do appear on the scene as engineers and inventors - function like *dene ex muchina.* Likc the Greeks, who used dramatic devices to lower their gods onto the stage by a machine, our contemporary mythologies often produce women as goddesses whose lives arc essentially off-stage, who appear to come from nowhere,

and whose plots are engineered elsewhere, In this construction. women who enter rhc male-defined technical stage always look like amateurs.

Engineers and their advocates were important actors ill rhe construction of such a plot. They came ıa be seen as rhe exclusive bearers of a domain we have come to call technology - both as an intellectual construct and material practice. They cmerged as the shock troops of modernity from the tracks deep into the western territories, rhc bottom of South African mines to rhe basements of New York drafring departments and rhe laboratories of General Electric bringing good things to life. Between 1870 and 1950, the number of engineers grew 17 ıirnes Iasrer than the U.S. labor Iorce as a whole. In the 1ineteenth century they specialized ill civil, mini ng, and mechanica] engineering; at the end of the century the chemical, electri cal, and aeıonauti eaI ind usrries demanded new kinds of engincering skil\ and knowledge. Engineers could be found in any function, industry, or geographical loc.uion, working for local, municipal, state, or federal governments, for large corporations, or as independent operators. Engineers helped organize capital, hired labor, calculated cstirnares, signed contracts or carried out research. Since the end of the nineteenth century, American engincering has expanded the most rapidly of all occupations, reflecting the growth and consolidation of modern industry anri ihe spectacular expansion of middle management in [he emerging corporations and federal bureaucracies. Ir was also transformed from an elite professi()ıı illto a mass occıipation. Moreover, it became a segmeıired and divided profession: by 1935 there were 2,518 different job titles under its rubric. Few could call themselves chief or consulting engineers; most worked in poorly-lighted, crowded, and dirty drafting departments tracing, detailing, lettering, checking, and copying maps, grade profiles, steel structures, plant lay-outs, and underground ıiine surveys."

In America engi nccrs th us belollged to a deeply divided, segmented occupation. It lacked such classic gate-keeping mechanisms of profcssionalizarion as crcdcnrialling and licensing. It also lacked a clear-cut identity - all irony, to say the least, given the role engineers were to play in the modern meanings of technology. Despite its relative open, eclectic, and segmented character American engineering remained the most male dorni nated of all. The numher of women who received enginecring degrees increased overall, but it did nor illcrease proportionally: rhey consistently accounted for about th rce percent of the profession during the tirsr half of the century or probably a few thousand women employed in engineering jobs in the Un ired Stares by the 1920s, and about six rhousa nd by the end of the second World War.'

Why so few women figured in cngincering is asking rhc wrong question, however. Aggregate figures arc a matter of definition. An exclusive atrcntion to figures tends to blame women for their inadequate socializ.uion and to ignore the proles-

siona l pol itics beh ind the crearion of such sratistics. Govern mcnr star istics and engineering school records fail to do justice to the daughters and wives who acquired rcchnical knowledge informally through family firms without ever attending a specialized school, to those who obtained engineering positions through corporate on-the-job training alrer cornplcring a science education, to the daughters of lower-class and irnmigranr families who attended evening classes in the hope of improving their chances for career advancement, or to thc hundreds of thousands of women who trained in engineering during the wars," More importantly, any estimates on the number of women engineers depend highly – if not primarily – on one's definition of engineering, Should it include the underbelly of the profession: lab assistants, drafrsmcn, chemists, dcrailers, checkers, tracers, and testing rcchnici.ms? These are hardly innocent choices for these definitions also have a history. Census figures have been subject to rhc changing definitions of engineering, reflccring not only statisticians' desire for more precision, but more importantly, the profession's aspirations for higher status by barring more and more groups previously included in the definition. These attempts at professiounlizarion often helped in reinscribing and maintaining engineering as a male middle-class domain in rhc course of the rwcnricrh (cmurl'. Such attempts to upgrade the profession involved cult ural work.

Engineers built bridges. They also constructed cultural infrastructures and engaged in narrative productions. Strategies of professionalizarion, the compilation of encyclopedias, the writing of autobiographies, the singing of songs, and the telling of jokes were all part and parcel of the cultural work of maintaining engineering as male occupation. As cnginccri ng transformed to a mass profession, students at the leading engi nccring school **MIT** Proudlv, if joki ngly, rccsrablished the male premise of their pro iession when confronted with a few women on campus. In a boisterous and rowdy mood, the male engineering students joked with their female colleagues in a 'co-cd song entitled *A Son (?) ofthe M. I. T.* composed in 19°7. They sang, "I would nOI be a Yale man, Reformers to annoy. Nor yet a Harward xrudicur [sic]: defeat [don'l enjoy...Such models I'd not choose.... [bur] I'm a son ofthe M.I.T." Alternatively – and this is the humorous point of the song - the few women who at the time attended the engineering school would interject, 'Tm *not* a son ofthe M.I.T." In the narrow space of one eighth note, "I'm *not,*" they sang, "certainly not, and I'm glad ofit!" or, "the idea is preposterous!" That eighth note in the musical phrase represents the narrow space allotted to women entering the engineering profession since as a poi ut olcntry it did not allow for passage into the bastion. Humor, a grateful tool, helped to relieve the tensions that were part and parcel of a society that opened its doors to new social groups. For these male and female voices were engaged in more than mere incidental banter. The songs showed the kind of negotiation ill which men and women were engaged at the

turn of the century when older engineering clitcs confronted scores of sons of immigrants, some African Americans, and a number of women starting (o demand their rightful place. The enuy of immigrant sons through rhc system of American engineering education required a lot of work to keep clas, within its bounds. They helped to revitalize the workings of middle-class manliness when boundaries of class were under negotiation and to recast the profession as a middle class, white, and male jurisdiction by the end of the nineteenth centmy. In these serrings, racial and gender lines were therefore more carefully drawn than those of class. Like all jokes, they released a host of tensions, and with them, new meanings in a society that sought to negotiate the challenges posed by Jllany of its citizens who were striving to be pan of the polity.

Hisrorians employ the nineteenth-century term "useful arts" and rhc modern word "technology" interchangeably, as if they were synonymous."As the history of the term technology suggests, however, they are not. Between the "useful arts" and "rcchnology" lay a world of difference." The change in terminology flagged a profound transformation in American society in both material and linguistic terms that came to be challenged along the way. Technology is a neologism. Only in the '930S did technology become a keyword of American grammar and an all encompassing concept that could explain human life itself. It then came re denote the useful application of scientific knowledge for the benefit of humankind, and engineers were designated as the sole bearers of rhat form of knowledgc. Rarhcr than a neutral term, *technology* is itself parr of a narrative production or plot of modernism, in which men are the protagonists and women have been denicd their part.

Technology presents us with an irony: the term *technology* could muster such universal claims for itself ill the twentieth cemmy, bur the modern meanings of the term arc of very recent vintage. Despite the evocative power of *lcclmology in* the late twentieth century, it failed to enjoy any currency ill the nineteenth century. Firsr introduced by engineering advocates in the nineteenth century and theorized by social scientists ill the 1920s, the term gained wide and popular currency only after the second World War. Yet the meaning of technology has been contested and gendcrcd rhroughout its hisrory as women, workers, and African American rights advocates sought to argue on the grounds of the inuc rnational fairs, withi n the halls ofr hc patent office, and in the pages ofdicrionaries, As used by Raymorid Williams and applied in this book, a "keyword" locates both the descriptive and prescriptive aspects in a defining process through which different groups – be they industrialists, esrablishmenr engineers, social scientists, or women rights advocates - helped shape meaning by contesting and contrasting these interpretations. These historical actors take on rhetorical positions and use words that operate as weapons in the contest with other. Words also produce metaphors - the very met-

aphors we jive by- rbus producing new meunings and experiences. More imporrantly, metaphors have the power to neglecr and suppress informatio n abo lit human experiences of the world that does not fit the relation implied by the metaphor. Ir is words, keywords, and metaphors rhar provide historians with windows rhrough which to view a segment o f rhe history of ideas and experience.[6] An understanding of their workings is therefore essential for a history of gender. Words matter, T ech n0]ogy is no exceptio11.

We need to understand then that our use of the term as a keyword of American culture is fundamentally new and to revisit its territory. The *Encyclopedia Britannica* included an emry on "'Technology" for rhc first rime only in 1978.' It asserted, thar rech n01ogy is the cxcluxive knowledge do rna in of engineers, best em bodicd by machines as the measures of men. The authors used technology to describe human nature itself- the idea that a human being is essentially *Homo Faber*, a producer of goods cncornpassi ng an entire system of people, means, processes, and artifacts, "Technology is," the most revered cncyclo pedi a concluded, "any mea ns o r acti vity by whi ch ma n seeks to change or manipulare his en vi ro nrncn t,"[7] However appcaling a metaphor, the norion of Man the Maker *(Homo Faber)* was a powerful intellectual construct that also had the power of neglecting the experiences and material practices that did not fit the relation implied by the metaphor.

Most telling, the entry on *Technology* replaced and reworked an earlier entry on *Engineering Schools* rhar described the emergence of American formal engineering institutions like *MIT,* where its students engaged in banter to negotiate new knowledge claims," Most scholars have elected MIT as the lens through which to view engineering education and the occupation ar large, but to look at engineering rhrough rhar lens only runs the risk of myopia, In the country as a whole, schools like MIT, the California Inst irutc of Technology, and The Stevens Institute of T echnology were a minority within the ranks of technical education even though the}' came [() wield enormous ideological influence over the hodgepodge of other engineering institutions. r[] the course ()F the nineteenth century, these inst itutions began to claim a new kind of knowledge they called technology. *Bntannica,* renewed entry on *Technology* foremost obscured irs origins from these academic surroundings, enhanced rhc role of engineers in neutral sounding terms, and disguised co ntests over its meaning,

We therefore need to examine technology's transformation from an ill-defined, lirtlc-uscd, and narrow concept to a keyword of American culture in the course of the nineteenth and iwcnrierh centuries: we need to rescue the original uses of the word, follow its trajectory to understand why technologv has become such a deeply idiomatic and powerful expression in American culture thar communicates a gender-neutral ser of meanings at the exclusion of others. To locate these srrug-

gles and understand their outcome, wc need to go back (() the many communities that played a role in its formation.

Bccause the emergence of industrial capitalism involved both material realities and rhetorical strategies, J use a variety of sources ranging from engineering journals to dictionaries rhroughour this book. The chapters that follow show how the modem meanings are of recent vintage becorning widespread 0111y after the second World War and after women and African-American rights groups had challenged its ascendancy. The embodiment of academic engineering knowledge incorporated machine aesthetics exclusively associating it with what Western men do, it also overlapped and competed with anthropological notions of material culture and civilization. Throughout the nineteenth century, women activists and women inventors' advocates like Gage and Charlotte Smith challenged the emergence ofa new ideology that began to foreground establishment engineers and their corporare allies.

The second chapter takes a closer look at how the foot soldiers of industrial capitalism came to monopolize the term and practice of rcchnology. Ir traces how notions ofwhite manliness helped to revitalize class boundaries through three hisrorical episodes when engineering was transformed from an elite profession to a mass occupation, and was remade into a middle-class occupation.

Engineering also helped build culrural infrastructure between t890 and the 1930s. While at work on production floors, construction sites, and in rhc lahoratories, engineers produced culture as well as goods. The construction of a male lraterna] world in wh ich women are merely bystanders is told through an exploration ofthe autobiographies ofengineers at the turn of rhe century when America's imperial project came to a head, scores of younger engineers came to question the professional standards, and establishment engineers were looking for ways to gain cultural authoriry. The chapter shows how engineers of an older generation reworked a middle-class white man's world through the explicit exclusion of family and rhc people with whom they worked on a daily basis. Engi necrs spun thei r fraternal plots over [he heads of (immigrant workers) as a play without women and non-western peoples. The issues of class identity shaped a male identity for engineers that Iocusscd on technical details to the exclusion of workers at a liisrorica! juncture when engincering became deeply divided, segmented, and a mass middle-class occupation.

The next chapter further explores how this white, middle-class, and gendered male engineering identity was shaped in competition with female professional models during the decades of American overseas expansion in the *18905.* In the decades after the Chicago Columbian Exposition, popular Victorian writers like Richard Harding Davis and Rudyard Kipling broughr this male white engineering idcnritv inro a broader cultural circulation. They cast ir into a middle-class idcn-

tity firmly linked to overseas expansion, aligned engineering and writing professionalism into a male alliance of sores, and pitched ir into sharp relief to Victorian womanhood. In their search for their own professional identity, male novelists magnified engineers as modern male heroes: but their late Victorian women colleagues like Mary Hallock Foote and Willa Carher questioned them. Earning a living with writing, they challenged the alliance between engineers and male authors who cast engineering as the antithesis of women's professional ideals and arriculated an alternative language. Their articulation of a separate female culture both empowered them as professional writers and reinforced a separation between a male technical and a female artistic world.

A younger generation of modernist artists and writers who came of age just before the first World War began to caricarurc the sharply drawn Victorian divisions in male iconography of the technical world. With hiring irony and exaggeration, Paul Haviland and others belonging to the modernist New York circle, used the sexualized machine meraphorx as a means to bend Victorian notions of gender in search for modern models. Some early modernist women boldly appropriated and cxploi red rhc new male subject matter or machincs and engineering. But ill the cultural hierarchies, women artists who trespassed had to deal with different power structures than rhei r male counterparts. In the end, modern artists also helped rcinscribc rather than subvert the male iconography in technical objects through their graphic, often sexually and gendered explicit, language and images in the period between the world wars.

!f the women writers, artists, and activists stood in a long tradition allowing them to articulate an alternative language, their slide-rule sisters within the engineering profession emulated rather than questioned male models of professionalism. The fifth chapter concentrates on the story of women engineering "firsts" whose history has been forgotten, erased, and rcinvcn\ed ill I he last hundred years. It analyves the ki nd of narrative devices available to women engineers. decodes their silence, explores why they became invisible both [() themselves and to others, and how governnment propaganda and corporate practice helped casr them as bystanders \o the technological enterprise.

As suggested by historian Mary Ritter Beard in rhe epilogue, however women have always been a force in, rather than bystanders. of history to quote her pioneering book of history. Beard, whose life goal was to show that history would be incomplete if women were to be left out, rescued them as inventors, engineers, and urban planners supervising sewer systems, designing houses, and spousoring public services. She also demanded women's rightful place in the modern canon Irorn archives to encyclepedias. But ill the modern na rra tivc produrt ions o f I he rwcnrieth cell tury like cncyclopcdi.is. wornc n were left o u t o f the story. As 101d tltrough the

lemma of the *Encylopaedia Britannica*, technology is a narrative production and plot of our modern myth making.

Taken together, the chapters suggests why in our modern mythologies we considcr middle-class white men like Morris Jr. as natural allies of the technical world rhat defies any explanation; they show how modern definitions of technology determine why we enter bridges under the definition of *technology*, but consider bras as outside its domain; they suggest why we believe that women when they enter the male constructed stage indeed looked like *deae ex mnchina* and why we continue to see them as suffering from the truest stage fright of all: tcchnophobin. Foremost, dlexe episodes show that rhrougho ut the last hundrcd years women havc always been part of the cast ofcliaracrers and have been engaged in an ongoing negotiation of their roles in this male play. We need to go back and review the history of engineering to re-examine what it meant not to be the son hut the daughter of the occupation. The story of the term "technology" as used ill the *Britannica* is both a curious and a crucial step in thar recxaminarion.

I

Unsettled Discourses

Technology has been neither a keyword to American cultural grammar nor the exclusive preserve ofengineers.' Language, quilts or corsets, all irnportaant objccts of women's invcnrivc acrivi*fy* in the njnetcenrh ccntury, do nor come readily to contemporary minds as significant inventions or as markers *of* technology today, yet they 0110: were. An early nincrecnrh-ccnrury speaker could discuss rnanufacruri IJg, industry, and industriousness, referring to any kind of production mechanical or otherwise that could even include agriculture; could mention science and useful knowledge in one breath without sensing any contradiction; could marvel about the wonderful inventions and discoveries that ran the whole gamut from languages to mechanical devices; and could speak of technology referring [()academic knowledge as well as to the skills of millers, bakers, farmcrs, teachers, and innkeepers. This was a rich world, proudly displayed at world's fairs – the nineteenth-century carnivals of industrial life. Over the course of the century, different historical actors began to label, classify, and lay claims on these objects, activities, and knowledge domains, privileging some and discarding others; other lobby groups offered their own classification systems of knowledge and obj ccrs to co umer rhis process. A CeIHUt-y larcr, however, agricultural product ion, nou-rnechanical devices, languages, teachers, farmers, bonnets, and corsets were banished to the basements of the modern classificarion systems of tcchnology. '1'hen machines were put ccnrcr stage as the measures ofmen .md markers ofmodern manliness. These selections were hardly innocent choices, but the outcome of hard-fought battles. The history of the selection, labelling, and designation of objects as *technology* is cxxcntia] for our current understanding ofwho is believed to be a true tcchnologist or an inventor, who possesses the right kind of technical knowledge; and who or what may be the authentic bearer of technology. These struggles - conducted in both linguistic and material terms - went io the heart of the question of what constituted technology and what was to be excluded from it.

Long before engineering hccarnc a clearly defined profession, middle-class men began to stake out their claims to the myriad *of* activities associated with industrial production as a uniquely male prerogative. Regardless of its eventual outcome, the historical evolution of the word *technology* was neither straightforward nor

self-evident. In Iacr, as a term technology was rarely used, if at all. Initially, in a rhetorical eftorr to establish their legitimacy, social groups ranging from indusrrialisr boosters, leading scientists, engineering advocates. and public intellectuals to women's rights advocates, African-American educators, and anrhropologisrs mobilized such terms as *useful knowledge, inucutit« genius, applied science,* and *the machine* rather than *technology* to claim their right and place in the polity, Among rhc grear variety of gl'Oups anth l'OpoJogists, academic engincerx, advocates of machinc aesthetics, and corporate spokesmen provided rhe terms that eventually would be incorporated inro our modern neologism *technology.* By appropriating the idiom of science, industry, engineering, and anthropology these loosely defined associations bolstered a new male authority at the end of the century. The outcomes of these struggles have coalesced into our current understanding of what the term technology connotes, hut only afrer much struggle during which the term shed many orits intimate associations with indusrrial labor only to become an emblem of Western man's superiority and civilization.

FROM THE USEFUL ARTS TO APPLIED SCIENCE

The *Useful Arts* were a keyword to the American cultural grammar of the early ninctecnth century. The founding generation of the Republic committed itself to the creation of a new American empire duough economic growlh. From Alcxander Hamilton's *keport on Manufactures* (1791) to Thomas Jefferson's grudging realizarion that industry would have to join agriculture and commerce to safeguard the nation's liberrv and prospcrity the so ealled useful arts were seen as the key to the Republic's internal, westward, and imperial programs. Manufacturing advocates began to employ [he idea of the useful arts as an alternative to the aesthetic arrs to boisrcr rhc cmerging ecouo111ic power of the bot!rgeoisic. Placing rhe111selves in opposition lO the aristocracy - or the 'parasites ofwealth,' as they were occasionally called .- advocates of manufacture argued that aristocratic forms of art were unproductive and worthless and served no purpose other than rhc aesthetic, In their discourse on the useful arts, manutacrurers and their republican political colleagues borrowed trorn the Enlightenment philosophers Denis Didcrot (1713-1784) and jean Le Rond d'Alembert (1717-17g3).' In North America, capitalist boosters did so by defining idleness and its oppoxire, industriousness or prcducriviiy, in monetary terms.' 1n these early discussions. in which manufacturers spoke of *manufacturing, industriousness,* and *industry,* rh is new branch ofcconorruc activity was nor necessarily tied to machine production, but merely referred to a certain kind of production. which could even include agriculture.

In the early American Republic, the discussions on *idleness* and *industriousness* were conducted increasingly in gendercd terms. The textile industry emerged as one of the first important manufacruriug industries through wh ich women and children entered the market economy as wage earners for rhc first time. Rapid economic changes during rhe 1830s began to mandate a reinterpretation of the young Republic's language of politics and gender. The textile industry became rapidly mechanized along with the important industries of flour grinding, saw milling, and iron production; it blossomed by embracing a system of hounrics, patents, public funds, industrial espionage, organized emigration, trial-and-error practice, readi ng of technical tracts, informal talk, and illegal importation of mach inex and skilled workers from Britain. Ill a short period of time wcavi ng workshops were rransforrncd illto massive rcxri le Iactorics where the many young farill women were drafrcd as wage laborers. Jn the early American Republic, [he employmcnt ofwomen in the I.owells' cotton and Berksl: ire's paper mills was pol irically reformulated and justified. Not only did manufacturers argue that the employment of young larm women prevented men from being diverted from the agricultural sector, they also asscrted that productive labor in textile factories rescued women frol11 their inherent idlenc«. The heroic figure of the female wage earner in textile and paper mills sustained a un iquc American argument issued from [he belief that the young Rcpubl ic embodied a community of vigorous freeholders who had a civic stake in the polity. Female employment in rhe textile mills bolstered the idea that American industrialization could be different from its European counterparts. The healthy and upright farm daughters who moved from the family homestead to eruploymcnt in texril« or paper mills in New England would human izc and muralize a male body pot irics thar exulted in electoral politics and rituals from which women were both implicitly and explicitly excluded. The rhetoric of American politicians and industrialists heralded female wage labor as a public boon, because women's work would preserve male work for the Republic's essential virtuous agricultural sector. \Xio lll1e ll and children were the *useful arts* ncarnare.

In these settings, the work of women and chi ldrcn operatives in Iactories alxo became semanrically Iinked to machincs - i.e. the ubiquiI()us indusrrial apparatus that in the discourses of early industrial capitalism received striking names like Spinning jennies. In the imagination of factory owners, women and children could pertorm rhei r labor in the same steady, predictable manner as machines that went through their repetitive mechanica] operations, forever memorialized in Herman Melvillc's short story "Maidens of the Tartarus." The textile industry thus introduced the prism of gender by inserting women workers into the equanon of men and machines.

A IIU ITIbcr of industrialists made common cause with the blossoming women's movement supporting wo men's education in the fjrst half of the century. American indu strialists, cha mpions of the *useful arts*, sponsored educational institutions designed "to educate labor and set knowledge to work", welcoming the cnrollment of farmers' daugh ters into the ranks of the necessary and disciplined work force that would feed the engines of American eco nomic growth.' The idea of useful knowledge first identified with the useful application ofknowlcdge Iashioncd after the formu lations of Enlightenment ph ilosoph ers, increasingly included rhe notion of profitabi lity. T hus, the idea of *useful knowledge* or *useful arts* became identified not on ly with practical and useful application as the ph ilosophers of the Enlightenment had formulated, but also with wages and commercial profits. Ill these settings, *useful knowledge* included needlework and metalwork as well as spinning and min ing."

The industrialists might have been eager to invest ill csrab lishmcnrs ofl earning that could set knowledge to work by consrrucri ng a noti on of the innate uti lity of useful arts, but \he emph asis on profitability ofknowledge elicited a respo nse. Earlier in the century *science* and *useful knowledge* were men tio ned as if there were no contradiction. In the growing urban ccnrcr of Philadelphia of the 1820s, managers established the I-ranklin Institute for the Promotion of Science and the Useful Arts modelled after rhc mechanics' institutes. Here as elsewhere science and useful kno wledge operated side by side, but rhe Iran klin Instirurc began to shed its broad commitment to technical knowledge for all designing separate lecture series for different groups: elevation for mechanics; instruction for youth; and rational amusement for women. A newly pro fcssionalizing group ofpure-science advocates increasingly stressed the disinrcresrcd, not-For-profit motive ill their search for kn owledge. Science boosters like the President of rhe American Association for the Advancement of Science, Alexander Dallas Bache (J806-r867), or chem ical scicnrisi Ira Rcmscn (1846-1927) and physicist Henry Rowland, both at the Johns Hopkins University, invoked the growing autho rity of science in order to set themselves apart from the association of the *useful arts* with commercial enterprises. With increasing tenacity, *scientists* - alxo a new term in the 1830s - insisted 0 11 the insulation of science from profits; they depended fur their professional identities 011 their ability to show the disinterested, pure, but neve rtheless useful nature of their enterprise. III these struggles for professional recogn ition, Bache, Rernsen, or Rowland's employment of the term *science* served as a rhetorical weapon against the perceived corrupting influence of those they feared most: rhe proponents of the useful arts. T heir stress 0 11 impartiality and service, used as a co unter argument to the useful-arts advocates' emphasis 011 the in nate utility and profitability of knowledge, was also a matter of numbers; a gro wing army of practicing scienti sts and engineers work ing out in the field at the Erie canal, the indus-

trial rnechan ics shops, and the raiIroad tracks began to 0 utnurnher scienrists and physicists.[7]

Between these positions, a small band of engineering educators began to lay claim on another domain. Within the academic walls of some newly established engineering schools, technology emerged as a label of self-identification Fora few ambitious engineering educators who self-consciously carved our a space between the useful arts and science during the second half of the nincrcenrh ccnrury.[8] 'The term *technology* was not exclusively reserved for engineers, but also sporadically used to include the kind of skills and procedures millers, bakers, farmers, teachers, aIId in11kecpc rs needed in thcir occuparions. Early academic engineers reinrroduced the term *technology* by extricating it from these artisunal associations and allying it to a 1110re prisrine scienrific discourxc, In rhis new sense, the term had first tentatively appeared in 1829 in the title of a series of lccrures published as *Elements of"!echnology* by Harvard professor and physician Jacob Bjgelow (1787-1879), who held a chair in the "application of science to the useful arts." By conjuring up the term. Bigclow sought to lay claim to a new domain of knowledge between science and the useful arts that straddled the genteel tradition of science and the plebeian ethos of hard work, endurance, and dirry fingernails on the shop floor, in the field, mine shafts, and engine rooms. Outsid« the small circle of academic engineers and students, however, few used the term "rcchnology" to refer to a new form of knowledge or reality. Fven few pracricing engineers and scientists employed the term, if at all. Bigdow's rcrrn would be mostly forgotten for the rest of the century. It elicited so little response and recognition that cven Bigelow dropped his own newly mimed term only to revert back to a more current expression for the expandcd version of his book rcn years later, now called *The Useful Arts.* Indccd no other nineteenth-century lexicographers followed *Webster's* cue on granting technology its own lemma for over a century.[10]

1ndustrialists, practical engineers, scientists, and engineering educators found the term *applied science* a much more powerful weapon for their rhetorical constructions than the term rcchnology. Even so hoth terms, *applied science* and *tecbiwlogy,* ran far ahead of nineteenth-century material and social realities. While a few pioneering schools like Massachussets and California Institutes of Tcch nology fostered the incorporation of scientific language ill their search for legitimacy and fiuancial resourccs during the final decades of the 11inerccnrh century, the overwhelming majority of engineering institutions were unwilling or unable to spend significant funds on scientific research in order to buttress such grand claims even as lare as the 1940s.[11]

Nut everyone was allowed to employ these terms however lirrle used or illdefined. Northern and Southern indusnialisrs considered the labor of African Americans useful in most social settings, but rhe: r skills, expertise, and experience

were never to be labell ed as *applied science.* In the Reconstruction era whe n a sma ll band of Northern engineering educators began to claim applied science as their domain and expertise, African-Americans interested in technical fields were sent on to different educational path". Between rhe C ivil and the first World Wars, freed slaves were rrai ned in the indusrrial arts at separate Afri can-A me rican manual training, industrial, no rmal schools, and land-grant institutions. At these separate institutions like Hooker T. \Washingw ll's Tuskcgcc Normal and Industrial Institutc in Alabama (1883) mater ial practi ces m ight diverge fmm the rhetorical positions. The pol lrical realities of the Ameriean Sourh proh ihired Africun-Amcrican educators from claiming scienti fic labels, but they some devised novel srrarcgics by teaching science su hjen s under other rubrics while carefully avoiding that contested discourse."

'**J**he Iamou» controversy between the Southern ex-slave Hooker T. Washington and the Hnrvarr] educated Boxronian W.E.B. Du Bois (1868-1963) cenrc rcri on what "useful' meant to African Americans and focussed on the issue of African-American vocational and technical education. Supported by Northern businessmen-philanthropists and Sourhcm whites, Washington believed rhar technical education (useful knowledge) would turn African Americans into self-sufficient workers and dignified first-class citizens, hut Du Bois radically opposed the norion thar knowledge should always be useful, profirahlc, and commodified. Ill the 1ighr of their slave lahor past and their econorn ic exploitation, the greatest liberation of African Americans and the finest marker of their manliness was the right not to be useful, Du Bois believed. He preferred the right to be genteel, intellectual, and professional in the cultural world of Shakespeare and Soul, over joining the ranks ofskilled labor in the employ ofindusrrial capitalists.[13]

Thus communities ranging from ind usrrialists [o Alrican-American cd ucators began to lay clai m on the l.ue niuerecnrh-cenrury world, The world of the useful arts from antebellum to Gilded-Age America enclosed different constituencies rhar converged and overlapped, bur also contradicted, clashed. and contested each other. Iudustria] advocates, philosophers, engineering educators, African-American leaders, and practical and academic scientists gave meaning to their experiences and hopes through the employment of terms like *useful arts, uti/it)', applied science* and *technology* that operated as weapons; they articulated inrcllccruul cousrrucis and material practices. Words and conceprs like technology fell out of favor while others were readily used, In [heir disputes and communications, these historical actors also created new shades of meaning, embracing some historical actors, and excluding others. The nineteenth-century inrcrnational fairs became [he prime sites for rhis selection process that eventually would separate the alphabel', corset, and bonnets from steam engines, trains, planes, and cars as the true,

gcndcred, and rucialized ohjecrs 0f rcch no Iogy. The 11incrccnth-ccllllL1ry wo rid's fairs became an important podium 011 which *the useful arts* were staged.

In the years before motion pictu res, radio, and television, nineteenth-century contemporaries went to sec worlds' fairs to sample and experience the world. Praised as *world universities* and *workshops of the world* by their boosters, world's fairs were rhc *encyclopedias of civilization, rituals of display,* and *competition between nations* of the nine rcenrb century. Fair-goers Irorn all social classes visired them to be amused, instructed, and diverted from rhc industrial sorrows \hat were raging around them. Before the expansion of such forms of communication as technical magazines, catalogu cs, advc rtising, and professional cnginccring conlvcn rio ns, world's fairs also provided manufacturers, new professionals, and activists with a primary forum, meeting pOiIH, and international network. It was the place where manufacturers and engineers sold thcir goods and ideas, disscrninarcd information about 11cw products and scientific discoveries, and bolstered rhcir knowledge claims on the nincrccnth-ccnrury world," Many other ninerccurh-ccruury aspiring professionals - including librarians, historians, scientists, and engineers - gathered rhere to launch their professional organizations to lay their own claims on the world around them.

In the U.s., the Smirhsonian Institution supervised most fairs and provided the intellccrual frarncworks for them, ()rganizcrs did not merely put dresses, bonnets, corsets, hooks, reapers, and steam engines on display, but also helped devise systems rhar became insrrumenra] in classifying both knowlcdge and objects [or the nineteenth century. No wonder fair grounds were contested terrains. Manufacturers sought to promotc their products, nations competed for prominence and investments, and different lobby groups - ranging from engineering advocates to women rights groups, African American activisrs. and labor leaders - fought for the inclusion of their causes into these encyclopedia's of civilization. The public exposure of rhesc fairs was as large and effective as any lobby group could hope for: between 1876 and 1916 nearly onc hundred million people visited 12 world's fairs throughout the U.S. Women and African-American rights advocates eagerly seized these occasions to challenge the new juncture of civilization, inventions, and white manliness as they would dernonsrrarc in the Eastern industrial hubs of Ncw York in 1853 and Philadelphia in 1876, the Western gateway in Chicago in 1893, 0 r rhe cotton eapitaI of Arlanra of the N cw Sourh. Fairs were the true stagi ng ground where conflicting undersrandings of technology were put on display, From 1876 the Smithsonian Institution provided the crucial support, personnel, and materials for the ethnological displays from its ethnological and anthropological departments. Most importantly it proved to be instrumental in helping to layour the exhibits in a classification system of the nincrccnth-ccnrury world that included women and non-western people. Significantly, after the first World War

rhc National Research Council (NRC) and the Departments of Commerce both closely connected to rhc corporate-military complex would take on that role for the twentieth century." This change would be as significant as f:ll' reaching.

FEMALE FABRICS VERSUS MANLY MACHINES

Well into the twentieth century, *inueutiue genius* was not necessarily understood (() be machine-bound. Inventions included the entire gamut that ran from fabrics, language, arts, and myrhology to mechanical devices. In the decade leading up ro the 1876 fair in Philadelphia, dcfin iticns of innovation and human ingenuity were still in flux and su bjecr to negotiation, as rhe work of the cultural anthropologist Lcwis Morgan and women's rights activists shows.

Social anrhropologisrs, among whom Smirhsonian scientists played major roles, [cnr stature to theories on the course ofcivilizatiou and the primary defining role of inventions. 111 mid-century, social anrh ropologists began to mobilize the idea of inventive genius as an index of civilization. This measure, peripheral at first, found its way into many a social anthropologist's overarching theory of the development of civilization, and eventually turned into the yardstick ofa nation's overall progress. l.cwis Morgan (J818-1881), the patent lawycr, businessman, railroad investor, and social anthropologist, accorded the notion of inventiveness a special place inhuman evolution theories in his *Ancient Society* published a year after the Philadelphia Centen nial exposition in 1877. He considered the rate of inventions as the prime mover in the evolution of societies, pointing to "inventions and discoveries" as the keys to society's ability to movc up or down rhe evolutiouary scale. In the first part of his thesis, entitled "Growth of! ntelligence through Jnvcnrionx and Discoveries," he asserted that "rhc most advanced portions of the human race were halted...until some great invention or discovery, like the domestication of animals or the smelting of iron ore, gave a new and powerful impulse forward."[16]

Morgan's overnrching theories o u invcn tions included women bcca use he jncorporarcd thc nincreenrh-ccnrury nonmechanistic inrcrprcrarion of inventions, This inclusion occurred in an accidcnral manner but proved to be nevertheless important. After all, Morgan's purpose was to validate a hotly debated proposition that absorbed the arrenriou of inrellecruals in both Europe and rhc U.S. in the era after Charles Darwin's publication of the *Origin of Species* in 1859: all human races shared a common origin and were monogenetic rather than polygenetic. Because the study of non-Western cultures served as a time machine for Morgan and his colleagues, onc that allowed them to look at the origins of human evolution, he sought to establish linkages in kinship systems, customs, and cultural attitudes

among the Iroquois and other American Indian peoples. Despite his practice as a parem lawyer for the railroads, Morgan did nor limit his understanding of inventions exclusively ro patent activity because of his focus on domestic instirurions - a natural outgrowth of his earlier work on rhe structure of family tics. He included in his gencalogy of invcnrions artifacts handled by men, like bows and arrows, bu[also female skills like basket weaving. By juxtaposing inventiveness and domestic institutions – at least for other cultures - Morgan unintentionally presented women's daily work as an useful activity on a par with men's. He suggests that women, too, were inventors.

Early in the century, inventions still embraced an array of human products from intellectual to practical skills, from corsets to cutting machines, but in the 1S90S true and important inventions increasingly took on rhc form of machine-bound and parenrcd objects. This change of emphasis would eclipse the norunechanistic and ncnparcnrcd formulations of inventions then fashionable in the field of anthropology; it also would eclipse the role that social anthropologists had initially accorded to women as inventors of nonrncchanistic objects. The place [hat inventions came to occupy in rhe cmerging understanding of technology became so central that ir served as a stock political argument and benchmark for gender and racial differentiation. Over the next century, much was ar stake in Ihe question of which nation state, social communiry, or racial group could lay claim to the highest rate of inventions. In the emerging paradigm, the answer to the rhetorical question of whether or not women possessed inventive genius was thought to bear on the issue of worncu's worthiness as full participants in the body politic. Because of the enormous political weight accorded to [hem, inventions were a hotly contested terrain throughout the ccnrury, and the scrutiny of women's invcntivc capacity was no exception to the national pastime of counting parents.'

The changing meanings of these terms categorizing inventions did not occur wirhout thc inrcllccrual inrcrvcnri Oll o[" women activists. In mid ccntury women's rights advocates qucsrioned the appropriation or inventive ability as a male preserve. They challenged the new idea that inventiveness represented an exclusively male prerogative. More fundamcnrally, early feminisrs positioned women at "rhc handle of [he crank": women were the catalysts who pushed human evolution upward and onward to the next stage of progress." Several feminisr critics went so far as to question the premises of male inventiveness alrogcrher, Women activists targeted an array of male institutions that increasingly canonized technology as a male preserve; they voiced their dissenting opinions again and again on the grounds of the \World's Fairs in 1853, 1876, and 1892 and ill the halls of the Parent Office on the occasion of its (:Clllelllllial Celebration ill 1890.. They would contest the nineteenth century's inventories of the world such as archives, dictionaries, and encyclopedius. These occasions also served as rallying poiors for feminisrs to

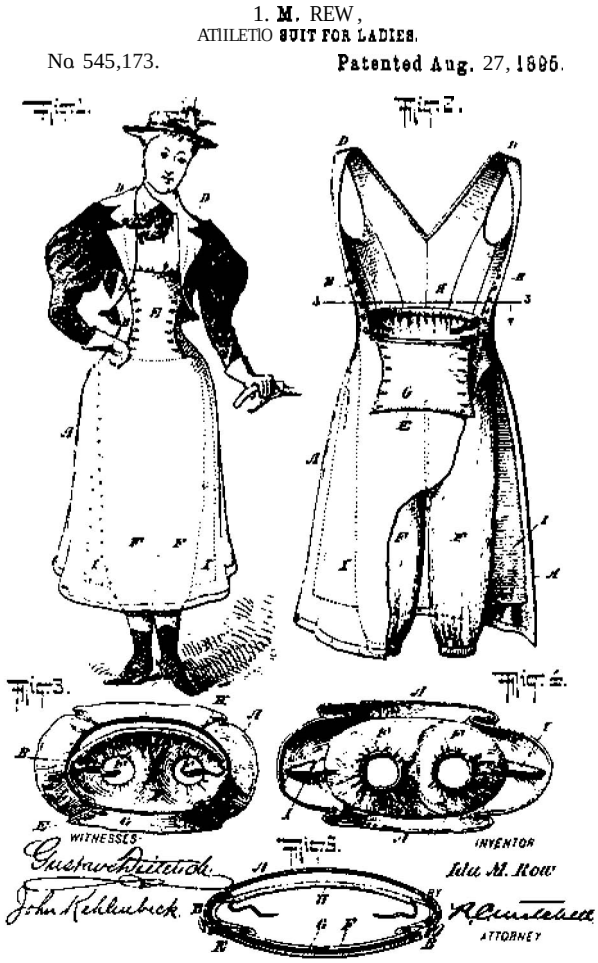


Figure 1. An example ofnineteenth-century feminine ingenuity authorized by the U.S. Patent Office. Ida Rew's 1895 "athletic suit" engineered a balance between freedom of movement and sense of propriety for middle-class women.

forge an alliance with the hundreds of female inventors - working wives and widows like Martha Coston, Harriet Hosmer, Helen Blanchard, Josephine Cochrane, and Ida Rew who worked to reap the profits of their ideas - and to advance their broader political agenda.[Figure 1] Women intellectuals from Matilda Joslyn Gage, Ida Tarbell, Charlotte Smith, Minnie Reynolds to Mary R. Beard championed female inventive activity in the post-Civil War period. Their strategies ranged from lobbying for women's equal representation to confronting the exclusionary policies and the building of alternative but often segregated institutions - whether the establishment of separate pavilions, the planning of fairs, or

Figure 2. Portrait ofIosiyn Gage, rhcorcrician of the radical wing of [he' WO JIIen's movement. who criticized rhe newly sanctioned ccn uul ii)' of paten red inv cn tions and demanded equitable distribution of resources Ior men and women. Here portrayed in the pensive pose "fall intcllcc-rual, Courtesy of Schlesinger Library, Radcliffe College, Cambridge, MA.

the composition of women's encyclopedias and biographical dictionaries entirely devoted to women's contributions to civilization. They countered the emerging male gencalogy orinvcnrions [hat sought to prove that only men had the irucllcc-rual acumen to producc significant invc[)rions.[8]

Women rights advocate Matilda E. Joslyn Gage (r826-1898) was the first Amer-ican wo11a11 to challenge the male gencalogy of inventions and to formulate the clearest ideological statement on female inventiveness as curly as 1870.[Figure 2]

Togethcr with Elizabeth Cady Sranron, Gage was the intellectual force behind the radical wing of the women's rights movement, Act ive in the wo men's rights eam-paign since rhe 1850s, she held the posi tion of president of the N ational Woman Suffrage Associntion, from whi ch she resigned ill May 1876, just be fo re the open-ing of the Ph iladelphia Centennial Exhibition, in order ro give cenrer stage to the more famous Sranto n. Years before the Phil adelphia Exh ibition of 1876 and M or-gan's rurn inarions on the importance of inventions as an index to rhe ontogenetic stages of civilization, Gage had argu ed in a 1870 suf-fragist pamphlet that women inventors did indeed exist. In this pamphlet, entitled "Woman as inventor," she had rescued Carh crinc 1.irrleficld, the widow of General Greene, from oblivion by describing her as the prin cipal mind and fi nan cial sponsor beh ind the cotton gill patented under the name of Eli Whitney. Gage's argument was quite ingenious because she positioned women ar the cenrcr of both national economic develop-ment and the invention of silk production. Engaging emerging nationalistic argu-rnents, Gage maintained that "these two invenrionx by women of silk and the cotton-gin have done much to build up the Stare, to define social and political po-sitions and to further the interests of mankind." She challenged the individualist understanding of inventions by arguing. first, that progress was a result of small and incremental changes: "All progress in the arts, in science. in wisdom, is the re-sult of successive steps; and it is impossible to foresee the consequences which may arise from the omission of an act hy even the most obscure person.": Second. she pointed out that many inventions could not be traced to a single author or era. Third, she contested the patent system and the manufacturing industry as society's exclusive sources for understanding inventive bchavior, since "the patentee is not always the invcn(Or; nci thcr is the manufacturer always the o riginato r." H er cri-liquc ccntercd in part on the narrow interpretation of the inventive process. To consider patents the only tangible evidence of inventive bchavir» was iIlCO!TeCl.

Gage based her argument on the same - and at the time widely accepted - tax-onomy of inventions as Morgan's. In her 1870 treatise, she included a range of hu-man products she considered important inventions: mechanical devices, fabrics, language, arts. and mythology. Thirteen years later. however, when she wrote a sccon d version o f her rrcarise o n wo me n inv cntors, th e crux of hcr argument had shifted. reflecting the emerging understanding of human inventiveness as heing inextricably linked to the search for bigger and better mach incs. In 1883, her defi-nition of inventiveness was confined to things mechanical. Writing for a national audience in the well-respected *North American Review*, Gage set out to show that women were not only genuine inventors but that they possessed "rncchan ical ge-nius" on a par with men.[21] Her article marginalized such nonindustrial or non-obj cct-relared fields as 1ireratu re, arts. and language. The eo nnecrio n she now drew between inventiveness and political freedom lormcd the crucible of her argument:

"The inventions of a nation," she argued, "are closely connected with the freedom of its people," and omitting women from the inventive process would endanger the progress of human evolution, At this point echoing Morgan, she concluded: "No less is the darkness of rhe world kept more dense, and its civilization retarded, by all forms of rhoughr, customs of society, or sysrems of law which prevent the full development and exercise of woman's invenri*vc* powers." jr mattered Jittle to her whether or not women possessed *mechanical genins*- what mane red more was an equitable distribution of, and access to, society's economic resources. Given that women lacked rhe most basic economic and political rights, Gage argued, she thoughr it remarkable that women should be capable ot invcnting anything at all.

In her 188} treatise, Matilda Gage tacitly acknowledged and engaged in rhc paradigmatic shift towards a machine-bound interpretation of inventions. But these more explicitly gendered definitions of human creativity proved problematic for women, since the tendency to glorify machines was axxociarci] increasingly with new dcvelopments in the machine-roo I and steel ind usrrics. Few women worked on these producrion tloors, as retorrner jaurna list and business hisrorian Ida Tarbell would point out in her article on women inventors. In particular, the steel industry's capital-intensive apparatus like Bcsscrncr converters from the hills of Pennsylvania to the city limits of Chicago functioned as a symbol of powcr - one mighr label ir a fetish - among capiralisr entrepreneurs.

Thus Gage's parameters of the debate concerning human ingenuity shifted dramatically in \he period between 1872 and 1883. In just tell years Gage moved from viewing human inventiveness as an gender-neutral activity to a ralcnr that was the prerogative of men - from mere discoveries to machines, trom genderless activities to male marked objects. Her shift in focIls rcflccrcd an array of actual social changes and class tensions in American society, On the heels of major Iabor disputes ill Pcnnsylvania and a national economic panic, the 1876 Centennial celebration ar Fairmonr Park ill Phi ladelphia, with the Machinery Hall and its Corliss engine on ccnrcr stage, both visually and viscerally foregrounded and forged the machinc-bound interprerario n of invc n tio us. 'I'he rnachinc, cmbodied in rhc smoorh-running and humming Corl iss' engine, became a national icon marked as male and middle-class, Characterized as "an arhlen, of steel and iron," the Corliss engine appropriarcd a sense of nariona] unity that belied the major divisions between capital and [abor, between men and women, and between white and black in American society. The allure of machines would continue to increase in the twen rierh century, when technological sophistication became a tropc design cd to authenticate male aurhoriry in American society and to corroborate the inherent superiority of the \Vcsrcm world,' Soon machines would mark male middle-class power in the West.

The prominent display of giant engines and massive machines in Philadelphia elicited negative commentary from women's groups, however, under the leadership of the conservative woman activist Elizabeth D. Gillespie, the granddaughter of Benjamin Franklin, various women's organizations raised enough funds to construct a Woman's Pavilion at the Philadelphia Fair, to "give to the mass of women who were laboring by the needle and obtaining only a scanty subsistence, the opportunity to see what women were capable of attaining unto in other and higher branches of industry."" [Figure 3] Although women contributed and won prizes throughout the Fair – in the fine arts, education, and farming, for example – the point of the Woman's Pavilion was to highlight women's share in industrial life. To lend greater authority to the Centennial sisterhood, Gillespie devoted special attention to attracting women inventors. In an effort to desrabilize that other "humming" metaphor of industriallife - the gianl twin-cylinder Corliss steam engine towering over all other equipment on display in the Machinery Hall- the organizers appointed a female engineer named Emma Allison as "the presiding genius of the engine room" in the Woman's Pavilion. In this separate women's domain Allison became a beloved attraction by operating a portable Baxter steam engine that drove six power looms at which women wove carpets, webbing - and silks. She thought herself quite capable of running these machines and declared that it was far easier for her to operate the steam engine than it was for mothers to "operate" their children. Allisons steam engine supplied sufficient energy for a carpet loom, a quiB wheel and a spooJing machine, a ribbon loom, a Jacquard loom, as wdl as the cylinder press which printed *The New Centuryjar Women* for the duration of the Fair. The \v-orld of the Lowell textile mills had been a female arena for decades, but the twin-cylinder Corliss steam engine so dominated the public's imagination at the Philadelphia Fair that a woman reporter of *The NI'1/1 Century for Women* criticized visitors who watched the Corliss engine in awe hut failed to admire the intricate machinery operated in the textile mills by wOllllcn," Her remark lay the foundation of a series of competing images as the true objects of technology that would linger ()nthroughout the century: female fabrics and male machines. [Figure 4]

\X/omen activists were hardly united on the issue of lemale participation in the fair. In the opinion of radical women's rights advocates like Marilda Gage, Susan g, Anrhonv, and Cady Sranron, however, Cillespic's droIts to parade wornen", work and their rill ventivencss were useless, '1'hey argued that the Woman's Pavilion and the female presence throughout the exposition, calling attention to the accornplishmenrs Of women's inventors, failed to disguise the grim fact that women were still denied the right to vote." Gage and other women suffragists dismissed the Woman's Pavilion because it did nothing to reveal a "true exhibit of woman's work." Most of the work done by women, they thought, took place in a business

Figure 3, Women's Centennial Executive Committee planning to parade women's skills, products, and inventions to demonstrate women's equal worth in civilization at the Philadelphia Centennial Exposition of 1876. These conservative women were opposed by radical activists, who protested against women's legal and political inequality throughout the fair. Reproduced from *Frau]: Leslie's Illustrated Journal Hisrotical Register* or 1876.

environment they neither owned nor controlled, According to the most vociferous champions of women's rights, no matter how many women inventors might have been present at the exposition - there were about seventy women who were demonstrating their talents to the public - "the most fitting contributions to the centennial exposition would have been these protests, laws and decisions which show [women's] political slavery,""]f married women were not even granted [he right to control their own earnings, as Gage wrote later, "should such a woman he successful in obtaining a patent...Would she be free to do as she pleased with it? Not at all... She would possess no legal right to contract or to license anyone to use her invention."[17] While Gage criticized the newly sanctioned centrality of (patented) inventions, she nonetheless conceded that the patent system was an important site of inventive behavior: Gage, in other words, altered her views without giving up on her desire to confront the dominion of men in the field of mechanical ingenuity,

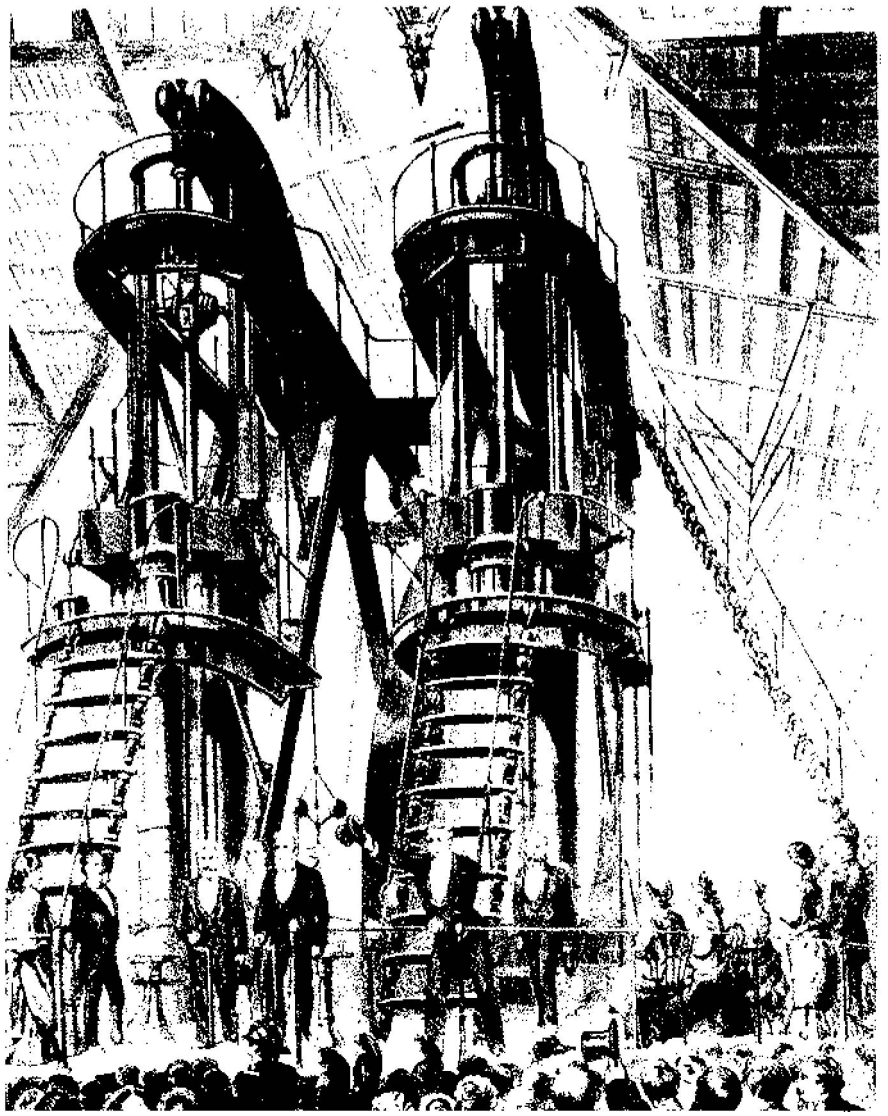


Figure 4. Corliss's giant steam engine located in the middle of Machinery Hall - here set in motion by President Grant and Emperor Dom Pedro II to open the Philadelphia Centennial Exposition on May 10, 1876 - came to symbolize America's manly industrial capitalism. Called "an athlete of steel and iron," its size, stratus, and position competed with the less visually spectacular women's skills and products on display at the Woman's Pavilion. Reproduced From *Frnn]: Lcslir's Illustrated Journal Historical Register* of 1876.

Figure 5. busiuess historian, muckraker, and rnocicrarc women's activist, Ida Tarbell (1857-1944) at work in 1917. She argued ih.u women's needle and rncns machine work were equally valuuhlc crc.uions. I'crtuisxion and Courtesy Of Culver Pictures, New York, NY.

The journalist, business historian, and lecturer Ida M. 'Iarbcll (1857-1944), best known later ill life as a muckrackcr against Standard Oil chose a ditlcrcnr strategy when she questioner] the male genealogy of inventions. ll;igllrc 5 I In an effort to subvert the newly dorninanr paradigm, the then rhirry-ycar-olt] Tarbcll who still felt strong affinities for the women's movement at that time and worked OJl the staff of the *Chautauqunn* magazine in the hills of Pennsylvania, tried to elevate the stature of women's domcsu« inventions in the hope lhey would no longer be dismissed as insignificant and incoriscqucnrial. lnxreati of trying to beat men on [heir own turf, she reclaimed the older meanings of inventions. She placed women's invcntivc crearivity firrnly ill the framework of rhe separate-spheres ideology that had become a stock argument of the middle class and her circle of educated women. In her 1887 article for the *c}Jtlllllfllluj!!{ll!,* a magazine that offered adult cducarion to traditional women who had come to subscribe to the cultural premises of separate spheres, she pointed out that women did not work in machine-too] related inciuxrrics." She argued rhar because "it was reasonable to expect that ingenuity will be exercised proporticnarcly to opportunity," OIIC had to look elsewhere. Tarbcll then rescued women's practical solutions at home as legitimate inventions because they were effective and valuable, thereby underrnining the new discourse

concerning women's supposed idleness. "An invention is an invention whether ir be for house work or mill-work, and the kind of mental quality it requires is the same," she eo mended. Much crcarivity and ski II were required for mothe15 to alter their daughters' dresses and then use the same fabric for bed quilrs. "It is the habit to speak of these women as 'handy' or 'full of ideas,'' hut she insisted that "such women are inve n tors: their work, inventions." In spite of her rccap irularion of rhc older meanings of in ventions in her own reformulation, T arbcll could nor escape the emerging machine-bound understanding of inventions be cause, like Gage, she felt compelled to argue that women could indeed be successful in devising things mechanical.

At the end of the de cade, Charlotte Smith (1843-1917) followed in Gage's foorsteps and took up the cause of women inventors by entering the hallowed halls of the new1)'corisrructed temple of in ven rions, the U.S. Patenr 0 ffice iii rhe nari on's capital. She championed working-class women rather than Tarbcll's middle-class women who worked at home. Smith, president of the \Voman's National Industrial League of America, directly challenged the Parent Office in a blitz campaign on the occasion of irs hu1xdredth an niversary in 1890. Unwirri ugly, her challenge only reinforced rhe notion that genuine inventive activity was to be found in the patent business, lending it a kind of authority that Tarbcll had denied and Gage had questioned. A flamboyant campaigner for working women and a shrewd congressionallobbyisr, Smith defended women inventors because she recognized that inventions could be a significant source of income for women. She published *The Woman lnurntor,* a magazine designed to coincide with the Centennial celebration for the Parent Office. {Figure 61 In preparation for the an nivcrsary and her own campaign, she first managed to persuade the Patent Office in Washington to compile a list of all women inventors since 1790.[5] Bur as historian Autumn Stanlcy has documented in her study of female patentees, when the Parent Office's wellinrenrioncd clerks compiled a list for Smith in 1S92 rhcy glossed over women's mechanical invcn rjonx – a fu rrhcr ind icarion of the growing importance arrributed to machinery and women's exclusion from its domain. By recxarnining the patents issued for t876, when the Cillcspic-sponsorcd women inventors exhibited in the Woman's Pavilion at the Philadelphia fair, Sranlcy found that the compilers had om itrcd one woman's invention for every four they recorded: she also concluded rhar these omissions on the list generated for Charlotte Smith were nOL random, Machines represented [he largest single category of the omitted inventions. cornpared Wirh categories like agriculrure, chem istry, rurn ish ings. healrh filled icine, heatiIlg, cooling, domestic Inbor-saving devices, and clothing. Morcover, Stanley found that the mechanical devices the patent clerks omitted (rOln the list were "strikingly nondomcsric or what might be called nonrradirional invenrions for women."[6] Thus, despite Smith's feminist intervention and the help of cooperative

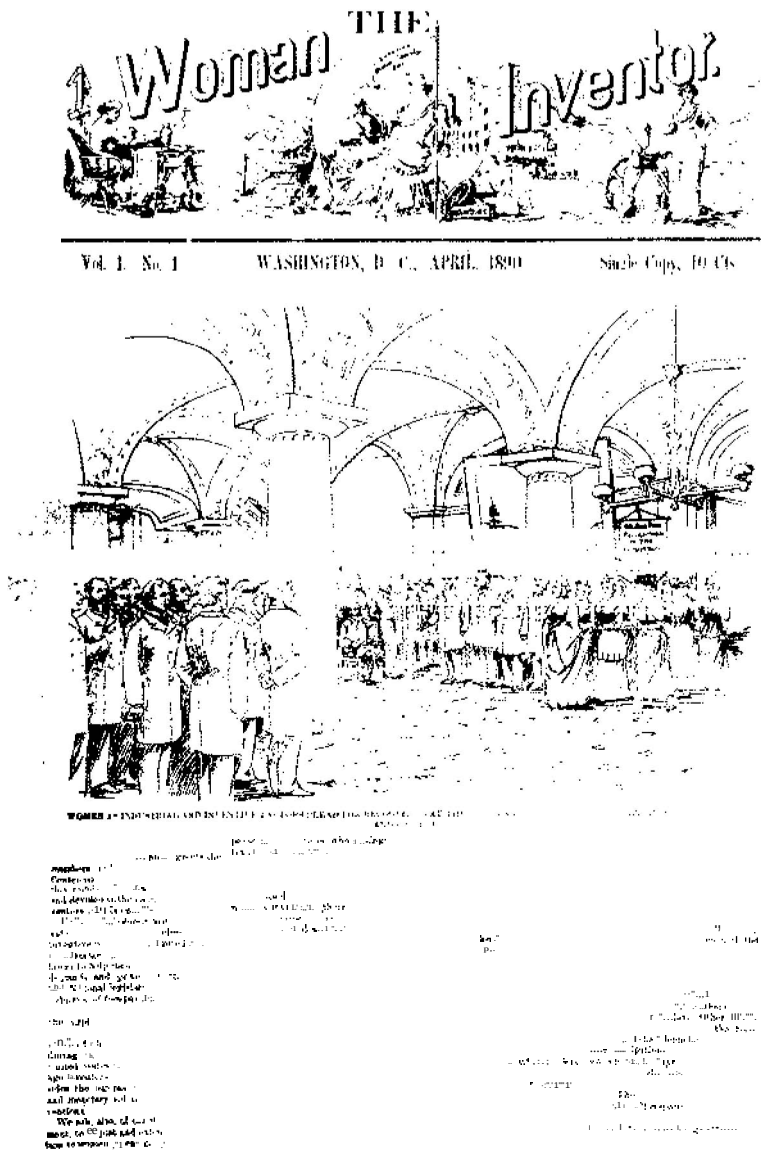


Figure 6. Etching ill *The Woman Inventor* dramatizing a group otwomcn inventors who petitioncd !;)f recognition anıI fair treat mcnt jn the newly constructed Hall of rhc Parent Office during its ccnt cnnial celebration in April 1890. Courtesy ofArchives Ceıırcr, Nai ion.tl Museum of American Hixrory, Smithsonian Institution, Wash ingtcn, DC.

clerks, the late nineteenth-century Parenr Office's list of women inventors provided a fascinating example of how new mentalities obscured the vision of federal employees in Washington DC, who appeared unable or unwilling to even *see* rhe tangible results of women's "mechanical genius." Such a suppression reflected a paradigmatic shift in American perceptions of the nature of invcntivencss as machine-bound and masculine.

In her challenge to the rnasculine alld middle-class raxonomy of illvenrions, Charlotte Smith did nor limit her efforts to the national preoccupation of counting patents. In her call for action, Smith went even further in reclaiming inventions for women by demanding that the l-edcral Govcrnment protect women inven[()rs and prosecute "those who infringe or haudulcntly obrain thcir invcurions." She argued that the Parent Office should establish a special office for women which would display rheir inventions and label them properly. She also called for solidarity among women inventors: "We have the genius, bur it requires development and encouragclllcllr, hence let us...cncourag]c] one anorher."[51]

Oris T. Mason (rH38-T908), the Smithsonian Insrirurions anthropologist, curator, and classifier, answered Smith's bold challenge to the male inxtitutionalizarjon of patents. As chief curator of the Smithsonian's Department of Ethnology, Mason was principally responsible for popularizing the evolutionary scheme of human development and the scientific racism that went along with it at the American jnrcrnarional Fairs in the ninercenrh century. He frsr visualized his view of women's indusrrial roie in the grand scheme of evolution in his ethnographic display starting with the 1893 Chicago Fair exhibit "Woman's Work in Savagery" he installed for the Woman's Pavilion at the request of women activists. Mason, a disciple of Lewis Morgan and influenced by German thinkers, had a vested interest ill placing inventions in an evolutionary rank-order. He also regarded the frequency and innovative quality of human inventions as an inventory of social progress which served, therefore, as an essential key that might be able to unlock the mystery of difFeremia[evolutionary paths on the basis of cross-cultural comparisons."[52] Filling in the broad outlines Morgan had provided, he felt a special inrcllecrual urgeney ro examine the role of female creativity. Mason explicated his overall rhcorics in his writings on women's inventiveness, and he popularized and visualized them through his design of the ethnographic displays at World's Fairs - sornc ar the request of women's champions. He also endowed them with further public stature in his ccntcunial address at the Parent Office. jn his speech on the occasion of the hundredth anniversary of the Patent Office in 1890, Mason al'gued for a much longer genealogy of invcnrions than the advocates of industrial capitalism, who had gathered to "glorify the ninctcent], ccnturv." Both men and women, he emphasizcd, had always functioned as invcntors. He posed a rhetorical question: who "quarried the clay, manipulated it, construcred and decorated the ware,

burned it in a rude furnace and wore it out in a hundred uses?" To an audience of manufacturers, politicians, government officials, and engineering educators who had assembled for the Patent Office centennial occasion he argued: "Over and over again, those who have preceded me on this platform have pointed to [amcs Watt as the true deliverer of mankind. Far be it from me to take one leaf from his laurel crown; but the inventor of the alphabet, of the decimal system of notation, or representative government, of the golden rule in morality, were greater than he.' While Smirh lobbied to protect women invenrors. Mason pondered the meaning of women's real patent: "The best woman to cook or sew or carry loads got the best husband. That was her patent.?"

In the halls of the Patent Office, Oris Mason continued on the path charred by Lewis Morgan, bur he also kept a safe distance from Smith's working-class women inventors, He prommed the cvo] urionary and comparative approach: at the Southern Expositions ill Atlanta and Nashville a few years later, he mounted life-size replicas of Native American, African, and Polynesia» women performing productive work, as he labelcd it. He showed women of other cultures weaving baskets and netting, and he held them accountable for humankind's inventions because "Women, among all the primi rive peoples, were the origin.uors of most of the industrial arts.: " Mason read in his objects – tools, artifacts, and skeletons – "the stories of their owners many centuries ago" and concluded that most of the artifacts he examined had been invented and used by women. He argued his case in *Woman's Share in Primitiae Culture* (1894). In excerpted and popularized form it also appeared as "Woman as an Inventor and Manufacturer" ill *l'opultlr Science Magazine*, a journal that served as an important forum for debates on the social and political consequences of gender differences. Mason used Lewis Morgan's notion that the rate of inventions is an index for human progress to suggest that woman, as food-bringer, represented "the earliest inventor" and that her "ingenuity has been an important element orprogress" since the early stages of human evolution.[55] Like Morgan, Mason considered food preparation, weaving, art, and language to be important discoveries and inventions.

Mason devoted much time and attention to highlighting women's economic, industrial, and inventive activities in his all-embracing theory, for which he would be gratefully quoted by feminists, bur he viewed women's skills as atavistically belonging to an earlier era. By equating working-class women with women of "dusky" and "savage" cultures, Mason racializcd working women.[56] The comparison went beyond the analogy; he considered working women as actual remnants of an archaic, less civilized age of the past. To Mason, in other words, wage-earning women in America's urban Ileighborhoods resembled a primitive tribe in the midst of civilized middle-class America. Ju the end, he dismissed women like Charlotte Smith and her working-class proteges as well as female inventors as irrel-

cvanr and inconsequential in the larger scheme of human evolution. The cross-cultural representations at rhc fairs reinforced the notion that middle-class WOIIH:11`s leisure time ill American society signified progress. Machine-bound technology remained rhus safely inscribed as male and Western.

In the years leading to the 1893 Columbia» Exposition, prominent women including Susun B. Anrhony had done everything in rheir power to question the course of civilization as an exclusively male cndcavor which Mason and other Victorian anthropologists were promoting. Early 011, they pressed the fair organ ivers ro place placards informing fair-goers what proportion of each exhibit was produced by woman's labor, urging women [()submit special exhibits throughout the fair, and trying to make sure these submissions received equal treatment in the selecrion process. Their desire to show that women were an inregral part of civilization met with complete resistance. As a last resort. they settled for a separate and segregated building, "'J'he Woman's Pavilion," designed by the young MIT architecrurc grad uarc Sophia G. Hayden under the auspices of the officially sanctioned Lady Board of Managers headed by Chicagoan socialite and feminist Bertha Honorc Palmcr (1849-1918). Choosing from among 3000 patents submitted by women and available on file at the Patent Office, the Lady Managers arranged the display of what they considered truly useful inventions in an Invention Room where Olivia llynr demonstrated her health corset, Joseph ine Cochrane her d ishwasher, and Martha Coston her night signalling system adopted by the Navy.' [Figure 7] Reflecting women's small space of negotiation, Haydcn's pavilion was the smallest of all and precariously IOGHed between the official White City and licentious Midway Plaisance, between white manliness and the dark effeminate races, between the manly Court of Honor - celebrari ng the seven virt ues of civilization through Manufactures, Mines, Agriculture, Art, Admi nisrration, Machillery, and Electricity - and the effeminate uncivilized, barbarous dark races. Even if the Lady Managers questioned the linkage between manliness and civilization, they did not dare to upset the racial h ierarchy in the Columbian "exhibition of the progress of civilization in the New World." They made common cause with the racial taxonomy through their sponsorship of Mason's ethnic display and their refusal to answer calls from leading African Americans including journalist Ida n, Wells and Frederick Douglass for inclusion.[6] In the end, the machinery of the brave new world was not only safely inscribed as male, middle class, and Western, but w]: ire as well.

Following the decades of the C:olumbian Exposition, the modern art movement exploded but ultimately reinforced the male, white notions of machines in their celebration of the mach:ne acsrherics. Their evocation of the machine in word and image turned into a powerful pillar for the modern understanding of technology. Ill the early teens, the machine became a buzzword Or modernism

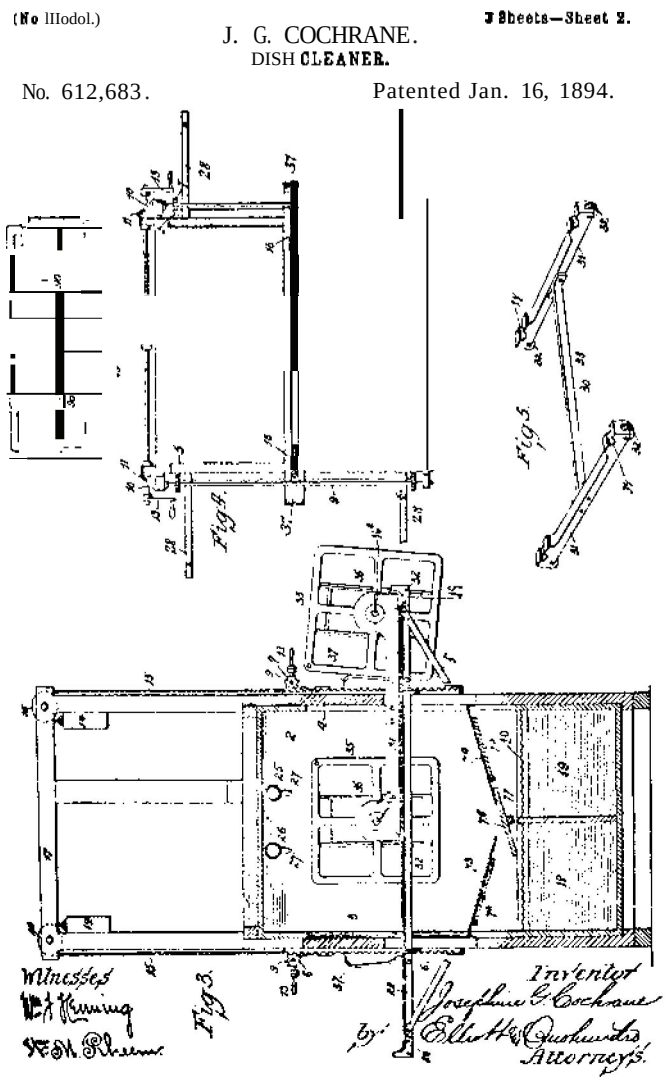


Figure 7 Parent drawing ofjosephine C, Cochrancs dish washer exhibited in rhc Woman's Building Invenrion Room and used in most large resraurnnts at rhe Chicago World's Fair of 1893.

with expl icir male iconography. American artists - among whom the Precisiorusrs, Futurists, and Dadaists most graphically - explored machines as male models, metaphors, and microcosms of modem life. l.ate Victorian writers and a new gencrari o n of modernists mobilized older transccndentalist writers like Carlyle for a

new understanding of machines rhar was understood to be at once material and metaphorical. This linkage had not been expressed so clearly up to this point. The metaphorical and visual allure of machines continued to be immensely appealing, precisely because of their concreteness and rnarcrialiry, To the modern world, rhcy also turned into fetishized objects of technology. As the world's fairs had done, they became the materialized gauges of Western identity. superiority, and hegemony. As such, machines functioned as measuring devices by which Western cultures gauged themselves with increasing confidence and assessed other cultures with increasing condescension. The selection, labelling, and designation of objects as technological proved essential for a new understanding of whar consrirurc.] technology, and what did not. Language, quilts, or corsets, all important objects of women's inventive activity throughout the nineteenth century, were increasingly filtered out of contemporary minds as significant inventions or as markers of true rcchnology. Under the auspices of a generation of culrural anthropologisrs, rhe Arncrican Smjthsoniaıı Insrirutıon had proved to be instrumenta! in helping to layout the exhibits in a classification of the ninctcenrh-cenrury world that could still include women and non-Western people, but after the first World War this would become less viable.

VEBLEN AMALGAMATING, ENGINEERS, MACHINES, AND TECHNOLOGY

The events of the first World War and the modern arts discourse mobilized the once discrete and dispersed discourses of the useful arts, applicd sciences, technology, inventive geuius, and machines into the more unified onc we now call technology. Byrhc 1920s technology was conceived as a self-contained, self-generative, and machine-bound object devoid of human agency, and engineers came to play a prominent role in it; they were thought to devise and supervise it. This remarkable and dramatic twentieth-century revision of technology had little to do with Bigelow's usage or even with engineers' employment of the term. As late as [932. the public inrcllecrua], political scientist, and hisrori.rn Charles Beard (1874-1948) could still believe that the term technology "is freely employed ill current writings lbut] its meaning as actuality and potentiality has never been explored and defined."[9] Once the term had moved into Beard's Progressive intellectual circles through discussions about the notion of tecllllolllgical unemployment, it migrated out in the late 1930S to become rather clichéd. As a keyword ill a new cultural grammar, it first appears ill the work of the institutional economist Thorstcin B. Vebien (1857-1929). Because of *his* status as major public inrcllecrual at the turn of the century, we can trace the transformation from the Victorian TO the modernist

cultural grammar through his work, While for Gage, Morgan, Tarbell, and Mason it had once been possible to conceive of women as active agents, inventors, and workers in the development of human evolution, Veblcn further privileged male engineers, and excised women and workers - a rhetorical strategy later canonized by *The Encyclopedia Brimnnica's* lexicographers. It is through his work that wc can carefully trace the migration of the rerrn and wirness its paradigmaric and scmantic shift. which makes his oevrc worth a careful reading. Vehlen not only helped to revive rhc term *technology*, bur also merged the three divergent nincrccnrh-ceruury rhetorical positions into one: male much ine metaphors, engineering professionalism, and cultural anthropology.

Trained as an economist and anthropologist, Vcblen was acclaimed by many disciplines as their paragon. When in 1938 *The New Republic* asked leading intcliccruals 10 name the books that had shaped their minds, the marginal academic Vehlen was first on the list. Duri ng the late 19!OS and 1920S, "everyone of inrcllectual prcrcnsions read his wo rks," as the eo nservativc cui rural critic H.L. Mencken remarked. "There were Veblcnists, Vcblen clubs, Vcblcn remedies for all the sorrows of the world."[4] Roosevelr's intellectual spokesmen (e.g. Rcxford Tugwcll and Fclix lrankfurter}, Vcblcns colleagues at the New School {e.g. Charles Beard and Wesley Mirchcll), leading left-wing publicists (e.g. Sruarr Chase and Max Ierncr), social scientists (e.g, Rohen !.ynd and William Ogbum), and advocates of Technocracy all considered his work brilliant and seminal. Vcblen crossed many discipiinary boundaries, profoundly shaping the public discourse through his own work and ll is disciples in the period between the world wars." By the 1940s, female Iabrics and the useful arts were no longer viable in the cultural grammar of the U.S.

Thorsrcin Vcblen was above all a wordsrnith, a master crafter of the English language, and an inventor of words, in short, a coincr of keywords for which he became famous. Always witty, ironic, and biting, he focused on the changing meanings of words and would analyzc them, turning commonplace terms upside down. In a memorable character sketch, the writer John Dos Passox described Veblen as "a man without smallralk... [whose] ...language was a mixture of old mechanics' terms, scientific latiniry, slang, and Roger's *thesaurus:*"? To many, his style seemed difficult, opaque or odd. But it could be easily argued that Vcblens style constitutcd his ideas: a turn of phrase, a string of metaphors, ora salicnr expression offered new points of view. He would continually change course and switch discourse to ourrnancuver his opponents. In his hands, words turned into powerful weapons that inspired generatiolls of intellectuals.[4]

In his IIIost influe IIIial books. *The Theory of the Leisure Class* (1899) and *The Engineers and the Price System* (1920), Vcblen mobilized different nineteenth-century discourses for technology, with a particularly gendered twist. In *The Theory of the*

Leisure Class (1899), Vcblcn showed how the various cultural forms and instiru-rions of the leisure class functioned economically, and ostensibly had merely a decorative valuc - as exhibired in the possession of dogs, the wearing of corsets, or rhc mounting of im eruarional expositions, In one of his more memorable passages, he argued, in effect ignoring the arguments of Tarbcll and other W0111cn reformers, rhar women of the leisure class had primarily a decorative role, deriving economic value only by virtue of the men with whom rhcy were associated. To the men of the leisure class, women's uselessness or idleness served as a roken of men's leisurc-class status. Woman "is man's charrcl.i.shc is useless and expensive, and is consequently valuable as evidence of pecuniary strength," tor the man who "supporred [her] ill idleness."[4] Vcblcn opposed the notion that marker rclarions determined value, because he believed that its true Standard ought to be set by what is produced rhrough socially useful labor; giving the cconorn isrs' understanding an ironic twist, he showed how uselessness and idleness could turn into valuable and *useful* assets, l-or this twist, he became Iamous, of course. Nevertheless, he only reinforced that middle-class women were merely decorative because in the truest economic sense they failed to produce any goods. Thcorcrically, his definition did nor consider engineers or managers as producers, bur when con fron red with a similar theoretical dilemma in the case of engineers, Vcblcn expanded rhc classical cco nom ists' dcf n ilion of urilitl' to incl ude cngineers ii nder its Iabd.[5] In his second book, *The Engineers and the Price System* (1920), Veblen classified engin ccrs as valuable by designating them as producers. Having gone this far, he was challenged by the question: if engineers were producers, what indeed did they produce? Vcblen argued that engineers were the actual producers of rcchnical knowledge, or a thing he now called technology.

Vcblcn's strarcgy of portraying engineers as the sole bearers of rcchnology is rather surprising. Jn his earlier work, hc not only reserved a role for skilled workers bur - more importantly in this stage of his inreilecruai dcvelopmcnr - during the first Wo rid War he wholeheartedly endorsed the goals of rhe Ill dusrrial Workers of the World (LW.\V.), who soughr ro claim technical knowledge for workers." Inspi red ill pan by Vcblen's book, rhe I.W.W. lcadersh ip dcvclo ped a rhco rctical posirion in November and December 1919 with regard to rhc usc and ownership of "the joint stock of knowledge of past experience," and launched the idea of compiling a systematic "Industrial Encyclopedia" for workers. The I.W.W. called for all workers to join the effort in order to make a smooth and orderly transition from capitalism to socialism. The encyclopedia "would serve as a practical guide to the workers in fitting themselves to take over and run their industry."[6] Irs initiators expected that the "joint stock of knowledge" would empower skilled and unskilled workers technically and would also preparc workers properly for the imminent takeover of the industrial system in the evenr of a revolution. For his part, Vcblcn

also had intimate ties with the Wobblies and sympathy with rhc plight of women. Nevertheless, in the course of defending engineering knowledge, he began to obscure the control of skilled workers and to omit the women's tradition of Philadelphia's Emma Allison, the female textile workers of Lowell, or women's patent activities of Smith's sisters.

As a word, *technology* was the key to Veblen's argument presented in a series of articles for *The Dial* in 1919 when the air was filled with talk of revolution. He considered American engineers the only suitable candidates for leading a peaceful revolution that could unseat the vested interests of business monopolies and national unions because engineers belonged to a small, disinterested, and apolitical community: their only true interest was in the advancement of neutral technical knowledge and the working of rhc system, which he construed as a machine. As a General Staff of the industrial system, they could therefore best serve as the impartial, dispassionate caretakers of industry.

With his definition of technology, he forged a bridge between the nineteenth-century discourse of the industrial arts and the twentieth-century talk of technology. "Technology - the state of the industrial arts - which takes in effect in this mechanical industry," he wrote, "is in an eminent sense a joint stock of knowledge and experience held in common by the civilized peoples." Here, Veblen referred to the old nineteenth-century meaning of technology as an inventory of industrial crafts that could be studied, but he also broached the idea that technology represented a disembodied object, devoid of any human agency. He now defined technology as an aggregate of knowledge and experience that could be held jointly, without exclusive rights to its ownership. In his formulation, technology was also an index to the level of civilization, as the anthropologists Morgan and Mason had argued.[1] Finally, Veblen pointed to mechanical industry as the locus of the "joint stock of knowledge and experience."

The designation of technology as an object resulted to a large extent from his frequent invocation of the machine as a metaphor - an image he exploited to the fullest, no doubt sensing the Dadaist vibrations also in the air at the time. Veblen, a historicist by training, often explained social phenomena in their institutional settings. Still, he made his unwitting contribution to the new economic and modernist language of machine efficiency that was devoid of social context. He spoke not only literally about mechanical engineering, but also metaphorically about the machine, to evoke both the industrial system and society at large. In his metaphorical language, he represented the industrial system as a self-generative and self-contained machine, where human beings were no longer needed. "The industrial system," he wrote, "is notably different from anything that has gone before. It is eminently a system, self-balanced and comprehensive; and it is a system of interlocking mechanical processes, rather than of skillful manipulation. It is mechani-

cal, rather than manunl. Y'Jndepcndent as the machine might seem to be, Veblen argued that production engineers would be needed at the helm and were the only ones who could be cnrrusred with its supervision.

The notion of rcch nology and the figure of the engineer entered Vcblen's work as an afterthought. It nevertheless proved to be a crucial one, His metaphorical language enhanced a modernist mode but also suppressed important experiences that did not fir the analogy. While he acknowledged the place Of workers' skills, he saw engineers as the chief bearers of technical knowledge.]n the American language, Vcbleu was the first to use the term "technology" so frequently and lavishly. He explicitly linked it with *engineers* and *producuuity.* Throughout his liFe, he had been concerned principally with monopoly capitalism and in particular with the "corporation financier" as the embodiment of the non-producing classes, but his main narrative strategy was to exploit engineers as a counterpnin1 to the corporation financier, '] () make this argument stick, however, he needed to extend the economisrs' definition otwhat consrirurcd productive labor, and also had to make sure that engineers would be producers of a product. Earlier, he had nor used the wo rd "technology," bu r the term was now [iberally sprinkled rh ro llgllOU t rh c pages of *Th« Engineers and ihr Price System,* along with a host of machi ne metaphors.' As the bearers of "thc joint stock of knowledge of past experience," he insisted in this '920 writing, engineers were producers of income. In Vcbleri's vocabulary, rcchnology had become a product, and englllcers were the producers of that product. But Veblen had been listening to a minority position in the enginccri ng profcssio 11. Ironica lly, different engincerin g eo m rnun ilies - ranging from academic cnginccrs, industrial researchers, and science-policy makers - still preferred the term *applied science* over *1echn%gy.*[2] This would soon change.

'fECHNOLOGY-AS-KEYWORD ON DISPLAY

T'en years after Vcblcn had argued that a government should be formed by rcchnically cornpetent Icadc rs. his work sparked the sho rr-lived Technocracy movemc nt. The discussion proved to be a watershed in the political alignment in the modern discourse on rech noJogy. About 1930, "technology" became a buzzword incorporating anthropological notions of civi lizarion, engineering professionalism, and machine metaphors. It also became heavily invested with ideological weight when the Technocracy movement captured the ongoing debate over rhc idea of technological unemployment ill the thirries." Technocracy helped popularize the notion oftechnological unemployment, giving currency to the view [hat there was a problem with the current relationship between mechanization and work, as historian Amy Bix argues. Supported by social scientists including William Ogburn, Sruart

Chase, and Elizabeth Baker. mainstream labor leaders like William Green of rhc American Federation of l.ahor and John 1,. lewis of the United Mine Workers began to sound the alarm over what they called "rcchnological uncmploymenr": rhc displacement of labor by mechanization as a fundarncnral feature of industrial capitalism. Carefully avoiding any Luddite associations, labor leaders worried about mechanization's "human scrap-heap." They neither insisted on halting mechanization nor on suspending science research, bur suggested that the burden should be carried evenly by the labor, business, and science communities. While sevcral labor leaders and social scientists offered remedial measures like rhc reduction of hours and aid for displaced workers to soften the blow, many proponents of the Technocracy movement criticized or opposed industrial capitalism altogether. The Technocracy movement offered a Veblenesque solution to the perceived problem: the restructuring of the price system and rhc government by engineers and scientists. According to its powerful opponents, however, the claim of the Technocracy movement to engineering knowledge was a damaging and onerous one that demanded forceful rhetorical answers.[4]

The established engineering community disavowed the Technocracy movemcnr with exceptional ferocity despite the mally personal and intellecruaI links between the Technocracy movement and engineering - especially the newer, corporate, and laboratory-oriented branches like electrical engineering during the Depression. Business leaders, research scientists, and academ ic engineers including Kart Compton, Roberr Millikan, Michael Pupin, Charles Kcrtering, Frank Jewctt, alld Anhur Little quickly closed ranks on the issue. The corporations aggressively sponsored the 1933 Chicago and 1939 New York World's l-airs as part of an elaborate public relations campaign to divert attention away from the discussion about the issue of tcchnological uucmployrnenr and the unemployment among ellgineers. 'I-he 1933 and 1939 displays shifrcd the focus from the early interest on producers and their products to the wonders of consurnprion instead.[5] Likewise, establishment engineers and scientists balked at the suggestion that they should be blamed for the human mixerv. In this controversy, rhe rhetorical use of the term "technology" proved to be essential, !r had been ofrcnsivc enough to suggest that scientists and engineers were responsible for the human misery of rhe Depression, bur the mere suggestion that Technocracy's leadership laid claim to the mantle of engineering knowledge ro advance its radical agenda was evert more unsettling. Business leaders, establisluncnr scientists, and engineers swiftly mobil izcd by denying rhe charges, ridicul ing the movement, and insisri ng that scienrific advance, economic success, and the progress of civililation were indispurably linked.

The mobil ization of rhc notion of technology against Technocracy served a rhetorical purpose. Responding to the claims of the Technocracy movement. physicist, Prexidenr of MIT, aljd publ ic spokesman for the science and engineer-

ing community Karl T. Compton (1887-'954) wrote in *Technology's Answer to Technocracy* that neither the movement, nor its analysis of an economic crisis, nor its concern for workers displaced *by* lab or-saving machinery amounted to anything new." As the rank-and-file members of the profession experienced a decline of wages by a third as well as bouts of unemployment, the engineering establishment reacted with ferocity to the association of their profession with technological unemployment and to the 'misuse' of engineering credentials by many of Technocracy's proponents, whom they labelled "pseudo-engineers" and "quacks." In '933, Arrhur Sheridan, a former president of the New York State Society of Professional Engineers, blamed political scientists for trying "to place Technocracy upon the doorstep of engineering" and "seeking to discredit engineering as a social factor in civilization through condemnation of Tcchnocracy.?" Arrhur D. Little (1863-1935), the industrial chemist, spokesman of engineering professionalism, and founder of the oldest and best-established firm in research and development contracting, contested even more sharply the claims of the Technocracy movement and the use of the word *Technocracy.* "In happy contrast to the gloomy futilities of Technocracy stand the solid achievements of that very different thing, technology. In a little more than 100 years technology has increased, immeasurably, the wealth of the world...Technocracv is destructive; technology is creative. Let us not confuse them."[8] He thus linked Technocracy ro rhe pessimism of the Depression, and technology with progress.

The public answers of Cornpton, Sheridan, and Little disavowed the revolutionary role Vcblen had suggested for engineers, denied allY links between engineers and unemployment issues, and above all reclaimed technology for engineering experts. As Veblen had ironically anticipated, Compton and Little resolutely aligned technology with a conservative agenda, cleansing it of any anri-capi taiisr contaminations and pro-labor associations, and casting engineers and scientists as producers of wealth. If, as Bix has argued, in the short run, the Technocracy movement popularized the discussion over technological unemployment, in the long run, it harmed the case of those willing to argue that technological unemploymenr posed a serious problem.Engineers like Shcridan, Lirrle, and others did much to define and prmect the boundaries ofengineering. Claiming semantic ownership of the term served this effort..)The discourse on technological unemployment and the fate of the Technocracy movement proved to be crucial factors in determining who could claim the true parentage of technology. The question of who owned technology, or who could claim its progeny, fundamentally redirecred the discussion.

In the 1930's, social scientists like the University of Chicago's William F. Ogburn reworked Veblen's oeuvre and the anthropological tradition of Morgan, granting scientists and engineers an active role as agents ofhisrory over and against

politicians and statesmen. They elaborated on Mason's genealogy of invention even further in merging the two discourses of academic engineering and cultural anthropology. In Abborr Payron Usher's words, scientists, engineers, and inventors were twentieth-century incarnations of Carlylc's heroes: small, anonymous, but essential." These early sociologists of invention rejected biological racism and firmly agreed with cultural anrhropologists like Franz Boas and Alfred Kroebcr that inventions could occur simultaneously in different cultural settings and were seldom creations *of* an inventive genius. Bur in their cross-cultural comparisons between primitive and civilized cultures, they also reiterated that inventions – understood as mechanical and patented – explained the difference.' When faced with an explanatory gap between the premise that all cultures shared the same human nature and the notion that in a short period of time the Western world had generated many patented inventions, theorists of invention including Ogbunl, Usher, S. Colum Gillif.lll, and the popularizer Waldemar Kaemfferr – the science editor of *Scientific American*, *Popular Science Monthly*. and *The New York Times* – allotted a crucial place to inventors with extra intelligence: the great men in history. More explicitly than Vcblcn, these sociologists turned engineers into male heroes using images from popular fiction. Like Mason, they recoiled from taking their monogenetic theory to its logical conclusion. They included neither other culrurex nor women in their theory to explain rhe difference between Western and other cultures, hut fixed scientists and engineers as male agents of history, who produced what they now called technology.

The rise of the National Research Council (NRC) and the Departments of Commerce after the first World War surpassed the Srnithsoman in classifying and in laying claims to the objects *of* the twentieth century. Up to the first World War the Smithsonian had been instrumental in fostering the material world that still could include a range of invcntions from clay pOts, and corsets to cars, but when the NRC joined hands with corporate sponsors in organizing the 1930s World's Fairs it legitimized a new language of technology closely associated with industry, the military, and the profcssioualizing communities of science and engineering. Establ{shed by Woodrow Wilson, rhe NRC would become the Primary agency for prornori ng the cooperation of science, industry, and the military. Big science and big engi nccring became ever more closely tied to the *military-corporate* complex. [f the Srnithsonian-organizcd fairs still included a hodgepodgc of artifacts from clay pots, and bonnets to reapers, the NRC's staged affairs resolutely resembled clean corporate machincs. More importantly, the risc to prolfinence o[the NRC in staging the World's Fairs shaped the emergence of a new paradigm rhar put scientists, engineers, and corporations cenrcr stage as rhc producers of technological artifacts and cast women, workers, and African Americans as consumers." In the course of a century. technology had been turned into a product, engineers into

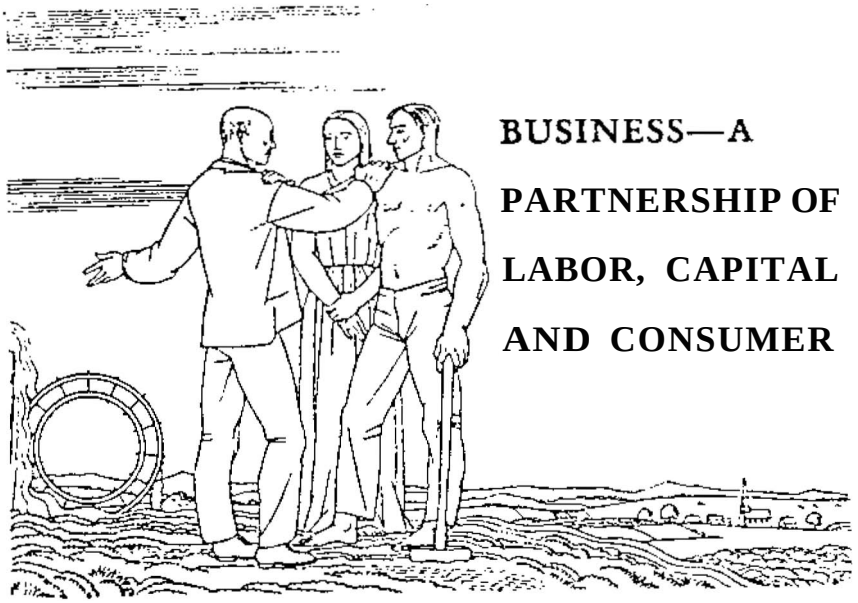


Figure 8. Corporate allegory of a manly part nership between Labor and Capital witnessed by a female Consumer. Reproduced from autobiography of engineer and captain of indusrry Paul Weeks Liichficld. *Autumn Leaocs: Reflections I/(a i/ Industrial Liemenant* (1945).

producers, and wom en and workers into consumers who were mere onlookers of the techni cal enterpri se. As time went by, technology would come to mean rhc history of corporate engineering. [Figure 8]

2

From Elite Profession to Mass Occupation

Engineers emerged " the sho ck troops of industrial capitalism. Nevertheless there was something cuneus about the cnguiccrs success to command male cultural authority. While intellectuals, artists, and social scientists endowcd them with great cultural meaning and importance, mallY engiuccrs felt misunderstood, disrexpccrcd, and undervalued. They suffered fi'oll1 existential anxieties what it meant to be an engineer and where the boundaries of its knowledge domain lay - anxieties that came to the forefront at three historical junctures.

From the World's Col umbian Exposition in 1893 through the aftermath of the first World War, many advocates for the engineering profession argued over rhc definitio 11 0 f engi nccr in countless articles [hat appeared ill the Icchn icaI press. These spokesmen for the OCCUP:H ion included engineering educators and reformcrs, editors of technical journals, ;Ind leaders of occupational organizations. Corning on the heels of hitter industrial srrugglcs, their articles expressed intense status anxieties of patrician engineers who faced an aggressive iudusrrial dcvcloprncnr and who felt threatened by a sense of class war and a menacing procession of i mrnigram culturcs, In this scrti ng, contests over the criteria for mern bership of the professional organizations between the various factions within cnginccri ng did not merclv define the rcrm enginecr. They helped claim a special knowledge for cngineers and legitimized their cultural authority coded in terms of a revitalized manliness. The leading American bridge engineer John A.L. Waddell (1854-1938), born of Irish-American parentage and closely associared wirl: America's imperial projects at home and abroad, had built the larger part of his career 011 overseas work ill Mcx ico, Cuba, New Zealand, Russia, and Japan. Waddell liked to lccru re srudcn ts and his peers on the many tactics of upgrading the status of engineers and expressed his concerns about the proper class, gender, and ethnic boundaries of the cngineering profession before a circle of academic engineers in 1903 rhus: "We have the man who fires the boiler and pulls the throttle dubbed a lotxnuorive or stationary engineer: we have the woman who fires the stove and cooks the dinner dubbed [he domestic engineer: and it will nor be long before the barefooted African, who pounds the mud into the brick models, will be calling himself a ceramic engineer."[1] Th rough his figure of speech, Waddell belittled the skills of mechanics,

women home economists. and bricklayers as a rhetorical strategy that sought to upgrade rhe profession. He incorporated a scientific racism that became more eohercnr and articulated in rhc decades after the World's Columbian Exposition in 1893: it was a racism that elected jamcs Watt rather than Mason's African women as early technologists. Establishment engineers - among whom academic cngincers were most vocal - insisted that the distinction and the term engineer be respecicd, as if to counter the occupational ambiguity that always seemed to be lurking ill the background.

American engineerillg transformed from an dire to a mass occupation, grew the fastest of all, and differentiated at a great pace from rhc 1890.1 onwards.]t was also a deeply divided and segmented profession whose practitioners could be found working anywhere from boardrooms to drafring departments, mechanics workshops, and chemical labs as executives, managers, designers, draftsrncn, derailcrs. checkers, tracers, and resting technicians: by 1935 there were 2,518 different cnginccring job titles. Lacking rhc classic gatekeeping mcchanism of a central agency. the state, or professional organization, American engineering neither became a closed profession associated with science as in Franee where the stare groomed a small clirc for leadership positions; nor did it lashion itself after the British engineering culture of small family firms, craft tradirions, working-class associations, and kinships. Instead, American engineering would evolve into something between the French and British models: a mass middle-class occupation with a hybrid form of professionalism and an almost knee-jerk aversion against classical blue-collar unionism.[7] When the gates were opened to newcomers from lower-class and diffel-elH erhn ic backgrou nds, maintain: ng the middle-class position proved to be tenuous, however. In an immigrant society where upward mobil it)' marked a bone of contention, the rhetorical positions on manliness and race often masked the rensio us of class.

Engi neering advocates were engaged in a balanciu g acr o f rnaintaining the class sratus of the profession when it transformed [rom a small elite profession ro a mass occupation. N incrccnrb-cenrury engineers, many of whom had been employed by the railroad corporations, formed a class of middle managers who invented, innovated, and arbitrated in the emerging federal and corporate bureaucracies. \Xihen rhe state and the corporations expanded dramatically in the early twentieth cellrury, new generations of engineers - lllallY now from ethnic backgrounds - starred ro fill positions in the lower rungs of the middle class.[8] As a group, engineers found themselves not merely caught in the middle, they also acted as an active and sell-conscious constituent as a middle class in formation.[9] Lsrablishmenrengineers like Waddcll tried to advance their lofty professional ideas within the pristine walls of engineering schools, the pages of technical journals, or the halls of professional organizations. Educational standards did not manage to lay a foundation for a mo-

nopol y or serve as a benchmark of competence. Subsequent movemen ts of engineering reformers failed to introduce a professionalism along the lines of their medi cal broth ers, Closely associated with industry, establishment engineers rejeered uniform education and crcdenrialillg rules. The ciforts of Progressive engineering reformers like Morris Cookc to sever rhe ties with the American business community failed during the pivotal period betwe en the 1910S and J930S when the disconrcm came to the fore. Nor were academic engineers successful in rcsrricring access to rheir ranks through educa1ion.[5]

The insistence o n a proper defiu irion Of the field stem rncd in part from the ambiguous and loose nature of engineering, the inability to find clear gatekeeping mechanisms. At a time when Waddell worried about the proper race and gender boundaries of the profession, the fastest growi ng occupation transformed into a mass career for many. In the balancing act, gender and race were more rigidly mainraincd in a society where upward mobility marked a bone of cont ention. Racial and gender lines were rhcretorc more carefully drawn. Often the rhetorical positions on rnanlinesx and race masked the tensions of class that were part and parcel of the mosr greatly expanding occupation of all. Waddell's rhetori cal position fell squarely with the leading engineers's search for protessionalization.

In the negotiations over boundaries of class, three major cultura] conflicts shaped cngineering rhar sought to renew its middle class character through a lauguage of manliness and whiteness. The first cultural conflict erupted over the question of where the true path lay toward an cngineering career and technical expertise and knowledge: through the doors of the rough workshop or the genteel schoolroom. It pitted propriety engineers and academic engineers against each other in a struggle over renewing male authority based on class relations of the workplacc or on science. This contest, at its height during the 1890s, has entered the secondary iirerarurc as the tensions between the shopfloor versus the school culture. In the decades that followed, esrabl ishrncnr engineers and the rank-and-file engineers struggled over the di rectio n of professionalism and cngineering unionism. In this struggle, the danger of being dcclasscd and demasculinized threatened the status of the engineer as a middle-class man. Finally, as the government-military complex gradually emerged as a result of the firsr World War, academic seicntis ts and indusrrial rescarchcrs like Karl Co mpton, Robert Millikan, Arrhur Sheridan, and Anhur D. Lirrle argued about the meanings of applied science and technology, The rhetorical contest cenrered on the corporate sponsorships, federal research and development resources, and the engineer's proper cultural authority and status as a corporate man. The contest culminated in the struggles over the meaning of technology during the 1930s that recaptured and reworked earlier episodes and came to mean how we understand rechnolopy today: a white, middle class, and male enterprise that sought to claim an exclusive expertise

for engineers over other forms of technical knowledge while at rhe samc rime making universal claims for it. Although each cultural conflict has received attention, they have been considered neither in terms ofclass, gender, and ethnicity nor in relation to each other. When immigrant and lower-class sons began to enter through the system of American engineering education, rhc boundary work of class became an ongoing process of redefinition, while at the samc rime gender and race boundaries were upheld, The sons ofthc lower middle class and immigrants joined, bur, wirh few exceptions women and African Americans were kept on scp-ararc educational and employment tracks. The boundary work of class was reworked, rejuvenatcd, nnd remade through ihese three hisrorieal episcdcs.

'SHOPFLOOR CULTURE' AND THE WORKPI.ACF AS MORAL GYMNASIUM

In the middle of the nineteenth century when America laid a grid over rhe newly eonqucrcd wcsrem tcrrirorics wirh canals. turnpikcs, and railroad tracks, and urbun ccntcrs sprang up along the way, engineering offered aspiring men social sratus and, later, the promise of upward mobility. It promised a more secure JIICOITIe and 0ppOlTunities for advancement to a young man who had decided rhc time had come to be a serious breadwinner. Alfred West Gilbert (1816-1900), the xnn of a tenant farmer, explained how he settled on engineering when he fell in love with his fururc wife and saw the rapidly expanding public works projects in the mid-Arlanric region." After his father offered to pay for his education, Gilbert becamc a city engineer. surveyor, and lawyer in Cinejnuatri, a city rhen emergi ng 0 n the banks of lhc Ohio river - the ccntcr olsrcarnboar building and repair, home of many steamboat-related indusrries of general machinc work and machine-tool manu facture. H is eareel'was closely associared with the bu ikding of the city's wate1-infrastructure. In a similar fashion and of the same generation, james Worrall (1812-1885), the son of an Irish-born bookseller in rhe manufacturing city of Philadclphia, aspired to rhe life ofgenteel culture bur abhorred the idea that intellectual ideas could be sold as books just like any other commercial goods. He wondered after meeting his future wife how he could escapc his father's business and find a job, and decided on engineering in the 1840s when "everywhere around me I saw constructors, builders of churches, of wharves, of canals, of fortifications." Some men wenr inro cngineering to affirm or replicate their comfortable backgrounds. Other» - like the sons of impoverished Southern plantation owners who became rhe shock troops of rh« New Sourh attcr the CivIl War - did so in an effort to reeapture rheir social status aIter famill' forrunes had been [osr. In America, ellginecring was an occupation of the middle class, Unlike France, in the U.S. shared

expectations, aspirations, and goals - not family backgrounds - came to shape the social cohesion of engineering since it was linked to industrial capitalism rather than state service. In America, engineering did not reproduce old clites or middle classes; it groomed young men into a sense of class through disci nct rituals , narratives, and self-representations when it expanded dramatically.

During the f rst half of the ninctcentll cenrury. it was quire comruon for ellginccrs to be trained exclusively on the job, In the absen ce of engineering schools it had been standard practice oii Erie canal's building sites to recruiting engineers by promoting capable chiefs of survey crews. Th is kind of informal recruitment and apprenticeship carried over from America's internal improvement projects to other sectors including the building of the milroads, The building of the first major American railroad, the Baltimore & Ohio, served as a laboratory for training Jllany civil engineers, and a generation later the construction of many railroad bridges spanning the major arteries gave many engineers the necessary experience to become bridge specialists, later used in co untries as far away as Uganda. In the gold and silver fields o f Cali fornia and Nevada, cngin ccrs learned new rcchniques ill deep gravel and hard-rock mining. Two generations of mining and civil enginecrs, following the tracks of the federal governmcnr's topographical engineers sinee 1824, extended the American sphere of influence, vcntu red inro thc American West in the 1840s only to move into Mexico, Cuba, Panama, the Philippines, Australia, and South Africa from the 1870s through 1890s; they sampled ore, staked out claims, supervised trial drilling, furnished drawings, calculated cstimares, and acted as promoters of mincs on behalf of invesrors with interested stockholders or as managers in hiring immigrant or foreign labor.[7] On-the-job training on the construction sites of canals, railroads, and urban ccnrcrs became a common method of producing civil and mining engineers. Here aspiring young men worked in sex-segregated workplaccs and shantytowus alongside common laborers and skilled workers from Englaiid. Ireland. Scorland, Gcrrna nv, Italy, and Mexico from whom they expected to learn all the aspects of their trade in order to move up and our of the lower ranks as soon as possible. Starting as laborcrs responsible for clearing land alongside the Irish and slave African-American workers, on rhc railroad and canal building sites, they worked with the expectation that rhcy would move up the ladder from chainman to rod man, to rrausiunan, to surveyor, and eventually to assistant engineer. The lahor camps along the tracing lines of projected canals and train tracks were largely societies of men, where hard living, hard working, and hard dFi n killg were cherished values, rem iIlding many an aspiring engineer of the kind of proletarian manhood they were determined to avoid at all costs. Always terrains of labor conflicts over wages, working conditions, and con trol, cmerging unscathed from the rough and tumble culture of the lahor camps heramc rites and sites of passage into manhood shaped by a contest over

claxs relations. "Cannallcrs," writes their historian Peter Way, "participated in sport, fighting, boozing and various contes ts of srrcngrh, in the process developing a proletarian sense of virility and physical prowess."[9] Rough amusement of drinking, laughter, and boisterous fighting expressed the deepest solidarities and resentmcnts of lower-class men, who came to embrace rhis rough code of manhood as a way of deriding and resisting respectable and moralistic manliness of the middle class into which the engineers entered.

In this context, practical training was nor only an important channel for the formation and social reproduction of middle-class identity, it also represented a formalized ritual of male sccializarion of middle-clasx men." Born into a family of lawyers, Robcrt Ridgway (1862-1938), who would become an important urban engineer of teeming New York later in the century, had received only a minimum of academic instruction because the panic of 1873 forced his lawyer farher to move his children back to the family farm. Instead of going to college, Ridgway went off west ro the field-school of engineering - the expansionist projects of the large railroad construction in the West. The young Ridgway rode the wave of the railroad building boom in the period between the economic busts of 1873 and 1893, entering upon his engineering career at the age of 20 as a rodman on a surveying expedition in Montana during the summer of /882, only to continue with the Northern Pacific Railroad in Wisconsin. He received his first engineering training on rhe building sites and in the labor camps in the newly acquired Western Territories in Montana where he hoped to find his manhood. After his initiation into manhood in the West, he returned East because "the frontier today is in the cities - not on the prairies." He built his career by participating in the new engineering infrastructure of streets, sewers, water supply, runnels, electrical lines, and subway systems that were laid out for the booming urban cenrer of New York - the pon of entry for millions of immigrants at the turn of the century. He obtained his first promotion to the position of leveler three years later, when he joined the building of New York State's aqueduct system at Croton. There, he had an explosive conflier with the lralian masons over the lining technique of the tunnelling. The conflier bcrwcen engineering knowledge and the skilled Jralian masons wax a classic contest over who possessed the best technical knowledge and controlled the workplace. Ridgway and his engineering corps wall. Ridgway worked ten more years before moving up from senior assistant engineer in New York City's Rapid Transit System building projects to division engineer on the New York East River Funnel construction works in 1900.

It would rake more than twenty years of informal recruitment procedures, on-the-job naining, and careful negotiation with workers and contractors over experrisc, command, and control on the building sites from Montana to New York before Ridgway coulr] call himself an engineer." To help ngoriurc the tension be-

Figure 9. Civil engineer Rohcrr Ridgway posing in Iroru of the field office near Old Croton Darn in 1887 and seared to!' xrcp 011 the left amidst young engineering trainees. Norc the skilled Italian mason at the extreme right whose knowledge of lllJlllding technique Ridgway and his engineering crew contested. Reproduced from Roberr Ridgway, "My Apprcnucc Days," *Ciri] Engineering* (1938). Courtesy of Delfr University of Tcch nology Del[t, The Nethcrland-.

twecn capital and labor, between field engineers and skilled workers, between white collar and blue collar, Ridgway's generation dressed for their outdoor acrivities on the building site while keeping a safe distance from rhcir working-class subordinates through carefully chosen headgear and shoes. [Figure 9] Well into the twentieth century, this kind of on-the-job training made up an important segment of the engineer's ovcral] schooling. III the textile industry, practical training also known as the "tour of the mill" was still the cenrerpiccc of mechanical engineering training and rounded ofTa formal education until the 1890s. In the nincteenth and early twcnricth centuries, proprietors' sons were no longer expected to master a trade, bur because of the increasing complexity of the manutacturi ng process they still trained in the plant [() acquire a working knowledge of all the facets of rlie firm, including the marerials used, processing, production, sales, and repair.[1]

The belief in and practice ofshopf1oor knowledge became canonized in the notion of the importance, if not the nccessitv, of hands-on and field [raining reproducing for a new age a patriarchal authority that wax based 011 class relations rather than on science, The ideological base for this shopfloor culturc came first of all from the machincshops in Pennsylvania. In Philadelphia and other eastern industrial ccnrcrs, advocmcs and managers of the shop culture formed a class-conscious elite with a network of family connections resembling British recruitment patterns. Many sons of this culture of family-owned business found themselves in a

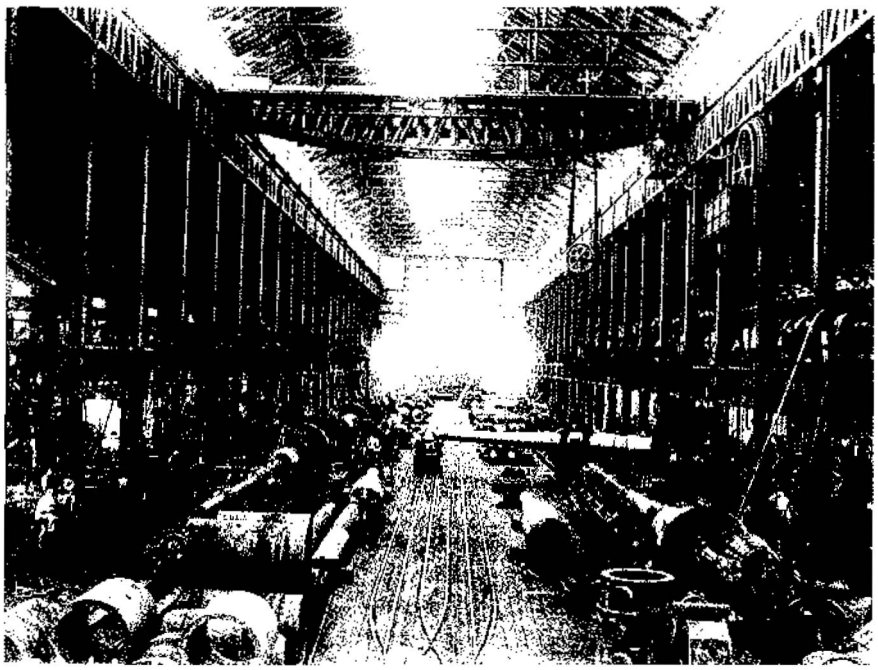


Figure 10. Bethlehem Steel's Machine Shop no. 2, site of Frederick Taylor's metal-cutting experiments around 1900. Mechanical engineers' moral gymnasium framed as a production How without workers. Courtesy of Hagley Museum and Library. Wilmington, DE.

period of transition when their opportunities for proprietorship was shaped by ill-defined, middle-level positions in large organizations. Working at the Baldwin Locomotive engineering shop, Raffe Emerson, the son of Taylor disciple Harrington Emerson thought the experience would make a man of him physically, something he believed mere strenuous exercise would not do. As he wrote to his father in 1904, "A few months of this kind of work will...be the best kind of a brain raser [sic] and body builder for me. Sailing a boat, or hunting might be somewhat more healthful, but not nearly so profitable as experiences?" Young men of Emerson's circle cherished Emerson's brand of manliness that valued bodily prowess, individualistic assertiveness, and valuable experience as measures of manliness, The machinists Emerson worked with, by contrast, defined their manliness in terms of skill and solidarity. These nineteenth-century male working codes not only served as an initiation rite for the profession, but for middle-class manliness in the 1895. For sons raised on a work ethic, the accumulated riches of successful fathers posed a threat to proper character development. The aura of independence, the esprit de corps, and the sense of service to society embodied in the ethos of professionalization offered an acceptable way out of the dilemma."

For men of l-rederick W. Taylor's generation, the factory and the field consritutcd a moral gymnasium for the exercise of character development. [Figure 10] Taylor (1856-1915) was not the only one of his generation and class who, after failing health, would abandon his classical education and turn to the field of engineering, After Reconstruction, many of his contemporaries treated the field or the shop as a sire where they could rcconfirm their qu intcsscn rial man liuexx defined by class." In arguing over what consrirurcd the true mechani cal engineer, members of the ASME discussed where the honor of engineering lay or what distinguished them from sraric nary. Tbcomorivc, or marine engineers - the kind of skilled workers that Waddell also contested. In 1895, one member "disavowed meaning any disrespect to overalls or greasy hands, and said he had worn overalls and had his hand and face as black as anybody else ever had, and was nor in the least ashamed of ir."[c] Neverth eless, such provisional dress was carefully coded to flag class distinc tio us ill rhc workplacc.

The rites of passages of grease, overalls, and blackface on production floors, building sites, and in mine shafts were closely linked to the network of kinship con necrions. For most of the nineteenth cenl'llry male socializurion resulted from paternal relations between fathers and sons, which developed in tandem with the fraternal relationships between fathers and their peers. These family networks and informal relations took their most institutionalized form in the more elire engineering societies and provided the sons with a platform for becorning engineers and advancing in their career. The wcll-rruvclcd mining engineer, author and editor Thomas Rickard (b,1864)' who boasted an international career in the mines of Colorado, France, Australia, and New Zealand, relied on his extensive experience when as late as 1906 he still adv iscd that a good start "such as a father able to pay for the nccessary education, a kind uncle to give the graduate a job, and friends glad to give a push when most needed" was viral for success."

This pattern of socialization and acquisition of technical knowledge occurred not only in small proprietary firms but continued in the emerging corporations that were based on the patriarchal culture of family firms. Even when the chemical firill Du POIIt Company went through a large organizational transtorm.u ion lrorn a Delaware family-run firm to a major vertically integrated corporation, expanding from 1,500 to (;0,000 employees from 1902 to 1915, the old social networks and func tions srill gu ided some aspects o f the managerial routines. As rnining cngi neer Thomas Rickard had advised earlier, lIarry Penningron turned to hix social peers on behalf of his nephew to request another position for him because of rhc arduous nature olrhc work he faced on his first job as a day Iaborcr at the Du Pour Company in 1915. In an apologetic rcspollsC, Dul'onr'» General Manager Ham ilron Barksdalc arranged a less strenuous joh for Penn ingtoll's nephew, but he pointed OUl, "he is, of course, ar the present time filling a minor position, as his lack ofex-

pcrience necessitates, hut [should say that his turure advancemen t dep ends only UPOIJ his making good the impress ion he has already created."[14] Barksdale found the assum prion that Pen ii ingto n cou Idill rerfere quite acceprablc, hur also cired his nephew's lack ofskill to underscore the rules of the system. The system combined paternal protection with the principles of meritocracy or "making good," Paternal prorecricn meant that seniors would recogni ze, encourage, and foster the aspirutions ofa youn g man who started at the bottom of the corporate ladder as a day laborer. To a certain degree, plant experiences were vestiges of an apprenticeship system that had soughr to integrate young malcs into the ran ks o f skillcd work ers, and had sym bolized their passage into their adult roles as husbands and fathers. These rites of passages of the workplacc revitalized a middle-class manliness for indusrrial capitalism when old patterns of male socialization had been broken. Such passages den icd, but also resolved dilfcrcnccs of class.

On the shop floors of the steel industry in Philadelphia, in the mine shafts of Colorado, along the railroad tracks in Montana, in the drafting departments ill New York and at the labs in Duponr, engi necrs encou ntered a host of other groups of workers like powerful iron puddlcrs, independent miners, unruly canallers, [ow-lcvel clerkx, and ill-paid chemical analysts. They competed with these male workers for authority and control, and sought to differentiate themselves from them as well. but – and this was the crux of ihe rnarrcr - the engineers also depended on these workers as they needed to learn the tricks of the trade from them.

As engineers became increasingly channclcd into white-collar jobs as managers, "rubbing shoulders" with the men on production floors and building sites assumcd a particularly symbolic meaning as markers of manliness. Engineers in managerial positions for the most pan sought to control the process of production and the performance of workers in the plant, but their association with working-class man] incss also "rubbed off," as it were, onto them. Their aurhoriry over other men depended on an abil ity to speak their language *with* them without becoming *of* them." The true engineer neither simply crnploved the chemical formular: once memorized at school nor learned the technical aspects of production. but perhaps more imporranrly, also sought to command a cultural fluency of the workpl.icc – rhe men who could talk shop with the workers, while simultaneously supervising and keeping a safe distance or, io put it in the words of civil engineer Otro Garman, the facilitv to "adjust your vocahulary to the shop, the camp or rhc rrcnch [without forgetting] that there is a different vocahularv and suitable subjects to be used i n the drawing room."[15] Ill order to gain authority over the Irish, Welsh, Scottish, Canadian, and Italian workers they supervised, management engineers needed to be able to speak the language of the workplacc, In the case of skilled workers, this learning process rested on the willingness and coopcrarion of workers to share thci r knowledge. Unlikc the fields of medicine and law, socialize-

(ion in engi nccring occurred through the association with and rhe sirnulrancous rejection of the manhood of the class of lower professionals, skilled workers, and corn mon laborers with whom engineers worked in the workplacc. Abstaining from alcohol and proper dress became important markers of class difference.

When engineering changed from an elite profession to a mass occupation and when management practices sought to reduce skilled workers to mere physical laborers by extracting skills and by removing work decisions from production floors and building sites and placing them in the hands of personnel officers and middle managers, middle-class men became even more heavily invested in the ideal of bodily prowess and hands-on experience, The romance of the shop floor, its cultiv.uicn of stamina, and bodily prowess gained ideological expression at the very time rhar management practices started to separate manual trom mental lahor and engineers became more removed from the tough talk on the production floors and bui Iding sites. " Th is ideal of rnanli ncss located manly characteristic, in the hody and in individual achievement. In contrast to the late eighteenth century's emphasis on refinement and status in the community or the body politic, the emphasis on the male body found its most forceful expression in upper-class men's ccicbration ofsports Iikc basketball, voll eyball and rugby." .J'his cml'hasis had a parricular meaning for management engineers. While men like Taylor, Raffe Emerson, Ridgway, and John Frirz celebrated their feelings of fraternity with .skilled workers, they also participated actively in reducing and controlling workers' skills. In recalling their work days, engineers portrayed themselves as active builders when they merely had the supervision over others carrying out the actual construction work. Thus, a switch occurred in both language and image. Management enginecrx and engineering educaror« appropriated not only the rncnral labor of skilled workers, hut also metaphorically appropriated their bodies. Rather than speaking of their supervisory functions, they seized the language of building and design as the tangible result of their own engineering creativity.

The association of engineering's identity with rough-and-rumhle and hands-on experience of production floors and building sites was both real and idealized, Business engineers came to articulate [heir shopfloor identiry when they became overwhelmed by the scienrific claims of academic engineers and hy the unions defense of workers' technical knowledge against management encroachments. The affection that cngi neeri ng managers cherished for the: r workers had distinct lirnirs for they showed un mistakable hostility to the desire of skilled workers like British mechanics, Welsh miners, and Italian masons for control over their work, and their aspirations to have [heir own un ions. Only rarely did successful engineers show support for workerx' un ions, or, for rhar matter, for engiuccrs' un ions. When lower ranking engineers articulated their own desire for an organization that would address their pay scales and working conditions, telephone engineer Garri-

son Babcock (b. 1879) insisted rhar the new organization of engineers "must overcome the impression that because we are an association of engineers we are a union."[7] Engineers had a knee-jerk aversion against blue-collar unionism. If a skilled industrial workers' organization based its strength on economic and social solidarity among workers, the social cohesion of engineering rested on the promise of individual social upward mobility and the simultaneous acknowledgment of such aspirations by men in the higher echelons.

'SCHOOL CUITURE' AND THE DOMESTICATION OF OUTSIDERS

Those who celebrated the production-floor manliness of grease also responded to other contenders of their technical authority. After the Civil \Val', proponents of formal schooling began to advocate a contrasting vision of engineering skills. Ellgineering schools openly challenged the experience-based education so firmly enrrenched in the industrial craft traditions ill the machine shops, mine shafts, and on the building sites of the canal, turnpike, and railroad projects throughout rhe U.S. and beyond. Catering to the new demand for young recruits to staff the industrial expansion, academic engineers sought credentials to monitor admission into the engineering ranks. They claimed to offer their srudcnrs "methodical and scientific application to everyday actions," instead of the unregulated and despised rulc-of-rhurnb method.[8] Wi rhin the engineering establishment, the conflict berwccn the two models of education - one based on formal education, the other Oil on-the-job-training - came to a head during the 1880s and 1890s. Despite the growing numbers of school-cdurarcd engineers over the following half-century, however. as [ate as rhe 1940S about 45 pereeIll of male engineers and chemists who worked in or had applied for engincering positions had yet to complete their college cducarions." Only .itrcr the second World War would engineering schools win this struggle over crcdcnrialling and acquire the kind of male privilege the old patriarchal culture of the family firms had once possessed.

On the eve of the Columbian Exposition, academic engineers began [() rally forces in establishing in 1891 the Society for rhe Promotion of Engineering Education. It was before this organization rh.u bridge engincer and the profession's prom incur promoter Waddell entertained his brethren by ridiculing railroad drivers, wo me 11 ho me eco no misrs, and "the ba refoorcd African, who pouuds the mud into [he brick models," bur called themselves engineers, His sneer was less a play on words as it appeared ar first, than a rhetorical strategy that sought to fix clear class, gender, and race houudaric« at a time when American education was expanding drnrn.nically to extend its promixes to lower class youths and a few

women and African-American graduates who scaled the engineering bastion. \Xaddcll drew on several vocabularies and reworked it into a new discourse.

In the decade following the Civil War, diversity and 0pcllless characterized American engi nccri ıg cd uca tio n. [ı neverthclcss eame to be bound by gender and race. Hailed as the landmark legislation aimed at pushing higher education to unprecedcnred levels, the Morrill Land Grant Act of 1862 helped establish several schools of engineering at land-gram stare universities, colleges, polytechnic institutes, and private universities throughout the land. During rhc Civil War, the Northern Congress had legislaled the Act for rhc express purpose of cd uca ring th e ch ildrcn of farmers and industrial workers. Its drafters had not stipulated with precisicn what they meant by "agricultural and mechanic arts," however, and in the early days, women, workers, and farmers attended courses given at institutions like MIT. Industrialists who had sponsored the Act not only had been the first in supporti ng cd uca tion of the "jnd ust rial classes", rh*ey* had also been at the fore fro n1 in sponsoring the instruction of women's in a temporary alliance with women's rights activists, As sponsors of the "useful arts." they welcomed the cnrollmcnt of women, viewing them as a porcnria] disciplined workforcc,

This broad commitment contiuued in rlic early days of rhc Morrill Act, but this would change in rh« course of the cenlury, Under the aegis of members of Congress from the North, state officials, local business men, and engineering educators "the agricultural and mechanic arts" often came to mean industrial rather than agricultural education, rcchnical rather than arrisanal training, and school-based engineering rather than a British-style apprenticeship. More often than nor the allocations came to respond to the need for engineers ill the development of industrial ccnrcrs in the East or ill the exploitation of the rich mineral resources and the expansion for mining and railroad lobbies in the Western Territories.

Over time, educators and local business men begall to upgrade rhc various industrial education programs and insrirurcd policies wh ich kept at bay those groups that had been the hill's main mission initially. The push of upgrading the field through the intusiou of professional ideals resulted in the rnasculinizarion of higher education of engineering in the U.S. that historian Margarcr Rossirer has demonstrated for the sciences as well. Leading engineering educators affiliated with the Massachusetts, the Calitornia. and the Srcvcns Insriuucs of Technology tried to formalize engineering knowledge by linking it with scientific tradition, or what they came to call applied science. Breaking with the traditions of vocational training, these advocates managed to seize all the arrributcs olscienrific rhetoric.

The term applied science seized the older terms useful arts and mechanic arts and imbued it with the cachet of science. After the depression of 1873, MII "s Francis Walker and his crew of young professors thoroughly transformed the insrirution from the original design of founder William Roger and his aholirionisi and

unionist circle. They closed down the school of mechanic arts and decmphasized popular lectures and the society Of the arts that catered to the local community. In this effort, rile terms applied science and technology marked rhetorical positions that allowed ihern to cleanse and sanitize the profession from the sweat, dirt, and cailouses associated with labor. jacob l3igdow's title of his chair at Harvard, "application of science to the useful arts", expressed rhar middling position between the skilled workers of the mechanics institutes and Harvard's gentlemen of science. *Technology*, as MIT srudcnrs sang in their college songs at ihe end of rhe century, was rounded 011 science and art, not on the skill or experience associated with workmen. And with an eye to rhe genrlemcn rhcn residing across the Charles River, rhr reformers of rcchnical education at M[T eventually appropriated the idiom of science to drive a wedge between Harvards genrecl education for the "genrlemcn of science" and the more vocational and shopfloor-orientcd instruction advocated by the mechanics' institutes. In the process of profcssional izarion, physicisis had dropped ropics like hydraulics and mechanics, while engineering advocates appropriated them. Both sanitized their fields from any working-class associarions.[27]

Even if rhc rhetoric of science began to enter the walls of some leading engineering schools, the funds such institutions and the hodgepodge of other engineering schools spcnr on scientific research did not reflect this ideal at all. Shifting coalitions between practical engineers, scicncc-orienter] academics, and curriculum reformers battled over rhc dirccrion of education all over the country in the period between 1880 until rhe second World War. Pecuniary reasons also protracted the ideal from becoming reality. Scientific research at engineering schools would become an option only after 1940 when the tcderal government earmarked large sums for rcsca rch as a result of major warrime allocations." Th« rhcrorical position in mid-century anticipated rather than lollowr-d social reality, yet it served a clear purpose. From Boston to Hohokeu, leading academic engineel-s began severing technical education's inrimare ties to local cornrnunities and shedding working-class roots and its alliance with women's rights' advocates. If in the early years of building an institution most engineering programs admitted a few women as special students ro increase cnrollrncnt numbers, once the educators felt on firmer ground, they started to spurn them as parr ofwhar Margaret Rossircr has called rhe mascuiinivarion of the protessions, Significantly too, the co-cducation.tl land-grant institutions were the first to sponsor horne economics as separate career tracks for women which diverted many rural women, interested in rcch nical fields.[28]

The chicf archirccr of the ideology of"schooJ culture" and shaper of the professional boundaries of mechanical engineering was engineering educator Robcrr H. Thursron (1839-1903). Thursron was descended from the early settlers of Rhode Is-

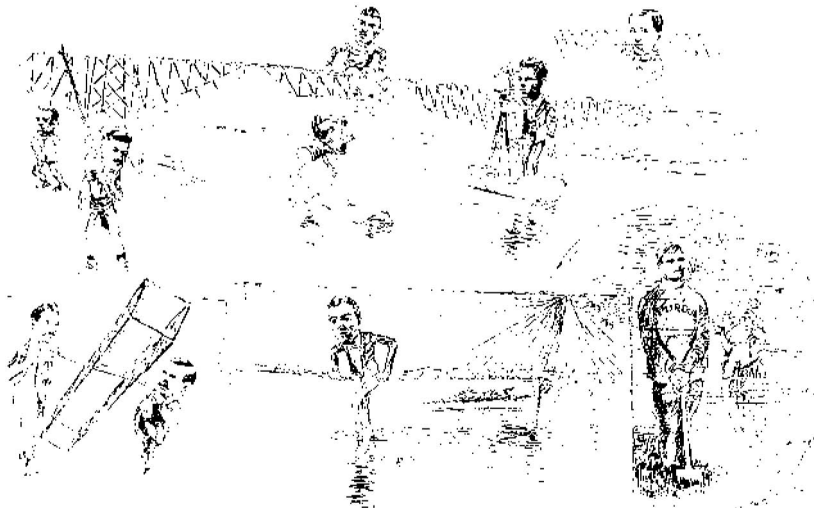


Figure 11. Cartoon Of civil engineering students at the Land-grant insti rurion Purduc Univcrsity presenting themselves as individual bridge builders working in the field rather than as participan[' in large [abor-i ntcnsivc projects. Rcproduccl from engineering class hook *Debris* of 1893.

land as the eldest son of a prominent manufacturer of steam engines, but had no knack for business to follow in his father's footsteps. Instead, he pursued an academic career as a professor at Srcvcns Institute of Technology and at the land-grant institution Cornell University, where he inaugurated the first mechanical laboratory and shop courses in the country, and became rhe first president of the ASME in 1880, and a member of the AAAS. He devclopcd his argument regarding the academic aspect of engineering knowledge ("the application ofscientific theories to the useful arts") in a debate with a Johris Hopkins physics professor, Henry Rowland, who espoused the notion that science rather than engineering stood at the pinnacle of true knowledge. Carving out a space between advocates of pure science and those extolling the virtues of practical engineering as a moral gymnasium, academic engineers like Thursron never grew tired of lobbying for formal rcch nical education as the true path towards engineering knowledge,[29] In the hope of achieving their aims, academic engineers increasingly relied on tactics of profcssionalizarion and adjusted their educational goal forging ties with national indusrrial corporations and visiting local tacrorics with their students.

Neverthcless, gradua rex from engineering schools found rhemselvcs unprepared for the resistance Iron: seasoned field engineers, powerful employers, auto-

cratic foremen, and skilled workers alike, who had little use for academic attitudes and continued to put their faith in knowledge learned rh rough their craft's tradition, their own experience, or existing plant routines, and who accomplished innovationth rough a merhod of trial and crror rather than th rough the scienri fie procedures advocated by the acadcmicians.j l'igure JlJ 'The experienced field cngineer Ainsworrh remembered rhc four engineering students and an assisranr professor from the land-grant institutions Iowa State, Wisconsin, and Michigan Univcrsi tics who had been assigned o n a survey job [o r the Chicago-Missouri and St. Paul railroad in rhe 1880s. Ir was not a happy meeting of work cultures: "'These men seem to think they were our for fun only, and I had to say to them, that it made no difference wheth cr they were from the slurns of a city, o r a State Un iversiry: if they remained in my camp they must behave decently." Ainsworrh coil-eluded: "the work should be done in my way."[4]

Others agreed. "That the professional schools can make engineers is absurd," wrote one reader of the widely read New York journal the *Engineering Neu.s* in 1915, expressing a strong belief in shop-floor knowledge." And even educators had to concede that, "engineers are not made in college." Many agreed that only a "long apprenticeship of practice" marked the true rile of passage into engineering. The engineering student "learns to be an engineer by his posr-graduare course in life, where he is rubbed bright by continual practice."[5] Such instruction in the workplace directly challenged the aurhority sought by engineering educators. Thc editors o f *Engineering dlld Contracting* of Chicago, for instance, quorcd their managing directo r, rhe civil engi necr and scientific management adept, Halbert P. Gillette (b. 1869), who had argued rhar a "complete education should give a man habits as well as ideas and training in logic. The habit of going among men, the habit of studying their habits... [arc]...certainly not less important than a training in science. 1fear they arc, however, the very things that few educators have tried to cultivate in their students."[6] The 'habit of going among men' represented a managerial ideal of engineering that carried a heavy political load. It rhus linked engineering professionalism closely to management and business.

Educational reformers like Thursron who sought to upgrade engineering training faced a dilemma, however. Their form ofengineering knowledge was based on the authority of science rather than on the authority of the workplace where class shaped rhe relations between management and labor. Jn rhc eyes of employers who were supposed to hire their students, academic knowledge did not prepare rliern for the rough-and-tumble realities of the production floors and building sites. Many cngineering educators tried to imitate "the methods and manners of real shop-life" ill college shops that housed steam engines, blacksmith tools, foundries and the like. Here hands-on experience could be acquired while preserving academic ideals. The issue did not turn on machines hut on men, However

well-equipped, the problem with the college shops was that the true confrontation with the attitudes of independent workers and bullying foremen could not be tested. The ability to "handle men" remained the true hallmark of the successful engineer of a management professionalism of engineering. This managerial ideal of engineering balanced precariously between working-class manliness and academic gentility." Work in the laboratory, rhe sbop, and the field, tough jokes, and overalls all added luster to the male rites of passages into the profession. It served not only an educational goal, bur also sought to enhance the prestige ofengineering educarion. 111 these environmenrs, women students were cncouraged to take rnarh classes bur often excluded from taking shop or field trips to factories rnandalory for graduation.

'Ihc balancing act between labor and capital, between working-class manliness and female gelHility found visual expression in the representational strategies of advocates of engineering education, The young California School of Technology chose as the cover of its new magazine the image of Douglas Tildcn's sculpture *Mechanics Fountain,* which celchrarcd the muscular masculinity of working-class men. The sculpture, T'll ich fashioned a fanciful machine correct in mechanical detail (lever, fixed pivot, and pivot link) but with an unworkable design, offered a sanitized vision ofthe union between capital and labor – the idenl that engineering educators espoused. The image of virile working-class men catered to a thoroughly middle-class audicncc, It also featurcd young apprentices dangling dangerously from the lever arm of [he punch press. [Figure 121 Consciously or not, the Californian engineering educators promoted an image [hat was strangely appropriate for the thousands of engineering students who, upon graduation, were desperately scckingentry-level jobs in the tighr market of the 1890s."

As engineering educators were aware, many graduates found themselves stuck in drafting departments rather than climbing the promotional ladder towards full-fledged engineering careers. Educators were caught between [heir own desire tor further formalization to meet the standards of academic colleagues of the sciences and the demand from industry Forpractical training of their personnel, They depended for the most part on the willingness oipowcrlu] employers to aeecp[engineering graduares. To circumvenr such contests over control and eommand in the American workplace and the dwindling opportunities in the American West, academic engineers helped their graduatcs gain practical experience on the building sires of the fast-expanding American empire from Cuba, Panama, Nicaragua to Hawaii and the Philippincs in the aftermath of the Spanish-American war. In a debate over the most appropriate engineering education, hridge engineer and advocate Waddell insisted that Spanish rather than French shuuld he taught because "I am fully convinced that the United States will soon dorninue the foreign lmxincxs of Latin-America: and rh.u such a result must come about primarily rhrough

Figure 12. Academic engineers projecting an athletic, muscular, and working-class but precarious manliness on the cover of the first issue of *The California Journal of Technology* 1.1 (February 1903). Apprentices are dangling dangerously from the lever arm of the punch press correct in mechanical detail but with an overall dysfunctional design. Courtesy of University of California Library, Berkeley, CA.

the efforts of American engineers."[6] For many, the emerging empire becume rhe moral gymnasium Foryoung graduates {() gain entry into the field through the rites of passages outside the U.S. in [he period after 1898.

In the American Sourh, Northern industrialists and philanthropists helped draw racial boundaries around rechnica] expertise during the same per iod of expansion. Many African-American slaves had received technical train ing through apprenticeships that had been used to teach slaves rhc voca tio nal skills needed to keep plantations sell-supporting. Th ey worked as skilled sto ne masons, blacksmirhs, all dinventoıs. Funded by Northem indusrrialisrs, promoters of the New South movement realized that after the abolition ofslavery [hey needed the scores offreed slaves as a new Iabor force to industrialize the South and defuse the hostility of white yOllllg men to do work tainted with the assoc iation wi th rnanual labor. Technical ed ucation for the freed slaves seemed a logical step after Abolirion, but African Americans did not benefit from the allo cations of the 1862 Morrill Act, intended to democratize higher ed ucation for the sons and daughters of farmers and workers. Insread, a coalition of missionaries, freedmen's bureau's officials, and Northern industrialists helped fund separate institutions for African-Americans including the Hampton Normal and Industrial Institute in Virginia (1872), Atlanta University, and the Tuskegee Normal and Industrial Institutc in Alabama (1883) to inculcate a Northern work ethic and industrial skills. Even the revision of the Act in 1890 stipulating that no state would receive federal money if ir did not admit people of color to its land-grant colleges failed to solve the problem because it also mandated rhar the states could provide such an education in "separate bur equal" insrirurions. As a result of the second Morrill Act, sixteen federally supporrcd and separate African-American land-grant institutions and seven stare-run African-American normal schools and colleges were established between 1890 and 1915.[7] Atrican-Americaus were shunned and scnt onto separare educational and employment tracks in the useful arts, but nor the applied sciences.

The additional funds for African-Americans provided separate educational paths towards technical work, carefully redrawing the lines of race when lllallY Southcrn African-Americans started to move to the North in the hope of escaping the growing oppression ill the South. This legislation effectively kept African-Americans from joining the ranks of the expanding engineering occupation. In the hardened racism o f the 1890S, African-Americans relied on scveral strategies to negotiate the narrow space left to them. Ar the Southern black schools, engineering topics were taught under the disguise Of the useful arts, while Howard Univcrsity in Washington DC started a genuine engineering program within its own walls as early as 1912. Individual African-Americans tried to scale the bastion by applying to white Norrhcrn engineering schools including Ohio State University, Yale, and MIT. The tactics to train African-Americans for technical fields was at least sue-

ccssful enough that by 1927 a newly established engineering organizution, the National Technical Association, could boast 125 academically trained members. Even though they were engineers by training, it is significant they were careful to avoid rhe term and instead chose to identify themselves as technicians. Similarly, for African-Americans, the mechanic arts might have been useful and profitable, but they were not allowed to be termed applied science." The African-American leadcrs Booker T. \Xfashington and W.E,B. Du Bois disagreed on what strategies to follow in this atmosphere of hardened racism duri ng the 1890s. The Southeru ex-slave \WashingtoJl opted (or a tactic of camouflage by which he mobilized the rhetorical positions of the useful arts for his own use. To the younger Harvard-educated Du Bois, true liberation would succeed only if African-Americans had the right to be Shakespcare scholars and enginccri ng professionals o n the same terms as whi res.

REVITALIZING MAJ.E AUTHORITY ΤHROUGH PROH,SSIONALIZATION

At the end of the nineteenth cemury pressures for inclusion came from all sides: labor, women, and African-American advocates all demanded their place. Through the language of the medical model of professionalism advocates of engineering recast a male middle-class discourse o f rcch nical mastery and contra1 that had also been part of the parria rchal cu lrurc of b usi ness model o f professionalism. The firs[contest of class identity between the advocates of [he shoplloor and those of school-culture sociaiizarion had been limi red to the establishment engineering. The second challenge to the reproduction of old patterns of male authority betwccn cstahlishmcnt engineers and the rank-and-file was fought in terms of different models of prolessionalizariou. Academic engi necrs, cuginccring advocates. and establish men t engi necrs employed rhetorical strategies and coined new words to support these efforts. Their border disputes with other workers grew out of a small eli re's efforts to establish professional organizations which reflected a larger movement of profcssionalizarion also witnessed ill many other spccializarions like law and medicine.[N]

As an occupation, American engineering both resembled and differed from other new professions because it was a divided house rhar was never able to establish the classical gatekeeping mechanisms like licensing laws, uniform education, and crcdentiall ing, other professions were able to mobilize. The conflicts over rhc true path towards an engineering career came to the fore in a battle over [hc kind ol professional model engineering would rake, As engineering transformed into a mass occupauon and leaders tried to control the process, three professional models competed for prorni ncnce in the first half of the rwcru ieth ccn tury. Business lead-

crs and establishment engineers working for private business patronized a professionalism steeped in management ideals of command and control. It had an ideological base in the shopfloor culture of the Eastern industrial establishment and had been reworked to suir the circumstances of industrial capitalism.

By contrast many academic, consulting, and urban engineers supported a professionalism modelled after the medical profession's emphasis on autonomy and ethics that would keep a distance from the business ethics of profiribility, Rank-and-file engineers rejected both management ideals and ethics; instead rhey focussed on employment servi ces, working condirions, and pay through separate engineering unions and bargaining un irs witliin blue-collar unio ns. In acceptance speeches, professional journals, and anniversary banquets, engineering advocates began to claim infinite expertise in aspe cts and directions far beyond purely technical knowledge, bur they simultaneously expressed the need to establish clear and unambiguous boundaries within an occupation where anybody from the boardroom and the research lab to the drafti ng department could claim to be engineer. Engineers engaged in different forms of boundary work because [hey did nor succeed in drawing on the classical gatekeeping mechanisms of the other professions. The csrablishrncnr of the early occupational organizations provided one means for developing rhe much-needed sense ofuniry that engineering lacked. These organizations helped to fix firm boundaries at points where they seemed particularly porous. In 1867, the older generation of civil engineers had established the firsr professional association (ASCE), which sheltered older, wealthier, and conservative members and upheld exclusionary requirements for new members for many years to come. In response to these elite organizations, more inclusionary local organizations that could better deal with the regional working conditions and welcorned young graduates sprung up everywhere in the urban ccntcrs of Pittsburgh, Chicago, St. Louis, San Francisco, and many other industrial cornrnun iries. In San Francisco, rhe Technical Society of rhe Pacific Coast served as a focal point for engineers as far as Hawaii, while rhe Cleveland Engineering Society tended to the local politics of the city's reform mayors. By 1915, onc observer estimated that about 20,000 engineers had banded togethcr in local clubs and the same number in nario nal associatio ns. These in itia tives we re so successful that wirh in thi ny years, 200,000 engineers had organized themselves in national societies; another 12,000 belonged to state associations, 27,000 to local ones, and 72,000 joined engineering honor societies and fraternities.[12] Many held multiple memberships, knitting the growing frarerriiry rogcrher rhar came to carve out an important niche of male middle-class identity, authority, and values. Professional organizations played important roles in setting occupational boundaries on both edges - upper and lower.

Just as America expanded its industries westward and onward into countries in South America and the Pacific and the field of engineering became a mass occupa-

rion in the process, engineering advocates left no scone unturned to define and restrict the field in thejr struggle for profcssiona l standards. In rhci r efforts to clarify the social boundaries of their occupation, they often defined their identity in exclusionary terms. Insrcad Of specifying wh ich skills warranted the title of engineer, their definirions cenrcred on those who failed to qualify *For* certification as an engineer and should therefore be excluded from the field. For example, in support of the new constitution of the American Society of Civil Engineers (ASCE), Hcrrnan K. Higgins, who had worked for the railroads tor many years in the U.S. and had reached the level of an assistant engineer on the politically tainted, ill-managed, and malaria-plagued Panama Canal project, forcefully argued in 1907 rh.u "the definirion of the term engineer should exclude the surveyor pcr se." Higgins' call for a clear professional boundary came on the heels of a major reorganization of the demoralized labor force and engineering staff ar his workplace in the Panama Zone after the management structure of the railroads. Lead: ng urban engineer) ohn A. Bcnsol (lu863), who had been formally educated at Srcvens Institute ofTechI1ology in the 1880s and practically trained on site in urban building projects such as water, sewage, and tunnel construction in New York Cicy, seconded Higgins a few years later. As the then President of the ASCE, Bensel, warned that "in our accomplishments we are not to be measured as skilled artisans bur the fact remains that...society at large does so rate us." In like manner, another member of the engineering establishment deplored in 1910 "the loose manner in which the term 'engineer' is applied to men in many dcparrmcnrs of work, and often appropriated by those who have no proper claim ro be so called." In 1917, the editor of *Engineering and Contracting* in Chicago offered some practical advice on how to curb the "usurpation of this professional title by mechanics," proposing that both railroad officials and unions be persuaded "to drop the use of the word 'engineer' as a designation oflocomonvc-drivcrs," and endorsing those who spon-sorcd licensing laws for engineers, He expected that such legislation would be the most effective instrument in restricting the free use of engineering titles.[4]

Champions of protcsxionalization of the electrical industry took similar rhetorical positions aimed at exclusion. In the 1880s, there had been no oflcnsc in calling businessmen-engineers like Alexander Graham Bell and Flihll Thornson elccrr]-cians or telegraph operators. To pur an end to this practice, the newly established professional organization, the American Institute of Electrical Engineers (AIEE), interfered linguistically with the introduction of the term "electrical engineer" as the field became reo crowded. Thomas l.ockwood, a long-ti me telegrapher, explained to the members of the AIEE in 1892, for example, rh:« the term "clccrrical engineer" had been adopted when a great number of people called themselves clcc-rricians and "the word [electrician] fell inro some disrcpurc." He recalled that, "ir was necessary to coin another and more euphonious one," and also pointed to the

irony that "thus it came about that before we had any institutions for learning in that line, we had electrical engineers."[45]

For similar reasons, leaders in the chemical industry like Arrhur [). 1.irrle introduced the new term "chemical engineer" to enhance their professional identity. In the case of chemical engineering, this act grew out of deliberate attempts to offset the inadequate pay, low status, and lack of promotion of chemists - Illany of whom were women who worked in corporate research laboratories. Chemical engineeri ng advocates like Arrhur D. Litt le were determined to distinguish themselves from ill-paid research chemists and analytical chemists. Chemists earned considerably lower wages because their work in chemical research and resting labs was often routine. monotonous, and dangerous. These chemical research jobs offered white men few opporrunirics for promotion to move up and out of these unpleasant working conditions, although it did provide the tew opportunities available to women and African-American scientists. When asked by the Woman's Bureau after rhc first World War, Little asserted that chemical research offered excellent employment oppo rtu nities for women, but he rejected these occupational models for men. To offscr the problematic rcpurarion of chemistry work, Litt le and other founding members of the American Institute of Chemical Engineers (est. 1908) deliberately associated themselves instead with the production process and with male management after Taylorite fashion rather than with industrial research dcparrrncnrs or academic science."

Thus, the semantic shift from chemist to chemical engineer established an alignment with management rather than with science work. The shift was not a rhetorical construct alone. It sealed a professional struggle that was ill part political. It linked chemical engineering to the patriarchal aurhoriry of business and management practices in a time when the chemical industry was consolidating into large corporations. As a consequence of this intense boundary work, chemical engineers could become plant managers rather than [ab technicians.

Engi neeri ng refo I'mers sharcd many of the same profcssional and class ambitions as lawyers and doctors, but there were also impnrranr dillcrcnccs between them. If doctors and lawyers serv ed largely unorganized clienrs, cngi ueers faced the formidable force of powerful political and corporate organizations.[4] Engineers faced the challenge of mastering both the ability of businessmen to offer tangible proof of their trade's worthiness, and the knowledge and skill of rhc specialized workers whom they sought to manage and on whose cooperation rhcy depended so considerably. Their managerial demea uor acquired a more disranr style when they supervised contractors and gangs of corn mon laborers like the Irish diggers of the North American canals, the Italian masons and the Chinese tr.ick workers in railroad construction. or African-American convicts in both industries. In i hix workplace context, the engineers with managerial skills were understood to be

male and white, as a matter of course. Increasingly engi ncers found themselves nor merely caught in the middle negotiating a narrow space between labcr and capital, bur also acted as an active and self-conscious constituent of a middle class in formarion, Engineers remained distinct in that they straddled the capitalist fence between the interests of proprietary firms, large corporations, and political machines on the one hand, and skilled and unskilled workers on the other. "The rcchn ical man," wrote one engineer in an engincering advocacy journal in 1918, "will join with neither capital nor labor bur stand upon professional and correct ethical principles."[3]

This position in the middle turned out to be an increasingly tenuous one, In December 1917 when the U.S. had entered the war and many in the profession began to articulate their worries, the chief enginecr of the Indiana Public Service Commission, Ono H. Garman (b. t880) fashioned the ideal of successful engineers in politically loadcd sartorial subtleties. "I.et me say it is all right to wear the overalls during the day, but have a different suit of clothes and use fine soap and water before going home in the evening," he advised his enginecring eollcagucs,[4] Educated at land-grant insrirurion Purdue University and employed as an urban engineer connected with the urban management movement rhar sought to circumvenr local politics, Garman projected an ideal world where engineers deftly shurtled back and forth between [he world of work and leisure, building sire and office, working-class and upper-class, labor and capital, and men and women. By donning the proper garb, engineers could hold these opposing domains together, he believed. Garman belonged to a group of city managers who rnaiurained tenuous relationships with corporate leaders, who sought to wrest control of cities from rhe working class and the political bosses, and who worked for the kind of issues advocated by the many women's clubs pushing for civic improvements. During the 1910s, this middling position became idealized in the notion rhat engineers occupied a unique and privileged space between labor and capital. [Figure 13] Ior patrician and urban engineering reformers like electrica] engineer Morris Cookc, the on ly guaran tee of preserving independence in rhe midd le was thro ugh rhc tactic of classical professionalism, with its emphasis on autonomy and ethics, shedding, like the rhetorical strategy of technology, its working-class, classic blue-collar associarious. However, this precarious position was rather idealized and nor attainable for all. Garman, Higgins, Bcnscl, Cookc, and other advocates of an engineering professionalism that emphasized ethics and esrhcrics represented only a minority.[5] [Figure 14]

For rank-and-file engineers the ubiliry to mai ntain this middle ground involved much more than donning rhc proper garb. They sought an engineering professionalism less preoccupied with ethics than with bread and butter issues including pay scales, medical insurance, and vacations without being associated with blue-collar

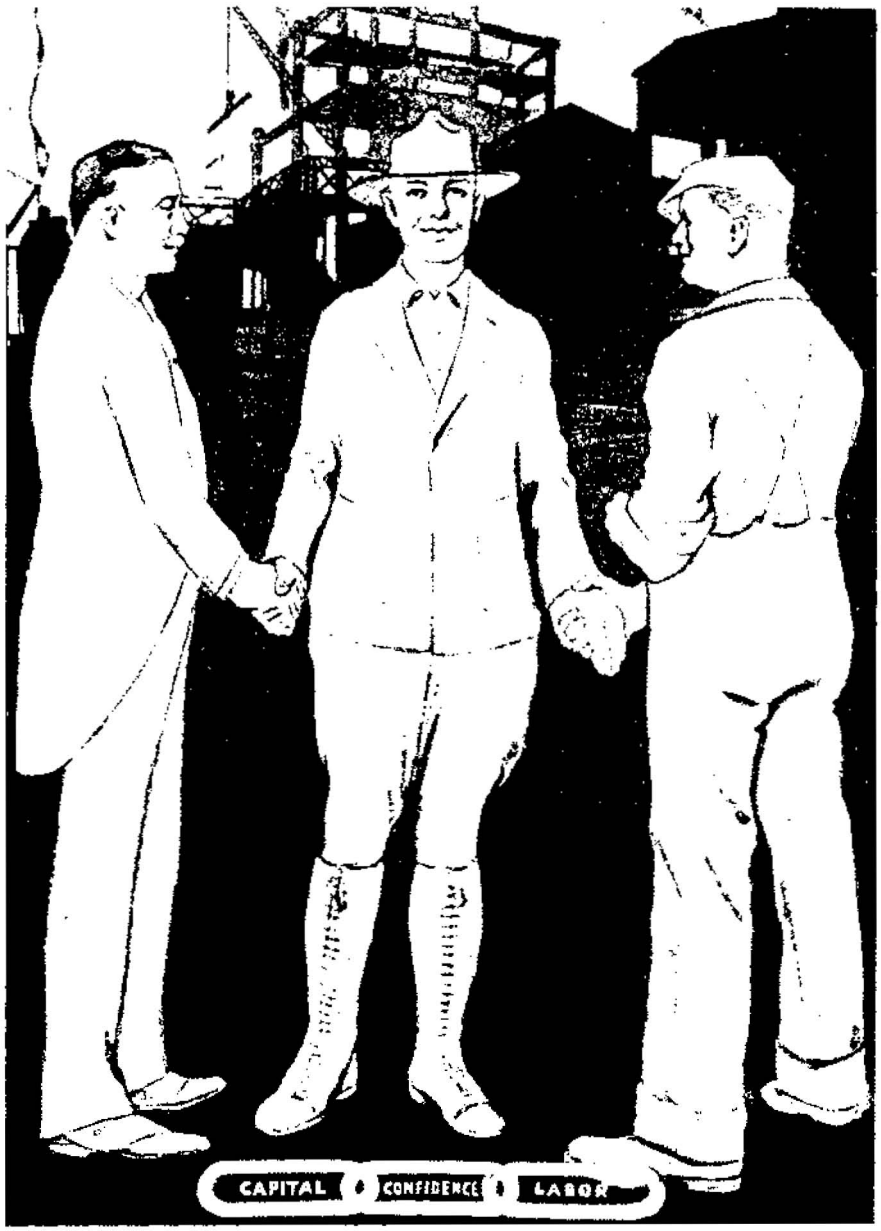


Figure 13. Idealized engineer in a Veblenesque position of Confidence between Labor and Capital published in the engineering's advocacy journal, *The Professional Engineer*, (1924). Note the archetypical but subtle sartorial distinctions of head and foot gear.

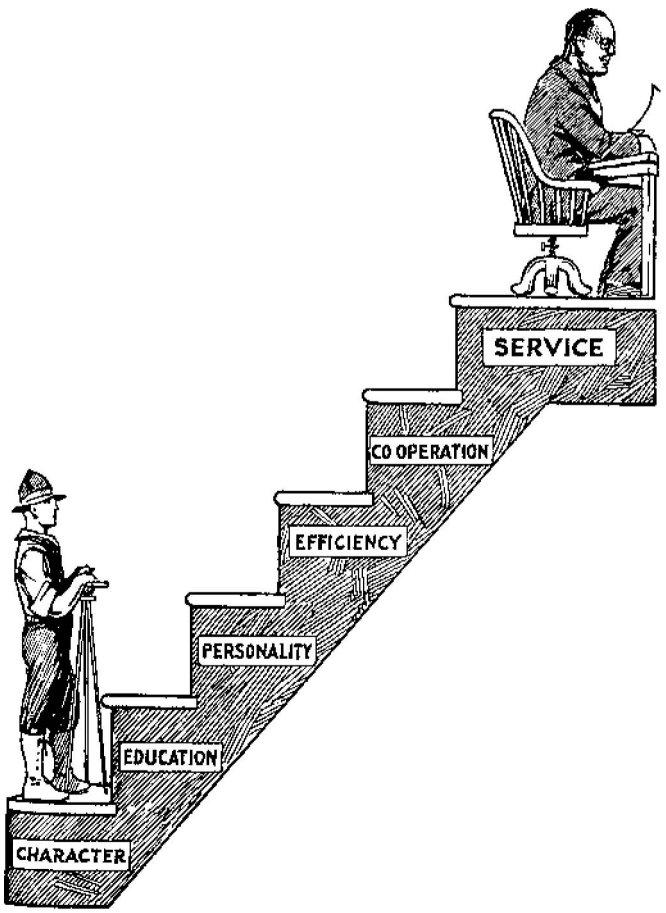


Figure 14. idealized mal,' path of promotion Irorn surveyor Oil the building site to a manage-mcnr position at the corporate office when all was not well in the profession. Rcprod uccd from *The Professional Engineer* (January 192J).

unionism. Their professionalism was neither modelled after the business cornmu-niry nor after the medical occupation. Whereas engineers seeking management profess ionalism saiv themselves p rimari ly as prop rietary-managers and the refo nu-crs viewcd th emselves as city ma nagers or academics in public and un iversi ty em-ploy, rank-and-file engineers came to accept their xtatus as employees.

Worrying about the worki ng and social conditions, rank-and-file mechanical engineer Norman Mcl.cod (b. 1879), the son of an Il-ish immigrant father and a graduate from Corncll with work experience at the large clccrrical corporations, expressed the scnrimcnr of scores of orhcrs who laborcd on the lower rungs of the occupation at the beginning of the century. In the same year thar Garman pro-

posed his sarr o rial pol itics, McI.eod scn t a letter to the newl y csiablished Am erican Association of Engineers (AAE) to express his frustra rion wi th the society's leadership, ft might be vcry well for the ME to talk about raising ethics and status, he wrote, but instead of blaming engineers for the wo rk ing conditions, he believed that "The ignorant capitalist...is the place to begin [raising ethics] and nor with the engineer." The spec rcr of a me dical model of professionalism, wi th its emphasis on raising standards and ethi cs, might be a prom ising tact ic for engineers in improving sala ries bur, M cl .eod warned, rhe organi zation failed to address rh« more basi c need of finding engineers jobs: "Do not continue to adv ertise en giuceri ng stude n ts and practi cal men 'for positions at sm all salary with the prospect of adva nce-ment.'" Mcl.eod, who had been trying to find a job on his own tor two years when the U,S. was preparing for war, wryly concluded his letter: "This advancement usually comes when the man is dead."[18] Another letter writer agreed with Mcl.eod's sentiment that rhc patrician leaders' emphasis on ethics was out of touch with the daily concerns of most engineers at rhe bottom rung of the profession. He employed a military and engineering metaphor to ventilate his anger and charged: "If you are going to raise the standards of ethics very much higher, you will have to provide it with an oxygen rank so that it does not start frorhing at the mouth, What you need is an organizarion provided with 42-centimeter anti-aircraft guns to puncture the bag of ethics and hring it a little nearer [o the earrh.)ust now we are so full of crh ics char there is no room for your economic and social welfare stuff."[19] Thus the cngineeri ng rank-and-file had different priorities than their more successful brothers at the top,

Many historians of the profession, however, have preferred to study the concerns Of Garman and his peers rather than those of Mcl.cod.' They regard Garma11's search for star us and for profess io 11al autono111y as a classi c expressio 11 0f middle-class aspirations resulting from responses to social pressures from above. In this view, the process of profcssionalizurion functioned as a mechanism by which engineers attempted [0 appropriate their status mainly from their social superiors or competitors - a status that could be shown by donning fine business suits and maintaining clean-shaven faces. This interpretation should come as no surprise given the choice of sources to wh ich most scholars have resorted in mapping the terrain. If one thumbs through the pages of professional journals and takes the words of arriculnrc establishment engineers at face value, rhe expressed anxieties about status can easily be seen in terms of rhe relationship between engineers and their superiors. To be sure, csrablishrncnr engineers like Garman dealt in their daily work with a host of businessmen, scientists, and politicians on whose power and favor they depended for employment and recognition. But rank-and-file engineers often felt the pressures from below, as Mcl.cod insisted. The danger of being dcclasscd always presented a rhrea t - a risk that entailed having to replace a white

Figure 15. Many engineering graduates final destination was corporate drafting roorns like this one at the Baltimore and Ohio Railroad in 1899. Courtesy of Division of Engineering and Industry, National Museum of American History, Smirhsonian Insriiurion. Washington, DC.

with a blue collar and facing the peril of falling off the pay scale into the trench." McLeod's concerns serve as a reminder rhar middle-class solidarity of American engineers did not result from contests with politicians, businessmen, and scicn nsts alone. Most rank-and-file engineers articulated their sense of middle-class cntirlc-mcnt and privilege ill a contest with those they encountered on a daily basis in the workplacc, like accountants, chemical analysts. drafrsmcn, surveyors, electricians. telegraph operators, common laborcrs, migrant miners, and skilled mechanics.[1] Unlike in Hrilain where enginecring was more closely hound [() the culture of family businesses or in France where its rn.uhcmatical and theoretical oricnration linked the profession to the state and to science, in the U.S, boundaries on both edges - upper and lower - defined the very fabric of American engineeri ng identity, On the lower edge of the occupation, the struggle of rank-and-file engineers with skilled and unskilled workers - subordinate or competing - equally shaped their unstable middle-class identity.' Thus, a crucial hut neglected mechanism of the engineers' identity also stemmed from the dynamics in the workplace. 1t sought to reproduce a distilledy male, white, and middle-class idcnriry for a new era,

BROKEN PATERNAL PROMISES OF PROMOTION

Despite the considerable sociological and historical literature 0 n the subject of professionalizarion, younger and rank-and-file members thus felt more concern with personal oppornuiirics for promotion than with professional ethics or ideals of national progress. Rank-and-file engineers like Mcl.cod had little interest in professional auronomy and found their way to the AAE because of its employment services.

The fine lines between engineers and blue-collar but increasingly also white-collar workers came to fashion engineers' distinct American middle-class identity. Between t910 and 1930 when businesses merged and consolidated, the opportunities for promotions in large corporations dwindled. This thereby jeopardized rhc paternal promise of promotion that had been essential when engineers belonged [() an elite. The vast majority of engineers - young graduates and rank-and-file seniors - found themselves doing routine, monotonous work as surveyors, draftsmen, tracers, copyists, and calculators in drafting departments bch:nd desks, wirh little hope of advancement, as one young graduate observed at the American Bridge Company ill Philadelphia. Like so many other big firms, the company employed thousands of drafrsmcn who designed, traced, and blucprinrcd bridges from New York to Uganda. Robcrr W. Shclmire (h. 1881), an engineering reformer and municipal engineer at rhe Bureau of Design in Chicago, was very concerned with the possible explosive nature of the issue. He stated the unspeakable when he said: "most of the young men are draftsmen. Even competent engineers alxo arc draftsmen. [f the tru th were known, one would probably find that the bulk of the entire profession were leaning over drafting tables."[4] [Figures 15 and 16] To be sure some engineers still adhered ro the managerial or classical professional ideal and

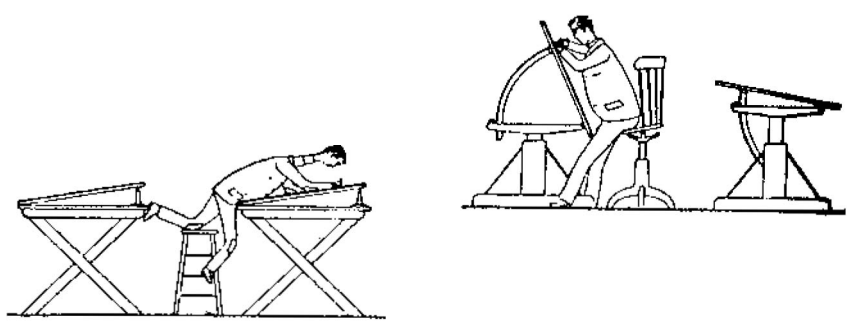


Figure 16. Drawing illusuaring rhe rough working conditions and long hourx of most draftsmen leaning over drafting tables. Reproduced from *The Draftsman* (1901).

worked as proprietors, entrepreneurs, managers, consultants, and professional expert witnesses, but the majority worked in the employ of others as drafrsrncn. tracers, blue primers, or lab assistants. "The engineer as a rule works for someone else, and is not his own boss unless he is so fortunate as to be able [o engage in private practice," as OIIC commcnraror remarked in 1917.[11] These working conditions were not limited to rhe field of civil engineering. Few mining engineers worked as operators or had jobs in managerial positions, as the idealized images of popular writers would have it. Many earned their livelihood ill claims offices from the anthracite district in southeastern Pennsylvania ro the coal and silver mines in the northwest region of Coeur dAlcne in Idaho. The increased divisio» of labor ill engineering work meant rhar young engineers found rhcir upwards path cut off. For instance, about 2.0 percent of mechanical engi nccring students who graduated before 1896 eventually became members or partners in a firm. That number rapidly dropped to ten pcrccnr in 1904. "It is doubtful if 10 per cent of graduate engineers become engaged in business for themselves, either as consulting engineers or conrrncrors", one contempory asserted. ,(At the same time, the number of graduates who became or remained draftsrnen increased, This was the other side of the increased division of labor and segmentation.[12] As the oPportunities for entreprencurial ventures decreased, large corporations began to hire lower middle-class youths and some well-trained middle-class women for low-level jobs, resulting in shifting pa[-[erns of mobility.

By the 1910s, the engineering occupation showed serious poinrs of tension between established engineers and the vast majority working in large corporarions many of whom were drafrsmen working as copyists, tracers, blueprintcrs or designers. The frictions were not new; they had existed throughout the history of engineering. In earlier times when discontented with the establishment's busincss-as-usual a[(irude, individual engineerx had refused to pay thcir dues for professional organizations while mining engineers in Colorado seriously contemplated joining the unions.[13] But for a long time these conl]icts never took any organized form. This friction became articulated and organized only in the 1910s and 1920s when engineers faced the increasing consolidarion of businesses into large corporations in the aftermath of the first World War.

Ill the ensuing confrontation, engineeri Ilg idcnrity became most ideologically cxpl icit in a variety of orgunizarions and also found articulation in the politics of the workplacc. Shclmire, learning his engineering skills through correspondence school and pracrice, warned jusr after the firsr World War, "Engincers have been raisi ng themselves as it were by kccping the drafrsmcn down. Naru rally draftsmen have become discontented; hence the prevailing and narionwidc unrest in drafting rooms."[14] In the aftermath of the first World War, the discontent of engineers in low and rnidlevcl positions interested in bread-and-butter issues and the criticism

of patrician reformers who pursued a classic form of professionalism led to a temporary bur powerful alliance both in the American Association of Engineers (AAE) and in its predecessor the Technical League, Under the leadership of patrician reformers CD, Drayer and F. Newell, the AAE attracted some 22,000 members in 1921, about 15 percent of the profession. It not only pushed for a code of erb ics, a major concern of the patrician reformers, but also campaigned for licensing requirements and a salary scale for engineers. In 1909 its predecessor organization, the Technical League, had already launched ;1 direct attack on the limircd opportunities for promotion and the cxclusiounry policies of the fraternity of the American Society of Civil Engineers (ASCE).

Weleoıı ing the establishmcnt o f the' j ech n ical League in 1909 "wi rh delighr." a young engineer from Ncw York City then wrote: "let us no longer disguise our poverty under a mask of dignity." Younger engineers, he asserted, "can expect very little encouragement from the generals of the profession who are mainly responsible for the conditions in which the young engineers find themselves.' Most engincers were "herded together as thick as the size of the room will permit with no other accommodations than a rough table or part of it, a stool, and a drawer."

Even ifmost no longer expected to set up their own firm. it was a true affront to the engineers' self-esteem and manhood to be treated as if they belonged to the class of clerical workers, like bookkeepers or low-level clerks. Worse still, this junior engineer implied that because engineers did not have unions to prmecr them, the senior engineer in charge "generally exhibits less respect tor the individuality of rhe young engi ncer than for that o l'a mechan ic who has the ma nhood to rell him what he should be paid and how many hours he is to work."" Hc acknowledged that although a ceiling prevailed for the relatively high salaries of mechanics. by contrast, the wages of engineers had no roof But here lay the crux Of [he matter. .Ihe viability of promotion and the ability to move through the ceil ing of the wage scales wax very much in question. "The proportion ofadequately paid engineers to rhe roral number engaged ill the profession is so small that, unless he be a genius," the disgruntled and indignant engineer stated, "his opportunities for earning a comfortable salary even at middle age may be considered extremely lirn ircd.' An editor ofa drafrsm.ui's journal in Cleveland, Ohio warned that draftsmen who did mental work bur whose employers paid and treated them as workmen were most envious of the "better paid union workmen in the machine shop." The editor offered the tactic of drawi ng linguisric bo ıı nda ries aro und the drahsmcn's occupati()n by reserving the term enginccr for the "draftsman who is a responsible designer, and whose work is as truly to be ranked with the work of professional men as that ofengineers in any other capacity" at the expense ofcopyists and tracers who "mighr better their siru.uion by trade un ion mcrhods." A chief draftsman "is in reality a conxtruct inj; engineer," pontificated another."

To counter the overcrowding of the engineering labor market, young and formally educated engineers pushed for licensing legislation and succeeded in sponsoring the first law in Wyoming in 1907.[m] The strategy of licensing as a way to limit the access to the labor marker had been highly successful with other aspiring professional groups like lawyers and doctors, bur as the editor of rhe liberal *Engineering News* retorted, such comparisons did nor apply because "doctors and lawyers are almost invariably independent operators; they neither hire nor are hired by their colleagues. Ellgincers. On rhe contrary, in their early years, and sometimes all their life, are in the employ of other engineers, and this brings up the eternally disturbing relation of master and servant." Engineers' direct dependence on the workings of industrial capitalism made them more vulnerable and less protected than lawyers and doctors. Generally sympathetic to the grievances of young engineers, the editor conceded that unionization would be an effective way to safeguard better pay and working conditions, but argued that rhe solidarity of workers which buttressed the strength of unions was precisely the point where engineers differed. Although unionization mighr financially benefit engineers in general, he thought it would void the promise to the individual engincer of becoming a manager: "If such a subordinate [junior engineer] ever expected to become a commander, he will hardly join a society the end of which will be the establishment of a lower grade of engineers, where the salaries to be sure, \Vill be higher than ill the lower grades now, hut whose members must remain at this slightly elevated lcve] with small hope of advancc.?" A[the heart of the self-esteem of engineers, as the young aspiring engineer and the outspoken editor understood it, was an acceptance of low pay and middle-class solidarity in exchange for the promise of promoiion and the opportunity to become a commander or a captain of indusrry.

Thus, the promise of promotion expressed a paternal pledge betwccu junior and scnior men of the midcilc class, albeit one severely rested and frequcntly broken in the first half of the twentieth century. This broken promise made eminently clear the very tenuous "middling" position in which the majority of junior and rank-and-file engincers found themselves. In an article entitled, "What is Wrong with the Ellgiuecring Professinn?" a civil engincer assessed rhc great Jisconrenr among engineers in 1915: "The great body of engincers ...arc on a par with the artisans, and there is small distinction between the ordinary draftsrnan or field man and the mason and mechanic. This is forcihly brought home by the facr that the wages paid to each are practically the same."[n] For engineers on the periphery of the occupational hierarchy, the prospect of further advancement greatly dirninished and caused great anguish. They expressed their anxieties by evoking images of slavery. Such characterization was an exaggeration, to say the least, but il did reflect the false image of mastery held our by the "commanders" of the profession

who resided in corporarc boardrooms to the bulk ofyounger and rank-and-File engineers who were leaning over drafting tables.

'The cvocations o f slavcry, howcvcr ovcrsrared, had rheir bearings on the trend of declining engineering wages. Before the second World War, local markets had depended 011 a variety offactors including the price oflabor, the particular industry, and material resources, and the infrastructure largely determined wage dilTel'cnrials. But even if wages varied according [o locale, xpcciaIiz.uion and industry, on average, wages had been higher throughout the nineteenth century. In the middl« decades. civil engineers had been among the highest paid railroad employees, Milli Ilg engineers conrinued ro earn high incomes, particularly between 1895 and 1914 - the Golden Age of mining - when American engineers with experience in the mining practices of the western United States were ill great demand horh at home and abroad from Chili to China, Furrhcrmorc, the discovery of precious metals deep below ground in countries likc South Africa rcsulred in a plethora of job opporrunirics. Chemical engineeri Ilg salaries tluctuared moxt often, whereas civil engineering pay tended to be lower but more stable. Rcgurdlcss of rhcir specialization, young engincering graduates would start their first job on the same salary At the beginning of their training, civil engineer trainees who worked as rodmcn received the same pay as common laborers, while [he lower assistarn engincers stood to earn slightly morc [hall skilled lahorcrs. But the wage differentials could become quite substantial as the engineers entered their rhirries and had worked for about ten years - the very momcnr yOUllg l'ngineers tended to get prornored." 1f they managed to clirnb the promotional ladder, successful engineers earned very high salaries. Only a few managed to command such generous incomes, however,

Engineering wages - and Ihis bccnm«a sore point f0r engineers - declined proponionally to other professions with which they competed for social standing. lrom 1')29 to '954, a period characterized by economic booms and busts, available data inciicarc that the average pay of engineers declined in relation to doctors' ineome alkhough it srill remained wdl above that of college tcachers. 'Jhe decline in wages occurred when the profession enjoyed considerable prestige and when public opinion polls regarded engineering as one of the most desirable careers for a young man. Ar the same time, the enginecring establishment continued to lobby for more funds (01' technical education, arguing that a shortage of technical personnel was near at hand which thrcatcncd to stunt national economic growth, 'The warning of an irnrninenr shortage was nor borne out by the continuing decline of engineering wages, however. More importantly, perhaps, their claim symbolized their ongoing push for public recognition and professional prestige insrcad of a realistic assessment of rhe nariou's needs. In the twentieth century, especially alter [he second \World War, engineering wages decreased more sharply relative to the

Figure 17. Cartoon "Hang on" expressing engineers' anxiety of unemployment and sense of precarious position between labor and capital in the post-war depression. Reproduced from *The Professional Engineer*, journal calling for better pay and promotion opportunities during the 1910s and 1920s.

income of other salaried employees.[69] Clearly this was not slavery but to those men who had been promised a place in the middle class it felt that way.

Thus, behind the continuing worries about pay scales lurked a more basic fear of being declassed and demasculinized.[Figure 17] When the federal government decided to recruit women for the war economy, a 1917 editorial on comparative wages singled out the following: "our government is paying typists direct from business college $100.00 per month. They are paying experienced tracers on electrical and mechanical design, $75.00 per month; general draftsmen, $100.00 per month; experienced detailers $125.00; and engineers with training and experience for responsible designing, $150.00." Spokesmen of the chemical industry "blushed" when a 1921 *Herald Tribune* article hinted that chemists might be classed with char women and laborers. The message was clear: the promise of upward mobility would turn into a joke if typists just out of school earned the same

or even more than aspiring engineers. On the way ro upward mobility from draftsman to engineer ill responsible charge, one had to leave behind rhe office where the typists spent their days. Similar precarious boundaries had to be mainrained between engineers and working-class men, if engineers "had any chance for being raised out of the class of high grade mechanics among whom he now accepts his place." In a more joking fashion, municipal engineer M.Y. Crowdus at the City Engineers' Office in Nashville, Tennessee, vented his anxiety about the wage level of engineers when he offered a rhyme to his engineering fraternity: "It gives my heart a painful wrench/ to know the fellow in the trench/ 'j'har I designed, draws in three days/more than my *weekly* striving pays.*pr.*,

Although money accounted for a large part of the disconrenr voiced by engineers, the issue had a direct bearing 011 the engineers' self-image and served as a living proof of rhe viability of upward mobility. Lacking the gatekeeping mechanisms of uniform licensing or education, the defining process of engineering took place in contests with other men and women in the workplace, where the space for negotiation continued to narrow. The decline in wages seriously challenged the dignity, self-respect, and expectationx ()fengineers.

While the urban workshops of Philadelphia and rh« expanding fields orthe empire of American industrial capitalism had been a moral gymnasium 1or male socializarion for men ofTaylor's class and an curly generation of young graduates of newly established engineering programs, the boundaries between white-collar and blue-collar work grew porous in the large corporate bureaucracies after the first \Xforld War. Thus, a dual peril lurked behind attempts to preserve an engineering identity as it became burcaucratized on the one hand, the danger of loss of status, and on the other, the threat to middle-class manliness. The majority of engineers began to acknowledge this rhrcar as the gap narrowed between their wages and those of skilled workers, to whom they considered themselves superior. The danger of being declassed, therefore, presented a frighlening prospect to an engineer's sense of identity. Yet when radical rctor mcrx put forth the possibility of unionization as a way our, the idealized image proved a major obstacle. 'Ihe young engineer, who had been so critical of the "commanders" of the engineering field, keenly observed the dilemma: skilled mechanics had unions to protect their manhood, but engineers lacked such lobbies because rhey continued to believe in individual distinction rather than economic solidarity. In effect, the belief in promotion prevented them from joining or forming unions. As one engineer wrote, "there is no halfway landing. All dlgi uecr is either a professional engineer or a union man - he can't be both."" In the aborted movement of the AAE from 1915 until 1925, engineers like Garman and Mcl.eod had argued over what direction the organization of engineering reform should take. At the end of a period between 1870 to 1920 when engineering became a mass occupariou, most American engi-

ncers preferred a male professional identity, however symbolic, over conventional, blue-collar unionism. Unlike their British counterparts, they could differentiate themselves from manual workers because of their access to schooling and the promised management positions, and from women engineers, technicians, draftsmen, and chemists who labored under various job titles often masking their high education and training, But that middle-class identity could only be tenuously maintained.

MAKING TECHNOLOGY A MASK FOR DISUNITY

Engineers had an almost knee-jerk aversion against blue-collar unionism, even if during the downturns in the engineering labor market during the 1930s and 1940s their middle-class loyalties were severely tested. By the end of those decades. many engineers had accepted their employee status. New engineering organizations sprung up in this period between the 1930s and the early 1950s. In the 1930s depression, those engineers who were able to find jobs saw their wages decline by a third, while 34 per cent of their colleagues experienced bouts of unemployment. Unemployment hit 20,000 chemists and chemical engineers in New York City. In Cleveland, Ohio, 1,400 of the 4,500 were out of a job; some of them were sent [0 farmland outside the city to "cultivate truck gardens, raising crops for their own use or for barter."[4] The government-financed construction spree amounted to $6,500,000,000 and was responsible for tunneling mountains, damming rivers, laying aqueducts, digging canals, restoring national landmarks, clearing slums, and building school houses. For engineers who had been clinging to their male middle-class identity finding themselves digging trenches was a true affront that demanded marshalling all their psychological resources in these times of economic bust, One married mechanical engineer with seven children, who dug ditches for the Civil Works Administration in 1935, wrote anonymously of his adjustment to blue-collar work: "The biggest thing to learn is to bring your mind down to the ditch." [5] Nevertheless, he was fortunate to be digging at all. Nora Stanton Barney, a feminist and civil engineer, correctly pointed out in 1933 that the Roosevelt reforestation, highway, building, and reclamation programs were all closed to qualified women of her generation. Moreover, the National Recovery Board still specified lower minimum wages for women than men while mobilizing men at lower wages far away from their homes, leaving women to head their households."

In response to the economic crisis, independent and self-employed engineers resorted to the classic tactic of licensing that had proved to be so successful for the medical profession in an effort to protect the engineering labor market from crowding. Working outside the large corporations, these largely self-employed en-

ginecrs ofsmall firms established the National Society of Professional Engineers in 1934. In the period between 1937 and 1957, rank-and-file engineers, many ofwhom worked in large corporate and federal bureaucracies as technicians, organized into engincering un ions. Afrer the passage of the Wagner Act in 1935, ind ust rial unions bcga 11 to rccru it engi11cerx into rh cir rail ks. The AFL affiliare American Fcdcration of Technical Engineers and the 1934 established CJO affiliare International Federation of Architects, Engineers, Chemists and Technicians recruited the lowest of the professioll like drnfrsruen. Even so, because the CIO engineering union, like other labor organizarions, failed to support the Equal Rights Amendment for ",'omen, equal pay for equal work remained an illusion for Illany women at the lowest rung of the profession. More popular were the exclusive engineering unions united in the urnhrelia organization the Engineers and Scientists of America, which kept a safe distance from traditional blue-collar unions. [2]

Engineers did not succeed in lending authority to the occupation through licensing controlled by a central state agency like their counterpans in France or in rhe American medical profession. The authors of the 1930 Wickcnden report on engineering educarion refused to standardize education or support licensing. Jnstead they opted for an open, beterogeneous, diversified, and stratified educational system. fully aware that not everybody could – nor should – rise to the top. The strong opposition of powerful employers prevented such licensing laws from becoming effective, while the federal government did not push for a centralized agency. As a result, the locus of the defining process of engineering - wh.u it meant ro bc an cnginccr - lay ne irhcr cxclusively ill cd uca rio nal insri ru tionx nor in licen se-granring agencies Instead, ihe workplace was an imP(Jrrant arena where engineering identity, authority, and control were shaped. Unlike continental European models, working experience rather than education represented the most important marker for American engineering identity and aurhority. Getting a promotion was the crucial marker of an engineer's identity. If, in thc course of the nineteenth century, most of his middle-class identity had been shaped in the noisy, dirty, and pedestrian surroundings of the production floors in thc Eastern corridor, the railroad heds in rhe Mid and Farwcsr, and the mine shafts in California and Colorado, by the twentieth century, his identity was more tenuous as he tried to hold his ground in the basemen rs of drafting departmenrx without falling off the pay scale into the ditch.

The encroachment of indusrrial corporations incrcasi ngly rendered the male prorcsxioua] ideal of autonomy and control an illusion. [Figure 18[The corporate ideal ran counter to a middle-class manly ideal based on individual autonomy, initiative, control, and creativity; it demanded that employees restrain their individualism and give in to the corporate collective. Thc public-rclarions department at DuPont Co., in 1951, phrased it thus: "The industrial chemist today stands in

Figure 18. Dupont advertising of 1922 projecting corporate image of the "[enc-wolfinvenror" when the company was consolid.ning into a giant enterprise cmployi ng thousands of ill-paid chemists. Courtesy of Haglev Museurn and Libr.uv. Wilmington, DE.

sharp contrast with the lone-wol} inventor common even a little more than a gen-cration ago. Although the initiative and creative thought of the individual is sri ll of prime importance, the modern researcher is a team player with a strong sense of cooperative effort."[Figure 19}. The remaking of this corporate manliness, coined [he "Organization Man" by General Motors's Prcsidcru Alfred Sloan, did not go without a hitch,' Because salaried engineers had to contend with pressures from both above and below, relinquishing building SilCS and production floors to women would have endangered the delicate balance of mastery and middle-class manliness that was increasingly under auuck in the growing federal and corporate

Figure 19. DII)'OIH public-rclarions' deparuncnr self-conscious 195I r.iprion to this photograph ratn: "The indusrria] chemist today stands in sharp eo III rasr IVlih rhe 10nc-wolf inventer cornrno n even a litrlc more than a genrr.ttion ago. Although tlie in itia tive and crcative thought of the individual is still of prirnr irnporr.mcc, tlic modern researcher is a team plavcr with a strong sense of cooperative effort "Courtesy of Hagley Museum and Library, Wilmington, DE.

bureaucracies. The exclusion of women from the production floor sealed a tacit pact hCIwccn the fraternity of clite engineers and rli« rank-and-file engineers, Il kept alive the promise, often unfulfilled, that upward mohil ity was still a viable op-rion for middle-class men ill rhe twcnrieth century.

By the 1930s engineers' professional status proved to be largely symbolic as crigineering clires blocked any effective mcchnn isrn of closure or effective profcssionul un ions. Business leaders, research scientists, and academic engineers including John Waddell, Arrhur Litrlc, Karl Coiiipton, Robcn Mill ikan, Michael Pupin, Charles Kettering, and Frank Jewett continued 10 upgrade engineering by

establishing schools, associations, and journals; they mobilized scientific authority and new funds through such organizations as the National Science Research: and they projected an overarching vision at America's World fairs. Together with corporations like Duponr and General Motors they pushed the 1933 Chicago and 1939 New York World's Fairs as part of an elaborate public-relations campaign to divert attention away from the discussion about the issue of technological unemployment and the unemployment among engineers.

Engineering might have been a divided house and a segmented occupation, bur it was precisely rhis disunity that prompted engineering advocates to claim rhc universe for it. They laid claim to the entire universe and needed a catch phrase to articula re the] r vision of t hei r professio nal legitimacy in part because o f the am higuity of lacking a specific technical object. The refurbished term "Technology" - now incorporating the discourses on machine aesthetics, academic engineering knowledge, and anthropological notions on civilization - provided thar, Esrablishcrnent engineering advocates defined their domain of expertise as "the exploiration of natural forces." This self-proclai mcd man da tc was *so* broad, and the skills needed for it were so varied, that the definition offered little common technical ground for its practitioners. "The true object of engineering is not to create machincs ... 1DU r] ...a masrery i11 the appl ication of the laws of narurc," as] oh n]. Carty (1861-1932) told an audience of his fellow electrical engineers in 1928 at the end of his very successful career in corporate employ. The chief telephone engineer supervising more than 2,000 researchers at the Bell Corporation's research and development department, he went on to say that "man will be liberated, and...the forces of the un ivcrsc wil] be employed in his service." He echoed the frequently q noted formulation of Thomas Tredgold (1788-1829), a British engineer of an earlier generation who had defined the field of engineering for the Charter of the British Institurion of Civil Engineers as "the an of directing the great sources of power in Nature for the use and convenience of mall" - a formularion which fell squarely within the tradition of useful knowledge and borrowed from an ideology of possessive individualism not available to the corporate employees he supervised." To be sure, Carry spoke about man metaphorically, but the singular also suggested a kind of individuality unavailable ro most working in the consolidated corporarions, Afrer the second World War "Technology" employed as a keyword became an important rhetorical device weaving compering threads together into a corporare fabric when the profession was deeply divided and its main tenets were questioned.

3

Bargaining for the Fraternity

Engineers nor only created bridges, They also produced culture in the gray areas of privately printed autobiographies and speeches at birthday parties. While at work on rhe producrion floors, huilding sites, and in laboratories, engineers produced culture as well as goods. They engineered plots that carved out a space in the middle: between labor and capital, Anglo-Saxoll culture and ethnic strife, rechnical reports and Iirerary autobiographies, crass Gilded-Age industrialism and genteel Iibcral arts. That position in the middle was a tenuous one which they tried to maintain by revitalizing a code of manliness. More than forty civil, mining, and mechanical engineers believed their lives worthwhile ellough ro write abou[[hem,' Wirhout apology, they traced the running points of rhcir lives along a chronology of work and promotion, cataloguing rhe formation of rhc most male-dominated occupation ofall. Even ifall had much to say about their pioneering efforts nejther women Iike Emily Roebling of the Brooklyn Bridge and the first engineering graduate Joscphinc Zeller nor African-American engineers like suecessful engineer-entrepreneur Archil.' Alexander and rhc industrial researcher Gordon Grady pUt pen [() paper. Autobiographies cousti tuted an approved [iterary genre for white middle-class men, who mobil ived the genre when they faced profound changes in their profession.

Autobiographers related their lives and emotions ro their colleagues, addressing the fraternity of their fellow engineers, exhorting young men to follow rheir example, and excluding blond relatives and women from rhe narrative. Jn their male addrcss frnIIIO ncgeneration [()the next, engi nccrs attemprcd to rcprod uce a yonnger generation of men bound by class, gender, and race.' Working in different industries covering a wide geographical area, these scribbling engineers might have led diverse lives, but in their autobiographies most employed a similar style of surveillanee: tunnel-vision observations, dry technical descriptions, and disembodied prose. Th is style served a rhetorical strategy for a managerial professional male identity that sought ro transcend the field engineers' day-to-day uxsoci.uions with the smell, dirt, and noise of rhe workers they supervised. They did so by reach ing OUt ro their professional hn:thn:n across the nation. Ill the depth of the depression

and debates about technological unemployment, rhesc autobiographies were reworked into stories of success, manliness, civilization, and national identity,

The first of these autobiographical products – often printed privately or endorsed byprofessional societies - entered the literary scene on the heels of the economic crisis of 1893 that ushered in a period of industrial warfare, corporate mergers, imperial expansion, and urbanization. The majority of autobiographies were published d.uring the 1930S depression when rhc civil build.ing boom had lcveled off and America's imperial projeers - from the transnational Pacific railroads in the U.S. to the Panama Canal and the urban infrasrrucrures ranging from Havana, Manila, and Kynto – came to a close. More often than not, the engineer. who sat down to write abour their lives came from the middlc stratum of America's first modern business and government enterprises, notably the railroads and urban ccnrers, Out in the field, railroad engineers ofren faced disappointments about their status and, in writing their autobiographies, worked through, sorted out, selected, and made sense o(rhe confusing experience of rheir 'middling' position in capitalist production. On the hissing production floors in the steel industry, mechanical engineers contested powerful skilled workers and their unions, and in writing an autobiography they claimed a technical expertise over and against them. Ill the scaffolded cities, municipaI engi necrs came to sec the mscl vcs as the stewards of good government etching out a position bcrween working-class ward politics and aggressive business communities. They too celebrated their posirion in the middlc.

Written ill the decades following the 1893 economic crisis and cui tiral rcoricnration to the 1930depression, the forty-odd autobiographies mark a collective moment of memory that was at once nostalgic and generative.' To be sure, they expressed the characteristic desire of autobiographers to invest in forms of work that will outlivc the self, but, even if ineffectively, rhcy also responded to rhc new demands for role models ill a vastly altered and rapid Iy changing profession when the profession was transformed into a mass occupation.' The rnidlevcl engineers crafted their narratives when American corporations consolidated into large bureaucratic structures. the number of job opportunities for engineers dropped, and rank-and-file members of rhc profession began to .irriculare rhci r discontent with their seniors. If ill the 1890s the authors merely addressed other men within the esrablishcd engineering fraternity, from the 1910s onwards, the narratives began to exhort a new generation of young men anxious about career perspectives to emulate the lives of their predecessors when the paternal pledges for promotion were broken. They waxed nostalgic as they described lives and careers no longer open to the young men they addressed dming the depth of the 1930s depression. Collectively they marked a moment when rank-and-file engineers and young engllleering graduates were beginning to give voice to their discontent over the increasing

lack of opportunities for promotion and employment. When discussions about technological unemployment rhrcarcncd to implicate rhc scientific and engineering communities in the human misery and many rank-and-file engineers found themselves out of a job, a wave of engineering autobiographies appeared on the commercial market. The octogenarian engineers who wrote and published their autobiographies during these pivotal decades spoke to, but nor necessarily for, the young engineers or, for that matter, the rank-and-file, who had not been promored as expected.' Frorn a literary point of view, however, they failed as authors because they rarely made themselves rhc ccnrcr of their narrative focussing instead on technical details. Yer their lircrary progeny helped revitalize a middle-class identity for men when the profession was transformed from an elite profession JIHO a mass occupation.

CARVINC OUT A SPACE BETWEEN LABOR AND CAPITAL

The engineers who chose to PLlt their lives in writing often came from the nine-reenrh-ccnrury world of canal, turnpike, and railroad consrrucnon, industries driven by cut-rh roar cornpcti tion and operating at a relentless pace, which hired thousands of Irish, Chinesc, alld AFrican-American laborers, who graded, shovcled, chisclcd, and blasted their way through rnounrai us, deserts, and swamps. Few specialists who worked in the new science-based corporations like the General Electric Company chose to put their professional lives on paper. Nineteenth-century railroads spearheaded modern management facing powerful railroad workers, who pioneered modern methods of collective bargaining. grievance procedures, and union organization. The railroads were America's firsr big corporations responsible for producing a major segment of America's middle management. Most aspiring civil engineers gained their initial training along the railroad tracks riding the employment waves from boom to bust in the industry before moving on to other stations in their work life. Their experiences with the volatile rai[road industry and the labor conflicts shaped their identities in profound ways. Despite the different work practices, they held in common their experience with America's large-scale operations and first corporarions. Engineers constituted the larger part of the emerging modern managerial project.

The Southern civil engineer jarncs M. Scarlcs was one of the first to put pen to paper as the 1893 economic crisis ravished the country. Scarlcs exemplified the post-Civil War wedding herwccn old Southern clitcs and the northern capir.ilists who soughr to mobilize the freed slaves for an industrial base for the Ncw South. Trained with the L',S, Coastal Survey, he quickly moved beyond his firxrstint with the railroads after deciding that the low pay and the back-breaking labor of a

chainman logging a 30 pound transit through {he dusty fields was beneath his worth. Insrcad, he picked the date of [he beginning of his career with an appointmcur as a manager of the levee work in the Mississipp i Delta "as it was then and there I was first clothes with the responsibilities attendant on a commandi ng posi-tion." Scarl es sought to justify himself, to prolllote the expertise of the engineering fraternity, and to convince Congress to allocate funds for the Mi ssissipp i river. "I propose, in writing of the life and times of a civil engineer," Scarlcs explained in 1893, "to speak of my experiences and thereby, perhaps, be insrrumenral in guiding my professional brethren amid the rocks and shoals which are to be met in the current life of real practical engineering." He hoped rhar Congress "may he convinced that the Mississippi river problem can be best, most economically, and permanently solved, by outlets, levees, and reservoirs."[4] He also mapped his involvement in many building projects. including the drainage of Cat Island, levee construction down in the Mississippi Delta, urban developments in Nebraska, and railroad building in Kansas, Kentucky. and Alabama - all of which, however, left him hitter and disappointed. Although be had a sense of bclongi ng to the engineering fraternity and maintained various management positions as resident chief engineer, Scarlcs never joined the newly established American Society of Civil Engineers. He belonged to the engineering rank-and-file working as a field engineer near construction sites, but never held a policy position at company hcadquarters that would have enabled him to influence or direct the plans of consrrucrinn in any significant fashion. Searles, the son of an impovcrished Southern family whose "stomach had been arisrocrarically trained," had no capital to invest in the projects he believed to be technically sound and commercially profitable. His opposition to raising the levees on the Mississippi River placed him at odds with the established political opinion and the financial interests of the planters, but his minority opinion signalled his allegiance to an emerging understanding of engineers' special claim to rechnical knowledge.[5]

Scarlcs introduced his narrative with a promise to tell the reader all: how engiuccrs had been cheated out of rewards for technical solutions rightfully theirs that had been appropriated by rhosc "who have been negative factors in the working-out process." The OUlcome courted disas[cr bcca use "arrogance can blind the eyes of capital." By the time he was through with hi" narrative, however, Searles decided "to go back on the premise [to rell all because] I should be obliged to mention names - for the owners of which, in their personal capacity, I have high respect - and whatever may be *my* estimate of their professional worth, is a matter of no concern to the general public." He felt bound by the "ethical code of rhc fraternity" thar demandcd full loyalty and rcluctant to divulge any inforrnarion about his employers. In his loyal attempt at sclf-rcsrrainr, however, he still struggled for sel[-courrol and continued ro wruc, "I will, however, say rhis much, that the

proper adaptability of means at hand never fails of legitimately corresponding results."[13] On first reading, Searles' opaque phrase seemed not to tell much at all. It contained no action and no players.

Searles' depersonalized prose is actually very revealing. His reluctance to name names and his choice of disembodied language expresses the narrow space he and his fellow engineers occupied professionally between capital and labor. He enjoyed the owners socially bur he mistrusted them professionally and felt vastly superior to the Irish, African-American, and convict laborcrs hc managed on the railroad tracks and the levee construction, even though [heir employee status resembled his own. Searles delended rhe engineering fraternity insrcad of publicizing the capitalists' malpractices he had witnessed, bur he considered "it a duty I owe to the many comrades who have faithfully toiled along the hard road of 'out door' Engineering, and to the profession at large, to protest against the money estimate of their services." Before he was done telling, however, he made his allegation and posed his vexing question: "Why don't these small salaried fellows [engineers] climb to the top rung of rhe ladder?" Having asked no one in particular, he promptly answered his own question: "because money and influcnrial circumstances. uncoupled with true merit, *push* so many up that ladder that the worthy ones can only *loo]:* up .',,, In this closing accusation lay the foundation of a powerful argument for merit and expert knowledge that other engineers and professional organizarions would develop in the following decades. Promoting expert knowledge offered a way out of the precarious position he held as a "small salaried fellow" in facing the "arrogance of capital."

Most engineers ranked among the first salaried middlc managers and experiencecd the contradictions of capiralisr production as professional workers. Occupying an ambiguous space between capital and labor, engineers epitomized this class conflict. Like wage earners, they faced seasonal unemployment, wage pressures, capital and political COntrol, but like managers, they were also in a position ofauthoriry over other wage earners and felt a sense of loyalty to their employers.[14] Searles could put an exact price on his own engineering labor and determine the profit it generated by taking on his employers' perspective, but he also articulated the powerlessness of his position as he described how helpless he felt after the Ship Island Company was sold and merged with the Hunrington and Wilson Railroad without his prior knowledge. In expressing his discovery of the merger, hc drew all the image of slave labor - unqucsrionably [he most horrifying irnage available to the son of a family of planters. He recalled his anger over the loss of control of the project as a consultant and chief engineer in these strong words: "*I found myself sold*" [his emphasis], and he concluded, "I have thus written in justice to rnyself."[15] Through writing his autobiography he bargained for his rightful place. He left no other trace in the written historical record.

The writing of an autobiography remained a singular act for many of these field engineers, whose lives would otherwise have been unraceablc. The majority had never written books before embarking on their autobiographies. This is nor to say ihar enginccrs shunned writing altogether. On rhc contrary, rhc writing of logs, diaries, account books, reports, specifications, and contracts formed an inregral part of the life o fan cngi necr, Morcovcr, his dai ly work requ ired rh e wri ti ng of proposals and of technical repons for public interest groups, investors, and ernplovers. An engineer who advised againSt the feasibility ota project also lost an employmcnr opportunity: but onc who wrote himself into a project often became responsible for its execution and success.' Doubtless Scarlcss appeal to Congress for the building of an integrated system of levees, outlets, and reservoirs for rhe Mississippi river ill 1893 showed his inrcresr in rhe technical issues in the debate. but the autobiography also amounted to a job application for the new engineering jobs should the federal government decide on financing such a large-scale underraking. Th rou gh wri ting an engi nccr bargained for his livclihood,

Searles, raised with Southern disdain for manual labor and hands-on training so celebrated by sons of the N orrh, composed an autobiography uniquely his own. As a middle-level manager, Scarles occupied a half-way position in rhe capitalist production and the political system of the New South. !Ic recast his identity from a plunrcrs son to a civil engineer in the ahcrmarl: of the Civil War.' Several other Sourhcruers also insisted on a depoliticized, neutral sounding life srory." Scarles's autobiography contained themes common to the dozens of other engineers - both from the South and the Norrh - who followed him ill the decades to come. By writing an autobiography, he and his colleagues pried opcn a space for the engineering fratcrnity. He expressed the horror engineers felt at the narrow space fOl' which they had to negotiate as employees in onc of America's earlicst corporate industrrics, In his efforts both ro tell and to suppress his story, Searles unveiled a male cngi neering identity ill the making at the end of the nineteenth century.

WRITING A WORLD Wrn-IOUT WORKERS

The engineering aurobiograph ics consriturcd a curious literary genre. They drew on a variety of literary forms including biographical sketches, portraits, memoirs, and obituaries that appeared in engineer: ng journals alongside numerous articles discussing the proper definition of an engineer. From a literary point of view, however, these were 'failed' autobiographies, as rhc engineers spun their narratives along elaborate descriptions ofengineering projects char read like rcchnical repons rather than narrations of the self.

No doubt the engineers' professed unwillingness to reveal their lives followed a nineteenth-century autobiographical convention: they often claimed to have begun writing only after insistent cajoling from family, friends and - more significantly perhaps - out of a sense of loyalty to the engineering fraternity." But engineers had many legitimate reasons for their reluctance. In the words of one self-reflective autobiographer, engineers possessed poor penmanship. Accustomed to rendering three-dimensional forms on paper and trained to thinking visually and spatially, engineers disliked expressing their thoughts in writing. Another engineer recalled how he was "once told that an engineer who wrote a book was not an engineer," reflecting a hardened sentiment of anti-intellectualism in engineering that is widely prevalent in engineering self-representations in America." Fully aware of the engineers' poor penmanship, academic engineers, organized in the Society for the Promotion of Engineering Education in 1891, worried about "the disgraceful ignorance of their native language on the part of a large majority of our students and alumni," in the words of leading bridge engineer John A.L. Waddell." Pushing for the inclusion of liberal education in the curriculum of engineers proved to be one of the many tactics they employed in raising the status of the profession. Beyond the lack of liberal preparation and literary practice, aspiring autobiographers had other worries. Engineers ranked among the first professionals to confront corporations that often forbade them to divulge any information about the projects they had worked on - and engineers had no intention of questioning the rules of an entrepreneurial class to whom they owed their sustenance and loyalties, as Sear]cs made dear.

As middle managers engineers felt responsible for the company and internalized their employers' demand for secrecy in their dealings with investors, competitors, and subordinates. Investors demanded [he utmost secrecy from surveyors and engineers during the projecting and surveying stages, when large sums of money and potential profits were at stake. "Secrecy as well as haste is frequently a good qualification for an engineer," counselled field engineer Danforth H. Ainsworth (1828-19°4) with a long career behind him in railroad employ in the wide expanse of the Northwest across the Mississippi river. As a company man, Ainsworth had struggled with establishing his authority among villagers charging high prices for food, shelter, and water, with maintaining control over local contractors, foremen, teamsters, and rodmen unwilling to obey his orders, and with keeping land speculators at bay. "It sometimes calls for a good deal of policy on the part of the engineer to avoid publicity," he asserted.[2] In a similar vein, one mining engineer told a young aspiring man to be tacit when handling different competing commercial interests. He advised, "Be as Cold Blooded and as Unenthusiastic as a Clam.?" This strict sense of loyalty could weigh so heavily on an engineer that he might refrain from publishing his autobiography altogether. Sworn to secrecy for the sake of a

company's success and profits, civil and mini Ilg engineers confronted the contradictions of corporate loyalty and the circumscribed space allowed for individual promotion and expression rhar was so critical to middle-class identity and male prowess. They were in the position of entrepreneurs without the capital to see a project through; rhey also worked as employees with full responsibility without any of the entrepreneur's power and freedom to negotiate. Mid-level managerial engineers like Searles and Ainsworrh were wedded so much to rhc ideals of capitalist production that they wore their discretion like badges of professional pride; but their faith in the business ideology was severely tested when many projects came to naughr because of local politics, failed capiral, mismanagemenr. or conflicting visions." Their autobiographies expressed borh rhcir need and thcir reluctance to bear witness. For these mid-level engineers to publicize themselves at all was borh remarkable and painful."

Ainsworrh showed how excruciating it could be for engineers to reveal themselves in a direcr and active voice. He had participated ill the official engineering fraternity as a member since 1886, but as a field engineer with his boots deep in the mud supervising construction sites and organizing labor camps along projected railroads west of [he Mississipi expanding into Illinois, Iowa, Missouri, Minnesota, the Dakotas. Nebraska, and Colorado, Ainsworth could llOl afford to parricipate in the ASCE's day-to-day discussions held far away in the smoke-filled rooms on the East Coast. He had bcnefirrcd From the boom in railroad construction during the 1870s, enjoyed managerial command, and could call himself a certified member of the fraternity, but Ainsworth nevertheless occupied rhe lower stratum of the managerial hierarchy. When he wrote his autobiography at the end ofhis career. he was finding ir increasingly dilficulr to get work at his usual rare, feeling the brunt ofthc collapse of the railroad consrrucrion industry. Recalling his precarious situation as a civi] engineer in railroad location and construction, Ainsworth referred to himself in rhc third person, using a passive voice: "His position," he said ofhis own situation. "was never a source of pride to him, and was anomalous to say the least. He was the company's disbursing agent, and deemed himself the ever accessible dog ro be kicked whenever anything went wrong." Ainsworrh used the same stylistic devices in describing his anger at the State of New York for losing his job on the Erie Canal: "Possibly one knows he is hurt when trampled upon, even if he has no corns. There is quire a distinct recollection," he said *of* himself, "rhar a tongue was nor under complete control, and perhaps the interest of fellow-sufferers were not for the rime considered. The State of New York still owes what was then justly claimed."[24] The occupational demands for secrecy shaped the mode of expression of Ainswonh and other engi necrs, They were not only caurious with information, bur also pracriced an economy ofexpression, prized tersencss as a professional asset, and employed disembodied prose.

The engineers replicated their occupationa l stance of inspection, supervision, surveying and surveillance rhar objcctifi ed land, environ s and people." Like the style of the surveyor who takes meticulous notes on the prof les of rhc land and the inhabitants with little personal involvement, civil engineer and surveyor Henry Root phrased his sur veying work wirh rhc Central Pacific Railroad in a r92! recollcction rhus: "On July 5, 1866, I went by tra in [() Sccrctrown and by stage from there paying $(,. 20 stage fare and stopping ar Dutch Flat for dinner, I lived in a log cabin on rhe cast side of Crystal Lake from this time until December 23, r866, when I moved with McCloud's party to camp 4' TO go into winrcr quarters to give lines and grades in Tunnels 3, 4, 5 and to work on estimates."[7] Root was not alone in wriring short sentences, using simple synrax, and emphasizing materials, dimcnsions, and prldunion instead of dwcIling on [he labor practices o n rhc buIlding sites, an angle of repose in their hom e lives, or the magnificant landscapes they were about to transform. Nor was Ainsworrhs use of a third-person narrative and passive voice exceptional. Through these co nveu tions engineers established [heir distance, objectivity, and veracity.

The journalist Bcss Dcrnarcc observed the disembodied landscape rhar engincers co nstructed. too. 'Like many other engineers,' she wrote, John D. I.irtlcpage, an American mi ning engineer who worked in the gold industry for the Soviet Cold Trust Company between 1927 and 1937, "can describe a mine with complete clarity and accuracy, but seldom bothers to describe a pet'son or scene. And he thinks, more ofrcn than not, in terms of production." [8] This tendency also struck Cccile Hulsc Marschat (1895-1976), the wife of an engineer, who highlighted the gendered differences between herself and her husband in observing the South-American landscape, "My husband was so absorbed with the odd little engiue, wl:ose ch ief funcr ion seerned to be to hook the cars to [he cable," she wrare of a joint nip, "that he paid no arrcntiou to the magnificent view. But 1 refused to be enthusiastic over what looked ro me like a glorified elevator. I rhoughr the scenery was stupendous."[9] Landscape was an asset to rhc professional lives of both husband and wife, bUI, as a botanist, Marschut looked at the landscape as a source of knowledge, beauty, and culinary resources: her gaze was expansive, peopled, and colorful. By cout rust, her husband I.ouis could nor see bcynnd the engineering aspects of the site.

The terse narrative style of engineers also reflected the changes in cnrnmunications within the emerging corporations. As employees in modern enterprises, engineers regularly used new forms of cornmunicarion like rhc telegraph and telephone ro transmit messages across the grea[distances separating the office horn ihe construction sire. Civil exchanges of intorrnation between Eastern financiers sitti ng in board rooms and managers far away ill the Iicld mattered Iiulc to the railroad corporations wlrcn haste and the high operari ng coxrx of telegraph and

telephone were involved. Field engineer Ainsworrh recalled how the corporations showed "littl e disposition to be communicative" ro management engineers like himself and pushed employees for economy of expression. Once when he wired a message to ask: 'Will the company build 100 miles this year? The answer promptly returned was 'No,' and when he sent another asking: 'Will 60 miles be built this year? he got the same negative reply followed by curt instruction: 'You will be censured here if sixty miles are not built this year.' Of course, the corporations' demand for economical use of language also embedded a form of command and control in the emerging corporations. In a 1913 repoft in which officials of the chemical corporation Duponr Company ordered the use of more efficient language for internal corporate communication, they asked managers to replace a phrase like 'we are in receipt of a request from St. Louis office for' wirh 'Sr. Louis asks for.' Similarly, they urged managers to replace a request which began with 'we would be glad to have you make an examination and advise,' with the formula 'please examine and report." As managing the overload of information became a serious concern of growing public and private corporations, engineers helped to shape a new, more economic language of command and control without subtle negotiations. They confronted and participated in the historical shift away from face-to-face communication toward increasingly mediated and indirect forms of exchange between superiors and subordinates.

The engineers thus wrote their autobiographies along the lines of the dry narrative style of technical reports and the form of their daily communications more than along any literary conventions. The intense descriptive gaze of Marschar's husband, Ainsworrh, and other engineers also turned [he readers' attention away from the surveyor himself.[50] From a literary point of view, these were 'failed' autobiographies that read like technical reports rather than like narrations of the self. Poor liberal education, corporate control, secrecy, information overload, a desire to transcend local circumstance, and a claim of technical expertise all shaped the engineers' characteristic writing style: dry technical details, short sentences, economic modes of expression, and disembodied prose. They spoke over and across building sites, beyond the horizon to imagined communities of other engineers. Bur the disembodied prose also went along with an embodiment of gender.

BUILDING THE ENGINEERING FAMILY WITHOUT WOMEN

Engineers might have been - contrary to autobiographical conventions - slow to position themselves at the center of their own narratives, but they were rarely self-effacing when discussing their dealings with men they considered their social peers or workers whose skills and organization posed a threat to their identities and

the knowledge they were claiming for themselves. At these two points – when discribing fraternal feelings or contests with competing workers - critical ruptures appear in their otherwise disembodied narratives.

Many engineers portrayed themselves as independent builders and producers, thus obscuring the intricate labor relations involved and the hitter industrial disputes that left deep imprints during these decades. They appropriated the physical activities of building and execution characteristic of the skilled workers they supervised while, in reality, they merely designed, organized, and supervised those workers who actually shovelled din, laid bricks, worked lathes, and lifted srcclplates, In their writing, they often asserted their technical authority over skilled workers. John Frirz (1822-1913), a mill foreman who climbed up the rnanagerialladder in the Pennsylvanian steel industry, had supervised the construction of a steel mill complex by bringing under one roof Besserner converters that could burn carbon our of molten iron by blowing cold air through it under high pressure producing steel more cheaply and introducing rolling mills that shaped red-hot iron ilHO sheets. He appropriated the language of building, implying that he had built a Bessemcr plant and a rolling mill with his own bare hands. "I built a good subsra0ria] srone buiIding," he said 0 f a consrrucrion job that reguircd a great deal of time and involvcd squads of masons, bricklayers, and eotimon laborers."

Fritz and other mechanical engineers often appropriated the skills of other workers in their narratives, jf only to [rcjclaim a position of authority over them. Elecrrica I and mechanical engineer William LcRoy Emmet (1859-1941), raised in a family left in financial ruins by the after shocks of the Civil War and with little interesr in formal learning, gained on-the-job training in the hierarchical work culture of the American navy and electrical corporations like Westing House and Ceneral Electric. In one of his first jobs for the Sprague Illuminating Company as a troubleshooter on electric strcercars in 1888, Emmet organized a group of! ralians into a team of mechanics to assist him in the overhaul of [20 electrical motors for the Railroad Company in Allegheny City. In his recollection fifty years later, Fmmer appropriated the work and skills of the Italian mechanics to highlight his own cnntriburions in the development of an insularing material of varnished cambric, a material he would later develop ill the shops of Ceneral Electric Co. in Chicago, New York, and Schenccrady, Describing his work for the electrical company Sprague in the 1880s, he wrote: "I stripped all the wire from the one hundred and twenty new motors and replaced it in a very different way. I completed one batch of motors before J dismantled another. ..I made the insulation of varnished cmbric with no sheIlac...I also rebu ilt all the controllers rnaking radical changes." He then continued: "I also built new rrolleys of greatly improved design and sold them to the Railway Company." Only at the point where a contest of skill erupted herwccn himself and the mechanic whom he had ordered to improve a swivelling trolley,

however, does he interrupt his narrative olcrcarion, swit ching back and forth be-twcen a language of making and a language of supervision: "I built them," – he wrote of the trolleys in terms of creation and then corrected himself in te rms of su-pcrvision - "or had them built...in a little machine shop run by a young fellow named R. D. N urrall. " Although he fran klyacknowledged rhe colleenve process of innovation when he spoke of his peers at General Electric labs in Schenccrady, he disavowed this kind of teamwork when it came to discussi ng the work of the skilled Italian mechanics.<

Searles, too, showed how slippery and problematic the language of singular creation co uld be when he recounted his story. "I was ordered to reconstruct [the bridge]," Scarles wrote of one job he supervised, "and had but little difficulty in stopping the rush of water thar had destroyed the bridge." He then significantly added, "as I was well supplied with sand-bags and Negro cavalrymen..." Catching himself using the language of building rather than supervision, he self-consciously interrupts his narrative for a clarification. The clarification of the labor process briefly restored the hierarchy of command and control, bur inadvertently exposed the racial distance between himsclfand the African-Amcrican laborers, Ridiculing the abolirionisrs' fraternal love as effetc, Scarlcs added parcnthct ically, "tor fear some supersensitive, tender-hearted commiserator of the colorcd brother might think that I dumped him in the crevasse hole instead of the sandbags, ir should be remembered that the cotton of which the bags were made were worth more...than rhc negroes."" In presenting h is managing job as an act of physical building, his slip of the pen opened up [he problematic race and class relations particular [() [he South. Painfully aware of his Northern allies, he sought to cover the tension with an intervention of sarcasm, but rhe damage was done. His rwo identities, one as a profcssioual engineer and rhc other as a white Southerner, were in contlict. In his correction, Searles tried to rcesrablish the proper order of supervision and mastery so vital to the white men of Brady's New South. Scarlcss narration might have been particularly his own, but his erasure of workers or his self-conscious identifi-cation with command, control, and whiteness was far from atypical.

Engineers also suspended their disembodied prose when writing about men of their own social class and often described them as family members. Some authors conventionally began their life stories as a genealogical record, only to nwlc! it into a resume of the: r professional life." Even when the authors gave genealogical rea-sons for writing their autobiographies, close relatives like parents .md siblings barely figured in the narrative. More often than nor they excised spouses and chil-dren - including sons - altogether from the genealogy and story line.

If engineers seldom included family members in their life stories or displayed a sense of inrirnacy, they often wove their narrauves around crnoriona] passages in-volving other men of thei r social class or their mentors, whom they did treat as

family members. Onward Bates (18so-T936), an esrabl ishmcm civil engineer with little formal educat ion , had received his rraini ng in th e fields of the railroad br idge con struction during the Gilded Age before moving to the urban frontier of Chicago to beco me a contractor. As an octogenarian looking back on his years as Charles Shaler Smith's apprentice, Bates noted in 1933, "I have always regarded him as my professional father."[8] Alfred West C ilherr (1816-1900), who later became a municipal engineer in C inc in uari's waterworks and sewcrxystcrrns when the city expanded as a result of the shipping business along the Ohio river, recalled a feeling of kin ship wirhin rhe community of en gineers on his first surveying mission in rlie hills of Pennsylvania, bur he restricted the sense of family to social equals. Likl' so many other engineers, Gilbert conveniently excluded their day-to-day de alings with fo reign-born common laborcrs responsible for clearing the path anu-setrlJ1g up camp.[16]

Sometimes the fraternal feelings between social equals would go so far as lOexclude blood brothers even when they worked side by side. John Frirz, whose brothers George (1828-1873) and William (J84T-1H84) worked with him in rhc steel industry at Bethlehem Steel mills in Pennsylvania and at a rolling mill at Chartanooga, 'Tennessee, failed [() portray either brother in a particularly jntimate or fam ilial fashion, except for onc passage where, ironically, he argued rhe importance of fraternal love among engi necrs over and against that of blood relatives. With pathos, Fritz recalled in 1912 the early history of the Ilcssemcr process when his colleagues Alexander Hollcy, Robcrt Hunt, William [ones and his brother (;corge would frequently come to Bethlehem to discuss rheir work in implcrncn ting the new steel making process in the plant that produced rails and armor-plare: "We did nor meet as diplomats... but we met as a band ofloving brother engineers trained by arduous experience, young, able, energetic, and determined to make a success, I doubt ifever five natural brothers were more loyal to each other than the five brother engineers above named,""

Urban engineer Onward Bales most explicitly showed how literally this male world could supplant patriarchal family life when he described his engineering work in terms of love and marriage. Fondly recalling rhe emotions he felt the day he was offered a job with the Edge Moor Company in Wilmington, a firm that specialized in bridge construction: "All I could think of at the moment was what the lady said when she received a proposal of marriage, "Ihis is very sudden;' I wired Mr. Whittemore: 'I accept Mr. Smith's proposal." rhe man he had earlier described as "my professional f:ltlter." Bates failed to regard marriage with the same affection, however. He likened marriage to an engineering specification and eo ntract: "We learued that mau i 1110 ny is not a joke, hu t a 1110s t serious matter, rhe most impo rra nr o f all eo11tracts, lasring through o11r the livcs of both parties... These specifications almost warrant one to avoid marriage as too great a risk to be

arrem prcd...?" Bates and other engineers erased women, and their wives in pan icular, from their narratives altogether despite the fact that wives, daughters, and other relatives lived with them in isolation in the engineering camps and often acted as the midwives of many engineers' autobiographical offspring in their roles as collaborators, writers, typists, and sponsors.[vo]

The erasure of women's presence and the celebration of the homo-social world clicired commentary from the women who observed them. In her own all,1 to biography, professional botanist and geographer Cecile Hulsc Matschat presented herself wryly, yet seriously, as the dutiful wife of an engineer during the time she spent in South America, where she had followed her husband on his job. She articulated the erotic but threatening undercurrent of the fraternal feelings that ran between her husband and his Sourh-American engineering assistant. Matschat opened her narrative with a vignette of her husband's assistant, Marco, and closed it with his tragic death on rhe job.

With great detail and much pathos, she described their mutual resentment and competition for her husband's attention and love. "They greeted each other like old friends," she recalled the moment when she first mer Mareo as she arrived as a young bride in South America with her husband. "No one could mistake the warmth of feeling between them. Bur there was nothing of affection in the beady black eyes thar swept *me* from head to foot." Marschat considered her husband's assisranr physically "monstrous," and as she told the story, each disliked and resented the other not only physically bur – only barely hidden under the surface – sexually. After her husband had introduced her to Mareo as the new bride, the assistant exclaimed: "*That* your woman?" His tone expressed complete disbelief. "Holy cow's blood!' The gaucho shook his head in disgust. "Damn skinny woman!" Cecile Marschar wrote of the incident, "I *thought* of a lot of things to say, but didn'r. I *felt* like a rag without a bone and a hank of hair." She felt betrayed and abandoned by her husband's failure to perform his duty to speak our for her. She then continued to describe her assessmenr of Matéo's capacity for love and sex, echoing a racial stereotype American whircs invoked when talking about African American men. "I feel certain, now, that Marco never loved a woman...He boasted three women, not wives, and to him they were merely goods or chattels, fit only to wOfk and to perform [heir natural functions." And in support of her claim, she asserted in conclusion rhar Marco's women merely "awaited the infrequent visits of their master and the rcsuhanr visits of the stork." Her husband's failure to speak up for her particularly offended Cecile Hulse Matschat because she expected his heterosexual and Anglo-Saxon loyalty in this far-away corner of America's expanding industrial capitalism. Matschat's sense of duty to follow her husband to South America and abandon her career as a professional was predicated on her expectation of the priority of heterosexual love and Anglo-Saxon solidarity. The Irarcrniz-

ing between her husband and his Latin-American assistant challenged her authority as a white North American woman. Marco's position in the engineering hierarchy placed him in the same social class as the Marschats, but his ethnicity called for other manners, she believed. The assistant's skills might have been essential to her husband's engineering work and survival but they were not crucial to her, or so, at least, she had assumed. To Marschat, her husband's declining fortunes and mood swings following Marco's death showed how dependent he had been on his assistant for his livelihood. In the manner she framed her autobiography, Marschat made her resentment of her husband's mixed loyalties quite visceral.

Marschat had not been the first to explore the homo-social world of engineering where the fraternal feelings posed a threat to the women married to them. The sense of loyalty that these corporate men felt towards each other and had internalized vis-à-vis their employers directly competed with the women whom they married or the women who were making professional claims for themselves. Professional women writers including Mary Hallock Foote, Anna Chapin Ray, Frances Elizabeth Foote, and Willa Cather gratefully explored the theme of engineers who were married to the job at the risk of losing the women they were supposed to wed. As we will see, women writers engineered their plots differently than their male colleagues to counter these professional models. As these professional women made clear they resented the way management engineers like Bates substituted marital and blood relations for corporate families. They objected to the construction of communities of men as a world without women; a world where male Friendships were marriages and marriages engineering specifications.

APPROPRIATING THE WORKER'S BODY

Civil engineers involved in canal, bridge, and railroad construction maintained a great social distance from the common laborers whom they supervised. The working camps of the diggers of the North American canal system, for example, were characterized by sporting, fighting, boozing, and other contests of virile strength that helped to develop a proletarian sense of virility closely associated with manual labor and physical prowess. Keeping a social distance created its own difficulties. Civil engineer James Worrall (1816–1885) might have disliked the pressure to drink with the laborers with whom he worked, yet he also noted that it was impossible to remove himself from the ritual if he wanted to retain their respect for his genteel manliness and authority. He called Benjamin Franklin's famous abstention from alcohol an isolated case, saying that "[the] men who followed his exemplary of life were called eccentric and individual - a kind of prigs...The growing youth of a

people natural ly prefer to be like the average manly character, and rhar character is nor to be priggish nor exclusive."[41]

Most of his scribbling colleagues ignored the travails of the Irish, Scottish, and French-Canadian canallers, who dug (he ditches with shovel and barrow. They removed from their stories the Chinese graders who shovelcd, chiselcd, blasted and bored their way through mountain ranges and deserts, the Irish workers who grabbed the rails with wngs, guided them over rollers and put them in place. the laborers wh o started the spikes, secured the fishplates and tightened the bolts, the track levclers who lifted ties and shoveled dirt, or the thousands of tampers who finished the track-laying work with shovels and iron bars.[42] The Southerner Isiiarn Randol ph (1848-(920) chronicled his railroad employ of seventeen years from his apprenticesh ip in clearing the way with axes to his arrival as management engineer before settling in the boomi ng city of Chicago, where he helped plot the railroad's round houses, shops. terminals, and freight houses and then moved to the urban frontier in rhc (:hicago of the Progressive Era. For the next fourteen years he prospered as an urban engineer, gaining local fame for his design of the city's water system - the Chicago Drainag« Canal that changed the direction of the Chicago River so rhar its waters would flow into the Mississippi instead of into Lake Michigan - an experi ence that landed him a job as a consultant on the Panama Canal later in life. But Randolph never men tioned the thousands of Afric an-American, Polish. and Irish quarry men and can alcrs who were driven hard to shovel forty miles of sand and solid rock for the much acclaimed Chicago Drainage Canal, nor did he dwell on the events of 1893 when these workers went 0 n a wildcat stri ke [0 demand hig her wages." Aga in and again. civil engineers skipped over the bu ilding sites and industrial struggles in rhcir stories, and instead fixed their gaze on technical details ;nid reached our to engineering com mun ities across the land. [Figure zo]

The socia l distance bet ween mechan ical engi neers and mechan ics was more com plicated. In the iron and steel industries, mechanical engineers faced the formi dable power and skill of tightly organized Welsh and English indusrrial craftsmen, whose bond was forged by pride of skill and an crh ical code of mutualism. In many industrial workshops, skilled master mechanics had been at the center of the enterprise, whos« reposi tory of techn ical knowledge had ofte n been the driving force behi nd mechanical inn ovation. T hese wel l-organized workers had developed craft-u nion solidarity as a strategy against the fallout fro m the 1873 panic and increasing management encroachments on the organization of their work in the heated years during the 1880s. In terms of eth nicity ant! skill. the Welsh and English mechanics claimed a more intimate link to the social class of mechanical engineers (() wh ich Frirz belonged as th e son of a Cerlllan im migran t than the largerly unorganized African-American, Chinese. and convict laborers that Searles,

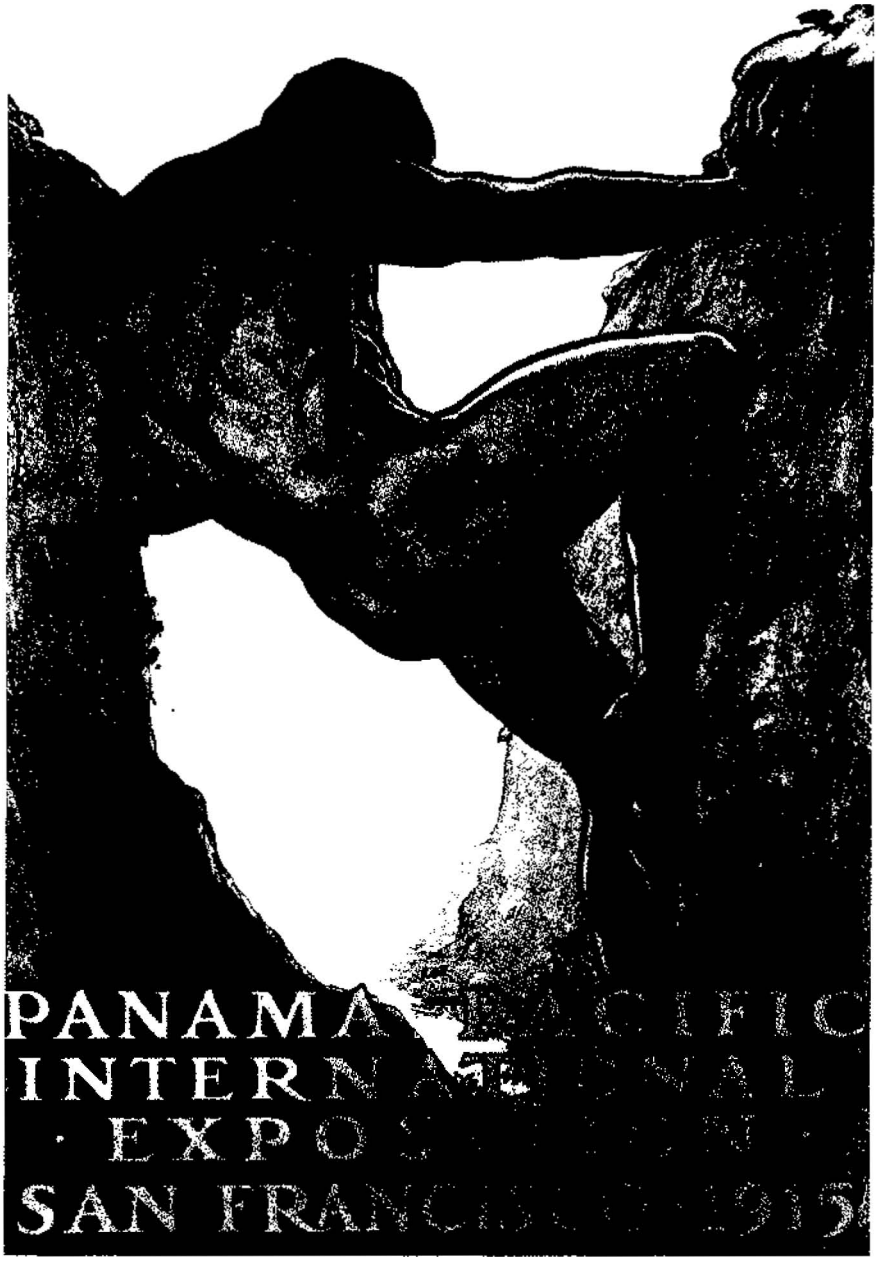


Figure 20. Plagued by political intrigue, dire working conditions, and outbreaks of malaria, the Panama Canal was built by a work force of 17,000 and organized on the management principles of railroad construction. Here allegorically represented as the work of one man: a modern day Herculrs, forcing apart the Culebra Cut to create the Panama Canal. Official poster for the 1915 San Francisco Panama Pacific International Exposition by Perham W. Nahl.

Ainsworth, and WorraJl faced in their supervisory duties as civil engineers. Ifcornmon laborcrs were safely removed from nearly all narratives of civil engineers, by contrast, the bodies of iron rollers, puddlers, heaters, and mechanics filled the pages of *Tbe Autobiography oj[ohn Fritz.* Mechanical engineers like Fritz participared in the rhetorical strategies that attempted to invigorate middle-class notions of manliness and civilization through a focused attention on working-class men."

Engineer-manager John Frirz could look back on a truly prominent career in the steel industry that had been a creation of the railroad and war industries. He was hesr known for his invention of the three-high rail mill that saved [he arm-brcaki ng labor needed to form square bars of iron into finished rails. Assuperinterujem of [he Bethlehem Steel mills, he had helped organize the largest plant of its kind in the U.S. in [860. His life, as he portrayed it in 1912, had been so successful because of his superior technical knowledge even if workers and higher management alike had opposed and reprimanded his hold moves, Most civil engineers who wrote their aurobiographics did so on their own, but Frirz's autobiography was almost a collective act of self confident captains of industry who found him the ideal corporate man.

The professional association of mechanical engi neers, 'I'he Arncrican Sociery ofMccha nical Enginccrs, actively shaped, endorsed, and published Fritz's *Autobiography* as the life of a man who represented the ideal of rhe mechanical-engineering csrablishmenr. His autobiography articulated the growing confidence and aggressiveness of the northeastern industrial establishment, shaped a managerial engineering identity, and cast it as a simple master mechanic ("iron master") who stood by his workers, purging the difficulties that gave rise to it. This was a remarkablc feat indeed. The endorsement came when both inside and outside the association tensions rose over the true path toward engineering knowledge, The challenge came from both craft unions who fought the encroachrncnrs ofmanagement and from a growing band of engineering educators like Thurston who sought to link mechanical engineering with science and its prestige. In marketing a male managerial middle-class identity for engineers, the association played an active role in sponsoring the autobiography of Frirz and other book-length biographies of mechanical engineers including Waltcr Clark, lrcd Colvin, ldward Hewirt, Ernbury Hirchcock, and Howard Pedrick during the 1920s and 1930s. Fritz's autobiography was published by William H. Wiley (b. 1842), a schooltrained mining engineer at Rcnsselaer Polytechnic Institute and the Columbia School of Mines, a loyal member and treasurer of the organization of mechanical engineers. Wilcy and other lcading publishcrs of tcchnicall ircrarurc like McGraw-Hill steadfastly supported the leadership of industry and management engineers, playing a prominent cultural rolc in efforls to build their identities through rheir publications." Fritz's *Autobiography* well suited the purposes of the emerging pro-

fessionalisrn of mechanical engineers in their claim ro a special kind of technical knowledge which labor unions were challenging during the decades of intense industrial struggle.

Frirz's narrative showed how among mechanical engineers pressures from below were resolved in a celebration of a shop-Floor rnanliness when ir was no longer viable. This celebration of the male working-class body went rogerher with the valorization of the bodies of middle-class athletes, a discrnpowermeur of African-American, Native American bodies, and an erasure of women's presence altogether. As the son of a farmer-millwright, Fritz had acquired an early familiarity with rhc machinery of the cotton mills in Pennsylvania's rural districts where his father earned a living with maintenance work. This was as good a technical cducarion as any young man could hope for. Later, as a supervisor of a large iron and steel operation, he had depended on the racir knowledge of boi lerrnakcrs, rollers, and puddlers at the Pennsylvania industrial machinc shops of Norrisrown (1846-1849), Safe Harbor (1849), Cambria (1854-1860), and Bethlehem Steel (J86o-1892.). Fritz's life exemplified the trial-and-crror era of industrial eapiralisrn, when skilled machinists and millwrighrs (like his father) improved and tinkered with new machines, materials, and metallurgical processes. From a technical point of view young Fritz had nor been the *tabula rasa* he and his colleagues made him o lit to be decades Luer in 1912. The ASME promoted John Fritz's autobiography as the nurrativc of a self-made man who had learned by doing. This portrait was quire seli-scrv: ıg because formaI educa tion was gencra lly unco mrnon during the early nineteenth century, only to become retrospectively an issue when school-trained engineers began to overwhelm traditional upper-class engineer-proprietors in their claim for true engineering skills. Frirzs autobiography merged three hisrorical and politically important moments into one powerful argument. The book included reports of the ostentatious birthday parties which the ASME staged in Frirz's horror in 1892 and [90Z - years rhar turned Out to be politically significant.

In the late summer of 1892, the captains, managers, and engineers of the xrce] ind uxrrics garhercd to celebrate hitz's seventierh hirrhday at the Opera House in Bethlehem. After the guests sat through a sumptuous banquet, sippi ng their coffee, puffing their cigars, engaging in founds of "merry jest.i.as friends were recognized up Of down the tables... amid a babe! of sounds mingled with bursts of uuconrrollable laughter", the fraternity not only toasted the srOlY of a self-made man and his manly individualism, bur also put the man [hey had come to celebrate to a mock trial. fFigurc 21] Through the practical joke, they charged Frirz with two offenses, accusi ng him *first* of having "misled the public into the belief rhar he was an enginccr, and an iron and steelmaker" and, secondly, of having "disturbed the peace." Frit», so the indictment read, had "changed beyond all recognition the old time peaceful hamlet of Bethlehem." [f it had not been for Frirz, "Bethlehem would

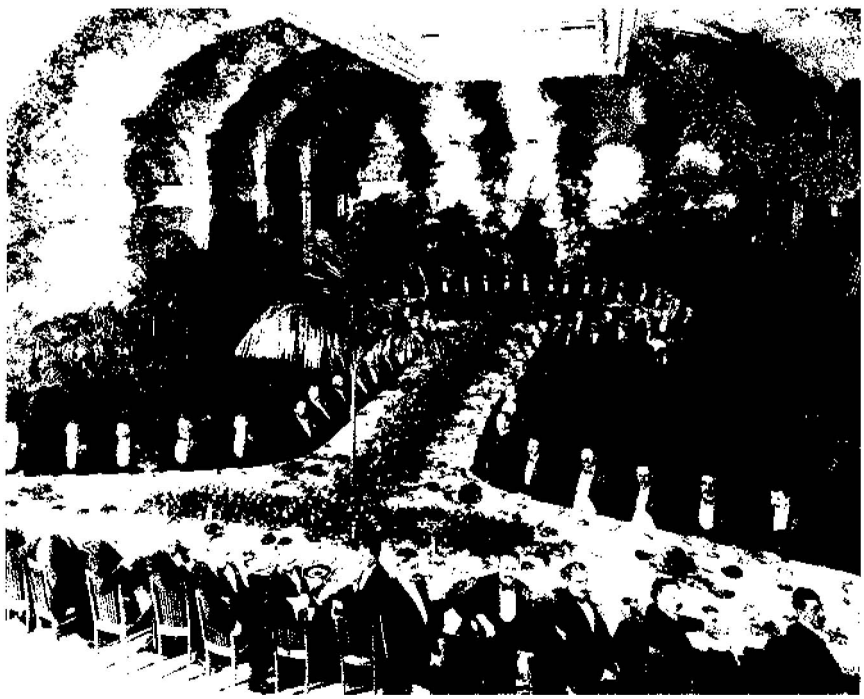


Figure 21, U.S. steel diuncr ill 1901 cclcbrari ng corporate organization sin:ilar to Fritz's birthday dinncr partie: clllogizing hi, manly corporate characrcr. Courtesy of Carnegie Library of Pittsburgh (neg. A-146).

have rcmaincd to this day the quier place lit was and} the waving grai n would srill be bending to the summer breeze over lands now..," so the [esrers charged. The lamenied loss of a golden pastoral past comrnon in the writings of many European and American wri rers acqui red a particu lar meaning for en gi neers. Many engineers presented their participation in engineering as contributions to the march of progress and as an illustration of their own self-improvement, but coming, as many did, from an agriculwral background, the authors often expressed ambivalence about the pastoral world their very profession had helped to destroy. "The indictment showed," the fraternity charged, "how the prisoner [Frirz] growing up, turned his back ... on the old farms, sought out a country blacksrr: irh and rnach incshop, where he thumped his fingers, greased his clothes, and grew black in the face, thinking he was becoming an engineer."[46] The creation of a professional autobiography attempted to recapture a past that engineers had helped to destroy, and served ro memorialize a pas[made obsolete by the very careers they described."

This concern with a loss of the pastoral past also displaced the contest between skilled steel workers and managers – a conflict that was on everybody's mind in

September 1892. Three hundred miles away from the celebration at Bethlehem's Opera House, the ongoing and bitter strike at the Carncgie Steel Company in Homestead just outside Pittsburgh in Pennsylvania divided the community if not the country. At the beginuing o f that sum mer the eonflicr had seemed to center merely on pay, hut as the months wore on the workers' demands, srrarcgies, and arguments focused on workers' control over the organization of their work. At the heart lay a classic contest over knowledge and skill between workers and managemenr." In this highly charged political atmosphere and amidst a dec pen illg economic crisis, the ASME esrablishmenr put John Frirz on mock trial during a banquet given in his honor jusr as he had retired from a long career as the quintcsscntial manager and corporate mall, The invited guests ar his table included steel barons like Andrew Carncgie, Henry C. Frick, and Abram S, Hcwiu, all of whom were involvcd jn the dccisivc labor eonrcstat the Hornesrcad steel works, Against the backdrop of the bitter lnbor-rnanagcmenr conflicts ar Homestead, the guests found their practical joke so "merry" that they were overcome with "unconrrollablc laughter."[49] With a nod to the labor battles being fought in the courts, the organizers accused Fritz of the pretense of possess: ng rcch nical knowledge .uul calling himself an engineer; in the opinion of the ASME establishment, the Homestead xtee] strikers showed an exaggerated confidence in their technical knowledge, as if their skills could not and would not be replaced, Frirzs second offense againsr Bethlehem's pastoral peace went beyond the inroads rhc steel industry had made into the agricultural world, A dcpoliricizcd narrative of the lost Golden Age thus allowed the ASM E cstablishmcnr to work rhrough their role in, and anxiety over, the transformation of labor relations. Male gendered language obscured and resolved the existing contests between managers and skilled workers in rhc steel industry, Fritz and the ASME appropriated the skill and manhood of the workers they supervised in language and images: "he rhurnred his fingers, greased his clothes, and grew black ill the f;lCe." 'I'he accusation of having posed as an engineer playfully referred to Fritz's lack of formal education, increasingly demanded by engineering educators, hut in the poliricaHy charged air of that summer, it also played on the professional skills engineers claimed vis-a-vis mechanics and management on America's production floors.

The male-gcndcrcd language of calluses, dirt, and sweat became more pol irically coherent in the narrative of 1902 - in the decade characterized by the bitter suikcs at rhc Homestead steelworks, [he Cocur d'Alcnc silvcrmincs, Pullman and Chicago raiiro.uis ihar proved to be decisive in the changing labor-rnanagemcnr relations when governrncnr intervened in rhcsc industrial conflicts on behalf of the owners and managers. This time the mechanical engineel-ing csrablishrnenr gathered to celebrate John Frirzs eightieth birthday and chose the Waldorf Astoria in New York *City* as their setting rather than the local Opera House in Beth[chcrn:

this was a sign of the growing confidence of ASME members in their national importance, and a reflection of their exclusive orientation towards the financial centers of the East Coast. Several guests sitting at Fritz's table had come to despise organized labor - the product of their conflicts with unions in the decades after the 1873 national depression, the Haymarket scare, and the Homestead strike. Rossiter W. Raymond (1840-1918), president of the American Institute of Mining Engineers (AIME), an influential writer for his profession and an arch opponent of unions, pitched the manliness of John Frizz against that of craft unionism embodied in his enemy John Mitchell (1870-1919), president of the United Mine Workers of America (UMW). Rossiter had developed his vitriolic antagonism against labor unions when he was working as a consulting engineer for iron manufacturer Cooper, Hewitt & Company during the 1880s; an antagonism he articulated more publicly and bluntly during the Homestead strike in the early 1890s. At Frizz's birthday party, Rossiter ridiculed the UMW's struggles for recognition and pay. "You will not find a great many pages about raising engineers. You will not find one single plan for shortening a day's work or diminishing the quantity of labor that an honest man gives for his labor (applause). You will find that Society [AIME] recognizing individual manhood." Closing his rousing speech, he asserted that the American manhood of individualism had been divinely inspired."

Abram S. Hewitt (1822-1903) further gendered Raymond's definition of a middle-class manhood. A steel baron and ex-mayor of New York, he had been the president of the Cambria Iron Works in Johnstown, Pennsylvania, where he had hired Fritz as a superintendent during the 1850s, and had been Rossiter's boss during the bitter labor disputes in the later part of his life. Hewitt celebrated the fraternal feelings that had blossomed in spite of - and that had also counterbalanced - the competition that lay at the heart of their relationship. "At times of competitive struggle, the friendship which has existed between us has never in the slightest been disturbed," he insisted of his loyal employee. "This happy experience is due, doubtless, to the amiable traits of Mr. Fritz's nature, which, with all its masculine energy, is tempered with the sweetness of the gentler sex," Hewitt added in a nod upwards to the balcony where their wives were segregated in the Angels Gallery and entertained with a watered-down version of the celebration that went on downstairs." To the ASME business community, John Fritz's life came explicitly to represent acquisitive individualism. And in a classic reinstatement of the ideology of the separate spheres, the ruthless competition between husbands was translated into fierce male love, but held in check by the sweet silence of their wives in the Angels Gallery upstairs. Through its narrative, the fraternity thus framed John Fritz's life as a paragon of American business and individual manhood, omitting the struggle that was part of it. For the steel barons and their associates who had been embroiled in the changing labor relations in the steel industry, Fritz's engi-

nccring managerncnr professionalism became their ideal vehicle. To emphasize it, they instituted the John Fritz gold medal in 1902.

John Fritz allowed the members of the ASME to shape his life story, but his autobiography - written 10 years later in 1912. - also diverged in subtle and significant ways from their construction. In the third narrative layer of the book, John Fritz recounted his life as a defcnse of his engineering knowledge, competence, and expertise while carefully stressing his good feelings and relations both with the workers and upper managemenr. following the tradition set by other engineers, Fritz told his life story through elaborate descriptions of the technical problems he had faced with [he staff at rhc Norrisrown, Carnbria, Safe Harbor, and Bethlehem Steel plants and of bis solutions to them. He described conflicts with skilled workers, foremen, formally trained engineers, managers, boards of directors, and hankers alike, many of whom had attended his birthday panics - conflicts from which he emerged victorious over his skepricai, ignorant, and rccalcirranr opponems because of his technical expertise. If the ASME defended an ideal manhood of individualism, Frirz's own definition of ideal manhood was to be "a man among men," or projected back into his youth, "a boy among boys" - a theme common among engineers often echoed in the pages of engineering magazines.[2]

The masculine rornanricization of rhc shop floor conveniently disguised the fundamental changes that had taken place and the tensions that gave rise to it. The engineer's ability to withstand workers' jokes and pranks, and his skill in speaking the salty language of the shop floor - coarse to the ear of the intended readers of his autobiography and ro his own middle-class sensibilities, but vital for gaining and maintaining his credibility with and authority oyer the workers – had been forms of initiation into the male world of industry. Frirz insisted, "I do not now forget the laboring man, and especially rhe able, brave, and noble men who loyally stood by me in times of severest trials...who were ever ready to face any hardship or danger...To these kilJd and loyal men much credit is due for success as J have attained."[3] In his all[()biographical tale of [912, Fritz sidestepped the tensions between the skilled workers and managers and rhe indusnial warfare that had raged around him: "I wish, also, to give credit to the brave and noble workmen ...All that needed to bc said was 'Cornc, boys,' bur never 'Go, boys', ...100 much crcdit eannor be given ro these fearlcss and energetic men for the marvelous progress that has been made in the manufacture of iron and steel in this country.?" His insistence on the skilled workers' high level of confidence doubtless represcnred Fritz's feelings and own social backgrou nd. It might even have been a subtle criticism of the ruthlessness of the steel barons, bur it also masked the sharply conrested changes (hat had occurred in the relations between management and skilled workers at Bethlehem Steel, Cumbria Iron Works, and elsewhere in the steel indusrry rhroughour his lifetime. Fritz had been celebrated for his invention of the

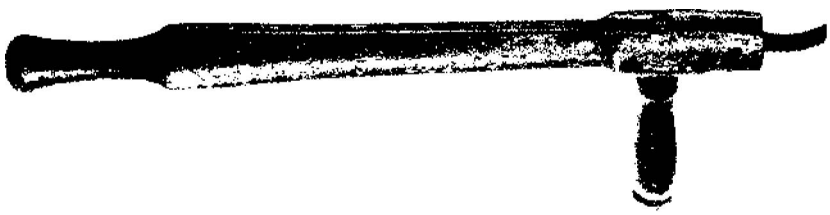


Figure zz. Thi« 1840s "hook tool" was used by rhc skilled machinist who rucked its wooden handle under his armpit to steady rhc curring edge againsr rhc rapidly "pinnjng work piece in rhc larhc. Presented h)' John Frir« in his Prcsidcnriul speech to the American Society "f Mechanical Engineers in 1896, irfunctioned as a relic ofthe mcchanists skills.u material trophy ofcorporate progress, and a fcrish of work: ng-clas munliness. courtesy of Division of Engineering and Jndustry, Nati(hal Muscum "f Amcrican History, Smithxonian Institurion, Washington, DC. (neg. 45210-A).

three-high rail mill that saved the arm-breaking labor needed to form square bars ofi ron into finishcd rails. Yet Frirz wa»also intirnarely involved and directly irnpl i-cared in the rmnstormarion ofanorher aspect of rhc labor process: he led the in rro-duction and improvement ofthe Bcsscmcr Steel process that eliminated the job of the puddler, wh() conxi irurcd the aristocracy of lahor and the vocal part ofthe in-dustrial craft unions movement.' In his 1896 Presidential speech Frirz presented the hook tool as a token ofhis own and the steel industry's youth to the American Society ofMechanical Engineers. 1t was also a relic of the machinists' skills, a ma-terial trophy ofcorporate progress, and a fetish ofworking-class manliness. Shop-floor manliness might have been viable in Philadelphia's machine shops of the 1840s the hookrool represented, but in rhc late 1890s this was no longer a reality and largerly symbolic.]] :igllre 221 The development of industrialization paralleled Fritzs rise to prorni ncncc in iron and steel manufacturing - an industry rhat had been the major engine for the railroad and war industries. It would become an icon and metaphor for industrialization itself - symbolized at the World's Fairs and sanitized in the prcscnrarion of clean machines.

From engineering's basement sounded dissonant literary voices, however. In ill-lit drafting roornx a few steps below rhc level of the sidewalk, thousands of drafrsmen worried about the height of their stools. the fumes, dusr, and noise coming from boiler rooms and foundries, or the trcarmcnt they received from their supervisors. The young graduates Irorn the engineering programs, corre-spondcncc schools, and evening classes cared little about mai ntaining managerial modes of manliness, They had come to expect their position in life as employees of

THE DRAFTSMAN

Who is it that sits perched on a high rickety chair
Draws lines all day with a learned air
And wears in the seat of his trousers a shiny glare:
The draftsman.

Who is it that sure must be wondrous wise
And for a few dollars on the blink puts his eyes
And whom it behooves new things to devise
The draftsman.

Who is it when a Job goe wrong
From the Bos gets ha; 1Columbia good + strong
And starts to whistle a cheerful song,
The draftsman.

Who is ;t that works \;ke a slave in chains
Then hears the Boss tell him of his aims
And say, surely haven't I serne wonderful brains
The draftsmen.

Who is it that gets a1\ the credit and praise
A pat on the back and a goodly raise
For th\nge You have done, and worked on for days
The Boss!

AJS

Figure 23 Sarcastic poem published ill the rank-and-file engineering journal *The Drafisma»* (Philadelphia) in 1928 showing rhar the paternal pledge and promise of promotion ID management poxition was nor rcadily available to most laboring in the basement of ehc profession.

such large corporarions as the American Bridge or the Duponr companies. Through organizations including the 'lcch nical League, the American Association Of Engi neers, and the Inrernariona I Federarin n of Technical Engincers', Architccts' and Draftsmcn's Union they began to articulate their demands for better working conditions and pay. When in 19t9 the air filled with talk of democracy and rcvo]u[ion, engincering rclorrner Robcrt Shelmire articulated rhc sense of class betrayal many aspiring engineers stuck in drafting dcpartrncnrx felt when the

paternal pledge of upward mobility was broken. He questioned the refusal of engineering organizations like rhc ASMF. to furnish employment services, He asked rhetorically if there was any excuse for failing ro help "the younger men who arc growing up in the profession and will succeed them. ... The exploitation of young cuginccr-drafrsrncn coustirutcs a most shameful chapter of the history of engi nccring... Much of the responsibility for the drafrxrnan's predicarnern is placed on the older engineers. The engi nccrs, the men who style themselves *the* profession,... who have tried the draftsman out of the engineering profession."[55] Instead o(composing autobiographies, these draftsrncn wrote poems or circulated [he verses written by writers like Rudyard Kipling. Poetry counselled the scores of sons from lower-middle and immigrant classes, and some African-Americans and women on how to keep their dignity, helped release the tensions suffered in the drafting departments, and ventriloquized the anxieties at the bottom of the engineering ladder'. From rhc basements, drafrsrncn approvingly read lines as: "Tomorrow, we will sweep all fears away/Tomorrow – we'll be dead/Go, fool – and play." They counselled on how to maintain dignity in the basement "Don't be afraid of the dirt/'!'hat comes from the furnace of [he file/Each man who is great... Has worked in the dirt for awhile." They ventilated their anger about bosses. "Who is it rh.u gets all rhc credit and praise/A pat on the back and a goodly raise/For rhings *YOU* have done, and worker] on for days/The BOSS."[56] [Figure 23]

(Re)Making the history of Engineering

Numcrous :\ll\obiographies chronicled the many conflicts which civil engineers faced and internalized during the second half of the nineteenth and the early rwcnticrh centuries, and many were, as Scarles had made so painfully clear, neither suecess stories nor narratives of autonomous, self.directed men, bur rather bore witness to the narrow space for negotiation which mid-level engineers occupied. T'his sense of failure and bewilderment shaped the way mallY authors structured their narratives. Engineering autobiographies, however imperfect they may be as literary works, thus often expressed the confusing experiences faced by individual engineers from rh« middle strata of corporations. -l'hcy established rheir own literary genre characrerized by dcrailed rechnical descriptions, disembodicd prose, and the erasure of workers' knowledge. Above and across the ditches, tracks, and canals, they reached out to the imagined communities elsewhere through their autobiographies. In them, engineers displayed their own n chniral knowledge, seekiIlg ro stake out an area of knowledge und skill enrirely their own, while celebrating malr bonds. Writing an autobiography became a personal and collective way of reworking past experiences in order to understand, interpret, and recast the present

in which the occupation had become deeply divided. Between the politically significant years of 1892 and 1912, the engineering establishment revitalized Fritz's life into an example of a self-made man who had pulled himself up by his own bootstraps - a story articulated in a language of shopfloor manliness that was dislodged from its original political context."

Following the publication of Fritz's autobiography, the ideal of the self-made man increasingly became a coherent narrative, a dominant strategy, and marketing device for those engineering autobiographies published by commercial presses during the 1930s when it became codified as a belief in initiative, aggressiveness, competitiveness and forcefulness. Commercial publishers and sponsors in the 1930s promoted engineers' lives as clear expressions of rugged individualism. But the construction of rugged individualism was more a product and a marketing device than an actual reflection of the time recalled in the autobiographies. "To me," wrote the publisher Rourledge in his 1936 foreword to the autobiography of Samuel Taylor (1869-1947), "[he] has always represented what is best in rugged American manhood. I never knew him to exaggerate a statement." Likewise, Alfred West Gilbert's son thought his father's autobiography exemplified "the simple story of a quiet, modest man, with no claims to either greatness or wealth." He endorsed its publication in 1934, almost fifty years after it had been written, because "[i]t is good in this distracted time to pause and give thought to those of an earlier day who served their country...for its development." As if to counter the Roosevelt version of state socialism and calls of solidarity, he continued to stress the importance of individualism as a source of inspiration during a time of economic hardship: "we must depend upon individual character to sustain the nation which our fathers so laboriously built."[81] In part because of the growing power of the large corporations, another civil engineer, Paul Starrett (1866-1957), who supervised the construction of several of the classic temples erected on the Columbian Exposition's midway for Chicagoan architects Burnham and Root, stated in 1938 with an air of nostalgia that the era of individualism had already passed: "There will always be individualism but the era of Fricks and Stillmans and Blacks is of the past, and with it the builders of that era they are like those vanishing Indians of my childhood."[82] The autobiographies appeared on the literary scene as the daily press, weekly magazines, and popular fiction devoted considerable attention to engineers and their work, thus enhancing and enshrining the profession of engineering. One establishment engineer noted with pleasure in 1936 that "it is gratifying to the engineers to know that year by year the great importance of the profession is realized by the general public..." This recognition was perhaps best symbolized by the election of Herbert Hoover, a mining engineer by training, profession, and political conviction, to the Presidency in 1927, but contrasted with the experience of the rank and file.

If the authors wrote about the nineteenth celHury, their autobiographies were also important products of the early twentieth cemury as they expressed the epoch's taste, tendency, o r need for memo rializing. The ir produc r ion and marketing rook place during a period which coincided with the passing of the Golden Age o(civil , mini ng, and mechanical engineering. Taken together, the writing and publication of the four dozen autobiographies constitute a significant narrative production and a professional and collective moment of mcmorializing. During rhc 1930S, the genre became more firmly established as presses like Wi ley and Sons and McGraw-Hill – major publishers for technical, vocational, and engineering schools and active participants in the campaign against rhc debate over technological employment - publicized the storie» of small heroes in the spirit espoused by Ogbum, Giedion, and Usher, who sought to write a new social and anonymous history." The spate otcommcrcialiy promoted autobiographies was also a defensc againsr the dern and of some social scicn risrs that engi nccrs and scientisrs share responsibility for the economic crisis of the 1930s; they came when the project of building an empire was in decline, corporations consolidated further, and the Federal government was investing hcav: Iy in major buildi ng through Rooscvclrs programs of public-work administration. "It is good in this distracted time to pause and give thought to those of an earlier day who served their country and labored to lay a sure fou nda tion for jrs dcvcloprnenr. Wirh all ou r laws, restrict ion s, new inventions, and so-called improvements, we must depend upon individual character to sustain the nation which our engineers so laboriously built," justified a widow of an engineer upon the publication of her husband's autobiography, which he had written some forty years earlier.[6] The autobiographies were responses to the growing worries over technological employment during the 1930s and the call for responsibility of engineers and scicnrisrs, If their autobiographies had not been commercially viable in earlier decades, during the 1930s commercial presses began to cater to a market that had come to believc that engineers a11d scientisrs rather than poliricians and sraresmcn were the small heroes of America and the true shapers of history. These publishers helped name and shape a new area of expertise and knowledge that could for the first time be designated as technology. This history of engineering would be cast as the history of technology.

4

(De)Constructing Male Professional Bridges

Late Victorian male writers of romance and modern artists of the visual arts began to build professional bridges between rhemxelvcs and engineers. Over the span of two and half decades fl"om 1890 to rhr first World War, male commercial writers staged the engineer as a male cultural hero, A decade later, the modern avanr-gardc followed their popular writing brothers by acsrhcricizing the visual language of machinery and by iuscribi ng machiuex as explicitly male symbols..Togerher these two professional groups shaped the symbols of rcchnology. Engineers and machines became the markers of modern manliness but not without protests from women professionals.

[f in rhc autobiographies of male engineers women were removed from the set, in popular engineering novels they occupied cenrer stage. \Vomcn played a crucial role in lending engineers their virility. Authors inrroduccd the heroine often to counterpoint or criticize the world of engineering work. No doubt because of literary convention, authors of [icrion inserted women as lovers, mothers, and duughtcrs into the engineers' world of work and threw them into sharp relief with male engineers. Within rhe pages of their own autobiographies, by contrast, engineers described their work as an affair between men only and replaced women and [heir lamily of blood relatives by a family of engineers, proving their manhood through their struggles with other men including owners, fcllow engineers, and laborcrs, But in the world of fiction, engincers won their badge of manhood through their associations with women: here the men of fiction acquired their distincrivcncss through the women's presence and prodding.

There was another major difference between writers and engineers, liowever. Male engineers placed their autobiographies in the tradition of vocational literarurc, which eagerly solicited the attention of young aspiring men, while the writers of popular fiction catered to rhc preferences of a mass audience dominated by female readers, "It is said that the success of a book," wrote a father-and-son team of writers in the foreword to their engineering novel *Web of Steel,* "depends upon women; that women buy, read, discuss, and promote a novel, and if the book has no appeal to women it is forever doomed." Slyly, the authors, one a popular writer of to ma nce, the oi her a civil cngi nccr, congrarula red rhcmsclvcs for havi ng dcf ed

women's dominance in the literary marker and "at leasr proved themselves men of courage, the publishers likewise, for it cannot be too insistently set forth that this is primarily a book... for men, about men, and written by men." As a concession to the female marker, the authors constructed their story about men "around the eternal feminine whom the authors have striven to make as feminine and charming, as appealing and delightful, as their large experience wirh the other sex permits and warrants!" The story line of their engineering novel revolved around the collapse of a bridge and the love between father and son, showing how the demands of engineering work and male horror were incompatible with women's demand for tarnily and community.

The authors of *Web of Steel* articulated a decade-long war of words between female and male authors who had been reflecting all rhc astonishing rise ofborh crir-ically and commercially successful women of letters throughout the middle and late nineteenth celltury. In the winter of]872, a famous conversation between Mark Twain and Charles Warner and their wives generated the classic answer to the nineteenth-century cultural wars of gender when the husbands questioned the state of popular fiction dominated by such succesful female writers as Harriet Becchcr Stowc and Louisa May Alcorr, The wives challenged rhei r husband w rir-crs to compose a better tale. In answer to the challenge, they publ ished their best-selling *The Gilded Age: A Tale ()/l'()da)'* (1873), a novel about the male industrial world of scoundrels and schemers that would give the era its namc.

Recasting this snuggle in new terms for the modern age, male and female anists minted the engineer as cultural hero between the economic downturn of the 1890s until after the first World War. Artists often portrayed engineers as visionaries and artists who stood for design, imagination, and leadership, rather than mere execu-rion.l ligurc 241 This portrayal fell squarely in line with the cagerness of engineering advocates to show rliar engineering works were in fact works of art, in an effort to obtain professional recogn irion from cultural elites.' The portrayal of the engineer as an artist depicted him as a visionary free agent who stood above the mere concern of making money and offered engineers an appcali ng professional role model,

But the mutual mirro ring between cngi neers and artists reflected a parricular male affinity and infatuation, perhaps even a male middle-class alignment ofsorrs between the male authors' search for social and economic status and the engineers' q ucst for cultural authority. The gender convergence of the artist-as-engineer and the engineer-as-artist infused both the engineering profession and the writing profession with manly qualities of independence, control, and physical vigor at a time when horl: professions were increasingly incorporated into modern, bureaucratic, and maxx institutions at the turn of the century. \X/omen novelists and artists, however, cared to disagree and devised their own narrative and visual strategies. If

Figure 24. Engineers as male professional role model for middle-class boys and popular authors stressing the outdoors. Book cover for *The Young Engineers in Mexico* as part of a juvenile series on engineers, 1913.

men ruled in the engineering profession, male authors believed that women dominated the arts. The popularity of the engineers as a protagonist helped to recast that contest in new terms. The manliness of the engineer bridged the professional asprirarions of male writing and engineering professionals. Modernist artists also increasingly projected themselves as engineers: they rejected academic traditions and [he arduous apprenticeship system of the studio, celebrating instead design over craft. Avanl-garde visual artists similarly adopted the machine's aethcrics as badges of male versionx of modernism to air out the Victorian parlors associated with genteel women. For them, Victorianism represented comfortable and overstuffed female parlors where women wrote and read in leisure. They adopted engineering aesthetics and devised an identity to counter it. The representation of ourdoorsy male engineers, [he protagonists of a great many popular writers, served as their agents to air out rhc stuffiness of the nineteenth-century parlor,

SCRIBBLING MEN DESIGN ENGINEERS

Promoters of an engineering professionalism looked for cultural stamps of approval by enlisting writers to enhance their prestige. "The soldier has long been the hero *par excellence* of the writer of romance; the statesman, lawyer, physician, and minister have received their share of glory, and even the business mall has not been overlooked...Bur what of the engineer and his work?" queried Edgar A. Van Dcuscn in the *Professional Engineer*, home journal of revolting engineers, in 1922. At 38, Van Dcusen (b. 1884) could claim an impressive heritage to the Hudson Dutch and to the British engineering profession, and a sound engineer: Ilg education, bur he had been employed in the lower ranks of rhc profession as ch ief draftsman with various corporations for almost ten years. After reviewing a number of popular writers' treatment of engineers published in the previous decades, Van Deusen advised that such literature should serve "to give the public a clearer conception of the value to the communiry of the engineer and his work..,Both rhc prolcssion and the public would owe the authors a debt of gratitude."[3] Van Deusen's call for literary recognition expressed the engineers' more general sense of cultural neglect and public indifferencne to their professional claims and echoed an earl icr plea of], H. Prior, chief engineer of the Illinois Public Urilirics's board, for raising the "social, economic and cultural status" of engineers.' Engineering patricians like Prior and Van Deuscn canvassed for financial reward and social statux hilt also sought to increase engineers' cultural capital. To engiueeri ng advocates, reading popular novels and poetry was more than a leisure activity: it signalled a potential asset that could increase engineers' much needed cultural capital.[5]

Male writers of popular fiction fought their own battles with women authors and wit h a predo m inantly female audicnce. To male authors the "Icm inization" of the writing profession threatener] their professional prestige or what Hawthorne had called a "damned mob of scribbling women" as early as 1855 when he witnessed rhc stellar rise of writers like Harrier Beecher Stowe and Mary Elizabeth Barren Browning in the literary marketplace.' The engineers' search for cultural authority paralleled the male professional writers' own quest for independence and financial reward. The creation of the figure of the engineer bridged these mutual male professional aspirations. In the period from the Columbian Exposition to the first World War, prior to Van Deuscns rhetorical question, arleast 20 novels and shor: stories appeared on the literary scene in which writers of romance cast the engineer as a white middle-class hero. Published during a relatively short period in the decades preceding the first World War, novels like *Soldiers ofForwne, Jhe Bridge Builders*, and *Still}im* enjoyed immense popularity at the time of publication, but have long since been forgotten, John Fox Jr.'s *The Trail of the Lonesome*

Pine (1908), Harold Bell Wright's *The Winning of Barbarn Wonh* (1911), and Zane Grey's *The U.P. Trail* (1918) ranked among the number onc bcsrscllcrs in the history of American publishing, each selling over a million copies.

The engineer of genteel [iction was a ruling class figure, a visionary, and a leader who was portrayed as an ideal professional: "social, civil, and stable." But this managerial professional ideal was also distinctly male and middle class, and did not include women, In his ruggedness, the engineer became the male successor ro the cowboy, rhc embodiment of physical vigor and control, who conquered and mastc reel Iemalc nature; he symbolized the romantic lone r who roamed the country in all ;ltTempt to escape the weakening influence of civilization associarcd with female values. In the portrayal of these male professional writers. the wellspring of the engineer's true manhood was his body. Yet he was also a professional who mapped and civilized the American West, and embodied the middle-class ideal of *Jhe Strenuons Life.*' Most fictional engineers were civil or mining engineers who supervised the construction of bridges, railroads, and dams, or the extraction of precious ores for the expanding American empire; few, if any, dealt with mechanical, chemical, or elccuica] problems. Thc fictional engineer was muscular and did not hexirare to get his hands dirty, hut he was never confused with the laborers he xuperviscd. Hc was a leader and a loyal eompany man married to his joh, and as such he became the premier male and middle-class role model of work during the [91OS for which the patrician Van Dcuscn longed,

One engineering story !-irst serialized in *McClure's* and illustrated hI' Charles Dana Gibson before being publ ishcd as a hook was Richard 1 lardi ng Davis's *Soldiers ofFortune* (1897); it was emblematic for the new genre. It tells of a min ing engineer, Robcrr Clay, who exploits the Valencia Mining Company for American absentee owners in a small South American country called Ol.mcha. As a journalist and short srory writcr, Davis (1864-1916) was closely associated with the male chivalrous ideals most succinctly expressed in 'I'hcodorc Rooscvclt's docrri ne of rhc "srrenuous life." In his novel. Davis exploited the themes of strenuosity and virilirv ro the Iullesr, explicitly linking them to American capitalist expansion ahroad, One character ill the novr] explains that engineers "were fighting Nature at every step and carrying civi]izario n wi rh them, They were do ing bcrrcr work rha n soldicrs, because soldiers destroy rhings, and these ch.ips [cngineersl wcre creating, and making the way straight," but doing so without recognition, In fact, "rhc Civil engineer," he continued, "is rhc chief civilizer of our century."

'l'he linkage between male conquest und the domes: ic.uion 01'nature - at once sexual, female, prim irivc, and wild – found its most eloquent and unambiguous expression in Harold Bell Wright's best-selling novel *The Winning of Bnrbarn Worth* (19u}. 'I'he novel's title borrowed from the frontier manliness encoded in Rooscvclrs *Winning ofthe West* (1896) .md his other writings, In popular-culture

representations, the West, in danger of becoming civilized and thus "feminized," figured as a place of male initiation by overcoming hardships." In Wright's novels, women's moral and civilizing influence threatens male enterprise and is therefore replaced by the kind of civilizing effort of engineers that Davis had in mind. Harold Bell Wright (1872-1944), a preacher turned writer of at least five best-sellers, reached millions of readers in American rural areas and small towns through a sophisticated advertising campaign of the Book Supply Company, a Chicago mail-order firm. Through his novels, readers learned to treasure middle-class values even if they had not yet joined the middle class in economic terms. Wrigln's writings romanticized the West, unspoiled nature, arduous labor, clean living, and neighborliness, all attributes of a Rooscvclrian *Strenuous Life*.[12] His plots tried to reconcile engineering construction with the exploitation, scarring, and rape of the land, and the demands of capitalist individualism with the ideals of community and service. In these and other narratives, novelists portrayed engineers as battling greedy investors and taming nature, who fought both the forces of nature and the greed of financiers threatening their designs. Many of the plots turn on how the engineer-hero overcomes these barriers by virtue of his vision, hard work, and expertise. In the end, engineers of fiction reclaim nature and heroines, while they hartJc with irresponsible politicians and greedy capitalist adventurers.

The sales figures reflect the large audiences which the engineering novels were able to attract, but the authors' handling of the subject matter also accounts for their ongoing fascination with engineers in their plots. The ourdoorsy masculine professional engineer carried great allure for male authors of popular fiction, who were writing and producing for a mass market, when popular magazines began to include articles o n busi ness, the professions, and pol itics ill an arrempt to court maJc readers.[13] The introduction of new publishing techniques and the emergence of popular magazi nes transformed not only publish: ng but also the market position of writers in relation to audiences, editors, and reviewers. Before the Civil War, writing had been on the whole a leisure pursuit for which authors did not receive any payment; but by 1900, writers entered a well-established and centralized market facing pressures similar to those of engineers. Not surprisingly perhaps, in looking for a new male reading market magazines like *Scrlbners'* and *McClure's* were the firxt to serialize rhc engineeri ng novels. Because the reprcsenration or the engineer could address male readers in a predominantly female reading public, as the father-son team understood so well, it had a spccific market value to wrirers and publishers looking for new markets. Thus, engineers were not alone in their ongoing search for status and recognition.

KIPLING AND M ARTHA'S M ANLINESS

Best-selling authors like Harding Davis, Bell Wright, Fox, and Grey endowed engineers with a new cultural authority that elite engineers Van Deusen and Prior rhought engineers so desperately lacked when the profession transformed into a mass occupation; bur the English-American poet and writer Rudyard Kipling did even more. Of Thorsrcin Vcblen's generation, Rudyard Kipling (1865-r936), the most popular poet and writer in the English-speaking world of his day, explored the male version of the engineering gcnre in a number of works. Like Veblen he was extraordinarily popular and a late Victorian helping to transform the age into one of Modernism. Kipling's readers were extraordinarily fond of quoting him, precisely because his work had different if contradictory layers and could be railored to suit each occasion. Around the turn of the century, he reached stellar commercial success and could claim to be the most frequently quoted poet of the English-speaking world. He had [0 his credit 5 novels, 250 short stories, more than 800 pages of verse, and several books of nonfiction prose; 15 million copies of his collected stories were sold. His popularity paralleled the rise of modernism, to which his work bore little resemblance at first.[3] Most importantly perhaps for his popular success, Kipling presented himself as the voice of the ordinary worker and established the world of work as an appropriate subject for literature, in contrast to many contemporary writers who were primarily concerned with aesthetic subjects. He made labor the subject of his work and appropriated many working-class images of physical toil. Nevertheless, his celebration was thoroughly middle-class in appeal,

Kipling wrote many short stories and poems about engineers and their work such as *The Deoil nnd the Deep Sell* (1895), "Mac/vndrcw's Hymn" (1896), *007 (1897)*, *The Bridge Builders* (1898), and "The Sons of Manha" (1907) in the span of fifteen years. In these stories, he used technology in various ways: he inserted solid technical descriptions and anthropomorphized technical devices or employed engineers and their work in his narratives and verse.[4] The affection between Kipling and engineers was mutual. Not only did Kipling use engineers in his plots, but many cngineers relished his work. He became their unofficial poet laureate. Engineers sponsored, quotcd, appropriatcd, and reworked his verse when writing about themselves. Engineering magazines often published his poetry.[5] Ralph W. Lawtou (1869-1943), all American civil engineer who managed the installation of sewer and water systems in Jndia for the British government, wrote his autobiography in the form of a dialogue with Kipling's verse.[6] C.E. Moorhouse, a professor of electrical cngineering, reportedly "made it a practice of commending Kipling [to his students] as a model of clarity in descriptive writing" because he considered Kipling's technical descriptions quite proficient.[7] In the pages of *Engineering*

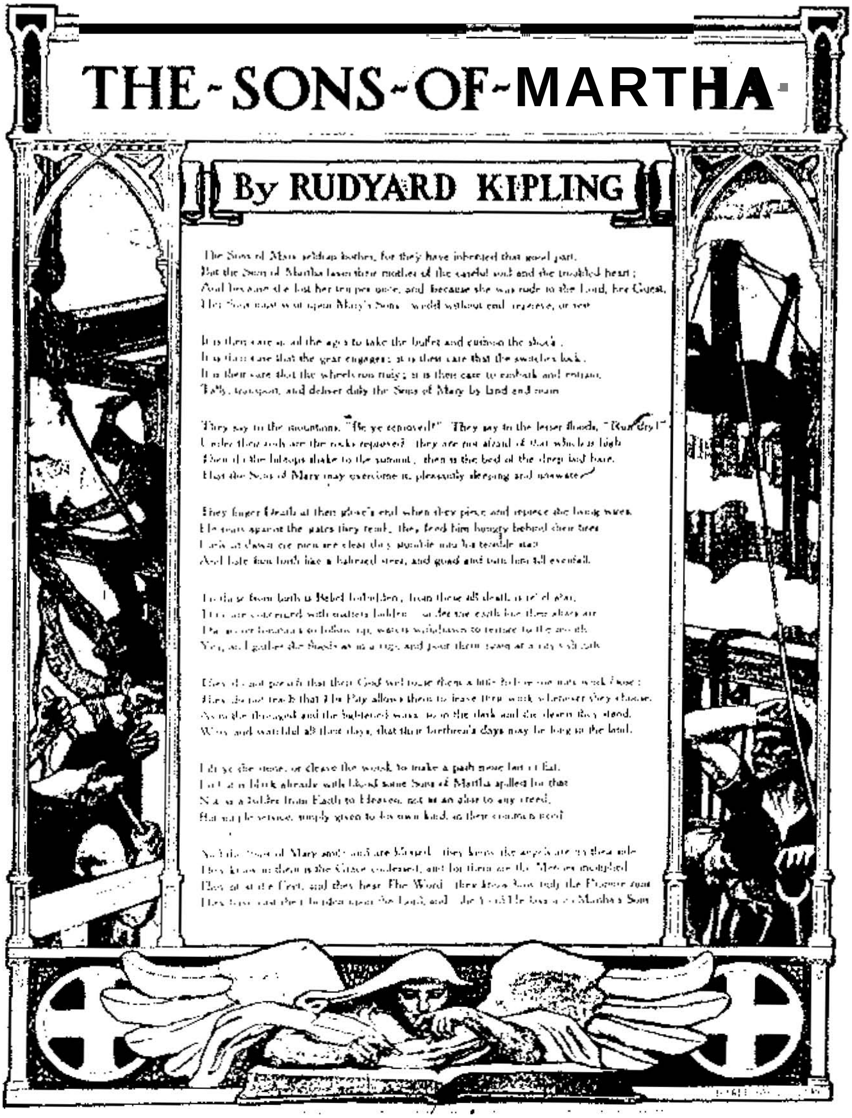


Figure 25. Kipling's poem, "The Sons of Martha," with focussed attention on the working-class male body illustrated in Gothic-symbolic style. *The New-York Tribune* (April 28, 1907).

News, Robert T. Gebler of the Technical Supply Company in Scranton, Pennsylvania, apologized to Kipling for attempting a verse very much like that of the master himself, which read in part: "But as I've often read it/The bloke who gets the credit/Is not the dusty khaki'd engineer/But the guys who 'ave the shillins.?"

Figure 26 Portrait of rhe mosr popular poet of the English-speaking world, R, Kipling, announcing his latest poem "The Sons oi Martha," in *The New-York Tribune* (April 28, '907)'

These and other engineers helped rework rhc working-class body for middle-class consumption,

Fnginccrs found in all of Kiplings work the recognition and the cultural aurhoriry they rhoughr thcv lacked. But one poem in particular, entitled "The sons of Marrha", resonated deeply with them because of the class issues embedded in it, expressed in gendered terms. [Figure 251111 rhar poem he touched them in a visceral way. In ir, he placed the issue of gendcr squarely in the middle (If rhc discussion of work, and reinforced a male iconography that represented engineers as workers rather than as managers. Des pitc jts ephemeral appearanee o ne wcekcnd in *The Ne/U-York Tribune, Philadelphia Press,* and the *London Evening Standard* in 1907, the poem acquired a subcultural following and became one of his more cclcbrared verses even though it never mentions engineers by name." [Figure 261 Engineers saw themselves mirrored in the poem. It appeared to deal with engineers' social class and position, exalting "simple service simply given," as a middle-class ideal of work. Kiplings representation was in accord with nineteenth-century

ideas of the work ethic ("It is their care that the wheels run truly; it is their care to embark and entrain/Tally, transport, and deliver July the Sons of Mary by land and main."). The import of the poem lay in its celebration and validation of the thankless, subjugating nature of hard physical labor.

The wide circulation and recircularion of Kipling's poem show how his readers interpreted and rewrote it to suit the occasion." "As in 'The Sons of Marrha,' which my cnginecr-brorher delights in," one reviewer reponed, Kipling "has a way of pounding in his ideas with admi rable economy of words."[13]]11 1928, the contracting company of Mason and Hanger published a book marking the centennial ann ivcrsary of the firm; they called it *The Sons of Martha,* appropriating the image of labor and building, as engineers were bound to do. No explanation of rhe title was offered, since the writer apparently assumed that his readers would be familiar with the poem." During the Great Depression the poem surfaced again, quoted in pan in the editorial pages of *The New York Times* when a reponer attempted to capture rhe heroic efforts of the rei ief workers following the devastation caused by a hurricane that year: "It was then [at the moment of disorder] - that the Sons of Marrha put on their boots and sou'westers and went out into the gathering darkness.,. In response to the editorial, one reader wrote ecstatically that the article was "one of the finest pieces of writing that has appeared in any paper. Every newspaper...should reprint it, and it should be read from every pulpit and from every radio station onc Sunday in every year in honor of the men who do difficult things of Jlfe for no reason other than their belief in the necessity of doing them."[14] And as late as 1989, the Society of American Civil Enginecrs published an anthology entitled *SOllS of Mart/M,* once again affirming their (engineering) readers' familiarity and ongoing identification with the poem.[15]

Engineers responded to the poem with pangs of recognition. In the poem, Kipling sang the praise of noble but unappreciated labor after the biblical story of Mary and Marrh» (l.ukc 10: 38-42). He turned the hihlical Marrha into a mother of men and Iashioned a new icon of engineering masculinity: robust, strenuous, muscular, honorablc, and anonymous. Kipling employed gendcred images of work in establishing a contrast between producers and non-producers, Martha's and Mary's, men and women, and engineers and capitalists. In the circles of women readers, the story of Marrha and Mary had served as a parable of women's socializarion as frctting housewives, *Tbe Woman's Home Companion,* for example, ran stories in which women who were called Marrh» invariably performed domestic duties. Even ill a spoof on the image, Marion Harland's short story for the *Women's l Iome Companion* "Marthn and Her American Kitchen" retained the cssenrial outlines of the parable by associating it with women's socialization into good housewives,[16] Kipling had to dispel] these notions.

In the traditional interpretation, Jesus's remark 1'0 Martha, that she should not be ovcrly concerned wirh her domestic labor and should ler Mary attend to her calling, became a canonical statement about rhc importance, if not the superiority, of spirirual labor for God's great work a11 earth. Contrary (() this traditional exegesis, Kipling glorified menial work. He could only accommodate Martha by extricating her from the biblical role of feminine toil and recasting her in a modern, masculine role as an engineer. Insrcad of domestic rcprcsenrarions of female roil, rhe poet laureate painted vistas of male work in engineering now associated with physical lnbor. In Kipling's reshaping of the parable, Marrha had become a man. Thus, "The Sons of Martha" is based on women but is about men; it assumes ceasceless labor, bur envisages toil as en nu bEng; it dispa rages rhe Word, bur spiritu - alizcs work.

Kipling added a class dimension (() the portrayal of engineers; but to do so he mobilized images of women, however idealized, that engineers had so carefully ignored in their autobiographies. In choosing this parable, the poet used gender not to expound on women and their sons offlesh and blood, bur rather to address issues of work and art. Kipling introduced gender inro the discourse on labor whether he had intended it or not. As the ride "The Sons of Marrha" indicated, modern-day sons had inherited the tradition of toil from their biblical mothers,

The stanzas in which he extolled on labor rather than on rhe Bible were quoted most often. As Kipling realized only later, the explicit, irreverent treatment in his poem of those who did nor gct their hands dirty - God and Mary's sons alike ("They have cast their burden upon the l.ord, and the Lord lays it on Martha's Sons,") - suggested to many readers rhar he had in mi nd the exploitation of workers by capitalists. In an introduction to a broadside reprint of the poem, Arrhur M. Lcwis explained why "it seems almost impossible to find rhis splendid poem in prim nowadays." He had heard "that Mr. Kipling himself opposed its further circulation, supposedly on the gro und of its class spi ri t." Lcwis confessed he could not find any trace of class antagonism, bur at least one reader-writer did."

An anonymous poet in *The Neui-York Tribun«* extricated the notion of Iabor from Kipling's ambiguous tangle and restored Ihe class and gender hierarchy left dangling. In November 1919, the reader-writer rewrote Kipling's poem by reversing the roles of Marrha and Mary, and entitled his "The Sons of Mary." The poet rejected Kiplings choice of Marrha as an appropriate image of engineers-managers. 1n imroducing rhc revised poem ro readers, rhe editor explained that givcn "the labor conditions in all parts of the world," hc believed the revision came "rimed to Ihe hour." The year 1919 was parricularly dram at ic for labo t--management relations. In that year workers staged a series of strikes iu response to skyrockcting increases in the cost of living during the war years. The many strikes such as the general strikc in Scarrlc in February, rhe Boston police strikc and the

nationwide steel walk-out, both in September, and the general coal strike in November left the middle classes ill shock." Reworking Kipling's poem to suit the highly charged pol irical climate of rhe postwar period, rhe anonyrnous wri rer defended management intcresrs. He lefr 110 doubt about who he thought the real workers of rhis world were and whose roil consri rurcd true dignified labor, 'The "Sons of Martha" lacked judgment, design, and initiative. Lest there be any doubt, the author made it plain that he viewed workers as mere instruments with no rechnical knowledge, resourcefulness or motivation - a description absent from Kipling's earlier evocation of labor. Insrcud, the poet ill 19J9 associated labor with unions and a rioting rank-and-file, while manager-engineers embodied rhc mental forces that directed and shaped production, Casting manager-engineers as the Sons of Mary, the author rhymed:

> The Sons of Mary in all the ages have dared the venture and taken the chance;
> They explore earth's riches and plan the bridges, invent the machinery, design the plants.
> Ir is through them that on every work-day the Sons of Martha have work to do,
> Ir is through them rhar on every pay-day the Sons of Manna get every sou.

And while:

> They draft the maps and they paint the pictures; they carve the statue; the speech they speak
> ...the S() 11s of Marrha sccking solely to do less labor for more per week.[29]

In short, in its 1919 revision, the poem became a vehicle for redefining class rclalions, shifting notions of labor from nineteenth-cent Llry ideas of male crafts - in wh ieh at lcasr a rhetorical harmony existed hcrwccn mcnra] and manual labor - to rwcntierh-cemury managerial images of work. In 1907, Kipling's toilers still wore badges of physical labor, bur by 1919 this poet identified design as the most important marker of engineering identity. By his reversal of Martha and Mary, the reader-writer cleansed Kipling's construction of work of any troubling working-class or female gender associations. Engineers were not alone in aspiring to a distinct ion bcrwc« 11 craft and design, bet wccn workers and ell gineers, 0r bcrwccn manual and rncur.il labor. This was also the year Veblen recast engineers as rhe true producers of rcch 11ical work,

Professional writers drew similar lines. If Kipling consciously positioned himself against the effete acsthcticisrn of an Oscar Wilde by aligning himself with vigorous craftsmen, while keeping a safe distance from unionized workers, modernist artists no longer saw themselves as crafrrncn but as designers and professionals."

They removed themselves from the crowds precariously associated with rhc mass of reading women, Modernists saw Kipling as representing everything rhcy were not, but rhe gap between Kipling and thc modernists was not so much a matter of content or style as a difference in rhc authors' relationships to rhcir readers and the markets they sought to target. T.S. Eliot (1888-1965), the male modernist poCt par excellence, once accused Rudyard Kipling of catering to the commercialized mass marker, arguing that true artists would only write exclusively for the "one hypothetical lnrelligcnr Man who does not cxist.:" Kipling did nor simply function as a straw man for an emerging modernist agenda, but his greatest ralem, Eliot accurately observed, was his ability to hold an audience beyond his own time. Kipling's very cordial relationship with a large and varied audience formed the basis for Eliot's critique and that of lllany male lirerary critics who came alter him: cornmcrcial success and the mass of female readers became closely connected in rhe male modern mind,

WOMEN ENGINEER ALTERNATIVE PLOTS

If male writers sought a new professional idenriry 011 gendered terms in the belief that women dominared the literary markets, women of the world of letters had to deal with the social realities of earning a living in a man's world, even if they enjoyed srcllar succcs,

In the late Victorian era, women authors who explored the engineel'ing genre problematized the newly forged alignment between engineers and male authors. The famed illustrator and writer, Mary Hallock Foore (1847-1938), the wife of the not-so-xuccesstu] [11ining engineer Arrhur De Wi nrc Foore, was the first female author to venture into the male domain of engineering, and perhaps also the first to claim it as an appropriate literary topic for women writers. Mary Foorc followed her husband in his mining career and entertained influential men of mining and geology including Clarcncc King, Samuel Erumons. Thomas Donaldson, and Rossircr Raymond. She used rhc engineering camps of Alm.idcn. Leadville, :Vlorclia, and Boisc in the Wcstern tcrritories as the setting and subject matter of many of her stories and illustration«. [Figure 27J Foorc did this so successfully that she became the sole breadwi nncr for periods of time when her husband's engineering projects failed ill the decades from the late 1870s until the first Wodd War. LJVillg in the West, she provided East Coast readers of *Harpers Weekly*, *St. Nirbolas*, and *Scribner:'Mouthlv* (later *Ceutury Magazine*) with images of the West complete with homes and families which differed radically from the howling wilderness and manly adventure that Frcdcrick Rcrningron, Teddy Rooscvclr, and Harold Bell Wnghr constructed ill rhci r depictions. They also differed from the eo10rlcss grids

Figure 27. Engraving "The Engineer's Mate," illusrrarion for an articlc promoring settlement and exploitation olthe Nevada desert for *Century Magazine* 1895 by author, illustrator, and engineers wife Mary Hallock Foorc, expressing her ambivalence alxnu moving west with her husband. courtcsj- of Lniversity of Amxterdam Library, Amsterdam, The Netherlands.

male engi neers laid over the Weste rn T erri to ries in rhei r autobiographica1 nar runves,

Mary Foorcs images of the West struck a responsive chord with her engineer-readers, whom she lovingly called "The Sons of Martha,"' These Sons of Martha, she wrote in a reworking ofKipling"s first stanza, "seldom saw themselves in pri nr in any respect not corinected with the paycheck or the announcement that the work didn't need them or had shut down." She received their letters in the engineering camp of Boise Canon, Idaho, where she and her family suflered fi'om isolation and the disasters that beset the irrigation project on which her engineering husband worked for almost 20 years. She reminisced how, "Most of [the letters] were in men's handwritings with queer postmarks, forwarded by the (:entury Company, from places as out of the world as the canon itself. They followed every serial or short story dealing with the lives of our engineers in the field, and they

came from mines and railroad camps on the far-flung lines of work, pushing new enterprises from Honduras (() Manitoba."[3] Bur the engineers were critical readers who closely followed every detail of her ventures into the male domain: "They took these stories with delightful seriousness, not borhering about my technique but jealous for their own. They watched every term I used, every allusion where a pretender might slip up, when I undertook to speak the language of the sacred profession." Ii the engiii cering camps, her stories would be collectively read and discussed for technical content: "These letters would be signed sometimes by a group of names from the 'Old Man' to the 'Kid.' The Old Man, they said, had just been reading aloud to them the last story (or installmcnt of a serial) under discussion, there being only one copy of the *Century* in camp; and would I please reil them how I came to know these things which the eye of woman harh not seen," she Iarer recalled. "I answered delightedly and told them that I had married one of their lot and knew *them,* in their remotest hiding places.'

As the wife of an engineer and as an artist who took herself and her writing seriously, Foore had wedded herself to engineering in more than onc sense. Reflecting on her own difficulties and those of her family, shc later playfully wrote, "often I thought o f one of their phrases, 'the angle o f repose,' which was too good to wasre oii rockslides or heaps of sand. Each one of us in the cañon was slipping and crawling and grinding along seeking to what to us was that angle, bur we were not any of us ready for repose." This passage gave author and. the historian of geology, Wallace Stegner, rhe ride for his Puiirzcr Prize-winning novel *Angle of Repose* in which the protagonist Susan Hurling Ward closely resembles the life and correspondence of Mary I-lallock Foote.[4] In lllany narratives - and Foore was not alone in employing the theme - the female protagonists routinely voiced criticism of indusrrialization and of the technical dcvelopcmenr symbolized by engineers. Women writers had, of course, a body of lircrarure and public discourse on which to base their criticism of the industrial commercialism associated with engineering. The early nineteenth-century canon of dorncsriciry formulated values of female disinreresrcd ness, xcrvice, and sacrificc to court rerhala nce and temper rhe male world of busi ncss and politics. Bur the emphasis in writing of these lare nineteenth- and early twentieth-century women, who depended for rheirlivclihood oii publishing, sh ifred to a critical exploration of a male professional ideal. In the development of their plots, the authors usually harmonized the apparent conflict between ruthless male enterprise and female love, sacrifice, and civilization - all ideological attributes of rhc female culture of domesticity. And loorc seemed iio cxccpriun, even if she had conquered cngi neering as her literary subject matter in a novel way.

In a central passage of Foorc's short story "In Exile" (1894), written at a time when her husband was struggling wirh career setbacks and alcoholism, Foorc pir-

red a female teacher against the engineer, the world of dorncsriciry against the world of industrialization and im migratio n. Arnold, who is responsible for the consrruction of the mi ning camp's water supply system, orders the destruction of a natural spring, the site of their first budding romance: "The discordant voices of a gang of Chinamen profaned the stillness which had framed Miss Frances' girlish laughter; the blasting of the rock had loosened, to their fall, the clustering trees above, and [he brook below was a mass of trampled mud. The engineer's visits to the spring gave him no pleasure, in those days. He felt that he was the inevitable insrrumcnr of its desecration."[5] The pervading discomfort in this passage – the presence of immigrant labor and the destruction of the spring – expresses arnbivalence about the engineer's work, but, wedded as she was to the premises of engineering, Foote would never fundamentally question it, as the story's ending makes clear. Despite their differences, the engineer and the schoolteacher reconcile their worlds.

Foorc depended on the values and the patronage of her East Coast publishers and readers and defended the expansion and the industrial development of the American West. As she was matried to a mining engineer, with whose career her life was inextricably linked, it would have been impossible for her to draw any other conclusion. By the rime she wrote "In Exile," Foote had decided to stick with her husband, even though she had seriously contemplated leaving him and his engi neering schemes.[6] Where engineers described the same sites only with technical detail and without people, women writers like Foorc filled the engineering camps they described with families and workers.

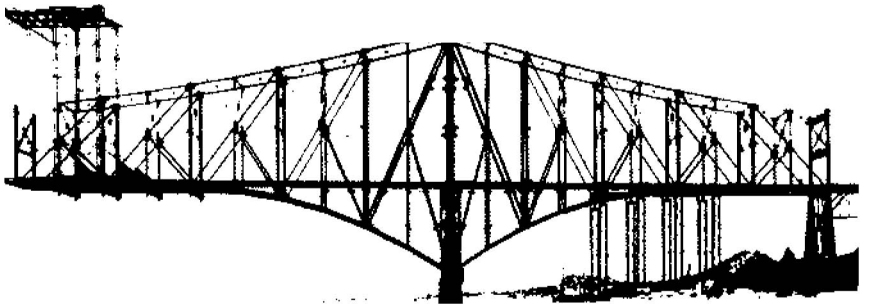
Another woman writer, the Westerner Charlorrc Vailc (1854-1902), portrays one of the women characters in a similarly critical manner in her novella *The M.M.C.: A Star» of the Great Rockies* (1898), in wh ich the wife of a Colorado silver minc superi nrendenr exclaimx in the critical tone assigned to women, "The gold and silver might stay in the ground for all of me! I don't believe 'rwas ever meant that men should spend their lives, burrowing like moles in the dark, for the sake of digging them cut." Yet Vailc never allows her characrcr to challenge fundamentally the inherently exploitative nature of the husband's work.[7] An even more critical distance from engineers' work and their emotional welfare is evident in short stories by two other women writers, Elivabcrh Foon: and !.. Franccs, published in r905 alld 19rr respectivc]y.[8] WiIh erllpathy, I,rances freused o n the d iscrcpancy between a man's stre nuo us \vork and his poor crnorio na l hea lrh in a srory enri rlcd, "The Engineer." And written from the "Girl of the Engineers" point of view, the highly educated New York reformer, librarian, and author Elizabeth Foote (b. 1866) - not to be confused with the famed wri ter and illust raror discussed above - exploited the same theme to the fullest and huil [a sarcastic story around the engineers' lack of emotional expressions and the result] ng failure to cornruun icare be-

rwccn the sexes. The emotionally segregated middle-class world led to close emotional relationships between women, binding rhem together in physical and emotional intimacy: middle-class women built a sororial world of love and ritual as historian Carroll Smirh-Roscnbcrg demonstrated many years ago. To support her argument, Roscnberg culled some of her most salient quotes from the voluminous correspondence and dairies of engineer's wife and renowned author Mal)' Hallock Foorc to her friend Hclcna spanning half a century from adolescence into widowhood." Foorc's Victorian life became emblematic for a genteel alternative female but segregated world as seen from the residential side of the engineering camps.

BURNING PROfESSIONAl. BRIDGES

A younger generation of women writers including Anna Chapin Ray, Willa Carher, and Mary Pickthall went further than Hallock Foorc in challenging rhc opposirio» between the male world of engineering and the female world of marriage, community, and art by their critical employment ora bridge collapse in [heir plots. They directly confronted the professional bridges [hat male writers and cngineers consuucring between rhe two professional cultures by burning them. All three women-authors suggested rhar the work ethic of men and the professional chivalrous code idealized in engineering were incompatible with gemcc! female culture. In the construction of their plots around disaster and collapse, Ray, Carhcr, and Pickthall had two other precedents, one historical and onc literary. The widely publicized collapse of rhc Quebec Bridge in 1907 provided the dramatic backdrop. This cantilever structure spanning the Sr. lawrence River was first touted as the greatest engineering achievement to date. When rhc bridge collapsed 011 August 29,1907, killing 81 workmen and leaving an enormous tangle of twisted and broken steelwork, both rhc engineering press and the daily newspapers questioned whether the design for the enormous span had not gone beyond what was rhcorcrically possi blc.[Figu rc 28 a and b] A well- publ ici/.ed illvestigation eventually exonerated engineering theory and blamed the collapse on human error."

In their novels, author of children's literature Anna Chap in Ray (1865-1945), novelist Will a Cather (1873-1947), and the poet and magazine writer Mary Pickrhall (1883-1922) expanded on the conclusion of official reports faulting not JUSt human but male error. Ray and Carhcr dramatically had their engineer-heroes fall with the bridges they had designed, while Pickrhall made the collapse of thc bridge the key metaphor in an engineer's Iailure to own up to his rcsponsihility for the construction disaster.[1] All rh rce women drew a close parallel between a faulty design ill bridge construction and the flawed character of the hero. All three em-



j'igure 28. The bui Icling (a) of the Quebec Bridge _'pa ni ing the St I.awrencc River. Irs collapse (ill on August 29, 1907, came to symbolize fauhy design ofrnale character and professional ideals in xcvcral plots engineered by women novelists. Photographs both courtesy of Division of Engi-nccrj ng and Ind usrry, Nati oria I M uxcurn of Arnc rican H istory, Smit hson ian Iusritu: ion, Wash-ington, DC. (neg. 91-6990 and ')1-6981).

ployed their metaphor as a criticism of engineering and the process of industrialization embodied by engineers. And through their plot design, Ray and Cather also implicitly rejected the engineering professional as an appropriate professional model for writing women.

The literary framework of collapse as a theme was provided by Kipling's short story "The Bridge Builders" (189,). If "The Sons of Martha" resonated with engineers above all because of its celebration of producers and irs condemnation of nun-producers, Kipling's "The Bridge Builders" held a special appeal for these female authors, who reworked his theme in a diflcrcndy g('ndered fashion. No doubt, as a literary theme the bridge offered mallY symbolic possibilities.

Set in India, "The Bridge Builders' firsr appeared in rhe *Illustrated London News* and was later published in *The Day's Work* (1898). The story's opening would later become a model for American writers, but the plot development also embodied preoccll patio ns spcci fie to British rule and economics ill colo nial India. Kipling begins the srorv as British engineers are finishing the construction of the Kashi railroad truss bridge over the river Ganges. The "bridge bui lders,' Chief Engineer Findlavson, his assisranr, Hirchcock, and Pcroo, the faithful Indian assistanr, arc suddenly faced with a flood of bib lical proportions thar rhrearens rhc new bridge - a triumph of Western engineering ingenuity. The issue is whether Mother Gunga, the river, will accept the confinement of her Hoods and the marriug of her banks by the new bridge. Although the depiction of the river Ganges as lcrna]e (mot her) was consistent withIndian cosmology, goddesses and animal gods were particularly disconcert: ng to the British colonial mind. Kipling exploited the association by extending this femininity to the colonial peoples as well, a trope that would become part of rhc cultural repertoire of Western racism.

Kipling specialized ill abru pt and unexpected plor twists. 1us[as the bridge is about to collapsc, the narrative shifrs from engineering realism to the world of fables inhabited by Indian gods, demi-gods, and heroes and - rhis is uncharacteristic of the American elaborations of the theme – through the engineering crew's rransformi ng experience with opium. Faced with the kind of crisis that would ordinari Iy invite the engineers of American fiction to flaunt [heir manly resolve, Kiplings Western bridge builders resort to drugs and are subsequently incapacitated. "It seemed rhat rhc island was fulJ olbcasr and men talking," ix all the engineer later recalls of [he crisis, while the Indian assist.mr gains insight from the experience. Hearing Mother Gunga's case for the preservation of Indian tradition and religion, rhc council of Indian gods votes to override her by accepting engineer: ng progress. Th e decisive argllment prcscnted in favor o f the engi necrs is rhar rhc "fire carriages" (Kiplings mythological concoction for trains) will bring more pilgrims to the gods' shrines.[47] The final scene shifrs back ro a rather unfavorablc depiction of the viceroy, the archbishop, and the colonial administration, who

prai se rhe engineers for their work, because thanks ro the gods, but not to the engineers, the flood has receded and the bridge has been saved. The dramatic shirt in narrative type from realism to fabulisrn and in character focus from the British engineers to rhc Indian assistant suggests the dissonance between the Western world of engineers and Indian society.[1] In other words, even though Kipling's story might be interpre ted on one level as a simple endorsement of Brirish colonial rule and industrialization - as many have argued - his plot development and resolution actually undcrrnine or at least complicare such a conclusion. The plot subverted rhe general scheme of the story.

Because of thei r very mulripliciry, Kipiing's stories, like his poem "The Sons of Martha," offered writers a palette of possible themes and made his work cminenrly quotable. Anna Chapi 11 Ray entitled her novel *Bridge Builders* (19°9) but set it in Quebec, the site of the bridge collapse over the St. Lawrence River the previous year. In her novel, Ray reworked Kipling's gendered imagery. She transformed Kipling's contlict herwccn traditional Indian society and Western technology by staging a dramatic contrast between the mal« profession of engineering and the female profession of writing. Educated at Smith College (clas: of 1885), Anna Chapi» Ray wrote at least 40 volumes, some of them under the male pseudonym of Sidncy Howard. She had spent most of her life in New Haven and Quebec, where she closely followed the reports on the collapsc of the Quebec bridge. She was well prepared to write about [he world of engineers: she regularly corresponded with her brother, Nathaniel Chapin Ray (1858-1917), a civil engineer working on railroad construction for the Burlington & Quincy, the Union Pacific, and the Oregon Short Line, in various parts ofIowa, in Boulder, Butte, and San Francisco. Over the years, brother and sister maintained a lively correspondence and exchanged details on their professional lives as a writer and a engineer.[2], She sent him clippings from technical journals. Hc advised her about marketing her work.

When Ray turned fifty, she wrote her own version of Kipling's *Bridge Builders.* Her plot revolves around two men, an artist named Kay Dorrance and an cngi neer named Asquirh, both competing for the love of an exuberant young woman named Jessica. Her father, Peter West, a railroad conrracror, appraises the manliness of his dallghn:r's artist-xuitor, observing to his surprise, "'That fellow's very much a man, even if he does wri te books." Hc eo uxide rs writing a "womanish" profession, contrasting it with Asquirh's chosen career of engineering: "that's a man, all over, takes the best of a man's body and mind and soul." And Dorrance. the writer, muses, while assessing his rival in love, "What a man [the engineer] the fellow looked, dashing offlike rhat. And after all, his was a man's profession, infinitely bigger, infinitely more virile than rhc mere knack ofsitring in a corner and \vri[ing on a pad of paper." After all initial romantic rapprochement with [he cngi-

neer, Ray's heroine falls in love with artist Dorrancc, "a most un heroic for a hero," a mall endowed with red hair, heckles, piercing brown eyes, brains, and money, but encumbered nevertheless by a "distressful limp," while the engineer is "tall, graceful, vigorous, virile." The story's climax comes at the moment when rhc artist and the heroine are about to confess their love to each other on the very banks of the river the engineer has attempted to span. Ar this point the bridge collapses, and Asquirh, the engineer and the embodiment of manliness and virility, disappears, crashing inro the water with his bridge, which he has finally realized is his real love.

Ray apparently did not dare to dramatize the story's implications as WiJla Carher did two years later in her novel *Alexander's Bridge.* For in Ray's novel, Jessica, portrayed as a New Woman, is a competent swimmer who scoops the engineer OUI of the water. Despite the rescue, she rejects rhe engineer's proposal of marriage, for she has come to realize that "this bridge of yours [is] the love of your whole life." Her father concludes likewise that "his very heart was in that bridge...He'll never care for any woman, as he cared for that steel arch." In the end, Jessica reconciles herself with the world symbolized by the geJHed world of the wrrrcr. Thus, where Kipl ing's "Bridge Builders" ultimately, if precariously, accepted industrialization, Ray reworked her plot in order to reject unequivocally the male professional model of engineering, In particular, she rejected the engineer's total absorption in his work and his "marriage" to the company. As the artist concludes in the closing passages, "to me rwriting] is rhe one great profession in the universe....That doesn't make me forget that the universe holds a few other things. though; love, family, friends."[4]

Willa Carher followed Ray's path to its logical literary conclusion. *Alexander's Bridge,* Willa Carhcrs first novel, went a step further in the rejection of the engineer as a professional model. Ju her plot, rhc collapse of the bridge kills the engineer. Familiar with *The Bridge Builders,* as a young writer Carhcr had admired Kipling calling him "a force to be reckoned with." Even if modcrnisr malc writers like Eliot rejected Kipling's mingling with the masses, Carher thought that "no man has ever written morc persistently or more vividly of the affairs which engage the daily life of men." As a young writer, Carhcr had associated Kipling with Alexander the Crear. the name she chose to give to the protagonist of her first novel. Unable to integrate the self of his youth with that of adulthood, Alexander, the engineer, dies with the bridge he has helped to design. The novel's premise - the engineer's faulty design and the collapse of the bridge - represent Carhcrs rejection, or so critics have argued, of rhc male perspective of Henry James and Rudyard Kipl ing, whom she had once considered her literary heroes."

Carher's choice of an engineering theme for her first novel was a calculated one and the year 1912 was crucial. After years of working as managing editor of

McClure's from 1905 to 1911 - the magazine that had featured Hallock Foote and sought to appeal to male readers by including more articles on business, professions, and politics - Carher was wel] awa re ofthe new trends in publishing. She left her editing job at rhc puhlishing company to devote hcrscif full-rimc to wr iti ng as her profession. Considered in the light of Carhcr's literary career afrel- her first novel, the theme of a collapsed bridge symbol ized a break with her male ment ors and cleared the literary path. Unencumbered by male precedents, she shortly thereafter entered a new domain she could clai m as her own and found her own lirerary voice the next year in *O, Pioneers* (1913) and later in *My Antonia* (19 1')), staking out and reaching her own audience." Hlstead of the Jamesian drawing roo m or Kiplingcsque engine room, she recreated the lives of immigrants in Nebraska, wh ere she had spent her youth. Delibcrarcly chosing the engineer as the protagonist for her novel , she chose to display her competence in a male genre for the purpose of casting it aside, thereby signalling a new relationship with the:r readers.

In various degrees and with different points of emphasis, these engineering short stories and novels deal wi th the demands of to tal commi rmcur to rhc company - a rclarionsh ip the writers were wont to descr ibe in terms or marriage and love. In the male authors' plots this co mmitment excl uded wo men but in explor- ing the hero-eng ineer, wome n authors offered an alternative. They subverted the popular male genre of (he period and rejected the engineer as a professio nal role model for female authors. Their enginccr-proragon ists failed because of shoddy workmanship, pressure of rhe marker, or flawed cha racters that failed to integrate past and present, love and work. Chapin Ray, Cathcr, and others rejected not merely the industrialization engineers stood for, hu t also the masculine and muscular claims of the engineering occupation as an inappropriate professional m irror for authors.

As illus rrarcr] by the ngarivc appreciation shown by male professionals for Carhcr's subsequent work, modern ist tas te makers rejected this female literary heritage and made male realism increasingly the standard for an American literary canon during the 1930s." Despite Carhcrs phenomenal commercial success and critical acclaim from the literary csrablishmenr ill rhc r920S, she received increasingly disparaging reviews during (he 1930s from a group of acaclcuric reviewers that was defining and establishing a distinctly male Am erican literary can on, In response, Cather tried to forge her own relationship with her audience by circumventi ng the new male group of professional reviewers altogether, as her biographer Sharon O'Brien has argued. Despite, or because of, the large presence of women in the field, the process of profcssionalizarion of literary culture rcinscribed ir as a male province.

MODERNIST MOMENT: MACHINES, SEX, AND WAR

If popular writers of romance had staged engi nccrs as a cul rural hero, the modern art community did much to acsthcticizc rhe visual language of machinery and inscribe machines as explicitly male symbols. In celebrating the cngi ncer, rhey Iol[owed the cue of popular romance writers. By the end of the first World War, engineers and the machines of industrial capitalism became closely linked in rhe literary imagination and visual grammar. After the economic crisis and cultural rcoricnration of the 1890s, the association between white Western men and machines was put ccnrcr stage, finding its most powerful expression iii the identification of male modern artists and writers with male-engineered machines. The mo de rn isrs carri ed their rebe11io]) forwa l'd in high ly gendered terms in tone> image, and practice. A generation of modernist artists and writers who came of age jusi before the first World War began to caricature the sharply drawn Victorian divisions between male iconography of the technical and nontechnical world. They employed the machine simultaneously as a metaphor, model, and microcosm of modernity in the making.[6] In the years leading up to the war, many artists explored this discourse as a self-conscious way to bccoming modern. By the 1920s, ir had become quire common, if somewhat clichéd, to speak metaphorically about the *Machine Age.* This rhetorical position became a pillar of the modern understanding of technology and would be incorporated in the corporate image at the World Fairs in Chicago in 1933 and New York in 1939, no longer under the supervision of the Smithsonian but the National Research Council.

As abstracted and metaphysical entities, machines functioned in several ways iii the visua] language of modern art. Tools, devices, and machines like the drill, incandescent lamp, camera, and radio were generalized metaphors and lost the specific and local industrial surroundings of their production, yet acquired an aura of universal authority. With few exceptions, modernist artists represented technological devices from the consumer's point of view, with little concern for their production.[7] Such images neither smelled nor left bch ind any noise. This srai nless consumer image of industrial production became incorporated in and mobilized for the new iwcnrierh-ccnrury visual understanding of technology. But the pristine and sanitized visualization also jettisoned the graphic language of the Progressivex' scarhi ng critique of living conditions and omitted fingerprints left behind by industrial workers. Instead of heeding the tradition of the women's reform movemerit that was helping to built urban infrastructures, their formal language coalesced into a corporate engineering vision of processes and design. The visual language stressed mechanically and structurally infused masculine codings of prowess.[8] Dadaists nci rhcr invented these gendered and engineering images of machines, nor stood alone amollg modernist artists in choosing this subject mat-

ter. They merely, albeit brilliantly, exaggerated irs latent meanings with biting visual iron y. Wi th anarchistic flamboyance and playful provocation, they turthcr elabora ted on rhe male align ment between engineers and artists that emerged in rhc popular literature during the previous decades as a strategy [()escape from Victorian ovcrstu tfed female parlors. And male engineers, always seeki ng recogn ition, eagerly welcomed such a cultural stamp ofapproval.

As the U.S. began to prepare for the war, modern visual artists and writers were among the first cultural commentators to explore graphic and gendered language ofwhat we now understand to be technology by linking men's control over machines and women. And when they did, the}' exploited its porcn rial ro the fullest. The Dadaisr artists Francis Picabia (1879-1953), Marcel Duch arup (,887-1968), and Paul Haviland, all resid ing in the scaffoldcd city 0 f New York d uring the 19 10s, sexualizcd the machine metaphor by playing up gendered associations of machinery and appropriati ng the male icon ography of engineers and mechanics, Like many of the ir modernist colleagues, they experimented with the tools and visual lang uage of the engineering curriculum. Visual arrisrs elaborated on the fascinarion of rhc ma le popul ar writers with the engineer as a male professional model, but like the mecha ni cal engineer John Frirz and Kipling, Dada artists flirted with male blue-collar work by their sartorial identification wit h overalls. [11] W ith biting irony and exaggeration, the New York group of Francis Picabia, Marcel Duchamp, Paul Haviland, and others often used the sexualizcd machine metaphors as a means to bend Victorian not ions of gender in search for modern models. As an act of transgression some modernist' women like Franccs Simpsori Srevcns boldly appropriated and exploited the new male subject matter of machines and engineering witho ut any apology. After meeting the Futurists ill 1913 in Florence, the young American Franccs Simpson Srevcns (b. r895), who had been raised in the genteel halls of New England womanhood, explored the new machine lan guage and trespasser] into the male do ma in by her speedily painted '9J4 work in oil and charcoal, *Dynamic Velocity.*[Figure 29] Her 1916 one-woman show in New York was a happening in good rnodernisr fashion. Although reviewers did not know what to make of it, she received the moxt praise from a New York municipal engineer who recognized the engi neering visual vocabulary in her work.`

By '9[5, the year that generated many works of <11-t in New York, the European war and the "sex war" were so thoroughly intertwined that one combat suggested the other, as M ina 1.oy's biographer Carolyn Burkc has suggested. Sensing these vibrations in the air, Marccl Duchamp and Francis Picabia developed a formal vocabulary of what they called mechano-scxual rneraph orx, all showing a kind of sexual impasse and m iscomm un icarions between the sexes. Picabia's 191 5 series of machine portraits of his artist friends in exile best represent rhe sexualized alld gendered visualizations of the new emerging not ion of technology in New York,

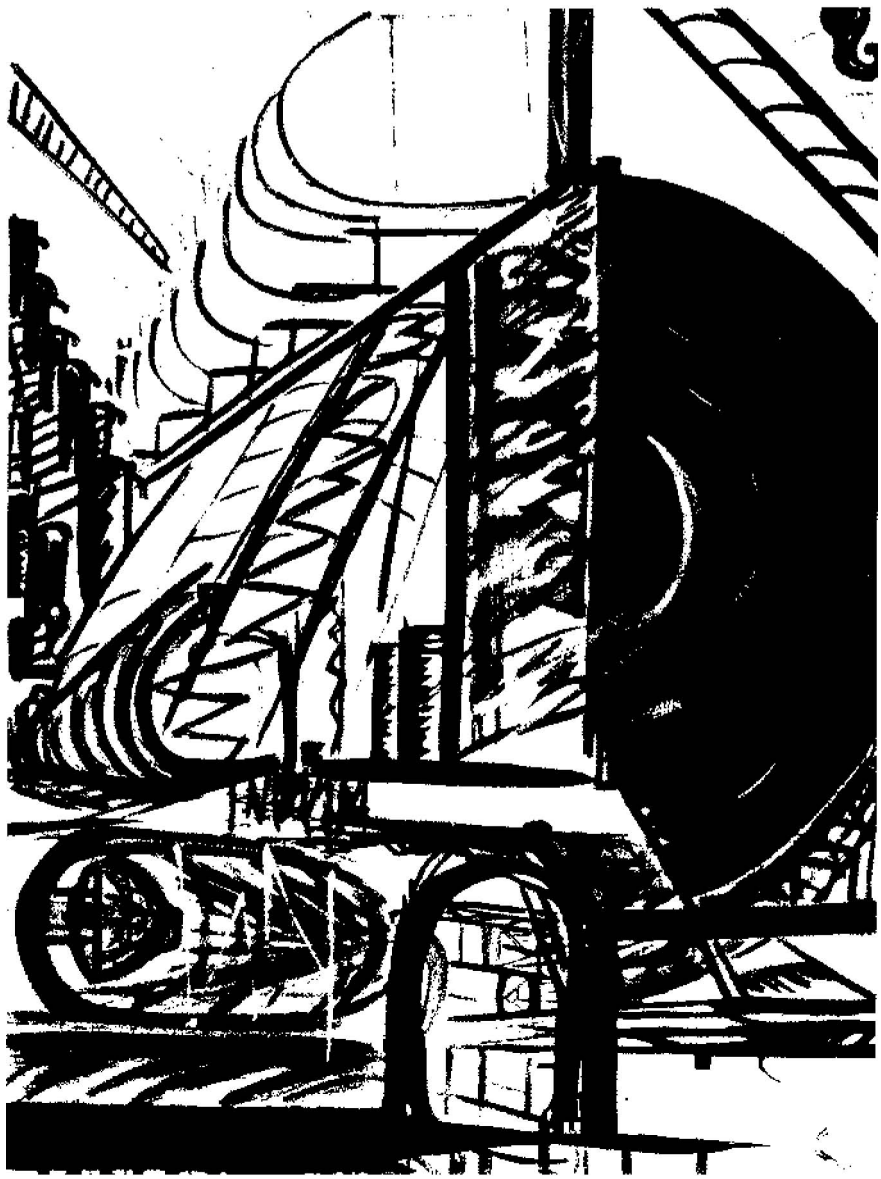


Figure 2). Onlv sllrviving work olArucrican [ururist woman painter lranccs Simpson Stevens appropriating the male encoded engineering sryle and subject lor mudcruist women, Oil and charcoal on canvas Painting entitled "Dvn.imic Vclocitv Intcr-Borough Rapid Tranxi: Power Station" of 1914. Permission Louise and Walter Arensberg Collection, Philadelphia Muxcum ol Art, Philadelphia, l'A.

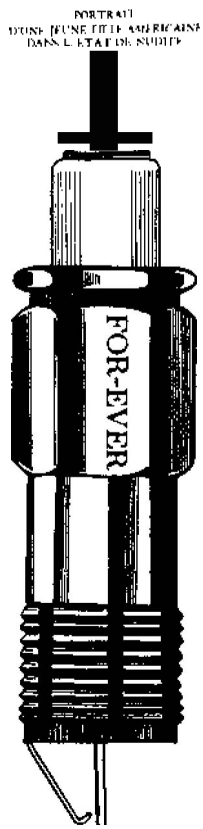


Figure 30. Dadaist engineering portrait hy Fr.mcis Picabia of "a Young American Woman in Naked Condition" drawn as a screwing device and spark plug representing rhc women colleagues of his modernist circle in New York. Published in Stieglitz's New York magazine *219* nos. 5-6 (July-August 1915).

the city that acqui red a myrhic status as the capital of modernity during the teens, Among them, Picubia drew photographer Alfred Stieglitz, Mexican caricaturist Darius De Zayas, and patron Paul Haviland. He laid out simple blueprjnrs of oxrensibly functional and operational devi ces like a camera, a radio diagram, and a lamp, which upon closer inspection turn our ro be slightly out of joint and non-functional. Mischievously, Picabia called his drawing of a screwing device *"Portrait d'une[eun« fille americaine dam l'état de nudite "* (or, "*a Young American Woman in Naked Condition"),* [Figure 30] He played up the sexual transgressions and battles in their avant-garde cornrnunirv. Ill another portrait of his Mexican friend, entitled *De Zayas! De Zayas',* Picabia drew a microscope with its gaze on a

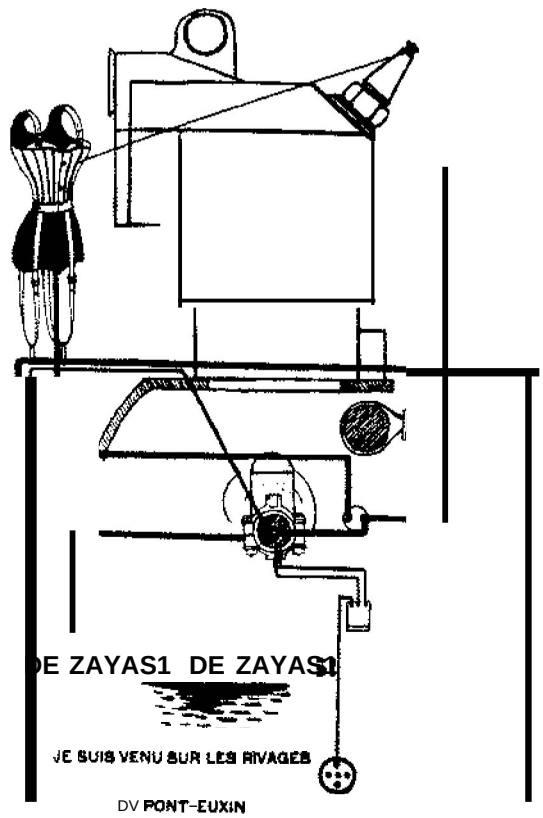


Figure 31 Picabia's Dada portrait ofhis tricru! Mexican friend. de Zayas, engineers a tenxion berwccn rhe male gaze and the female body in Dada visual vocabulary. Reproduced from Stiegliz's New York magazine *2i9* nos. 5-6 (July-August 1915).

corset. Here, Picabia juxtaposed a scriouxlv encoded male instrument with a symbol offemale frivolity and sexuality. He surely meant to parody the newly drawn gendered boundaries between the technical and the non-technical. H is parenr-l ike depiction of rhc corset also alluded to a long-standing tradition *of* women's inventing practice and turned it into a figure of irony."[Figure 31J

Marcel Ducharnp, fllllowillg Picabia's ironic and scxualizcd depictions of muchines, engaging ill one of his most elaborate and extended modernist jokes. He entitled his more notable art piece "*The Bride Stripped Bareby her Bachelors, Even,*" on which he worked for eight years (1915-1923). It represented the bachelors as mechanical devices going through a seemingly functional treadmill, while it porrraycd the bride as a static, separate, and shapeless space. Whatever his intcnr – the

subject of heated debates in the literature - Duchamp engineered a tension between the enigmatic messages of gender relations and the simplicity of the lines rhar mocked, modelled, and commented on the male engineering ethos of simple, clean, functional, and minimalist lines." 'To symbolize sexual intercourse in such bare, stark, and mechanisric terms was a severe affront to Victorian aesrhericsand epitomized the modernist rebellion against it.

Iu the same year that Picabia drew his mechanical portraits and Duchamp began to cngineer his mechanical *Bride*, the Dadaisr Paul Haviland, lawyer, patron, and member of the Alfred Stieglitz circle in New York City. elaborared on rh« new and explicitly male vocabulary of technology his friends were developing. Marveling at such new technologies as the hand-held camera, the phonograph, and clccniciry, Haviland called for the mastery of mell overr machines. Hc offered an explanation for men's tcchnophilia: "the machine is his 'daughter born withour a mother,' that is why he loves her. He has made the machine superior to himself. That is why he admirex her." 'To emphasize rhc sensc of male mastery implied in his metaphor. he concluded: "she brings forth according to his conceptions."' He likened machines to women's bodies – something already implicit in the Spinning jennies of the textile mills of an earlier age – but Haviland made an explicit gcndered connection ofwhat would. become a common Hope: men's mastery over machinery and women, Men were producers, while women were merely instrumenrs.

Ifrhe Victorian male and Iemale writers had worked separately and in isolation, the modernist men and women mingled freely, often visiting each others' studios and apartments on a daily basis. The French-speaking women artists including !\1ina Iov, Picahia's wife Gabrielle Buffet, and Julictre Gleizes who [requcntcd rhc Arensberg soirees ill New York all felr awkward, distressed, and ill at easc when warching their malc colleaguc Duchamp encourage rhcir American Icrnalc colleagues to enact their loss of sexual innocence and pcrtorm his extended scxual linguistic plays at [he expensc of the American \\Ol11el1 who were less versatile in French.' To avanr-gurdc women it might have been liberating, but to contemporaries, sexual lihcrariou, women's suffrage, artistic innovation, and political protest were all part of the same conrrovcrsia] landscape. To be sure, Mina Loy, Frances Sirnpson Stevcns, and Baroness Elsa von Freytag-Loringhoven fought rheir own battles [() become modern as women and as .urixr«, but increasingly rccognition for women artists had come just as modernists began to question the academy system. Modernist women also flouted bourgeois manners and criticized rhc hegemony of classical antiquity romantic love, painting from the model, and csrablished cultural inxrirurions like art acadcmics and muscurns, bur rhcir gender-bender battles took orhcr [orms, Not ill rhc least because for women the act of trespassing had a different price tag attached rhan it did for men.

Prances Srevens's older friend, the English-American artist Mina 1.oy, a painter, poct, and playwright, explored but ultimately criticized this new modernist sexual izcd Janguage. , n her *Feminist Mnnifesto*, she wrote that shc belicvcd men and women were enemies: "The only point at which the interests of the sexes merge is the sexual embrace." And in a poem, entitled "H urnan Cylinders," she first adopted. then disregarded the Futurist vision which likened humans to machines in answer to her futurist lovers Martincrri and Papini. Intercourse was just a collision of bodies and "Love with me is a mechanical inrcracrion," she wrote." As Mina I.oy understood only too well, gender bending carried a higher price for women than it did f()r men artists. Nurturcd in distinct women's rrndirions, Victorian women writers had been able to engineeer their own plots, but for modem women artists whose work and social life were so closely Jinked to men, it was much harder.

In the end, modern artists too helped rcinscribc rather than subvert the male iconography in technical objects through their graphic, often sexually and gendered explicit language and images. Despite the iron ic sexual negotiations alld the explorations by other women artisrs, by the 1920s the mach inc aesthetics of art was thoroughly revitalized as a modern male icon in which a new generation of public intellectuals, social scientists, scientists, and engi nccrs began to pnrticiparc with new vigor. In the end, gender bending too was nor the same for -n.

5

Women Reweaving Borrowed Identities

If women writers, artists, and activists articulated an alrcrn.uivc language, their slide-rule sisters within the engineering occupation emulated rather than questioned male models of professionalism. American women engineers have left few wri tten traces of rheir exisrence, unlike rhci r male cnllcagues o r their sisrers in the world of literature. They could have flaunted their pioneering struggles in the manner typical of autobiography, bur they neither adopted autobiographies as a form of sclt-cxpression nor created alternative plots of rheir own. Steeped in the ethics otsclf-discipl inc, stoicism, and overqual ification, they had few narrative devices available to them.[1]

Among American women engineers, only one started an autobiography, Nora Stanion Blarch (IXX3-r9/1), whose rich feminist hcrirugc enabled her [() envision a narrative device in which to frame her life story.[Figure 32] As a third-generation feminist figh ting for suffrage, N ora Blatch could project herself into a well-defined feminist genealogy. She descended from a line of Iamous feminists - her mother, Harrior S. Blatch, and her grandmother, Llizabcrh Cady Sranron - and earnpaigned for suffrage .u C:ornell University, where she had chosen civil engineering as her major because, she said, it was the mosr male-dominated field she could find. I lcr generation of women engineers grew up in rhc nincrccnrh ccntury, when the bond of sol idarity among women was more firmly entrenched, but Bl.uch went a step further than her conrcrn poraries, She contested the American Society of Civil Engineers (ASCE) on grounds of gender discri rni nation when in 1916 it tried to bar her from full membership; moreover, she campaigned for pay equity between men and women through the National Woman's party for many years. Where Blatcl: found literary and (Jrganizar io nal mod cls i11 the fc111 in isr movcmcnrs of her mother and grandmother, she Found none among her women colleagues in engineering.[2] Raised ou the expectation of the governmnent's propaganda for more technical personnel during the first \X/odd War, the next generation of women engineers grew up in an era where suffrage had been won and professional women seemed to bc l11aki ng headway. They adhered to a helicf in gender neutral ity and the merit of professionalism. l-ew women engineers publicly rallied to feminist causes.[3] This disinreresr was mutual. The American women's movement invested

Figure 32. Nora Stanton Blatch, civil engineer and descendunr of two generations olwornen rights acrivixrs shown on suffragist campaign on horseback in New York State in 1913 challenged the engineering establishment ;ll 1916 on charges of discrimination. Reproduced lrorn *Civil Engineering* (1971). Courrcsy of Delft University of Technology, Delft, The Netherlands.

in the sciences rather than in engineering because it lacked the same cultural authority. American women's education activists and female philantbropists neither paid any special attention to the engineering profession as a vch icle toward women's equality nor helped establish separate engineering institutions,' Rapidly becoming a mass occupation, engineering failed to attract bright American young women of high standing looking for a suitable vocation. On average, women in engineering came lrorn a higher class background than their male counterparts.

Most American women engiueers ignored the kind Of bridges Nora Blatch tried to build berwecn the women in the technical field and those working in the woman's movement, They houorcd the model Nom Blarchs contemporary Lillian Gilbreth (1878-1972) offered instead. Cilbreth borrowed Rudyard Kipling's reword] ng of the biblical allegory of Mnrrha ("simple service simply givcn") rhar was supposed to be the inspirarjon for women engineers. Cilhretli, earning a

Ph.D. in psychology, had received her technical knowledge and her legitimacy ill engineering through her husband - a "borrowed identity" she expertly managed. Although actually a widow for the larger part of her life, she projected herself as a married career woman.' Avoiding rlie open confrontation for which Blarch opted, she advocated a professional strategy for women engineers based on hard work, sell-reliance. and Stoicism. Her employment of Kipling's poetry embodied her conservative strategy and showed all the ambivalence of rhc position of women engineers as rank-and-file members.

Such strategy involved tactics of "quiet but deliberate over-qualification, personal III odesry, strong self-discipi ine, and inf ni te stoicism," as his to rian 0 f scicn ce Margarcr Rossiter has poi nted out to describe "the classic tactics of assimilation requ ired of those seeking acceptance in a hostile and competitive atmosphere, the kind of atmosphere women heading for basrion, of men's work encountered ar every rurn,"[6] Indeed American women engineers maintained their loyalty to male models of rhe profession at great personal cost. Vera Jones Maclvay, a chcm ical engineer who had managed to find work on pilot plants for fertilizer production with the Tennessee Valley Authority, recalled the painful memories when looking back on her career in 1975: "it is hard to discuss my working days as an engineer without s()undillg like one of the most militant of the women's libbcrs,"[7] Jones's public admission of the personal costs i1N01 ved in her career cho ice is un usual because most women cngi ncers kept a stiff upper lip. Yet her sentiment offers a rare glimpse into the struggles and strategies of women engineers in the period before affirmat ivc action, Most women engineers who preferred as their role model Lillian M. Gilbrcrh over her contemporary Nora Blatch followed this strategy. They drew their literary models and organizational forms from their engineering fathers rather than from rhei r feminist sisters. They cultivated silence as a survival strategy and venrriloquized, but never directly articulated their discontent. As rank-and-file members of the profession working for corporate and military establishments, women engineers became invisible not only to themselves, hut also 10 history.

SURROGATE SONS AND TilE INSIDE JOB

A great many American women, most of whom never appeared in any statistics, claimed family ties to engineering through their fathers, brothers, and husbands. They found their pathway into engineering through what might be called patrirnonial patronage and matrimonial sponsorship. Supported by kinship ties, such familial patronage and matrimonial sponsorship often offered relatively easy access bur also resu lrcd in what Cerman historian Margot Fuchs has called a borrowed identity. Most did not have female models but looked to their fathers and

brothers for orientation. Their identity as engineers was therefore largely one "on loan," even if some, like Cilbreth, managed to stretch the terms to socially approved limits.'

Formal training might have been an important credential for continental Europe and served as a wedge into other professions in the U.S., bur it did not play such a decisive role in ernployrneut opportunities in American engineering before 1945. By the end of the Forties and beginning of the Fifries, only 55 percent of American men - and even fewer women (20 percent) - in engineering had com-Plercd an engincering educa rion. In the nincreenth ccntury bu t probably also well into the twentieth century, a few hundred women continued to manage their husbands' engineering work after his death, having received enough informal rcchnieaI rrai ning to eall rhcmsel vcs enginccrs. They acq uired rcch uica I k nowlcdgc o n the job or through an informal system of education within family firms without ever arreudi ng a specialized school. Famous examples of women who learned the trade through rhei r family or husbands include Lillian Gilbreth and Frnily Warren Rocbling (1841-1902), who kept the family firm going when illness incapacitated her husband, a chief engineer, from leaving his house. She acted as his proxy throughout most of the building of New Yorks Brooklyn Bridge during the 1870s and 1880s. Trained in rnarhemarics, Rocbli ng learned to speak the language of engi ncers, made daily on-site inspections, dealt with contractors and materials' suppliers, handled the technical correspondence, and negotiated the political fricrions that inevitably emerged in such a grand public project. The Brook!yn Bridge had been a Roebling ideal on which the family's fortunes depended, and Ern ill' Ruehli ng had been her husband's proxy for decades, Less famous than Roehli Ilg, most wives worked in anonymity in family businesses. As late as 1922, a woman active in civil engineering wrote the editor of *The Professional Enyineer* that she greatly appreciated [hat the journal finally acknowledged the wives of engineers Wirho u r spcci alizcd degrees: "My rrai ningin cngi nceri ng began wi rh marriage aIld 1have filled about every job ... from rodding and driving stakes to rullning a lcvc] party, or setting grade and figuring yardage in the office."'

These women would be largely forgotten. Lillian Gilbrcrh, however, became America's mosr celebrared wo man cngi nccr in part because she ma llaged to expand the limits of her borrowed idcnrity into socially permissible terms. Frank Gilbrcrhx untimely death in 1924 migh[have been devasta[ing For a mother with twelve children but, aided by a ream of domestic hands, it also allowed Lillian Cilhreth to eujov considerable freedom in her role as a widow for nearly fifty years. She expertly managed her image, fostering publ iciry rh.it cast her ill rhc role of a manict] career woman. This public persona provided perfect protection against the possible disapproval of her career ambitions. Similarly, she allowed her marriage, long after Frank Gilbreth's death, to be promoted as [he most efficient way

ofli fe: as a business-love partnership - analogous ro her husband's advocacy ofcf-ficicncy by performing tasks in the "one-best-way.?" As Cilbreth 's strategy shows, women might also have invoked family connections as a way of protecting (hem from publi c scrutiny. Newspaper reports and government propaganda keenly played up women engineers' suong family ties to men in engineering as a way to ward off the possible threat of these female incursions inro the male domain. The effort to 'domesticare' women's ealenrs into fami liar categories prevailed during the second World War, when war propaganda emphasized wom en's tam ily ties to engineering, Most of rhc available biographical informarion on the social background of women engineers was generated as part of the war propaganda campaign during the Forties; hisrorical narrative sources on women engineers therefore tend to ove rexpose women with family connections. Nevcrthclcss, it is evident thar formal engineering education with or without a degree in hand could be particula rly useful for some, like the daughrers ofproprietors of small manufacturi ng firms, Beatrice Hicks trai ned at the Srevcns Insri tu re o l'Technology ro become first chief engineer, then Vice-President, and finally owner of her father's Ncwark Comrols after his death. After their graduation in engineering, Jean Homing Marburg supervised the plant construction for her family's mini ng property in Alaska, while Florence Kjmball worked at her family's elevator firm, drafted plans fOf the remodding and building of its real estate property, and drew several blueprints for patents - the most exacting of all drafrrnanship. Small family firms like the Kimball and Homing companies not only tried to maximize producrion and profits, They wcre also in the business of pcrpcruarinz a family legacy.'

Succession ill patriarchally organized family firms was exclusively an affair between fathers and sons, but circumstances sometimes pushed daughters iruo rh« positions of surrogate sons. The most celebrated and best-documented case is that of Kate Gleason (1865-1933), the eldest daughter of \X!illiam Cleason, who had starred his own 1001 making shop, the Gleason Cear Planer Company in Roches-[er, New York, that would be one of the largest of its kind, Gleason combined her feminist inde pendence with acu re busi ness sense and family intcrcsrs wh ich aP: pealed to both women engi neers and popular writers. Encouraged by feminist Susan B. Anthony's example and prompted by the early death of her half-brorhcr ar the age o(20, Karc Gleason began to work for her father after taking courses in mechanical engineering at Corncll Univcrsity and the Mechanics Insrirutc in Roches-(er. Her rraining followed the course of many sons or01 her family manufacturing firrns, whu were no 1011ger expeered to mastcr a craft eompletely, hllt to havc a working knowledge of all the various aspects of the firm. Gleason was her famill' finn's business manager for many years when the business expanded dramatically and successfully into a major player in the industry." I'arrimonial patronage thus

encouraged daughters like Kare Gleason [o seek formal education with or without completing a degree because it fit into a family business's srraregy.

For similar reasons husbands encouraged their wives to seek formal training. Such active matrimonial sponsorship nor only provided women with a legitimacy their engineering accomplishments would otherwise have lacked, but also offered them the hope of establishing a family firm in partnership with [heir husbands. The pooling of resources of man and wife in an enterprise offered the 0pp0l'lunity for a partnership of business and love. Sometimes, however, engineering marriages offered an advantage that could turn inro a liability. Many women met their partncrs at college or in the field of engineering, allowing them to enter into male social and study circles otherwise closed to them. But because of the inherent power relationship, the built-in mcnrorship in such relationships could [Urn into a disrinct disadvantage for rhc wife's career advancement later on when they questioned the terms of matrimonial sponsorship and their borrowed identities that went along with it."

As a young feminist activist and engineering graduate, Nora Blatch and her husband, the engineer and inventor l.cc De Forest, first shared in the excitement of new emerging technologies such as the radio, but in the end they disagreed about who was to shape and direcr the possibiliries of these novel developments. On their first meeting, Blatch "tremendously admired" the young radio inventor Lee Dc Forest and explained that "a life in the midst of invention appealed to me srrongly.?" For his part, De Forcs: thought "destiny" had brought her to his door and pursued her relentlessly. In desperate need of money for various ventures, he received funds from his future mother-in-law Harrier S. Blarch, while Nora's rech nical training, her love for music, and the connections with rhc New York powerful, brought enormous technical, [iunncial and social resources to his flagging career. No doubr seeing an 0pp0rtunlty to fulfill her life's goal of combining career and marriage, Nora Blatch fell in love with lee De Forest, took extra courses in electricity and mathemaucs wirh Michael Pupi n, a well-known New York electrical engineer, and worked in De Forest's laboratory on rhc development of the radio. Together, Lee and Nora were able to air the firsr broadcasts of music and converxarions in the New York area. On their honeymoon to Paris, the newlvwcdx seized the opportunity to promote their wireless phone by a demonstration from the Eiffel Tower, organized through Blatch's Iarnily connections."

Both Blarch and De Forest shared an cxciternen I about participaring ill the new technological dcvclopructus with their contemporaries. To 1 larrior S. Blatch - and rhcrc is no reason to believe N ora disagreed with her mother on this issue - technologies such as rhc radio were new tools fOl- women to use Ior their own ends. At onc or the promotional experiments for the "wireless phones" in New York in 1909, Hurrior, Nora, and I.ccwere positioned at one end of the I rausm irrer at rhc

Terminal Building, while a group of women's students from Barnard, their physics professor, and some male interlopers from Columbia stood listening ar the other end at the Metropolitan Life Building. "I stand for rhc achievements of the twentieth century," Harriot Blatch declared in the first message transmined. "I believe in its scientific developments, in its political development. I will nor refuse to use the tools which progress places ar Illy command... not forgetting that highly developed method of registering my political opinions, rhe ballot box." Since the transmitter was only a onc-way communication, she continued uninterrupted - despite a protest from a male student from Columbia: "That is a mean way to talk at a poor chap when he can't say anything." Believing that technical modernity was inextricably and inevirably linked with politically progressive ideas, she continued: "Travel by stagecoach is out of date. Kings are out of date: communication by canalboar is out of dare; an aristocracy is out of date, none more so than a male aristocracy."[57] The speech was used by De Forest and his business agent to sell stock of his Radio-Telephone company to suffragists and their supporters.[58]

Even if Nora Blarch and Lee De Forest shared in the excitement of the new technologies, disagreemenrs emerged over the financial status of the firm once they had married and their child was born. De Forest so strongly opposed to his wife's management views on the family firm and the work she continued to do in engineering that ir caused their separation in 1911. Explaining his divorce, De Forest told reporters of a national newspaper that "his matrimonial catastrophe was due to the fact that his wife... had persisted ill following her career as a hydraulic engineer and an agitator [for women's suffrage]... ;lfter the birth of her child."[59] He warned other men against employing their wives, conveniently omitting all mention of Blatchs technical and financial participation in his ventures. Eventually, Blarch starred her own architectural firm with family capital. It allowed her ro remain independent from partners like De Forext and from rhc corporate emplovers she had earlier learned to avoid. Although offered more than expert labor, De Forest and other husbands were inrercsred in a jnint vcnrure but not all equirablc partnership with their wives. To De Forest, who insisted that he wholeheartedly supported suffrage for women, admired Nora's intelligence, and enjoyed her technical training, his wife's greatest oflcnsc had been that after marriage and motherhood she had rejected an Oil-loan identity and continued to assert her feminist heritage of three generations and her own career as an engineer.

SCHOOL CULTURE AND THE STRATEGY OF OVER-QUALIFICATION

Family businesses were based on a form of engineering knowledge which tinked them [() the patriarchal authority of the traditional workplacc where class shaped

ihc relations between management and labor, Formal education, by contrast, was to be a more democratic form ofknowledge accessible to all, but it was still in need of establishing and reproducing its own malc model of authority. In the decade foilovving the American Civil War, diversity and openness characterized American cnginccring ed ucation, bur it ncverrh elcss eame to be bou nd by gender and race. Hailed as the landmark legislation that pushed higher education m unprecedented coeducational levels, the Morrill Land Grant Act of 1862 helped establish several schools of engineeri ng at land-grant state universities, colleges, polytechnic institutes, and private universities throughout the land. Its drafters had intended it for the education of the children of farmers and induxtrial workcrs, but had not stipulated the character of "agricultural and mechan ic arts." In the early days, women, workers, and farmers attended courses given at the land-grant colleges institutions like MIT. Industrialists had been the first to support education of workers and women viewing them as a potential disciplined work force,

Th is broad com mitrncn t of the Act changed in the cou rse o f the ccntu ry, "The agricultural and mechanic arts" often came [() mean industrial rather than agricultural education, technical rather than arris.mal training, and school-based engineering rather than a British-style apprcnticesb ip. Engineering educators began breaking with the traditions of vocational training, managing to seize all rh« arrrihutcs of scientific rhetoric. 'Ihc push of upgrading the field through the infusion of professional ideals resulted in [he masculiniznrion of the higher education of engincering, sending women into separate fields of chemical lab work or home cconorrucs.

Before this closure, American women were welcorncc] as spccial ruirion-paying students when engineering educators sought to incrcase their enrollmcnr figures for their ncwly mimed programs. American women had free access to primary and secondary education and came relatively well prepared compared with their sisters elsewhere. In particular the recently mimed programs were more welcoming than the cstab lished jns rirurio ns. 'rhus, the cocd uca rional land-grant insritu tio ns and stare universities showed a more favorablc attitude towards women's higher education in engineering than privately owned and sex-segregated institutions like denominational colleges, mil irary academies, and high-status pri varc schools. 'Ihe state-sponsored land-grant institutions (e.g. Purduc, M IT, lowa Srare, Ohio State, Cornell. Bcrkclcy, and the Universities ofWashingron, Illinois, Colorado, Michigan, and Kentucky) and many municipal universities (rhc l.lmvcrsitics of Cincin nari, LOII isvillc, New York, Il ousruu, and Toledo) pioneered in cocducation in engineering. Even some mining schools adrn itrcd women to their engineenng departments."

In the prc-prorcssional ern, when neither engineering institutions and occupariona! clubs had yet raised their standards to meet the prestige of rhc orhcr proles-

sions and home economics had not yet been established as a separate field for women interested in technical fields and applied sciences, pioneering wornen students began to graduate in engineering from the 1870s onwards. Even so, they received mixed messages. Engineering educators searching for higher cnrollrncnts might have admitted some women to their programs, but aspiring women faced outright discrimination at every turn, requiring a stamina not all women could muster. A complete set of data on the enrollmcnt and graduation figures of three schools (Ohin State University, Un ivcrsi ty of Alaba rna, and Stanford Un iversiry) suggests - not surprisingly perhaps – that the dropout rate for women was 25 pcrcent higher than for men, 50 insrcad of 40 percent of those enrolled." Even women who managed to complete their course work did not always receive the official recognition they deserved. The experiences of! .ena Haas at Columbia, Eva Hirdlcr at rhc University of Missouri (1911), and Mary and Sophie Hutson at 'Texas A&M (1903) are telling examples of women students who satisfied all their requirements without receiving the appropriate degrees during a period when engi neering educators tried to raise academic standards to compete with their colleagues in the humanities.

Facing discrimination, women engineers paired their strategy of ovcrqualification wirh stoicism. The experienced mechanical engincer Margaret Ingels warned in the 1930s that a woman engineer "must in many cases work even harder than a man to build up confidence." Two decades later another woman found the situation unchanged and concluded that "a dedicated woman can succeed [but has tol run twice as hard as a man just to stay even."[2] Women who were willing to fit into the tightly knit male world ofengineer: ng could force the doors slightly more ajar by concentrating on their math abilities and doubling their efforts. Many wo men of the earll' generation opted for multiPle degrees wirh which to scale the academic walls of engineering.

If wo men en gi uccri ng srudcn ts ill the n inereen rh and earll' twen rieth cell tu ries faced formidable Jifficulkiex, the lack of preparation ill marhcrnatics does not seem to have been one of them. In high school, for one, American girls and boys rccivctl an equal amount of instruction in calculus and geometry and came relatively well prepared.' Moreovcr, because women who entered engineering [ended to come from higher social backgrounds than their male coumcrparts, [hey ofren came academically better prepared. A few decades ago, sociologist Sally Hacker argued that the high standards of marh in engineering education effectively served to exclude women, but in the transitional period Irom a proro-professional to a pro-[essinnal era, marh offered a window of opportunity f0l- those women interested in a rcch n ical education, however briefly. Before the second World War, an understanding of mathematics was required for practicing engineering, bur in America it never formed the kind of obstacle or rite ofpassage that it would later when it be-

came part of the tactics to raise the standards of engineering, Hacker observed at schools like MIT during the 1970s. On the contrary, many women who went into engineering could claim superior ability and knowledge in mathematics. The increased importance that engineering educators placed on mathematics as a means of upgrading the profession might have been a major hurdle to many engineering students with average ability - women or men - but it also acted as an advantage for brilliant women in a school culture that stressed academic skills over hands-on experience. Exceptionally competent women like Elsie Eaves (1898-1983), Alice Goff (b. 1894), Dorothy Hanchett (1896-1948), and Edith Clarke (1883-1959) used their mathematical skills and multiple degrees as a wedge into engineering work and mobilized them as a shield against outright discrimination.[35] For brilliant women, excellence in math proved to be a window of opportunity at first.

Educational reformers like Thurston who sought to upgrade engineering training with a new emphasis on mathematics, history, and the humanities faced a dilemma. Their form of engineering knowledge was not linked to the patriarchal authority of the workplace where class shaped relations between management and labor, but based on the new cultural authority of science and math. Not only were academic engineers often accused of failing to prepare their students to face the reality of the production floor, but academic ideals threatened to become associated with gentility and femininity. In this balancing act, engineering educators became the most articulate purveyors of an academic male esthetics [that stressed hands-on experience and a slap-on-the-back kind of manliness. Many engineering educators tried to imitate "the methods and manners of real shop-life" in college shops that housed steam engines, blacksmith tools, foundries and the like. Here hands-on experience could be acquired while preserving academic ideals. However well-equipped, the problem with the college shops was that true confrontation with the attitudes of independent workers and bullying foremen could neither be simulated nor tested. The ability to "handle men" remained the true hallmark of the successful engineer of a management professionalism of engineering. In the schools of engineering, this managerial ideal of engineering balanced precariously between working-class manliness and academic gentility. Within the walls of academia, work in the laboratory, the shop, and the field clad in overalls with a knack for tough jokes added luster to the male rites of passages into the profession. It served not only an educational goal but also sought to enhance the prestige of engineering education.

In these environments, women students were encouraged to take math classes but often excluded from taking shop or field trips to factories mandatory for graduation. Around 1904, when Nora Blatch's classmates prepared to pose for a photograph showing them working as civil engineers in the field, they arranged for a male friend to date their female colleague on the day of the photo session so that

she would not be in the picture, They thus deliberately excluded her [rorn this male rite of passage and era sed her from the visual histori cal record. 1n 1925, M1'1' professors prohibited Olga Soroka from participating in a field trip required for graduation in civil engineering. Her professors organized a special internship with rhc New York subway for her instead, considering it more appropriate to concernporary (but always changing) definitions of women's publ ic bchavior. An na Lay Turner, a chemical engineering student at Rice Universi ty in '924, recalled that women were tolerated in genteel academic environments, but barred from mechanical labs. To pLlt on overalls was to challenge prevailing codes. While engineering educators might encourage women students to take courses involving the sciences and mathematics, they tried to bar them from practi ce classes and laboratories, even when these were necessary for their graduation. All these prohibitions expressed the strong resistance to any female incursions into this specifically male engineering rire of passage of class.".

The workshop and building sites thus functioned as a way of screening out women "[fori it must he clearly understood," as one critic of women in engineering and other technical occupations wrote in 1908, that "the road to the drafting board and the laborarory of the engineer lies through the workshop, and workshop practice means hard work and blistered hands, not di Ierrante pouering and obscrvation."[2] Women might be eompetent in draiting, culcu lario 11, research, and analysis, as employers testified in the 1920s, but sweat, dirt, and calluses made the engineer a real man. Or, in the words of one scholar, "if science wears a whirl.' lab coat, technology wearx a hard hat and has slightly dirty fingernails."[3] Ideally, middle-class men belonged on the producri on floors aIId buiIdiIlg sites where [hey managed other men, while women dealt with more technical details in genteel environments. But this was true only as an ideal to be aspired to.

Foot soldiers of Bureaucracy

Most women engineers were employed by the emergiIlg military-industrial complex. Women also found thei r way into enginceri ng through what should be called corporate and federal apprcnricesh ip, particularly when corporations and rhe government worried about a shortage of technical personnel ill times of war and cornpetition with foreign countries. Among entry-level jobs, women made the most headway in the labor.uory-oricnred and newer fields which did not carry gender codings .ir first and required more academic skills: chemical analysis, electrical, and - after the second World War -- aerouaurica] engineering. If small businesses provided a way into engineering for women with famiIy ties, the large emerging corporations did so for women without family capital or resources, to whom me-

chanical engineering - steeped in craft traditions - remained a closed shop. This is nor to say that women could not be found working in mechanics shops: during the first and second \Vorld War, corporations hired working-class women as lathe and punch press operators and as assembly workers Mechanical engineering implied a differenr class rhan rhe engineering rrades, howcvcr, one that involved supervision." These temporary encouragements women received in pursuing engineering were ambivalent to say the least.

For employees of large corporations without rlmily connections or capital, an enginccring job held the promise of promotion, even if it became marc a vision than a reality in rh« course of the twentieth century. The formal and bureaucratic rulcs both insrirurionalized endemic gender discriminarion and helped to secure better opportunities for women engineers without the proper family ties than the informal but parriarchally infused rituals of firms where shop-floor culture encouraged male patterns of advanccmenr. These were open only to the few women like Karc Glcason who could crack the male code of the shop floor by invoking an authority stemming from family ownership. The growing importance of formal rules and the move toward protessionalizauon in the twentieth century proved [Q be a two-edged sword for women engineers who chose to enter the profession wirhour capital or connections. The two world warx – and the state – offered windows of opportunities, but nor full-fledged careers. The war economy also insritutionalizcd and created new discriminatory practices.

Women migh t find formal educatio n a viable means o f access to entry-level engineering jobs, but those who excelled academically did not fare well subsequently in their cngi ncering careers, either because of marri moriia] d isloyalry or because of male codes of the workplacc, Highly trained women including Flsic Eaves, Olive Dermis, Parricia Srockum, and Mabcl Macferrcn, all of whom had earned two or three degrees and showed the stamina to succeed, found that this initial advantage turned into a liability once [hey entered the workplacc. In the workplacc environment male codes of managerial command and hands-on experience determined one's professional standing, nor academic excellence. Many ovcrqualified women ended up either as (high school) teachers in mathematics and sciences or as calculators in corporate offices and at research institutions. Dororhy Tilden Hanchert first trained in civil engineering at the University of Michigan ('17). No doubt she belicvcd rha t additional M.A. and Ph. D. degrees at Colum bia Un ivcrsi ty ('27) and Logan College ('45) would help [() advance her career. Instead. she ended up at Battle Creek High School as head of the marh department, In the aftermath Of first World War, Hancherr and many other highly qualified women found that governmcnr propaganda had contained more rhetoric than reality. They were forced to accept temporary teaching jobs in elementary and high schools, reaching instrucrorships at engineering colleges, or editing positions ill professional organi-

zations," Thus, rhe tactic of obtaining multiple degrees did not guarantee employment.

ln times of economic bust, only government highway projects and bureaucracies could offer academically trained women employment, however ill-paid. Even if proportionally more women trained in civil engineering than in any other specialization, in this already overcrowded labor market, they earned the lowest salaries, ended in low-level positions in federal and corporate bureaucracies, and found fewer employment opportunities rhan in any other branch of engineering. Although rhesc bureaucratic jobs migln have been demeaning for young men who expected management positions, for women such positions offered relatively high wages compared with other jobs available to them at the time. The drafting deparrmcnrs of State Highway Commissions gave temporary jobs to Knudscn in Wisconsin and Elsic Eaves in Colorado during rhe 19205, to Myra Cederquist ill Ohio in the 1930s, and to Emma Crabtrcc in Nevada in the *1940S.*" The emerging large corporarions such as Westinghouse, General Electric, and Booing also offercd women an avenue to technical training through a kind of corporare apprenticeship. At Westinghouse, Bertha Larnmc found ample opportunity to use her superior mathematical knowledge and her engineering skills to design motors and generators for over ten years, until she had to relinquish her job in *1905* when she married a eo-worker, Finding the door to engineering slightly ajar during the war ill 19[7 as a young civil engineering graduate from the U niversiry of Michigan, Hazel lrcnc Quick established a long career, lasring until *1950,* as a fundamental plan engineer; she was in fact the only woman employed by the M ichigan State Telephone Company.[37]

Even if the world wars offered opportunities ((women, employers also responded to rhe modest increase ,n the number ofwomen by serring up clear gcndcr boundaries and by creating separate social and spatial arrangements. To deal wi rh the small incrc.isc of women, employers instituted sex-segregated offices and drafting departments where some academically trained womcn could move ilHO supervisory but temporary positions. After gt'aduating from Iowa State University in civil engineering in 1894 and doing some graduate work at MII", Alda Wilson (b. 1873) worked in architectural firms ill Chicago and New York for over ten years, before she found a managerial job us supcri nrendcnr of the women's drafting dcpan mcm at rhc Jowa Highway Commission in 1919. Unable ro find an engineering position after the first World War, the ovcrqualificd and brilliant Edith Clarkc spent several years training and supervising women in rhe calculation of mcchan ica] srrcxxcs in turbines in a separate women's department within rhc Turbine Engineering Department at General Electric ill Schenectady, N. Y. 'Ihcsc separate female spaces might have offered women a temporary niche hut rarely a solid stepping stone for full-fledged careers as designers, executives. or managers.[38]

Before the era of affirmative action, therefore, neither the federal government nor the corporations offered true alrernarives to the kind of patriarchal patronage found by daughters of small firms. At the end of her career in T947 when the government campaigned for women's return to their homes, the experienced Dennis wrote ill the true spirit of belief in meritocracy: "we certainly do nor want to discourage the ambitious young woman with the right qualifications for an engineering career," bur she warned, "anyone pioneering in this field must be made to see that, ourside of the lowesr levels of clerical and manual work, there are almost no standard [management] jobs for wornen.?" Dermis knew what she was talking about. Qualified women engineers and scientists of her generation had weathered the storm during the Depression in order to continue their careers. As Nora Blatch correctly observed when she worked as an engineering inspector for the Public Works Administrations in Connecticut and Rhode Island, federal sponsorships of women were limited during the New Deal. The investments of Rooscvclr's public-work administration in major building programs provided engineering work for men only. The reforestation, highway, building, and reclamation projects were all closed to qualified women while they mobilized men at lower wages far away from their homes, leaving their wives TO head their households. Moreover, the National Recovery Board sri1] specified lower minimurn wages for women than men.[5]

These highly educated women waited for better times and looked for jobs in teaching, drafting, or editing and secretarial positions with engineering firms and professional organizations. Strategically located as manager of the Business News Dcpartrncnr at the journal *Engineering News-Record,* the Colorado graduate ('20) and socially well-versed Elsie Eaves provided rncntoring and career guidance TO many young women engineers during the *t930S* and 1940s. She counselled [hem on how TO get rhrough the Depression, and encouraged them to acquire srenographic and secretarial skills in the hope of "a position with a fine engineer," bur she warned, "I never encourage a girl to study engineering on the theory that ifshe wanrs ir badly enough she will do it in spite of all discouragement."[6] During the second World War, when younger men went to the front and others moved up, women srood ready to take on the new jobs rhar were opening up, bnr never materialized. Instead of recruiting among the experienced women already available, [he federal government chose to train young and inexperienced women. The state thus helped to institutionalize and intensify old patterns, as can best be illustrated by the politics surrounding the federal joh of engineering aide.'

During the second World War, the federal job title "engineering aide" carried with it ihe heavy baggage of gender politics and amplified old habits. It defined women as non-engineers. As part of the war effort, American women like those elsewhere in Europe were encouraged for the first time to seek training in reel:nical work. Under the auspices of the federal government and in cooperation with uni-

Figure 33. Three women draftsmen trained as engineering aides posing in classic Rosie-rhc-Rivctcr Covcrnmcnr propaganda srvle in 1943. Photo campaign promoted hy rhc Department of Labor's Woman's Bureau to .uivcn isc their importance to the war industry. Permission of Schlesinger Library, Radcliffe College, Cambridge, MA.

vcrsirics, large corporations urged young and bright women to apply for engineerillg jobs.[Figure 33] Federal agencies, large aircraft corn panics, and engineering schools pushed over 300,000 women through various kind of engineering programs ranging from thrce-manth crash courses to college engin eeri ng curri cula condensed into two years. Georgia Tech Universiry in the South, like many other well-established schools hostile to any him at coeducation before the war, opened its doors [()women for a special training program sponsored by the U.S. Chemical Services when shortages of technically trained personnel threatened the war industries.. The aircralr eo rpo rat io n Curriss-\Xirigh t sponsored a eo urse for women engineering students at several American universities including Iowa State, University otMinncsora. and Rensselaer Polytechnic.[Figure 34] The women received an enginccring certificate after completion of the course which includcd work in engineering mcrh ads, rncchan ics, drafti ng, and processi llg.[Figure 35J Many of these specially trained women, who had been the best and the brightest in rhci r high school and college, ended up in drafting, resting, and routine lab work, however.

Figure 34. Women trainees posing for propaganda photograph for the Curtiss-Wright corporations Cadetre Program, an engineering crash course for women during the war in 1943. Courtesy of Archives of Women in Science and Engineering, Iowa State University.

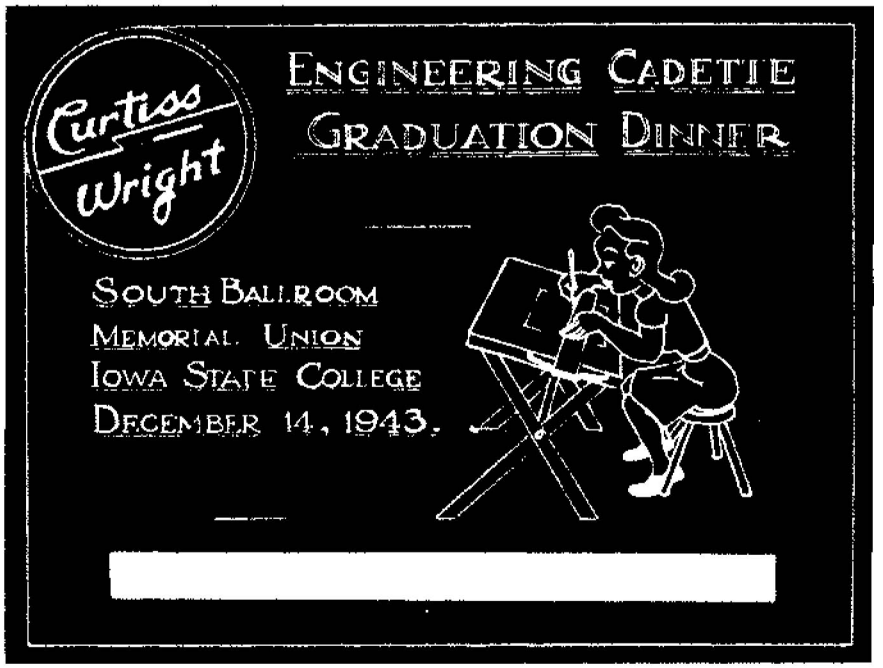


Figure 35. I),aw;ng of a poster annoi ncing dill ncr cclcbraring \he graduates of the (:1lmiss - W'ight Program. Courtesy of Archive. of Women in Science and Engineering, Iowa State L'ni - vcrsirv.

Julict K. Coylc trained in medical tcchnology and biology as a young college student in 1943, when she was recruited by an aircraft company for a short course in engineering where she learned to read blueprints, drafting, statistics, and rncchan i- cal practice. When the war ended and she finished her studies, however, rhc company had no idea what to do with her and her equally well-trained womcn colleagues. 'Thc firm not only moved them around through different departments and paid them less than their male counterparts, but gave them explicit instructions to avoid giving orders to workers on the production floor - the male avenue to further promotion on the managerial ladder.[8]

Coyle's experience illusrrarcs rhar none of these cduc.uional efforts, either during or after the war-rime labor shortages, were meant 10 turn women i1110 full-fledged engineers, [Figure 36] All programs were clearly imended for womeri'x temporary employment as technical assistants to the various engineering departmcnrs, despite propaganda agencies' claims to the contrary.' During the second World \X/ar, vocational literature attempred to assure female recruits that such en - gi uccri Ilg work would lead to full careers, bur Margaret Barnard Pickc], an adviser to graduate students at Columbia, questioned rhur promise and advised women to prepare for a backlash in peaccri me. "Are the educators of women justified in en-

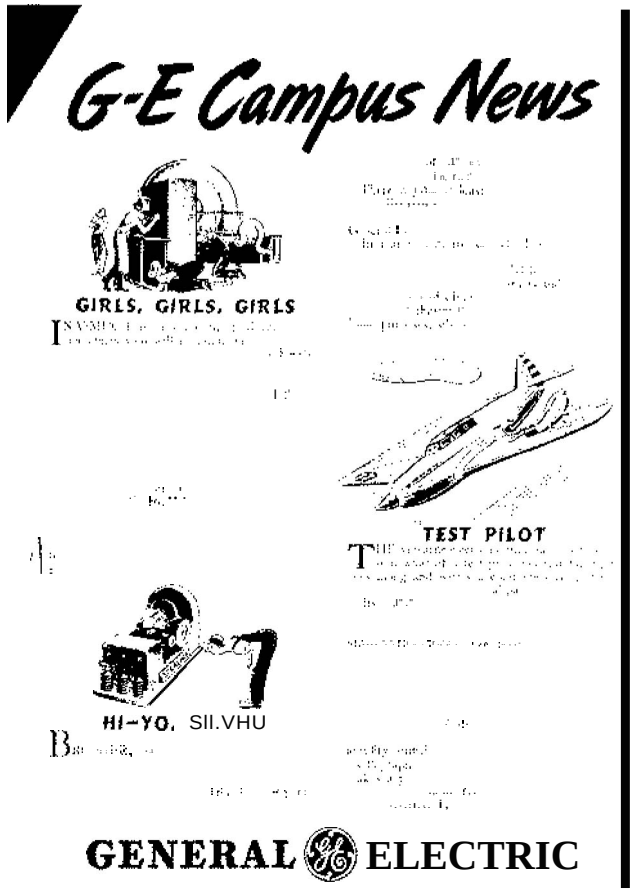


Figure 36 Propaganda carroons "Girls, Girls, Girls," as published by General Electric's Campus News, 1942-43.

couraging their studcur« to start on the long, arduous and expensive train ing for an engineering degree with the expectation of a career at the end of it?' she asked. Afrer taking an inventory of the barriers women would face. she concluded, "it seems hardly honest to hold out such a prospect as a professional possibility for women. Dermis, oircn quoted by the Baltirnorc and Ohio Railroad lor their public-relations literature during rh« war, also pointed out rhar "Women engineers have been ignored or else glamorized with newspaper publicity that is harmtul ro serious advancement in their work."" The Women's Bureau's investigation into rhc cmploymcnr opportuniirics in peacetime was equally rc.ilisric and cautious based on their experiences during the xccond World War. In explaining their research project, the officials at the Women's Bureau stared in their corre-

spondcncc that "it isour opinion that the increase of women lin technical and scicnrific work] duri llg the war has been greatly cxaggcrared because of the publicity presented to attract them . However, we want to find the facts through first-hand contact with professional organizations... those who employ women in technical and scientific jobs, and with training ccnicrs."[43]

Indecd, Margarer Pickel had been jusrified in xnunding the alarm, as the Women's Burcuu found . Tactics to constrain women - 1110st of whom were college educated - took on various forms. Not only was a woman's job given the title of "engineering aide," but the implicit gender-based division of labor relegated WOl1H;n to dl':lfting dcparrrn cnrs and laboratories, while men were assigned johs on rhe production floor that enabled them ro udvaucc to managerial positions. In short, the federal policy created the term "engineering aide" to refer to women engineers, while it continued to use the title of "engineer" to denote men. The job title of "engineering aide" thus forcefully drew a linc between tcchn ical expertis e and management, and both reproduced and created a standard practice."

In the U.S., as elsewhere, the rclationship between management and the technical content of engineerillg as an occupation is critical to understanding the fornulariou of a male professional identity. Overqualified women found thau the initial advantage of education would turn into a liability once they entered the workplace where male codes based o n managerial qualitics and hands-o11 experiencc determined one's professional standing. The gender division ofengineering I;\hor – between production floors and drafting offices - hinged on rhc very same (class) distinctions hywhich male engineers sought to distinguish ihemselves Irom self-traincd foremen wh() had risen rhrough the ranks, Th c divixinn ()f labol' berwccn the laboratory and the drafting department on the one hand, and building sites and production nODI'S on the other, bccame the single most important delinc.uor between men and women in engineeriIlg. Wherever women engineers did succeed ill gain illg cmploymcnr, they were mosr likely to be hired in drafting, calcul.ui ng, or design departments, or laboratories and claxsroomx, In other words, women enginccrs joined the rank-and-file of the protcssion.

No woman without a family connection ever moved into supcrvisorv positions in family firms. Women like Rocbling, Gleason, and Gilbreth, who were steeped in the patriarchal culture of [he family business advanced in cngi nccring through a combinat ion of excellence, perseverance, family connections, and the pooling of resources. But assessing rhc chances of women's employment in 1940. Olive Dennis (1880-1957), who like Blatch had received her rduc.u inn from Cornell l.Inivcrsity in civil engineering ('20) in addition to degrees in marhcrnarics, warner] th.u "unless a woman has a family connection in an engineering firm, or enough capital to go into business herself, her chances of rising to an executive position in structural engineering seem negative."[44] Lmplovcd first as a draftsrnan in rhc bridge di-

vision of the Baltimore &. Ohio Rail road and later transferred to the company's service deparrment for inrcrior couch design, Dennis's response during the 1940s is the more revealing: She was always touted as a woman's success story, both by women engineering advocates and by her employer the Baltimore & Ohio Railroad, especially during the second World War, when the War Manpower Commission and the Office of War Information launched an intense propaganda campaign to lure women into the technical fields. Dennis's warning points to the split between government rhetoric and women's experience of it, the difference between women with family resources and those trying to make it on rhcir own in the ernerging eorporatc and federaI hurcaucracics, the gap bcrwccn women's rechnical expertise and rhcir abiliry to move into managerial positions, and the Contrast between lli ncrccnrh-cenrury ideals and rwcnricih-ccnrury practices.„

More explicitly than any woman might have said it, the introduction of the term "engineering aide" encapsulated the story of women's marginalizarion as a labor reserve force without rhe possibility for career advancement. Wilh a single linguistic stroke, the term placed women with technical ability and training outside rhc emerging domain of technology.

FACING MALE PROFESSIONALISM

National professional organizations became the most visible if not the on Iy inxrirurion of the engineering fralernity, Few scholars still regard the nineteenth-century movement of professionalization as a trend towards expertise, knowledge, rational behavior, peer review, and values void of any ideological concern. Most consider it a form of occupational control and autonorny with exclusive jurisdiction and privileges which conceal the advocacy behind the cloak of political disinrcrcsrcdncss and objectivity. The engineering societies were by 110 means exceptional; they explored some of the classic tactics pioneered by other protessions, looking for new means to enhance their status and cultural authority. The classic model of professionalism defined by medical practice emphasized the work ethic, trust. professional associations, licensing, collegial control. and strong client and practitioner relationships was problematic for American engineers, as many historians of engineering professionalism have argued, In engineering rhe classic model also competed with business and rank-and-file models of professionalism, as Peter Meiksins has correctly argued. The American Institute of Mining and Metallurgical Engineers (AI*ME*) advocated business values, closely associated with the culture of fami Iy firms, and adhered less strictly to the newly emerging ideology of professionalism. Its business-oriented policy had an imrnediarc impact on the number of women admitted: while only 25 women had majored in mining

by 1952 and many states had laws prohibiting women working underground, the mining engineers admitted more women to their ranks than any of the other major organizations. In 1943, the AIME membership included such daughters offarnill' firms like Jean Homing Marburg, then member of the National Resources Planning Board, Helen A. Antonova, an assayer at the R&F Refining Co., Edirh P. Mcycr, a development engineer at Brush Beryllium Co., and another [9 women in addition to a large number of female students." For daughters of family firms like Jean Marbllrg business professionalism opened some doors that would have remained closed otherwise. Thus, business models of professionalism were more open to women if they were connected to the patriarchal culture of family firms like Gleason, Gilbreth, and Marburg. They were closed to women without the proper family connections.

Even if engineers did nor succeed to maintain strict professional boundaries compared to other professions when successful the classic model of professionalism turned out to be a thoroughly male and middle-class endcavor. The more an organization strove for professicnal ization modelled after the medical occupation, the more it was inclined to bar women." It was not the number of women engineers in either absolute or relative terms which determined the percentage of female membership, bur rather the level of professional claims to which the leadership of the respective national organizations aspired. Significantly more women engineering students opted for civil and electrical than other enginecri ng fields, but this population was not reflected in the membership of the American Society of Civil Engineers and the American Institute of Electrical Engineers, whose requirements were more strict than those of their brothers in mining.

The American Society of Civil Engineers (ASCE) and other major societies guarded their boundaries against any female incursions. Other organizations also granted secondary mcm bcrsh ip without voting rights [() unimportant rank-and-file engiueers and women who managed to infiltrate them.[18] The American Institute of Electrical Engineers (AIEEl, emerging in a field with high aspirations towards a medical model of profcssioualizarion, refused to admit Susan B. Loiter, a lab assistant at the 'resting Bureau in New York, to membership in 1'104, when the organization was looking for ways to upgrade the profession." When Llmina Wilson and Nora Blatch applied for membership to the Amcri can Society of Civil Engineers, \hey found the doors closed. With a *cum laude* ill civil engineering fwm COfl1ell University, Nora Blarch could claim superior mathematical ability and theoretical engineering knowledge, the kind of credentials advocates of engineering schools thoughr crucial for any engineer to succeed. But Blarch had more to offer: she also possessed the necessary hands-on experience that advocates of shop floor and field training saw as hallmarks of rhc true engi nccr. These was all to no avail. In 1916 when she turned 32 and rhe society dropped her from irs member-

ship, Nora Sranron Blarch filed a lawsuit agai nsr the ASCE. As an experienced engineer, she had accumulated over ten years of experience to meet the Society's rcqui rernents. In addition to her four-year education in civil engineering at Cornell, she had taken courses in electricity and mathematics with Michael Pupin at Columbia University. She had practiced as a draftsman for the American Bridge Co ınpany an d th e New York Ci ty Board of Warer for abo ıır two yearxand as an assistant engineer and chief drafrsrnan at the Radlcy Steel Construction Company for another three years and finally as an assistant engineer at rhe New York Public Service Co ıı ıuissio ıı, Most important ly for the requircmcnrx for [-ull rucmbcrsh ip, she had supervised over thirty drafrsmen when working at Radley Steel. Blatch, a feminist, divorcee, and single mother whose income depended on her engi nccring work at the rime, challenged the ASCE when more women and sorts of lower-class men were trying to curer the field through the new institutions of higher cducation and when cngi nccring advocates were busy def ni nl', the occupation as a profession by excluding more and more groups of practitioners such as draftsmen and surveyors. I lcr suit marks one of many contests in which the emerging professions staked out their professional claims by means of border disputes with other competing fields."

In addition to outright exc]usion, the professional organivariou dealt with what they saw as female incursions through the tactic of granting women secondary membership without voting rights. The controversy over Frhcl Rickcrs Tall Beta Pi membership marked yet another drawn-out contest over gender boundaries in the fields Of civil engineering and architecture where women were 1ll1111el'OllS, In 1903, the local chapter of Tau Beta Pi elected Ricker. an archircctur e student at rhe Univcrvity of Illinois, to the engineering honor society, hut the national executive board and the soci etv's convenrio n no t o nly ovcrturned the dcc isio ıı to elect her. but went so far as to amend its constitution to specify that henceforth only men would be eligible for membership, During the 1930s depression, when many civil engineers faced uncmploymcnr, the Tau Beta Pi honor society introduced a Women's Badge in an attempt to deal with the (small) num her of qualified women who had made their presence felt. To make it clear that their acceptance should be considered an act ofbenevolence, Women's Badge wearers were neither rncrnbers nor allowed to pay initiation fees. Disapproving of such "separate bur unequal" recogn itio n, some women refused them. Noncthclcxx, it would rake three-quarrel's of a century before women woulti be accepted as equal partners in the organization: in 1969 the honor society changed its constirurion to admit women, in 1973 it xanitized the consrirurion and bylaws of sexist language, and in 1976 it elected a woman as a national officer for the first time, By changing its constitution and by designing a "woman's badge," the fraternity of young aspiring cngineers set up cxpl icir gender barriers around engineering when job markets were

particularly right. The resistance of Tau Beta Pi resulted from a mutual shaping process between the newly established specialization's need for social and professional status and the increasing numbers of women architects and civil engineers demanding their rightful place behind drawing boards and on building sites.

Like the various scientific fields, engineering specializations were sanitized from the perceived threat of feminization either by excluding women from full membership in professional organizations or by relegating them to a secondary status without voting rights. The development of subordinate, segregated female professional cultures in areas such as chemistry, however, proved to be the most crucial tactic to the very definition of a profession. In the words of Margaret Rossiter, "the very word *professional* was in some contexts a synonym for an all-masculine and so high-status organization."[9] Women faced outright exclusion, were relegated to secondary membership, and banished to separate organizations.

DIVIDE AND CONQUER

The definition of separate labor markets for male and female engineering work presented another tactic to deal with women who started to seek engineering education and employment. The best example comes from the chemical industry where many women found employ as chemists. To deal with the female incursions the American Institute of Chemical Engineering did everything in its power to define the occupation in such a way as to effectively bar women from the field and relegate them to chemistry,

The ability to manage other men became the key to the chemical engineers' definition of their profession in an effort to distinguish themselves from chemical analysts - a large proportion of whom were women - whose status and pay diminished dramatically around 1900. In response, production chemists sought to align their occupation with the male world of mechanical engineering rather than with the world of science. Chemical engineers saw themselves as running plants, as opposed to labs. As one of the most important founders of The American Institute of Chemical Engineers (AIChE), Arthur D. Little (1863-1935), spokesman of engineering professionalism and the nestor of commercial chemical research, introduced a key concept for the development of a distinct chemical engineering identity in 1915: the notion of "unit operations." Little argued that unit operations involved neither pure chemical science nor mechanical engineering, but distinctly physical, man-made objects in the plant operation rather than chemical reactions in the lab. In the same year that Little refined his notion of chemical engineering in a report for the AIChE, his opinion was solicited by the Bureau of Vocational Information for a report on employment opportunities for women in chemistry and

chemical engineering in the righr engineering labor market after the first World War. Recommending chemical analysis as "one of the most promising fields of work for women,' Lirrlc reserved chemical engineering as an exclusive specialization for men, arguing that "it is probably the most difficult branch of the profession," In addition to the long hours, the extensive travel, and the physical endurance needed, he considered the "rough and tumble of contests with contractors and labor unions," involved in the new construction and design of u plant, to be prohibitive factors."

Little's rhetorical posirion was broadly shared by male chemists working in the field. While stressing women's strength in all other lines of work connected with the chemistry Jab, the chief chemist of the Calco Chemical Company voiced the general sentiment in 1919: "It is impossible to use women chemists on developmcnr work which has to be rranslared into plant practice by actual operation in the plant. This is the only limitation.' Other potential employers of women chemists elaborated on that particular theme by explaining that "research men must go into [he Plant and manipulate all sorts of plant apparatus, direction [sicl foreign lahor of every sort. You can readily sec that a woman would be at a great disadvantage in this work," or that, "it often involves night work and almost always involves dealing with plant foremen and operators not easy to deal with." The work of chemical engineering involved "large rough mechanical apparatus... which work is usually carried on by unintelligcur labor, in a good many cases the roughest kind of materia]," the representative of the Grasselli Chemical Company's research department wrote in 1917.[1] By establishing 1llch boundaries, Little and other chemists sueccdcd in safely associating their work with borh rhe male codes of the machine shop or the plant operation and managerial control since the power struggle in the workplacc where matters *of* class were contested was a matter *between* men,

Despite these ideological constructs of women's and men's engincering work, it is questionable whether women did not, in fact, do such work. Women chemists were sometimes responsible for tasks bordering on chemical engineer:ng. bur they were rarely upgraded to that level. Often discrepancies existed between job title and job content. Take the casc of Clenola Bchling Rose, whose job title was chemist but who described her duties in 1920 as follows: "I left the chemical dept. to go into the Dyestuffs Sales Dept. I have but one man over me and as his assistant, 1 am the *Exccutiue Office Snperoisor* of the Dyestuffs 'I'cchnieal Laboratory and have charge of ail dealings with the chemical dept. such as deciding what dyes they shall go ahead to investigate & in what quantities, and keep track of their work in order to sec whether they produce the dyes economically enough for us to marker them. In a way I am rhe link between rhc research, the manufacturing and the selling of dyestuffs... As you will see a good deal of my work is supervisory." With Bachelors degrees in geology and chemistry, and a Masters in chemistrv, the highly qualified

Clcnola Rosc felt shc was technically well-prepared for such a job. In response to the question Of what training shc thought wo uld be mostbeneficial to wo men ellrering her field, she replied that there was a "need for a thorough foundation and a training with men,' by which she meant the task of managing men. And Florence Rcnick wrote that, in fact, "I have had to deal considerably with tabor ofall kinds, mostly ignorant and many foricgncrs [sic] among them, and nonc of them but consider me 'boss' so far as the laboratory is concerned." O il this particular point jcssie Elizabeth M inor, chief chemist ar the Hamcrslcy M anu fact u ring Company, articulated wome n's ambivalence: "There is still much masculine prejudice to combat. Many labo rato ries are not arrracrive looking. We come in contact wi th work ing men (which may be construed as an asset or liubiliry)."" Thus in these con texts, white wom en chemists actually did supervisory work and would have qualified as engineers according to the terms Lirtlc and other chemical engineering advocates had established for their engineering specialization. ([1 all these instances, rechni ca] qu alificati on or experience was less decisive in considerations for job assign me nts and promotions than rhe issuc of supervision.

Women chemists were thus kept under job titles they had actually outgrown. Significantly, traffic between chemistry and chcm ica] cngineering also went in the o ther direct ion. Womcn who trained as chemical engineers ended lip ill lowerpaid positions as chemists. D ororhy Ha ll (1894-J989) might have bee n the success story of a woman advancing on the corporate ladder at GE as a research and later chief chcm ist, bu t wirh a Ph.I). in chemical enginecring (UnivelSlry of Michigan '20) she was ovcrqualificd for her job. When asked, most employers said they thought women compctent and excellent for research and analysis; few raised ohjecrions of a rcch nical nature. But all drew the line at work related to the plant operation: they stressed, as had Arrhur l.irtle, labor-rclarcd issues. Indccd, in 1948 the Women's Bureau reported that most women who rraincd in chemical engineering were employed as chemists,[58]

These examples are telling indeed. Large numbers of women interested in the sciences in the U.S. and elsewhere flocked to the field of chemistry. The same held true for chemical engin ecring: more women graduated in chemical engineering than in any of the oth er engineering spccializations. In fact, a higher proportion of female enginecri ng students than of male engineering students majored in chemical engineering. In a limited way, chemical engineering offercd a niche to women students interested in engineering. Prominent chemical engineering advocates pushed for an explicitly male professional ethic by defining their discipline as an exclusively male domain which required supervisory skills. Tens of thousands of women chemists and chemical engineers were banished to chemical labs, where work ing conditions were dire and the pay scales low.[5] In these contexts, a che rnixt

meant being an ill-paid woman while a chemical engineer often denoted a man in command of higher wages and managerial authority.

The male establishment engineers' push for profcssion alixarion was in par r a response to rhe enormous expansion of engineering work, which provided new opportunities to lower-class youths and sons of recent immigrants. The call for clear boundaries of class, however, resulted in the kind of male middle-class reinscri pr ion. The census dara fur ther symGolizcd the process of cxclusion and reinscription arricul.ucd in these linguistic boundary wars. In rheir un ceasing efforts to find new carego rics for reliahl c enumeration, censuS rakcrs eonri nued to look for a standard of consistent classification by excluding more and more groups of skilled workers from the category of engineers, induding boat and steam shovel engineers, foremen of radio stations, engineers under 35 without a college cduca-[ion, and chemists. According to economists who have worked with the dara, however, the star isricians made these adjus rrnc nrs wirhout much success ill terms of uniformity. 'I'hcsc statistical and linguistic inter v entions did Iirrle to generate a satisfying set of data.` More broadly speaking, these interventions were part of the process of professionalizarion in which men like Arthur Little engaged. Nevertheless, historians have reproduced rnany of these figures, including the dcfinirional exclusions they represent. The definition of who would count as a true engineer and the production of statistics to jusrify this illusion mutually shaped each other. More generally, the example of the chemical industry shows the kind of linguistic constructs and social practices involved in making women invisible as engineers.

ORGANIZING AT LAST

Women engineers responded to such tactics with stoicism bur also with collective action. Before the first World War, the early generation of women engineers like Richter, Wilson, Blarch, and Lcirer had rricd to g;lin access to the cxisring male organizat ionx as individua Is. -They were rebuffed o ut righ t, gran red scco ndary starus, relegated to separate-bur-unequal organizations, o1' segregated into different labor markets. A second generation of young women students and recent graduates including Lou Alra Mclron, Hazel Quick, Elsie Eaves, Hilda Counts Edgecomb, and Alice Goff, who had found curry-level employment opportunities during the [irsr World War, tried in 1919 to organize collectively into a separate women's organization, but failed. The post-suffrage generation championed the cause of women engineers with great enthusiasm. Yet, at least publicly, none of the women's advocatcs rallied to the feminist eause, even jf they grounded their promotion of women enginccrs as professionals precisely in one of the important principlcs ()f modern feminism: as individuals, wo men sho uld be abIc to develop

themselves ID their fullest poten rial, All supported rhc notion that WOJI1cn had rhe freedom to choose whichever line of work suited their abilities, without the obligalion to appeal to feminine propriety by arguing rhar such a choice was inspired by higher morals. All ardently believed the engineering profession's promise of upward mobility. Resisting any direct association with the women's movement. rhey claimed instead ihar they just happened to have a knack for engineering - a kind of discourse particularly dominant in 1943 when government propaganda sought argUll1el1ls ro mobilize women for the war industry." The majority of women cngincers then belicved in, and had inrernalizcd, the values of corporate engineering, merit, and self-reliance.

The second generation saw their organizing efforts thwarted partly because, ill search of much-needed recognition, they cried to keep up with emerging high professional standards by excluding from membership engineering students and \Vorki1g wome11 engineers IVithout forrnu] educatio11 like no n-coilegiare draftsmen, chemists, and testing rcchn icians." They did so no doubt in an dTort to defend against sexism and to garner greater prestige, but emulating high professional standards prevented them from gathering the critical mass necessary for such an organizano11.

In the same year rhar American women tried to organize, rheir Bri rish colleagues succeeded. British women established the Women's Engineering Society (\VES), an inclusive organization that encompassed women engineers with or without formal collegiate education as well as machinists who were skilled or semiskilled workers. The British successfully, albeit briefly, united across classes ill part because they did not adhere to the classic model of medical professionalism but to the tradition of 11igh-class busi ncss professionalism and trade assoc iario11s co mbining them wirh feminist ideals. In the end, the British women leaders too abandoned their policy of "gender solidarity for male privilege and class advantage" and narrowed "their focus to exclude the great mass of women who had entered the engineering trades during the first World War directly out of the working class,' as its historian Pursell has argued." Between the world wars, when job opportunities virtually disappeared, American women engineers soughr temporary shelter with their British colleagues through membership in the WES and kept in touch through informal networks. Clinging to the medical model of professionalism, but failing to gather a crirical mass, Arneri can women engineers of the inrcrwar period turned instead to the tactic of trying to shape public opinion and writing biographical sketches of each other according to well-established formulae v,hich stressed that with hard work and self-reliancc women could indeed becornc engincers, to paraph rase Alice Goff's publication during these years. American women engineers borrowed from male models of merit, but neither questioned the structure of engineering that fundamentally hampered their chances nor campaigned for equal rights.

The final push towards organization in the U.S. did nor come from the hundreds of thousands of women working in fede ral engineering jobs during rhc second World War, from rhc informal networks of academically ove rqualificd women engi neers who had learned to be stoic and self-e ffacing during hard times or from the women urban planners who had been nu rtured by the women's re-[orm movement. It came once again - as ir had ill 1919 - fro m youg stude nts and recent grad ua res eager to enter the job rnarker and yearning for o fficial recognitio n and respectability.

Afrer the gap between rhetoric and reality had widened once again, American wo me n engineers united ar last in 1949. They did so long after other female professionals like lawyers and doctors had succeeded. An energetic and ambitious junior student leader on a scholarsl:ip, Phyllis livan s, won the support of Dean of Women Dororhy R. Young and university counsel A.W. Grosvernor to organize the first meerings ofwornen engineers at Drexe] University in 1949.[Figure 37] She and her colleagues organized over seventy young women engineering xrutlenrx from 19 colleges on the East coast to have their "voices... heard in the rcch Ilo[ogical world," to address inequities in engineering work. In the greater New York area a group of women engineers who had been working in war-related industries - srudents from Cooper Union and City College of New York coupled with graduates working in Ihe area - also struck up conversations about their plight with their sisters in the college libraries and Manhattan's coffee shops. Soon the long hidden tensions over leadership and the direction of women engineers' professionalism burst Onto the scene."[Figure 38]

In the founding years, the student group at Drexel University in Philadelphia and a coalition ofvarious groups in the grea[er New York area were in competition with each other for leadership. Its origins can be traced to a contest over the different professional strategies. Phyllis Evans – like *so* many other young women who had begun studying engineering during the war - was not yet married, about to graduate, and facing unemployment. Echoing the governmental war rhetoric, shc cherished high expectations for her future. Explaining her choice for engineering, shc rold a journalist of her war experience as a cadet sergeant char had inspired her to go into engineering and her hopes for the future in military research: "I want to build rockcrx and I want to go to Mars," she said with youthful optimism. Fsrablishmenr engineers like Lillian G. Murud and I.illian Gilbrcrh, propriety owners who were steeped in the crh ics o f the parria rchal cu lturc of f:1111ily firms, o ptcd for a more conservative strategy involving supervision and high professional sran-dards. Alrhough I.illiaIIC; ilbroth had been supporrive of wo men engineers, she did not favor a separate women's organization and was disinclined to head the SWE when it firxr looked for leadership. She was most concerned about the hold appreach of a separate organization and its feminisr implication and warned against

Figure 37. Photograph ofPhyllis Evans posing in overalls in Rosie-the-Riveter iconography illusrrating a newspaper report on the first organizing efforts of women engineering graduates in *The Christian Science Monitor* (Apri] 19, 1949). Courtcs, of Royal Dutch Library, The Hague, 'Jhe Netherlands.

blaming men for the difTiculties women encountered in entering the field; instead she accused women of a lack of requirements. "The reason for women not heing admitted into the National Engineering Society was not because they were women, but rather because they did not yet meet the qualification," she said. But the elder Gilbreth was somewhat at odds with Dororhy Young, Drexel's Dean of Women's students, who pushed for an activist strategy that confronted the inequity between men and women, whih. also striking a conciliatory note: women "need to realize that it is necessary to work cooperatively with men in larger field, planning together to abolish those inconsistencics that mar our democratic society".[65]

Figure 38. Group portrait of women attending the founding meeting of the Society of Women Engineers at Green Engineering Camp of Cooper Unions, New Jersey, May 27, 1950. as a response to the government's back-home campaigns just after the war. Courtesy of Archive of Labor and Urban Affairs, Wayne State University Detroit, MI.

For the young organization, its strategy remained a balancing act between the impatience of the younger women students of Miller's generation whose expectations had been raised by the government propaganda of Rosie-the-Riveter and the cautious but conservative strategy of a previous generation of daughters and of wives wedded to the patriarchal culture of family firms. The SWE tried to inspire younger women to go into engineering as a promising career path by using individual women's careers as role models. Through the establishment of award medals and scholarship programs, biographical narratives, and pictures, the organization stressed lone individual efforts rather than the new corporate male ideal of team players propagated by corporations like Dupont and General Motors. It sponsored merit and self-reliance rather than a collective movement battling inequality for which Blatch campaigned.

The SWE never resolved these conflicting goals. It sought to attract more young women into engineering schools yet necessarily had to deal with the long-entrenched patriarchy of family firms, the tactics of the professional organi-

Figure 39. Part of the campaign to recruit women for engineering positions for the U.S. military as the Cold War heats up in 1953. Gender relations are preserved rather than subverted by the photographer's frog-eyed truiuc stressing masculin" features of [he woman in charge and the 'subordinate position of her reclining colleague. Permission uf Schlesinger Library, Radcliffe College, Cambridge, MA.

various, the discriminatory employment practices of corporations and the federal government. To the extent that it openly battled prejudice and sexism in engineering schools and practice, however, it risked frightening off prospective recruits." If the SWE had been established in 1949 in the postwar period of "adjustment" when government and corporations devised policies to push women back into their homes, the organization would ride a new wave of ambiguous government encouragement during the Cold War. [Figure 39[Like the former Soviet Union, the former German Democratic Republic, and other Eastern European countries, the American military collaborated with corporations in actively recruiting women as technical personnel and initiated its "Woman Power" campaigns after the Sputnik panic in the West in 1957. Despite its evocative title *Woman Power*, a 1953 report

Figure 40. General Hccrrics advertising promoting rh. company through fou' of its women engineering employees against a male-coded apparatus. The imugc countered the working-class ;mage of Rosic rhe Riveter of the governmen r war propaganda campaigns ro show women could bc engineers wirhour losing rhcir femininity during the (:"Id War. Reproduced lrom Cincinatti News 1959.

issued by the Narional Manpower Council at Columbia Univcrsiry had little [() do with feminist calls for equal rights: it shied away from corn rovcrsial issues like equal pay for equal work and job discriminarjon, for which N ora Bl.uch had campaigned throughout her life. It neither upset gender hierarch ics nor helped foster a separate women's culture. Instead, it did provide a certain legitimacy to a cnnservat ive part of the women's movement stressing that women, jf they worked hard, eo uld labo r for the nccds arisi ng o ut of natio nal sho rtages.[N] The new socicty suecessfully gathered the critical mass necessary for such a separate organization despire its high professional ideals because of the cold-war indusrry's demand for tech nical personnel that had been lacking three decades earlier in 1919. The truth was rhar women engineers' individual opporrunirics were part of America's military-industrial complex and highly depended 011 it. At rimes its doors might be open to women, but it almost always reproduced old patriarchal patterns in a new corporate eo nrcx t. [Figure 40J

"WOMAN POWER" AND DAUGHTERS OF MARTHA: FAILED ALLEGORIES

The government's campaign of *Woman Potoer* was a borrowed identity. So was Lillian Cilbrcth's appropriation of Rudyard Kipliugs 1907 poem "The Sons of Marrha."[·] At the 1901 opening of the S\XE's headquarters in rhe United Engineering Building, Gilbreth tailored the poem to the needs ofwomen engineers by entitling her speech "The Daughters of Marrha." The modernist United Engineering Building towered high in New York and expressed the coming of age of the engineering professions, but the new hcadquarrers (;ilbrcrh was ahout to open were tiny and symbolic for women's place in the profession. Her reworking of Kipling's allegory showed the narrow place of women within the male world. Cilbreth sought to empower women in the rcchnical professions by invoking the specter of service, sacrifice, and self-reliance. It was an unintentional bur correct assessment of the douhlc hardship of women who laborcd on the lower rungs of the profession as rank-and-file engineers and corporate workers. She thus validated a model that doubled the burden of women who aspired to be engineers: women engineers were expected to make sacrifices by virtue of both their gender and their profession.[·] By the 1960s, Gilbreth's professional strategy of "simple service simply givcn," as she cited Kipling, or as she had advised earlier, "helping others express themselves [as] the truest self expression," was out of dare for women." IIcr 1961 call for the inclusion ofwomen in the profession was based on her own long career, on the trying experiences of Jllany orher women engineers, but principally on a conservative strategy of stoicism and overqualification for women professionals in general. Despite her attempt to redefine the place of women in engineering, the celebration of service, sacrifice, and self-reliance also reinforced some very traditional notions about women's proper place in engineering. Her employment of Kipling's poem threatened to become a failed allegory. When male engineers used the pocm, it could be mobilized [() appropriate working-class badges of manliness or to symbolize them as underdogs, bur when women mobilized the pocm for thei r cause the figure ov Marrh« turned into an image ofsubordination, stoicism, and lack ofadvancemenr. Men perhaps could pass "down," but women could rarely pass "up" the cui rural hierarchies as women found here and elsewhere.

Women engineers in the military-industrial complex or in the patriarchal culture of family firms had no appealing role models except the very ambiguous iiii-age that Lillian Ciilbrcrh supplied. Outside the rnilitary-indusrria] complex and the patriarchal family firms, women were building their own structures: the women of the Progressive era who participated in the women's reform movcmcnr helped shape an alternative women's technical culture thar was mu-tured by

women's traditions." Throughout the country from Boston to San Francisco, women reformers helped build the public infrastructures in the civic improvements movement as private citizens rather than as corporate employees. Highly organized in private philanthropic organizations like the General Federation of Women's Clubs, these women reformers effectively became "municipal" housekeepers of the world. They conducted surveys, drew up plans for urban infrastructures, pushed for better housing, and helped finance public facilities from streetlights to sewer systems. They forged coalitions with local politicians, architects, civic leaders, and professional women like Ellen Swallow Richards, Alice Hamilton, and Ruth Carson in public health, science, and social research. As historian and suffragist Mary Beard demonstrated in 1915 in *Woman's Work in the Municipalities*, these women of the Progressive civic movement became in fact urban planners of the modern age. This rich female heritage of building was not available to women engineers working in family firms or military and corporate industries. In fact, the women of these separate technical cultures never met or built bridges between them. More importantly, perhaps, the kind of distinct female building tradition Beard traced fell outside the modern but recent definitions of engineering and technology.

EPILOGUE

Gender, Technology, and Man the Maker

The inrellect ual constructs and material practices of rcch nology discussed in this book came to produce the world of industrial capitalism. Modern meanings of rcchnology arose from the co1nvergence of discou rscs arou nd a number of niuctccnrh-cenrury terms rclared ro the rise of industrial capitalism, most importantly the rhetorical positions about *useful arts, inuentiueucss,* and the *machine.* Each of these terms was the focus of struggles m which middle-class professional men - among them engineers – staked their claims on key aspects of illdusrrial capitalism, to the exclusion of women, African-Americans. and workers. In rhc US, these discourses merged in the 1930s, first through the work of Thorxrcin Vcblcn, who turned technology into an all-embracing concept linking it to engineers rather than workers, and through the debates over technocracy, By the lure 1930s, technology had become firmly linked m the male, middle-class world of esrablishrncnr engineering. Signall illg the success of that century-long ascendancy, in 1978 *Encyclopaedia Britannica* dcsignated engineers as the true bearers of that knowledge in irs first entry on technology. Dictionaries and encyclopedias have always been more than descriptive rcxtx prescribing and shaping new categories of thought and recapturing old ones. Operating in a larger political universe, they canonize the dominant discourse through their choices of whar to include or exclude from their pages. The 1978 edition of the *Encyclopaedia Britnnnica* included an entry on "Technology" for the first time, stating that "[b[y virruc of his nature as a roolrnakcr, man is therefore a technologist from the begin ning, and the history of technology encompasses the whole evolution of man."[1] The *Britantuca* canonized rhe term as late as 1978 because it is only in rhc twentieth ccnrury that we encounter the idea of technology in its present popular 1orm: as all autonomous factor. an artifact, a fact, bUI alxoas an essentially pristine and neutral form or reality that requires little explanation. Engi nccrs were designated as the so Ic bearers of this form o f kn owledge. *Technology* as charted by the Encyclopedia functioned as a kind Of narrative strategy that includes both inrcllccrual constructs and material practices.

Historian. author, and suffragist Mary R. Beard (1876-1958) confronted Brilallnica's assumptions and challenged its male genealogy. The *Encyclopaedia Hritan-*

nica, which despite its name had come under American inrcllccuial and financial control in the early rwentierh century, claimed inclusivcnexs and objectivity. The mantle of cultural authority assumed by the encyclopedia did nor go unchallenged. From the very start, *Briiannicas* slogan, "All life in one set of books - the richncss of the human mind, the achievements of all civilizations, the problems and hopes of rhe future", made it vulnerable to accusations of exclusion and disrorrion.' Understanding the importance of the *Britannicns* growing cultural authority in the first part of the twentieth century, Beard tried to (rclinscrr women and their contributions into the canon. After her activism ill unions and the suffrage movement, she turned to a life of writing and lecturing. From her early book *Woman's Work in Municipalities* (19J5) to her most famous book *Woman as a Force in History* (1946), Beard's main goal in life was to set the historical record straight by arguing that women were a powerful force in rhc creation of civilization and culture and that a history without them would be incomplete. Among her many activities as a feminist historian, Beard first campaigned for a World Ceurcr for Womcu's Archivcs, When the initiative failed, she and Marjoric Whire opted for an encyclopedia of women in the 1940s, and began to contest past encyclopedias' clairns *or* all-inclusiveness. In response ro her arrack, the *Britannicn«* editor Walter A. Yust invited her to make suggestions. Beard and several women researchers responded to his overture by offering some corrections and by attempting to rectify the Hritannica's overall male taxonomy and bias. Beard pointed not only to the many women who should have been included, bllt described a pattern of sexual differentiation over time and suggested how old materials should be reinrerprcrcd anew. She also showed the mechanisms that reduced and excluded womcn'x roles in modern civilizations.

The work of Gage, Morgan and Mason influenced Mary Beard when she argued rhar the elltry on *Lnbor. Primitive* was among the weakest of [he articles. It ignored the "story of woman's original creativeness as inventor of rhe industries, arts, and as rhc first farmer by reason of her concern with soil - not her slavcrv." Along the same Iincs, she criticized the entry on *Weapons, Primitiu«,* suggesting rhar it ought to be called *Socia! hnplemeut,* instead. "They [the weapons] are reviewed as features of the male's fighting function or inclination. But primitive weapons for social construction arc nor even hinted at. Surely rhcy were even more important.' Echoing Gage and Mason, Beard suggested "introducing an article on constructive implements (not calling them weapons), beginning wirh a section on *l'rimiuues* and frankly acknowledging the leadership [of women] in rhis connection as inventors of cooking (with implements), spinning, weaving, ere," Despite the invitation of rhe *Britannica.* Beard and her eo-workers' two years of hard work came to nothing. Insread of revising the vcry bui Iding blocks of the *Briianntea,* its editor chose to include some biographical sketches of notable women. Ir did little

to challenge the encyclopedia's parameters and only reinforced women's marginality." As *Britannicns* most recent entry on technology illustrates, Beard's critique remains as valid today as it was fifty years ago.

The swry of the entry on technology in the fifteenth edition of the *Encydopardirt Britanuica* in 1978 epitomizes the paradigmatic shifr in the understanding of technology over the last two hundred years. It is emblematic for the formation of the new terminology that we have come to accept it as a natural male domain dcrying any explanation. The *Brirannica* contained no entry for technology before the supplemental J4th edition in 1968, yet by the completely revised 15th edition in 1978, technology had been elevated to a central position. The *Britnnnica* was not alone in the lure admission of technology to its pages: other encyclopedias likewise neglected inclusion of the category well into the 1960s. Alongside such other categories including Matter and Fnergy, the Earth, Life on Earth, Human Life, Human Society, Art, Religion, the History of Mankind, and the Branches of Knowledge. *technology* 11ow assumed ccntcr stage as one of the ten organizing principles of knowledge.' Significantly, *Britnnnica«* 11cw entry replaced the one 011 rcch 11icaI schoolx, whose enginceri ng educarors had firsr iiitroducetJ the wo I'd to the English language to stake out a new area of expertise: ir was absorbed with in the narrative of technology.

By 1970, the term had migrated out from the walls of engineering schools to enter the world ar large to appropriate a kind of objectivity. Bur its claim went furrher. If irs new lemma *Technology* encapsulated rhe old onc o n *Engineerilig Schools*, the claim was even much more dramatic, for it also bid for the entire expanse of the human universe. As *Technology* was promoted from sub-entry to main entry, so its authors, Eugene Ferguson (1917) and Mclvin Kranzbcrg (1916-1996), were prornorcd to th« higher echelons of the editorial board. FergLlson had trained as an cngincer and had worked for the chemical corporation Duponr in \XlilminglOll, Delaware, from 1938 unril 1942, before tcachi ng the hisiory of rcch Ilology; for Kranzberg, his couracrx wirh the military duri Ilg rhc second World War and the Srcvcns Institute of Technology proved to be seminnl in shaping his understanding of technology. After receiving a PhD in French history from H arvard in 1942, Kranzberg enlisted in the military, where he trained in electrical engineering at Catholic University, Johns Hopkins, .ind Philco Radio I.aborarorics. While teaching at the Stevens Instirurc of Technology in 1946 and 1947, he sough [to bring history closer to the experiences or his engineering students. Both Fcrguson and Kranzberg were movers and shapers of America's first professional organization, The Society of the History of Technology, and its home journal *Technology and Culture,* in the late lifrics.'

While Kranzberg and Ferguson were still debating the concept, approach, and material for the entry with each other, a chief editor of the *Eucyclopaedia Briton-*

nica informed rhe wrirers, "[wle have finally come to believe that wc cannot, after all, push technology under the big 'arts' tent, no matter how broadly 'arts' is defined. You have, therefore, been elevated from *Division* to *Part* status."[7] With these words, the editor congratulated Ferguson and Kranzberg all their new joh description. He promoted rhern from the subordinate position ofa sub-cnuy, or *Division* of the Encyclopaedia, to one of the ten slices, or *Parrs*, of what the ehief editors called "The Circle of Learning." In proposing the image of the circle, the editors sought to avoid any implications about a hierarchical order or unilinear and evolutionary development of knowledge.' That, at least, signalled the intention, but as classifiers and encyclopedias are wont to do, the editors created hierarchies of knowledge, produci ng a narrative of their own. The authors charted a new course for technology: the entry first described prehistoric times according to archaeological classificarions, whieh measured periods in terms of the materials and rhc LOO]S found in excavations including stone, fire, bow and arrow, porters wheel, and building structures. Throughout the entry, the writers emphasized the beneficial relationship between science and technology, which they believed to be part of the development oftechnology.[8] Despite rhe considerable attention devoted to prehisroric times, the Middle Ages, and to a period called "The Emergence of Western Technology (1500-1750)." the Indusrrial Revolution assumed ccntcr stage. In their discussion of technological developments in agriculture, the authors emphasized rhc British enclosure movement as a prelude to the Industrial Revolution and neglected the groups dislocated by these movements. The types of tools and devices discussed also reflected this bias. About a quarter [() a third of [he entry dealt with tools rha: skilled and unskilled workers designed, produced, or handled. *By* contrast, rhe majority ofthe machines and devices listed belonged to engineering."[9] In general, the enrry orni rred all groups opposed 10 and displaced by such developments as well as the roads-not-taken in the development of technologies. Few if any of rhc technologies discussed had any association with women's work. Moreover, the writers otrcn removed social actors from the story, describing instead the rnanufacruriug processes involved. In a short concluding section, [hey sought to correct and justify some oftheir choices, for example, by devoting special attention to [he science and technology relationship, the inrcllccrual protests against rcchnology, its ccologieaI costs and destructivc side cffects, and jts po renria I Ior "underdeveloped regions."[10] The writers defended the inherent incvitabi liry of technology, for example, by asserting that Gandhi might have hoped for a return to the pro-industrial economy symbolized by the spinning wheel, but that [his idea was hardly shared by his countrymen who cmhraced modem technology.

Kranzberg and Ferguson alxo wrestled with rhc new importance accorded to machines that had been so popular with visual artists, public inrcllecruals, and enginccri ng and scicnee spo kesmen like Ducha mp, Veble11, and Mumford. They

rccogn izcd that rhc rraditional artifactual approach to what they referred to rhc "taxonomy of mach incs" hampered rather than helped their project. As Fcrguson explained, "[b[ecause I have been familiar with earlier attempts to classify and anatomize mucliincs, I have been quite skeprical ()(finding any parricular sensible approach since 'machines' can only be anuromized.,.if [hey arc restricted to an asscmhlagc of linkages," He especially questioned the methodology of the German acadcm ic cngi nccr and wri rer Franz Reulcaux (1829-1905), whose hicrarchical classificarill n sysicm .urem prcd to gro\lp mach incx by rhcir inrerna] srructure withour looking at the cnviron meut in wh ich they had been produced and used." Ferguson objecrcd ill particular to the emphasis on formal and academic knowledge of Amcrican mechanical engineering education over that of tacit knowledge, but at this rime he did not follow up on this insight in the entry." More importantly, the authors sought to distance themselves from the idea that technology could be carried on autonomously wirhour human agency. In the final analysis, the writers asserted ihar man remained the master and rhc ccntcr.

The authors did not question the new central ity of engineers, srrcssing that "better educated scientists, engineers are needed both to operate and to criticize the increasingly complex technological apparatus." As a matter of fact, they did much to single ouI and bring engineers, scientists, and inventors to the fore, not shying away from somewhat novel and even anachronistic classifications to attain that goal. They charted a new liisroriography in their choice of privileging mechan ical and civil engineering and departing from earlier genealogies. Jn an effort to place the history of technology on an engineering base, they claimed that the cotton and textile industry's "importance in the history of technology should not be cxaggerated," despite their acknowledgment rhalit "Probahly more rhan any other, gave its character to the British! ndusrrial Revolutio[1," Whether inrenrionally or not, the shift in hisroriographic focus from the textile and cotton industries to engineering meant that both women and workcr« lost visibility, These choices rendered the technological dornai n even more exclusively male-coded rhan bctore.

The 1978 *Brirannicas* entry for technology is emblcrnaric ill many ways. Jts late appearance indicates that as an intellectual construct and material practice the concept belonged ro rhc post-World War cultural pracricc. Despite its late entry within the encyclopedic production, when it Iinally appeared it was as swift as it was profound. The editorial board's decision to elevate technology from its status as a sub-entry to one (Jfthe ten wcdgcx in the circle of human knowledge revcals in a single incident the enormous importance that the term and concepr acquired within just a few decades. While the idea took two centuries to ripen, the prorninencc of technology as a keyword was sudden and far-reaching. By 1978, technology had become the most important diagnostic tool to measure human worth. Most remarkable to historians of technology, the *Britannlca«* wheel of human

knowledge excluded science. Scientific knowledge and research still found its way into many entries, bUT science was neither a constituen t element uor an organizing principle of the *Brimunic«*. Technology now performed this role. This was perhaps not such a radical departure as it first seemed. As spokesmen for technology, ellginccring advocates fnltll Thursron to Karl Compron, Roberr Millikan, and Arthur Lirrlc had extricated the profession from its labor associations and shop-Hber knowledge by appropriating the idiom and authority of science. This new discourse was subsumed into the discourse of technology. By extension, the *Britunnica*entry may be seen as a triumphant munifesro of technologists' independence from th e attempts of pure science advocates ro relegate the useful arts [o an iuicrior place. If Science - in the sense of a capitalized, (orporate, commodified, theatrical, and exhibiriol1istkind o fs cienc e as Americans experienced it at World's Fairs - developed a language through which rechnology came to be understood in the ninerecurh cc[]tury, the reverse held true for the rwcnticih cenrury.[1] Sciencc and technology had long played musical chairs in their quest for cultural aurhority, but when technology suddenly rushed on the American scene as a keyword duri Ilg the 1940s, it was far reaching and enduring.

The *Britannicas* entry on technology represents at once a description of the rechnological development, a rccapirularion ofthe scholarship, and all elaboration of an emerging popular understanding of the concept. Kranzberg and lcrgusun reformulated and formalized a discourse classified as icchnology th.u by 1978 embraced rhc cntirc span olhurnan evolution. While lewis !Norgal1 had argued that inventions pushed forth human evolution ill the ninerccnrh ccnru*ry*, technology now represented the very substance of human evolution, In addition. the en*cry* had a programmatic inrenr, because the writers wanted [o engincer a new program for an emerging discipl inc, the history of technology: they placed engineering at its ccnrcr.[2] This was no coincidence. Ferguson, like many orhcr piouccri ng historians of technology. was a lapsed engineer in search of status for his profession by providing u wirh firm anrecedents in history while Kranzberg was one of those historians who worked at cnginccring programs and looked for novc] approaches [o teaching the past in ways that would interest undergraduates.[3]

lcrguson and Kranzberg's *Britannica* project illustrates a laudable attempt ro avoid ihc pitfalls of a m.ich:ne-bound understanding of technology rhnr had captured the literary, visual, and public imagination heron: rhc second World \XI:II'. It also offers a fascinating insight into why rhar attempt failed, .md the reasons \vhy it has been so hard [o sec soci.i] actors, includ] ng women, in the post-World War inscriprious of rech Ilology. Despite their Mumfordian idealism - which priviledged culture and people in describing technological development - they built upon a tradition which saw mechan ical, civil, and mining engineering as [he pivot of rechnological change, ro the exclusion of more anthropological and sociological con-

Figure 11 Lord package engineers listening enwrapped attention to Madeline Pajas explaining computer solutions in design problems. Photograph figured in an article under the headline: "Women Engineers: Cure for Your Engineer Shortage?" "Producer Engineering" (April 1968). Courtesy of University of Delft Library, Delfr, The Netherlands.

cepts of technology that had allowed such earlier thinkers as Morgan, Gage, Mason, Smith, and Tarbell to perceive women in the technological project. The *Technology* entry emphasized capital-intensive industries and engineering, relegating the textile industry, where women and children worked in large numbers, to a minor plane, omitting household technologies altogether, and privileging the West, the U.S., and the twentieth century. And as the authors positioned mechanical and civil engineering at the center of their story, they traced the genealogy of these fields to ancient times. Strictly speaking, the causality and tradition inferred prescribed more than described these links. They implied that the history of engineering provided a road map for technological change. These notions were both exclusionary and limiting.

Emblematic, its lemma showed how the concept and definition of technology had undergone a dramatic transformation. After a century-long contest over their meanings, patents and machinery occupied center stage and stood at the heart of sexual and racial differentiation and class distinctions. Engineers were cast as its sole bearers at the expense of workers, African-Americans, and women.

Figure 42. Photo in advertising style appearing in *Prodi«: Engineering* reporting on women in engineering ill April 1968. Invixihlc bur th rough her red-painted lips and nails, rhc wo m .in engincer i, left ouixidc ihe frame and c.isr in oppositio n to male technical expertise represented by engineering knowledge and tools. Courtesy of University of Dclft Library. Dc llt. The Netherlan ds.

The ink of the entry had barely dried when a younger generation of women, inspired by a new wave of feminism in the 1970s, qucstioucd Ferguson and Kranzberg's carefully crafted genealogy of the history of technology. Published in 1979 and 1980, two collections entitled *Virgin and thr Dynamo Revisited* and *Dea Ex Mncbiu*« challenged the engineering genesis of rhe field, arguing that its male domination excluded those historical actors operating outside its definitions where women must remain bystanders of a male-created stage. They linked back to some of the early critiques and struggles in the tradition from Miuhildn Gage to Mary Beard; they questioned the banish mcurs of corsets to the basemen rs of rho modern classification systems of technology; challenged the idea that women when they do appear on the scene as engineers and invenrors [unction like *deaex machina* as if appearing to come from nowhere, lFigure 42J In this male-constructed stage, women who enter the male-defined technical stage must always look like amateurs, or as }an Zimmerman wryly remarked in those years, reel:nology is what women don't do." [Figure 41l But as Gage, Smith, Tarbell, and Beard had shown before, tcchnology is a narrative production of our own rimes,

Notes

Introduction

John Markoff, "Computing in America: A Masculine Mystique," *The New York Times* (February 13, 1989): A1, 1-1; B10, 1-6; Michael Wines, "A Youth's Passion for Computers. Gone Sour," *The New York Times* (November 13, 1988): A1, 1; A28, 1, 28. Within one week, at least twelve articles in *The New York Times* were given journalistic center stage.

2 Alva T. Matthews, "Emily W. Roebling, One of the Builders of the Bridge," in *Bridge to the Future: A Centennial Celebration of the Brooklyn Bridge*, eds. Margaret Latimer, Brooke Hindle, and Melvin Kranzberg *Annals of the New York Academy of Sciences* (1984), 63-70; "Air Engineer," *The Christian Science Monitor* (February 25, 1943): 2; "Jersey Girl Has Job as Shipyard Engineer," *The New York Times* (May 8, 1949): 29; "Iarharn Girl Goes to New CE Position." *The Schenectady Gazette* (November 3, 1960); "Women Have Part in the History of General Electric," *General Electric News* (December 2, 1927); "Eyeball Engineer Draws Id Glance," *The Philadelphia Inquirer* (March 30, 1970): 2. See also Clipping file, Ethel Lou Bailey, Hall of History Foundation, Schenectady, NY; Clipping file, Women Engineers, Schlesinger Library, Radcliffe College, Cambridge, MA.

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6 Letter Carnegie Institute of Technology to Hilda Counts, February 5, 1919, Box 146, SWE Collection; Julict K. Coyle, "Fvolution of a Species - Engincering Aide," *Us. Woman Engineer* (April 1984): 25-26; I'\.K, Krenzcr. .Early Leader still I-Ias Jmpact: Lois Graham,' *U.S. Woman Engineer* (july-Augusr 1987); Clipping file, Women at GE. Hall of Hisrory Foundation, Schcnecmdy, NY; Margarer W. Rossircr, *Women Scientists ill America. Before Affirmative Aaillll!, 1910-1972* (Baltimore: The Johns Hopkins Univcrsiry Press, 1995), 267; "New Members of The Women's Engineering Sociery,' *Woman Engineering Society* (1949), 315; "Lnuna Barth, PE. One o(the First," *WOi!lfli/ Engineer* (March-April 1986): 17; U.S. Burcau of Census, *Abstrnct to the Eleventh Census* (Washington: U.S. Printing Office, 1890), 29; U,So Bureau of rhc Census, *Twenty Censuses: Population and Housing Questions, 1790-1980* (Washington, I>C: U.S. Printing Office, 1979), 29.

The term is Marrha Bant.i's in her imagin ative, *1aylored Lives: Narratiuc Productions in thr Age ofTnylor, Veblen and Ford* (Chicago: University of Chicago Press, 1993).

8 ;'Ason (?) or rhe M.I.T.." Words from *Tcclmique* (1897) ro rhc melody of "The son of a Gambolier," arranged by F. F. BuILII·d, ill *Techsongs: The M.I.T. Kommers Book,* rev. by a committee of rhe class of 1907 (Boston: O. Dibson Co., 1907 [1901]).

9 For example, see John Kasson, *Civilizing the Macbiuc: j'echnology and Republican Values ill America. '776-f9011* (New York: Penguin, 1977 [1976]). Many scholars have atremprcd to define the scope of technology wi rhou r much success. Sec for sociology, Diana Crane, "Iu Scareh of J'echllology: DefiniliollS of Jechnlllogy in I) ifferent Fields -

An Essay Review" (paper prepared for presentation arrhc Mellon Foundation Seminar on 'Teel:nology and Culrure, Fcbruary 4, 1987); for anrhropology, Bryun Pfaffenberger, "Fcrishised Objects and Humanised Narurc: Towards an Anrhropology of Technology," *MAN* 23 Ounc 1988): 236-52; for the history of technology, the work of John M. Sraudcnmaicr, esp. *Technology's Storytellers: Retoauing the H/IJI/,m Fabric* (Cambridge: MIT Press, 1985); for economics, Nathan Roscnbcrg. *Pcrspectires of Technology* (New York: Cambridge University Press, 1976) and *lusid« the Black Box: Technology and Economics* (New York: Cambridge Universiry I'rcss. 19H2); Sec also, Michacl Forcx, "Tcchnical Change and rhe 'Technology' Myrh," *The Scandinavian Economic History Rnneu:* so, 3 (1982): 167-88. Political scientist Laugdon Winner forms an exception. Rarhcr than decrying the absence of rhc term in early nineteenth-century discourse, he uses it as his point of departure in *Autonomous Technology: Tcchnics-out-oj-Coutrol as Theme in Politiral Thought* (Cambridge: MIT Press, 1989 [1977]), 8-12.

10 Nina E. Lerman, "The Uses of Useful Knowledge: Science, Technology, and Social Boundaries in an Industrializing City," cds, Sally Kolhsrcdr and Lllcn Longino, *Osiris. Special Issue Women, Gender, and the Science Question* (1997); Ronald Kline, "Construing 'Technology' as 'Applied Science', Public Rhetoric of Scicnrists and Engineers in rhe Unircd States, 1880-1945," *ISIS* 86 (1995): 194-221.

11 On the notion ofkcvwords. sec: Rayrnoud Williams, *Keywords. A Vocabulary of Culture and Society*, revised edition (New York: Oxford Univcrsitv Press, 1976) [1953] and his earlier important book, *Culture and Society, 1780-1950* (New York: Harpcr and Row, 1983 [1958]). See also Daniel T. Rodgers *Coutestod Trntb« Keywords in Amcrican Politics sinc« Independence* (New York: Basic Books, 1987). The literature on metaphors is vast, hut sec: Max Black, "More about Metaphor," and Thomas S. Kuhn, "Metaphor in Science," in *Metaphor and Thought*, cd. Andrew Orrony (Cambridge: Cambridge University Press, J97')), 19-43 and 409-19, respectively; George Lakoffand Mark Johnson, *Metaphors We Liue By* (Chicago: Univcrsiry of Chicago, 1980); see also Nancy Leys Sicpan's important con rribu tion. "Race and Gender: The Role of Analogy in Science," *Isis* 77 (1986): 261-77.

12 S,,,,, "Technology," *Encyclopaedia Brimnnira*, 15th cd, (Chicago: Lncyclopcdia Briannica, 1978), *The Index to Periodical Literature* does not list rhc category separately until the 1930s. The Library of Congress's *Subject Headings* (1914-1986) does not list "rcchnology" as a separate entry. hUI only as a heading co point the reader to other categories such as bridge building, chemical enginccring, ere, in ihc sixth edition of 1957 there is a remarkable expansion of the category. "Technology" did nor show lip either in cornpurer searchcs ihrough various databases or in encyclopcdic dictionaries published before the rwelli icth ccntury.

13 *Encyclopaedia Britnnnir«* (1978), 452.

14 *Encyclopaedia Britnnnicn* (Chicago: Encyclopaedia Brittanica, 1929), s.v., "Technical Education" and "Engineering Lducarion." Cf. *Encyclopaedia Americnna* (1920), s.v., "Schools of 'Icchnology."

CHAPTER r

Based on various database searches and a survey of various cdiricns of major dicrionaries and encyclopedias including John Kcrscy's *Dla ionarium Anglo-Britannicum* (London: Pbillips, 1708): *Cyclopnedia* (London: Longman, 1819); John Pickcring, *A Vocabulary or Collntlon of Words and Phrases Which Hauc Beeu Supposed la b, Peculiar to the United States etc.* {Boston: Cummings and Ililliard, 1816); Noah Webster's *Amrrican Dictionary of the English Language* (New York: Converse, 1828 examined through *1972); Century's Dictionary and Cyclopaedia* (1911): *The Fncydopnedia Britnnnic«;* first through fourteenth editions: *New Americanieed Encyclopaedia Britnnnic«* (1896-1904); *Tbe Ncu. Encyclopaedia Britannica* (Chicago: Encyclop.icdi» Britannica, 1974-1985); and *Tbe Oxford English Dictionary* (Oxford: Cl.ircndon Press, 1933). Significantly, Raymend Williams in *Krytoords. A Vocabulary of Culture find Society* (New York: Oxford University Press, 1976). did not include technology as a keyword in either rhi.\ or a l.ircr edition of his book,

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Sec Jeanne Boydston's critiquc of this limited understanding of women's economic role in "'To Earn her Daily Bread': Housework and Antebellum Working-Class Subsisrcnce," *Rt/dim! History Rcuicu.* 35 (April 1986): 7-25, and her *Home {/lid Work: Housetoorl: Wages and the Ideology of Lnbor* ill *the Early Republic* (New York: Oxford Univcrsity Press, 1990),

4 Edith Abbott, *Women in lndttstry: A Study in American Economic History* (New York: D, Appleton. 1910), Chapter 4; Paula Baker, "The Domestication of Politics: Women and American Political Society, 17HO-1920," */unrrican Historica] Review* 89 (junc 1984): 620-47 and *The Mora! lrrnnrtoorl: of Public Life: Gender, Politics nud tl« Stnt»* ill *Rum! Neio York, 1870-1920* (New York: Oxford Univcrsiry Press, 1'J91), 24-55; Judirh A. McGaw, *Most Wonderful Machine: Mecbnnization nud Socia]Change in Berkshire Paper Making, 1801-1885* (Princeron: Princcron University Press, 1987); John Kasson, *Civilizillg the Machine: Technology and Republican s/nlnrs ill America* (New York: Crossrnan. \976), 27, Cf. Franccs Gouda, *Poverty (/wl Political Culture: Tbe Rhetoric of Social Welfare Nethcrland: and France. 1815-1854* (Lanham, MD: Roman Lirrlefield, 1995)· 148.

David F. Nohle, *A World Without Women: The Christian Clerical Culture of Western Science* (New York: Alfred A. Knopf, 19'92), Chapter 10.

6 Tenson Coxe... All Address to an Assemhiy of the Jriends of American Manufacturers, (:0nvened for the I'll rpo.sc of Estahlishitlg a Society for the Encouragemen\ of Manu-

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7 Sinclair, *Philadelphia's Philosopher Mechanics;* Nina E. Lcrman, "The Uses of Useful Knowledge: Science, Technology, and Social Boundaries in an Industrializing City,' *Osirls. Special Issue Women, Gender, (ild the Science Question*, cds, Sally Kolhsredr and Ellen !.ongil1o (1997). Ronald Kline, "Construing 'Technology' as 'Applied Science'. Public Rhcroric of Scientists and Engineers in rhe LTnircd States 1880-1945," *fSfS* 86 (1995): 194-221; David Hounshell, "Edison and the Pure Science Ideal in America." *Science* 207 (February 8, 1980): 612-7. Arrhur 1'. Molella and Narlian Reingold, "Theorists and Ingenious Mcchanics: Joscph Henry Defines Scicnee," *Science Studies* 3 (1973): 322-35. In Britain, scientists enlisted manufacrurcrs and engineers a: rank-and-file members ro show science's material alliance ro rhc idea of progress, but rhcy were careful to keep them otherwise at bay. Jack Morrell and Aruold Thacktay. *Gentlemen of Sciencc. Early Years IIf the British Association for the Advanccmcut of Science* (1.0ndon: Clurcndon I'rcss, 1981), 256-66.

8 Bruce Sinclair, "Invcnring a Genteel Tr.idiricn: MIT Crosses rhc River." In *Neu- perspectives (III Technology and American Culture*, cd. Brucc Sinclair, American Philosophical Society Library Publication 12 (Philadelphia: American Philosophical Society, 1986), 1-18; Kline, "Construing 'Technology' as 'Applied Science'." Ior an indication, in chronological order, of rcchnology as a labelo f self-idcntificati on: Massachuscrrs Insritute of Technology (1861); Stcvcns Jnstirurc of Technology (1870); Georgia Institute of Tcclmology (1885); Clarkson College of Technology (IH9(,); Carnegie-Mellon (1')'2): California Institute of Technology (I')20): Jawrcncc Jll,ltirure of Technology (1932). Most other institutions were cirher csrahlishcd or renamed afrer the second World War including such schools as: Rochestcr Institute of Technology; Ilorida Insrirute of Technology; Illinois Institute of Technology, sec *American Uniocrsitirs aur! Colleges* (New York: Walter de Gruytcr. 1983 [12th editionj),

9 Edward Hazcn. *rOPUIIr Technology: or, Projrssions and Trades* (New York: H.rrper and Hrorhcrs, 1841). Introduction. A similar and hroad usage is cxcmplified in an editori.i I, "'The Terhnology o F(.cr.unic Art," *j he New Century for Woman* 23 (Saturday, Oci obcr 24, 1876): 179 and in a paper by P. Geddes, "Economics and Statistics, Viewed from the Standpoint of the Preliminary Sciences," *Nature* 24 (May-October, 1881): 523-6.

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21 Murildu jo slyn Gage, "Woman as invcnror." *Norr h America» Review* 136 (May 1883): 478-89.

22 Rydell, *A/! the World's Fair*, 14-5. Sec also Adas, *Mnchiru« as the Measure of Men*; Bryan Pfaffenberger, "Fctishiscd Objects and I Iumaniscd Nature: Toward an Anrhropologv of Technology,' /11(11 23 Uun e 1988): 236-52.

23 As cited in Warner, "Women Invcnrors .u the Ccnrcnn ial,' 102; Virginia Grant Darncy , "Women and World's Fairx American International Expositons, 1876-1904,' (I'h.D. diss., Emor y Un ivcrsity, 1982).

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26 St.uiton et al., *I listory of Woman Suffrage*, 54.

27 Gage. "Woman as Inventor" (1880), 488.

28 Ida M. Tarbcll, "Women as Inventors." *Chautauquan* 7, 6 (March 1887): 355-7; *Dictio-1111],' of American Women Historians* (Westport, CT': Greenwood Press. 1996) and David M. Chalmer *Notable America» Women* (Westport, CT: Greenwood I'rcss, 1996), s.v., "I arbell", See also the discussion ill Macdonald, *Feminine Ingenuity*, 118-9 and her (;ncorrcct) dating of Tarhclls article.

29 Onlv one issue of the magazine, *The Woman Inucn to*r, was published. See 1,)[' Smiths acknowlcdgcmcn r of (;age: cditorial of I. 1 (April 1890): 2. I.irrlc is known aho ui Charlotte Smith, bur see *The New Yor]: Times* Ohitu.rry (December 6 1)17)' 13; 4. See also Weimann, *I he Fair Women*, 507-11; Carroll Pursell, "Cover Design: Women Inventors in America," *Technology and Culture* 22 (1981): 545-48, 547, fn 11; U.S. Patent Office, *Women Inventors to Whom Patents Have Been Granted by the United States, 1790 to July 1, 1888, with Appendices to March 1, 1895* (Washington, DC.: Government I'rint; ng Office, 1888, 1895).

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tions, ed, Barbara \X/right Drygulski and et al. (Ann Arbor: The University of Michigan, 1987), 118-36, 128.

31 Edirori al, *Woman Inventor*, J.

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34 On the expositions, sec: Rydell, *All the World's a Fair*, 2)-4; 57-60; ')7-100.

35 Oris Tufron Mason, *Woman's Share ill Primith» Cnlture* (New York: D. Applcron. 1894), T1. For an excerpt sec, "Woman as an Inventor and Manufacturer," *PopulnrScience Monthly* 47 (May 1895): 92-103. Sec also, Louise Michclc Ncwman, ed., *Men's Ideas/Women's Rrnlities: Popular Science. 1870-1915*, (New York: Pergamon, 1985), foreword bv Ruth Hubbard,

)6 Mason, *Woman's Share ill Primith.« Culture*. 2; Nancy Leys Srcpun, "Race und Gender: The Role of Analogy in Science," *Isisr:* (T986): 261-77.

37 Jeannc Madcline Weimann, "The Great 189:; Woman's Building: Can We Measure Up in 1992?" MS Magazine 41 (March 1983): 65-7 and *Th« Fair Wonteu*, 429-33; Macdonald, *Fcntiuinr Ingenuity*.

38 Ann Massa, "Black Women ill the 'White City'," *[onrna] ofAmerican Studies* 8 (1974): 319-37; Lliotr M. Rudwick and August Mcicr, "Black Man in the 'White City': Negroes and the Columhian lxposirion, 1893," *Phylon* 26 (Winter 1965): 354-61; Gail Bederman, *Manliness & Civilization: /1 Cnlrurn! History ofGender and Race in rhe United States, 1880-1917* (Chicago, The University of Chicago Press 1995), 31-41.

39 JJ\. Bury, *The Idea of Progres: An Inquiry int» [ts Origin and Growth* (New York: Dover Publicurions. 1932 [1927]), intra. by Charles A. Beard, xxii.

40 Henry L. Menecken, "Professor Vehlcn and the Cow," *Smart Set* 59 (May 1'1'1)): 138-44; Icwis A. Coscr, *Masters of Sociological Thought: Ideas* ill *Historical and Social Context* (New York: Harcourr Brace {ovanovich. 1977 Jznd eel. j), 263-302.

41 For an indicution of hil influence, see Coscr, *Masters of Sociological Thought*; Lcwis Mumtord, *Technics and Civilization* (New York: JIarcourr, Brace, Janovavich, 1934), 25, 55, 96, 226, 284, 317, 354, 366, 401, 472, 475. Sruarr Chase wrote in his im roducrion to *Theory of the Leisure Clnss* (New York: Modern Library, 1934 [1899]): "Thorsrein Vcblcn was one of my idols as a young man. When a new book of his was published I secured it at once and read it many times."

42 John Dos Passos, *The Big Money* (New York: Washington Square Press, T)(;1 [1930]), 107·

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CHAPTER 2

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49 Letter to the Editor, *Th« Monad* 1 (May 1916): 10.

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51 Angel Kwolck-Folland, *Engendering Business: Men and Women in tbe Corporate Office, 1870-1930* (Baltimore: The johns Hopkins University Press, 1995).

52 Real Engineer, "Quacks," lerrcr \o the Editor. *Professional Engineer* (September 1920); "The Tirlc of Engineer,' *Amrrican Mnchinist* 16 (1895); Caivcrr, *The Mecbanica! Engineer*, Chapter 10; Calhoun, *The Americaii Cinil Engineer*, 193; Lavton *The Revolt of the Engineers*, chapters 2-3; Mcjvlahon, *The Making of« Profession*, 36-40; Spence, *Mining Engineers*, 338-9; Rcynolds, "Defining Professional Boundaries.'

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fcssionalism in America"; Andrew Abborr, *The Systems of Profession: An Essay on the Division of Expert Labor* (Chicago: Chicago Univctsity Press, 1988) is an important conrriburion ro the sociological lircrarure. Sec also Edwin Layron [r. , *The Reuol: of the Engineers* and his essay, "Science, Business and the American Engineer," in *Engineers and the Social System,* 5r-72 , p. 62, fn. 4·

S4 Roberr W. Shclmire, "The Drafting Room.' *1 be Monad* i , 11 (Novcmbcr 1917): 13-4. Also: "C eneral Interest," *Draftsman* I, (, (190 2): 21S, Ellcn Dulsois. ed., "Spanning Two Centuries: The Autob iography of Nora Stanton Barncy.' *History Workshop* 22 (1986): 131-52, p. 150.

55 W.B. Gump, "Why Have Technical Men Not Been Recognized As They Should Be?" *The Monad* 2, 10 (Oc tober 1')17) , 11-3.

56 Cllmp, "Why Have Te chni cal Men," 11-13.

57 Calverr, *The Mechnnica] Engineer,* 149-51.

58 For glimpses of earlier forms of discontent, sec: Calhoun , *Tbe American Civil Engineer,* Chuprcr 6; Calvert, *Tbr Mechanical Engineer*; Sinclair, *A Centennial of the American Society of Mechanical Engineers,* 67-9; and Spencc, *Mining Engineers,* 179, 345.

59 Robcrt W. Shclrnirc, *The DmfisII1t11l* (Chi cago: Chicago l'ubli,\hing Bureau, 1919), 9.

60 l.ctter to the Editor, "T he Engineer's Compensarion and His Attitude Toward the Profession," *Engineering Nnas* 61 (May 20, 1909): 553-4.

61 "Is the Drafrsrnan a Worker ar a Trade or a Professional Man?" *The Draftsman's Bulletin* I, 6 (1')01): 6. "The Modern Mechanical Drawing Room": Editorial *The Draftsman's Bulletin* 1, 19 (1901): 1.

62 Many states did nor pass laws unril the late 1930s and 1940s. In 1937, rhc first year srarisrics were gathered, ahour 47,000 engineers were registered, and about ')2,000 hy 1945. *United States Directory of Registered Professional Engineers: A Biennial Publication* (New York: Lcwis Historical Puhlishing Company),

63 Editorial, *Engineering Neu»* 61 (May zo, 1909): 554.

64 (;. I'. C., E., "What is Wrong wirh rhc Engineering Profession?", JOO.

65 Blank and Stigler, *The Demand nud Supply,* 124, 134-6, and Tables A-10 and 1\-11. For figures over time and by spccialivariou, sec p. 132. l-rorn 1929 to 1946, millIIIlg engineers commanded the highest base salarv, while chemical engineers received a hIgh base pay ill 1929 but the lowest pay ai rhc end of the period. III civil engineering, the base salaries were the most stable in the inter-war period thanks ill part to the federal public works projects, For comparisons of civil engineers' income to that of other occupations. Raymond H. Merritt, *Engineering in American Society, 18so-1875* (l.cxington: The University Press of Kentucky, 1969), 113-7; see also, Spencc, *Mining Engineers,* 167-170, 304-16.

66 Blank and Stigler, *The Drnutnd /111n Supply,* 24-5.

67 M.Y. Crowdus, "The Odious," *Professional Engineer* (December 1921): 15. Editorial, "Salaries of Engineers," *The Monad* 2, 10 (October 1917): 16; "Special Experts: Charwomen and Chemists," *Chemical and Metallurgical Engineering* 4, 11 (1921): 415; also Walter Ferguson, "Cornpcnsa: ion ore .hcm ists and Salesmen," *Chemical {/lid Metnllnrgical Engineering* 24, 11 (1921): 460.

68 l.crrcr to the ldiror, "Professional Obligations of rhc Engineer," *Engineering Neu/s-Record* 83, 18 (October 30-November 6, 1919): 828; W. W. K. Sparrow, "Uniouism in the Profession," *Professional Engineer* (April 1920): 14-5.

69 As cited in Pursell, *Tbr Machine,* 255-6

70 "In the Ditch!" *New Outlook* 163 (February 1934): 35-6.

71 Nora Sranron Barncy, I.encrs to rhc Editor. "Indusrrinl Equality for Women," *I'll. Y. Herald-Tribune* (April 21, 1933) and "Wages and Sex," *N.Y. Hernld-Tribune* (July 21, 1933).

72 Mciksins, "Professional Autonomy," and "Engineers in the United States"; Nora Blarch Barney to Thomas R. Sullivan, December 21, 1944. Nora S. Blarch Papers, Courtesy of Rhcda Barney jenkins, Crcenwich, CT.

73 Alfred P. Sloan, Jr., *Adventures oja White-Collar Man* (New York: Doublcday, Doran & Company, 1941); Ruth Oldcnzicl, "Boys and Their Toys: The Fisher Body Crafrsman's Guild, 1930-1968 and the Making of a Male Technical Domain," *Technology and Culture* 38, 1 Uanuary 1997): 60-96.

74 Bensel, "Address at the 42d Annual Convention."

75 John.l. Carty, "Ideals of rhc Enginee!'," address delivered ar rhe Presentation of rhe .lohn Fritz Medal at A.I.E.E. Convention, New York, NY, February 15, 1928, *[ournal of the American Institute of Electrical Engineers* 47, 3 (March 1928): 210-2. See, for his earlier position, when he tried to exclude managers [rom the field of clccrrical engineering, Spencc, *Mining Engineers,* 111.

76 Great Engineers and Pioneers in Technology I. cds. Ronald Turner and Srcvcn L. Gouldcn (New York: Si. Martin's Press, 1981), 413-4. For an early asscssmcnr of rhc appropriatcncss of the ddinition, see Fdirorinl, *Engineering News* 52, 1 Uuly 7, 1904): 8; McMahon, *The Making of a Profession,* 108-9.

CHAPTER 3

This chapter is bused on a lisr compiled by Louis Kaplan, *A Bibliography of American Autobiographies* (Madison: University of Wisconsin Press, 1963) to which other entries have been added, culled from library collections, secondary litcrarurc, and a shelf-list search at the Library of Congress. The number of autobiographies discussed in rhis chapter is by no means exhaustive as new material continucs [() surface, but it provides a rough estimate of the literary production of engineers. On producing culture while at work, see: Cynthia Cockburn, *Marbiuery of Dominance: Women, Meu, and Tcchnicnl Knau/-bou/* (Boston: Northeastern Univcrxirv Press, 1988), 167-97.

2 Secondary lircraturc on the writing of autobiographical narratives is vast, varied, and very uneven in quality. It has preoccupied hisro rians, psychoanalysts, and lircra'y critics alike. Much confusion and controversy has centered around the similarities and differences between biographies and aurobiographics. My urulcrsranding of allobiographies is derived from a multitude of secondary writings on the subject. of which the following I have found the most useful: Jan Romcin. *De Biografie: een inleiding* (Amsterdam: Ploegsma, 1946); Pall Ide Man. "Autobiography as De-facement," *MLN* 94, 5 (December 1979): 919-30; Daniel Berteaux, *Biography and Society: The Life History Approach ill the SocialSciences* (Beverly Hills: SAGE Publicarionx, 1981); Avmill Heishman, *Figures of Autobiography: The Language of Self-Writing in Victoria» t!!lrl Moder» Fi/glanrl* (Berkeley: Univcrsitv of California Press, 1981); Estelle C. jelcnik, cd., *Women's Autobi-*

ogra phics: Essays ill Criucisn: (Bloomington: Indiana Univcrsiry Press 1980); Sidonie Smith, *A Poetics of Women's Autobiography. Marginality aur] the Fictions of Self-Representation* (Bloomington: Indiana University Press, 1987). The journal *Biography* is devoted to specialized topics in this field.

John Korre, *Outliving tb«Self: Generativity and th« Intrrpret.uion of Lives* (Balrimorc: The Iohns Hopkins University Press, 1984), 10, Korrc's work elaborates on Erik Erikson's and Daniel Levinson's notion of generativity and creativity. Ilis study is particularly salient for white middle-class men such as those discussed here. Carol Cilligan has severely and effecrively challenged rhe male conccprunlization of rhis body of literaiurc. While historically valid, both approaches suffer from univcrsaiisr claims. Erik H. Lrikson, *Childhood and Society* (New York: W. Norron, 1950); Daniel Levinson et al., *The Seasons of Man's Life* (New York: Alfred Knopf 1978); Carol (:illigan, *in a Different Voice: Psychological Theory and Women's Denelopm cnt* (Cambridge: Harvard University Press, 1982), 150-5.

4 In the tradition of the work of Samud Smiles (1812-1904), *Self-Help* (London, 1859) and *Sclectio»; from Liue: ofth e Engineers, with till Account of their Principal Works*, ed. Thomas Purke Hughes (Cambridge: MIT Press, 1966). On Smiles' inspiration of engineers, see for example: Onward Bates, "Onward and Onward: A Romance of Four Continents. Memorabilia of an Engineer" (mimco by Rurh I. Hill, 1933), 15. For a general assessment of Smiles' work, see: Tim Travers, *Snmuel Snrilesand the s/victoria» Work Ethic* (New York: Garland Publishing, 1987 [1970]).

Lrnbury A. Hirchcock, *My Fifty Years ill Engineering* (Caldwcl], Idaho: Caxton printers, 1939), Dedication. The following autobiographies directly addressed young male adolescents: John Frank Srcvcns, *An Engineer's Rerollea ions* (New York: McGraw-Hill, 1936), xiii, 66; William LeRoy Emmci, *The Autobiography O/rlll Engineer* (Alhany: Fon Orange Press, 1931), foreword and xi-xii: Albcrr Sauvcur, *Metallurgical Reminiscences* (New York: American Insrirurc of Mining and Metallurgical Engineers, 19,37), iii: "Selecring and TI';lining of Men," in Paul Weeks Lirchficld, *Auuann Leaves: Reflections of an Industrial Lieutenant* (Cleveland: The Corday & Gross, 1945).

6 Leigh Bristol-Kagan, "Chinese Migration to California, 1851-1882: Selected Indusi rics of Work, rhe Chinese Insrirurions and the Legislative Exclusion 01" 1 Temporary Labor Force" (Ph.D, diss., Harvard Univcrxiry. 1982), zr-jr.

7 Michacl L 1'1IpiJl. *From Immigrant to Inventor* (New York: Scribncrs, 1923); Benjamin G. Lammc, *Elcaricnl Engineer. An Autobiography* (New YOll: l'utnam. 1926): Lmmct. *Autobiography*; Lirclificld. *Aurum» Leaves.*

8 Jimcs M. Scarles, *Life and Times of a Civil Engineer; Slipplemented by rhr True Theory of the Mississippi Riccr* (Cincinnari: Robcrr Clarke, 1893), 3, 21. In his preface and appendix, Sculcs used excerpts from Charles Llett Jr.'s 1857 report ro Congress on rhc Mississipp] River to support his argument for an inregrarcd warcr systcn: which would prevent severe flooding. The argument for a comprehensive plan rather than further strengthening the levees represented a minority position in 1893 Rchcrr W. Harrisou, *Lruc« District, and Leuee Buildillg in Mississippi: A Study O/St([ll' rllld Local Efforts to Conirol Mississippi River Floods* (1951), 121-41. On the role of the levee system in the SOllrhern economy, see Robert L. Branfon. *Cotton Kingdom of the Neu, South: A History of the*

Yazoo – Mississippi Delta from Reconstruction to the Twentieth Century (Cambridge, MA: Harvard University Press, 1967), 1-38.

9 Scarles tried to convince both Deer Creek planters and Vicksburg merchants of the feasibility and profitability of the Memphis and Vicksburg Railroad Company, Searles, *Life and Times*, 91-2. Except for his autobiography, no information appears in specialized engineering biographical dictionaries, biographical sources of the Mississippi and Louisiana region where Searles worked for the greater part of his life, or in Congressional records. I am grateful to Nancy Bercaw, however, (or bringing to my attention two references in the *Greenville Times* (Mississippi) which places him in Greenville in 1874 as part of a United States Army Levee investigation. ASCE Application Register. *Greenville Times* (5 August and 12 September 1874).

10 Searles, *Life and Times*, 4.

11 Searles, *Life and Times* 10-12. Irish immigrants were recruited for levee work, Robert W. Harrison, "Early State Flood-Control Legislation in the Mississippi Alluvial Valley," *Journal of Mississippi History* 23, 2 (April, 1961): 104-26, p. 125.

12 Peter L. Meiksins, "Science in the Labor Process: Engineers as Workers," in *Professionals as Workers: Mental Labor in Advanced Capitalism*, ed, Charles Derber (Boston: G. K. Hall, 1982), 121-40; Alfred D. Chandler Jr., *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, MA: Harvard University Press, 1977), 2.

13 Searles, *Life and Times* 17. James L. Roark *Masters without Slaves: Southern Planters in the Civil War and Reconstruction* (New York: Norton, 1977), Chapter 5. His involvement in engineering before the Civil War suggests his family was already in economic decline before Emancipation. I am grateful to Joe Reidy for sharing his thoughts with me on this issue. Elmer similarly could put a price on his labor and the profit he made for his employers, expressing his frustration at being undervalued, Emmet, *Autobiography*, 94.

14 Clark C. Spence, *Mining Engineers & the American West: The Lace-Boot Brigade, 1849-1919* (New Haven: Yale University Press, 1970), 98-103; John Brit, *The Autobiography of John Hall Fritz* (New York: John Wiley & Sons, 19(2), 99-107.

15 See Branson, *Cotton Kingdom*, 1-38; Robert W. Harrison. *Levee Districts and Levee Building in Mississippi*, 130 and "Early State Flood-Control Legislation", 104, 107.

16 After the Civil War, many Southern men went into engineering in order to replenish their finances and tried to reconstruct their (problematic) Southern identity as a professional one, with varying degrees of success. Wilson and Searles were the most successful at this transformation. Pickett, however, wrote two autobiographical narratives: an engineering autobiography signalling his allegiance to white northern manhood, and the other, a hunting autobiography, suggesting his loyalty to Southern white manhood. Robert Milton Howard, *Reminiscences* (Columbus, GA.: Gilbert press, 1912); William D. Pickett, *A Sketch of the Professional Life of William D. Pickett of Four Bear, Wyoming* (Louisville: John P. Morton, 1904) and his "Memories of a Bear Hunter," in *Hunting at High Altitudes: The Book of the Boone and Crockett Club*. ed, (George Bird Grinnell (New York: Harper and Brothers, 1913). Frank E. Smith, *The Yazoo River* (Jackson: University Press of Mississippi, 1954), 217-42; William H. Wilson, *Reminiscences*, ed. Elizabeth B. Pharo (Philadelphia: Patterson and White, 1937). See also: Isham Randolph, *Gleanings from a Harvest of Memories* (Columbia: E.W. Stephens,

1-37); Richard Jusr:n McCarty, *Work and Play* (Kansas Ciry: Empire Press, 1912); Matrhcw Walton Venable, *Eighty Years After: or Graudpn's Story* (Charlesron: Hood-Hciserrnan-Brodhag, 1929).

17 Wilson, *Rcminiscencrs,* 1. John D. Lirrlcpagc with Dcmaree Bcss, /1/ *Search of Soviet Gold* (New York: Harcoun, Brace and Company, 1938), xii-xiii; Emiller, *Autobiography,* xiv; Charles T. Porter, *Engineering Rcminiscenc«:* (New York: Wiley and sons, 1912), preface.

18 Robcrt Ridgway with lsahcllc Law Ridgwuy, *Robrn Ridgway* (New York: privately printed. 1940), Prcl acc: R. W. J.awrou, *An Engineer in the Orient* (Los Angeles: Walton & Wright, 1942), Jmrodu crion. See for examples of rhc technical knowledge and eloquence contained in visual representations: Engineering Notebooks Collection. Archivcs Cenrcr, National Museum of American Hisro11', Sillirhsonian lnsrirution, Washington, DC. 011 th(: communicative power of visual language, Fmbury A. Hirchcock, a mechanical engineer who "carried 011 quite a conversati on Ion air brakes] by means of a noteb ook and pencil and look and nods," with a French colleague ar rhc 1900 Paris exposition. without either of rhcm knowing rhc orhcrs narive tongue: Huchcock, *Fifty Years,* 154. Also Eugene S. Ferguson's classic article: "The lll ind 'x Eye: Nonvcrbal Thought in Technolo gy," *Science* (August 26 1977): 827-36; Hurold Bcloisky "Engineering Drawing - a Lllvcrsal Language i[1 Two Dialects,' *Technology and Cttlrurc* 32, 1 (January 1991): 23-46; Srcvc l.ubar, "Rcprcscming Technological Knowledge," (paper presenred at the Society of the History of Tcch[1010gy COiference, Madison, October 19<)1).

1<) JA.L. Waddell, "The Engineer's English," and "Technical Book Writing," both ill *Memoirs and Addressc: of Two Decades bvf.A]; Waddell, Consulting Engineer,* cd, Frank W. Skinner (Easton, I'A.: Mack Printing. 1<)28): 355-9, p. J56 and 325-53. See also: l.ditorials in *California [ournn] of Technology* 1, 2 (April 1903): 100-1; 1,3 (November 1903); Thomas A. Rickard, *A Guide to Tcrlmical Writing* (San Francisco: Mining and Scientific Press, 1908) and *Technical Writing* (New York: John Wiley & Son.l. 1920); Hitchcock, *Fifty Years.* 169-70, 240.

20 I)an[olTh H. Ainsworrh, "Discussion on Railroad l.ocario 11," *Tiansaaions of the American Society of Civil Engineers* 31 (January-June 1894): 95-8, p. 97.

21 Daniel M. Barringcr to Guy 1'. Bcnnctt in 1899, as quored ill Spence, *Mining Engineers,* 89.

22 George \\(/. Brown, "Privarc Log Book of a litrle rrip to Nicaragua, 1897-8," Division of Ellginccri ng and Jndus rry, Nationa[Muscurn of American Hisrory, Sillirhsonia ll Insrirution, Washington, DC, (F& I, NMAH. SI, hereafter). For other examples, sec: Novcrnbcr 3, 1880, Nathaniel Chapin Ray correspondence to his sister Anna, New Haven Historical Society, Ncw 1Iavcn, Cr., (Ray Papers, hereafter); Cccile]-Iulsc Marschar, *Seven Grass Hilt.': An Engineer's Wife ill Central-and-South America* (New York: larrar & Rinchart, 1939), 133; Ainsworth. *Rrcollccrion«,* 172-3; Herman Haupt, "Rcminiscences of Early History of the Pennsylvania Railroad Company," typescript, Division of Engineering and Industry, Biographical File, NMAH, SI. 3; l.ittlcpagc, *In Search of Souier (;old,* xii-xiii: Hitchcock, *My Fifty Years,* 60, 240.

23 On ward Bares used this rhird-pcrsoll narran vc in his all{0biography as a rhetorical device, *Onward flld Onward,* 3; Wilson, *Reminisccncrs.* 1; l.irrlepagc, *In Search ofSo oi»: Gold,* xii-xiii: Emmet, *Autobiography,* xiv.

24 Aiusworrh, *Rccollections,* 12, 31, 187. Ainsworrh, a member of the ASCE from 1886 until his death in 1904, appears only o nce the urganization's annals wirh an obituary: *Proceedings oftbc Am ericanSociety ofCio}! Engineer* 31 (1905), 241-2

25 For examples o f rhcir occupational writing, see: John L. Pou. Orchard Iron Works day hook, July 6, 1861-1862. MSS Collection, #1990.0178; G.S. Morison Engineers' J.ogbooks, 1863-1903, MSS Collcction both in Div. of E&I, NMAH, SI; Engineers' Norebook Collection, Archives Cenrcr, NMAH, SI, Washington, DC. The diary of Erasmus D, l.cavitt, intended as an engineers' log, was exceptional in evolving into a personal record. Lrasmus D. l.eavitr Jr. Collection, E&I, NMAH, SI.

26 Henry Root, *Henry Root, Surveyor, Engineer, and Inventor* (San Francisco: privately printed, 1921), 7.

27 Lirrlcpagc, *In Search of Soviet (;(lld,* xv.

28 Marschar, *Seven Grass Huts,* 54. Ohituarv. *The New York Times* (March 10, 1976): 42- I am grateful to Jeffrey K_Stinc For calling my arrcnrion to Marschars autobiography. On gendered differences of the fronricr landscape, sec: Anncrrc Kolodny, *The l.and before Her: Fantasy and Experience o{the American Frontiers, 1630-1860* (C hapel Hill: The Univcrsiry of North Carolina Press, 1982), 35-54.

29 Ainsworrh, *Recollections,* 33. Sec for a derailed discussion, JoAnne Yares, *Controlthrough Connmtnicauon: Th« Rise of System in American Management* (Baltimore: The Johns Hopkius University, J989), 252, 232; Spcncc, *Mining Engineers,* 99. On rhe use of ctficicnr language, sec: Cccilia Tichi, *Shifting gears: Technology, Literature, Culuire in Modcrnis: America* (Chapel Hill: The Universiry of North Carolina Press, 1987).

30 Ainsworrh, *Rrcollectious;* l.irrlcpage, *Il Search of Soviet Gold;* Charles T. Porter. *Engineering Reminiscences* (New York: Wiley and Sons, (912): Ridgway, *Robrrr Ridgway;* Scarlcs, *Life and Times;* and Wilson, *Reminiscences.*

31 Iritz, *Autobiography,* 153, and 156, 168, J7J.

32 Emmerr, *Autobiography* 86-92, *I17.*

33 Scarlcs, *Life and Times,* /3. Donald Yacovone, "Abolitionists and the Language ofFrarernal Love," in *Meanings for Manhood,* eds. Mark C. Carncs and Clyde Griffen (Chicago: Univcrsiry of Chicago Press, 1990), 85-95.

34 Ainsworrh, *Recollections;* Ernrnet, *Autobiography;* Porter, *Engineering Reminiscences;* Ridgway, *RobertRidgway;* Roor, *Surveyor, Engineer.*

J5 Bates *Omcnrd and O/1ward,* 3; see also *Bates et ill. of Virginia and Missouri* (Chicago: prinrcd for private circulation, 1914), 155,

J6 Alfred West (;ilhert, *ColonelA. W. Gilbert; UI)i! Engineer* (Cincinnati: Historical and Philosophical Society of Ohio, 1934), 25; Obituary, *The Neu: York Times* (August 18, 1938): 19; J. See also: Walter Holcornb, *Memories of Walter Holcomb of Torrington, Litchfield County, Connecticut urul) a few departures in genealogy, public records, customs etc.* (N.p., 1935), 25-

37 Frirz, *Autobiography,* 160-1. and 146, 3°1; Benjarnin lranklin Fackenrhal. "John lrirz, rhe Iron Master," *The Pennsylvania German Socirt»34 (1929):* 95-112, pp. *102, 104.*

38 Bates, "Onward and Onward," 4, 20,

39 Sec the roles of women in the production of the autobiographies (Fl.irrlcpagc (initiated and produced by iournalist Demarce Bess), Ridgway (instigatcd by, told ro, and wr: r-tell by his second wife Isabcllc Ridgway), Wilson (edited and published hy his grand. daughter), Bares (mimcographed by Ruth Hill); Torn Cooncy, *Meet Tom Cooney* (collahorared wirh Mildred H. Comfort) (Minucapolis: I.und Press, 1945). Sec also the Nathaniel Chapin Ray papers which were preserved and donated by his sister, the author Anl1<1 Chapin Ray. His sisrer failed to leave any of her own papers, as did her brot her, Also. sec: Brown diary, "Private I.og Book." I.xceprional in this respect were Emrnci, *The Autobiography* and Hitchcock, *Fiji) Years*, 138, 140.

40 Marscbar, *Seven Grass Huts*, 8, 6-7. Taciturnity returns throughout the narrative as a powerful rhcrnc, sec pp. 122, 135, 158, 231.

41 jamcs \Xorr;lll, *The Memoirs of James, Civil Engineer: Illid; Obituary Postscript by a Friend* (Harrisburg: E. K. Mcycr, 1887), 5. See also his *Report of il Survey ojSo«th Penusylvania Rtli!rot/d(n.p.:* 1862) and *Report of the Pmwy{vtlnitl Board of Pennsylvania and New York [oint Boundary Commission* (l Iarrisburg: I..S, Hart, State Printer, 1878). On contracts with working-clas manliness, sec also lcrrcrs September 8, 1878 and O ctoher 13, 1880, Ray papers: Spcncc, *Mining Engineers*, 338; Peter Way, *Common I.abor: Workers and the Digging of North American Canals, 1780-1860* (Balrimorc: The johns Hopkins Univcrsiiy Press, 1993), 14-J5.

42 Sec Ior a vivid description: Thomas J. Misa, *A Nation of Steel: Tb« Making of Modern America, 1865-1925* (Haltimorc: The Johns Hopkins Univcrsirv Press, 1995), 1-4.

43 Isham Randolph, *Gleanings from a Harucst of Memories* (Columbia, E.W. Srcphcns, 1937); *DAB*, s,v., "Randolph": Donald L. Miller, *Cit)' of the Century Tbe Epic of Chicago and the Making ojArncrica* (New York: Touchstone, 1996), 429-,11.

44 David Monrgorncrv, "Workers' Control of Machine Production in the Nincrccnrh Century," in *Workers' Control in America* (New York: Cambridge Univcrsiry Press 1979),]-:,1; and *The Fall of the House of Labor* (Cambridgc: Cambridge Univcrsiry Press 1987), Chapter 1; llcrherr G. Gutman, "Two Lockouts in Pennsylvania, 1873-1874," *Pennsylvania Magazine of History and Biography* 83 (July 195')): 307-326; Gary M. rink, cd., *I.abor Unions* (Westport, C'I: Greenwood Press, 1977), 158-60; [..T.e. Roll, *A Shore History of Machine Tools* (Cambridge: MIT Press, 1965), huroduction: Melissa Dabakis, "Douglas Tilden's *Mcchnics Fountain:* Labor and the 'Crisis of Masculiniry' \JI rhe 1890s," *Arneriatn Quarterly* 47,2 GUlle J99\): 204-35.

45 For example, the ASME published: *[ohn Edsan Suree:* (192\), *A Biography of Walter Craig Kerr* (1927) both by Albert W. Smith; William F. Durand, *Rober: Hcurv Thurston* (1929); L P. Alford, *Henry Laurcnce Gantt: l.eadcr in Industry* (1934), joseph W. Roc, *[ames Harness* (1937), Morrimer E. Coolcy. *Scientific Blacksmith* (1947). *National Cvclopaedia*, s.v., "Wiley"; Misa, *Ntltioll of Steel*, 74 n. 76; Amy Slle Hix, "Inventing Ourselves Out of Jobs: America's Depression Era Debate Over Technological Unemployment," {Ph.d. Diss., The Johns Hopkins University, 1994}, 459.

46 Fritz, Autobiography, 236, 241, 245, 249.

47 See also: Warren I. Susman's classic, "Culture Heroes: Ford, Barton, Ruth," in *Culture as History. The Transformation of American Societ), ill the Twentieth Century* (New York: Panthcon Books, 1984), 122-49.

48 Arrhur G. Hurgoync, *Homcstrad* (Pittsburgh: privately printed, 1893), 130-J97; Montgomery, *House ofLabor,* 36-43; David Brody, *Steeluorkers in America* (New York: Harper Torchbooks, [1960J); Jcremy Brechcr, *Strihe!* (Boston: South End Press, 1972), 53-63; l-ink, cd. *l.abor Unions,* 160,

49 On the functions ofjokes. see: Mary Douglas and Robcrt Darnton ill *Rethinking Popu-Inr Culture: Contemporary Thought in Cnltuml Studies,* eds. Chandra Mukerii and Michncl Schudson (Bcrkcley: University of California Press, 1991), 291-310.

SO Frirz, *Autobiography,* 296-7. *DAB,* s.v., "Rossircr." Philip S. l-oner. *The Polcies (1/0 Practices of the American Federatian of Labor, 1900-1909* (New York: Jnrernarional Publishers 19(4), csp, chapter 4; John W. Hcvcner in *l.nbor Unions* 412-13; Bruce Sinclair, *A Centennial o[th« American Society ofMecbanical Engineers, 1880-1980* (Toronto: Univcrsiry of Toronto Press, 1980), 65-7, 85. 98, 128-9. 184-6.

S1 Frirz, *Autobiography,* 278-9; A female perspective on the celebration was provided anonymously by "The Banquet as Seen by One in the Gallery," who wryly commented thar "all human hisrory arrests: Thar happiness for mrnn, rhe llllngry sinner; Since Eve atc the applcx, much depends on dinner!", pp, 313-18; S.v_ *DAB* "l-rirz."

52 Iritz, *Autobiography,* 22, 33, 62, 82, 100, 129, 126-27, 132.

53 Iritz, *Autobiography,* 275, 3IJ.

54 Fritz, *Autobiography,* 53-4, 205, 28-9, 33-34. See for orher examplcs, Hitehcock, *Fifiy Years,* 48, 82, 98, 107, 1H (jokes); Ray Papers, lertcr. Ociobcrjr. 1878 and November 31, 1878 (on jokes): September 9, 1878 (language).

55 Frirz, *Autobiography,* Chapter 20. "Puddling."

56 Robcrr W. Shelmire, *The Draftsman* (C11icago: Chicago Tublishing Burcau, 1919), 10-11, 33; Peter I. Meiksins, "Professionalism alld Con Tict: The Case of the Arncrican Association of Engineers," *[oumal ofSocia! History* 19, 3 (Spring 1986): 403-421, p. 406; Fink, *I.al/or Unions.*

57 Fdward Carpenter, "Tomorrow," *Tbc Draftsman* (Cleveland) 2, 4 (April 1903),

58 A.J.S_ "The Drafrsman." *The Draftsman* (Philadelphia) 1, 6 Unuary 1928): 16.

59 See also Misa, *Nation of Steel.* 174-

60 Samuel W. Traylor, *OUI of the SouthWest: A Texas Boy* (Allenrown, I'A: Schlicher & Son, 1916), Forcword; Jnhn G. Cawclti, *Apostles of the Self-Made Man* (Chicago: University of Chicago Press, 1965).

61 Cilbcn, *ColonelA. W. Gilbert,* Foreword.

62 Paul Starrci, *Changing the Skyline* (New York: Wittlesley House, 1938), 316.

63 Stcvcns. *Rccollrctions of an Engineer,* 65; see also J. F. Stevens to Profcssor Carpsis of Manila, March 27, 1936, Dibner Library, NMAH, SI, Washington, DC.

64 Oaviu McGee, "Making Up Mind: The Early Sociology of Invention," *Technology and Culture* 36, 4 (October 1995): 773-801; Bix, "Invcnti ng Ourselves Out of lobs," 458-9; *DLB* 46, s.v., "McGraw-Hill"; Arthur P. Molclla, "The First Generation: Usher, Mumio«], and Gicdion," in /11 *Context: The History and the History of Technology,* cds. Stcphcn H. Cudil[c and Roben C. Post (Berhlehem: Lchigh University Press, 1989): 88-105. On collective mcmory: Maurice Halbwachs, *The Collectioc Mcntory,* Intro. Mary Douglas, trans, lrancis J. Diner and Vida Yazdi (New York: Harper & Row. 1980 [1950]); Philip Nora, "Between Memory and History," *Memory and Counter-Memory.* Special Issue, cds, Nathalie Zemon Davis and Rudolph Starn, *Representa-*

nons 26 (1989): 7-22; David Thelcn. "Memory and American History," *[ournal of American History.* Special Issue 75, 4 (March 1<)89): 1TJ7-2<).

65 Gilbert, *Colonrl 11. W. Gilbert.* Juircdu crion.

CHAPTER 4

Cyrus Townscnd Brady, *Web of Steel* (New York: Flcming H. Rcvell, 1<)16). Preface,

2 *Tb« Neio York Sun* (January 16, 19(6): 7; juli an Chase Srnallwcod. „Engineering and Art." *Cassier's* 37 (january 1<)lO): 213-6; Louis H. Cibson. "Art and Engineering," *Scicntific American Supplement* 58 (October 1<)04): 240H-4: James 1'. l laney. "An and the Engineer: Combining the Useful and the Beautiful," *Scientific American Supplement* 71 (February 25, J<)II): JI<); "Artistic Bridge and Highway Railings," *Amerioun City* 20 (March J91<)): 234-3<); "Structural An," *l.itrrary Digest* 67 (December 25, 1(20): 26-7. See also for a similar trend in the Nctherlnnds. Harry Lintscn's *Ingenieur van beroep: historic, praktijk, nutcht ru opvattingen uan ingenieurs in Nederland* (Den Haag: Ingcnicurspcrs, 1985), 12-3,

E.A. Van Deusen, "The Engineer's Place in Fiction :' *Professional Engineer* (September 1922): 15-

4 J.H. Prior, "Potential C;ood of A.A.E. Beyond Recognition," *The Monad* (December 1<)16): 11.

The dissemination of the figure of the engineer occurred both through popular fiction, the progress reports on engineering projects appearing in the daily press (e.g. *Tbc New York Snll)* and genteel periodicals including *McClure's, Scribners', IInrprr's,* and *The Century.* all of which frequently featured articles on engineers starting in the 1890s.

6 Echoing Hawthorne, Ann Douglas presented the classic arglllllent in *The Femiuization ofAmerican CII/lif!'"* (New York: Alfred A. Knopf (977), which has been critically revised: Sandra M. Gilbert and Susan Cuhar, *No Man's Land: The Placeof the Woman Writer in the Troentirtl: Centuiy_ The War of the Words* (New Haven: Yale University Press, 1988); janicc A. Radway, *Reading the Romance: Women, Patriarch». and Popular lireraturc* (Chapel Hill: The University of North Carolina Press, 1984); Carhy N. Davidson, *Reualraion and the Word: The Rise of the Novel* ill */uncrictt* (New York: Oxford Un iversity Press, 1986), 45-9, J12-2S; Barbaru Sichcrman, "Sense and Sensibility: A Case Study of Women's Reading in Late-Victorian America," in *Reading in America: l.itcraturc and Social History,* cd. Cathy N_Davidson (Baltimore: The johns Hopkins University Press. 1989), 201-25; see also T.]_jackson 1.ears, *No Place of Grace: Antimodernism and the Transformation of American Culiure, 1880-1920* (New York: Pantheon, 1981), 103-4.

7 Unless otherwise indicated in rhe texr, this chapter is based on the following: Harold Bell Wright, *Tbc Winning of Barbara Worth* (Chicago: Book Supply, 1912); John Fox [r., *The Trail ofthe l.onrsontr Pine* (New York: Scribner's Sons, 1908); Zane Grey, *The UiP, Trail* (New York: Harper and Brothers, 1918). l-rancis l.yude, *Tbe Quickening* (Indianapolis: Bobbs-Mcrrill. J906); Frank H. Spearman, *Whispering Smith* (New York: Charles Scribncr'x Sons. 1906); j.nncs Oliver Curwood, *Tb« Danger Trail* (New York: Grosset and lJunlap, 1(10); Rex Beach. *Tb« Iron Trail: An Alaska» Romance* (New

York: Harper and Hrorhcrs, 1913); H. Irving Hancock, *The Young Engineers in Nevada* (Philadelphia: Henry Altcmus. 1913); The work of Honorc (McCue) Willsie Morrow, *The Enchanted Canyon* (New York: A. l.. Burr, 1921), *Stilllin,* (New York: Frederick A. Stokes,)014) and *The Heart oftl« Desert* (New York: A.L. Burr, 1913); Brady *Web of Stcc]:* Francis Aruold Collins, *The Fighting Engineers: The Minu te Men of Our Industrial Army* (New York: Century, 1918); Fdward Ilalscy Foster, "Th is Cowboy Is an Engineer: Popular Fiction, Politics and the West," *Rendezvous* 19, 1 (Fall 1983): 1-7.

8 Cecclia 'Tichi noted, but did not claborate' un, the manliness in the representation of' engineers in her well-researched and beautifully wriucn book, *Shifting Gear: Technology, Liter:nt«re, Culture ill Modrruis: Americn* (Chapel Hill: Univcrsiry of North Ca rolina Press, 1987), 99. Iespecially bcncfirrcd from Elizabeth Arnmon ss article, "The Engineer as Cultural Hero and Willa Carh er's lirsr Novel, *Alexander's Bridge,*" *Americun Quarterly* 38 (Winter 1986): 746-60, in which she deftly treats the issue of rnas cul in - ity in Carher's novel. Thcodore Ziolkow,lki, "The I.xistenrial Anxieties of Engineering," *Tbc American Scholar* 53 (Spring 1984): 197-218.

') Sec for the *locns classicus* rhe doctrine of the srrcnuous Iitc, "of toil and effort, of labor and srrifc: to prevail rhut rhc highe.l[form of success whi ch, 110t from the man who desires mere easy peace, hut the man who does 110t shrink (ro m danger, frolll hurdship, or frolll hiucr roil, and who ou[of these wi111 the splcnd id ulrimure tri111ph." 'Thcodorc Rooscvclr, "The Sucnous Life: Speech Before rhe Hamilton Club," April 10, 1899, in *Th« Strenuous Life* (New York: Century, 1902 [1899]), 1-21. The argument is presented by Foster in his article 'This Cowboy Is an Engineer", bur is implicitly refuted by Tichi who sccxrhc engineer as foremost a ruling-clas: figure and professional in the midst ofa civilizing efforr. Foster concentrates 011 the western novels within the genrc, while Tichis analysis focuses on writers from the eastern establishment. Tichi, *SII/fiing Crcars,* 117-20, and esp. 123. Sec also David B. Davix, "Marlboro Counrry," in *Front Homicide 10 Slavery: Studies ill Amrrica» Culture* (New York: Oxford University Press, 1987 [1979]), 104-12.

10 Richard Harding Duvis, *Soldiers of Fortune* (Nt'w York: Ccurury, 1897), 1)-4; James R. McC-overn. "David (; raharn Philips and the Viri Ii n Y Jmpulse of the Progressives," *Ncio Filglllllt! Quarterly* 39 (1966): 334-55; Le.us. *No Place of Grace.*

11 Anncrrc Kolociny. *Tb« Lnnd Before Ilet: Fautus» aur! Experience oftbc Amrrican Frontiers, 1630-1860* (Chapel Hill: The University of North Carolina Press, 1984); Brady, *Web of Steel;* Wright, *Tbc Wimillgof Barbara Worth.* Their I)ulch counterparts socialized in comfortable bourgeois settings fully 111 habited by importaiit ternalc characters. In American representations. the American West posed a challenge; whereas 111 the Duich novels, *female fatale* threatened the engineers' road to success. lor examples, sec: Buskcn Hver, *Lideuijde* (1868); P.A. Daum, *fl. van Bral«], illg. B.* 0, *W.: voorspronkelijke ronuin do!!i'Maurits* (Leiden: A.W. Sijthoff, 1890); Cornélie 11uygens, *Barthold Meryan* (Amsterdam: 1'. N. van Kampen & 1oon, 11.d.),

12 The threat was mO.lr clearly formulated ill Wright's *When (I Mrlil:' {I Ivfrtll* (1916), as Fri[{ H. Oehlschlaeger argues in"(: ivilization as Emasculation: '[he' 'Threatening Role of Women in the Frontier Fiction of Harold Bell Wright and Zane Grey," *The Midwest Quarterly* 22, 4 (SIImller 1981): 346-60. John P. Ferre, *A Social Gospel for Millions. The Religious Bestsellers of Charles Sheldon, Charles Gordon, and Harold Bell Wright* (Bowling

Green, OH: Bowling Green University Popular Press, 1988), 12, 56-68; Edward Jakovic ill *DNB*, s.v., "Wright."

11 Christopher P. Wilson, "The Rhetoric of Consumption: Mass-market Magazines and the Demise of the Gentle Reader, 1880-1920," in *The Culture of Consumption*, eds, Richard Wightman Fox and T. J. Jackson Lears (New York: Pantheon Books, 1983), 39-64, pp. 50-56.

14 Charles Carrington in *DLB* 19, s.v., "Kipling"; Mary A. O'Toole in *DNB* 34, s.v., "Kipling."

15 On Kipling's engineering stories see Jean-Francois Orjollet, "Individu, type, règle: Kipling et ses *engineers*," *Cahiers Victoriens et Edouardiens* 18 (Novembre 1983): 59-67; Christopher Harvie "'The Sons of Martha': Technology, Transport and Rudyard Kipling," *Victorian Studies* 20 (1977): 269-82.

16 "Kipling Writes Poem for Technical Magazine," *The New York Times* (March 6, 1935): 17; R. Kipling, "Hymn of Breaking Strain," *Civil Engineering* (1935); "Romance of Engineering," *Scientific American* 106 (February 10, 1912): 124.

17 R[alph] W[aldo] Lawron, *An Engineer in the Orient* (Los Angeles; Walton & Wright, 1942). Obituary, *The New York Times* (August 22, 1943), 36:5; see also Walter Holcombe's use of Kipling, *Memories of Walter Holcombe of Torrington, Litchfield County, Connecticut with a Few Departure, in Genealogy, Public Records, Customs etc.* (N.p., 1935), 47.

18 C. E. Moorlouse. "Mr Wardrop's Problem: Excerpts from a Talk on Kipling and Technology," *Kipling Journal* 61 (March. 1987): 10-22, p. 10.

19 Robert T. Gebler, "The Engineer (with Apologies to Kipling)," *Engineering News* 73, 2 January 14, 1915): 17.

20 I am especially grateful to Matt L. Turner with whom I collaborated on a close reading of the poem. See: "Contesting the Good Part: Kipling's Sons of Martha and Definition of Labor" (paper presented by Matt L. Turner and Ruth Oldenziel at the Department of Comparative Literature Seminar, Yale University, April 11, 1990) The poem first appeared in the following dailies: *The Standard* (London), April 29, 1907; *Associated Sunday Magazines* (April 28, 1907); *The New York Tribune* (April 28, 1907), illustrated by Winter; *Philadelphia Press* (April 28, 1907), In pamphlet form, it appeared in the following editions: "The Sons of Martha." (New York: Doubleday, Page, 1907,) Broadside. Description: Title within ornamental border, [Photostat copy]: "The Sons of Martha," (Garden City: Doubleday, Page & Company, 1907), Broadside. Description: First American edition_Livingston Supplement, 151; "The Sons of Martha," New York, 1907. Copy detached from *Sunday Magazine* for April 28, 1907, No detailed critical analysis exists of the poem, Despite the title "The Sons of Martha," Harvie's article deals not with the poem but with Kipling's views on technology and society.

21 Kipling's replilation with the critics was declining, but this poem was well-received: "The Sons of Martha." *The Independent* (New York) 62 (May 23, 1907): 1217-8; Lyman Abbott, "The Book Table: Devoted to Books and Their Maker. Kipling's Latest Word," *Outlook* 123 (Sept. 24, 1919): 144. F.H" "Literature. Recent Poetry," *The Nation* 109, 2821 (July 26, 1919): 115-7; "Volumes of Poetry," *The American Review of Reviews* 60 (September 1919): 446-7; Charles Hanson Towne. "The Vanished Years, The Never-Vanishing Kiplilng," *Bookman* 49 (1919): 617-2; The reviewer in the *Dial* found

Kipling politically repulsive because "a mind so obviously wrong about women (The Female of the Species will probably [be] distrusted when it considers labor (The Sons of Martha)..." yet believed that the poem offered a rare glimpse of the author's old power, "Notes on New Books," *The Dial* (May 31, 1919): 57.

22 H.M.. "Kipling as a Poet," *Poetry* 48, 3 (April 1936): 32-6.

23 Dixon Merritt, *Sons of Martha». A Historical and Biographical Record Covering (/ Century of American Achievement by an Organization of Master Builders* (New York: Mason and Hanger Company, 1928).

24 "The Sons of Martha.' *The New York Times* editorial (September 23, 1938): 26:2; Albert J. Iranck, Letter to the Editor, *The New York Times* (September 28, 1938): 24:7.

25 Augustine J. Frederich, ed., *Sons of Martha: Civil Engineering Readings in Modern Literature* (New York: American Society of Civil Engineers, 1989).

26 Marion Harland, "Martha and Her American Kitchen." *Woman's Home Companion* (March 1905): 12-13, 51, 55. See also: Elizabeth Foote, "Girl of the Engineers," *Atlantic Monthly* 95 (March 1905): 381-91; "From a Sister of Martha,,. *Atlantic* 27 (March 1921): 424-6

27 "The Sons of Martha by Rudyard Kipling," (Chicago: printer John F. Higgins, n.d.). According to Harvie, by 1912 Kipling "had come to fear the growing confrontation between labour and management." Harvie, "The Sons of Martha," 278.

28 Philip S. Foner, *History Of the Labor Movement in the United States. Post-War Struggles, 1918-1920* (New York: International Publishers, 1988).

29 (; .S,B" 'The Song of Mary,' *Literary Digest* 63 (November 8, 1919): 39.

30 On Kipling's attitude toward unions, see Hurvie, "Sons of Martha,": on modern artists representation of themselves as designers, see Tichi, *Shifting Gear:* 173.

31 Surprisingly, T.S. Eliot was in large part responsible for restoring Kipling's reputation as a respectable writer. By examining the most frequently quoted and popular writer of the late nineteenth and early twentieth centuries. Eliot was able to define his own modernist agenda with greater clarity and precision. To him, Kipling represented everything he was not. T.S.E[liot], "Reviews, Kipling Redivivus," *Athenaeum* (May 9, 1919): 288-9, f). 289.

32 Mary Hallock Foote, *A Victorian Gentlewoman in the Far West: The Reminiscences of Mary Hallock Foote,* ed. Paul Rodman (San Marino: Huntington Library, 1972), 305. For a very moving appreciation of Kipling see, pp. 336-41, 397.

33 "The Endurance Test," Book 5 in Foote, *A Victorian Gentlewoman,* 285-330; and Introduction, 24-7.

34 Wallace Stegner, *Angle of Repose* (New York: Doubleday, 1971).

35 Mary Hallock Foote, "In Exile," *In Exile and Other Stories* (Boston: Houghton, Mifflin, 1894), 1-58, p. 33.

36 Paul Rodman's introduction in *A Victorian Gentlewoman;* Barbara Cragg, "Mary Hallock Foote's Images of the Old West," *Landscape* 24, 3 (1980): 42-7; *Encyclopedia of Frontier and Western Fiction* (New York: McGraw, 1983), s.v. "Foote."

37 Charlotte M. Vaile, *The Mt. Desert Song Book of the Great Rockies* (Boston: W. A. Wilde, 1898), 150. Quite possibly, Vaile was inspired by Foote's *In Exile.* Like Frances Newall, the heroine Alice Hildreth is a school teacher in a Colorado mining camp confronted with the world of mining; like Foote the tension between the norms of the East coast es-

rablishment and the West are solved through women's civilizing values: also compare pp. 38, 40. See also Wright *The Winning ofBarbar« Worth,* Chapter 4; Morrow, *Still [im,* 271, 340.

38 Fliznhcrl: Foote, "Girl of rhc Engineers," *Atlantic Monthly* 95 (March 1905): 381-91; L. l-runccs, "The Engineer," *Overland Monthly* 57, 1 (junu ary 1911): 271-3.

39 William R. Tay lor and Christopher Lasch, "Two 'Kindred Spirits': Sorority and lamily in New England, 1839-1946," *New :Ilglai/({ Quarterly* 36 (1963): 25-41: Carrell Smith-Rosenberg, "The Female World of Love and Ritual: Relations between Women in Nineteenth-Century America," *Signs* 1 (Autumn 1975): 1-29: Jean Liprnan-Blumcn identificd hon to-social rclations as a rool of male power wirh which women had to compete. "Toward a Hornosocial Theory of Sex Roles: An Explanation of Sex Segregation of Social Institutions," *Signs* t. 3 (Spring 1(76) Part II: 15-31, P: 16,

40 John C. Vitalc, "j he Great Quebec Bridge Disaster." *Consulting Engineer* 38, 2 (lebruary J9(7): 92-5.

41 Marjoric Lowrv Christie Pickthall, *Thr Bridge: A Story of the Grcnc Lalecs* (New York: Century, 1922).

42 Here, Kipling plays o n the wo I'dused in Ind ia for bridge 'tirrcha whicl: means both an overpass and a lord in the river, syrnbolizing pilgrimage. I .un grarcful to Richard Davis for helping mc understand Kipling's story ill its British-Indian context.

43 Ann Parry, "Imperialism in 'The Bridge-Builders': Metaphor or Reality?" and "Imperialism in 'The Bridge-Builders': The Builders of the Bridge and the Iururc of rlic Raj," *f(1)Jillgj0IIJ'il/{* 60 (March 1986): 12-22 and (June 1986): 9-16. See also: Michael Adas *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Donunnncc* (Jiliaca: Corncll Uni versity Press, 1989): 235-6; Ammo ns, "The Enginccr as Culture Hero."

44 For examplc, see the exchange on another bridge disaster. Narhanicl ro Al11\a Rav, September 21, 1916, Narhanicl Chapin Ray Papers, 1878-1916 New Haven Colonv Historical Society, New Havcn, CT. No ui tical work or hiographical information has appeared on Ray, bur see: A.A.C. "In Mcrnoriarn: Anna Chupin Ray," *Smith Alumnae Quarterly* 37, 2 (lebruarv 194(,): 87. *Sheffield Scientific School* (New Haven, 1917), 742-3.

45 Auua Chupin Ray. *Tl« Bridge Builders* (Bosron: Little, Brown, 1909), 25. 78, 11(" 246

46 Ray, *The Brige Builders.* 198, 392. 397.

47 As cited in Amnions, "Engineer as Cultural Hero," 748-9; Willa Carlicr, *Alcxnndrr': Bridge* (New York: Signet, 1987 [1912']), Inun, by Sharon O'Brien; Tichi, *Shifting Gears,* 173-80; Ziolkowski, "Existcnrial Anxieties."

48 Carhcr, *Alexander's Bridge,* Inrroduction. jumcs Woodress in *DLB* 9, s.v., "Cather."

49 Sharon O'Brien, "Bccorn ing Noncauonical," *Amcric«n Quarterly* 40, I (March. 1988); Gilbert and Gubar, *No Man's Loid.*

50 Barbara Zabel, "The Machme as Mciaph or, Model, and Microcos m: Technology in American Art, 1915-1930," *Arts Magazine* 57 (December 12, 1982): 100-5.

51 Protesting against rhc dcconnxtualizcd artistic rcprcscnrarion of technology were 1)iego Rivicra's Detroit mural of the Ford factory at Rivcr Rouge of 1932 and Lewis)jinc' photo-documentary suggestively called *Men at Work.* "This is a book of Men at Work; Ille'J1 o!' courage, skill, daring and imagination," Hine wrote. "Cities do nOI build themselves, machines l"IInot make machines, unless back of ihem all are the

brains and toil of men. We call this the Machine Age. But the more machines we use the more d" we need real men ro make and direct them." I.ewis W. Hine, *Men at Work* (New York: Dover, 1977 [1932]): Inrroducrion: Ruth Oldenziel, "Artistics Crossings: The Ford (plant) at River Rouge, 1927-1949," in *High Bran. Meet, l.otu Brou.: American Culture as an Iutrllccutal Concern*, cd. Rob Kroc, (Amsterdam: Free Universiry Press, 1988), 37-60.

52 Tirhi, *Shifting Gears.* Tichi calls it the gear-and-girder understanding of technology. Compcting wirh the aesthetization of industrial life or wharJohn Stilgoe has coincd the "Pullman-car vision of the indusrrial zonc" were rh« dcpictions in word and image of Progressive reformers concerned with the working and living conditions of imrnigrants in back alleys of the industrial cities. John R. Stilgov, "Molding the jndustrial Zone Aesthetic, 1880-1929," *[ournal of American Studies* 16 (April 1982): 5-24, p, 12. 'This Ulldersrandi ng was not incorporated into the definition of technology, however.

53 Molly Ncsbirr, "Ready-Made Originals: rlu: Duch.unp Model." *October* 37 (1986): 53-64. For the Russian Conscrucrivisr movement, see L. Lissirzkys drawing cxpcrirncnts exploring the differences and similarities between art and engineering, and Varvara Stepanova and Alcksandr Rodchcnko's devcloprncnt of working methods and curriculum. /Irl *int» Life: Russian Constructiuism 1914-1932*, Minncapolis. Walker Art Center, Ocrober 7 - lJccembcr 30, 1-)))0. At the Bauhaus, Walter Gropius led the art school into a firill alliancc wi th indusrry, againlt the proponenrs of the crafts such as Johannes Iucu, a direction Hauncs Mevcr uppropriarclv called a polyrcchnic cduculion, Frank Whitford, *Bauhans* (London: Thames and Hudson. 1984). Chapter 11, and documents 202-10; Krzysztof Fijalkowski, "Duda and the Machine," *[ournnl of European Studies* 17 (1987): 233-51.

54 Oil the elusive but fascinating Srevens: Irancix Naurn.um. "A Lost American Iururist." *Art in America* (April 1994); Carolyn Burkc and Naorni Sawelson-Gorse, " n Search of Frances Simpson Stevens," /Irt in *America* (April 1994); Carolyn Burke, *Becoming Modern. The Life ojiHillt1 l.oy* (Berkeley: University "f California Press, 19')(,); Naumann person.il f lcs: and Franccs Simpson Sicvens marcrials in possession of the author.

55 2') I nos, 5-6 (New York. July-Augusr 1915). The New York uvant-gardc journal, csiablished by Stieglitz With financial backing from Ilavil.uul, became a fertile meeting ground for artist-refugees from Europe and their American colleagues for Iormularionx on modernism during the war, On I.ovs attempts to patent her inventions. see, "Invcnrion Corselet. n.d." Series IJ, Box 6, Iilc 186, Mina Lov Papers, Beinecke Rare Book and Manuscript Library, Yale University, New Haven, CT. and Burke, *Becoming Modern.*

56 Ernest Gombrich, "Visual Metaphors of Value in Art," *Meditations oil a Hobby Horse: Ami Other Essays on the Theory of Art* (1963), 12-29. 011 the engineering vision as process in photography, see Terry E. Smith, "Tracing the 'Eye o(Power': Foucault, Factories and Photography, U.S.A. 1900-1930" (paper presented at rhe College Art Association Conference, Washington, February 23 1991). For a general overview, Richard Wilson, Di,Ulllll' H. Pilgrim, and Tashjian, *The Machine Age iil America, 1918-1941* (New York: Brooklyn Museum, 1986).

57 I'alll' Iaviland, *211* (March 1915).

58 Burke, *Becoming Modern,* 217-8.

59 Burkc, *Becoming Modern*, 178-84

60 Sec for a rich and general discussion on rhc issues of cross-dressing, trunsscxualiry, passing, camp, and voguing as forms of subvcrsion or survcillanee: Anne McClinrock, *Imperial Latthrr: Rac%, Gender and Sexuality in the Colonial Contest* (New York: Rouilcdgc, 1995); Marjoire Garber, *Vested Interests. Cross Dressing and Cultural Authority* (New York: Rourledgc, 1992).

CHAPTER 5

Unlcss otherwi se indicated, wh.u follows is based on my survey of *all* Am eri ca» acc rcdired enginccring schoo Isprior to 1945. A query was sc nr to 274 schools. This correspondcn cc was followed lip by letters to registrar's offices, engineering colleges. university archivcs and alumni assoc iarions, In total, 175 schoo Isanswercd: 82 reportcd on wo men graduates. Of th e 99 schools rhar did not respond, 10 appear to have awarded a significant number of degrees to wo men, Based on th is survey and oth er sou rces. over 600 women in engineering have been identified by name. *Women Engineering Grndnat.* « ill *tbc U.S., 1877-1945 Papers* Amsterdam, [he Netherlands, (Women Engineering Graduates Papers, hereafter). Orher sources include: The Society of Women Engineers Collection, Walrer Reuther Librarv, Wayne Srate Univcrsirv, DCITOit, MI; The Society of Women Engineers's directories of the 1950s; The Gilbreth Papers .u Purduc University and Purduc's Institurional Archjvrx, Lataycuc, 11; Inxtirurc Archives and Special Collcctions, MIT Libraries, Cambridge, MA; The Records of rhc Women's Bureau, Bulletins of the Women'x Hurcau, RG 86, Boxes 699-701, Narional Archives; Census Records, *Who's Who in Engineering (1922-23)*; and General Hccrric Hall olHistorv Collccriou, Schenectady, NY.

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415-10; see also Eva Mae Burken, *Americnu Dictionaries of the English Language Before 1861* (Mcruchcn. NY: Scarecrow Press, 1979).

2 William A. Lydgate, "The 32 Million-Work Classic," *Sarurday Rcoiaoz«*, 18 (May 2, 1942): 3-4, 22-3. Willard H unringrou Wright, *Misinforming a Nation* (New York: B. W. Huebs ch, 1917), 19. contested *Brltnnnicas* canonical claims. Cf. in his review, "The Engineer and the Encyclopaedia,' *Cassicr's* 40 (December, 1<)11): 753-60, Herry Harrison presented engineers as scholars rather than as shopflcor-traincd rcclmicians.
Ann J. Lane, *Mar» Rittcr Bean]: A Sourtrboole (New* York: Schockcn Books, 1977), 47, see also Chapters 3 and 5. Ior Gage's influence, sec Beard's lcucr tu Mrs. Schlcsingcr, where she writes that "[ojnly Marikia [oslyn Gage seems to have known much abour rhc history of worncnand she narurally sawit as a history of subjccrion to sadism via Canon Law in which she rather specialized," Beard to Mrs. Schlcsinger, June 15, 1944, in *A Woman Making History. Mary Ritter Beard Through Her lrttrrs.* cd. and inrrod, by Nancy F, COlt (Xew Haven: Yale University Press, 1991), 243. Ior indications of the influcnce of evolutionary anthropologists's theories on Bcards thinking alld Mason in particular. see ill additio ll rhe assessment of 1he entry o(*Social Authropology*, Lanc, *219-20;* Con, *A Womtln Making History.* 26-27, 32. for an early letter on her understanding of women's inventions. see: Mary Beard, "Inventions Are for Men," Letter to the Editor, *The New Yorl: Times* (August 17, 191)). See also, Marv Ritrcr Beard, *Woman a, Forcein History* (New York: Macrnillan, 1946).

4 Cott, *A W()llltm Making I Iistory*, 51, 221, 227, 237-8, 247-51, 283-4.

5 *Encyclopaedia Britanuica.* 14rh cd. (1968), s.v.. "History of Technology," by Robert S. Woodbury, Professor of the History of Technology ar MIT since 1963.

6 Telephone inrcrvicw with Melvin Kranzherg. September 15, 1990, Prior to his consulrant work for the *Encyclopaedia Britannica*, he wrote its entries 011: "Indusrrial Rcvolulion" (1964) and "Inventions and discoveries' (19(7). His encyclopedic ocuvrc did not stop here: he wrote 1,)1' *Crnolos Comprehrnsine Encyclopedia* "Transportation" (r967), for *All Encyclopedia Of World History* sections on rcchuological developments (1968); For the *World Book Encyclopedia* the following curries: "I nvcnrion" and "Technology" (1972), "Transportation" (1981 and subsequent editions). Kranzberg was also a special consulranr for the *Harper Encyclopedia of Science* in 1')(;2, a consulrnnr for ihe *Cowles Comprehensive Encyclopedia* from 1963 to 1967, an adviscr for rhc *The New Columbia Encyclopedia* from 1974]() 1')77. Mclvin Kranzberg Papers, Archives Ccnrcr, National Muscurn of American History, Srnithsonian Insrirutiou, Washingron,])(:, (Krunzbcrg Papers, hereafter).

7 Philip W. Goetz, Executive Fdiror, The Encyclopaedia Briiannica. to Eugene S. I'crguson, May 9, t967, Series l, Box 42, Kranzberg Papers.

8 Morrimcr J. Adler, "The Circle of Learning," *Encyclopaedia Britnnuic«, Propaedi«: Outline of Knowledge* (Chicago: The Encyclopaedia Hritanuica, 1974), 5-9, p. 6,

9 For example, they stressed how the scientific observations by Sumcrian astrologists were used to benefit their counrry's irrigarion systems and how the theories of Boyle, Guericke, and I'af)in had paved the way fur the invention of the steam engine (462). Bruce E. Seeley, "SHOT, the History of Technology and Engineering Education,' *Technology and Culture* 36. 4 (Ocrober 1995): 739-72.

10 The New Encyclopaedia Britannica, *Propaedia: Outline of Knowledge*, 434-97.

11 Lugene S. Ferguson to Warren E. Prcecc, Editor-in-Chief, The Encyclopaedia Britannica, Junc 23, 1967, Box 42, Series I, Kranzberg Papers. Franz Reulcaux, *Thcoretischr Kinematlk: Grundzüge einer Tbeorie des Mnschineruoescn«* (Braunschweig, 1875) translatcd as "Technology and Civilization," *Annual Report of the Smirbsonian Institution: Genera! Appendix* (Wa"hington, DC: Covernment Printing Office, 1890), 7° 5-20. See also: Jeffrey Hcrf "The Engineer as Idcologue: Reactionary Modernists in Weimar and Nazi Germany," *[ournal O] Contemporary History* 19 (1984): 631-48; Karin Zachmann, "'lnvolvcmcn1 wirh Tcch110logy Does not Harm'Their Charm and Fcminiriry'. Mobilizarion, Modcrnizario11, and Ambivalence of Women Engineers in l.asr Germany," *Crossing Boundaries: History of Women Engineers in Cross-Cultura! Comparison*, eds. Ruth Oldenzicl. Karin Zachmann, and Annie Cane! (London: Harwood Academic Press, Forth coming).

IZ Eugene S. Ferguson, "Kincrnarics ofMcchanisrns from the Time of Watr," in *Coniributions [rom the Museum of History and Technology r;* (1963), 186-230, pp. 216-27. French philosopher and theologian Jacqucs Ellul (b. I[)IZ) undermined rhc treatment of technology as an artifact with which Ferguson and Kranzberg wrestled, jacqucs Eilu], *La Technique* (1954), published in I:ngli.\h under the title *The Technological Society* (1963), defined *"technique"* as "the totality of methods, rarionally arrived ;n and having absolute efficiency." The Ccnrcr for the Study of Dcrnocraric lnsriruuons, responsible for disseminating of Ellul's work to an American audience and for organizing a confercnce in 1962under the auspices of the *Encyclopaedia Britannica* called "*The Technological Order,*" homage to Lllul's work. The conference would become the basis for the *Briumnicn»* entry on Technology providing the newly established Society of the History of T'cch nology and its jou rnal *Technology and Culture* the financial and in rcllccrual boost they dcspcrarcl y needed. jn preparation Forthe conference on T'cchnology ai the Cenccr, Roberr M. Hutchins and Scott Huchanan sought advice for a l.uropcan coruribuiion from Aldous Huxley, who recommended Ellul, Merron and Buchanan endorscd the translation of rhe book ito English. {acqucs Hlul. *Tb« Tcchnoioeica! Society* (New York: Knopf 1963): Sratcmcnt from the publisher. Telephone interview with Mcl\'in Kranvbcl'g, August 31, 1990. Sec, f0l' the proceed ings of the Conference, the special issue of *Technology and Culture* (1963). Robcrr M. Hurchins was President and chairman of the Board of Fdirors of the *Briumnic«* fmlll 1947 until 1974 and president of the Ccmcr for the Study of Dcmocr.uic Institutions from 1954 until 1974. He had also been president of the University of Chicago between 1929 and 1945, as well as its chancellor from 1945 10 1953. *Proceedings of the Encyclopedia Britnnnica Conference on the Technological Order*, ed. Carl F. Srover (Dcrroir: Wayne Stare L niversity Press for the Society of the Hisrory of Technology. 1962).

t3 For a treatment of rhc historiographica] debate, sec John M. Staudenmaicr, S.)., *Technology's Storytellers: Reweaving the HIIman Fabric* ((.ambridge: MI['Press, 1985): Mark H, Rosc, "Science as an Idiomill the Domain of'Technology," *Science uild Jechnology Studies* S' 1(1987): 3-11; Arthur P, Molella and Nathan Reingold, "Theorists and Ingenious Mechanics: Joseph Henry Defines Science, *Science Studies* 3, (1973): 322-35; Ronald Kline, "Con.l Il'uing 'Technology' a1 'Applied Science'. I)ubUe Rhetoric of Scientists and Engineers in the Unired States, 1880-1945," *ISIS* 86 (1995): 194-221. For example, the engineer Vannevar Bush entiled his blueprint for government support for applied

research, *Science, The Endless Frontier: A Report to the President* (Washington, DC: Government Printing Office, 1945); Arrhur P. Molella, "The Museum That Might Have Been: The Smirhsonian's National Museum of Engineering and Industry, Technology and Culture," *Techno!ogy and Culture* 32, z, pr.T, (April. J99r) : 237-63,

14 This approach is most obvious in "Part Seven. Technology," *Propacdiu: Outline of Knowledge*, 265-97.

15 Sccley, "SHOT, the History of Technology and Engineering Education"; H, W. Lintsen and E. Homburg, "Tcchnickgcschicdenis in Nedcrland;' *Geschiedenis van de Teclmiel: in Ncderland. De wording van een moderne samcnleuing. 1800-1890* IV (Zutphen: Walburg Pcrs 1995), 255-66.

16 jan Zimmerman, *Once Upon the Futur« A Womtlll's Guide 10 Trnnorrou's Technology* (London: Pandora Press, 1986), Introducrion: Marrha Moorc Trcscorr, cd., *Dynamos and Virgins Revisited: Women and Technological Change* ill *History* (Mcuichcn, N]: Scarecrow Press, 1979); joan Rorhschild ed. *Mnchiu« Ex Dea: Feminist Perspectiveson Technology* (Xew York: Pcrgamon Press, 1983);]udirh A. McGaw, "Review Essay: \Xomcn and the History otArnerican Technology *Sigm* 7,4 (Summer 1982): 798-828.

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