NAKADA MACHINERY COMPANY, Ltd.*

—— A Case In Production Control ——

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Since the latter half of 1958, the Nakada Machinery Company, Ltd. had been doing a heavy volume of business, the amount of orders received being always in excess of production. Delays in delivery, therefore seemed to everyone within the company to create a serious problem that must be solved as soon as possible.

On July 30, 1960. Mr. Susumu Kitamura, who had been transferred from the head office in Tokyo to the Yokohama plant as chief of the Scheduling Section only three months earlier, received a report on the present status of the delayed deliveries. This report had been prepared by the Sales Section at his request, and it revealed the following facts:

	sets	%
Delivered on time or with delay of less than 6 days	128	64.0
Delay of 6—10 days	29	14.5
Delay of 11—20 days	13	6.5
Delay of 21—30 days	16	8.0
Delay of more than 30 days	14	7.0
	200	100.0

These figures were the result of a sampling research concucted concerning products shipped out during May and June of 1960.

In addition to this information, Mr. Kitamura had been collecting opinions about this delivery problem from key persons within the company. These opinions could be boiled down to the following points. The delivery difficulties could be attributed to:

1. receiving orders for which the delivery date is either too tight or not specified at all,
2. delay in delivery of materials or parts to complete the order,
3. poor materials,
4. insufficient production capacity,
5. too many varieties of products,
6. unexpected difficulties arising from receiving orders of a nature involving trial manufacture,
7. too much time required for office procedures in processing the order,
8. unsatisfactory stock control of standard parts,
9. lack of standardization of materials and parts,
10. frequent requests by customers for a change in product specification,
11. insufficient capacity of the design section.

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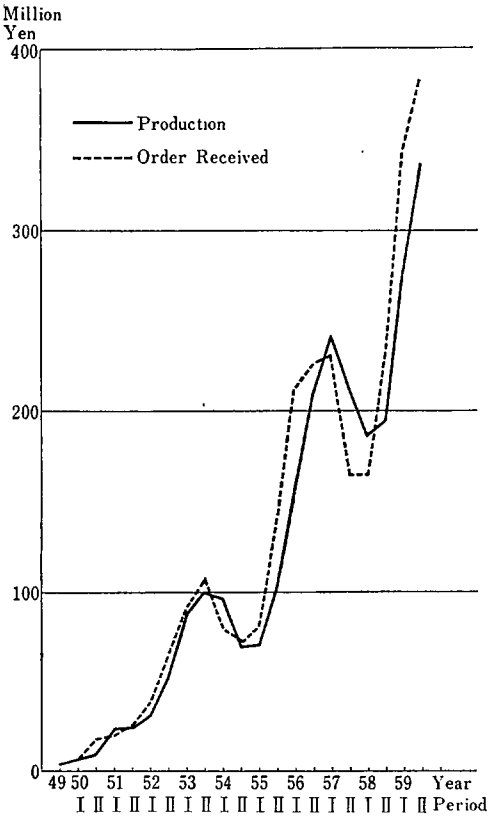
* All names used in this case are disguised.

This case material has been prepared as a basis for group discussion, and is not intended to present illustrations of either correct or incorrect handling of administrative problems.

I *Company Background*

Exhibit 1 *The Growth of Production and Order Received*



Nakada Machinery Company was established in 1949 by Mr. Nakada, with equity capital of one million yen, and started to produce flow meters using a specially industrialized gear system. The company enjoyed a remarkable growth as seen in *Exhibit* 1.

The main customers for the flow meters the company produced were business firms belonging to such industries as chemical, petroleum, ship-building and machinery, chemical fiber, steel, etc., and the percentages of sales value to these industries during the six months ending March 31, 1960 were as shown in *Exhibit* 2.

Exhibit 2 *Sales Ratios by Industry*
(6 months ending March 31, 1960)

Industry	Percentage of Total Sales
Chemical	22.5
Petroleum	15.0
Ship-building & Machinery	14.2
Chemical Fiber	10.5
Steel	5.7
Others	32.1
Total Sales	100.0

The average monthly production of flow meters during the recent six months was 600 sets. These could be classified into two broad categories: 1. standard-type meters (80%) and 2. non-standard-type meters (20%).

The standard-type flow meters, designated as MS, were produced to stock, and accounted for 33% of the sales value. The non-standard-type flow meters, designated as MT, were manufactured to order, and could further be divided into two main categories: 1. MTA, for which blueprints were available because some similar meters had been manufactured in the past; and 2. MTB, for which no available blueprint was on hand.

The meters were otherwise classified according to materials used; that is, stainless steel, cast iron, and brass. These three categories accounted for, in terms of set, 50%, 30%, and 20%, respectively. But in terms of sales value, stainless steel meters stood first, accounting for more than 80%.

In July, 1960, the number of company employees was 296, 49 of these being female. The average age of the workers was 25.2 years, and the average wage earned was about

16,000 yen for direct workers, and 22,000 yen for indirect workers (engineering and inspection).

President Nakada's guiding principles in management were:

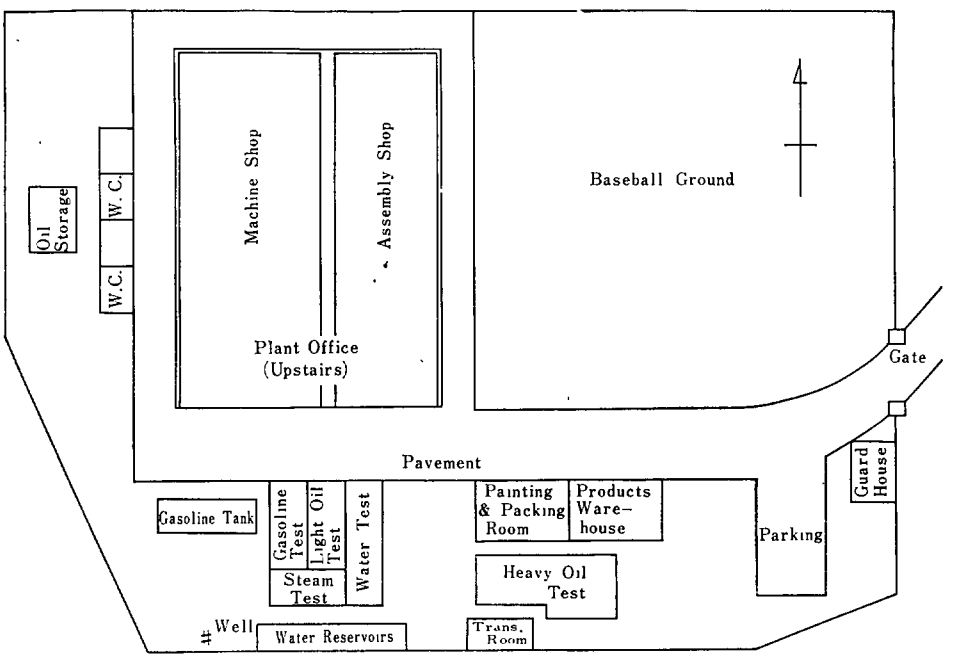
1. to provide employees with a pleasant life-time working place,
2. to provide customers with the best product conscientiously manufactured,
3. to make the company worthy of the reliance of investors, suppliers, customers, and the public.

II *Yokohama Plant and Production Process*

To meet ever-increasing demands of the business, the Yokohama plant, the company's main plant, was erected in 1957 on an area of 53,000m^2 in a well-wooded suburb of Yokohama. It was commended by the Japanese Government as model plant.

The plant layout and the layout of machine tools are shown in *Exhibits* 3 and 4, respectively. The main building, which accommodated the machine shop and the assembly shop, was of light-gauge steel-frame construction, and a part of it was two-storied, the second floor being used as the plant office.

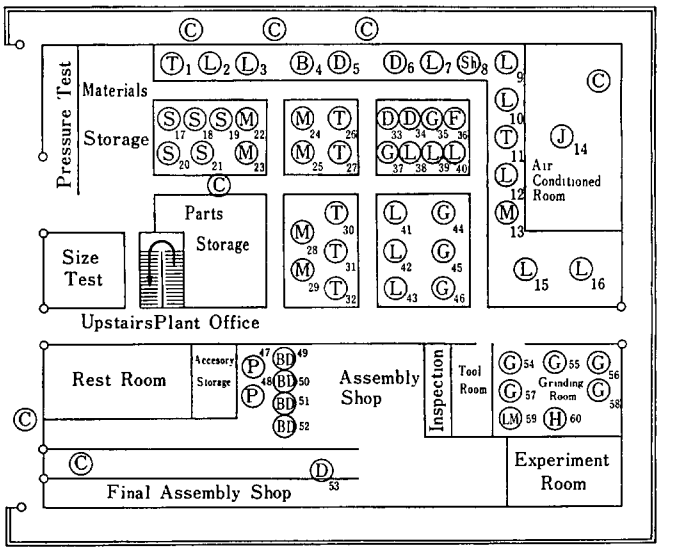
Exhibit 3 *Layout of the Yokohama Plant*



The flow meter the company produced consisted of three parts: the outer casing, the measuring elements, and the counter parts. It was constructed to measure continuously and automatically, by means of the number of revolutions of the rotor within it, the *volume* of liquid flowing through it; the *rate* of liquid flow was measured by the revolution

Exhibit 4 *Layout of Machine Tools in the Yokohama Plant*

	Machine	Number
(B)	Boring Machine	1
(BD)	Bench Drilling	4
(C)	Chain Crane	7
(D)	Drilling Machine	5
(F)	Fine Boring Machine	1
(G)	Grinder	10
(H)	Horning Machine	1
(J)	Jig Borer	1
(L)	Engine lathe	14
(LM)	Lapping Machine	1
(M)	Milling Machine	7
(P)	Press	2
(S)	Slotter(Cutting Machine)	5
(Sh)	Shaper	1
(T)	Turret Lathe	7



speed of the rotor. An appropriate type of flow meter was selected for a particular use, depending upon the special kind of fluid, pressure, and temperature, as well as upon the purpose of the use, the diameter of the connecting tube, etc..

The outer casing and the counter parts were manufactured by outside suppliers, the blueprints being prepared by the company (the Englineering Section of the Yokohama plant in the case of the outer casing, and the Manufacturing Section in the case of the counter parts). The major parts of the measuring elements were the inner casing, the upper and the lower covers, and the rotor. The Design Sub-section of the Engineering Section in the Yokohama plant was in charge of the design of the measuring elements; and the manufacturing of these parts and the assembly of the manufactured and the purchased parts constituted the production process of the Yokohama plant. Besides these major parts, there were several kinds of accessories, such as strainers and air releasers. Some of these accessories were manufactured in the Tokyo plant.

Purchased parts were inspected by means of a size test and a pressure test, and, if they passed the tests, were stored in the materials storage section.

The process charts of the machining operations for the four major parts of the measuring element of a typical standard flow meter are shown in *Exhibits* 5–8.

The flow meters assembled in the final assembly shop were sent to an appropriate test room. There were a gasoline test room, a light oil test room, a heavy oil test room, a steam test room, and a water test room. In many cases, a test in the presence of the customer was called for by the contract. The tested products were either shipped out immediately after being painted and packed, or were stored in the products warehouse.

Exhibit 5 *The Process Chart for Manufacturing the Inner Casing*

(Lot size: 20 units)

Dist. in Meters	Time in Hours* A	Time in Hours* B	Operation	Move	Storage	Inspection	Description of Operation	Machine Tool Used
			○	o	▲	□	Store in materials storage	
40			○	●	△	□	To engine lathe	
			○	o	▲	□	Waiting for operation	
	0.4**	0.4						
	0.5	0.45	●	o	△	□	Rough turning	Engine lathe ⑦***
			○	o	▲	□	Waiting for the lot (20 units) being operated	
5			○	●	△	□	To turret lathe	
			○	o	▲	□	Waiting for operation	
	— ***	—						
	0.4	0.4	●	o	△	□	Boring	Turret lathe ⑪
			○	o	▲	□	Waiting for the lot being operated	
20			○	●	△	□	To inspection	
			○	o	▲	□	Waiting for inspection	
	—		○	o	△	■		
	0.04							
			○	o	▲	□	Waiting for the lot being inspected	
20			○	●	△	□	To drilling machine	
			○	o	▲	□	Waiting for operation	
	0.3	0.3						
	0.2	0.2	●	o	△	□	Drilling	Drilling machine, ㉝ or ㉞
			○	o	▲	□	Waiting for the lot being operated	
30			○	●	△	□	To bench drilling machine	
			○	o	▲	□	Waiting for operation	
	—	—						Bench drilling machine, one of ㊾～㊿
	0.4	0.4	●	o	△	□	Tapping and drilling	
40			○	●	△	□	To fine boring machine	
			○	o	▲	□	Waiting for operation	
	0.4	0.4						
	0.3	0.3	●	o	△	□	Finishing	Fine boring machine ㊳
20			○	●	△	□	To inspection	
			○	o	▲	□	Waiting for inspection	
	—		○	o	△	■		
	0.1							
			○	o	▲	□	Waiting for the lot being inspected	
20			○	●	△	□	To parts storage	
			○	o	▲	□	Store in parts storage	
Total of Machine Time	1.8	1.75						

Notes: A: Bronze B: Cast Iron

* In the case of stainless steel, the machining time was about three times as long as the figures shown here.

** The upper figure is set-up time, and the lower figure is machine time. —shows negligible time.

*** See Exhibit 4.

Exhibit 6 *The Process Chart for Manufacturing the Rotor*

(Lot size: 40, 2 for one unit)

Dist. in Meters	Time in Hours A	Time in Hours B	Operation	Move	Storage	Inspection	Description of Operation	Machine Tool Used
			○	o	▲	□	Store in materials storage	
30			○	●	△	□	To turret lathe	
			○	o	▲	□	Waiting for operation	
	0.4 0.47	0.4 0.47	●	o	△	□	Surface grinding and boring	Turret lathe, one of ㉚～㉜
5			○	●	△	□	To inspection	
			○	o	▲	□	Waiting for inspection	
	0.05		●	o	△	□	Air-micro inspection	
			○	●	△	□	To milling machine	
			○	o	▲	□	Waiting for operation	
	0.7 0.22	0.7 0.24	●	o	△	□	Concaving	Milling machine ㉙
7			○	●	△	□	To slotter	
			○	o	▲	□	Waiting for operation	
	0.7 0.23	0.7 0.3	●	o	△	□	Gear cutting	Slotter ⑲
30			○	●	△	□	To engine lathe	
			○	o	▲	□	Waiting for operation	
	0.3 0.25	0.3 0.25	●	o	△	□	Turning	Engine lathe, ⑮ or ⑯
15			○	●	△	□	To inspection	
			○	o	▲	□	Waiting for inspection	
	0.02		○	o	△	■		
10			○	●	△	□	To grinder	
			○	o	▲	□	Waiting for operation	
			●	o	△	□	Finishing	Grinder, one of ㊹～㊻
10			○	●	△	□	To parts storage	
			○	o	▲	□	Store in parts storage	
Total of Machine Time	1.17	1.26						

Note: See the notes of Exhibit 5.

Exhibit 7 *The Process Chart for Manufacturing the Upper Cover*

(Lot size: 20 units)

Dist. in Meters	Time in Hours A	Time in Hours B	Operation	Move	Storage	Inspection	Description of Operation	Machine Tool Used
			○	o	▲	□	Store in materials storage	
40			○	●	△	□	To engine lathe	
			○	o	▲	□	Waiting for operation	
	0.4 0.3	0.4 0.35	●	o	△	□	Rough turning	Engine lathe ⑦
3			○	●	△	□	To drilling machine	
			○	o	▲	□	Waiting for operation	
	0.3 0.12	0.3 0.15	○	o	△	■	Drilling	Drilling machine ⑥
3			○	●	△	□	To drilling machine	
			○	o	▲	□	Waiting for operation	
	0.1 0.1	0.1 0.1	●	o	△	□	Drilling	Drilling machine, ㉝ or ㉞
15			○	●	△	□	To engine lathe	
			○	o	▲	□	Waiting for operation	
	0.3 0.15	0.3 0.15	●	o	△	□	Turning	Engine lathe ㊵
10			○	●	△	□	To engine lathe	
			○	o	▲	□	Waiting for operation	
	0.4 0.05	0.4 0.05	●	o	△	□	Surface grinding	Engine lathe, one of ㊶～㊸
5			○	●	△	□	To inspection	
			○	o	▲	□	Waiting for inspection	
	0.06		○	o	△	■	Depth inspection	
5			○	●	△	□	To bench drilling	
			○	o	▲	□	Waiting for operation	
	— 0.1	— 0.1	●	o	△	□	Finishing	Bench drilling, ㊿ or ㊿
10			○	●	△	□	To parts storage	
			○	o	▲	□	Store in parts storage	
Total of Machine Time	0.82	0.90						

Note: See the notes of Exhibit 5.

Exhibit 8 *The Process Chart for Manufacturing the Lower Cover*

(*Lot Size:* 20 *units*)

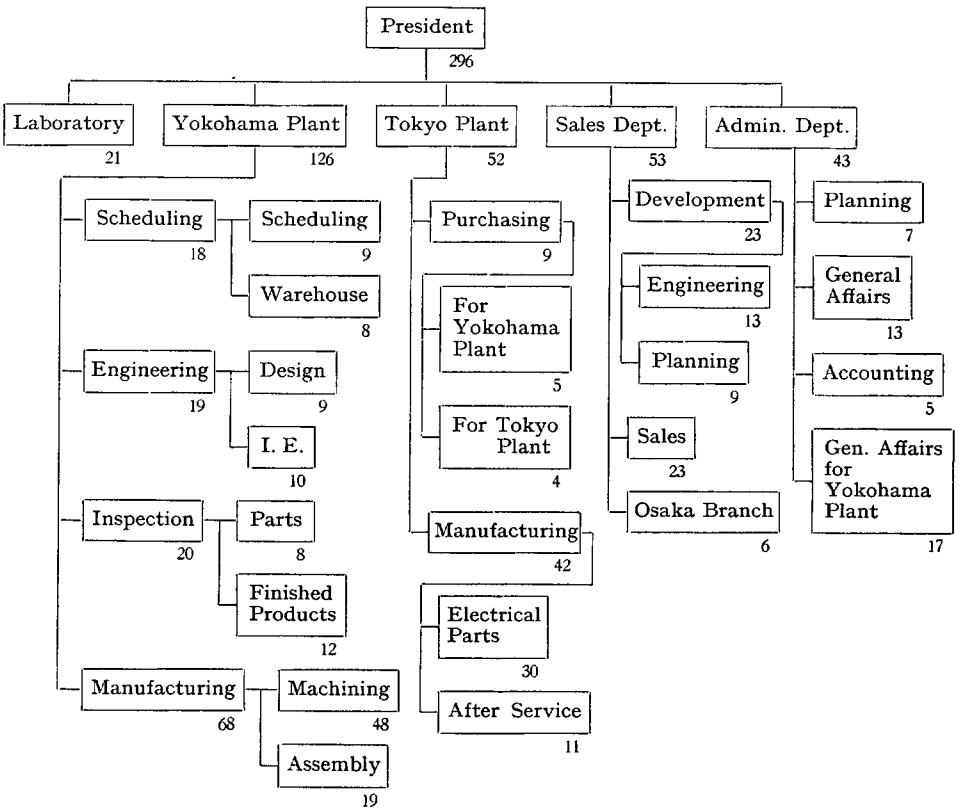
Dist. in Meters	Time in Hours A	Time in Hours B	Operation	Move	Storage	Inspection	Description of Operation	Machine Tool Used
			○	○	▲	□	Store in materials storage	
40			○	●	△	□	To engine lathe	
			○	○	▲	□	Waiting for operation	
	0.4 0.3	0.4 0.35	●	○	△	□	Rough turning	Engine lathe ⑦
3			○	●	△	□	To drilling machine	
			○	○	▲	□	Waiting for operation	
	0.3 0.2	0.3 0.15	●	○	△	□	Drilling	Drilling machine ⑥
3			○	●	△	□	To drilling machine	
			○	○	▲	□	Waiting for operation	
	0.1 0.2	0.1 0.15	●	○	△	□	Drilling	Drilling machine, ㉝ or ㉞
			○	○	▲	□	Waiting for operation	
	0.3 0.1		●	○	△	□	Drilling	Drilling machine, ㉝ or ㉞ (only A)
15			○	●	△	□	To engine lathe	
			○	○	▲	□	Waiting for operation	
	0.4 0.05	0.4 0.05	●	○	△	□	Turning	Engine lathe ㊵
10			○	●	△	□	To engine lathe	
			○	○	▲	□	Waiting for operation	
	0.3 0.05		●	○	△	□	Surface grinding	Engine lathe, one of ㊶～㊸ (only A)
5			○	●	△	□	To inspection	
			○	○	▲	□	Waiting for inspection	
	0.06		○	○	△	■		
5			○	●	△	□	To bench drilling	
			○	○	▲	□	Waiting for operation	
	— 0.1	— 0·1	●	○	△	□	Finishing	Bench drilling, ㊿ or ㊿
10			○	●	△	□	To parts storage	
			○	○	▲	□	Store in parts storage	
Total of Machine Time	1.0	0.8						

Note: See the notes of Exhibit 5.

III *Organization and Procedures for Production*

The company was organized as shown in *Exhibit* 9.

Exhibit 9 *Organization Chart*



Note: Figures show the number of employees.

When an order was received by the Sales Section of the Sales Department, the information was relayed to the Engineering Sub-section of the Development Section, and the details of the customer's requirements were examined by the engineers there, with special reference as to whether one or another of the standard type (MS) products could be adjusted to such requirements. Then a proforma specification was prepared, after the customer's requirements had been confirmed by telephone or by interview.

The manufacturing order form shown in Exhibit 10 was then issued by the Planning Sub-section, and sent to the Scheduling Section of the Yokohama plant. The number of copies of the manufacturing order form sent to the Yokohama plant was different for the three types of products—two for MS; two for MTA; and three for MTB. The frequency of the issue of manufacturing orders was about 1,000 a month, and it usually took about

two weeks from the date when customer's order was received until the manufacturing order arrived at the Yokohama plant.

When the Scheduling Section received the manufacturing order, Mr. Kitamura or Mr. Yasui, the chief of the Scheduling Sub-section, examined the delivery date and the product specification, and put the order into the appropriate monthly production schedule. But it often happened that the delivery date seemed too tight. In that case, the necessary coordination was made at the weekly conference on production promotion, attended by the chief of the Scheduling Section, the chief of the Scheduling Sub-section, the person in charge of procurement, and the chief of the Planning Sub-section of the Development Section. In most cases, however, the customer's request was given first priority in view of the possibility of keen competition for orders in future. In addition, the situation tended to become worsened because the specifications of such items as flow meters were usually decided at the latest stage of the construction of a plant where they would be needed. Such "rush orders" disturbed the scheduled factory operations.

It also happened quite often that the specification prepared by the Development Section was not complete and several exchanges of telephone calls were necessary between the two sections. "This takes a great portion of our time," complained Mr. Yasui.

The Scheduling Sub-section, Mr. Yasui as the chief, consisted of nine persons, three of them women. There were included four expediters who were working mainly in the machine and the assembly shops.

In the case of the MS type products, one copy of the manufacturing order was retained in the Scheduling Sub-section and used for scheduling of production (see the note to *Exhibit* 10).

Exhibit 10 *Form of Manufacturing Order*

Manufacturing Order	Date of issue / Date of delivery		Person in charge	Pres.	Chief of Develop. Section	Chief of Sub-section	
Customer / Location				Factory Mgr.	Chief of Schedul. Section	Chief of Sub-section	

Item	Type	Diameter	Number of unit	Price per unit	Total value	Notes
Flow meter						
Strainer						
Other accessories						
Total	—	—	—	—		

No. of Mfg. Order		No. of Spec. Form		Sales Agent		Shipping date	
		No. of Customer		No. of order		Method of shipping	

A	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Kind of Liquid	Nature of Liquid	Rate of Flow (l/h) max.	normal	min.	Degree of Usage
					Steady Continuous Pulselike Intermittent

Temperature (°C) max.	normal	min.	Pressure (kg/cm²) max.	normal	min.	Test Pressure	Direction of Flow	Diameter of Connecting Pipe	Min. Scale Unit
									l

No. of Spec. Form		Relation of Meter, Pump, and Strainer	Spare Parts	Error Limit
No. of Est. Form				± %
No. of Est. Material				

Notes

Note: A strip of carton which is a copy of the part of the manufacturing order form denoted by A above was used for the purpose of scheduling weekly production on the scheduling board. Entries are: 1. No. of manufacturing order. 2. Type of product. 3. Customer. 4. Number of units. 5. Date of delivery. Dates of finishing; 6. Design, 7. Outer casing, 8. Inner casing, 9. Counter parts, 10. Others, 11. Assembly, 12. Test. 13. Date of completion. 14. Date of shipping out.

The other copy was sent to the Inspection Section, and after the product was inspected, it was sent to the products warehouse. In the case of the MTA- and the MTB-type products, the copy sent to the Inspection Section was returned to the Scheduling Sub-section after inspection, and then was sent to the products warehouse as the shipping order. It was finally sent to the Accounting Section of the Administrative Department and was used as a cost-accounting material. The third copy of the manufacturing order, in the case of MTB, was sent to the Engineering Section, and after the scheduled date of the completion of the blueprints was filled in, it was sent back to the Scheduling Sub-section, and then to the Accounting Section for cost-accounting purpose.

Mr. Yamada of the Scheduling Sub-section was quite busy because, assisted by only one woman, he was in charge of preparing the manufacturing specifications (as shown in *Exhibit* 11) for the MAT-type products, and the material control sheets (as shown in Exhibit 12) for all types of products. The manufacturing specifications for the MTB-type products were prepared by the Design Sub-section of the Engineering Section. The manufacturing specifications were sent to the Manufacturing Section as the manufacturing orders for the shops. Within the shops, the process sheets (such as shown in *Exhibit* 13 and 14) were used in controlling operations and in making a report to be submitted to the Accounting Section. The material control sheets were sent to the Warehousing Sub-section, and if the required materials or parts were out of stock or below a minimum stock level, the procurement order was issued to the Purchasing Section of the Tokyo plant. According to Mr. Kitamura's estimation, it usually took two or three weeks from the time when a manufacturing order was received by the Scheduling Section until the manufacturing speci-

Exhibit 11 *Form of Manufacturing Specification*

Manufacturing Specification			Dept. Manager	Section Chief	Sub-section Chief	Persons in Charge
Customer			Number of Units		Kind of Liquid	
Type						
Rate of Flow	max. nor. min. (*l*/h)		Temperature (°C)	max. nor. min.	Pressure (kg/cm²)	max. nor. min.
Standard of Flange		Test Pressure	Water (kg/cm²)		Air (kg/cm²)	Direction of Flow →

Item	No. of the Blueprint	Materials	Number	Notes
Flow Meter				
Outer Casing				
Flange				
Inner Casing				
⋮				
Strainer				
⋮				

Date of Delivery		Date of Issue		Number	

Exhibit 12 *The Materials Control Sheet*

Material Control Sheet					Date of Issue						
Line	No. of Part	Name of Part	Material	Volume	Way of Procurement	Date of Completion Desired	Date of Order	Supplier	Delivery Date	Stock Taking Date	Notes
1											
2											
3											
⋮											

No. of Mfg Order	Type	No. of Mfg Spec.	Customer	Delivery Date	Assembly Date	Shipping Date

Exhibit 13 *The Machining Process Sheet*

Date of Issue Scheduled Date of Completion		Schedule Sheet			Prepared by			Expediter
Sequence of Operation	Operation	Standard Time			Volume	Good	Failure	Bad Material	Notes
		Set-up	Machining	Total					
1									
2									
3									
⋮									
No. of Mfg Order	No. of the Part	Name			Material	Volume	No.		

Exhibit 14 *The Assembly Process Sheet*

Schedule Sheet			Prepared by			Expediter	
Date of Issue Scheduled Date of Completion			Units	Good Date of Completion		Assessories	
Sequence of Operation	Operation	Date Time	Standard Time		Acual Time (B)	B/A	Name of Worker	Notes
			Per Unit	Total (A)				
1								
2								
3								
⋮								
Total								
No. of Mfg Order	No. of Spec. Form	Type		Units	Customer			

fication and the materials control sheet were issued; and one week more until the procurement order was received by the Purchasing Section.

The monthly production plan was discussed at the meeting of the section chiefs presided over by the plant manager, Mr. Eguchi; then the weekly production schedule was prepared in the Scheduling Section, using a scheduling board (see the note to *Exhibit* 10). The

necessary changes of the production schedule that would require some important type of coordination were discussed at the weekly conference on production promotion.

IV *Engineering Section*

The Engineering Section of the Yokohama plant, headed by Mr. Oka, consisted of two sub-sections, the Design Sub-section and the Industrial Engineering Sub-section. The Design Sub-section, in charge of the design of the MTB-type flow meters and of the fundamental elements of the newly planned products, consisted of nine persons, including Mr. Oka, five designers, one tracer (female), two inspectors (including Mr. Oka), and one person in charge of general affairs (female).

The number of MTB-type products was about sixty per month, and the time consumed in designing one ranged approximately from 30 minutes to 100 hours (20 hours in the average). One or two of the fundamental elements that were designed per month required 150 to 300 man-hours of work.

For the MTB-type product, a copy of the manufacturing order, with the desired date for completion of the design filled in, came from the Scheduling Section and was regarded as the design order. Then Mr. Oka selected a designer and scheduled the date for completion of the design, taking the scheduled work load and the ability of each designer into consideration. If the scheduled completing date was later than that desired by Scheduling Section, Mr. Oka talked with Mr. Kitamura and made the necessary coordination. When the required change was too important for an agreement to be reached between them, it was discussed at the weekly conference on design promotion, attended by the plant manager and the chiefs of the Scheduling Section, of the Engineering Section, and of the Manufacturing Section.

The designer who was ordered to design a product judged which parts of the product needed to be newly designed and which parts the blueprints in stock would be applicable to, on the basis of the product specification. At the same time, he prepared the manufacturing specification, and filled in the number of the blueprint for the part to which it was applicable, and attached the newly drawn blueprint for the part for which no blueprint in stock was available.

The process of drawing a blueprint usually included some kind of technical computation, such as the computation of the moment of rotation and that of the tensile strength of the material. Mr. Oka estimated that the average portion of time consumed in computation would be about 15% of working time, but there were differences in skill among five designers; that is, the least skillful designer consumed three times as much time as the most skilled. No kind of numerical tables had been prepared yet within the company.

The Industrial Engineering Sub-section consisted of ten persons (all male), and was engaged in the planning of the machine tools to be used in the machine shop, in designing work of a research character, and in the designing of tools. Almost all the time of two persons was devoted to the planning of machine tools. The number of tools designed per month was about thirty, one tool design consuming 2 to 120 man-hours (20 man-hours in the average). But the time devoted to the second kind of job was quite difficult to estimate.