The Chromium-Plated Tabulator: Institutionalizing an Electronic Revolution, 1954–1958

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The computer promised business of the 1950s an administrative revolution. What it delivered was data processing—a hybrid of new technology and existing punched card machines, people, and attitudes. The author examines how first-generation computers were sold and purchased, and describes the occupations (analyst, programmer, and operator) and departments that emerged around them. This illuminates claims of a more recent electronic revolution in business.

> In many organizations, data processing is looked upon as simply 'the old tabulating operation with chromium plating.'
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> —Richard G. Canning and Robert L. Sisson, *The Management of Data Processing*, 1967

The history of computing has had, as yet, remarkably little to say about the people who ordered and used computers, or of the purposes to which they were put. This has been particularly true of the use of computers in business, despite the insistence of historian and consultant James Cortada that "a quick look at how computers were used suggests that the history of the digital computer is every bit as much a business story as it is a tale of technological evolution."[1] My aim here is to follow that quick look with a more considered examination of the acquisition and usage of computers to give a new perspective on an established topic: the transition during the mid-1950s from electromechanical punched card technology to the first generation of electronic computers.

Work by historians such as Martin Campbell-Kelly, JoAnne Yates, and William Aspray has consistently shown that the computer industry was, more than anything else, a continuation of the pre-1945 office equipment industry—and in particular of the punched card machine industry.[2] Their careful exploration of computer technology and the dynamics of the computer hardware industry leave little doubt that IBM's eventual dominance of the computer industry owes as much to the events of the 1930s as to those of the 1960s. This is in itself a major departure from the perception, common during the 1950s and common today, that each new generation of computer equipment is a revolutionary technology without historical roots, a breakthrough plucked fully formed from the forehead of (to mix a metaphor) Prometheus.

The next stage in our exploration of the history of computing must take us beyond the suppliers of computer technology and into the firms and occupations using it. By examining the crucial initial shift from punched card to computer, in the context of historian Ruth Schwartz Cowan's "consumption junction" (the place where technology meets user), we find new dimensions of continuity and discontinuity in usage to complement those in technology, distribution, and production already explored by historians.[3]

This article examines the early use of computers for routine clerical and accounting jobs by large American corporations—an activity I refer to here as administrative computing, but which was firmly established by the late 1950s as data processing.[4] For several decades, such routine administrative work had dominated usage of the punched card machine, and, during the mid-1950s, this activity edged out scientific and technical computation as the primary function of electronic computers.

The first managerially oriented discussion of the computer's possibilities for business, a subject that peaked about 1954, presented it as a scientific marvel of electronic technology, poised to spark a "second industrial revolution" that would transform the office much as the

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first had transformed the industrial workshop. The postrevolutionary order would mark a sharp discontinuity with the past. But while the rhetoric of revolution continued to sweep the computer field at periodic intervals, it was rapidly eclipsed in practice by the conservative reality of data processing. Promoted by IBM and embraced by punched card staff, the concept of data processing included both administrative computing and conventional punched card work. It served both well, by reinforcing the continuing importance of punched card technology, and the organizational and professional continuities between the two kinds of machine. My emphasis is therefore on the construction of a new corporate institution—the data processing department—from a combination of the existing tabulating, and systems and procedures, functions.[5] By 1958, thousands of computers had been installed, and the shape of the data processing department had been largely standardized. It would change only slowly over the next 20 years. Alongside the new department came the occupational identity of the data processing worker, an identity that was itself a hybrid of new computer influences and old punched card culture.

I begin with the efforts made by computer salesmen and other computer enthusiasts to market the computer as a revolutionary technology in the world of industrial management, and examine how these ideas influenced the corporate committees set up to justify substantial investment in an unproven technology. I then explore the applications for which computers were most commonly used and compare the tasks performed by the "revolutionary" electronic marvels with those of a more mundane technology, punched card machines. I pay particular attention to the physical environments accorded to the two kinds of machine, and to the continuing reliance of computers on broader systems of punched card and other data processing technologies.

My focus then shifts to the origins of, and initial expectations for, the four main data processing tasks of operation, analysis, programming, and supervision. In each case, I explore continuities between these tasks and those involved in earlier work of tabulating, office management, and systems and procedures. Examination of various computer-related jobs shows how they were accommodated into the broader occupational identity of data processing, an occupation in which managerial orientation rather than technical excellence marked the professional. I conclude by reexamining the implications of these findings for the history of computing, and exploring the lessons we might draw by comparing this particular electronic revolution in business with the so-recently ballyhooed explosion of electronic commerce technologies over the Internet.

Selling a revolution …

Early managerial discussion of the computer treated it as an electronic marvel about to transform the world of business. Although experimental computers such as the ENIAC received a reasonable amount of publicity during the 1940s, businessmen would at first read little about them on the pages of *Fortune*, *Forbes*, or *Business Week*. These "giant electronic brains" were presented as scientific curiosities. From 1953 onward, however, the arrival of commercially available computers from Univac and IBM made the computer an object of professional concern for managers. At the same time, the computer manufacturers began a concerted push to "educate" management as to the value of their wares.

The object of discussion in the early 1950s was not so much the computer but the more general topics of "electronics for the office" or of automation. As consultant John M. Thesis informed an audience of cost accountants in 1954, "The word 'electronic' has become a 'buzz word' joining 'atomic' and 'space flight' in conveying the impression of scientific magic."[6] It was by no means apparent in the early 1950s that the stored-program, electronic, digital computer was the key electronic product. Initially, it seemed merely a representative of a much more general class of electronic technologies, which would replace humans in the performance of an ever-wider collection of tasks. Even in the managerial press, considerable credence was given to the imminent arrival of totally automated factories, triggering massive technological unemployment and fundamental social change. Thus the potential of electronics in business was frequently claimed to lie in its corresponding ability to automate many activities currently conducted by white-collar workers and managers. As Thesis remarked later in the same article, "Electronic data processing systems are now the highest form of mechanization available for business procedure applications."[6]

Edmund Berkeley, an actuarial methods expert turned computer evangelist, set the pace early on, in his 1949 classic *Giant Brains or Machines That Think*. Not only did Berkeley claim for the new machines a "power … very similar to the power of a brain," but he also launched a thousand confused misappropria-

tions of technological history with his suggestion that it would "take a load off men's minds as great as the load that printing took off men's writing."[7] A year later, the inaugural editorial of *Systems and Procedures Quarterly* suggested that future historians would view this "coming revolution in paperwork" as equal in magnitude to the earlier revolution in industrial production. The editorial writer, who was also the head of Shell Oil's Methods Department, continued his argument in a 1951 article in which he claimed that "[p]aper work may be entirely eliminated" by the automatic transmission of electronic impulses.[8]

Another article, published in 1953, extended this theme in a way that affords us a valuable insight into the role of revolutionary rhetoric in selling an unproven technology. Its author, W.B. Worthington (a systems expert then working for Hughes Aircraft), trumped even Berkeley's expectations with the claim that "The changes ahead appear to be similar in character but far beyond those effected by printing." If, as he suggested, "the ominous rumble you sense is the future coming at us," it could be assumed that any firm not agile enough to jump on board this noisy juggernaut was liable to be crushed by it. He revealed the kind of thinking that led aerospace firms like Hughes to be among the first to order a large electronic computer:

> It takes about five years for Mr. Management to get his feet on the ground in this field of application of electronics to administrative systems.... The first competitor in each industry to operate in milliseconds, at a fraction of his former overhead, is going to run rings around his competition. There aren't many businesses that can afford to take a chance on giving this fellow a five-year lead. Therefore, most of us have to start now, if we haven't started already.[9]

This argument illustrates one of the most remarkable continuities in the discussion of corporate computing. For a half century, enthusiasts have used the dazzle of microseconds and megahertz, joined more recently by the exponential curves of Moore's law, to argue that the unprecedented power of the latest revolutionary computer technologies is about to dictate a corresponding and almost effortless revolution in business. The only thing to do is to get out of its way, and maybe to employ their own services. Yet on the human level—the level of organizational structure, productivity statistics, and managerial practices—change has been at best evolutionary and invariably painful. Worthington's claims closely mirror those used by a more recent cohort of technology pushers to persuade firms to sink vast sums into unproven and immature technologies for electronic business. It is a timelessly powerful and seductive claim: The new technology will rapidly and fundamentally reshape your firm's competitive position, it will take years to fully implement, and it will confer insurmountable advantages on the first of your competitors to embrace it. As a result, there is no choice but to invest massively in this "disruptive technology"—anyone waiting to see how and if it works will be swept into the dustbin of business history by the insurgent competitors that really "get it."[10]

The computer moved rapidly from a subject of speculation among systems experts into an actual tool of corporate administration—bringing rhetoric of revolution into the mainstream of managerial discussion along with it. The *Harvard Business Review* had little time for understatement in 1954 when it published its first detailed article on the application of electronic computers to business. The article, a shameless piece of corporate self-promotion by General Electric, boasted of the firm's success in applying a Univac to automate its payroll production. GE's Univac was the first purchased by a private corporation and the first American computer of any kind to be installed primarily for corporate administration. This move, the editors opined, "may eventually be recorded by historians as the foundation of the second industrial revolution ...." According to the article, the computer could pay for itself by processing payroll for just 5,000 employees and running for two hours a day. Anything accomplished by the computer beyond that would go straight to GE's bottom line. The following year, another GE manager laid down the gauntlet to management in impassioned terms. Urging them to embrace the power of operations research and the computer to automate their decision making, he asked, "Isn't there a danger that our thought processes will be left in the horse-and-buggy stage while our operations are being run in the age of nucleonics, electronics, and jet propulsion?"[11]

The claim of revolution thus came in two conceptually distinct forms. One was the operations research or management science position that the computer would automate, optimize, and therefore revolutionize the organizational decision-making process. These arguments received early and powerful expression at a 1955 Harvard University conference, at which Herbert Simon, Russell Ackoff, and others explored the computer's potential as a

scientific tool to fundamentally reshape the practice of management. The title of a 1956 article, "Can You Afford the 'Practical' Approach to Electronics," captured the claims made for this approach. Its author, a consultant, argued against the apparently low-risk approach of using computers to gradually automate current processes while leaving the overall management structure intact. Instead, he warned, the potential of the "visionary" approach was so great that the true risk lay in evolutionary thinking.[12]

The other claim of revolution was in clerical cost reduction through the direct substitution of capital and electronics for clerks and mechanical devices. This more conservative idea of revolution required its adherents to argue that the associated cost savings were so huge that any hesitation in this area would be irresponsible. As one consultant put it, "The estimated savings have sounded almost unrealistic … if your company is not presently engaged in an electronics study program, is your reason good enough?" This view was backed by the influential and generally conservative Controllers Institute in its first evaluation of computing's economics. Its author, Frank Wallace, a partner with consulting firm Peat, Marwick, Mitchell & Co., explained to his penny-wise fellows that "unwarranted caution can deny a company a major instrument of competitive and financial leverage."[13]

These two distinct claims (clerical and managerial) of benefits that were too good to miss, and too urgent to defer, came together in a powerful way. Order a computer now, save a million dollars a year on clerical costs, and use its spare capacity to revolutionize management. Or prevaricate, and so sit out the second industrial revolution and be crushed by your competitors.[14]

… Buying a computer

For many companies this was an easy choice to make. Hundreds of computer installations were ordered long before the computer's economic value could be demonstrated. Contemporary estimates valued the hardware in a typical installation centered on a single large computer at $2 million—around $13 million in today's dollars. In 1955, IBM had installed only about 25 of its large 700-series computers, chiefly the 701 and 704 models intended for scientific and engineering calculations. Although the first of these had been supplied in 1953, the majority of these installations were still in the experimental stages. GE's pioneering Univac installation had garnered a spate of publicity in 1954. Yet, as Peter B. Laubach, part of a Harvard Business School group investigating administrative computing, admitted in a 1955 *Harvard Business Review* article, the "revolution … appears to be off to a faltering start. Too much was promised too fast, with the result that many businessmen have grown skeptical of the entire electronic data-processing field." Of the dozen or fewer computers at work on administration, accounting, and statistics for business, he estimated that no more than two or three were in full operation.[15]

An internal IBM market analysis, produced during February 1955, indicates the company's progress in introducing large computers for business administration. As the report's foreword noted, "Industry acceptance has been ever increasing, as evidenced by the many letters of interest received …." The orders, it continued, "seem to indicate a substantial market for machines of this capacity." By this point, IBM had already taken orders for 99 of its large, administratively oriented computers. The situation brought some comfort. But a question mark remained because so few of these machines had yet been delivered, almost none doing useful work. As the report noted, there was "very little actual experience, particularly on commercial accounting applications where the bulk of the potential lies, to substantiate their worth to the eventual user." It concluded that administrative computing had reached a turning point, at which "[t]he success of the entire program will undoubtedly rest on the success of the first few installations."[16]

Without any proven savings, and few functional installations, to order a computer was an act of pure faith in technology's transformative power. Even the bullish consultant Thesis had been obliged to concede that a manager looking for a demonstration would find "few examples to be seen. You probably cannot see a computer performing an operation similar to your own." Yet 1955 was a banner year for IBM, despite the firm's caution. As well as working its way through the fat order book for its 700-series machines, it began to deliver its medium-sized 650 machines. An average 650 system cost about $3,750 a month to rent (equivalent to a purchase price of about $200,000). Although it was a true electronic, programmable computer, it processed information much more slowly than the large machines of the 700 series and was designed to work closely with existing punched card machinery. It proved to be "computing's Model T"[17] —more than 1,100 were in use for business applications by 1958. Both the 700s and the 650 were first-generation

machines, reliant on bulky and unreliable vacuum tubes for their electronic capabilities. Other firms produced large computers (notably RCA and Univac) and small ones (Burroughs and Univac), but these fit the same general pattern as the IBM models and offered the same capabilities. Not until the end of the decade were all these first-generation machines rendered obsolete by a second computer generation of transistorized machines.[18]

In 1954 the computer was a revolutionary novelty; by 1958, several thousand had been installed. During the first four years of administrative computing, estimated annual shipments of computer hardware rose from $10 million to $250 million. Companies were ordering the machines faster than IBM could build them. New machines were normally announced a year or two before the first models were delivered. Even in 1958, a company would typically spend a year or two waiting for its newly ordered computer to arrive. Scarcity was an incentive for companies to gain a place in line by rushing in an order that could later be canceled or delayed. IBM granted preferential treatment to those firms that had placed an order, both in admission to its programmer training courses, and in the allocation of precious practice sessions on its own computers. This practice gave these firms a sporting chance of having some programs in a state of advanced development by the time the computer arrived, but it also made it hard to complete a thorough study without placing an order.[19]

How to sell a revolution? At least some of the eager new computer salesmen sought to bypass their traditional contacts in office management, punched card, or systems departments. In 1954, Dun's *Review and Modern Industry* hosted a roundtable discussion among representatives of office machine companies—whose candor was solicited by anonymity. The new technology, they confided, demanded a new approach, one to which their existing salesmen could not easily adapt. The salesmen had "to sell above normal channels. We've got to go to the top." Claimed one of the computer company executives: "We just will not talk to anybody below controller." Office managers, a traditional audience for the salesmen, had little clout. Even time spent cultivating the higher powered administrative "systems man" would likely prove wasted on discovery that "he has no power to purchase." Instead,

> [W]e try to use him as a bridgehead within an organization to get an opportunity to study and make a survey of that particular company's needs. Then we go back and make a proposal and try to see to it that the systems man, either as our ambassador or going with him, presents that proposal to the person who has authority to buy.

Along with this new audience went a new kind of pitch. Rather than selling individual machines, they asked instead "[d]on't you think that the office should be sold to management as a production unit like the machine shop?" To this end, one firm boasted that "We have stopped our salesmen using the word 'machines'; it's out of the vocabulary entirely …. That's shown last and talked about last, no matter what the application is …. If you sell the idea, then you've got the sale."[20]

How, and why, did so many companies choose to order such expensive and unproven machines? Clever salesmanship could not, in itself, explain why executives were willing to talk to computer salesmen, still less why they agreed to order a computer. Were the potential savings gained from replacing clerks and punched card machines with million-dollar computers so compelling as to render the wait-and-see approach more dangerous than the fools-rush-in philosophy? It seems unlikely. There is little evidence that companies that waited until, say, 1960 to install a computer suffered any negative results. So why did so many large, well-run companies manage to order so many computers before either the costs or the benefits were known? While scholars of the "new institutionalism" in organizational analysis have drawn attention to fads and herd behavior as powerful factors in spreading organizational features, this does not explain how momentum first gathered. After all, our impression of 1950s corporate management is one of conformity, conservatism, and inflexibility than a group willing to gamble millions of dollars on a whim.[21]

The answer lay in a ritual known as the feasibility study, used by businesses from the early days of administrative computing to investigate the computer's potential. This study wrapped a host of unknowns, unknowables, and hopeful guesses in the apparently rational language of financial analysis. Some of the earliest books and articles on the use of computers in business devoted themselves to examining how such a study should be conducted. My analysis here relies primarily on five book-length guides to the study of computing. Two were published by the Controllers Institute and written by consultants (one by Wallace, one by a Price Waterhouse team). Two were written by Richard G. Canning (author, consultant, and

publisher); the final one was written by the Harvard group's Peter B. Laubach.[22]

These authors agreed that the feasibility study should be rigorous; they included the comparison of machines from several manufacturers and identified potential areas for computer application. In a good study, they suggested, sufficient analysis and preliminary programming would be conducted to accurately judge how efficiently each possible computer model would run a given job, and how many hours each month it would take. Armed with this knowledge, a company could calculate how many clerks and punched card machines the computer would save once it was fully operational. This exercise would yield an estimate of the computer's benefits. The costs seemed easier to estimate—rental for the computer, the one-time costs of installation, analysis, and programming, plus the recurring costs of consumables (tapes and cards) and of computer department operators and supervisors. If the discounted benefits exceeded the costs, then the machine should be ordered.

On its face, this exercise appeared to place the installation of a computer on the same rational basis as the decision to invest in a new set of lathes or to build a warehouse. In practice, however, it was deeply flawed. Although some companies ordering these computers spent many man-years of effort learning about computer technology, the information needed to judge the computer's economic potential simply did not exist. Nobody knew what the cost of programming might turn out to be, whether obsolescence would be a serious problem, how to quantify the so-called "intangible benefits" of improved management, or whether the computer could cope with nonroutine activities. Pioneers had already discovered that the studies made by eager representatives of the computer manufacturers could not be taken seriously—these systems studies tended to underestimate everything from the floor space required to the complexity of the programs needed to undertake a task to the cost of converting data from manual methods.[23]

Estimates of how much computer time a program would need to run were sometimes off by a factor of ten. This meant that the computer would run fewer tasks and generate fewer benefits. The lack of available computer capacity made it almost impossible to write and run programs before making the commitment to order a computer. In addition, the expense of programming was massively underestimated. As late as 1956, it was often viewed as a one-time expense to be amortized over the life of the computer, rather than an ongoing and constantly increasing black hole in the budget.[24]

Another problematic aspect of any calculation was the computer's assumed life span, which determined the period over which the start-up costs of programming, conversion, installation, and training could be spread. In his well-researched 1956 book, *Office Work and Automation*, Howard S. Levin presented some return-on-investment figures, using estimates that represented the prevailing consensus. Levin showed that, while purchase (as opposed to rental) could be justified using accepted cost estimates and a 10-year assumed life span, "neither rental nor purchase is supported if we assume a five-year useful life for the computer system." Thus, even the optimistically low estimates of costs and high estimates of benefits in the mid-1950s could justify a computer's acquisition only if the computer were assumed to remain useful for substantially longer than five years. Punched card machinery, after all, was depreciated over 16 to 20 years according to IRS guidelines of the period—and none had yet been established for computer equipment.[25]

Benefits were just as hard to predict. The Controllers Institute study outlined a reasonable start to estimating clerical cost savings. A firm should chart its most important clerical costs and show the amount incurred performing each task. Then came the leap of faith—how much of this could the computer save? "It is obvious," wrote Wallace,

> that a computer could not replace all clerical costs. Therefore, the clerical costs must be higher than the cost of operating a computer. The art is not sufficiently advanced to give any rule of thumb indications of how much higher present clerical costs must be.[26]

Estimates of high cost savings were premised on the idea that all or most of the clerks could be eliminated after conversion was complete—what else could automation mean? Later studies found the actual potential for elimination to lie between zero and 25 percent of the existing clerical workforce in the area automated, although many firms claimed to have reduced the rate at which their clerical staff expanded. Existing clerical work was much less routine than had been assumed.[26]

The longer a company spent on its study, the more momentum built up behind the computer. Before it was ordered, still less installed, the computer gave office managers, and clerical systems and procedures experts, a means to increase their status in the eyes of their superi-

ors. The Harvard team, for example, documented several firms in which their role in the study led to a formal upgrading of such groups while the study was still in progress. Experts with a strong systems and procedures background were adamant that the study should produce figures on different options, including improved efficiency through better procedures or the improved use of conventional punched card equipment. All agreed, however, that the study team was far more likely to be charged with a "yes" or "no" answer to the question of computer acquisition than with an open-ended study of all possible technological, procedural, and organizational avenues for administrative improvement. Given this, the study was liable to become an exercise in the rationalization of a decision to acquire.

Case studies of processes used by actual companies showed that the ordering decision was usually made without detailed estimates of costs and savings, and certainly without the trial programming work that experts recommended. Canning, for example, confided that "Too often, the phrase is heard, 'We are going to use the XYZ machine but we're not just sure how we are going to use it.'" In those firms where initial interest came from top management—rather than from lower level accounting, systems and procedures, or tabulating personnel—purchase was still more likely to be authorized without detailed planning. Experts also accused firms of relying too closely on the estimates and studies provided by computer manufacturers.[27]

Study teams acquired a particular kind of bias. Their self-selected members had spent months or years immersing themselves in the exciting new world of computing, learning about hardware, writing sample programs, attending conferences, bonding with manufacturers' representatives, and hiring consultants. By the end of this process, they had begun to reorient their careers away from accountancy or office management and toward the emerging field of electronic data processing. Moreover, as a firm's computer experts, they could expect to wield considerable power within a new department if they recommended the acquisition of a computer. As John Dearden, a prominent skeptic, later observed:

> Management should recognize that the recommendation of the feasibility study will almost certainly be to acquire a computer and that it will be difficult, at that time, to override this recommendation. In fact, in many instances the only decision management really makes is to authorize an initial study. From the moment of authorization, the project develops momentum that is just about impossible to stop.[28]

Doing the same things, faster

Whatever the stated reason for ordering it, as the delivery date for a computer approached, the recipient had to choose specific tasks for it and undertake the necessary programming and conversion work. At this point, the wide-eyed enthusiasm, such as evinced by methods expert Berkeley and others intent on the computer's undergirding a new approach to managerial decision-making, was often displaced by the urgent need for the installed computer to do useful work immediately. This more pragmatic mind-set took hold, as word of difficulties spread and earlier language came to seem embarrassing. As the Harvard group concluded, "the so-called giant brains cannot think. Looked at in proper perspective, automatic data processing methods are merely an extension of present punched-card data-processing methods …."[29]

To cause a revolution, the computer would have to offer something businesses had been unable to achieve without it, whether an enormous reduction in clerical costs or a transformation of its operations. The evidence is clear that, typically, the administrative computers of the 1950s merely supplied what was already perfectly attainable with punched card machines or manual methods. The computer may have provided reports, totals, and other output more rapidly—and almost certainly at higher cost—than previous methods, but it did not substantially alter the domain of possible work.

In 1957, a survey conducted by the National Office Management Association found that half of the largest firms examined (those with more than 5,000 office workers) had already installed at least one large computer, such as the IBM 700 series. An additional 14 percent had ordered their first large machine but not yet received it. All these firms were still running conventional punched card installations alongside the new machine.[30] At this point, more computers were running engineering computations of one kind or another (56 percent) than payroll or inventory control (38 percent each), reflecting the early dominance of scientific over administrative computing. However, companies still awaiting delivery of their first computer were much less likely than the pioneers to have earmarked it for technical calculations, as the dominant corporate applications of large computers were already shifting from scientific and technical computation to administrative tasks. When asked about future intentions, 98 percent of the

firms already using computers either had inventory control programs running or planned to deploy them in the future, making this by far the most widely considered application.[31]

The purposes to which the new million-dollar electronic computers were applied bore a striking similarity to those already performed by punched card machines. One third of the overall sample were using punched card machines, in contrast to the 0.4 percent using large computers. The average punched card installation ran six different jobs on its machines. The three leading punched card applications were (in descending order) sales statistics, payroll, and inventory calculations—the same applications that dominated the computer's administrative use.

Why payroll? The payroll run had a number of attractive characteristics. It took place every week and was handled in the same manner on every occasion. It applied to the whole company yet seemed reasonably straightforward and routine. A large company had tens of thousands of people on its weekly payroll, ensuring a respectable volume, and the job required enough calculations to be highly time-consuming by manual methods. Tax, overtime, union dues, retirement benefits, vacations, and bonuses all had to be considered. Much of the complexity in the process came from legislative requirements, making it a process that would be around for some time to come and could not be eliminated by procedures improvements or organizational streamlining. But, in principle at least, it was not so complex and full of special cases requiring human judgment as to be impossible to automate by computer. Many companies had standardized and centralized payroll operations, reducing the chances of conflict with divisional managers. As we have seen, many firms were already using punched card machines in their payroll runs, meaning that much of the required data had already been coded into machine-readable form. Payroll stood as good a chance or better as any potential application to pay for itself through clerical savings.

The publicity given to GE's choice of payroll as the first application for its administrative Univac also directed attention of subsequent computer installations toward payroll. This led the Harvard report's authors to worry that influential "leader" firms might lead follower firms astray through blindly emulating their choices. Some observers, especially those with an orientation toward operations research or management theory, complained that to use such a powerful machine on such a mundane task was to squander its potential in making a significant difference to company management. But it was the similarity of payroll and other early computer applications to routine clerical tasks already performed by punched card machines (together with their potential for tangible job savings and the lack of upheaval to managerial culture) that made them so attractive. The Harvard team found that one of the firms it examined had made this choice quite deliberately. On the advice of a consultant with a punched card background, the firm had chosen to "mechanize the existing system. In his opinion, it was hard enough for existing clerical personnel to adapt to the process of mechanization without having to face changes in the system as well." Given the shambolic process by which many orders were placed, this attitude might have unavoidably affected companies, as they pondered the alternative of a computer sitting idle while management hired operations research specialists and haggled over politically charged corporate reorganizations.[32]

This conservative application of computer technology, as an extension of the punched card machine, triggered a rethinking of the role of punched card specialists in the new order of things. Early computer studies tended to downplay the importance of punched card experience when working with the new machines. The Harvard group advised those assembling study teams that the punched card people were likely to be inflexible and tied to outmoded thought patterns. As the group snidely put it, "company executives need have no concern if punched-card tabulating equipment men were not available to work on an automatic data processing project." In practice, however, continuity in the tasks to which the machines were applied was superficial—inside the new computer department were many of the people, attitudes, and occupational identities of the old tabulating group. It was the revolutionaries, not the punched card staff, who were most likely to feel out of place there.[33]

Life in the tab room

To understand the roles that eventually emerged for the punched card machine staff within America's new electronic data processing departments, we must explore the culture and work practices of the "tab room." By the 1950s, the corporate punched card department had been evolving for decades, but was still a relative novelty. Although the first punched card machines were used during the 1880s, it was not until the 1930s that the machines entered the mainstream of corporate adminis-

tration. Punched card technology advanced gradually over the intervening decades, producing machines that could print (as well as display numbers on dials), manipulate letters as well as numbers, and store more information on each card. It spread slowly from its early niches in actuarial and cost accounting applications into a host of others, such as billing and payroll. By the 1930s, IBM had begun to refer to them as accounting machines, signifying an attempt to reorient the machines toward the work performed by conventional bookkeeping machines and away from purely statistical tasks. Historians recognize the New Deal in the US as a turning point in the fortunes of the punched card machine industry, already dominated by IBM. Thanks in part to the massive number of machines supplied to the Social Security Administration from 1936 on, IBM doubled its revenues to finish the Depression as America's most profitable office machine company.[34]

Punched card machines were specialized to particular tasks. The tabulator was the central and most complex of these machines, but it could do little on its own. When appropriately wired, the tabulator could print reports based on the cards fed through it. These reports included totals, subtotals, headings, and textual information (such as names and addresses) from the cards. To include in these totals information from only some of the cards (say, those for a particular department or job code) required that the cards be run first through a different machine, known as a collator. The machine operator would then pick up the appropriate cards and carry them over to the tabulator. The card order was important. To list salaries, by department and then by job classification, required collating the cards into separate piles for each department and sorting each pile by job classification. Only then, when it sensed the department or job classification code changing, could a tabulator properly insert the appropriate totals and headings.

Even running a simple salary report required a functional installation to have at least three machines—one keypunch machine, a tabulating machine, and a sorter. Most installations also had a collator. The machine operators had to wire each one for the new task, then split the overall job into a series of steps in which they ran the cards through each machine and manually moved card stacks between them. Transferring information onto the cards in the first place required a keypunch (like a typewriter, but it put holes into cards rather than letters on paper). This operation was often repeated using another machine, a verifier, to ensure the initial input was correct. Keypunch, tabulator, sorter, and collator were just the most common kinds of machine—by the 1950s, IBM offered gang punches, interpreters (for printing text onto cards), reproducing punches, multipliers, calculating punches, and a number of hybrid machines. The most technologically advanced of these already included electronic components and could be configured with a measure of programmability.[35]

Renting these machines was not cheap, so a large and well-run department would try to schedule its jobs so that most machines were in use at any given time. Their use was labor-intensive. First, each machine had to have its control board specially wired for a given task (printing a report, copying certain parts of a card, or sorting by a certain field). Second, operators had to feed batches of cards in and out of each machine, deal with jams and other problems, and transfer cards between machines. Most punched card departments of the 1950s were small, probably employing a national median of fewer than 10 people. The largest companies, however, had enormous punched card departments. By 1951, Prudential Insurance already spent more than $1.6 million a year on salary alone for 600 tabulating staff spread among its 13 separate punched card installations, plus another $700,000 on key punching and verification.[36]

Punched card departments included two almost entirely separate classes of worker. Keypunching was a clerical job, and operators were invariably female. As in most other white-collar women's jobs, their most realistic avenue of advancement from this position was to oversee other women, in this case as a supervisor of keypunch operations. On average, two keypunch machines kept up with the work handled by one tabulator, though this ratio varied according to the type of work. The only change the computer made to keypunch work was to greatly increase its volume.

The other kind of role, typically known as a machine operator, was usually filled by men, particularly in the larger and more formally organized installations. The punched card machine operator was in essence a skilled craft worker. Although manufacturers offered short courses in punched card skills, most learned their trade on the job. Trainee machine operators carried cards between machines and ran the most routine jobs. As they progressed, they were more likely to be trusted with the execution of complex jobs and the wiring of machine panels. The most experienced operators were

charged with establishing wiring diagrams and procedures for new jobs, and supervising more junior employees. This progression remained standard practice well into the 1950s.[37]

Most punched card installation heads had worked their way up from machine operators. Few punched card groups enjoyed high organizational status—the heads of most installations were formally known as supervisors rather than managers. They often gained experience in large, frequently governmental, installations before accepting more senior posts in smaller, newly established departments. Few punched card staff members had college degrees, although almost all had graduated from high school. The rapid proliferation of punched card technology from the 1930s to the 1950s meant that openings were plentiful for the ambitious technician. This boom continued well after the computer was introduced. A 1958 survey of 42 installations in Oklahoma City found that most had been created since 1952, and that only one was more than 15 years old. In 1961, the US boasted more than 35,000 punched card installations. Not until 1962 did IBM's revenue from its computer activities finally overtake the continuing flow of rental income from its punched card business.[38]

Working the computer

This growth might have been assumed to offer a steady future to the punched card technician. But in 1953, Richard W. Sprague confronted his audience of punched card supervisors with the disturbing question, "Are punched card machines on the way out?" Sprague was in charge of applications and sales for Computer Research Corporation, then a small manufacturer of computers owned partially by the cash-register giant NCR. Sprague answered his own question with a qualified "yes." While he accorded the punched card itself a secure future as a medium for information exchange, he suggested that the traditional punched card machine was about to be cut down in its prime. Sprague's reasoning illuminates for us the power attributed to the computer at a singularly optimistic moment in its history. Electronic computers had been shown to work, and their commercial development was proceeding apace. The computer's potential was clear, but as yet unsullied by the practical frustrations and limitations that would emerge when the computer was applied to administrative problems. While Sprague's sales position gave him little incentive to express reservations, he had cofounded the company, and his address was marked by the unmistakable fervor of a true believer.[39]

According to Sprague, the computer's power lay not just in its speed or in its superiority to certain existing punched card machines, but in its power to replace the combination of humans, machines, and procedures that made up a punched card installation. He suggested that

> the electronic machine is capable … of performing automatically and with no human intervention not only all of the functions being accomplished by all of the card machines, but also all of the functions performed by all of the people involved in a punched card system up to and including the head of the department.

Sprague saw the replacement of the punched card staff as a boon to efficiency: "People drop cards, forget to pick up cards, get called away for something and let cards pile up, forget what they are supposed to do with them …" When listing the human foibles to which the computer would be immune, Sprague mentioned cigarettes, Cokes, pregnancy, resignation, psychological problems, and union membership. Furthermore, modifying a punched card operation or introducing a new one required retraining the operators of each kind of machinery and enduring a period of inefficiency and inaccuracy until the operators mastered the new job. A computer, however, could take a new program and run it perfectly every time.[40]

The flip side of this flexibility was that it took a great deal of work to program the computer to undertake a single, specific task. To achieve such automatic operation, the program had to perform the operations of the more specialized punched card machinery and also to replace the procedures, judgment, and exception and error handling formerly supplied by the machine operators. When Sprague wrote his article in 1953, almost no administrative tasks had yet been programmed. His expectations for the programmer were high:

> He can program in all of the sets of rules being followed by all of the present card machine operators, supervisors and department heads. He can include all of the exceptional cases that have occurred, and are likely to occur, and instruct the machine as to what to do about them. He can program the function of upper management in making decisions if he puts in all the possibilities.[41]

In reality, operators proved as essential to the smooth operation of the computer as they remained to the operation of the punched card machines running alongside it, though the

character of the job was rather different. Early computers did not have operating systems. Like punched card machines, their continued operation from minute to minute demanded constant attention from human operators, just like punched card machines. True, there was no need for an operator to rewire a control board in order to ready the computer to run a job. And, within a program, the computer could advance from one instruction to the next without waiting for the operator to pick up a pile of cards or flick a switch. But readying the computer to run a program and then shepherding the job to completion was not the effortless operation that Sprague promised. The most senior operators would schedule jobs and work the computer console, basically a large desk filled with switches. Tasks here included resetting the computer and configuring it for each job, loading programs into memory, restarting the computer after hardware or software errors (ideally, without losing all the work in progress), responding to errors raised by the application program, terminating a program that had malfunctioned, and supplying the programmer with clues needed to debug it. Tasks for the more junior operators included the mounting and de-mounting of tapes into drives, copying cards onto tape, sorting cards, configuring printers, and loading them with appropriate forms.

Sample 1956 staffing figures presented by Wallace's report for the Controllers Institute suggested that a large computer installation would require three operators per shift plus a chief operator and a tape librarian—a total of 11 operators for a three-shift, five-day-a-week computer operation. In contrast, only four programmers were budgeted for, which was likely a substantial underestimate. A 1957 survey of installations of the large, administratively oriented IBM 702 computer suggested that a typical installation might have a dozen tape drives, while Prudential Insurance had hooked up an impressive 19 to its computer. With two large printers and two card readers accompanying these machines, it's easy to see why so many people were required to work them. Despite the number of operators required, business computing literature of the late 1950s paid less attention to the problem of hiring operators than to hiring programmers because a convenient source of operators lay close at hand: punched card machine operators. As *Computing News* advised its readers in 1957: "As a rule, your good tab operators will make good EDPM [electronic data processing machinery] operators.... Your operators know their present jobs—a paycheck is still a paycheck, even when processed by EDPM. Through experience, they know the pitfalls and exceptions."[42]

Throughout the 1950s, computers were more likely to supplement than to supplant punched card systems. Even the medium-sized IBM 650 still relied on punched cards for input and output. The traditional assortment of sorters, collators, and tabulators worked alongside this electronic marvel. The first 650 models could not print without the intervention of a regular tabulating machine, and even the capability to handle alphabetical characters involved an optional upgrade. While nobody was in danger of mistaking a "large" computer, such as the Univac I or the IBM 702, for a mere tabulating machine, even these room-filling monsters were almost invariably used alongside punched card machines.

These machines were particularly important for input because there was no means of punching input data directly onto magnetic tape—the first such machine was produced only in 1965. No business computer of the 1950s allowed data entry directly into its internal memory from a keyboard; instead, all input was punched onto cards. Whenever a new job was converted for the computer, it required an army of keypunch operators to enter every account code or transaction record onto cards. Keypunch workers made up the majority of all data processing staff at most computer installations—outnumbering programmers, operators, analysts, and managers combined. Keypunching was exceptionally time-consuming—in the first textbook of administrative programming, Daniel D. McCracken noted that conversion could take more man-hours than everything else combined, while *Business Week* reported that an unnamed insurance company spent $12 million readying its files for the computer. Each record was often entered twice, to verify its accuracy. Consolidating existing files could require a great deal of computer time and special programming. Paper records themselves often contained many errors and inconsistencies, so although the "cleanup" mandated by a computer conversion could be rationalized as a long-term benefit, it was also difficult enough to cause many early efforts to overrun severely on both time and cost.[43]

Even once a job had been converted to the computer, punched card machines remained much better at some tasks, notably the sorting of records into a particular order. In a punched card system, each record had its own card. (For this reason, *unit record equipment* gained widespread use as a formal term for punched card equipment during the 1960s.) Sorting was

highly important in punched card or early computer routines, because neither machine could do much more than work on one record at a time. For example, to update account balances or print statements, it was necessary to sort all new transactions records in order of their account codes and then merge information on the latest transactions with information from the master account records. Sorting records on punched cards was easily accomplished by shuffling them into order. Because tape could not be cut into little pieces and strung back together in the right order, a sort required, minimally, two tape drives for reading and one for writing, a complex program, and many repetitions before the file was finally sorted. Coupled with the unreliability of early tape drives, the repetition was often enough to negate their raw advantage in terms of speed. Consequently, sorting the punched cards mechanically before transcribing them onto tape could be beneficial. As it struggled to improve its efficiency, GE's pioneering payroll effort was eventually forced to go one step further: It used three clerks to sort the paychecks after they were printed, rather than wasting hours of valuable machine time on the task.[44]

Sorting was perhaps the most common task where computers fell short. The sequential nature of tape storage meant that it was prohibitively slow for cases when a single record needed to be looked up—the computer might have to read through the entire file to find it. If the file was big enough to justify a computer, then it was too big for this search procedure to be cost-effective. Clever programming allowed such requests to be batched and combined with routine updates, but, even in the best case this meant that the information could not be retrieved until the next day. The only solution was for the computer to print out enormous report books, enabling the required detail or summary information to be looked up manually. Because these operating reports could easily reach a size that demanded the use of a handcart or small truck to deliver, this situation led to a great deal of interest in microfilm as a possible distribution mechanism for computerized reports.

Business computers of the 1950s were also unable to exchange data with each other directly or to drive remote terminals. To transmit information from a remote site for computer processing—for example, to send orders from sales offices to a warehouse, or time sheets from plants to the payroll office—a company required another set of intermediary technologies, known collectively as integrated data processing. The same forward-looking firms that flocked to the computer were also fitting their offices with communication systems such as pneumatic tube networks and centralized dictating systems. But the most versatile technology for data transmission was the five-track paper tape—a ticker tape punched with up to five holes across its width—widely promoted as a "common language" for the interchange of information between different kinds of office machines. It could transfer information from bookkeeping machines into punched card systems, or automatically operate specially adapted typewriters called Flexowriters.[45] Some firms tied punched tape readers to leased data lines and telegraph-style message forwarding to build their own national networks.

Throughout the 1950s, therefore, the computer remained just one technology in larger administrative systems, supplementing rather than replacing punched cards, paper tape, and multipart forms. Its symbiotic relationship with these technologies created many opportunities for people already familiar with them to shift into computer operations. Computerization created new demand for their skills, and in general this was a move up.

The shock of the new furniture

For the punch card staff who became operators of the new machines, the computer's arrival brought an immediate upgrade in status and organizational prominence, if not in formal authority. They moved, quite literally, upward into the light. Unlike punched card workers, who progressed gradually from the slavish execution of existing procedures to the design of new ones as their careers developed, computer operators were neither expected nor allowed to modify the programs that they ran. They might therefore be seen as (in the terminology of labor history) deskilled in relation to their predecessors. But, in practice, computer operators were better paid and more respected than punched card operators, if less well paid than programmers. In addition, their work was closely allied with programming and could become an avenue for upward mobility within the data processing department. Work as computer operators provided many punched card personnel with a bridge into the computer age.[46]

The useful punch card machine and its humdrum technology was an unlikely attraction for visiting dignitaries, although it stood at the apex of office machinery as one of the most complex mechanical devices ever to be mass-produced. Its thousands of parts, miles of wire, enormous speed, and formidable accuracy earned it a place

in the heart of the mechanically inclined. In its earlier years, it had itself been no stranger to hyperbole. But the spread of punched card technology had been so gradual that the machines' capabilities—and their limitations—were a matter of fact rather than fancy.

Nowhere was this difference more pronounced than in the physical environment of the two technologies. The tabulating department was a noisy, often uncomfortable place. The machines clanked and rat-tat-tatted as hundreds of cards per minute poured through them. Even those that did not punch new holes, such as sorters, made a racket as they read the cards and dropped them into different chutes. Duplicators and punches thrust rods in and out of the cards, and tabulators printed columns of results. The department was also likely to be hot much of the year—neither the impervious punched card machines nor their operators were likely to command the comforts of air conditioning. Punched card machine installations were also crowded. According to a contemporary survey, most installations were crammed into the "left-over space" of existing buildings, so that "the space is often overcrowded by the machine and operators have almost no room in which to maneuver." This was not an altogether white-collar environment. As one punched card veteran of the 1940s recalled, "When the weather got too hot (and after the women secretaries and control clerks left), we men would strip down to our shorts." On one occasion a sudden thunderstorm left many cards damp, after which they had to be ironed carefully before they could be read.[47]

If there is one aspect of corporate administration in which early computer installations truly launched a revolution, then it is an unexpected one: interior design. IBM apparently pioneered the design in 1948 with its SSEC, a one-off machine whose role served public relations more than anything else. It boasted flashing lights, glass panels, and a publicly accessible location on the ground floor of its world headquarters in midtown Manhattan.

Nomadic computer pioneer Herb Grosch took this aesthetic with him when he left IBM to head the first scientific computer installation at GE. Although the computer was originally slated for basement installation, Grosch soon had it housed in what he claimed to be the world's first specially designed computer building. Grosch chose futuristic Herman Miller office furniture, modernist design, large windows, and a carefully coordinated color scheme. The building's unveiling was part of an event attended by a host of senior GE and airline executives, IBM's leadership, and the top brass of the armed services. But while its wooden floors and tropical fish tanks impressed international visitors, they also attracted the ire of GE managers working in more dowdy surroundings (or, as Grosch put it, "my peers and their jealous minions"). Meanwhile, the gradual transfer of power within IBM between Tom Watson senior and junior led to a redoubled interest in industrial design in its regular product range. The result was IBM having its own prestigious showpiece 702 installation behind plate glass windows and on perpetual display to passersby.[48]

A distinctive architectural style developed, as firms maximized their computer room's visibility in the most literal sense, placing the computer behind huge plate glass windows and applying diffuse lighting to illuminate it against a brilliant white background. Throughout the 1950s, a large computer installation's novelty and symbolic modernity could be counted on to unleash a flood of upbeat local news stories about the newly installed giant brain. Whether or not the computer was yet doing useful work, it became the site of a Potemkin village of clattering printers, spinning tape drives, and flashing lights. Visitors and reporters could not judge the usefulness of what was being produced, still less its cost savings, so it was more important that the computer be seen to operate than that it improve managerial effectiveness.

After acquiring a Univac, the comptroller of Pacific Mutual Life went so far as to hire a full-time publicist to speak before local groups, conduct tours, and entertain the policyholders, agents, and international visitors who passed through the specially constructed viewing gallery. He was "convinced that our company has benefited from the publicity of having the first commercial installation of this type west of the Mississippi …." As late as 1960, a trade magazine reported with approval that, "A computer installation can have tremendous public relations value to a company. Attractive, long windowed corridors permit an unobstructed view for the visitor without interfering with the system …. The dull and drab grays and blacks, once the official colors of the machine accounting industry, have given way to the rainbow."[49]

While the fish tanks, glass windows, and designer furniture were of symbolic importance, the computer—because of its large numbers of temperamental electronic components—demanded a different environment than the punched card machine. Despite the improved surroundings, the vacuum tubes were prone to burn out unexpectedly, especially when the machine was switched on. Many companies got

their first taste of this with electronic punched card machines, such as the IBM 603 and 604. When a 604 was first installed, it might be turned off each weekend. After discovering that turning it back on usually caused a vacuum tube to fail, however, its operators realized that they should leave it powered up permanently. Such was their introduction to the electronic age. When computers arrived, things only got worse.[50]

The only thing that early computers could be relied on to do was break down, exemplified by the first scientific computer installed at GE, an IBM 701. During 1955, GE kept its computer turned on for 6,600 hours—paying the additional rent to IBM for a three-shift operation. About 1,400 hours of this was lost to maintenance (most of it scheduled). Unreliable electrostatic memory, used on the 701 and the administrative 702, was to blame for most of this downtime—within a year or two, the superior core memory of the 704 and 705 had reduced it dramatically.

Magnetic tapes were even more temperamental. Early users of the large IBM computers found that they needed to clean each tape twice daily to ensure reliability. Even the tape storage area had to be kept at carefully controlled levels of humidity and temperature. Tiny amounts of dust could wipe out data, meaning that a computer installation might require its own meticulous janitor. Although IBM engineers designed much more reliable models than their counterparts at Univac, even IBM drives functioned well only under a very narrow range of environmental conditions. Early users reported error rates of one per 2,000 records before the environmental conditions were adjusted and a suitable cleaning regimen introduced.[51]

A Univac I installation occupied around 2,500 square feet, and the 5,000 vacuum tubes in its central processing unit burned enough electricity to require a two-and-a-half-ton power supply. Cooling all this involved a system of internal water pipes and an air-conditioning system. Air conditioning was still novel for office use, and the equipment remained bulky and temperamental. As a magazine article reported, "For the average punched card installation these things were considered luxury, but for a computer system these are absolute necessities."[52] The mass of cables, pipes, and power lines demanded by the installation prompted most firms to install raised floors and false ceilings. These not only preserved the clean, modern look of the computer installation but also spread the enormous weight of the equipment more evenly and absorbed noise. Fitting this equipment into an existing building might require the temporary removal of a large part of a wall, the installation of many temperature and humidity monitors to ensure even airflow, the removal of existing sprinklers, the sealing of walls and floors to reduce dust, and the installation of expensive vinyl flooring.[53]

Systems analysis and flowcharting

While operation of the computer fell to the staff and supervisors of existing punched card departments, its application to administration problems was coordinated by a different figure: the systems analyst. The analyst was expected to serve as intermediary between the technical internals of the machine and the needs of different managerial and operational groups within the corporation. The primary tool of the systems analyst was the flowchart—a symbolic description of administrative procedures intended to provide an unambiguous description to guide their successful computerization. As one analyst wrote in 1957, "It is not too far amiss to think of the systems profession as stemming in large part from the development and refinement of the flowchart."[54] Yet neither the role of analyst nor the techniques of flowcharting originated with the computer. As a result, their relationship to the rest of the computer department was initially uncertain. Their tools and approaches sometimes had more to do with managerial aspirations than with the specific demands of early computer technology.

During the 1950s, a new occupational group was claiming specialist authority over the improvement of clerical procedures and the reorganization of interdepartmental systems of coordination. While the new specialists were given different titles, such as methods analyst or clerical procedures specialist, their preferred description of "systems man" was reflected in the name they gave to their association, the Systems and Procedures Association (SPA).[55] While many of the systems men used punched card machinery when instituting improved office procedures, they were careful to avoid undue association with office machinery. Their overriding concern was to be credited as truly managerial in their concerns and methods, rather than narrowly technical and machine oriented. In practice, the SPA functioned as a loose assemblage of specialists in obscure subjects like form design, work simplification, and procedure documentation. But its leaders were keen to recast these disparate activities as mere tools in the belt of the true generalist expert in administrative techniques.

Most of the articles written about computers for a managerial audience came from members of this broader systems community: from computer vendors eager to promote their own skills in systems work, from corporate systems men, or from consultant systems experts. Indeed, many prominent data processing experts switched repeatedly between these roles. These systems-oriented experts were keen to point out that computerization benefits would come more from the attention given to the rationalization and improvement of procedures in preparation for automation than from the computer itself. As a result, the idea that "quality systems analysis is the key" to real savings had become a cliché long before there were any real savings to examine.[56]

As experts on business procedure formalization and improvement, the systems men were assured an important place in the preparation for a computer's arrival. Among the most widely practiced duties of the systems and procedures department were the design of forms, the writing of procedures manuals, and the evaluation of office machinery. Systems men believed that their existing methods would prove sufficient for the computer. Indeed, adoption of the computer would trigger a massive boom in the business of documenting and redesigning clerical procedures. A 1957 survey of systems work observed that "the reorganization and organization of so many systems departments within the past decade has been kicked off primarily by rumors of what electronic data processing can do." Systems men were often involved in the ad hoc teams convened to perform feasibility studies to evaluate the computer's potential and select a suitable model. These teams became the nucleus of the new computer departments that grew up around the machines. But although many individual systems men were involved in administrative computing efforts from the beginning, the assimilation of systems work into the new computer department was a slow and uneven activity.[57]

Although different firms' organizational arrangements differed greatly, the systems and procedures department of the early 1950s was typically separate from the punched card department. Both departments usually grew out of a firm's accounting operations and, in most cases, remained under the corporate controller's authority. The systems and procedures department, however, held a mandate that was supposed to extend throughout the corporation's administrative activities. In contrast, the punched card department was machine oriented and inward looking, with its members identifying closely with their machinery. While they would work out appropriate machine routines to handle the jobs they were given, the staff typically had little say in designing the administrative systems their machines were to help process. Contemporary observers sometimes complained that this led to an uneven application of the machines. Jobs better handled manually or with a desk calculator were finding their way onto punched cards, while other jobs were performed manually because the responsible managers had little interest in punched cards. IBM salesmen usually had more experience in establishing machine procedures than punched card supervisors did, and so, guided by a cookbook of standardized methods, they often played a leading role in setting up new systems.

Most of the specific techniques that systems men used, and much of the framework they imposed on systems analysis, had been pioneered well before World War II. The biggest difference between systems men and the earlier office managers was not specific techniques but organizational position in a corporate staff department, separate from daily business activities or direct supervision of clerical workers. Around the turn of the century, expertise in systematization techniques was a hallmark of the modern and professional manager. As a specialist activity, its roots go back to the 1910s and the first attempts to constitute office management as a professional activity. The best known of the early office management enthusiasts, William Henry Leffingwell, was inspired by the work of Frederick W. Taylor to apply the methods of scientific management to the office. This involved carefully analyzing office routines, such as opening envelopes or writing letters, to simplify and standardize them. Leffingwell also pioneered the clerical application of flowcharting, in which the physical path of a form or letter through the office was charted together with all the operations performed on it. Although Leffingwell and his colleagues did not enjoy enormous success in having their ideas implemented, their work remained well known.[58]

As these techniques developed, the flowchart moved further away from its origins as a literal depiction of the physical flow of paper through an office. By the time Richard Neuschel wrote his 1950 *Streamlining Business Procedures*, the manifesto of the systems and procedures movement, a wide variety of charting techniques were in use. The layout flowchart—where document flows were superimposed on a drawing of the office—most closely resembled the origi-

nal. The popular vertical flowchart was much more schematic, using rows to show each step in a procedure and columns to show different kinds of activity—production, transportation, inspection, and filing. The more complex horizontal chart mixed organizational structure and clerical operations. By the 1930s, punched card equipment companies used flowcharts to illustrate the physical transfer of cards between different machines, the role of humans in providing inputs to the system and as machine operators, and the various files, forms, and printouts involved in machine operations.[59]

Flowcharts had already been applied to punched card operations by some of the larger and more organized punched card departments, which found it useful to produce charts at different levels of detail. An application flowchart showed a job's overall outline—how the original records and accounting transactions were combined to produce work files, report sheets, and so on. This was intended to communicate the purpose of a procedure to management in terms it could understand, by describing the "accounting job which a procedure accomplishes." In contrast, the operational flowcharts were more voluminous and dealt with "machine and clerical operations in their proper sequence and the movements of cards from operation to operation." Each step was numbered, and cross-linked to a written description for the machine operator. Such elaborate formal procedures were far from universal in the punched card world. Many punched card operations never bothered to diagram their control board wiring patterns and were content to leave elaborate procedures in the heads of the punched card staff.[60] The important thing, however, is that more formal techniques existed and could be adapted for use with computers.

Earlier flowcharts and written procedures, whether written for clerks, bookkeepers, or punched card machine operators, were invariably read and followed by humans, not by machines. Humans can tolerate ambiguity. Even the most detailed instructions written for human clerks do not begin to approach the crushing literalness required in those given to a computer. When an exception occurs—a case for which the standard procedure cannot be applied—then a human will be quick to ask a colleague or call for a supervisor. A clerk will notice when codes, amounts, or dates written on a form are missing or obviously incorrect. Should a clerk run out of paper or need to sharpen a pencil, the clerk resolves this hardware failure without undue problems. Clerks are also not forced to transcribe all information before reading it, or to squeeze both instructions and data into a few thousand characters of memory.

Systems analysis for the computer, however, came with its own set of problems. Most managers who ordered computers during the 1950s were aware that some effort would be needed to translate existing procedures into a form suitable for machine execution. But few grasped the enormous gulf separating a satisfactory clerical procedure from a computer program. It was often assumed that the systems analysis task would concern itself only with managerially oriented questions of policy and procedures; the work of translating flowcharts into computer programs was a lower status, and often entirely separate, activity. Thus, in many firms, the systems and procedures department remained a separate entity from the new computer department, and only programmers were given detailed instruction in the computer's workings.

Programming—The new task

As a corollary, the programmer's job was heavily circumscribed. The idea was that analysts could give high-level flowcharts showing overall runs and processes to programmers, who would fill in progressively lower level charts to create explicit block diagrams of program logic. At one company, the job was defined as follows: "The programmer is expected to take the broad flowcharts presented to him by the systems analysts and to develop the detailed flowcharts for the computer runs." The programming of administrative applications was constructed as an extension of the higher level and more managerially focused work of systems analysts, to bring their results closer to the form demanded by the computer. Most authorities of the 1950s did not consider the final translation of this detailed chart into instructions the computer could run as part of programming but as a third activity: coding.

Despite some early hopes that the programmer's labors would automate those of top management, the work of programming instead involved heroic efforts to make underpowered computers perform conceptually trivial administrative tasks with a modicum of efficiency. Even if the programmer did not physically interact with the computer's hardware, it was never far from his or her mind. Effective programming demanded clever sequencing of operations and juggling of resources similar to that practiced by a generation of punched card operators. For example, GE found that its elab-

orately charted payroll program, once converted to code, required 80,000 instructions and 36 hours to run.

Results such as this demonstrated the problems involved in treating analysis as a self-contained operation, performed without close attention to the details of the computer itself. As we have seen, the tiny internal memories of first-generation computers meant that a job like payroll was split into dozens of separate runs. During each run, a small program updated one or more of the master files or produced temporary working files to be processed further by the runs to follow. Some runs would do nothing more than sort or check data. The computer's efficient use demanded that the number of runs be kept to a minimum. It was the systems analyst's task to break a job into separate runs and sketch the requirements for each—yet without a strong background in programming's arcane details, it was impossible to judge exactly how much the computer could accomplish on each pass. In one case, attempts to handle all exceptions manually created a payroll program that required 90 separate runs to produce the weekly paychecks. Subtle variations in code quality could dramatically increase or decrease the feasibility of a particular overall structure.[61]

Because of the limitations of early machines and programming techniques, most of the administrative programs in the 1950s were written in low-level, machine-specific languages. The GE payroll program was coded directly into the form executed by the computer—all instructions were punched as a series of octal (base 8) numbers. Most computer installations soon adopted "automatic coding" techniques to assist in code preparation—including the use of symbolic assemblers to translate mnemonic codes into instructions, assign convenient labels to specific memory locations, and assemble various subroutines into a single executable program. But the notation had simply become a little more convenient—programmers were still in the business of writing each instruction that the computer would run. By the mid-1950s, the use of generalized routines to perform input and output, generate reports, and manage files was also well established. The highly constrained resources available to the programmer forced many computer installations to adopt rigid standards on things like memory organization, the means by which subroutines communicated with the main routines that called them, and even the tape drives to be used for specific purposes.[62]

Successful systems analysis work thus proved to require thorough consideration of programming and operations issues during design stages. But exposure to programming was no panacea. The very nature of programming work thrust one deep into the world of the machine and away from the administrative perspective on which analysts had prided themselves. This was a hard gulf to bridge. Some companies of the 1950s explicitly combined programming and analysis roles, or at least grouped both programmers and analysts into project teams rather than separate departments. However, through the 1950s and 1960s, programming and analysis remained notionally separate in most firms, with analysis always of higher status and better paid. Within data processing, the question of whether programming and analysis should be separate careers or different stages of a single career was widely debated. In practice, the business-oriented aspects of analysis were often neglected, as the title became a way of giving additional status and higher pay to someone whose job was really that of a programmer.

Programming's relationship to operation and coding was also unclear, although these boundaries were resolved more generally and appear to have been enforced more successfully. According to one consultant, when organizing a data processing department, "the fundamental number one rule is to keep the programmers out of the machine room." The separation of programming and operation duties occurred early in the history of administrative computing, although programmers were not always complete strangers to the computer's hardware. Many pioneers recall with pleasure the chance to operate the machines during their brief testing sessions with IBM's installations, a few months before their own computers arrived. In some companies, operators were given the same basic training as programmers. At least a few companies of the mid-1950s experimented by combining coding and operation. They viewed these two skills as complementary because both demanded an intimate knowledge of the computer's workings. Sometimes programmers gained access to the machine during the night, although most computers of the 1950s were leased from IBM, and running the computer for an extra shift added 50 percent to the cost of its lease. Companies using the smaller 650 computers were less likely to enforce a rigid separation between programming and operation.[63]

Despite early efforts to rigidly separate programming and coding, by the mid-1950s it was increasingly recognized that both activities should be performed by the same group of peo-

ple. One of the first detailed reports on computer use stated simply, "Experience indicated that the best programmers were also the best coders." Efficient coding proved vital to project success, and there was no way for the programmer to unambiguously communicate exactly what code was required without effectively doing the coding as well. Strict separation of coding was apparently rare in practice, despite its continuing presence as a job title in some firms and in the standard job descriptions issued by the US federal government.[64]

How did companies hire programmers and other computer staff? Early in the 1950s, as the first corporations ordered their Univacs and IBM 700-series machines, there could have been no more than a few hundred programmers working in America. Pioneering scientific and university computing installations supplied a trickle of intelligent and experienced programmers to industry, including many of those who headed application development efforts for computer manufacturers. Most business application programmers, however, had no previous programming experience or formal training other than a short course from the computer manufacturer. As Wallace reported in his early guide to computer acquisition,

> Usually, the computer team should be made up for the most part of men who know the company and its operations. Their backgrounds might be in tabulating, procedures work, accounting systems development, or industrial engineering …. [65]

In 1957 alone, IBM trained more than 14,000 people to prepare them for work as programmers. According to *Business Week*, most had no more than a high school diploma.[65]

Some experts with practical experience counseled that the benefits of having at least a department head or a chief programmer with computer experience would sufficiently outweigh the cost of hiring such people. But a consensus soon developed that it was easier to teach the fundamentals of programming to somebody who already knew something about business than to teach the culture of business to someone with programming experience in an unrelated area. The Harvard team examining computer acquisition policies reported that "Several executives said … it was easier to train an accountant to program than to train a programming expert in accounting …." These executives were likely parroting what they had heard from computer salesmen. This idea was easy for IBM to sell to managers, because it fitted their own assumptions that managerial knowledge of business is more valuable and harder to replicate than technical knowledge or skills. The idea also benefited IBM, since it assured potential customers that the terrible lack of programmers was not a problem. Instead, IBM supplied its Programmer Aptitude Test (basically a standard verbal reasoning and mathematical examination) and a short training course. Some companies offered all their white-collar employees a chance to take this test, while others recruited more narrowly from the accounting, systems, and punched card departments.[66]

Punched card machine + computer = Data processing

Programming, systems analysis, and operations were well established by the late 1950s as the three main tasks of the data processing department. The data processing manager was also responsible for a number of supervisors, and in most cases a group of keypunch operators, usually women. His department was typically responsible for punched card operations as well as computers. But how did the computer's administrative use become electronic data processing? This question can be addressed both literally (as a question of linguistic usage) and sociologically. Acceptance of the computer as a data processing device greatly strengthened the efforts of existing punched card supervisors to redefine their identities as data processing managers and to lay claim to the computer as their rightful domain.

Linguistically speaking, early computing was a mess. No term, from program to file, was so self-evident that it was not widely quibbled with, and usually for good reason. *Computer*, for example, was a confusing name. First, traditionally it referred to a person. Second, and more importantly, it referred to a person who performed scientific or technical calculations. As Robert Mauchly, one of the Univac's inventors, observed in 1953, "To call these devices computers is nowadays a misnomer…. 'automatic clerical equipment' would better describe what we are talking about." It would have made more sense to call the machine a clerk or an accountant than a computer. While *calculator*, IBM's original term for its "calculating punches" and the large 701 scientific computer, was well suited to these machines, it was equally unsuited to describe a machine used primarily for business applications. Tabulating machines had been known more formally by IBM as accounting machines since the 1930s, so *electronic accounting machine* fit the new electronic models, but was altogether an inadequate term to describe the larger devices. On

the other hand, *electronics*, as in "electronics for the office," was hopelessly vague.[67]

As we know, *computer* was the term that eventually triumphed. By the mid-1950s it was already widely used to describe administratively oriented machines, albeit with occasional reservations. What might not be apparent today is that during the 1950s and 1960s its use was somewhat colloquial. IBM's adoption of the term electronic data processing (EDP) to formally describe the new activity of business computing was one of the cleverest marketing moves in its history. Its masterstroke was to rename its existing punched card gear as data processing (DP) equipment. Just as the name shift from *tabulating equipment* to *accounting machines* in the 1930s reflected a symbolic broadening of the role of their products, so DP and EDP announced that the new machines were good for more than just accounting. More importantly, the nomenclature showed that computers and punched card machines were different flavors of the same thing and belonged together.[68]

IBM symbolized the unity of data processing through the retention of a standard numbering system for all its products. This gave rise to the "number soup" that makes reading any discussion of early computing a frustrating mess of 602As and 709s likely to baffle all but the most committed of readers. The uninitiated are liable to feel that they have inadvertently strayed into a corporate history of Levi Strauss's jeans. But how better to emphasize the continuum from the humble keypunch to the biggest computer than to quantify it as the difference between 024 and 705?[69]

The power of this approach was not lost on IBM's competitors. A 1957 study commissioned by Burroughs on its "corporate image planning and development" suggested that IBM had succeeded in using the data processing concept to gain a competitive edge on other office equipment firms. Burroughs was still the leader in adding, calculating, and bookkeeping machines and had acquired Electrodata as the foundation of its computer range. While an earlier 1953 study concluded that "IBM's technical monopoly was due to disappear rapidly" in switching to electronics, the consultants were now forced to report that the enemy had turned this new technology to its advantage:

> IBM has tended to use the term 'data processing' to designate the general area. This term, though unsatisfactory in many respects, has become generally accepted making it difficult for would-be competitors to define the field and their equipment in it in any other way.

The report urged Burroughs to follow IBM in offering a "stepped-up line of machines, proceeding from the least complex and inexpensive to the most complex and expensive." This should "be a 'data processing line' rather than a 'business machines line'." While IBM only began to unite its computer families technologically during the mid-1960s, with the famous System 360 range, it had already achieved a much broader semantic compatibility via the concept of data processing.[67]

Toward data processing management

What of the final category of data processing staff, the supervisors and departmental managers? The installation of thousands of computers meant the creation of thousands of supervisory jobs. For IBM, the definition of the computer as part of a larger, hybrid activity of data processing, rather than as a revolutionary departure from punched card methods, was a foundation on which it could marshal its existing dominance of the punched card industry to crush insurgents, such as RCA, GE, Philco, and Sylvania, with superior credentials in electronics. This evolutionary approach had equally profound, although perhaps less widely appreciated consequences for the punched card staff, who seized on the identity of data processing as an entry to the world of the computer.

As Thomas J. Watson Jr., the head of IBM, told his audience of punched card supervisors at their 1954 conference, "those with the best background for stepping into the 'electronic office' of the not too distant future [are] the managers of today's punched card installations." He reiterated this in 1958, challenging his audience to demonstrate the professional characteristics that their future in data processing demanded. Now, however, the generality of *electronics* had been replaced by the more clearly defined *data processing*. "[T]he very name that we have applied to our jobs—Data Processing," suggested Watson, implied a new focus on the provision "of relevant facts on a timely basis, on a basis equal or better than our business competitors. You will gain prestige and responsibility from the excellence of the facts, counsel, and advice that you supply." If they could "become more professional than ever before" then soon "top management will have begun to look for data processors to infiltrate into the very tops of their businesses."[70]

The deliberate attempts of punched card staff to construct data processing as a new occupation are most clearly evidenced through the transformation of the main association for senior punched card staff, the National Machine

Accountant's Association, into a "data processing" association and its attempts to certify data processing management as a professional field. Founded in 1951, the NMAA grew rapidly during the 1950s, passing the 10,000 member mark in 1957. Throughout the 1950s and 1960s, it was by far the biggest professional organization identified with the computing field. Its concern with business data processing was unchallenged by the scientifically oriented Association for Computing Machinery or the computer groups of the engineering societies (the Institute of Radio Engineers and American Institute of Electrical Engineers). Its explosive growth was partly a result of its federal structure—members joined individual chapters and were only indirectly members of the national association. But although policies differed somewhat between chapters, membership was generally available only to supervisors and managers of punched card installations rather than to the rank-and-file machine operators.

The association's strong punched card roots ensured its strength in the hybrid field of data processing. In 1962 the association adopted a new name: the Data Processing Management Association (DPMA). The name change ultimately expressed the evolutionary progression through which the new institutions of data processing formed around the older ones of tabulating. Here, as in individual firms, the transition was slow and incomplete. The association faced many obstacles in its quest to build a new profession, foremost being its own membership. Reformers within the DPMA saw the computer as something that could assist them in their continuing attempts to build a profession regarded as managerial rather than purely technical, focused more on systems than individual machines. But attempts to break with its past were thwarted or blunted seriously by the continuing power of older, more conservative, punched-card-oriented men. Change took place slowly—the adoption of a logo showing magnetic tape spools and punched cards side by side, the renaming of the association's journal from the machine-oriented *The Hopper* to the ambitiously broad *Journal of Machine Accounting, Data Processing, Systems, and Management*. Even the name change from machine accounting to data processing had been under consideration for six years before its final adoption. This was not a group fitted by temperament, abilities, or organizational mandate for leading a revolution.[71]

Work from the mid-1950s onward to improve data processing education, and so forge a recognized profession, culminated in 1962 with the introduction of the Certificate in Data Processing (CDP). Nowhere can the painfully slow evolution of data processing be more clearly seen. Reformers wanted to use the certificate to raise standards and attract more able young men into the field. Their goals had been strongly shaped by exposure to the corporate accounting profession, especially its managerial orientation and certification system. Yet enormous pressure was exerted within the association to make sure that it would be possible for at least some of the rank-and-file members of the association to receive the certificate—men who had no college education and had come to their supervisory posts from jobs as machine operators. If such men were not eligible for the certificate, and so were excluded from the new profession, then the association would be using their dues to underwrite the destruction of their own careers.[72]

The certificate was therefore an uneasy compromise. Caught between the need to include as many current members as possible and the conflicting requirement to raise professional standards, the certificate was unable to accomplish either. Most who eventually passed it were not members of the DPMA. But pressure from within the association ensured that the test remained easy, and plans to demand college training as a requirement were eventually dropped. This deterred the better educated outsiders that the test had been designed to attract. The CDP qualification never acquired critical mass, and few employers ever required or recommended that their staff attain it.

The NMAA's professionalization efforts illustrate both the domination of administrative computing departments by a relatively conservative group and the strong limitations this domination placed on the development of a more broad-based approach to corporate computing. The certificate enshrined two desired forms of social mobility for its holders, both geared to evolutionary development. The first allowed punched card supervisors to strengthen their professional credentials for the new age of electronic data processing. The second form reinforced the conceptual ladder of advancement in data processing that integrated different jobs in data processing departments as part of a single career trajectory. Punched card machine operators and computer programmers would aspire to achieve professional status by becoming supervisors and department heads, not by strengthening their craft skills. While business application programmers were data processors (although not at the professional

level), so were punched card machine operators, systems and procedures analysts, keypunch supervisors (if not keypunch operators), and data processing managers of all ranks. The certificate ensured that its holder knew something of all these areas—meaning that to qualify for it a programmer or punched card expert had, theoretically, to acquire a broader appreciation of data processing as a whole. Though the certificate itself was a failure, the vision it enshrined of administrative computing as part of the hybrid field of data processing remained dominant during the 1960s, and with it the influence of punched card culture.[73]

Data processing and the history of computing

In professional identity, as in other respects, ad hoc arrangements made during the mid-1950s proved remarkably persistent. The name, organizational location, occupational culture, internal structure, and corporate mandate of the data processing department had essentially standardized by 1958. It changed only slowly through the 1960s, despite the considerable expansion and proliferation of such departments and the deployment of two further generations of computer hardware. Yet, as we have seen, the data processing department's initial template came from a convergence of factors quite specific to the 1950s. These factors included the need for punched card equipment to work alongside computers, and the need to integrate formerly separate tabulating departments and analysis groups. Well into the 1970s, Electronic Data Processing remained the accepted name of the computer department. EDP was the subject to which textbooks, conferences, and journals on administrative computing were devoted, and the term adopted by administrative computing staff when defining their own identity.

Although it has sometimes been noted in passing that the administrative use of computers has been called electronic data processing for most of its history, few historians have seriously considered the data processing concept or its evolution. A history of data processing would look markedly different from the present-day history of computing. Particularly in its early days, the historical study of computing was oriented toward actual "computing." A more recent shift toward consideration of business matters has not yet triggered a rethinking of some of these old assumptions. For historians of technology in general, and of computing in particular, a sticking point has been the sheer magnitude of such a project. The use of computer technology in a particular social space (such as the laboratory, office, or factory) cannot be addressed without also studying the earlier history of this setting, the people in it, and the objectives to which the machine is put. So, while coherent one-volume histories of the computer hardware industry and its technologies can be written, it seems unlikely that we can produce a single coherent narrative about the use of computers or of associated tasks such as analysis, programming, or operation.[74]

Historians have also paid much less attention to analysts, supervisors, or operators than to programmers. The term programmer has sometimes been used to encompass the entire data processing staff. This may in part reflect the interests of early computer scientists, and more recent historians of science, in computing's scientific or theoretical aspects. Analysts, operators, and supervisors were irrelevant, from these perspectives, and even applications programmers did little work of note.[75]

The development of programming as a corporate occupation had much more to do with what the corporation was already like than it did with the scientists and mathematicians who programmed the first experimental computers. Programming was neither the most common data processing job, nor the best paid, nor the one held by managers and supervisors in the highest esteem. The data processing department was structured in accordance with the managerial conception that business knowledge was higher and more valuable than technical knowledge. (The boundaries between the two are arbitrary but powerful). The intimate rapport with machine demanded of a good programmer during the 1950s drew many programmers ever deeper into a specialized occupational subculture. Yet the data processing prestige ladder progressed upward from operator, to coder, to programmer, to analyst, to data processing manager and finally to general manager. At each stage, one moved ever further from the machine itself and gained ever more prestige and pay.

Of the four main data processing jobs (supervisor, analyst, programmer, operator), the programmer's was undoubtedly the biggest departure from the earlier practices of punched-card work. But even here, programming was initially viewed more as a redistribution of responsibilities previously split between operators and analysts than as a revolutionary departure. Managers preferred to view programming as a new activity that their existing staff could pick up than as a new profession. The corporate applications programmer has

historically been squeezed between the machine-oriented, craft knowledge of the machine operator (later the systems administrator) and the ostensibly business-oriented domain of the analyst. The new role was constructed on rickety foundations in space hurriedly cleared between these two much older occupations. The gulf between these domains has remained the most important stumbling block in the troubled history of administrative computing. Successive waves of facilities management, charge-back schemes, software packages, programming methodologies, end-user tools, outsourcing, and nontechnical CIOs (chief information officers) have failed to resolve it.

The male domination of corporate computer programming should not, in this context, be surprising. Jennifer S. Light has recently argued that "the job of programmer, perceived in recent years as masculine work, originated as feminized clerical labor." Whatever the merits of this argument with respect to ENIAC, the focus of her paper, it is clearly not viable in the context of corporate applications programming—the dominant programming activity from the mid-1950s on. Applications programming evolved at the fuzzy interface between punched card machine operation (a predominantly masculine activity) and systems and procedures analysis (an almost exclusively masculine one). The clerical job was that of keypunch operator—feminized in the punched card era, feminized after the computer arrived, and (as data entry clerk) feminized to this day. Given that few corporations relied on mathematicians as administrative programmers, the influence of human scientific "computers," whether male or female, on the culture of rank-and-file administrative applications programmers is marginal at best.[76]

No wonder, therefore, that nothing approaching a single community of computer professionals or programmers has ever existed in the US. Had the computer really been a revolution, had businesses rushed to adopt operations research and to use the computer primarily as a tool of managerial analysis and scientific calculation, then things might have been different. Perhaps computer staff might have rushed to embrace a fundamentally new identity, premised on computer science, or software engineering, or management science. This is not what happened. While the Systems and Procedures Association provided a separate identity to analysts, not until the end of the 1960s was there a serious attempt to organize a separate association for computer programmers, to promote programming as a profession in its own right, or to offer certification in programming. It was not until the 1970s and the surge of interest in software engineering concepts that any serious attempt was made to develop a more technically rigorous yet theoretically grounded alternative to data processing as a professional identity for the ambitious applications programmer. Even today, relatively few practicing administrative programmers would identify themselves as software engineers or computer scientists, or hold degrees in these fields.[77]

Revolution revisited

When we consider how computers were purchased and used, rather than how they were built and sold, we see a gradual evolution alongside continuing expectations of a looming and revolutionary shift. The seemingly revolutionary technology of computing had, within a few short years of its introduction, been brought down to earth and contained within the fundamentally evolutionary corporate institution of the data processing department. What began as a panacea became a placebo, as technological upheaval substituted for managerial reorganization.

The gulf between revolutionary dreams and incremental realities was not lost on contemporary observers. In 1967, a decade after the publication of his first books, Canning could still report that computers were used primarily to automate individual tasks. He also reported that most data processing staff had little more professional background than a couple weeks' training from IBM, and that "data processing is looked upon as simply 'the old tabulating operation with chromium plating.'" Few programmers were interested in professional education or learning more about business. In practice, the "data processing department has usually remained at the same organizational level as the tabulating operation—at either the fourth or fifth level" and somewhere under the controller. Canning reported that in some firms the tabulating department had absorbed the "systems and procedures" group, while in others the reverse had taken place, but that resulting hybrid had so far failed to achieve what he still considered its manifest destiny and "elbow its way up the ladder."[78]

Canning remained confident that this situation was about to change in favor of a more integrated, management-science-oriented approach and a higher level of top management involvement, thus illustrating a strange but remarkably enduring feature of corporate computing. Following a pattern already well estab-

lished during the 1950s, throughout the subsequent four decades most discussion of the current state of administrative computing practice has been remarkably critical of its failure to fulfill its promise. A 1958 *Business Week* report discussed in detail the serious problems that firms were having in making computers pay off economically and the highly conservative way in which they were being used. Not once during this saga of disasters and broken promises did the reporter's faith in the computer falter. Criticism, however scathing, of current usage became a means of protecting the dream. If computers could be used correctly, then problems would evaporate. Consider its opening:

> Just four years ago, at Louisville, Kentucky, a new industrial revolution started .... it has become perhaps a most perplexing and disgruntled—but inevitable—revolution. It's perplexing because industry, which has adopted the marvelously complex electronic computers with an almost religious fervor, often seems unsure of what to do with them after it has them. It's disgruntled, because early results have fallen far short of the rosy dreams in which they came wrapped. Yet it's inevitable, because the computers still hold the key to new systems of organization for the sprawling giants of industry, commerce, and government ...[79]

These new systems of organization continue to tantalize. During the recent "new economy" years, business travelers were unable to turn on CNN or open a magazine without encountering commercials for a new Internet service, communications tool, or personal computer product that will shatter corporate orthodoxy and put the viewer back in control. Yet recent claims for the revolutionary nature of computing products stemmed largely from their promise to liberate us from centralized computing facilities associated with the IBM mainframe—the self-same technology that was originally destined to usher in the revolution.

It is now 40 years since these once-precious first-generation machines were taken from their glass-fronted, air-conditioned, meticulously clean showpiece installations and rehoused unceremoniously in dumpsters. In hindsight, did the computer bring a second industrial revolution (or a third, depending on how you count)? Nothing in economic figures from 1955 to 1995 suggests that an industrial revolution occurred in the office during this period. Companies did not massively slash their clerical or administrative work forces. Administrative productivity increases continued to lag those in other sectors. Even before first-generation computers were obsolete, it was a truism that most administrative computing installations cost far more than they currently saved. Assuredly, these particular computers did not usher in a revolution—as for their distant descendents, the jury is still out.[80]

It seems unlikely that there ever was, or will be, a generally applicable administrative technology that is truly revolutionary in the sense used to sell first-generation computers, management information systems, e-commerce systems, and many other electronic tools—a technology that changes business rules so rapidly and fundamentally that to wait for proven results before applying it is to flirt with disaster. We can readily document new products or production technologies that so quickly become so important in particular industries that failure to swiftly adopt them would prove disastrous. Think, for example, of the successive waves of rapid technological advancement that affect the manufacturers of computer parts such as disk drives or processors. But the incremental advantages provided by even the most important administrative technologies have rarely been compelling or proprietary enough to reward those early-adopter companies that rush in to pioneer new techniques at their own expense.

Corporations have usually had cause to regret their periodic excursions to the "bleeding edge" of administrative technology. However great the apparent potential, it has been wiser to learn from the mistakes of others—thus far at least, every important advance has been debugged and packaged long before failure to adopt it would have spelled commercial disaster. The genius of the computer revolutionaries has been in their ability to blur this fairly obvious distinction between universally applicable administrative technologies and industry-specific technologies of production and distribution. Again and again, they have sold the claim that here is a technology simultaneously "disruptive" in a fundamental way (that is, its adoption compels an organizational paradigm shift), offers a sustainable and proprietary competitive advantage to its early adopters, and applies to the core managerial or administrative concerns of every business. When faced with such a technology, to wait for widespread and sustainable results—as opposed to a few vague but widely circulated claims of spectacular success—would be irresponsible. If such a technology exists, we can now state with confidence, it was not the computer.[81]

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References and notes

1. The need to examine the usage of computers is a major theme of J.W. Cortada, *Information Technology as Business History: Issues in the History and Management of Computers*, Greenwood Press, Westport, Conn., 1996. The quotation is from p. 160. See also P.N. Edwards, "Making History: New Directions in Computer Historiography," *IEEE Annals of the History of Computing*, vol. 23, no. 1, Jan.–Mar. 2001, pp. 85-87. One exception to the general lack of attention to use has been the work of JoAnne Yates; see particularly J. Yates, "Co-evolution of Information-Processing Technology and Use: Interaction between the Life Insurance and Tabulating Industries," *Business History Rev.*, vol. 67, no. 1, Spring 1993, pp. 1-51 and J. Yates, "Early Interactions between the Life Insurance and Computer Industries: The Prudential's Edmund C. Berkeley," *IEEE Annals of the History of Computing*, vol. 19, no. 3, July–Sept. 1997, pp. 60-73. Yates argues that the demands of user organizations played an important part in shaping the hardware of punched card machines and early computers. For a first-hand account of the challenges involved in constructing the first administrative computing installation (one facing the additional challenge of building its own computer), see J. Aris, "Inventing Systems Engineering," *IEEE Annals of the History of Computing*, vol. 22, no. 3, July–Sept., 2000, pp. 4-15. For an excellent and historically informed overview of changes in the development of computer application systems, see A.L. Friedman and D.S. Cornford, *Computer Systems Development: History, Organization and Implementation*, John Wiley & Sons, New York, 1989. The corporate use of computers from 1960 onward is discussed in R.L. Nolan, "Information Technology Management since 1960," in *A Nation Transformed by Information: How Information has Shaped the United States from Colonial Times to the Present*, A.D. Chandler and J.W. Cortada, eds., Oxford Univ. Press, New York, 2000, pp. 217-256, while a set of historical case studies are presented in J.L. McKenney, D.C. Copeland, and R.O. Mason, *Waves of Change: Business Evolution through Information Technology*, Harvard Business School Press, Boston, 1995, and, for the Dutch case, D. de Wit, *The Shaping of Automation: A Historical Analysis of the Interaction between Technology and Organization, 1950–1985*, Verloren, Hilversum, Netherlands, 1994.
2. The evolutionary progression from punched card technologies to electronic computers is a major theme of M. Campbell-Kelly and W. Aspray, *Computer: A History of the Information Machine*, Basic Books, New York, 1996; J. Cortada, *Before the Computer: IBM, Burroughs, and Remington Rand and the Industry They Created, 1865–1956*, Princeton Univ. Press, Princeton, N.J., 1993; and J. Cortada, *The Computer in the United States: From Laboratory to Market, 1930–1960*, M.E. Sharpe, Armonk, N.Y., 1993.
3. R.S. Cowan, "The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology," in *The Social Construction of Technological Systems*, W.E. Bijker, T. Pinch, and T.P. Hughes, eds., MIT Press, Cambridge, Mass., 1987, pp. 261-280. The classic examination of the concept of computer revolution remains L. Winner's "Mythinformation in the High-Tech Era," in *Computers in the Human Context*, T. Forester, ed., MIT Press, Cambridge, Mass., 1991, pp. 82-132.
4. What I call administrative computing is more generally known as business computing. During the 1950s and 1960s, it was frequently distinguished from scientific computing—the use of computers to automate scientific and engineering calculations, and for purposes of modeling and simulation. The latter was sometimes also known as technical computing. The reason I use *administrative* rather than *business* or *commercial* is one of precision—much scientific computing took place within aerospace and other engineering companies, while a great deal of administrative computing took place within government and military institutions.
5. The concept of a social institution is important, implying that when senior managers establish new departments, evaluate their success, and determine their organizational position they do so primarily with reference to the prevailing consensus on what is appropriate. Thus the process by which a particular organizational form (like a new department or function) comes to enjoy widespread acceptance is only indirectly determined by objective experimentation in individual firms, and different firms come to look more and more alike. See W.W. Powell and P.J. DiMaggio, *The New Institutionalism in Organizational Analysis*, Univ. of Chicago Press, Chicago, 1991.
6. J.M. Thesis, "Practical Application of Electronic Equipment," *J. Machine Accounting*, vol. 6, no. 3, Mar. 1955, pp. 5, 7-8, 16-17, reprinted from the August 1954 issue of the *Nat'l Assoc. Cost Accoun-*

tants Bull. The term automation was coined within Ford during the late 1940s, but only became widely known following its tireless promotion by consulting prodigy John Diebold during the early 1950s. See J. Diebold, "Automation—The New Technology," *Harvard Business Rev.*, vol. 31, no. 6, Nov.–Dec. 1953, pp. 63-71.

7. E.C. Berkeley, *Giant Brains or Machines That Think*, John Wiley & Sons, New York, p. vii.
8. J.W. Haslett, "The Coming Revolution in Paperwork," *Systems and Procedures Quarterly*, vol. 1, no. 1, Mar. 1950, p. 1, and J.W. Haslett, "Is the Modern Office Vanishing?," *Systems and Procedures Quarterly*, vol. 2, no. 2, June 1951, pp. 11-13.
9. W.B. Worthington, "Application of Electronics to Administrative Systems," *Systems and Procedures Quarterly*, vol. 4, no. 1, Feb. 1953, pp. 8-14.
10. Modern consultants call this the fear factor, pointing out to executives that their companies have lots of money but little time, and so it would be wise to part with a lot of the former to gain a little of the latter. As a best-selling business book published in 2000 claimed, things moved so fast in the Internet age that to adopt the "fast follower" tactic of adopting only proven approaches was enormously irresponsible. In this argument, the lack of demonstrated savings or debugged systems is actually a selling point. See P. Evans and T.S. Wurster, *Blown to Bits: How the New Economics of Information Transforms Strategy*, Harvard Business School Press, Boston, 2000. For discussion of the mass hysteria whereby investors threw money at startups without clear projected profits or even revenue streams, and established companies threw money into creating unviable spin-offs to stave off their challenge, see A. Harmon, "What Have E-Consultants Wrought?," in the *New York Times*, 13 May 2001, p. 1.
11. R.F. Osborn, "GE and UNIVAC: Harnessing the High-Speed Computer," *Harvard Business Rev.*, vol. 32, no. 4, July–Aug. 1954, pp. 99-107; M.L. Hurni, "Decision Making in the Age of Automation," *Harvard Business Rev.*, vol. 33, no. 5, Sept./Oct. 1955, pp. 49-58.
12. R.L. Ackoff, "Operations Research—Its Relationship to Data Processing," *Proc. Automatic Data Processing Conf.*, Graduate School of Business Administration, Harvard Univ., Boston, 1955; R.R. Ross, "Can You Afford the 'Practical' Approach to Electronics?" *Management Methods,* Nov. 1956, pp. 36-37, 56. This thinking reached its zenith in the celebrated H.J. Leavitt and T. L. Whisler article, "Management in the 1980s," *Harvard Business Rev.*, vol. 36, no. 6, Nov.–Dec. 1958, pp. 41-48.
13. F. Wallace, *Appraising the Economics of Electronic Computers: An Approach for a Company to Determine the Feasibility of Acquiring a Computer*, Controllership Foundation, New York, 1956, p. 50.
14. V.F. Blank, "Electronics—Possibilities and Limitations," *Systems and Procedures Quarterly*, vol. 6, no. 3, Aug. 1955, pp. 8-15.
15. P.B. Laubach and L.E. Thompson, "Electronic Computers: A Progress Report," *Harvard Business Rev.*, vol. 33, no. 2, Mar.–Apr. 1955, pp. 120-128.
16. J.W. LaForte, *Market Analysis—Electronic Data Processing Machines Types 702-703-705*, Feb. 1955, Cuthbert C. Hurd Papers (CBI 95), Charles Babbage Inst. (hereafter CBI), Univ. of Minnesota, Minneapolis.
17. T. Watson Jr. and P. Petre, *Father, Son & Co: My Life at IBM and Beyond*, Bantam, New York, 1990, p. 244.
18. For the technical and business history of first-generation computing, see C.J. Bashe et al., *IBM's Early Computers*, MIT Press, Cambridge, Mass., 1986; M. Campbell-Kelly and W. Aspray, *Computer: A History of the Information Machine*, Basic Books, New York, 1996, pp. 105-130; P.E. Ceruzzi, *A History of Modern Computing*, MIT Press, Cambridge, Mass., 1998, pp. 13-78. For contemporary descriptions of two of the era's most important administrative computers, see C.J. Bashe, W. Bucholz, and N. Rochester, "The IBM Type 702: An Electronic Data Processing Machine for Business," *J. Assoc. Computing Machinery*, vol. 1, no. 1, Oct. 1954, pp. 149-169; F.E. Hamilton and E.C. Kubie, "The IBM Magnetic Drum Calculator Type 650," *J. Assoc. Computing Machinery*, vol. 1, no. 1 pp. 13-20.
19. Figures on shipment value are taken from J.W. Cortada, *Information Technology as Business History: Issues in the History and Management of Computers*, Greenwood Press, Westport, Conn., 1996, in which they are attributed to a 1974 International Data Corporation report. For order backlog figures and average rental and purchase costs, see the early computer census included in R.H. Brown, *Office Automation: A Handbook on Automatic Data Processing*, 1959, Market and Product Reports Collection (CBI 55), CBI. For a discussion of the experience of a preinstallation practice session, see R.E. Porter, "First Encounter with the 701," *Annals of the History of Computing*, vol. 5, no. 2, Apr.–June 1983, pp. 202-204. On the difficulty of completing a thorough study without ordering a computer, see P.B. Laubach, *Company Investigations of Automatic Data Processing*, Graduate School of Business Administration, Harvard Univ., Boston, 1957.
20. "The Office Equipment Industry: They Sell Answers to Problems that Executives Don't Know Exist," *Dun's Rev. and Modern Industry*, vol. 64, no. 3, Sept. 1954, pp. 101-119.
21. The classic examination of organizational mimicry is P.J. DiMaggio and W.W. Powell, "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields,"

American Sociological Rev., vol. 48, no. 2, Apr. 1983, pp. 147-160. For an examination of the dynamics of managerial fads, structured around the concept of the "management-knowledge entrepreneur," see E. Abrahmson and G. Fairchild, "Management Fashion: Lifecycles, Triggers, and Collective Learning Processes," *Administrative Science Quarterly*, vol. 44, no. 4, Dec. 1999, pp. 708-740.

22. The books referred to are, respectively, F. Wallace, *Appraising the Economics of Electronic Computers: An Approach for a Company to Determine the Feasibility of Acquiring a Computer*, Controllership Foundation, New York, 1956; B. Conway, J. Gibbons, and D.E. Watts, *Business Experience with Electronic Computers: A Synthesis of What Has Been Learned from Electronic Data Processing Installations*, Controllers Inst. Research Foundation, New York, 1959; R.G. Canning, *Electronic Data Processing for Business and Industry*, John Wiley & Sons, New York, 1956; R.G. Canning, *Installing Electronic Data Processing Systems*, John Wiley & Sons, New York, 1957; and P.B. Laubach, *Company Investigations of Automatic Data Processing*, Graduate School of Business Administration, Harvard Univ., Boston, 1957. An initial version of the latter appeared in article form as P.B. Laubach and L.E. Thompson, "Electronic Computers: A Progress Report," *Harvard Business Rev.*, vol. 33, no. 2, Mar.–Apr. 1955, pp. 120-128.
23. An enormous amount of work is conducted within large organizations to hide the true causes of the adoption of new technology (often located in organizational politics, emotion, and occupational subculture) and to present it as the result of a rational process of cost-benefit analysis originating at the top of the managerial hierarchy. For a theory of this process grounded in ethnographic case studies, see R.J. Thomas, *What Machines Can't Do: Politics and Technology in the Industrial Enterprise*, Univ. California Press, Berkeley, 1994.
24. F. Wallace, *Appraising the Economics*, 1956, p. 47 and 65.
25. H.S. Levin, *Office Work and Automation*, John Wiley & Sons, New York, 1956, p. 95. His opinions echo those of J.M. Thesis and R.E. Slater, "What Management Has 'Discovered' about Computers," *J. Machine Accounting*, vol. 6, no. 7, July–Aug. 1955, p. 24. On the depreciation of punched card equipment, see D.C. Niles, "Purchase versus Rental of Data Processing Equipment," *Systems and Procedures*, vol. 8, no. 1, Feb. 1957, p. 28. The topic became much more important around this date, as IBM was forced on antitrust grounds to offer purchase as well as rental options. Experts continued to discount the importance of obsolescence even after transistorized models had been announced and disk drives were becoming common. See N.J. Dean, "Computer Installation—Will It Pay To Wait?," *The Management Rev.*, vol. 49, no. 3, Mar. 1960, p. 25, and J.H. Dillon, *Data Processing in Navy Management Information Systems, SecNavInst. P 10462.7*, Dept. of the Navy, Washington, D.C., 1959, p. V-9.
26. F. Wallace, *Appraising the Economics*, 1956, p. 21. The difficulty in achieving projected savings was already apparent—see P.B. Laubach and L.E. Thompson, "Electronic Computers: A Progress Report," *Harvard Business Rev.*, vol. 33, no. 2, Mar.–Apr. 1955, p. 125.
27. R.G. Canning, "Planning for the Arrival of Electronic Data Processing," *J. Machine Accounting*, vol. 7, no. 1, Jan. 1956, pp. 22-23, 30. For case studies of actual companies, see P.B. Laubach, *Company Investigations of Automatic Data Processing*, Graduate School of Business Administration, Harvard Univ., Boston, 1957, pp. 29-121.
28. J. Dearden and F.W. McFarlan, *Management Information Systems: Text and Cases*, Richard D. Irwin Inc., Homewood, Ill., 1966, p. 23.
29. P.B. Laubach, *Company Investigations of Automatic Data Processing*, Graduate School of Business Administration, Harvard Univ., Boston, 1957, p. 3.
30. A full decade later, a leading trade publication could still report that "experience has established that the installation of a computer does not obviate the need for punched card systems. In fact, the opposite may often be true," in "The Indispensable Card Machines," *Business Automation*, vol. 14, no. 1, January 1967, pp. 37-39.
31. *Automation in the Office*, Nat'l Office Management Assoc., Willow Grove, Pa., 1957. These findings are broadly in agreement with the results Cortada recently achieved by examining the frequency of discussion of particular applications in the computing and specialist business press of the era. See J.W. Cortada, "Using Textual Demographics to Understand Computer Use: 1950–1990," *IEEE Annals of the History of Computing*, vol. 23, no. 1, Jan.–Mar. 2001, pp. 34-56.
32. The precise quotation is from a case study of an unnamed shoe company in P.B. Laubach, *Company Investigations of Automatic Data Processing*, Graduate School of Business Administration, Harvard Univ., Boston, 1957, p. 126. The Harvard team gave the same firm's computer planning exercise a book-length treatment in E.L. Wallace, *Management Influence on the Design of Data Processing Systems*, Graduate School of Business Administration, Harvard Univ., Boston, 1961.
33. P.B. Laubach, *Company Investigations of Automatic Data Processing*, Graduate School of Business Administration, Harvard Univ., Boston, 1957.
34. For figures on IBM revenue see J. Cortada, *Before*

the Computer: IBM, Burroughs, and Remington Rand and the Industry they Created, 1865–1956; Princeton Univ. Press, Princeton, N.J., 1993, p. 153. For the history of the tabulating machine and the importance of the Social Security Administration to IBM, see also M. Campbell-Kelly and W. Aspray, *Computer: A History of the Information Machine*, Basic Books, New York, 1996. Early use of punched card machinery is discussed in A.L. Norberg, "High-Technology Calculation in the Early 20th Century: Punched Card Machinery in Business and Government," *Technology and Culture*, vol. 31, no. 4, Oct. 1990, pp. 753-779. Very little has been written on the clash between revolutionarily inclined computer specialists and old-school punched card experts. For an insightful Finnish analysis, see M. Vehvilainen, "Gender and Computing in Retrospect: The Case of Finland," *IEEE Annals of the History of Computing*, vol. 21, no. 2, Apr.–June 1999, pp. 44-51.

35. M.L. Edwards, *The Effect of Automation on Accounting Jobs*, unpublished doctoral dissertation, Univ. of Oklahoma, Norman, Okla., 1959, p. 156, lists the machines in use.
36. Ibid., and F.M. Johnson, "Control of Machine Accounting Equipment," *Systems and Procedures Quarterly*, vol. 4, no. 2, May 1953, pp. 18-22, 26.
37. The best source on punched card careers remains M.L. Edwards, *Effect of Automation*, 1959. For a fascinating discussion of punched card work on the cusp of the computer age, see E.P. Daro, "Workshop Seminar on Selection and Training of Personnel," in *Data Processing: 1958 Proceedings*, C.H. Johnson, ed., Nat'l Machine Accountants Assoc., Chicago, 1958, pp. 324-338. For an early attempt to apply scientific testing to operator selection, see E.J. McCormick and R.H. Finn, "Tests for Use in Selecting IBM Operators," *J. Machine Accounting*, vol. 6, no. 2, Feb. 1955, pp. 12-13, 17.
38. See M.L. Edwards, *Effect of Automation*, 1959, p. 114, on department age. For IBM's revenue, see C.J. Bashe et al., *IBM's Early Computers*, MIT Press, Cambridge, Mass., 1986. The estimate of the number of installations is from A.E. Keller, "Crisis in Machine Accounting," *Management and Business Automation*, vol. 5, no. 6, June 1961, pp. 30-31.
39. R.E. Sprague, "Are Punched Card Machines on the Way Out?," *The Hopper*, vol. 4, no. 7, July 1953, pp. 2-7.
40. Ibid.
41. Ibid., p. 4.
42. For the survey, see "Survey of the 702," *Computing News*, vol. 5, no. 94, 1 Feb. 1957, pp. 3-5. The quotation is from "Staff Organization and Their Training," *Computing News*, vol. 5, no. 95, 15 Feb. 1957, pp. 8-11. Computer operators remained a substantial proportion of the data processing workforce for decades, but continued to be largely ignored by commentators.
43. "Business Week Reports To Readers on: Computers," *Business Week*, no. 1503, 21 June 1958, pp. 68-92. This company might be Prudential Insurance—for premium billing, its first application, Prudential had to convert 13 million cards, holding records of 320 characters each for three million policies. "Survey of the 702," *Computing News*, vol. 5, no. 94, 1 Feb. 1957, pp. 3-5. For the eventual arrival of equipment to transcribe directly onto tape, see A.L.C. Chu, "Key-to-Tape: K.O. For the Keypunch?," *Business Automation*, vol. 17, no 4, Apr. 1970, pp. 52-59.
44. On the importance of sorting, see D.D. McCracken, H. Weiss, and T.-h. Lee, *Programming Business Computers*, John Wiley & Sons, New York, 1959, pp. 300-330. On GE's reintroduction of manual sorting, see "Business Week Reports To Readers On: Computers," *Business Week*, no. 1503, 21 June 1958, pp. 68-92.
45. For the origins of integrated data processing, see *A New Approach to Office Mechanization: Integrated Data Processing through Common Language Machines*, American Management Assoc., New York, 1954. On the use of pneumatic tubes alongside computers, see A. Newgarden, "Men, Machines and Methods in the Modern Office," *AMA Management Reports*, vol. 5, 1958, p. 7.
46. For early data on relative pay in computing installations, see R.F. Clippinger, B. Dimsdale, and J.H. Levin, "Automatic Digital Computers in Industrial Research," *J. Machine Accounting*, vol. 6, no. 2, Feb. 1955, pp. 7-11, 14-16; F. Wallace, *Appraising the Economics*, 1956; and R.G. Canning, *Installing EDP Systems*, 1957.
47. The first quotation is from M.L. Edwards, *The Effect of Automation on Accounting Jobs*, unpublished doctoral dissertation, Univ. Oklahoma, Norman, Okla., 1959. The second is from J.J. McCaffrey, *From Punched Cards to Personal Computers*, 10 June 1989, John J. McCaffrey Memoirs (CBI 47), CBI.
48. On the SSEC (or Symbolic Sequence Electronic Calculator) and the GE installation, see H.R.J. Grosch, *Computer: Bit Slices from a Life*, Third Millennium Books, Novato, Calif., 1991. On IBM and design, see T. Watson Jr. and P. Petre, *Father, Son & Co: My Life at IBM and Beyond*, Bantam, New York, 1990.
49. A good overview of the new physical environment of the computer is given in "Basic Elements of Computer Environment," *Management and Business Automation*, vol. 4, no. 5, Nov. 1960, pp. 28-30, 32, 48; the quotation is from pages 29 and 48. These issues are also discussed in D.R. Daniel, "Getting the Most Out of Your Computer," *EDP: The First Ten Years: Highlights of*

Management Experience and a Look Ahead, McKinsey & Company, ed., Am. Soc. for Public Administration, Chicago, 1961, pp. 15-21, and retrospectively in T. Kishi, "The 701 at the Lawrence Livermore Laboratory," *Annals of the History of Computing*, vol. 5, no. 2, Apr.–June 1983, pp. 206-210.

50. The unreliability of the 604 is discussed in J.J. McCaffrey, *From Punched Cards to Personal Computers*, 10 June 1989, John J. McCaffrey Memoirs (CBI 47), CBI. On the need for air conditioning with a 603 or 604 see B.J. Lappeus, "Moving Day ... In the Machine Accounting Department," *The Hopper*, vol. 3, no. 3, May 1952, pp. 20-26.
51. J.B. Hughes and D.D. McCracken, "IBM 700 Series," *J. Machine Accounting*, vol. 7, no. 10, Oct. 1956, pp. 26-29, 48.
52. "Basic Elements of Computer Environment," *Management and Business Automation*, vol. 4, no. 5, 1960, p. 32.
53. Figures are taken from an internal IBM intelligence report on the Univac: W.R. Elmendorf and W.W. Peterson, *A Study of the UNIVAC,* IBM, 1954. Cuthbert C. Hurd papers (CBI 95), CBI. For a detailed account of physical installation, see R.G. Canning, *Installing EDP Systems*, 1957, pp. 103-114.
54. R.W. Pomeroy, "Basic Flow Charting Techniques," *Systems and Procedures*, vol. 8, no. 3, Aug. 1957, pp. 2-8. Pomeroy was a management consultant, and his article was, revealingly, a plea to his fellows not to abandon their unglamorous yet proven flowcharting techniques in the face of the new fervor over electronics.
55. Inasmuch as historians have documented the existence of the systems men at all, they have been conflated with computer experts, office managers, industrial engineers, or operations researchers. In fact, they considered themselves quite separate from all these groups. See T. Haigh, "Inventing Information Systems: The Systems Men and the Computer, 1950–1968," *Business History Rev.*, vol. 75, no. 1, Spring 2001, pp. 15-61 for their story.
56. The quotation, an early example of what was already a mantra, is from N. Chapin, "Justifying the Use of an Automatic Computer," *The Hopper*, vol. 5, no. 8, Sept. 1954, pp. 9-10, 14. While on the one hand, the stress on systems analysis was also a call for business reorganization (and so for revolutionary rather than incremental change), it was also a claim that office systems experts had made about dictating machines, accounting machines, and many other previous technologies. This emphasis on the analysis of business systems over technical knowledge was very familiar in theory—if not widely followed in practice.
57. I. Place, *Administrative Systems Analysis—Michigan Business Reports, Number 57*, Univ. Michigan, Ann Arbor, 1957.
58. Leffingwell included a detailed office flowchart in his W.H. Leffingwell, *Scientific Office Management*, A.W. Shaw, Chicago, 1917.
59. R.F. Neuschel, *Streamlining Business Procedures*, McGraw-Hill, New York, 1950.
60. A. Whitney, "How to Prepare Machine Procedures," *The Hopper*, vol. 4, no. 2, 1953, pp. 1-5.
61. P.B. Laubach, *Company Investigations of Automatic Data Processing*, Graduate School of Business Administration, Harvard Univ., Boston, 1957, p. 52.
62. The best single source on early administrative programming is the first textbook devoted to the topic, D.D. McCracken, H. Weiss, and T.-H. Lee, *Programming Business Computers*, John Wiley & Sons, New York, 1959.
63. T. Stein, "Managing the Data Processing Department," presented at Int'l Data Processing Conf. of the Data Processing Management Assoc., New York, 1962. For case studies in which operators and programmers are either selected as part of the same pool, or share training or tasks, see R.H. Brown, *Office Automation—Selecting, Training, and Organizing Computer Personnel*, 1959, Market and Product Reports Collection (CBI 55), CBI, and R.G. Canning, *EDP for Business and Industry*, 1956, p. 45.
64. The quotes are from R.G. Canning, *Installing EDP Systems*, 1957, p. 41 and 85. Canning's stress on the separation of analysis from programming struck at least some of his contemporaries as unrealistic, suggesting that a variety of approaches could be found between different companies. See McGee, W.C., "Book Revie –Installing Electronic Data Processing Systems," *Computing News*, vol. 15, no. 115, 15 Dec. 1957. These jobs may have been more frequently separated in administrative computing installations than in technical computing installations. On the failure of efforts to establish *coder* as a separate job, see B. Conway et al., *Business Experience with Electronic Computers*, 1959, pp. 88-90. Early on, detailed diagrams of computer program logic were often called block diagrams, to distinguish them from the true flowcharts that showed the flow of documents through office systems.
65. F. Wallace, *Appraising the Economics*, 1956, p. 24.
66. The quote is from P.B. Laubach, *Company Investigations of Automatic Data Processing*, Graduate School of Business Administration, Harvard Univ., Boston, 1957, p. 146. Similar sentiments are expressed by the manager responsible for General Electric's seminal Univac installation in G.M. Sheehan, "An Application to Payroll," *Proc. Automatic Data Processing Conf.,* R.N. Anthony, ed., Harvard Univ., Graduate School of Business

Administration, Division of Research, Boston, 1955, p. 155. The figure comes from "*Business Week* Reports to Readers on: Computers," *Business Week*, no. 1503, 21 June 1958, p. 87. See also R.H. Brown, *Office Automation—Selecting, Training, and Organizing Computer Personnel*, 1959, Market and Product Reports Collection (CBI 55), CBI, for a discussion of programmer training, and B. Conway et al., *Business Experience with Electronic Computers*, 1959, pp. 83-93. For an earlier statement of the theme, see P.B. Laubach and L.E. Thompson, "Electronic Computers: A Progress Report," *Harvard Business Rev.*, vol. 33, no. 2, Mar.–Apr. 1955, p. 127. On programmer testing, see T.C. Rowan, "The Recruiting and Training of Programmers," *Datamation*, vol. 4, no. 3, May-June,1958, pp. 16-18. Those with more intimate experience of computing, such as R.G. Canning and D.D. McCracken et al., tended to put more emphasis on the need to include at least some experienced programmers in the new department.

67. J.W. Mauchly, "Electronic Accounting," *The Hopper*, vol. 4, no. 12, Dec. 1953, p. 2. Prominent author, consultant, and publisher Richard Canning, for example, initially felt that the electronic data processing machines should not properly be called computers or vice versa. See R.G. Canning, *EDP for Business and Industry*, 1956, pp. 82-83.
68. Nowland & Co., *Management Report: Burroughs' Corporate Image Planning and Devlopment*, Nov. 1957, Burroughs Corporation Records (CBI 90), CBI. Very early use of data processing does not follow this neat divide between administrative and technical work—the scientific 701 was renamed from the defense calculator to an electronic data processing machine. But by the late 1950s the distinction was generally observed, to the extent that *computing* and *data processing* were sometimes spoken of as distinct activities. See, for example, the reference to the "operation of a data processing or computing installation" in H.R.J. Grosch, "Software in Sickness and Health," *Datamation*, vol. 7,no. 7 July 1961, pp. 32-33.
69. While Levis' classic 501 denim jeans never shared its designation with an IBM model, the 501 was an RCA mainframe. In Japan, more obscure pants carrying designations such as the 701 and 702 are highly collectable today and share their names with IBM's first large computers.
70. "Glowing Future for Machine Accountants Described by Convention Speakers," *J. Machine Accounting, Systems and Management*, vol. 5, no. 7, July–Aug. 1954, pp. 3, 8, and T.J. Watson Jr., "Address by Thomas J. Watson Jr., President, International Business Machines Corp.," in Charles H. Johnson (ed.) *Data Processing 1: 1958 Proceedings, National Machine Accounting Association, Chicago, 1958*. For examples of the early discussion of the challenges and potentials of computer technology within the community of punched card supervisors, see R.G. Wright, "Electronics Challenge to Machine Accountants," *J. Machine Accounting*, vol. 7, no. 4, Apr. 1956, pp. 4-7,27, L.E. Hill, "The Machine Accountant and his 'Electronic' Opportunity," *J. Machine Accounting*, vol. 8, no. 1, Jan. 1957, pp. 12-14, 23-25.
71. The name change was defeated on separate occasions by the Executive Committee and the chapter delegates who made up the International Board of Directors.
72. Although these tensions dogged the certificate throughout its history, they received their clearest statement during the initial planning period. See National Machine Accountants Assoc., "Executive Committee Meeting Minutes—Verbatim," 5-6 Aug. 1960, Data Processing Management Assoc. Records, (CBI 88), CBI.
73. To receive it, a candidate needed to demonstrate three years' experience with data processing (punched card or computer) and provide three references to show the "moral character" demanded of a professional. Candidates also had to pass a short test dealing with three main subjects: punched card techniques, computer technology, and "systems." (This last was a grab-bag category that included analysis and management as well as "systems machines" such as optical scanners and data transmission.) The three subjects together counted for about 80 percent of the marks. The final 20 percent were split between knowledge of paper tape (used to transfer data between telex machines, mechanical office machines, and electronic systems) and some elementary questions on statistics. Executive Committee Minutes, 31 Aug.-1 Sept. 1962, Data Processing Management Association Records (CBI 88), CBI, p. 123 and Executive Committee Minutes, 30 Nov.-1 Dec. 1962, p. 279.
74. Inasmuch as the concept of data processing has appeared in the historical literature, it has been used primarily as a neutral description of a particular kind of work. M. Campbell-Kelly, "The Railway Clearing House and Victorian Data Processing," in *Information Acumen: The Understanding and Use of Knowledge in Modern Business*, L. Bud-Frierman, ed., Routledge, London 1994, even extends data processing back to the 19th century—a deliberate anachronism that succeeds in highlighting surprising historical continuities, but threatens to obscure the historical specificity and culturally charged nature of the concept. The data processing concept is inextricably tied to particular technologies and to a particular concept of how they should be

used and who should use them. It does not meaningfully predate the computer.

75. Even some of the most insightful recent work, such as N. Ensmenger and W. Aspray, "Software as Labor Process", in *Mapping the History of Computing: Software Issues*, U. Hashagen, R. Keil-Slawik, and A. Norberg, eds., Springer-Verlag, New York, (to be published) does not address the different uses to which the computer was put or to differentiate systematically between the different social institutions within which the activity of programming was practiced. Without such differentiation we cannot explore what is truly common or divergent between different kinds of computer user, and risk the reification of ideas like "the community of software workers" or "professional programmers," which imply strong identities where none existed.
76. J.S. Light, "When Computers Were Women," *Technology and Culture*, vol. 40, no. 3, July 1999, pp. 455-483. Light's formulation mirrors that of P. Kraft, *Programmers and Managers: The Routinization of Computer Programming in the United States*, Springer-Verlag, New York, 1977. A 1960 survey by *Management and Business Automation* magazine examined more than 7,000 data processing staff at 489 companies across the US. It found that less than 15 percent of the programmers surveyed were female.
77. While private trade schools offered education and tests in programming, no generally agreed standards were in place. The CDP was not a certificate for programmers—no experience in programming was required, and the DPMA never made a serious effort to interest scientific programmers in the certificate or to adapt it to their needs. The first serious attempt to provide a programming credential came with the DPMA's Registered Business Programmer (RBP) examination in 1968, when the DPMA recognized that certification of programmers might provide a valuable alternative to its supposedly broader and higher level certificate in data processing. The RBP examination (a name deliberately chosen to sound less impressive than a certificate) was greeted by widespread apathy and proved a financial disaster for the association.
78. R.G. Canning and R.L. Sisson, *The Management of Data Processing*, John Wiley & Sons, New York, 1967, p. 9. The idea that the data processing department remained a simple extension of the old tabulating department is also expressed strongly in E.H. Brock, "Coundown to ADP Management Crisis," in *Data Processing XII: Proc. 1967 Int'l Data Processing Conf. and Business Exposition*, Data Processing Management Assoc., ed., Chicago, 1967, p. 213.
79. "Business Week Reports To Readers on: Computers," *Business Week*, no. 1503, 21 June 1958, p. 59.
80. For a good summary of the "productivity paradox" discussion, see D.E. Sichel, "Computers and Aggregate Economic Growth: An Update," *Business Economics*, vol. 34, no. 2, Apr. 1999, pp. 18-25, and J. Madrick, "Computers: Waiting for the Revolution," in *New York Rev. of Books*, vol. 45, 1998, pp. 29-33.
81. On disruptive technologies, see C.M. Christensen, *Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Harvard Business School Press, Boston, 1997.

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