John Deere Component Works (A)

The phone rang in the office of Keith Williams, manager of Cost Accounting Services for Deere & Company. On the line was Bill Maxwell, accounting supervisor for the Gear and Special Products Division in Waterloo, Iowa. The division had recently bid to fabricate component parts for another Deere division. Maxwell summarized the situation:

> They're about to award the contracts, and almost all of the work is going to outside suppliers. We're only getting a handful of the parts we quoted, and most of it is low-volume stuff we really don't want. We think we should get some of the business on parts where our direct costs are lower than the outside bid, even if our full costs are not.

Williams asked, "How did your bids stack up against the competition?"

Maxwell replied:

> Not too well. We're way high on lots of parts. Our machinists and our equipment are as efficient as any in the business, yet our costs on standard, high-volume products appear to be the highest in the industry. Not only are we not competitive with outside suppliers, but our prices are also higher than two other Deere divisions that quoted on the business.

Deere & Company

The company was founded in 1837 by John Deere, a blacksmith who developed the first commercially successful steel plow. One hundred years later, Deere & Company was one of seven full-line farm equipment manufacturers in the world and, in 1963, had displaced International Harvester as the number one producer. During the 1970s, Deere spent over $1 billion on plant modernization, expansion, and tooling (see **Exhibit 1**).

Note: *John Deere logo used by permission.*

Research Associate Artemis March prepared this case under the supervision of Professor Robert S. Kaplan as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

During the three-decade, post-World War II boom period, Deere expanded its product line, built new plants, ran plants at capacity, and still was unable to keep up with demand. Deere tractors and combines dotted the landscape throughout America.

During this same period, Deere had diversified into off-the-road industrial equipment for use in the construction, forestry, utility, and mining industries. In 1962 it also began building lawn and garden tractors and equipment. By the mid-1980s, Deere had the broadest lawn and garden product line in the world.

The collapse of farmland values and commodity prices in the 1980s, however, led to the worst and most sustained agricultural crisis since the Great Depression. Several factors exacerbated the crisis. The high dollar reduced U.S. exports and thus hurt both American farmers and American farm equipment producers. Farmers had been encouraged to go into heavy debt to expand and buy land, so when land values and farm prices plummeted, the number of farm foreclosures skyrocketed. Few farmers were in a position to buy new equipment, and resale of repossessed equipment further reduced the market for new equipment.

In response, Deere adjusted its level of operations downward, cut costs where possible, increased emphasis on pushing decision making downward, and restructured manufacturing processes. While outright plant closings were avoided, Deere took floor space out of production, encouraged early retirements, and did not replace most of those who left. Employment was reduced from 61,000 at the end of 1980 to about 37,500 at the end of 1986. It implemented new manufacturing approaches such as just-in-time production and manufacturing cells that grouped a number of operations for more efficient flow-through production and placed quality control directly at the point of manufacture. To add production volume, Deere wanted its captive component divisions to supply other companies and industries.

John Deere Component Works

For many years, all the parts for tractors were made and assembled at the tractor works in Waterloo. To generate more production space in the 1970s, Deere successively split off parts of tractor production. Engine machining and assembly, final tractor assembly, and product engineering each were moved into new plants in the Waterloo area. By the end of the decade, the old tractor works buildings were used only for component production, ranging from small parts to large, complex components such as axles and transmissions. The old tractor works buildings in Waterloo were renamed the John Deere Component Works (JDCW).

In 1983 JDCW was organized into three divisions. The Hydraulics Division, which was soon consolidated into a nearby, refurbished warehouse, fabricated pumps, valves, and pistons. The Drive Trains Division made axles, transmissions, and drive trains. The Gear and Special Products Division made a variety of gears, shafts, and machined parts and performed heat treating, cast iron machining, and sheet metal work.

As part of a vertically integrated company, JDCW had been structured to be a captive producer of parts for Deere's equipment divisions, particularly tractors. Thus, it had to produce a great variety of parts whose volume, even in peak tractor production years, was relatively low. During the 1970s, operations and equipment had been arranged to support tractor production of approximately 150 units per day; by the mid-1980s, however, JDCW was producing parts for less than half as many tractors. The lower volume of activity had a particularly adverse effect on JDCW's machined parts and sheet metal businesses, since its machines were most efficient for high-volume production.

Internal sales and transfer pricing Virtually all of JDCW's sales were internal. Deere equipment-producing factories were required to buy internally major components, such as advanced design transmissions and axles, that gave Deere a competitive advantage. For smaller components, corporate purchasing policy placed JDCW in a favored, but not exclusive, position for securing internal business.

Corporate policy stated that transfers between divisions would take place at full cost (direct materials + direct labor + direct overhead + period overhead). Corporate also had a make-buy policy that when excess capacity was available, buying divisions should compare component divisions' direct costs, rather than full costs, to outside bids. (Direct costs equal full costs less period overhead.) Thus, for example, if JDCW full costs were $10, its direct costs $7, and an outside bid $9, the make-buy decision rule held that the buying division should buy from JDCW. But, the transfer pricing policy required the buyer to pay $10 to the component division. Bill Maxwell described the conflict:

> The equipment divisions looked only at price, and acted like profit centers rather than cost centers. They are starting to act in the interest of their factory rather than the corporation as a whole. The transfer pricing policy wasn't a problem until times got bad and capacity utilization went down. At Component Works, we said to our sister divisions, "You should look at our direct costs and buy from us." They replied, "We don't want to pay more than it would cost us from outside vendors."

In practice, equipment divisions did not always follow the corporate guidelines for internal sourcing, and JDCW lost a portion of the equipment factories' business to outside vendors.

Machine Products Business

Deere's effort to push decision making down into more manageable units encouraged divisions to view their product lines as stand-alone businesses that sold to external markets. By early 1984, JDCW operations were so far below capacity that managers realized they could not wait for the agricultural market to turn around. In the Gear and Special Products Division, several people thought that complex machined parts offered a promising niche.

Turning machines transformed raw materials (primarily steel barstock) into finished components and were the most autonomous of the division's operations. As one manager put it, "We could shut down the turning machine area and not affect the rest of the plant—except that we would then have to buy machined parts from outside suppliers." Only the master schedule connected the area with the activities of the rest of the plant.

Turning machine operations were organized into three departments. These departments were distinguished by the diameter of the barstock its machines could handle and by the number of spindles on each machine. A six-spindle machine could handle six different orientations, for example, and thus make more complex parts than could a four-spindle machine.

Machine capabilities and operations Turning machines automatically fabricated small metal parts. Raw barstock was brought to a staging area near the machines by an overhead crane, the amount depending on the lot size to be run. Barstock (in round, square, or hexagonal sections) was fed horizontally by the operator into the back of the machine. Multiple stations each performed different operations simultaneously on what would become parts; when the longest cycle time (they ranged from a few seconds to six minutes) was completed, a machine indexed to the next position. Small parts, such as pinions, collars, gears, bushings, and connectors, continually emerged from the final station (see **Exhibits 2** and **3**). Finished parts were transported in 50-pound baskets stacked in trailers that carried up to 1,500 pounds.

Once set up, automatic turning machines were very fast, had excellent repeatability, and were particularly good at drilling, threading, grooving, and boring out large holes. New, the machines could cost as much as $500,000 each; their replacement value was estimated at about half that amount (see **Exhibit 4**).

Operators were assigned to a battery of two or three specific machines; they did their own setups and tool changes. Setups, like runs, were timed; operators punched in and out, creating a record of how long setups actually took. Operators were also responsible for quality, machine cleanup, and housekeeping in their areas. Following first-part inspection by an inspector, operators ran the lot. Roving inspectors also checked samples from each lot or basket for conformance to quality standards.

Layout Component Works had 120 automatic machines lined up in four long rows in an 80,000-square-foot building—almost the size of two football fields (see **Exhibit 5**). The chip and coolant recovery system was constructed under the floor, running the entire length of the building. It was connected up to each machine, much like houses are connected to a sewer system, to carry off the tremendous amount of chips generated by the machines, as well as to cool and lubricate the machines. The layout of the cooling system made it infeasible to redesign the machine layout into cellular configurations that would group attendant secondary and finishing operations together.[1] The machines could be shifted around or dedicated to certain parts, but due to the prohibitive expense of duplicating a chip coolant system, they were forced to remain in rows in S Building.

During the 1970s, secondary operations had been moved off the main floor in S Building to make room for more turning machines; this increased materials-handling distances for most parts. For example, the enormous heat treatment machines were located about one-quarter mile from the main machine area.

Process engineering To bring a new part into production required extensive process engineering activities. Operations had to be sequenced and tooling requirements specified for each spindle. If the appropriate specialized tooling did not exist, it had to be either purchased or designed and built (usually outside). Both setups and runs had to be timed and standards established. Process engineers had to make sure that the process they had designed would in fact make the part correctly. Data bases then had to be set up for each machine.

All of these activities had to be conducted whether or not the part number ever ran. John Gordon, head of the process engineering group for automatic machining, commented, “We have to do as much work for a part we run once a year—or one we never even run—as for one we set up every month or that runs every day.”

Recently, process engineering and production people had begun to make changes in how they ran machined parts. On setups, for example, they tried to “family the parts.” Rather than sequencing setups so that each required a distinctly different set of tools, they started grouping similar parts (in terms of diameter, length, and shape) so they could run on the same machine, thereby reducing tool changes and setup times. They also began to reduce the number of parts being run on the turning machines. As Andy Edberg, head of process engineering for the division, noted, “The automatic machines are extremely high-volume machines so you want to dedicate them if possible.” Process engineers were starting to outsource some low-volume parts or to transfer them to more labor-intensive processes. Edberg pointed to the fundamental nature of the shift:

---

[1] Secondary operations included heat treating, cross-drilling, plating, grinding, and milling; most parts required one or more secondary operations.

> We always made all the components for tractors, so we ran lots of part numbers but never really looked at the costs of individual parts. What was important was the efficiency of the whole rather than the efficiency of making the parts.

Competition and strategy By 1984, Gear and Special Products had roughed out a general strategic thrust toward marketing machined parts to the outside world, such as automobile OEMs (original equipment manufacturers). Initial efforts to gain outside business, however, soon made it obvious that competing in the external market was going to be harder than anticipated. Competition came in two forms: (1) captive producers of other vertically integrated companies (about whom Deere found it difficult to obtain information), and (2) independent machine shops. The latter had sprung up around geographical clusters of end users. On the East Coast, the independent shops fed the defense industry, particularly shipyards; on the West Coast, they supplied the aircraft industry; and in Michigan and Indiana, they sold to the automotive industry. Dick Sinclair, manufacturing superintendent, observed:

> The key to successful competition in the outside market is price. We found we have a geography problem. We are not in the midst of heavy users, and it is expensive to ship steel both in and out. We also found our range of services to be less useful than we thought they would be.

Bid on 275 Machined Parts

Both excess capacity and its new thrust toward developing stand-alone business motivated Gear and Special Products to bid on 275 of the 635 parts Deere & Company offered for bid in October 1984. All 635 parts had high potential for manufacture on automatic turning machines. Gear and Special Products bid on a subset for which it had the capability and where the volume was large enough to exploit the efficiencies from its multiple-spindle machines. The buying group consisted of several equipment factories plus a corporate purchasing group; its aim was to consolidate turning machine purchasing by dealing with just a few good vendors and to gain improved service, quality, and price for these parts. Gear and Special Products had one month to prepare its bid. Results of the bid are summarized in **Table A** and represent the annual cost for the quantity quoted.

Table A Comparison: JDCW vs. Vendor ($ in thousands)

	Parts with JDCW Low Total Cost	Parts with JDCW Low Direct Cost	Parts with JDCW High Direct Cost	Total All Parts
Part numbers	58	103	114	275
JDCW direct cost	$191	$403	$1,103	$1,697
JDCW full cost	272	610	1,711	2,593
Low outside quote	$332	$491	$684	$1,507
Percent of $ value	22%	33%	45%	100%
% JDCW of low vendor				
Direct cost	58%	82%	161%	113%
Full cost	82%	124%	250%	172%

The purchasing group awarded Gear and Special Products only the 58 parts for which it was the low bidder on a full-cost basis. Most of these were low-volume parts that the division did not especially want to make. Gear and Special Products could be the source for the 103 parts on which its direct costs were below the best outside bid only if it agreed to transfer the parts at the same price as the low outside bidder. The division passed on this "opportunity." The bidding experience generated a good deal of ferment at Gear and Special Products and confirmed the feeling of many that "we didn't even know our costs." Sinclair recalled:

> Some of us were quite alarmed. We had been saying, "Let's go outside," but we couldn't even succeed inside. Deere manufacturing plants in Dubuque and Des Moines also quoted and came in with lower prices—not across the board, but for enough parts to cause concern. If we weren't even competitive relative to other Deere divisions, how could we think we could be successful externally? And when we looked at the results, we knew we were not costing things right. It was backwards to think we could do better in low-volume than high-volume parts, but that's what the cost system said.

JDCW Standard Cost Accounting System

A standard cost accounting system was used throughout Component Works. The industrial engineering (IE) department played an active role in supporting the accounting function.

Industrial engineering standards The IE department had established standard hours for direct labor run time and for setups for every operation. Hourly workers were paid on a piecework basis; the incentive system allowed them to make up to 125% of their base pay for performing setups or runs more quickly than the standard rate. IE issued weekly efficiency reports detailing performance at different levels, including department and individual workers. It gave information concerning percentage of time on or off incentive, the level of incentive, time delays, setups, number of pieces produced, and other data. All of this information was based on labor hours and generated many percentages, often comparing actual to standard.

Materials The quality assurance (QA) department maintained control over materials usage. No materials usage variances were computed. The QA department recorded scrap when bad material was discarded. Weekly reports were prepared that summarized dollars of scrap, high scrap parts, reasons for scrap, and an overall quality level index.

Responsibility accounting The accounting department issued weekly and monthly reports on expenses incurred in each support department. Only costs incurred within a department appeared on these periodic reports. The reports were used primarily to see how areas were operating rather than to evaluate performance.

The weekly reports showed only actual labor overhead and materials overhead costs. On the monthly report, actual labor overhead costs were compared with budgeted rates applied to actual direct labor dollars (see **Exhibit 6**).

Part Costing

Standard costs were used for inventory valuation and for part costing. The standard or full cost of a part was computed by adding up the following:

direct labor (run time only)
direct material
overhead (direct + period) applied on direct labor
overhead (direct + period) applied on material dollars
overhead (direct + period) applied on ACTS machine hours
standard or full cost

Establishing overhead rates Once each year, the JDCW's accounting department re-established overhead rates, based on two studies: the normal study and the process study. The normal study determined the standard number of direct labor and machine hours and total overhead for the following year by establishing a "normal volume." In order to smooth out sharp swings, normal volume was defined as the long-term "through the business cycle" volume. One of the measures for setting normal volume was the number of drive trains produced per day.

The process study broke down projected overhead at normal volume among CW's 100-plus processes, such as painting, sheet metal, grinding, machining, and heat treating. To determine the overhead rate for each process, accounting computed the rate from actual past charges and then asked, "Do we expect any changes?" (Accumulated charges were collected by charging the specific process code as production took place.) Applying judgment to past rates, next year's normal volume, and any probable changes, a new overhead rate was established for each process for the coming year.

Evolution of bases for overhead rates For many years, direct labor run time was the sole basis for establishing overhead rates at Component Works. Thus, if $4,000,000 in overhead was generated by $800,000 of direct labor, the overhead rate was 500%. In the 1960s a separate materials overhead rate had been established. This rate included the costs of purchasing, receiving, inspecting, and storing raw material. These costs were allocated to materials as a percentage markup over materials costs. Over time, separate rates had been established for steel, castings, and purchased parts to reflect the different demands these items placed on the materials handling resources.

Both labor- and materials-based overhead were subdivided into direct and period overhead. Direct (or variable) overhead, such as the costs of setups, scrap, and materials handling, varied with the volume of production activity. Period (or fixed) overhead included accounts (such as taxes, depreciation, interest, heat, light, and salaries) that did not vary with production activity.

In 1984 Component Works introduced machine hours as well as direct labor and materials to allocate overhead. With the increased usage of automated machines, direct labor run time no longer reflected the amount of processing being performed on parts, particularly when one operator was responsible for several machines. Every process was studied and assigned a machine hour or ACTS (Actual Cycle Time Standard) rate. Labor hours were retained for processes where labor time equaled machine time; where these were different, ACTS hours were used to allocate overhead. Total overhead (other than materials overhead) was then split between direct labor overhead and ACTS overhead. As before, each overhead pool was subdivided between direct and period overhead.

Launching a Cost Study for Turning Machines

Keith Williams had been aware that the existing standard cost system, although satisfactory at an aggregate level, was ineffective for costing and bidding individual parts. He was experimenting with other ways to apply overhead to products. When Maxwell called him in November 1984, Williams realized that the situation at Gear and Special Products provided an opportunity to demonstrate the weaknesses of the current system and to develop a new approach that would be more useful for decision making.

After his phone conversation with Bill Maxwell, Williams quickly put together a proposal to management at Deere & Company and to the division manager of Gear and Special Products. The study would focus on one cost center—the three turning machine departments—because turning machine ACTS hours were the biggest chunk of costs in the bid; more than 60% of total machining for the parts occurred on the turning machines. To conduct the study, Williams chose Nick Vintila, who had begun his career at Deere as a manufacturing supervisor at Component Works. During his second year, Vintila had worked in the turning machine area. Not only had he become very familiar with its operation, but he had worked with people such as John Gordon, then in methods, and Andy

Edberg, then a manufacturing superintendent, who would now also be working on the cost study. Vintila had subsequently served as a liaison between systems development and manufacturing to implement a labor reporting system that tied into MRP, and he then became an accounting supervisor at the Tractor Works.

As a first step, Williams and Vintila studied a sample of 44 of the 275 bid parts. (See **Exhibit 7**.) This examination showed (a) an enormous range of variation among quotes for many parts, (b) a large dispersion between JDCW and vendor quotes, ranging from 50% to 60% on some parts and 200% to 300% on others, (c) that JDCW estimated standard costs exceeded vendor prices by 35% on average, and (d) that JDCW appeared to be most cost-effective on low-volume and low-value parts. (See **Exhibit 8** for summary measures of the characteristics of the 44 sample parts.) These findings raised numerous questions about the validity of the standard cost system for determining costs of individual parts and reaffirmed the need for an alternative costing method.

Vintila spent the first half of 1985 working full-time on what became known as the ABC (Activity-Based Costing) study. After detailed study of the shop process flow, he and Williams learned that use of overhead resources could be explained by seven different types of support activities: direct labor support, machine operation, setup hours, production order activity, materials handling, parts administration, and general overhead. Vintila then went through each overhead account (e.g., engineering salaries, crib attendant costs), asking others and himself, "Among the seven activities, which cause this account to occur? What creates work for this department?" He began to estimate the percentages of each overhead account that were driven by each of the seven activities. He conducted specific studies to estimate the total volume of each of the seven overhead driving activities (such as number of production orders, total machine hours). This work was circulated among people like Maxwell, Edberg, Gordon, and Sinclair, who, drawing on their experience and judgment, accepted the seven activities as the key overhead drivers and adjusted the final percentages for allocating budgeted items to each activity. (See **Appendix** for a description of the seven overhead drivers and how Vintila arrived at the seven overhead rates.) When the ABC method was used to allocate overhead, 41% of the overhead shifted to activity bases 3–7 (see **Exhibits 9** and **10**). The data needed to estimate the cost of a particular part are shown in **Exhibit 11**.

The detailed work to design the ABC system had now been completed. The next step for Williams and Vintila was to test and gain acceptance for their new costing approach.

Exhibit 1 Deere & Company, Selected Financial Data, 1975-1985 ($ in millions)

	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Sales											
Agricultural equipment	$3,118	$3,504	$3,314	$4,033	$4,665	$4,489	$3,936	$3,297	$2,934	$2,681	$2,543
Industrial equipment	943	894	654	575	782	981	997	858	670	452	412
Net sales	4,061	4,398	3,968	4,608	5,447	5,470	4,933	4,155	3,604	3,133	2,955
Operating Profit (loss) from Operations											
Agricultural equipment	56	179	178	268	555	399	464	451	437		
Industrial equipment	22	6	(65)	(131)	(39)	71	100	86	46		
Total	78	185	113	137	516	470	564	537	483		
Net Income: Consolidated Group	(64)	21	(52)	(39)	160	184	274	225	226	216	
Net Income: Unconsolidated Subsidiaries	95	84	75	92	91	44	37	39	30	26	
Net income	31	105	23	53	251	228	311	264	256	242	171
Identifiable Assets											
Agricultural equipment	3,625	3,838	3,971	4,141	3,868	3,429	2,668	2,370	2,278		
Industrial equipment	732	726	727	775	890	883	696	637	611		
Corporate	1,105	1,133	1,182	1,020	926	890	815	885	540		
Total	5,462	5,697	5,880	5,936	5,684	5,202	4,179	3,892	3,429		
Capital Additions											
Agricultural equipment	117	75	72	115	243	300	219	197	190		
Industrial equipment	27	14	8	15	59	87	46	26	35		
Corporate	–	–	–	–	1	6	1	5	8		
Total	144	89	80	130	303	393	266	228	233	126	215
Depreciation expense	$184	$191	$194	$197	$177	$145	$119	$102	$84	$66	$53

Exhibit 2 Machined Parts

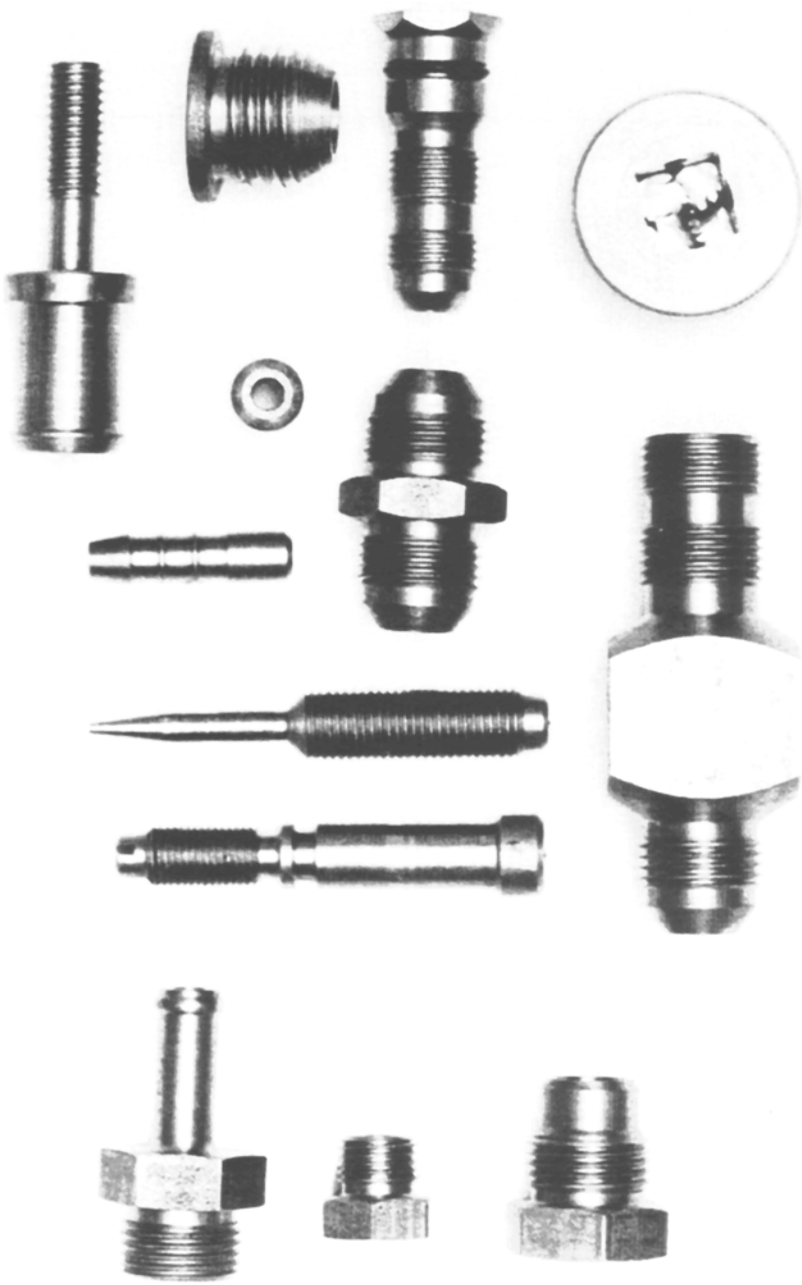

Exhibit 3 Engineering Drawing of Part A103

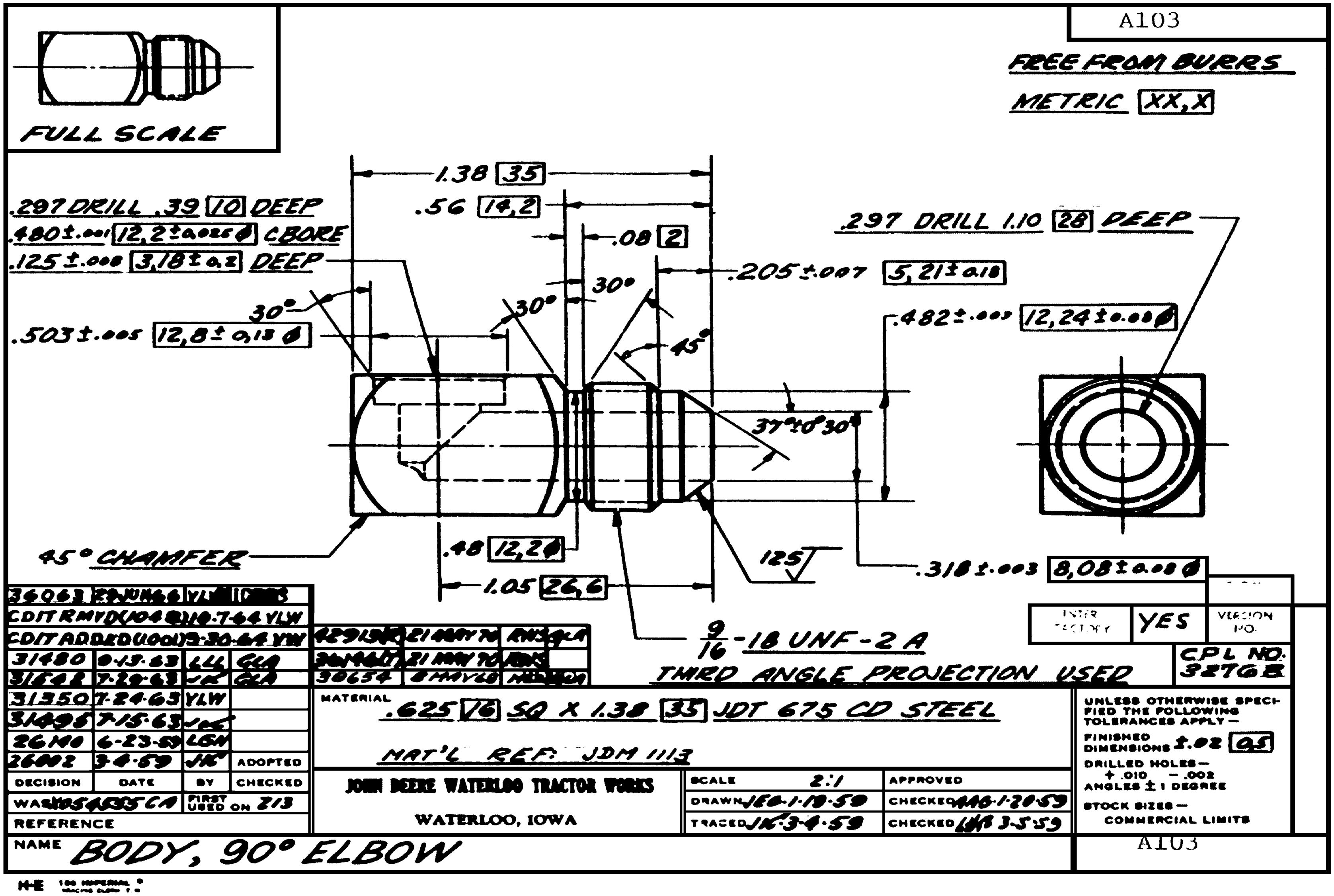

Exhibit 4 Turning Machine

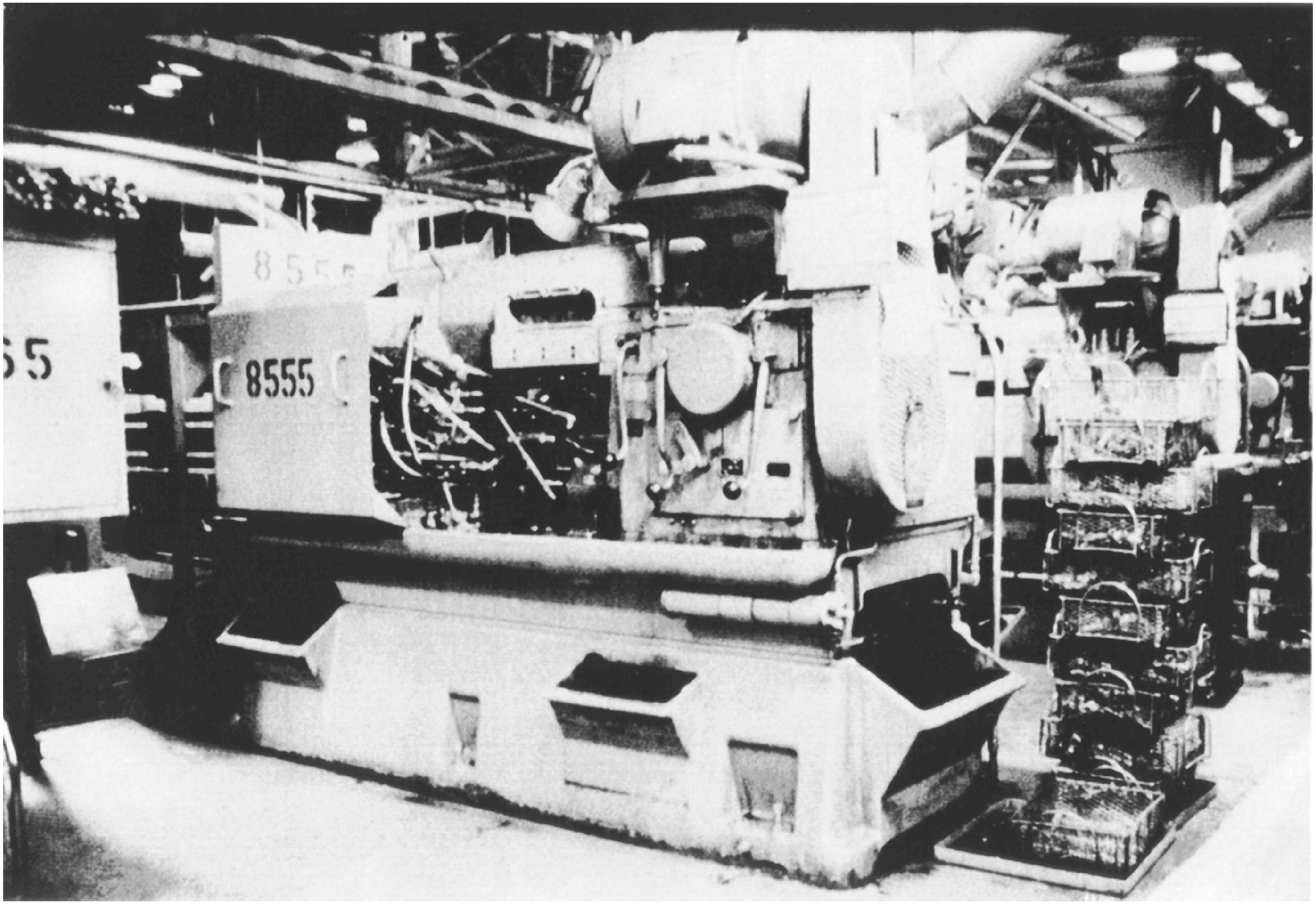

Exhibit 5 Rows of Automatic Turning Machines

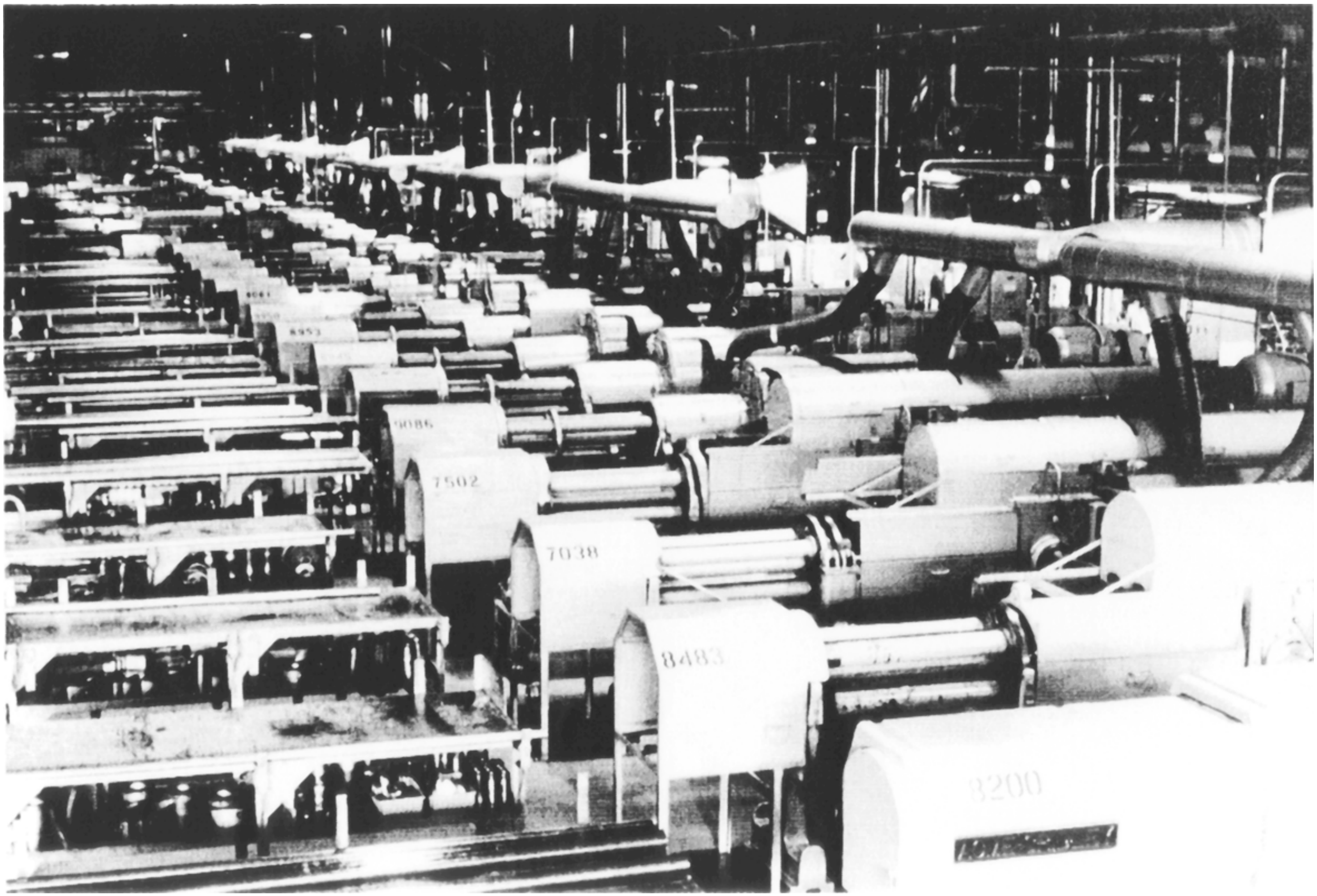

Exhibit 6 A Machine Department Budget Report

(BUDGET BASIS FOR MONTHLY ONLY) TONS PRODUCED: 3133 — PLANT PRODUCTIVE LABOR: 12914.70

DEPT. LABOR DEPT/LEVEL 126

(BUDGET BASIS FOR YEAR TO DATE ONLY) TONS PRODUCED: 30935 — PLANT PRODUCTIVE LABOR: 118273.95

	Budget for the Month					Ratio To Budget Basis				Budget for Year to Date				
Account Number	Labor	Material	Total Expense	Budget Allowance	Over Under	Actual	Budget	Actual	Budget	Labor	Material	Total Expense	Budget Allowance	Over Under
83-501	12796	0	12796							116783	0	116783		
83-511	338	0	338							4260	0	4260		
86-021	2241	891	3132	3208	76-	2425	2484	3430	2488	12659	30277	42936	29423	13514
86-022	244	148	392	430	38-	304	333	217	333	1714	854	2567	3944	1377-
86-024	0	0	0	5	5-	00	04	39	04	458	0	458	47	411
86-041	34	43-	8-	1565	1563-	07-	1204	1265	1206	565	14402	14958	14261	696
86-061	0	5143-	5143-	3611	8754-	3982-	2796	3230	2800	0	38201	38201	33118	5082
86-081	0	0	0	1	1-	00	01	00	01	0	0	0	12	12-
86-083	0	0	0	6	6-	00	05	04	05	40	4	44	59	15-
86-111	1359	0	1359	1304	55	1052	1010	486	1011	5772	0	5772	11963	[illegible]
[illegible]		0	173	[illegible]	134	104		04	1189			[illegible]		
BUDG TOT 86	24671	3147-	21524	25400	3876-	16466	19468	23158	19496	183498	90398	273897	232952	40944
OTHER	0	6	6	1	5	05	01	03	01	0	36	36	12	24
TOTAL	24671	3141-	21530	25402	3872-	16671	19469	23161	19497	183498	90434	273932	232964	40968
NON BUDG	13134	0	13134							121043	0	121043		
GRAND TOT	37805	3141-	34664			26841		33395		304541	90434	394975		

Accounts: 83-501 = direct labor incentive work; 83-511 = day work direct labor; 86-021 mechanical machine maintenance; 86-xxx other overhead accounts

Terms: Labor = actual labor; Material = actual material; Plant Productive Labor (PPL) = budget base used to generate overhead ratios; is sum of incentive work plus part of day work

Ratio to Budget Basis (using account 86-021 as example)

Actual (month): 24.25% = $\frac{\text{\$3,132 mechanical machine maintenance expense}}{\text{\$12,914 actual labor cost for month}}$ = actual overhead rate

Budget (month): 24.84% = a given, estimated during the budgeting process

Actual (YTD) : 36.30% = $\frac{\text{\$42,936 YTD mechanical machine maintenance expense}}{\text{\$118 YTD actual labor cost}}$

Exhibit 7 Comparison of JDCH Bid vs. Outside Vendor Bids for Sample of 44 parts

			JDCW Est.		Competing Vendor Quotes							% of JDCW to Vendor 2		
Part Number	Part Description	Quote Volume	Dir. Cost	Mfg. Cost	1	2	3	4	5	6	7	Dir. Cost	Mfg. Cost	Direct Labor $ Each
Component Works Low on Full-Cost Basis:														
F382	Fitting	4,009	$2,248	$3,153	$3,940	$9,822	$13,550					23%	32%	$0.05
S209	Spacer	950	183	291	399	522	551	$1,244	$1,244			35	56	0.03
P594	Pin	692	297	430	692	796	817	1,012	1,509			37	54	0.03
T815	Stud	3,150	719	1,162	1,712	1,859	2,158	2,300	3,131	$9,356		39	62	0.03
P675	Pin	3,596	1,703	2,649	3,587	3,740	6,024	7,947				46	55	0.07
H622	Hub	4,450	3,207	4,365	5,687	6,324	6,743	7,518	8,463	12,875	$12,875	51	69	0.05
S245	Spacer	4,912	1,249	1,917	2,210	2,335	2,536	3,276	3,585	4,076		53	82	0.03
R647	Sprocket	5,167	6,792	9,196	11,907	12,142	12,400	13,124	16,116	16,674	17,516	56	76	0.10
T501	Stud	4,879	902	1,492	1,537	1,610	1,625	1,820	2,196	2,976	6,294	56	93	0.03
S071	Spacer	5,661	4,896	6,885	8,378	8,433	10,133	58				58	82	0.09
C784	Cap	71,200	13,101	19,537	17,088	22,072	22,606	23,332	29,832	41,253		59	89	0.04
P583	Pin	3,402	2,775	4,285	4,380	4,467	4,826	5,233	5,391	17,200		62	96	0.09
R410	Sprocket	792	878	1,226	$658	1,349	$2,162	$2,273	$2,866	$2,946	$3,983	65	91	0.08
Total or average		112,860	$38,949	$56,590		$75,471						52%	75%	$0.05
Component Works Low on Direct-Cost Basis:														
R918	Rocker	1,091	$663	$1,063	$905	$1,036						64%	103%	$0.05
P220	Pin	3,204	6,685	11,754	9,048	10,413	$12,655	$14,642	$18,711			64	113	0.45
P057	Pin	1,281	979	1,675	1,460	1,487	2,306	2,985				66	113	0.09
T566	Stud	2,452	7,925	12,037	9,563	11,843	12,628	13,461	18,568			67	102	0.42
P736	Pin	38,955	6,837	10,475	9,181	10,167	11,492	11,492	13,323	$22,983		67	103	0.03
P904	Pin	950	1,170	1,801	1,606	1,729	1,767	1,995	3,420			68	104	0.10
H355	Hub	1,155	1,947	3,090	2,552	2,872	2,979	3,026	4,775	6,846		68	108	0.13
P423	Pin	3,402	2,661	4,157	2,994	3,912	5,137	5,477	11,805			68	106	0.09
B605	Bolt	10,561	2,239	3,373	2,893	3,273	3,485	3,707	3,970	4,718	$4,718	68	103	0.03
H346	Hub	1,088	2,223	3,570	3,007	3,122	3,151	3,242	3,438	4,034	4,128	71	114	0.15
H554	Hub	1,490	1,551	2,214	1,967	1,997	2,077	2,216	2,298	2,459	2,459	78	111	0.06
P244	Pin	7,383	7,438	10,948	7,591	8,786	9,498	10,705	11,270	12,677	23,773	85	125	0.11
L209	Lever	5,351	2,480	3,827	1,578	2,745	3,692	4,334	4,486	4,548	4,826	90	139	0.05
R316	Roller	18,058	2,470	4,610	2,257	2,691	3,250	4,050	4,231	4,939	4,984	92	171	0.03
S451	Spacer	2,785	645	1,226	390	697	852	1,104	1,253	1,276	$1,306	93	176	0.04
P333	Pin	4,258	6,818	12,088	6,898	7,324	9,197	11,113	12,008			93	165	0.32
P379	Pin	6,807	6,984	10,249	5,037	7,352	7,760	9,394	9,421	$21,919		95	139	0.11
P682	Pin	3,402	4,037	5,880	$2,824	4,208	$5,035	$5,817	$11,533			96	140	0.11
Total or average		113,673	$65,753	$104,038		$85,654						77%	121%	$0.08
Cumulative		226,533	$104,703	$160,629		$161,125						65%	100%	$0.08
Component Works Not Cost-Competitive:														
H265	Hub	4,464	$15,311	$24,341	$13,570	$15,236	$17,275	$17,454	$17,901	$20,489		100%	160%	$0.57
A152	Shaft	2,972	7,749	12,841	6,685	7,667	8,470	10,877				101	167	0.38
R717	Sprocket	4,869	6,834	10,003	6,205	6,707	7,421	7,839	7,887	8,868	$9,450	102	149	0.16
S771	Spacer	11,092	971	1,689	909	942	1,053	1,275	1,852	2,107	2,203	103	179	0.02
R428	Sprocket	3,180	4,374	6,888	3,637	4,226	4,285	4,293	4,624	4,709	5,599	103	163	0.18
R946	Roller	5,904	6,254	10,727	4,815	6,022	6,199	6,494	7,947	9,269	19,837	104	178	0.14
R157	Roller	3,181	1,651	2,934	1,082	1,565	1,645	1,749	1,890	1,917	2,004	106	188	0.08
B823	Button	18,200	3,296	5,622	2,347	3,094	3,257	3,276	3,314	3,516	6,042	107	182	0.03
T863	Stud	7,120	11,136	17,790	8,231	8,590	9,185	13,243	24,706			130	207	0.37
T237	Stop	4,258	12,719	18,713	7,877	8,516	9,112	9,623	10,228	16,606		149	220	0.35
N281	Nut	8,500	6,350	11,322	3,392	3,789	4,114	6,375	7,548	8,925	$15,640	168	299	0.18
T166	Stud	5,645	8,766	16,014	3,912	5,024	5,701	13,209				174	319	0.41
T586	Stud	10,000	15,957	27,273	$7,525	8,900	$9,540	$11,000	$11,520	$26,700		179	306	0.40
Total or average		89,385	$101,367	$166,157		$80,278						126%	207%	$0.21
Total/Avg. all parts		315,918	$206,069	$326,786		$241,403						85%	135%	$0.11

Exhibit 8 Characteristics of Sample of 44 Parts

Category	Number	Volume	Direct Labor $	ACTS Hours per 100 Parts	Annual ACTS Hours	DL $/ Material $
Low on full-cost basis	13	4,009[a] [692; 71,200]	.05 [.03; .10]	0.4 [0 3; 1.5]	19 [2; 266]	21% [9; 51]
Low on direct-cost basis	18	3,402 [950; 38,955]	.09 [.03; .45]	1.2 [0.3; 2.8]	31 [10; 159]	23% [9; 224]
Not cost-competitive	13	5,645 [2,972; 18,200]	.18 [.02; .57]	1.5 [0.2; 3.4]	70 [18; 150]	57% [22; 480]
Total	44					

[a]Top number is the median value in that category. Beneath the median appears the range [minimum; maximum].

Exhibit 9 1985 Turning Machine Overhead Allocation Using Standard Cost System

	Applied Based on Direct Labor		Applied Based on Machine Hours		Total	
					$000s	%
Direct overhead						
Maintenance	$32	0.3%	$1,038	10.2%	$1,070	10.5%
Labor allowances	459	4.5	0	0.0	459	4.5
Machine setups	0	0.0	524	5.2	524	5.2
Other OH labor	130	1.3	164	1.6	294	2.9
Scrap and misc.	80	0.8	96	0.9	176	1.7
Employee benefits	1,296	12.7	556	5.5	1,852	18.2
Total direct overhead	$1,997	19.6%	$2,378	23.4%	$4,375	43.0%
Period overhead						
Maintenance	$127	1.2%	$527	5.2%	$654	6.4%
Salaries	796	7.8	826	8.1	1,622	15.9
Depreciation	0	0.0	1,790	17.6	1,790	17.6
General and misc.	227	2.2	717	7.0	944	9.3
Employee benefits	354	3.5	432	4.2	786	7.7
Total period overhead	$1,504	14.8%	$4,292	42.2%	$5,796	57.0%
Total overhead	$3,501	34.4%	$6,670	65.6%	$10,171	100.0%
Overhead base	$1,714 DL$		242,000 ACTS hrs.			
Direct overhead rate	117%		$9.83 per hr.			
Period overhead rate	88		17.73 per hr			
Total overhead rate	205%		$27.56 per hr.			

Exhibit 10 Turning Machine Overhead Allocation Using ABC Method

	Direct Labor Support Overhead		Machine Operation Overhead		Machine Setup Overhead		Production Order Overhead		Materials-Handling Overhead		Part Admin. Overhead		General and Administration Overhead		Total	
	$000s	% Total	$000s	% Total	$000s	% Total	$000s	% Total	$000s	% Total	$000s	% Total	$000s	$ Total	$000s	% Total
Direct Overhead																
Maintenance	$0	0.0%	$899	8.8%	$45	0.4%	$62	0.6%	$63	0.6%	$0	0.0%	$0	0.0%	$1,069	10.5%
Labor allowances	329	3.2	47	0.5	61	0.6	10	0.1	12	0.1	0	0.0	0	0.0	459	4.5
Machine setups	0	0.0	146	1.4	378	3.7	0	0.0	0	0.0	0	0.0	0	0.0	524	5.2
Other OH labor	0	0.0	67	0.7	0	0.0	106	1.0	122	1.2	0	0.0	0	0.0	295	2.9
Scrap & misc.	0	0.0	141	1.4	0	0.0	30	0.3	6	0. 1	0	0.0	0	0.0	177	1.7
Employee benefits	$1,100	10.8	339	3.3	246	2.4	77	0.8	90	0.9	0	0.0	0	0.0	1,852	18.2
Total direct OH	$1,429	14.0%	$1,639	16.1%	$730	7.2%	$285	2.8%	$293	2.9%	$0	0.0	$0	0.0	$4,376	43.0%
Period Overhead																
Maintenance	$10	0.1%	$333	3.3%	$40	0.4%	$9	0.1%	$8	0.1%	$238	2.3%	$17	0.2%	$655	6.4%
Salaries	270	2.7	179	1.8	62	0.6	243	2.4	0	0.0	421	4.1	448	4.4	1,623	16.0
Depreciation	27	0 3	1,424	14.0	226	2.2	25	0.2	0	0.0	43	0.4	45	0.4	1,790	17.6
Gen. & misc.	59	0.6	323	3.2	19	0.2	152	1.5	0	0.0	90	0.9	298	2.9	941	9.3
Employee benefits	103	1.0	147	1.4	34	0.3	103	1.0	2	0.0	207	2.0	190	1.9	786	7.7
Total period OH	$469	4.7%	$2,406	23.7%	$381	3.7%	$532	5.2%	$10	0.1%	$999	9.8%	$998	9.8%	$5,795	57.0%
Total overhead	$1,898	18.7%	$4,045	39.8%	1,111	10.9%	$817	8.0%	$303	3.0%	$999	9.8%	$998	9.8%	$10,171	100.0%
Overhead base	**$1,714 DLS**		**242,000 annual ACTS hours**		**32,900 annual setup hours**		**7,150 annual orders**		**15,600 annual loads**		**2,050 part $'s**			10,887 Value added –		
Direct overhead rate	83.4%		$6.77 per hr.[a]		$22.18 per hr		$39.86 per order		$18.78 per load		—			9.1%		
Period overhead rate	27.4		9.94		11.58		74.41		.64		$487 per part			9.1%		
Total overhead rate	111.0%		$16.71 per hr.		$33.76 per hr.		$114.27 per order		$19.42 per load		$487 per part					

$1,714	DL$
$1,893	DL$ OH
4,045	Mach. Oper. OH
1,111	Setup OH
817	Prod. Order OH
303	Mat.-Hand. OH
999	Part Admin. OH
$10,887	Value added

[a]Rates shown are averages across all turning machines. In practice, separate machine overhead rates were calculated for each major class of machines.

Exhibit 11 Elements for Costing Parts A103 in 1985

Materials cost per 100 parts	$6.44
Materials Overhead Rates	
Direct	2.1%
Period	7.6%
Direct labor hours per 100 parts	.185 hr.
ACTS hours per 100 parts	.310 hr.
Labor rate for turning machine operation	$12.76
Machine setup time	4.2 hrs
Part weight	0.175 lbs
Quote volume[a]	8,000
Runs per year	2
6-Spindle Machine Rates[b]	
Direct	$8.99
Period	$7.61

[a]Annual volume as specified by user.

[b]Under ABC system.

Appendix

ABC Activities for Applying Overhead to Turning Machine Parts

The ABC study used the accounting estimate of normal volume and total overhead costs as its starting point. Overhead costs were then allocated to seven rather than just two activities. A separate overhead rate was derived for each activity. (See **Exhibits 9** and **10** for comparison of the two methods.) Vintila used the following approach to apportion overhead and to develop overhead rates:

1. Direct labor support overhead was generated by incentive employees working on parts. It included allowances for benefits, break periods, and a percentage of supervision, personnel, payroll, and industrial engineering salaries. All direct labor support overhead costs were summed ($1,898,000 in 1985) and divided by the total amount of direct labor dollars ($1,714,000) to derive an overhead rate for this activity (111%).

2. Machine operation overhead was generated by operating the turning machines, plus an allocation of facility and capacity charges. This activity received most of the costs of machine maintenance, small tools, jigs, and dies, as well as smaller proportions of inspection and defective work, engineering and supervision salaries. Allocations were also made for depreciation, taxes, interest, and utilities. The total dollars required to operate the machines ($4,045,000) were divided by the total number of machine hours (242,000) to develop the $16.70 per hour overhead rate for this activity.

Whereas the standard cost system used the same ACTS rate for all turning machines, Vintila examined the machines individually and ultimately developed separate rates for four different size machines. He gathered data on several factors to create machine-specific estimates of the costs of running them. For example, kilowatt hours multiplied by the load factor was used to generate utilities cost; replacement costs to estimate the share of insurance, taxes, and depreciation; square footage to calculate a proportion of facilities costs; and the “spindle factor” to allocate tooling and maintenance costs. The spindle factor took into account the number of spindles on a machine; when multiplied by its annual load (or ACTS hours), it provided a basis for allocating tooling and maintenance costs according to size and use of the machine. For all of these factors, Vintila obtained percentages by dividing the total (e.g., replacement costs of all turning machines) by that for the particular machine. To obtain an overall direct overhead rate for a machine, he divided all its direct overhead by its ACTS hours.

Once this information had been generated for each of the turning machines, similar-size machines were grouped and a single overhead rate determined for each group. In this way, machines that happened to have a lower load would not be penalized by a higher rate.

3. Setup hours overhead was generated by changing the job to be run. It included actual setup costs; a small share of machine and small-tool maintenance, supervision, and engineering salaries; and a share of depreciation and other facility costs. These costs ($1,111,000) were divided by the estimated number of setup hours (32,900) to arrive at an hourly overhead rate ($33.80).

The number of setup hours was estimated through an examination of production control data, which showed the average setup time to be 4 hours. This figure was multiplied by the average number (4) of annual runs per part number, and by the 2,050 parts in the system.

4. Production order activity was generated by shop activity resulting from each production order. The largest cost was materials control salaries. Percentages of crib attendant costs, inspection, defective work, and manufacturing costs were also applied. The sum was divided by the total number of annual production orders (7,150) to yield a cost of $114 per production order.

5. Materials handling overhead arose from moving barstock to the machines, and then moving the parts to the next operation. The major cost elements were materials handling labor and equipment maintenance. This activity also received a share of inspection and defective materials costs. An overhead rate ($19.42) was derived by dividing the total allocated costs ($303,000) by the number of loads (15,600).

Appendix (continued)

The number of loads was estimated through a six-step process:

a. $\frac{\text{part weight x annual volume}}{\text{runs/year for that part}}$ = weight/run

b. $\frac{\text{weight/run}}{\text{pounds/load}}$ = loads/run
(average of 2,000 lbs. per transport container)

c. loads/run + .5, then round result to nearest full integer
(a calculation to correct for incomplete loads)

d. multiply result in (c) by no. of runs of that part/year = no. of loads/year moved away from machines

e. loads/year x 2 (movement to and from machine) = total no. of loads/year for that part

f. repeat process for all part numbers, and add no. of loads/part (to obtain total no. of loads per year).

6. Part administration overhead was incurred just by having a part number in the department's repertoire. It included the cost of establishing and maintaining records and systems documentation and a share of salaries in process engineering, industrial engineering, supervision, and materials control. The sum of $999,000 in overhead, when distributed among the 2,050 parts in the system, generated a head tax of $487 per part number.

7. General and administrative overhead was attributed to the entire factory, not to a particular manufacturing process or activity. It included a large share of taxes, utilities, and depreciation, as well as smaller shares of salaries, such as accounting, reliability, and manufacturing engineering. The $998,000 of G&A overhead was prorated to products based on their value added: the sum of direct labor plus the other six overhead activity costs for each part. The value-added sum became the denominator for determining the G&A rate to be applied to the part.