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8 Scientific Management and Industrial Engineering at Du Pont

Frederick W. Taylor's death did not signal the passing of scientific management. On the contrary, in the years after 1915, the techniques of scientific management were applied as part of a broad effort to rationalize production and enhance managerial control over the workplace. A new figure in American industry—the industrial engineer—played a key role in this continuing effort to apply scientific management. Industrial engineers utilized techniques derived from scientific management to reduce information about production to a set of standard data that managers could use for more effective labor control. They sought to develop for management "scientific facts [that could] be used to reach a reasonable solution" to the question of "what should be considered a 'fair day's work.'"[1] In doing so, they hoped to effect what Taylor termed "the substitution of exact scientific investigation and knowledge for the old individual judgment or opinion, either of the workman or the boss, in all matters relating to the work done in the establishment."[2]

This essay reviews the application of scientific management at a leading American firm, E. I. du Pont de Nemours & Company,

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during the first half of the twentieth century. Until the late 1920s and early 1930s, efforts to apply techniques of scientific management within the company were limited, largely because managers did not give their full support. As they struggled to reduce labor costs in the wake of the Great Depression, however, company managers increasingly turned to Du Pont's industrial engineering force for assistance in implementing techniques intended not only to increase efficiency, but also to enhance managerial control over the work force. By the 1950s, industrial engineers had succeeded in Taylorizing the workplace at Du Pont.

Early Efforts to Apply Scientific Management at Du Pont

Du Pont has long been regarded as a paragon of modern managerial and organizational techniques. The executives who reorganized the company at the turn of the century, including Pierre and Coleman du Pont, Arthur J. Moxham, J. Amory Haskell, and Hamilton M. Barksdale, introduced improved administrative methods, new accounting techniques, and systematic internal communication procedures. The result, as Alfred D. Chandler, Jr. stated, was that by World War I "few American industrial enterprises had as modern a management as Du Pont."[3] Yet these reforms affected the administration of the enterprise as a whole; they had relatively little impact upon factory management. For the most part, labor at Du Pont's fifty-odd plants was still managed under the paternalistic practices developed during the first century of the firm's existence.[4]

Only in Du Pont's High Explosives Operating Department (HEOD) was much consideration given to reforming factory management. Senior managers emphasized the need to reduce labor costs, improve methods, and find the most effective way of performing tasks.[5] The department held regular superintendents' meetings to discuss improvements and set up special commissions to develop and adopt new machinery and processes. In the spring of 1911, these efforts received new impetus with the formation of an "Efficiency Division."[6] The decision to organize it reflected the vogue for "efficiency" that followed the publication of Frederick W. Taylor's *The Principles of Scientific Management.* Hamilton M. Barksdale, until recently director of HEOD and now the company's general manager, read Taylor's book and decided that an effort should be made to apply scientific management at Du Pont.[7] As Harry G. Haskell, Barksdale's successor at HEOD, reminded superintendents, "to feel satisfied of the men as working *hard* is not sufficient in our days; [you] must know that the men are all working *well*, and that is the gist of the efficiency idea." The Efficiency Division, he stated, would try to determine "by scientific trial" whether employees were indeed working well.[8]

Rather than utilize the services of Taylor or another consultant, the HEOD turned to two of its own staff in the Efficiency Division. Edward Montgomery Harrington, the director, was an MIT graduate (1886) with some twenty years' experience in the explosives industry; his assistant, W. Maxwell Moore, had worked for nearly a decade at Repauno, the HEOD's largest plant.[9] From 1911 to 1914, the two men visited all of the HEOD's dozen plants, conducting time and motion studies of workers. They determined standard times and methods for tasks, set standard speeds for machinery, and made suggestions for rearranging the flow of work, improving tools, and installing labor-saving equipment.[10]

The Efficiency Division's efforts were hampered, however, by several problems. Not the least was a lack of clear support for, or understanding of, its work. Its findings remained strictly advisory; plants were not required to adopt its recommendations. Harrington sought to expand the work of the division to include studies of fatigue, the scientific selection of workers, and employment departments, but these studies were referred to other divisions or were not approved.[11] Some HEOD officials and plant superintendents were skeptical of its efforts or showed little understanding of scientific management. Neither of the company's other manufacturing departments—Black Powder and Smokeless Powder—established efficiency divisions, and officials in these departments took only passing interest in the work of the HEOD's. Apart from Hamilton Barksdale and his assistant, Irénée du Pont, both of whom received the division's reports and attended HEOD meetings at which its work was discussed, other top company executives apparently paid little attention to its activities.[12]

Another problem related to the hazardous nature of explosives manufacturing: the threat of an explosion prohibited the use of incentives that might encourage workers to speed up their production. This imperative conflicted with a key tenet of Taylorism and other efficiency systems—that workers should earn a bonus for completing a task in or before a standard length of time. As Harrington stated, it was difficult "to make employees see where they are to gain by changing methods of operation which may give increased production [but] with no monetary gain to themselves." The division never resolved the conflict.[13]

The Efficiency Division also faced challenges over its approach. Harrington warned against expecting quick results, arguing that only prolonged studies of work would lead to increased efficiency.[14] Senior officials and superintendents, however, sought immediate gains in efficiency and measurable reductions in labor costs. As one superintendent bluntly stated, "the Efficiency Division would have to show a saving in dollars and cents or there would be no reason for [its] existence."[15] In 1913, Harrington estimated that the division had produced savings amounting to $6,500 during 1912; he also admitted, however, that it had found "comparatively little for which [it had] recommended remedies."[16] The division's failure to produce more significant results disappointed senior officials, who expected a greater return on their investment. Hamilton Barksdale, for example, warned that if the quest for efficiency was "left to a desultory sort of consideration . . . [it] will not get anywhere." He urged Harrington to make a "clear cut, well defined method of getting at" efficiency, proposing that the division undertake trials of functional foremanship.[17]

In September 1913, Harrington began these tests in a dynamite mixing house at the Repauno Plant. Only a day after "an old hand" was placed in the building as a functional foreman, however, an explosion levelled the house, killing him and three other workers, and injuring six others. Harrington shifted his experiments to another building housing a different process. In December, however, an explosion destroyed another dynamite mixing house, killing and injuring several more workers, causing "a wild scramble among employees," and throwing residents in neighboring communities into a state of panic. As rumors spread that the accidents were the result of "the foremen . . . rushing the men," Harrington and Repauno officials suspended further experiments. Damages to plant property from the two explosions, together with payments made to dependents, exceeded $34,000, or nearly six times the estimated savings for 1912.[18]

Following the disasters at Repauno, the Efficiency Division's operations were scaled back considerably; early in 1915, the HEOD suspended its work entirely.[19] This action temporarily ended further systematic efforts to apply scientific management at Du Pont. The division's experiences, moreover, suggested that future attempts to install scientific management would likely fare poorly unless managers at all levels gave their full support—something this initial effort never received.

During World War I, "efficiency" or "time-study" departments were organized by some of the company's larger smokeless powder plants. At the Haskell Plant in New Jersey, for example, an efficiency section made time and motion studies, set standards for a "fair day's work," and installed labor-saving materials handling equipment. Such efforts, however, should be placed in proper perspective. The resulting improvements were minor; as one plant manager observed, "the labor situation did not warrant the expenditure of the money" required for full-scale efforts to improve efficiency. Interest in efficiency emerged only at a late point in the war effort; not before the spring of 1918. Moreover, attention centered upon a small segment of the work force—laborers and construction gangs—rather than on the much larger group of production workers.[20]

Similar limited efforts were made to apply techniques of scientific management during the 1920s at plants operated by Du Pont or by its subsidiaries. "Planning" departments in some plants conducted time and motion studies to analyze jobs and develop standard work crews.[21] Other plants used scientific management techniques to resolve specific labor problems. In 1921, for example, the Du Pont Viscoloid Company (a wholly owned subsidiary that manufactured "pyralin" plastic articles) formed a "Time Study Section" to study the jobs of production workers at its Arlington Plant in New Jersey.[22] The Viscoloid Company's efficiency engineers installed a "task and bonus system," similar to that devised by Henry Gantt, under which workers began earning a bonus on each piece produced when their output attained a certain level (typically 45 percent) of the standard established for their task. By 1927, the system covered nearly all production workers, most of whom earned bonuses.[23] Another subsidiary, the Du Pont Rayon Company, in 1926–1927 adopted a similar plan to reduce turnover among female workers in its Richmond and Buffalo plants. These employees worked at highly repetitive manual tasks; their work was tedious and fatiguing, and annual turnover often exceeded 100 percent. To keep workers from leaving, the levels at which they began earning bonuses were set very low—as little as eight percent of standard. Turnover fell sharply after the system was installed; at Richmond, for example, it dropped to 5 percent by 1930. The earnings of many workers rose markedly as they reached or even exceeded the theoretical maximum 100 percent standard.[24]

These instances should not obscure the fact that interest in applying scientific management techniques at Du Pont during the 1920s was not widespread within the company as a whole. Two particular factors served to reduce interest. One was a preference for other company measures designed to increase efficiency, chiefly the "Merit Pay Plan." Open to all hourly workers employed more than one year, the plan paid a monthly bonus of 5 to 20 percent over their regular pay, based on length of service and attention to factors such as care, quality, and attendance. Officials who promoted Merit Pay argued that it was preferable to other incentives since it not only promised to increase efficiency, but also, thanks to its service provision, to stabilize employment. However, high annual rates of turnover (170 percent in 1923) and an annual cost of $770,000 to administer the plan, convinced senior managers in 1925 to end Merit Pay as a companywide program. Some departments, however, continued their own merit pay plans through the 1940s.[25]

Another factor that lessened interest in scientific management among executives was Du Pont's prosperity during the 1920s. Apart from the years immediately after World War I, the company's business expanded as production shifted from explosives to chemicals and synthetics. Sales rose from $74 million in 1923 to $203 in 1929, fueled by new products such as tetraethyl lead, rayon, and cellophane. This prosperity, along with the need to strengthen Du Pont's position within the chemical industry, led executives to emphasize research and development, diversification, and market expansion more than efficiency.[26]

The Great Depression and the Rise of Industrial Engineering

The company's rosy earnings picture changed dramatically with the onset of the Great Depression. Du Pont's sales dropped to

$186 million in 1930, and to $118 million by 1932. Hardest hit were the departments and subsidiaries that made acids, fertilizers, paint, coated fabrics, and other chemical products used in the automotive, mining, steel, construction, and agricultural industries. Struggling to maintain profits despite decreased production and falling sales, managers faced two alternatives: raising prices or cutting manufacturing costs. They chose the latter option. Labor, as a major cost item, did not escape the pressure for economy; the need to cut costs heightened interest in measures aimed at improving labor efficiency.[27]

These developments coincided with the emergence of industrial engineering as a separate function at Du Pont. In 1928, an "Industrial Engineering Division" (IED) was formed within Du Pont's Engineering Department to wage what one official termed a "continuous struggle to reduce operating costs."[28] The company's hard fortunes during the depression years of the 1930s gave added impetus to cost-reduction efforts; indeed, Du Pont's Executive Committee advised departmental managers to give full attention to "perfecting the efficiency of their operations, by intensive study of manufacturing processes, elimination of waste, discard of superfluous practices, development of labor-saving devices, substitution of mechanical for manual operations, and other means of reducing costs."[29] The IED quickly moved to the vanguard in coordinating cost-reduction and efficiency work within the company.

The rapid growth of the IED offers a good measure of the interest Du Pont management took in its work. From a staff of twenty-eight engineers in 1928, its ranks swelled to over 200 by 1940, and to some 500 six years later. The IED's engineers specialized in every aspect of production, including chemical processes, materials handling, packaging, waste recovery, water filtration, power conservation, instrumentation, maintenance, lubrication, equipment development, and plant design.[30] Its ranks also included engineers, trained in such techniques of scientific management as time and motion study, wage incentives, and job analysis, whose efforts were directed at making "continuing studies . . . which should result in . . . more effective use of manpower."[31]

The techniques applied by industrial engineers who were concerned with labor efficiency dovetailed with managers' perceived need for "fair standards of productivity to be expected of employees."[32] As one company executive observed, among the responsibilities facing management was that of "making certain that our working force produces a fair day's work for a fair day's pay under good operating conditions."[33] Increasingly, however, managers asserted that the diversified and varied nature of Du Pont's production made it much harder to be sure that workers were performing efficiently. One manager, whose plant turned out over 3,000 separate products, stated that while he once felt confident "that he knew what a day's work was and that his operators were effectively busy," he now believed that "it is impossible for him and his supervisors to know the content of a day's work in a multiproduct unit."[34] Company managers also believed that foremen and lower-level supervisors could not be relied upon to evaluate workers' performance. "The foreman doesn't know what a normal work pace is," one official stated, since "he is expected to be judge and prosecutor at the same time; and he omits part of a job because he doesn't analyze it sufficiently."[35] Another official stated the problem somewhat more pointedly: "The bodies are moving, but how effectively we don't know."[36] This need to determine "how effectively the bodies were moving" led Du Pont managers to devote increased attention to scientific management from the 1930s onward.

Work Measurement, Incentive Wages, and Labor Standards

Initially, Du Pont's industrial engineers focused upon improving the efficiency of chemical workers in production operations demanding a high degree of manual labor. They assumed that "the science of time and motion study" would "increase [chemical workers'] productive efficiency considerably."[37] Labor costs constituted a lower percentage of overall costs in chemical production than in the manufacture of rubber, automobiles, steel, and other products; however, in the production of many chemicals they remained high. In the "batch" operations, which typified the manufacture of small quantities of paints, dyes, resins, explosives, coated fabrics, and other specialized products, production remained highly labor intensive. Workers hauled and conveyed raw materials and semifinished products during processing; cleaned, repaired, adjusted, and set up equipment; and sorted and inspected finished products. Finishing operations in the production of rayon, plastic, or cellophane articles also demanded considerable manual labor. Continuous-flow automatic (or nearly so) equipment was used for the high-volume processing of acids, ammonia, methanol, and other fluid chemical products. The force of workers needed to operate such equipment was small, but manual labor was still needed to handle ingredients, charge boilers with fuel, maintain equipment, and remove wastes and byproducts.[38]

The application of scientific management techniques at a Du Pont plant began with a preliminary survey of its operations to "indicate the number of men in [each] building and what each one is doing and how they can best be handled to improve their work or become better fitted for it." Based on the survey, industrial engineers consolidated processes, rearranged the layout of work areas, installed materials handling equipment, and trimmed work crews.[39] Engineers then made motion and time studies of workers in specific operations. To analyze motions, they utilized stroboscopic, micromotion, and memo-motion (time-lapse) photography, and the chronocyclegraph, in which flashlight bulbs were fastened to a worker's wrists and long-exposure photographs were taken to create "light patterns" tracing the movements followed in performing a task. While Du Pont engineers relied on the traditional stopwatch to make time studies, they also consulted published tables of predetermined standard time values for basic motion elements. Using such tables, they simply "synthesized" the time values of individual elements to obtain the net time for a task.[40]

The net time, along with any allowances for fatigue or difficult working conditions, established the "standard time" for an operation; a standard or "normal" production level was also defined. Together, they comprised the "job standard," in which, barring unusual conditions, workers were expected to achieve normal levels of production. Engineers also defined a "100 percent effective point," a theoretical maximum limit that only the best workers could achieve. Workers were rated in terms of their efficiency: if the job standard for an operation was 500 pounds in four hours and a worker produced 250 pounds, he or she was rated 50 percent efficient.[41]

The job standards and ratings served as the basis for incentive wages designed to stimulate employees to become "more efficient and better operators." Encouraged by news of the satisfactory results obtained in plants that had installed incentive plans during the 1920s, officials in other Du Pont departments and subsidiaries increasingly became interested in placing their production employees under an incentive wage plan. By 1938, at least thirty plants had installed such plans, covering 9,400, or 27 percent, of the company's 34,000 hourly employees. Coverage ranged from three percent of the work force at some plants, to as much as 90 percent at others.[42]

Du Pont's wage incentive plans took various forms. At least three plants installed the Bedaux Company's system. While generally good results were reported with the Bedaux System, it contained some undesirable features that limited its wider use within the company. Du Pont managers objected to the Bedaux consultants' "insistence on their plan being worked in, even if some of it does not fit," while the sizable expenditure required to install the system—over $200,000 in some cases—dissuaded other plants from applying it.[43] A few plants used a similar though cheaper plan, the "KIM System," named for the three engineers (King, Irvin, and MacLachan) who developed it.[44] Another alternative—and the one most widely pursued at Du Pont—was for industrial engineers to study existing systems, both within and outside the company, and then to borrow liberally from them to create an "in-house" version tailored to the conditions of a particular plant. Ammonia Department officials, for example, sent an industrial engineer to the Dye Works to "skim off as much of the cream as we can" about the Bedaux System, rather than hire Bedaux consultants to install it at its plants.[45]

Though they differed in detail, all of the incentive plans shared a common principle: employees earned "extra wages for extra effort" based upon their ability to meet or exceed the standard established for their job.[46] Typically, an employee began earning a bonus when he or she attained a 75 percent efficiency rating. Loren I. King, the IED's "Wage Incentive Consultant," described how such a plan covered workers who soldered wires at one plant:

> We . . . set a rate for each bunch of wires to be soldered say 15 minutes and set the normal at 20 minutes giving the operators 5 minutes in which to make a bonus. Penalty values are set up just as are bonuses set up. If an employee fails to do his job in the normal time or fails his duty altogether he is penalized.[47]

The amount of the bonus decreased as the worker's output rose above the standard. The advantage, as one observer noted, was that "the required increase in production is greater than the attainable increase in pay, so that the company shares in the gains of a man's increased output and the labor cost per piece declines as the pay goes up."[48]

Initially, most incentive wage applications covered only production workers whose duties required considerable hand work. At some plants, however, engineers devised plans for operators of continuous-flow equipment, whose duties were more "mental," such as taking readings from instruments or adjusting dials that regulated temperature, pressure, and other variables. The plans set standards for accuracy in monitoring instruments and controlling process variables, for conserving power, water, and materials, and for attaining predetermined levels of quality and yield. Such a plan was installed at the Belle Plant in West Virginia, which manufactured ammonia and antifreeze. As the industrial engineer who developed the incentive plan recalled,

> Usually if [an] operator was watching a chart, for example a temperature chart, [a] pressure chart, and so forth, the basic approach would be how accurately, how closely did he control the temperature, which was critical to the operation of course, or the pressure. And some of the operators were far more adept at this than others and it showed up in the performance of the operation.

Operators who met or exceeded the standards received bonuses; those who did not were penalized.[49]

The efforts of industrial engineers to study jobs and to place workers under incentive plans produced mixed reactions among Du Pont employees. Some workers opposed such efforts. A carpenter at the Dye Works, for example, recalled he "told the management plain" that the "B-Doe" would "make a man run on one of these rip saws, buzz saws, Lord knows, maybe he'd cut his damned hand off." Management considered his protests, but "they still installed it and run it for quite a while."[50] Similarly, the former manager of the Belle Plant stated that "the men were suspicious" during time studies, refusing to answer questions about their work.[51] The caption of a cartoon published in one plant's employee magazine, showing a stopwatch and a clipboard, was pointed: identifying time study engineers as "the enemy of all piece workers," it asserted that "they never lie boys."[52]

Workers also complained about job standards and incentive wages. Works Councils (Du Pont's employee representation plan) at several plants asserted that workers "[did] not understand" the incentives and could not "calculate at least approximately their current earnings."[53] Some employees of the Dye Works were "kicking" over the Bedaux System, a foreman reported, because "they are not getting their rate of which they are right," and because the plant penalized them for mistakes by "cutting their rates or taking their Bonus away."[54] The "Employes Mutual Association" (an independent union) at the Ilion Plant of Du Pont's Remington Arms subsidiary wrote Lammot du Pont about "excessively tight" job standards, which forced operators "to work at a speed that not only is detrimental to the safety rules of the plant but also to the health and good will of the employees." Remington officials sent industrial engineers to Ilion to review the standards and resolve the situation.[55]

On the other hand, while employees may not have been wholly pleased by their job standards or incentive plan, many apparently welcomed the opportunity to earn extra money. The Dye Works carpenter who initially opposed the Bedaux System, for example, nevertheless praised management for being "always liberal enough to set a price that'd give you the time to do it" (i.e., to make a bonus). As he recalled, many employees also learned how to turn the system to their own advantage: "[The Company would] put a price on [a job] and maybe two or three fellows would have to work on [it] and . . . naturally they'd talk among themselves and find out what was the best way to do it in which you could make more money." Evidence suggests that many Dye Works employees learned "the best way to do" their jobs to earn more money: by the 1950s, workers covered by the Bedaux System were receiving, on average, $688 per year over their regular base pay.[56] At some locations, employees whose work was not covered under an incentive plan protested such "discrimination," demanding that they be given an opportunity to add to their earnings. The Grasselli Chemicals Department, for example, citing "continued requests for extension of the [Wage Incentive] System to now uncovered operations," reported that it was "being extended as fast as accurate studies and evaluations can be made." Similarly, in response to numerous requests, in 1939 the Dye Works began placing maintenance, craft, shipping, clerical, and laboratory employees under the Bedaux System; by 1955, the plan covered 99 percent of the work force.[57]

If workers were divided over wage incentive plans, so too were company managers. Some managers asserted that incentives were necessary to insure that workers give their full effort to keeping output levels high. Other departments reported that industrial engineers' efforts had produced huge savings and gains in productivity. The Grasselli Chemicals Department, for example, stated that its expenditure of $141,500 on time studies and incentive wages had resulted in savings of nearly $850,000. The Organic Chemicals Department claimed that the Bedaux System had caused productivity to increase nearly 31 percent while labor costs fell from $3.47 to $2.81 per pound.[58]

These sanguine opinions, however, were not held unanimously within the company. By the late 1930s, many departments were cutting back or eliminating their incentive plans due to employee dissatisfaction, soaring labor costs, failure to achieve prior levels of quality and output, and the work of administering the plans. The former manager of the Belle Plant, for example, recalled that its plan "became . . . burdensome to the local financial people, the control people, the payroll [people]." When the decision was made to abandon it, he said, "a lot of [them] sighed a sigh of relief." At the Dye Works, management realized that the full-scale extension of the Bedaux System had backfired: clerks objected to the extra paperwork needed to compute payrolls, supervisors found inflated reports of work done, and labor costs rose so high that German and Japanese dye manufacturers undercut the prices of its products. The local union, however, rejected proposals to write the system out of its contract until management granted an increase in base rates to "buy out" the plan.[59]

By the 1940s, despite the belief that "fundamentally, there is nothing wrong with [this] system of payment," the trend at Du Pont was running "toward lessening the number of employees paid on wage incentives."[60] Some plants changed to "Good Performance" plans, under which groups of workers shared monthly bonuses based on output and quality. Others gradually phased out incentives altogether. At the rayon plants, for example, operators who reached maximum levels of efficiency "were changed to a straight hourly rate with practically no loss of earning." By the early 1950s, only a few plants still retained incentive wage plans.[61]

While company managers abandoned incentives, they regarded time study and job standards as essential tools for controlling labor. "Labor measurement based on time study," stated one supervisor, "is a pre-requisite when planning for the effective use of labor."[62] Only "the organized analysis of work," another official asserted, would give management "the necessary elements of control."[63] By the 1940s, most Du Pont plants formed "Methods and Standards Sections," staffed by industrial engineers, to develop information and controls to assist managers in planning production. Using techniques derived from scientific management, these industrial engineers "place[d] the management of [labor] on a truly business basis."[64]

Methods engineers conducted a continuous program of job analysis in the plant, studying the work of production workers and also of "indirect labor" such as maintenance, construction, laboratory, warehouse, shipping, and clerical employees. They made time and motion studies of jobs to determine standard time values for each operation and to see that proper methods were being followed. Engineers also set labor standards for each job, establishing "the content of a fair day's work, or what should normally be expected from each individual for his day's pay."[65]

This ongoing job analysis program was only one of the duties performed by the Methods and Standards sections. Another was the preparation of written work plans. Supervisors and foremen sent all work orders to the section, where analysts converted them into detailed plans before jobs were begun. An industrial engineer described the process:

> The analyst studies the job first. He determines the best methods, tools, materials, safety requirements, and standards for manpower (by using standard time data). He writes store tickets for needed material. He prepares work sketches or photographs to assist foremen . . . and workers in visualizing the work. [The] result . . . is a completely analyzed job written in clear, concise form.[66]

This work plan established the "standard practice" for the job—defined as "a carefully thought out, officially approved method of performing a function."[67] Such a work plan, asserted one methods engineer, would "cause each operation to be performed in a stipulated manner at a designated time for an acceptable cost," enabling management to plan production more effectively.[68] Moreover, if this work plan was "'religiously' adhered to," a Methods and Standards manual promised, it would reduce "the good operation to a habit or routine [and release] the full faculties of management to be directed along other paths of progress."[69]

Du Pont managers relied on labor standards and work plans developed by Methods and Standards Sections to estimate work loads and to schedule crews. "Job methods planning," one analyst stated, gave managers "a measurement tool . . . to calculate the labor required for any job."[70] It also provided them with a tool for evaluating workers' performance. Supervisors could compare the job standard and work plan with the actual time of the job and the methods followed to measure how well workers performed the task. Labor standards, a methods engineer stated, formed "a common unit of measurement, understood by management and labor," which provided "a reliable means of objectively measuring . . . performance."[71] Standards were also used to rate jobs to determine payment differentials and to establish job promotion ladders based on the relative difficulty of different tasks.[72] Because each standard represented a specific output of an individual product, managers also utilized standards as administrative tools for production control. Based on forecasts of anticipated sales and orders, they estimated the volume of production, scheduled equipment utilization, predicted the labor costs of different products, and monitored inventories. At the end of the period, they compared actual production with the estimates to determine the causes of delays and overruns. Standards were also used for allocating labor and overhead costs among various products. "The use of [labor] measurement data," stated one engineer, "takes the elements of guesswork out of many of the problems . . . which management is called upon to evaluate."[73]

In addition to developing labor standards and preparing work plans, Du Pont's Methods and Standards sections engineers oversaw one other element of the company's efficiency efforts: its "Work Simplification" program. Developed by Allan Mogenson, an editor of *Factory Magazine* who was retained by the IED as a parttime consultant during the 1930s, work simplification was a training program designed to "[tap] the available brains in the plant for their constructive ideas."[74] Methods engineers delivered classroom lectures to groups of foreman and workers on basic principles of motion economy, instructing them how "to develop time and labor savings methods and to put that thinking into operation." The trainees then went back to their work sites, where, under an instructor's supervision, they identified jobs needing study and improvement. The trainee broke the job down into its constituent elements; prepared a written description for each element; plotted the job on process flow or work distribution charts; questioned how individual elements might be eliminated, simplified, or combined; and then implemented the improved method.[75] IED representatives stated that work simplification produced significant cost reductions, reduced the need for more sophisticated forms of job analysis, and fostered a "cooperative approach" to improving work methods. Moreover, they asserted, it would be "easier to sell" workers on the need to change their methods, since decisions about such changes would be based on "facts, not opinions" and made by workers themselves.[76]

From the 1920s to the 1950s, industrial engineers at Du Pont developed and implemented a variety of techniques, derived from scientific management, to provide managers with data for reducing production costs and controlling labor. "Those responsible for production," wrote a senior supervisor of one Methods and Standards Section, now "had available [to them] information, validated by established facts, on which to base their decisions."[77] In short, Du Pont engineers effectively "Taylorized" the workplace.

The Broader Context: Industrial Relations at Du Pont

These efforts to apply techniques of scientific management to cut costs and enhance managerial control should be considered within the broader context of Du Pont's industrial relations environment. As early as the early 1930s, Du Pont officials launched a none-too-subtle effort "to create an atmosphere of understanding . . . which will permit management to make and carry out those decisions which must be made if we are to operate successfully." During the 1930s and 1940s, this campaign relied on plant and companywide employee magazines, leaflets, films, posters, and lectures.[78] In 1950, the company began a broader, more ambitious effort—its "HOBSO" ("How Our Business System Operates") program, in which workers received classroom training on the American system of free enterprise. By 1953, over 80,000 employees had attended HOBSO sessions.[79] Among the messages employees received through such forums was the need to lower costs, maintain quality, and increase productivity. Du Pont held out the promise of job security, longer service, and "better living" (also the title of its company employees' magazine) in exchange for "more work, better work, and more continuous work" from employees.[80] The alternative was stated implicitly or even explicitly: as one worker recalled being told, "If we didn't modernize we couldn't compete with other companies and it would mean all our jobs."[81]

These actions helped to create a climate for efficiency within the company. Moreover, from the 1920s through the 1950s, one essential fact distinguished Du Pont's overall employee relations environment: unions never mounted a serious challenge to management. Although various national unions, including the CIO, District 50 of the United Mine Workers, the Textile Workers Union of America, and the International Chemical Workers Union, at different times waged vigorous campaigns to organize Du Pont employees, they never represented more than eleven percent of the company's eligible work force. Instead, until 1937 most employees were represented by Works Councils, and thereafter by their successor organizations, independent plant unions (in most cases the break between the two amounted to little more than a name change). The Works Councils were dominated by the company, which actively resisted any efforts by representatives to hold meetings off plant property or to join their colleagues in other plants. With few exceptions, the independent unions were poorly financed, waged few strikes, and gained few concessions from plant managers. Although some independents tried to federate for greater strength, Du Pont's policy of local bargaining blocked their efforts; the company was never forced to negotiate at the corporate level.[82]

For its part, Du Pont management took a tough and unyielding stance towards unions, whether national or independent. Company managers refused to cede any authority over production. They denied unions any voice in setting work rules and output quotas, evaluating jobs, developing labor standards, and determining work schedules; they also refused to link wage hikes to productivity increases.[83] In the early 1950s, senior executives reassessed Du Pont's policy *vis-a-vis* unionism; the result was a shift from a preference for independent unions, to a goal of eliminating existing unions and maintaining, at all costs, the nonunion status of the company's unorganized plants. The Employee Relations Department conducted industrial relations training seminars for managers, sent specialists on "fire-fighting" visits to plants to head off any labor problems, and prepared wage surveys so that departments could time increases to defeat organizing efforts. At the same time, managers sought to reduce interest in unionism by cultivating workers' loyalty to the firm. The company paid high wage scales (at or above local going rates for comparable work) and offered a full package of benefits, including pensions, disability wages, vacations, termination allowances, group life, accident, and health insurance, and a thrift program. Managers used safety contests, recreational programs, plant tours, and other occasions to continually reiterate the theme that mutual interests linked managers and workers. These efforts had dramatic results: the percentage of unionized workers fell from 94 percent in 1946 to 66 percent by 1960, while none of the twenty-five new plants built by Du Pont during the same period was successfully organized.[84]

From management's perspective, most workers responded favorably to the company's efforts to improve their efficiency. The director of Du Pont's Employee Relations Department, Emile du Pont, maintained that the effort to educate workers led them to work more efficiently, lessened their resistance to technological change, and caused productivity to increase.[85] Indeed, levels of output per man-hour rose by 165 percent while labor costs rose only 12 percent from 1939 to 1955, suggesting that many workers *had* become more efficient.[86]

Generalizing about how workers responded to the efforts of industrial engineers to install scientific management at Du Pont is made difficult by the size of the work force and the virtual absence of employee records (most independent unions, for example, did not maintain files). The available evidence, however, indicates that at least some workers responded negatively—and even aggressively—to industrial engineers' attempts to alter their jobs. Even if management was unwilling to negotiate, workers persisted in making wage incentives, work loads, job evaluations, and other job-related concerns the focus of union organizing efforts and grievance sessions. Indeed, as recently as 1988, an internal company memorandum on unionism voiced concern over increased "militancy and opposition to management initiatives around the issues of O[perational] E[ffectiveness], wage increases . . . and productivity improvements."[87]

If the surviving evidence of one unauthorized work stoppage is any indication, workers were willing to take shop floor actions to protest changes in their jobs. In 1946, some 150 operators at the Seaford, Delaware, nylon plant left their stations and went to the cafeteria to protest their increased duties resulting from a recent analysis of their jobs. They were required to tend twice as many machines, but at the same wages as before. The workers complained that they had "too many machines to run"; while they "agreed that they could do the work," they refused to do so unless management increased their wages. The standoff was brief (lasting only a few hours) and production never stopped; foremen of the affected sections ran the machines.[88] But the incident demonstrated that at least some workers were unwilling to accede silently to unilateral efforts by management to alter their work. The available records shed no light on whether workers engaged in day-to-day actions to maintain some element of control over their work. In his study of operators in an automated chemical factory in New Jersey, David Halle found that workers "[became] well versed in concealing information and practices [about their jobs] from management so as to manipulate them."[89] Presumably, at least some Du Pont workers responded in similar fashion to the efforts of industrial engineers to "Taylorize" the workplace.

Conclusion

Addressing a group of supervisors and employees at the Dye Works in 1919, Du Pont Company president Irénée du Pont denounced as "fallacious" the notion that workers served their interests when they restricted output. Instead, he maintained, workers should adopt "the principle of 'all-pull-together' [to] produce as efficiently as possible." The key, he said, was for "every employee [to become] a unit in the brain of the company." Lest anyone gain a misguided notion of what he meant, however, he quickly elaborated on this comment:

> I do not mean by this that a skilled mechanic ought to try to work out some complicated chemical reaction. . . . We want thought applied where it will do the most good. Intelligent following of detailed instructions worked out by the chemists and technicians will yield astounding results in this extraordinary complex manufacture. That is: if experience shows that a certain material should be boiled ten minutes, boil it exactly ten minutes—not nine or eleven. If a charge should require 1,000 pounds of caustic, put in 1,000 pounds and not 950 and put it in just when instructions require that it should be put in.[90]

The worker's role in production was limited to carrying out accurately the instructions of superiors.

Irénée's remarks echoed those of Frederick W. Taylor. Here was the substitution of scientific knowledge for the judgment of the workmen. Here, too, was the task set forth for industrial engineers: reducing workers' jobs to a set of "detailed instructions," which they would be given by supervisors and told to execute. From first to last, Du Pont's industrial engineers sought to achieve that objective.

NOTES

1. Lucien Brouha, *Physiology in Industry: Evaluation of Industrial Stresses by the Physiological Reactions of the Worker* (Oxford, 1960), p. xii. See also DeNord B. Kirk, "Increased Efficiency Through Production Planning," *Advanced Management* 18 (April 1953), p. 25–28; Organisation for European Economic Co-Operation, European Productivity Agency, *Fitting the Job to the Worker: A Survey of American and European Research into Working Conditions in Industry* (Productivity Missions to the United States, Project no. 355, Report of Mission to the United States of September 5, 1956–November 3, 1956), pp. 17, 35; Harry Braverman, *Labor and Monopoly Capitalism: The Degradation of Work in the Twentieth Century* (New York, 1974), pp. 113–22, 140; John Storey, *Managerial Prerogative and the Question of Control* (London, 1983), pp. 147–49.
2. Remarks of Frederick W. Taylor, in testimony before the Special House Committee: a reprint of the public document "Hearings Before Special Committee of the House of Representatives to Investigate the Taylor and Other Systems of Shop Management Under Authority of House Resolution 90," in Frederick W. Taylor, *Scientific Management* (New York, 1947), p. 31.

3. Alfred D. Chandler, Jr., *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, MA, 1977), pp. 438–50 (quote on p. 450). See also Chandler, *Strategy and Structure: Chapters in the History of the American Industrial Enterprise* (Cambridge, MA, 1962), chap. 2; Chandler and Stephen Salsbury, *Pierre S. du Pont and the Making of the Modern Corporation* (New York, 1971); H. Thomas Johnson and Robert S. Kaplan, *Relevance Lost: The Rise and Fall of Management Accounting* (Boston, 1987), chap. 4; JoAnne Yates, *Control through Communication: The Rise of System in American Management* (Baltimore, 1989), chap. 8.
4. See John C. Rumm, "Mutual Interests: Managers and Workers at the Du Pont Company, 1802–1915" (Ph.D. diss., University of Delaware, 1989), chaps. 1–4; Glenn Porter, *The Workers' World at Hagley* (Wilmington, DE, 1981), pp. 7–16; Norman B. Wilkinson, *Lammot du Pont and the American Explosives Industry, 1850–1884* (Charlottesville, 1984), chap. 1.
5. See, for example, comments of Hamilton M. Barksdale and W. B. Lewis in minutes of High Explosives Operating Department (HEOD) Superintendents' Meeting No. 13 (November 1905), and minutes and discussions in other HEOD Superintendents' Meetings, 1904–1909, Longwood Manuscripts, Group 10, Series A (Pierre S. du Pont Papers), File 418, Box 13 (hereafter cited as "LMSS/10/A/418, followed by box number). See also Yates, *Control through Communication*, pp. 235–53; Ernest Dale and Charles Meloy, "Hamilton MacFarland Barksdale and the Du Pont Contributions to Systematic Management," *Business History Review* 36 (1962), pp. 127–52.
6. The following discussion of the efforts made by the HEOD to apply scientific management at Du Pont is derived from Rumm, "Mutual Interests," chap. 6. A somewhat different perspective, emphasizing conflicts between scientific management and safety work, appears in Donald R. Stabile, "The Du Pont Experiments in Scientific Management: Efficiency and Safety, 1911–1919," *Business History Review* 61 (187), pp. 365–86.
7. Hamilton M. Barksdale to Frederick W. Taylor, March 28, 1911, Acc. 500, Series II, Part 2 (Post-1902 Du Pont Company Records), Box 1005 (hereafter cited as "Series II/O2," followed by box number); Fin Sparre to Charles L. Reese, December 5, 1911, Series II/2, Box 205. Several Du Pont Company executives knew Taylor and were familiar, at least in general terms, with his ideas. In 1897, for example, T. Coleman du Pont and Pierre S. du Pont had retained him as a consultant at the Johnson Company, manufacturers of equipment for electric street railways. Chandler and Salsbury, *Pierre S. du Pont*, p. 32; Stabile, "Du Pont Experiments," pp. 367–68.
8. Harry G. Haskell, "Opening Address," HEOD Superintendents' Meeting no. 34 (April 1912), manuscript transcript (MT), pp. 3–4, LMSS/10/A/418, Box 15; Haskell, "Opening Address," HEOD Superintendents' Meeting no. 33 (April 1911), printed text (PT), p. 7. Copies of the printed texts of HEOD Superintendents' Meetings 30–36 (1909–1914) are found in the Hagley Library.
9. Frank C. Evans to Charles H. Herrick, April 1, 1943, Acc. 1078 (Edward M. Harrington Papers), Item 5; Arthur P. Van Gelder and Hugo Schlatter, *History of the Explosives Industry in America* (New York, 1927), p. 547; Stabile, "Du Pont Experiments," p. 371.

10. See, for example, reports and memoranda issued by the Efficiency Division (ED), including "Scientific Management as Applied to High Explosives Works," HEOD Superintendents' Meeting no. 34 (April 1912), PT, p. 181–93; W. M. Moore to W. C. Spruance, Jr., "Report on Box Packing House Operations at Du Pont Works," HEOD Bulletin 311 (May 22, 1912), Series II/2, Item 553; ED, "Efficiency as Applied to High Explosives Works," HEOD Superintendents' Meeting no. 35 (April 1913), PT, pp. 571–96; ED, "Mechanical Dumping of Powder from Box to Hall Machine Belt," HEOD Bulletin 413 (September 12, 1913), Series II/2, Item 554; ED, "Efficiency," HEOD Superintendents' Meeting no. 36 (April 1914), PT, pp. 615–26; [Edward M. Harrington], "Annual Report [of ED]—1914," Jan. 25, 1915, Acc. 228 (Irénée du Pont Papers), Box 104. Harrington's notebooks, containing notes on plant processes and data from time and motion studies of workers, are found in Acc. 1078. See also Stabile, "Du Pont Experiments," pp. 372–76.
11. "Efficiency as Applied to High Explosives Works," PT, pp. 573, 580; "Efficiency," PT, pp. 616–17, 622–24.
12. See, for example, comments of W. M. Moore and H. G. Haskell in discussion section, "Efficiency as Applied to High Explosives Work," PT, pp. 602, 607; comments of W. B. Lewis, F. T. Beers, and W. C. Spruance in discussion section, "Efficiency," PT, pp. 632–34; Stabile, "Du Pont Experiments," pp. 369, 381–82. In 1912, T. Coleman du Pont arranged a meeting between senior Du Pont executives and John Dunlap, editor of *Factory* magazine, to discuss the work of the Society for the Promotion of Scientific Management (the Taylor Society); Harrington and Moore were not invited to attend, nor, apparently, did du Pont inform Dunlap of the Efficiency Division's existence. Du Pont to Dunlap, February 19, 1912 (copy), Series II/2, Box 1005.
13. "Scientific Management as Applied to High Explosives Work," PT, pp. 184–85; "Efficiency as Applied to High Explosives Work," PT, pp. 581–82; "Efficiency," PT, p. 622 (quote). On incentives, see comments of Frederick W. Taylor in discussion section, "Shop Management," American Society of Mechanical Engineers *Transactions* 24 (1903), p. 1470; see also Hugh J. Aitken, *Scientific Management in Action: Taylorism at Watertown Arsenal, 1908–1915* (1960; reprint ed., Princeton, 1985), pp. 34–47; Daniel Nelson, *Managers and Workers: Origins of the New Factory System in the United States, 1880–1920* (Madison, WI, 1975), pp. 51–54.
14. "Efficiency as Applied to High Explosives Works," PT, pp. 574, 584, 589; "Efficiency," PT, p. 619.
15. Comments of A. P. Van Gelder in discussion section, "Scientific Management as Applied to High Explosives Works," MT, p. 134; see also comments of W. B. Lewis and T. W. Bacchus, pp. 128, 141; and comments of C. A. Patterson in discussion section, "Efficiency as Applied to High Explosives Works," PT, p. 596.
16. "Efficiency as Applied to High Explosives Works," PT, pp. 594–95.
17. Comments of Hamilton M. Barksdale and other officials in discussion section, "Efficiency as Applied to High Explosives Works," PT, pp. 605–6 (quote on p. 606); see also Stabile, "Du Pont Experiments," p. 376.

18. Edward M. Harrington, "Explosion in Building #539, 'C' Line Gelatin Mixing House, Repauno, December 8, 1913," n.d., Acc. 1078, Item 4; "Efficiency," PT, p. 621, and comments of C. A. Patterson in discussion section, p. 631; *Philadelphia Public Ledger*, December 9 (quote), December 10, 1913; L. A. DeBlois, "Repauno—Explosion 'C' Line Gelatin 'Old Mix' Mixing House—Sept. 22, 1913," and "Repauno—Explosion 'C' Gelatin Mixing House—Dec. 8, 1913," March 29, 1922, Acc. 1615 (Records of Du Pont Employee Relations Department), Box 4; Stabile, "Du Pont Experiments," pp. 376–77.
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21. See, for example, "Industrial Engineering Division," in Organic Chemicals Department, Chambers Works Plant, Du Pont Company, *Chambers Works History*, 4 vols. (typescript, Carneys Point, New Jersey, 1956–1959), vol. 4, *Auxiliary Services*, chap. 4, pp. 1–2, Acc. 1387 (Miscellaneous Records of Chambers Works Plant), reel 1 (hereafter cited as *Chambers Works History*).
22. Arlington Plant, Du Pont Viscoloid Company, *Pyralin-Articles* 1 (Feb. 16, 1921), p. 1.
23. E. S. Cowdrick, "E. I. Du Pont de Nemours & Company," in "Methods of Wage Payment: Report of a Fact-Finding Study in the Companies Associated with the Special Conference Committee," August 8, 1927, pp. 2–3, copy in Acc. 1699 (Records of Bethlehem Steel Corporation), Box Lot 235 (hereafter cited as "Methods of Wage Payment"); Lammot du Pont to W. C. Spruance, April 13, 1928; Spruance to du Pont, April 18, 1928; W. B. Foster to Spruance, April 17, 1928, Acc. 1662 (Administrative Files of Du Pont Company), Box 46. On Gantt's task and bonus system, see Taylor, "Shop Management," pp. 1376–78; Nelson, *Managers and Workers*, p. 57.
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Series II/2, Item 353; H. O. Blumenthal, "Compliance with Fair Labor Standards Act," in minutes of Meeting of Managers and Directors of the Explosives, Technical, and Nitrocellulose & Sporting Powder Divisions, Explosives Department, May 1946, pp. 47, 56, Series II/2, Item 395.

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31. Walter S. Carpenter, Jr. to Major-General T. J. Hughes, January 20, 1943, Series II/2, Box 840 (quote); see also Read, "Fundamentals," p. 12; Ackart, "Some Notes and Anecdotes," pp. 48–49; Industrial Engineering Division, Engineering Department, Du Pont Company, memorandum, "Field Engineering Department, Du Pont Company, memorandum, "Field Engineering—Scope of Work," circa April 1932, Acc. 1813, Box 12; R. T. Van Ness to E. G. Ackart, memorandum on Industrial Engineering, Development Engineering, and Planning Divisions, February 4, 1946, Series II/2, Box 832; and "The Du Pont Company Wants Management Engineers," advertisement in *Advanced Management* 16 (February 1951), p. 28.
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33. Donald F. Carpenter (vice president, Remington Arms Company, a wholly owned Du Pont subsidiary), "Management's Responsibility in Increasing Manufacturing Productivity," in *Organizing for Cost Reduction*, p. 4.
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42. Comments of Loren I. King in discussion section, "Incentive Wage and Its Possible Application," pp. 47–49 (quote on p. 49); *Chambers Works History*, pp. 1–2; Emile F. du Pont to F. S. Johnson, memorandum on "Motion Economy," October 13, 1938, Acc. 1813, Box 27; minutes of General Managers' Meeting, June 20, 1932, Acc. 1813, Box 12; minutes of General Managers' Meetings, February 20, March 20, 1933, Acc. 1813, Box 16; H. F. Sedwick to Jasper E. Crane, May 5, 1936, Series II/2, Box 1046; E. R. Murch to F. C. Evans, report, "Extent of Wage Incentive Coverage Within Du Pont Company," September 1, 1938, Acc. 1813, Box 27 (hereafter cited as "Wage Incentive Coverage").
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44. "Wage Incentive Coverage," p. 3; *Chambers Works History*, p. 2; Charles Lytle, *Wage Incentive Methods: Their Selection, Installation and Operation* (New York, 1942), p. 254. One of the KIM engineers, Loren I. King, in 1933 became Du Pont's first "Wage Incentive Consultant." Ackart, "Some Notes and Anecdotes," p. 49; minutes of Explosives Plant Managers' Meeting, May 1933, pp. 47–49; G. E. Minshull to Plant Managers, Department Heads, and Presidents of Subsidiaries, October 3, 1933, Acc. 1662, Box 9.
45. Foster to Spruance, April 17, 1928; *Chambers Works History*, pp. 1–3; Wardenburg to Crane, March 9, 1932 (quote); author's interview with Ernest R. Habicht, Wilmington, Delaware, May 3, 1985. Habicht, who later became manager of Du Pont's Belle Plant in West Virginia, installed a version of the Bedaux System at Belle in the early 1930s.
46. Crane to Irish (quote); "Wage Incentive Coverage"; Incentive Wage and Its Application," pp. 47–49; Emile du Pont to Johnson, "Motion Economy"; Wingate, *Colorful Du Pont Company*, pp. 194–95.
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50. Author's interview with John L. Barnhill, Wilmington, Delaware, January 23, 1984. Barnhill worked at the Dye Works from 1919 until about 1962.
51. Habicht interview.

52. Arlington Plant, Du Pont Viscoloid Company, "Around the Plant," *Pyralin-Articles* 1 (May 5, 1920), p. 6.
53. Minshull to Plant Managers, Department Heads, and Presidents of Subsidiaries, October 3, 1933; see also H. F. Sedwick to Works Managers, November 16, 1933, LMSS/10/A, File 1173-5; Service Department, Du Pont Company, report to Executive Committee on "Employees' Representation Plan," January 1, 1935, Acc. 1662, Box 74; Willis F. Harrington, notes on General Managers' Meeting of March 1936, Acc. 1813, Box 22.
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59. Habicht interview (quote); "Wage Incentive Coverage," pp. 1–3, 6–8; Wingate, *Colorful Du Pont Company*, pp. 197–99; *Chambers Works History*, pp. 12–14.
60. Emile du Pont to F. S. Johnson, "Motion Economy" (quote); Middleswart, "Time Standards," p. 8; *Fitting the Job to the Worker*, p. 56; Service Department, report to Executive Committee on "Company Labor Policy," July 14, 1941, Acc. 1813, Box 35.
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62. Kirk, "Increased Efficiency," p. 27. For similar statements, see Middleswart, "Time Standards," pp. 3–12; Heritage, "Work Measurement," pp. 86–93; John S. Sayer, "The Measurement of Maintenance Labor" (paper presented at joint meeting of Society for the Advancement of Management–American Society of Mechanical Engineers, New York City, April 28, 1954), pp. 1–9, D.A. 708, Item 54-58; Quinn, "Discussion of Objectives," pp. 7–8. See also Robert H. Roy, "Commentary on the Future of Work Measurement," in Seymour M. Selig and Morton Ettelstein, eds., *New Horizons in Industrial Engineering* (Baltimore, 1963), pp. 196–97.
63. Heritage, "Work Measurement," pp. 88, 92.
64. Heritage, "Work Measurement," p. 88 (quote); Kirk, "Increased Efficiency," p. 26; Carpenter, "Management's Responsibility," pp. 4–5; U.S. War

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65. Kirk, "Increased Efficiency," pp. 25–27 (quote on p. 27); Heritage, "Work Measurement," pp. 86–92; Middleswart, "Time Standards," pp. 2–12; Sayer, "Measurement of Maintenance Labor," pp. 1–9; "Instructor Training Program," exhibit E-3, pp. 2–4, 19–24; Hugh Richmond (Personnel Division, Service Department), "Some Problems Encountered in Substituting Women for Men in Industry" (paper presented at National Industrial Conference Board Meeting, March 19, 1942), pp. 1–3, 5–8, copy in Acc. 1813, Box 38.
66. Heritage, "Work Measurement," p. 92.
67. "Instructor Training Program," exhibit E-3, pp. 22–25 (quote on p. 24).
68. Kirk, "Increased Efficiency," pp. 25–26.
69. "Instructor Training Program," exhibit E-3, pp. 22–25 (quote on p. 22); see also Heritage, "Work Measurement," pp. 90–93; Middleswart, "Time Standards," pp. 9–11.
70. Sayer, "Measurement of Maintenance Labor," p. 1; see also Kirk, "Increased Efficiency," pp. 27–28; Heritage, "Work Measurement," pp. 86–88, 92; Middleswart, "Time Standards," pp. 12–14.
71. Heritage, "Work Measurement," p. 88.
72. "Wage Incentive Coverage," p. 6; Habicht interview; *Fitting the Job to the Worker*, p. 56.
73. Kirk, "Increased Efficiency," pp. 25–28; "Methods of Wage Payment," pp. 5–8; Heritage, "Work Measurement," pp. 86–88; Sayer, "Measurement of Maintenance Labor," pp. 1–12; Middleswart, "Time Standards," pp. 7–14 (quote on p. 14); Wingate, *Colorful Du Pont Company*, pp. 198–99.
74. Bailey, "Work Simplification," p. 232 (quote); Emile du Pont to F. S. Johnson, "Motion Economy"; Read, "Fundamentals," p. 13; Kirk, "Increased Efficiency," p. 26; Rossmore and Aries, "Time and Motion Study," p. 3144; W. R. Bonwit, "Work Simplification—Applications to Plant Maintenance" (paper presented at Sinclair Refining Company Maintenance Symposium, Philadelphia, October 12, 1954), Du Pont D.A. Item 54-79.
75. Kir, "Increased Efficiency," p. 26 (quote); Bonwit, "Work Simplification—Applications," pp. 1–7; Bailey, "Work Simplification," pp. 232–33.
76. Bonwit, "Work Simplification—Applications," pp. 4–11 (quote on p. 4); Bailey, "Work Simplification," pp. 232–33; Read, "Fundamentals," p. 13.
77. Kirk, "Increased Efficiency," p. 25.
78. Emile F. du Pont, "'How Our Business System Operates (HOBSO)': Discussion of Company Objectives and Guiding Principles of the Program with Trained Leaders," February 17, 1950, p. 1 (quote), Emile du Pont Papers (EDP); George Miller, report, "Dissemination of Economic Information Among Employees," October 14, 1938, Acc. 1813, Box 26; C. M. Hackett to L. F. Livingstone, circa September 1946; James Q. du Pont, "List of Present Du Pont Public Relations Department 'Objectives' Versus 'Targets,'" May 2, 1949, both in Acc. 1415 (James Q. du Pont Papers), Box 31;

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79. Emile F. du Pont, "How Our Business System Operates"; du Pont, remarks to Du Pont Board of Directors, September 17, 1951; du Pont, "Suggested Thoughts for 'HOBSO II' Luncheon Talks," March 14, 1952, EDP; Employee Relations Department, Annual Report to Executive Committee for 1952, February 13, 1953, Acc. 1615, Box 3.

80. Service Department, "Outline of Collective Bargaining Within the Du Pont Company," January 20, 1942, Acc. 1813, Box 38; Emile F. du Pont, "Current Statue of Labor Relations within the Du Pont Company," September 4, 1952; du Pont, "Oral Report before Board of Directors," September 15, 1952, EDP; Employee Relations Department, Annual Reports to Executive Committee, 1952–1960, 1615, Box 3; Julius Rezler, "Labor Organization at Du Pont: A Study in Independent Local Unionism," *Labor History* 4 (1963), pp. 178–95; Ken Tucker, "It Got My Back Up," in Alice Lynd and Staughton Lynd, eds., *Rank and File: Personal Histories by Working-Class Organizers* (Boston, 1973), pp. 224–32; James Phelan and Robert Posen, *The Company State: Ralph Nader's Study Group Report on DuPont in Delaware* (New York, 1973), chap. 3. See also Walter S. Carpenter, Jr. to Willis F. Harrington, November 10, 1941, Series II/2, Box 827; Harrington to Robert B. Wolf, October 13, 1942, Acc. 1813, Box 38; Lammot du Pont to William H. Dow, October 31, 1946, Acc. 1662, Box 69; Emile F. du Pont, speech at Plant Managers' Meeting, Textile Fibers Department, November 3, 1955, EDP; E. F. du Pont, remarks at Ilion Plant Supervisors' meeting, 1956, EDP; "Questions Which Might Border on Employee Relations Raised in Other Panels," July 1959, EDP; Lammot du Pont to John Suman, November 5, 1946 (quote), Acc. 1662, Box 28; Harold Brayman to Walter S. Carpenter, Jr., March 31, 1947, Series II/2, Box 834; *This is Du Pont*, pp. 38–39.

81. Quoted in "No Shuttlecocks at Parlin," *Fortune* 63 (February 1962), p. 190. The curious title refers to a comment by the manager of Du Pont's Parlin Plant, quoted in the article, that the aim behind efforts to furnish information to employees about the need for technological improvements was "to keep things down in the area where people know each other and aren't just badminton birds in somebody's game."

82. Service Department, "Outline of Collective Bargaining"; du Pont, "Current Status of Labor Relations"; du Pont, "Oral Report before Board of Directors"; Employee Relations Department, Annual Reports, 1952–1960; Rezler, "Labor Organization at Du Pont"; Tucker, "It Got My Back Up"; Phelan and Posen, *The Company State*, chap. 3.

83. Service Department, "Outline of Collective Bargaining"; du Pont, "Current Status of Labor Relations"; du Pont, "Oral Report before Board of

Directors"; Employee Relations Department, Annual Reports, 1952–1960; Rezler, "Labor Organization at Du Pont"; Tucker, "It Got My Back Up"; Phelan and Posen, *The Company State*, chap. 3. See also Carpenter to Harrington, November 10, 1941; Harrington to Wolf, October 13, 1942; L. du Pont to Dow, October 31, 1946; E. F. du Pont, speech at Plant Managers' Meeting; E. F. du Pont, remarks at Ilion Plant Supervisors' meeting; and "Questions Which Might Border on Employee Relations."

84. G. Gordon Mitchell, "A Look into the Future of Labor Relations," 1946, EDP; Spencer Brownell to Walter S. Carpenter, Jr., March 18, 1946, Series II/2, Box 841; Carpenter, "Comments before the Personnel and Industrial Relations Conference, Nemours Auditorium, Sept. 19, 1947," August 20, 1947, Series II/O2, Box 842; "Company's Philosophy on No-Union Status," January 4, 1956, EDP; Employee Relations Department Annual Reports, 1953–1960; Rezler, "Labor Organization at Du Pont," pp. 181–82, 187–88; Smith interview; author's interview with George Miller (Special Assistant, Employee Relations Department, Du Pont Company), January 16, 1984.
85. See, for example, du Pont, "Current Status of Labor Relations"; Emile F. du Pont, remarks at Seaford Plant Supervisors' meeting, June 23, 1949, pp. 7–8, EDP; see also "No Shuttlecocks at Parlin," pp. 189–90.
86. See the table accompanying Ira T. Ellis, "Topics for Discussion with Executive and Finance Committees, Tuesday, May 15, 1956," Series II/2, Box 103-A.
87. Quoted in *Wilmington News Journal*, April 24, 1988. For earlier instances, see, for example, Halsted to Lammot du Pont, January 26, 1942; minutes of General Managers' Meeting, June 16, 1941, Acc. 1813, Box 36; F. C. Evans to General Managers, "Premium Pay to Shift Workers for Sunday Work," May 29, 1946, Series II/2, Box 834; lists of pending grievances, in Employee Relations Department Annual Reports, 1952–1956; "CIO's Program for du Pont Plant Announced," Staunton, Virginia, *Leader*, June 11, 1947; "2-Hour Work Stoppage Precedes Du Pont Pact," *Newburgh [NY] News*, June 20, 1955.
88. Pierre S. du Pont, notes of interview with Edgar Smith *re* Seaford Plant, July 7, 1946, pp. 4–5, LMSS/10/A, File 418-14.
89. David Halle, *America's Working Man: Work, Home, and Politics among Blue-Collar Property Owners* (Chicago, 1984), pp. 119–26, 145–47 (quote on p. 146). See also Theo Nichols and Huw Beynon, *Living with Capitalism: Class Relations and the Modern Factory* (London, 1977), which also examines the extent of workers' control in a modern chemical plant.
90. Address of Irénée du Pont before Dye Works Employment Conference, August 13, 1919, reprinted in "Plant Pioneered Labor Relations Steps," *Chambers Works News*, December 1, 1967, p. 8 (copy in Hagley Library).